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February 1, 2023

Submitted via electronic mail

Ms. Ann Bekta
Wisconsin Department of Natural Resources
2514 Morse Street
Janesville, WI 53545

**Subject:** **Plan of Operations Modification Request – Addendum #1**
**Initial Permitting of CCR Landfill**
**Wisconsin Power and Light Company**
**Dry Ash Disposal Facility (WDNR License #3025)**
**Columbia Energy Center**
**Portage, WI**

Dear Ms. Bekta,

On behalf of Wisconsin Power and Light Company (WPL), Alliant Energy is submitting this Addendum #1 to the Plan of Operations Modification intended to meet the requirements of NR 514.045 for Initial Permitting of a CCR Landfill. As described in the document and discussed with the Department staff via conference call, this Plan Modification Request for the Dry Ash Disposal Facility located at the Columbia Energy Center (#3025) will be supplemented with additional information in the coming weeks.

Thank you very much for your consideration of this initial submittal. If you have any questions or comments regarding this information, please call me at (608) 458-3853.

Regards,

Jeff Maxted
Manager – Environmental Services
Alliant Energy

CC: Tyler Sullivan – Wisconsin DNR
Eric Sandvig, Director of Operations – Columbia Energy Center
Brian Clepper, Lead GENCO Environmental Specialist – Columbia Energy Center
Phil Gearing, Eric Nelson – SCS Engineers

February 1, 2023
File No. 25222260.00

Ms. Ann Bekta
Wisconsin Department of Natural Resources
2514 Morse Street
Janesville, WI 53545

Subject: Addendum No. 1 to Plan of Operation Modification Request WDNR CCR Code Update
Dry Ash Disposal Facility, License #3025
Columbia Energy Center
Town of Pacific, Columbia County, Wisconsin

Dear Ms. Bekta:

On behalf of Wisconsin Power and Light Company (WPL), SCS Engineers (SCS) prepared this Addendum No. 1 to the Plan Modification Request/Plan of Operation Update for the Dry Ash Disposal Facility, License No. 3025, at the Columbia Energy Center. This addendum covers additional information for the Wisconsin Department of Natural Resources (WDNR) Coal Combustion Residuals (CCR) Code Update dated December 2022 to demonstrate compliance with NR 514.045. WPL and SCS plan to submit additional addendums, as discussed below.

## FUTURE ADDENDUM ITEMS

As discussed during the January 23, 2023 teleconference, attended by representatives from the WDNR, Alliant Energy, WPL, and SCS, there are additional items in progress that maybe addressed through future addendums to this Plan Modification Request/Plan of Operation Update. These items include, but are not limited to:

- Groundwater monitoring network demonstration under NR 514.045(1)(h)
- Updated sampling plan under NR 514.045(1)(h)
- Leachate/Contact Water Pond abandonment strategy
- Phase 1, Modules 5 and 6 Final Cover Permanent Haul Road
- Plan for care and maintenance of the leachate collection system tanks and pumps
- Module 12 Liner Design, or proposal for the removal of the Module 11 liner runout

If you have any questions regarding this addendum, please contact Jeff Maxted with Alliant Energy at (608) 458-3853.

Sincerely,

Mark R. Huber, PE
Design Director
SCS Engineers

Phil Gearing, PE
Senior Project Manager
SCS Engineers

MRH/AJR/mjt/PEG

cc: Tyler Sullivan, WDNR
Jeff Maxted, Alliant Energy
Matt Bizjack, Alliant Energy
Brian Clepper, WPL

Encl. Addendum No. 1, Plan of Operation Modification Request WDNR CCR Code Update

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# Plan of Operation Modification Request
# WDNR CCR Code Update
# Addendum No. 1

Columbia Dry Ash Disposal Facility
Pardeeville, Wisconsin

Prepared for:

Wisconsin Power and Light Company
Columbia Energy Center
W8375 Murray Road
Pardeeville, Wisconsin 53954

SCS ENGINEERS

25222260.00 | February 1, 2023

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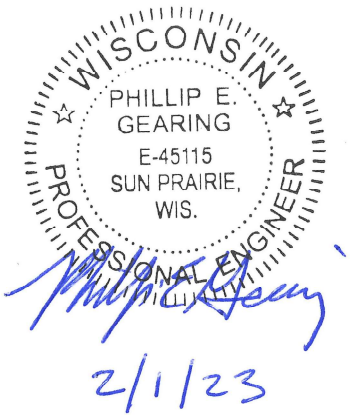
# CERTIFICATIONS

"I, Phillip E. Gearing, hereby certify that I am a licensed professional engineer in the State of Wisconsin in accordance with the requirements of ch. A-E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code."

_____, Senior Project Manager E-45115
Signature, title and P.E. number

February 1, 2023
Date



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# 1.0 INTRODUCTION

On behalf of Wisconsin Power and Light Company (WPL), SCS Engineers (SCS) prepared this Plan of Operation Modification (Plan Mod) Request – Addendum No. 1 for the Columbia Dry Ash Disposal (COL) Facility. This Addendum includes the information submitted with the original submittal and additional information developed since that submittal.

See **Figure 1** for the site location. This Plan Mod Request is submitted in accordance with the requirements of NR 514.045 and to demonstrate compliance with coal combustion residual (CCR) regulations that became effective in August 2022.

The COL facility includes an existing CCR landfill (Phase 1, Modules 1 through 3) and a new CCR landfill (Phase 1 Modules 4 through 6), all of which are contiguous and managed as a single landfill. In addition, the new CCR landfill will include Phase 2, Modules 10 and 11, which is currently under construction. The new modules will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for Wisconsin Department of Natural Resources (WDNR) review early in 2023. This Plan Mod Request addresses Phase 1, Modules 1 through 6 and Phase 2, Modules 10 and 11 (the CCR landfill). Construction of additional modules is not currently planned prior to retirement of the Columbia Energy Center, which is currently scheduled to occur no later than June 1, 2026.

# 2.0 PERFORMANCE AND LOCATION CRITERIA

NR514.045 (1)

> *"…The plan of operation modification shall address all phases of the CCR landfill. At a minimum, the plan of operation modification shall include all of the following:"*

## 2.1 PERFORMANCE CRITERIA UNDER NR 514.045 (1)(b)

NR 514.045 (b)

> *"A demonstration that all phases of the CCR landfill meet the performance criteria under s. NR 504.04 (4) (a), (b), and (c)."*

NR 504.04 (4)

> *"PERFORMANCE STANDARDS. No person may establish, construct, operate, maintain or permit the use of property for a landfill if there is a reasonable probability that the landfill will cause:"*

### 2.1.1 Compliance With NR 504.04 (4)(a)

NR 504.04 (4) (a)

> *"A significant adverse impact on wetlands as provided in ch. NR 103."*

Phase 1, Modules 1 through 6 are not located in wetlands. The location of Phase 1, Modules 1 through 6 is shown on **Figure 2**, and maps from a September 25, 2017 wetland delineation study conducted by Mach IV, are included in **Appendix A1**.

A wetland delineation conducted in 2017 (**Appendix A1**) identified one artificial wetland ("Wetland 1") within the Phase 2, Module 10 and 11 area (**Figure 2**). The artificial wetland was not identified as a mapped wetland in state or federal resources, and it was not located adjacent to the Waters of the State. WPL consulted with the WDNR to confirm its status as an artificial wetland and received concurrence that it is exempt from the permitting requirements of NR 103. Through the exemption process, WDNR and WPL determined that construction of Phase 2 Modules 10 and 11 would have no adverse impact on wetlands as provided in NR 103, and the artificial wetland was removed prior to construction of the Module 10 and 11 liner in 2022. No additional wetlands were delineated within the Phase 2, Module 10 and 11 area.

Run-off from the active portions of the facility is handled as contact water and is collected by a leachate collection system and internal swales, which route the contact water run-off to a lined contact water basin (shown in **Figure 2**), preventing contact water from having an adverse impact on wetlands.

The South Sedimentation Basin, shown on **Figure 2**, is designed to collect storm water diverted from covered portions of the CCR landfill. The South Sedimentation Basin discharges to a wetland area to the south of the pond. The South Sedimentation Basin is sized to handle storm water from a 25-year, 24-hour storm event without overtopping the 100-year, 24-hour emergency spillway and to allow a 15 micron particle size to settle out during a design storm event to prevent adverse impacts on downstream wetlands.

Storm water from northeast and northern parts of the CCR landfill, outside of the CCR landfill footprint, flow to swales south of Murray Road. The storm water from these swales is directed through a culvert under Murray Road, where the water infiltrates in a low spot on the north side of Murray Road. Storm water from these areas of the CCR landfill does not result in adverse impacts to downstream wetlands.

### 2.1.2 Compliance With NR 504.04 (4)(b)

NR 504.04 (4) (b)

*"A take of an endangered or threatened species in accordance with s. 29.604, Stats."*

In October 2022, an endangered resources review approved by WDNR was renewed for the construction of Modules 10 and 11. The review indicated that one federally endangered species, the slender glass lizard (*Ophisaurus attenuatus*) may be present in the surrounding area resulting in mowing and clearing requirements to ensure that the species, if present in the landfill footprint, would not be affected by construction activities or operations. The site adheres to these requirements to prevent the take of endangered or threatened species.

### 2.1.3 Compliance With NR 504.04 (4)(c)

NR 504.04 (4) (c)

*"A detrimental effect on any surface water."*

Storm water runoff calculations were performed to demonstrate that the existing storm water sedimentation basin and proposed storm water management features included in the CCR landfill can accommodate and safely convey the runoff from a 25-year, 24-hour storm event during post closure conditions. Storm water that comes into contact with waste is routed to a lined basin and

then hauled as needed to the plant for management in accordance with the facility's Wisconsin Pollutant Discharge Elimination System (WPDES) permit. Calculations were provided with the May 2022 submission of the Plan Modification Request/Plan of Operation Update.

## 2.2 LOCATIONAL CRITERIA UNDER NR 514.045 (1)(c)

NR 514.045 (c)

> *"A demonstration that all phases of the CCR landfill meet the locational criteria under s. NR 504.04 (3) (g), (h), and (i)…."*

NR 504.04 (3)

> *"LOCATIONAL CRITERIA. No person may establish, construct, operate, maintain or permit the use of property for a landfill where the limits of filling are or would be within the following areas:"*

### 2.2.1 Compliance With NR 504.04 (3)(g)

NR 504.04 (3) (g)

> *"Within 200 feet of a fault that has had displacement in Holocene time."*

Based on a review of the U.S. Geological Survey (USGS) Quaternary faults database and map as shown in **Appendix A2**, the CCR landfill is not located within 200 feet of the outermost damage zone of a fault that has had displacement in Holocene time. In NR 500.03 (103), Holocene is defined as the most recent epoch of the Quaternary period extending from the end of the Pleistocene Epoch to the present. The USGS map shows that no faults are located in Wisconsin.

### 2.2.2 Compliance With NR 504.04 (3)(h)

NR 504.04 (3) (h)

> *"Within seismic impact zones."*

The CCR landfill is not located in seismic impact zones. NR 500.03(208) defines a seismic impact zone as an area having a 10 percent or greater probability that the maximum expected horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10 g in 50 years. Based on a review of the USGS 2014 Long-Term Model National Seismic Hazard Map (see **Appendix A3**), the maximum expected horizontal acceleration for the majority of Wisconsin, including all of Columbia County, is less than 0.04 g, below the threshold for a seismic impact zone.

### 2.2.3 Compliance With NR 504.04 (3)(i)

NR 504.04 (3) (i)

> *"Within unstable areas."*

Unstable areas are addressed in **Section 2.2.4**

### 2.2.4 Compliance With NR 514.045 (1)(c)(1)

NR 514.045 (1)(c)

> *"…The demonstration shall address all of the following factors, at a minimum, when determining whether an area is unstable:"*

NR 514.045 (1)(c)(1)

> *"On–site or local soil conditions that may result in significant differential settling.*

As discussed in **Appendices A4** and **A5**, and as shown by the geologic cross sections from the June 1980 Supplementary Feasibility Study prepared by Warzyn Engineering Inc. (see **Appendix A6**), the CCR landfill is not located in on-site or local soil conditions that may result in significant differential settling. The site soils consist primarily of sands of alluvial and glacial origin overlaying sandstone bedrock. Based on the Standard Penetration Test (SPT) blow counts on the geologic cross sections, the soils are typically medium dense to very dense and therefore not susceptible to appreciable differential settlement under the CCR landfill loads.

### 2.2.5 Compliance With NR 514.045 (1)(c)(2)

NR 514.045 (1)(c)(2)

> *"On–site or local geologic or geomorphologic features."*

As discussed in **Appendices A4**, **A7**, and **A8**, and shown by the geologic cross sections in **Appendix A6**, the CCR landfill is not located in on-site or local geologic or geomorphologic features that are unstable. The cross sections show medium dense to very dense sands of alluvial and glacial origin overlaying sandstone bedrock. These geologic features provide a stable foundation for the CCR landfill.

This assessment is confirmed by the slope stability analyses completed for Phase 1, Modules 1 through 4, Modules 5 and 6, and Phase 2, Modules 10 and 11 that indicate the slope stability safety factors are acceptable.

The slope stability analyses in **Appendix A7** were performed for Phase 2, Modules 10 and 11 with maximum waste slope heights of 101 feet, and slopes of 3 horizontal to 1 vertical (3H:1V) and 4H:1V. The results in **Appendix A7** confirm that the slope stability safety factors for Modules 10 and 11 are acceptable.

The waste slopes in Phase 1, Modules 1 through 6 do not exceed 101 feet, so the results of the analyses in **Appendix A7** are representative of conditions in Phase 1, Modules 1 through 6.

### 2.2.6 Compliance With NR 514.045 (1)(c)(3)

NR 514.045 (1)(c)(3)

> *"On–site or local human–made features or events both surface and subsurface."*

As shown by the geologic cross sections in **Appendix A6**, the CCR landfill is not located in on-site or local human-made features or events (both surface and subsurface) that are unstable. The predominant native sands are overlain by sand fill in some areas of the site. The sand fill was placed

in the CCR landfill area during excavation activities for construction of the generating station. Based on the SPT blow counts for the sand fill on the cross sections, the fill is typically medium dense to very dense and therefore provides a stable base material where present below the CCR landfill.

As discussed in Appendix A8, groundwater or surface water movement is unlikely to cause instability. The facility is designed with adequate run-on and run-off control systems, and is constructed above the water table.

## 2.3 LOCATIONAL CRITERIA UNDER NR 514.045 (1)(d)

### 2.3.1 Compliance With NR 514.045 (1)(d)

NR 514.045 (1)(d)

> *"A demonstration that the facility or practices near floodplains may not restrict the flow of the regional flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste so as to pose a hazard to human life, wildlife, or land or water resources."*

The CCR landfill is not located within a floodplain as shown in Appendix A9.

## 2.4 LOCATIONAL CRITERIA UNDER NR 514.045 (1)(e)

### 2.4.1 Compliance With NR 514.045 (1)(e)

NR 514.045 (1)(e)

> *"A demonstration that the facility or practices may not result in the destruction or adverse modifications of the critical habitat of endangered or threatened species as identified under s. NR 27.03 (1)."*

An Endangered Resources Review for the recent Proposed Columbia Ash Landfill Expansion was renewed on October 24, 2022. No area affected by construction of operations of the CCR landfill has been identified as critical habitat for endangered or threatened species. Information in the Wisconsin Natural Heritage Inventory are considered confidential by WDNR, so this review has been redacted from this submittal.

# 3.0 LANDFILL DESIGN DEMONSTRATION

## 3.1 LANDFILL DESIGN DEMONSTRATION UNDER NR 514.045 (1)(f)

NR 514.045 (1)(f)

> *"A demonstration that the CCR landfill design meets requirements under s. NR 504.12 or an alternate design under s. NR 504.10. The demonstration shall include a design report, engineering drawings, and calculations."*

### 3.1.1 Landfill Design Demonstration under NR 504.12

#### 3.1.1.1 Compliance With NR 504.12 (2)

NR 504.12 (2)

> *"RUN–ON AND RUN–OFF CONTROLS. An existing or new CCR landfill or any lateral expansion of a CCR landfill shall be designed, constructed, operated, and maintained with a run–off and run–on control system in accordance with the requirements under s. NR 504.09 (1) (f) and (g) and all of the following:"*

NR 504.09 (1)(f)

> *"Storm water shall be diverted away from the active fill area of the landfill and any borrow areas to a sedimentation control structure."*

Storm water run-on is controlled by berms and swales around the perimeter of the landfill that divert storm water away from the landfill. Run-off from areas outside existing CCR units and areas of the existing CCR units where final or intermediate cover is in place is diverted into the perimeter drainage swales, which drain to the South Sedimentation Basin. Intermediate swales/berms and downslope channels on the final cover help minimize erosion of the final cover and divert water to the perimeter drainage system, and ultimately to the South Sedimentation Basin. Run-off from the active portions of the facility is handled as contact water and is collected by a leachate collection system and internal swales, which route the contact water run-off to the lined Leachate/Surface Water Pond.

NR 504.09 (1)(g)

> *"Containment berms placed around active fill areas shall be designed to control and collect the liquid volume resulting from the 25 year, 24–hour storm event. The design shall consider the volume of liquid generated from active fill areas which shall include areas with exposed solid waste or areas with waste covered by daily cover. Storm water in contact with active fill areas shall be handled and treated as leachate in accordance with ch. NR 506."*

The storm water features described above are designed to handle run-on and run-off from a 25-year, 24-hour storm event. Storm water run-off calculations are included in **Appendix B1**, including calculations from the 2000 Plan of Operation Update (**Appendix B1.1**), the 2021 Leachate/Surface Water Pond Capacity Evaluation calculations (**Appendix B1.2**), the 2022 Leachate/Surface Water Pond Evaluation calculations (**Appendix B1.3**), and 2022 Storm Water Management Calculations for post-closure conditions (**Appendix B1.4**). These appendices describe the storm water management design and provide calculations showing that the run-on control system will prevent flow onto the active portion of the CCR units during the peak discharge from a 25-year, 24-hour storm. The 2021 and 2022 calculations also describe the storm water management design and provide calculations showing that the run-off control system for the active portions of the CCR units will collect and control the water volume resulting from a 25-year, 24-hour storm. The South Sedimentation Basin and associated basin outlet structures are designed to safely pass run-off from a 100-year, 24-hour storm event.

NR 504.12 (2)(a)

> *"A run–on control system shall prevent flow onto the active portion of the CCR landfill during the peak discharge from a 24–hour, 25–year storm."*

The entire facility has run-on and run-off control in place, as approved by the WDNR and described further in **Appendix C2**. Run-on is controlled by berms and swales around the perimeter of the landfill that divert storm water away from the landfill.

NR 504.12 (2)(b)

> *"A run–off control system from the active portion of the CCR landfill shall collect and control, at a minimum, the water volume resulting from a 24–hour, 25–year storm."*

Run-off from the active portions of the facility is handled as leachate and is collected by a leachate collection system and internal swales, which route the contact water run-off and leachate to the lined Leachate/Surface Water Pond. Intermediate cover will be added as CCR placement progresses to reduce contact water that is directed to the pond. The contact water in the pond is used for dust control or other actions within the active landfill or, if needed, is transported with a water wagon to the generating station where it may be discharged through Outfall 003 inside the plant in accordance with a WPDES permit.

Run-off from areas outside existing CCR units and areas of the existing CCR units where final or intermediate cover is in place is diverted into the perimeter drainage swales, which drain to the South Sedimentation Basin or a low area north of the facility. Intermediate swales/berms and downslope channels on the final cover help minimize erosion of the final cover and divert water to the perimeter drainage system.

A temporary rain cover will be installed as needed over landfill liner not currently in use, to limit leachate and contact water production. Storm water collected on the rain cover will be diverted to perimeter swales, and ultimately to the sedimentation basin. The rain cover will be removed in sections to accommodate waste placement. As the rain cover is removed, new diversion berms will be constructed to form the perimeter of a storm water containment area. The berms will prevent contact water from running onto the rain cover and will anchor or ballast the rain cover at the new limits. When the rain cover has been fully removed, run-off will be controlled by the limits of the developed modules, and all water inside the lined waste limits will be managed as leachate.

#### 3.1.1.2 Compliance With NR 504.12 (3)

NR 504.12 (3)(a)

> *"LINER DESIGN. (a) A new CCR landfill or a lateral expansion of a CCR landfill shall be designed, constructed, operated, and maintained with a composite liner that meets the requirements under s. NR 504.06 (2) and (3) and a leachate collection and removal system that meets the requirements under s. NR 504.06(5). The composite liner shall consist of 2 components; the upper component shall consist of a nominal 60–mil or thicker geomembrane liner, and the lower component shall consist of a minimum 4–foot–thick layer of compacted clay. A GCL and soil barrier may be used in place of the clay layer of a composite liner in accordance with s. NR 504.06 (7). In addition to the minimum design and construction criteria for landfill liners and leachate collection systems under s. NR 504.06, the liner and leachate collection system shall meet all of the following:"*

Construction commenced prior to October 19, 2015 for Phase 1, Modules 1 through 3. These modules do not fall under the NR 500.03 (152m) definition of "New CCR landfill" and meet the definition of "Existing CCR landfill" under NR 500.03 (76m). As existing CCR landfill modules, NR 504.12(3) is not applicable to Phase 1, Modules 1 through 3.

Phase 1, Modules 4 through 6, and Phase 2, Modules 10 and 11 were designed with a composite liner in accordance with NR 504.06 (7), shown on **Figure 3**, consisting of the following three layers from top to bottom:

- A 60-mil thick HDPE geomembrane
- A geosynthetic clay liner (GCL)
- Two feet of compacted clay soil with a hydraulic conductivity of no more than $1 \times 10^{-7}$ cm/sec

A review of chemical resistance documentation for high-density polyethylene (HDPE) geomembrane provided by geomembrane manufacturers indicates that the HDPE geomembrane is chemically resistant to the CCR and CCR-generated leachate. The chemical resistance assessment is also based on a review of Columbia leachate pond analytical test results from 2011 to 2020.

The GCL specified in the design includes a polymer-enhanced bentonite clay that has appropriate chemical properties in contact with the Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11 CCR leachate. Testing was performed to demonstrate that the GCL is compatible with the site-generated CCR leachate as shown in **Appendix B2**.

The composite liner layers have sufficient strength and thickness to prevent failure due to pressure gradients, climatic conditions, installation stresses, and daily operation stresses expected in Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11.

GCLs used in the construction of the liner and final cover systems at the CCR Landfill meet the specifications of NR 504.07(4)(a)1 to 11. A 60-mil HDPE geomembrane is to be placed directly above the GCL. The geomembrane meets the specifications of NR 504.07(3).

The new CCR landfill has been designed with a composite liner that meets the requirements under NR 504.06 (2) and (3) and with a leachate collection and removal system that meets the requirements under NR 504.06(5).

### NR 504.12 (3)(a)(1)

> *"The leachate collection and removal system shall be designed, constructed, operated, and maintained to limit the leachate head level on the liner to one foot or less."*

The Hydrologic Evaluation of Landfill Performance (HELP) Model was used to evaluate the leachate head on the Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11 liner. Based on the model results, the head on the liner will be maintained below the maximum allowable 1-foot (30-centimeter) head. The HELP Model calculation is provided in **Appendix B3**. Based on the model, Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11 are designed and will be operated to maintain less than a 30-centimeter depth of leachate over the liner.

NR 504.12 (3)(a)(2)

*"The leachate collection and removal system shall be constructed of materials that exhibit all of the following properties:"*

NR 504.12 (3)(a)(2)(a)

*"Chemically resistant to the CCR and any non−CCR waste managed in the CCR landfill and the leachate expected to be generated."*

The leachate collection and removal system consists of HDPE pipe, leachate drainage layer, drainage filter, coarse aggregate bedding, and geotextile as shown on **Figures 3, 4,** and **5**. The leachate drainage layer consists of imported granular soil. The drainage filter and coarse aggregate bedding are imported granular soils. The pipe, granular soils, and geotextile are chemically resistant to the CCR and CCR-generated leachate.

The pipe consists of HDPE, the same material as the HDPE geomembrane. Both the HDPE pipe and the geomembrane are resistant to the CCR and CCR-generated leachate as confirmed by the manufacturer's literature.

The geotextile may consist of polypropylene, polyester, or polyethylene. Based on testing by the manufacturers and other researchers, these materials are resistant to municipal solid waste landfill leachate that is much more aggressive than CCR leachate. Therefore, the geotextile is chemically resistant to the CCR and CCR-generated leachate.

The granular soils used in the leachate collection and removal system meet the same Wis. Adm. Code standards as the granular soils used in municipal solid waste landfills. The municipal solid waste landfill leachate is much more aggressive than CCR leachate so the granular soils are chemically resistant to the CCR and CCR-generated leachate.

NR 504.12 (3)(a)(2)(b)

*"Of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used at the CCR landfill."*

During the design of Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11, the HDPE collection and removal pipe was evaluated for pipe strength using construction/operation loads and post-closure loads to determine the required materials of construction. Based on the pipe strength calculations in **Appendix B4**, the HDPE pipe will have sufficient strength to prevent collapse under the pressures exerted by the CCR, cover materials, and equipment used in the operation of the CCR landfill, based on the equipment currently used to operate the existing CCR units at the facility.

NR 504.12 (3)(a)(3)

*"The leachate collection and removal system shall be designed and operated to minimize clogging during the active life and during the long−term care of the landfill."*

The leachate collection and removal system is designed with a drainage filter as shown on **Figure 3**. The filter minimizes the movement of fine particles into the leachate collection pipes to prevent clogging**.** Filter calculations are provided in the documentation report for each module construction based on the specific gradation of material provided for coarse aggregate and drainage material. The

leachate collection and removal system is designed with cleanout riser pipes as shown on **Figures 3, 4,** and **5** to allow pipe cleaning and prevent long-term clogging. The leachate collection pipes are cleaned a minimum of once per year in accordance with Wis. Adm. Code.

NR 504.12 (3)(a)(4)

> *"The geomembrane component of the liner shall be installed in direct and uniform contact with the compacted clay soil component."*

Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11, are designed with a composite liner, shown on **Figure 3**, consisting of the following two components from top to bottom:

- Upper Component :
  - A 60-mil thick HDPE geomembrane
  - A GCL
- Lower Component:
  - Two feet of compacted clay soil with a hydraulic conductivity of no more than 1 x $10^{-7}$ cm/sec

This is the same composite liner that meets the requirements of NR 504.06 (2) with the addition of the GCL layer to the upper component, in accordance with NR 504.06 (7). The GCL provides an extra layer within the composite liner to reduce the potential for liquid flow through the liner.

The presence of the GCL provides better protection against liquid flow through the Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11 liner than a composite liner with two layers (HDPE geomembrane and 2 feet of compacted soil). The upper component (geomembrane and GCL) has direct and intimate contact with the compacted clay soil as the lower component. Laboratory test results reported by Koerner and Daniel (1993) show that the combination of a GCL in contact with a geomembrane is significantly lower in transmissivity of liquid than a compacted clay liner in contact with a geomembrane.

NR 504.12 (3)(a)(5)

> *"A liner that utilizes a GCL and soil barrier layer in accordance with s. NR 504.06 (7) shall be designed to have a liquid flow rate no greater than the liquid flow rate through 2 feet of compacted soil with a hydraulic conductivity of 1 x $10^{-7}$ cm/sec. The liquid flow rate comparison shall be made using the following equation, which is derived from Darcy's Law for gravity flow through porous media:*
>
> $$Q/A = q = k\,(h/t + 1)$$
>
> *Where:*
> *Q = flow rate (cubic centimeters / second).*
> *A = surface area of the liner (squared centimeters).*
> *q = flow rate per unit area (cubic centimeters / second / squared centimeter).*
> *k = hydraulic conductivity of the liner (centimeters / second).*
> *h = hydraulic head above the liner (centimeters).*
> *t = thickness of the liner (centimeters)."*

The lower component of the composite liner is the 2-foot-thick compacted clay soil layer. The addition of a GCL to the composite liner system reduces the hydraulic conductivity of the composite liner below the maximum required value of 1 x $10^{-7}$ cm/sec. In combination, the GCL and the compacted clay exceed the design requirements. The hydraulic conductivity of the GCL specified in the design of Phase 1, Modules 4 through 6 and Phase 3, Modules 10 and 11 is a maximum of 5 x $10^{-9}$ cm/sec. The hydraulic conductivity of the compacted clay specified in the design of Phase 1, Modules 4 through 6 and Phase 3, Modules 10 and 11 is a maximum of 1 x $10^{-7}$ cm/sec, which meets the rule requirement.

The flow rate per unit area ("q") of the GCL underlain by 2 feet of compacted clay is less than the "q" of the minimum 2-foot-thick compacted soil layer required under NR 504.06 (2) as shown by the calculations in **Appendix B5**. Therefore, the hydraulic conductivity of the GCL in combination with the 2 feet of compacted clay soil has a liquid flow rate that is no greater than the liquid flow rate through 2 feet of compacted soil with a hydraulic conductivity of 1 x $10^{-7}$ cm/sec. In addition, a paper by Koerner and Daniel (1993) shows that the liquid flow rate through a GCL alone is equivalent to the flow rate through 2 feet of compacted clay.

### NR 504.12 (3)(b)

> *"A new CCR landfill or a lateral expansion of a CCR landfill shall be designed and constructed with a subbase grade that is located no less than 5 feet above the upper limit of the uppermost aquifer, or shall demonstrate that there will not be an intermittent recurring or sustained hydraulic connection between any portion of the base of the CCR landfill and the uppermost aquifer due to normal fluctuations in groundwater elevations, including the seasonal high water table."*
>
> *Note: A new CCR landfill or lateral expansion of a CCR landfill is also required to comply with s. NR 504.06 (2) (b) or (4) for zone–of–saturation landfills. The definition of an uppermost aquifer can be found under s. NR 500.03 (246m).*

The high water table within the uppermost aquifer below the CCR landfill is at an approximate elevation of 789 to 790 feet above mean sea level (amsl), based on a review of water table observation well water levels near the CCR landfill, for the period from October 2012 to December 2022; refer to **Appendix B6**. The highest water level elevation measured at a well in the area of the CCR landfill was 789.71 feet amsl recorded at MW-5R, which is located near the southwest corner of Phase 1, Module 1. The highest water level elevation measured in a well in the area of Phase 2, Modules 10 and 11 was 788.21 feet amsl recorded at MW-86.

**Figure 6** shows the lowest subbase grades in Phase 1, Modules 4 through 6 and Phase 2, Modules 10 and 11, which represent the top of subbase soils and bottom of the clay liner. The lowest subbase elevation within Phase 1 Module 4 is approximately 801 feet amsl. The lowest subbase elevation within Phase 1, Modules 5 and 6 is approximately 802 feet amsl. Within Phase 2, Modules 10 and 11, the lowest subbase grade is approximately 794 feet amsl.

Based on this information, the CCR landfill is located at least 5 feet above the uppermost aquifer.

### NR 504.12 (3)(c)

> *"A new CCR landfill or a lateral expansion of a CCR landfill may not be constructed over a closed CCR surface impoundment."*

The existing CCR landfill has not been constructed over a closed CCR surface impoundment.

### 3.1.1.3 Compliance With NR 504.12 (4)

NR 504.12 (4)(a)

> *"A new or existing CCR landfill or a lateral expansion of a CCR landfill shall be designed and constructed with a final cover system that meets the requirements under s. NR 504.07."*

Phase 1, Module 1 has received final cover over outer sideslope areas that will no longer receive CCR. The existing final cover in the Module 1 area will be extended to cover the remaining portion of Module 1 as shown on **Figure 8**.

The existing final cover consists of a composite cover (**Figure 7**) with the following components, from bottom to top:

- Three-inch-thick grading layer
- GCL
- Forty-mil polyethylene geomembrane
- Twelve-inch-thick drainage layer (sand)
- Twelve-inch-thick rooting zone layer
- Six-inch-thick topsoil layer

An alternative final cover system was approved by WDNR in July 2022 for future remaining areas of final cover north of Module 1. The alternative cover consists of the following components, from bottom to top:

- Three-inch-thick grading layer
- GCL
- Forty-mil polyethylene geomembrane
- Geocomposite drainage layer
- Twenty-four-inch-thick rooting zone layer
- Six-inch-thick topsoil layer

The alternative final cover design has been developed to meet the requirements of NR 504.12(4)(b) and is discussed in detail below.

Calculations for the final cover designs are included in **Appendix B7.**

NR 504.12 (4)(b)

> *"The owner or operator of a new or existing CCR landfill or a lateral expansion of a CCR landfill may propose an alternative final cover system design within a written closure plan in accordance with s. NR 504.10 and all of the following:"*

The alternative final cover system design previously approved by the Department in accordance with NR 504.10 is described further within the written closure plan provided in this Plan of Operation Update (**Appendix C3**). The final cover system design is in accordance with the federal requirements under 40 CFR Part 257, Subpart D.

NR 504.12 (4)(b)(1)

> *"The permeability of the final cover system shall be less than or equal to the permeability of any bottom liner system or natural subsoils present or shall be no greater than 1 x $10^{-5}$ cm/sec, whichever is less."*

The permeability of the alternative final cover system is less than or equal to the permeability of the bottom liner system and is less than 1 x $10^{-5}$ centimeters per second (cm/sec) required by the rule. The CCR landfill cover system contains a GCL with a permeability of 5 x $10^{-9}$ cm/sec. Please see the Closure Plan (**Appendix C3**) for more information. **NR 504.12 (4)(b)(2)**

> *"The design of the final cover system shall include an infiltration layer that achieves an equivalent reduction in infiltration as the layers specified under s. NR 504.07 (4)."*

The alternative final cover contains a GCL infiltration layer. Water infiltrating the final cover will be contained in the drainage layers (sand, geocomposite, and high capacity geocomposite), which will limit infiltration through the final cover system geomembrane and GCL. Further discussions with the WDNR will be needed to determine whether updates to the design are required, including potential addition of a soil barrier layer. An updated design, if required, will be provided as an Addendum to this document.

The geocomposite drainage layer will have a minimum transmissivity of 8.55 x $10^{-4}$ $m^2$/sec unless drainage outlets are constructed within the final cover. For the converging flow areas in the final cover inside corners near Phase 2, Modules 10 and 11, a high capacity geocomposite drainage layer with a minimum transmissivity of 1.0 x $10^{-3}$ $m^2$/sec will be installed. Please see the Closure Plan (**Appendix C3**) for more information.

NR 504.12 (4)(b)(3)

> *"The design of the final cover system shall include an erosion layer that provides equivalent protection from wind or water erosion as the topsoil layer specified under s. NR 504.07 (7)."*

The surface layer of 30 inches of soil supports vegetation that assists with erosion control. The surface has intermediate drainage swales to reduce the flow lengths down the final cover slope, also aiding in erosion control. Where needed, the intermediate drainage swales are connected to downslope channels to control storm water runoff and prevent erosion of the final cover.

NR 504.12 (4)(b)(4)

> *"The disruption of the integrity of the final cover system shall be minimized through a design that accommodates settling and subsidence."*

The design of the final cover system accommodates settling and subsidence of the CCR fill below the cover. The CCR at the CCR landfill is placed dry and is compacted in place. CCR continues to consolidate and gain strength as filling progresses prior to final cover placement. The final cover system is designed with a maximum slope of 25 percent (4 horizontal to 1 vertical). Because the final cover has a relatively large positive slope and the CCR has been gaining strength over time, the final cover is expected to easily accommodate the remaining relatively minor settlement potential of the CCR fill when fill placement ends and the landfill is closed.

### 3.1.2 Alternate Landfill Design Demonstration under NR 504.10

NR 504.10 (1)(a)

> *"An applicant may design a high volume industrial waste landfill to meet the standards contained in ss. NR 504.05 to 504.09 or may propose an alternative design in accordance with the provisions of this section."*

The CCR landfill has been designed to meet the standards contained in NR 504.05 to NR 504.09. However, an alternative final cover design that meets the requirements of NR 504.07 is being proposed, as discussed in Section 3.1.1.3. The alternative final cover design was approved by WDNR in the July 2022 plan of operation modification approval.

# 4.0 OPERATIONAL PLANS

## 4.1 LANDFILL DESIGN DEMONSTRATION UNDER NR 514.045 (1)(g)

NR 514.045 (1)(g)

> *"The plans required under s. NR 514.07 (10)."*

### 4.1.1 Plans Required under NR 514.07 (10)

NR 514.07 (10)

> *"ADDITIONAL REQUIREMENTS FOR CCR LANDFILLS. The owner or operator of a new or existing CCR landfill or lateral expansion of a CCR landfill shall update the plan of operation every 10 years during the landfill's active life to comply with regulations in place at the time of the update. The plan of operation update will be considered a plan of operation modification, but shall follow the completeness, review times, and pre−plan of operation submittal public meeting requirements under s. NR 514.04. The plan of operation for all CCR landfills shall include all of the following:"*

#### 4.1.1.1 Compliance With NR 514.07 (10)(a)

NR 514.07 (10)(a)

> *"A CCR fugitive dust control plan in accordance with all of the following:*
>
> *1. The plan shall identify and describe the CCR fugitive dust control measures the owner or operator will use to minimize CCR from becoming airborne at the facility. The owner or operator shall select and include in the CCR fugitive dust control plan the CCR fugitive dust control measures that are most appropriate for site conditions, along with an explanation of how the measures selected are applicable and appropriate for site conditions. Control measures may include any of the following:*
>
> *a. Locating CCR inside an enclosure or partial enclosure.*
>
> *b. Operating a water sprayer or fogging system.*
>
> *c. Reducing fall distances at material drop points.*
>
> *d. Using wind barriers, compaction, or vegetative covers.*

*e. Establishing and enforcing reduced vehicle speed limits.*

*f. Paving and sweeping roads.*

*g. Covering trucks transporting CCR.*

*h. Reducing or halting operations during high wind events.*

*i. Applying a daily or intermediate cover.*

2. *The plan shall include procedures to wet CCR with water to a moisture content that will prevent wind dispersal but will not result in free liquids. In lieu of water, wetting of CCR may be accomplished with an appropriate chemical dust suppression agent.*

3. *The plan shall include a description of the procedures the owner or operator will follow to periodically assess the effectiveness of the control plan. At a minimum, the assessment shall include a visual inspection at least every 7 days, unless the CCR landfill is inactive and all areas are covered by intermediate or final cover.*

4. *The plan shall be modified in accordance with s. NR 514.04 (6) whenever there is a change in conditions that may substantially affect the plan of operation.*

5. *The plan shall address the preparation of an annual fugitive dust control report in accordance with s. NR 506.20 (3) (a).”*

A CCR fugitive dust control plan that complies with NR 514.07 (10)(c) is in place. The amended CCR fugitive dust control plan is included in **Appendix C1**.

#### 4.1.1.2 Compliance With NR 514.07 (10)(b)

NR 514.07 (10)(b)

*“A run–on and run–off control system plan that includes all of the following:*

1. *A run–on and run–off control system designed in accordance with the requirements under s. NR 504.12 (2).*

2. *Plan sheets depicting the location of run–on and run–off control features, detail drawings, and supporting engineering calculations.*

3. *Construction procedures and a schedule for construction.*

4. *Modification every 5 years from the date of the most recent plan approval or whenever there is a change in conditions that may substantially affect the written plan in effect. The modification shall be requested by the owner or operator in accordance with s. NR 514.04 (6) prior to the 5–year deadline.”*

A run-on and run-off control system plan that complies with NR 514.07 (10)(b) is in place. The amended run-on and run-off control system plan is included in **Appendix C2**.

### 4.1.1.3 Compliance With NR 514.07 (10)(c)

NR 514.07 (10)(c)

*"A written closure plan in accordance with the requirements under s. NR 514.06 (10) and all of the following:*

1. *A narrative description of how the CCR landfill will be closed, including a description of the steps necessary to close the CCR unit at any point during the active life of the CCR unit, consistent with recognized and generally accepted good engineering practices.*

2. *A description of the final cover system, designed in accordance with s. NR 504.07, and the methods and procedures to be used to install the final cover.*

3. *A demonstration, including a narrative discussion, of how final closure will meet the performance standards under s. NR 506.083 (6).*

4. *An estimate of the maximum volume in cubic yards of CCR that will be disposed on–site over the active life of the CCR landfill.*

5. *An estimate of the largest area of the CCR landfill that will require a final cover at any time during the CCR landfill's active life.*

6. *A schedule for completion of all closure activities, including ban estimate of the year in which all closure activities for the CCR landfill will be completed. The schedule shall provide sufficient information to describe the sequential steps that will be taken to close the CCR landfill, including identification of major milestones such as coordinating with other agencies and obtaining other necessary approvals or permits, installation of the final cover system, and the estimated timeframes to complete each step or phase of CCR landfill closure. If the estimated timeframes to complete closure exceed the timeframes specified under s. NR 506.083 (3) (a), the plan shall include the site–specific information, factors and considerations that support any time extension.*

7. *The plan shall be modified in accordance with s. NR 514.04 (6) whenever there is a change in conditions that may substantially affect the written closure plan or unanticipated events necessitate a revision of the written closure plan. The modification shall be submitted to the department in writing at least 60 days prior to a planned change in the operation of the CCR landfill, or no later than 60 days after an unanticipated event requires the need to revise an existing written closure plan. If a written closure plan is revised after closure activities have commenced for a CCR landfill, the owner or operator shall submit the modification request to the department no later than 30 days following the triggering event.*

8. *If closure of the CCR landfill will be accomplished through removal of CCR from the CCR landfill, the closure plan shall be modified and approved by the department prior to implementation in accordance with s. NR 514.04 (6). The closure plan shall include a description of the procedures to remove the CCR and decontaminate all areas affected by the CCR landfill in accordance with s. NR 506.08 (5).*

A written closure plan that complies with NR 514.07 (10)(c) is in place for Phase 1, Modules 1 through 6, and Phase 2, Modules 10 and 11. The amended written closure plan is included in Appendix C3.

### 4.1.1.4 Compliance With NR 514.07 (10)(d)

NR 514.07 (10)(d)

*"A written long–term care plan that addresses all of the following:*

1. *A description of the monitoring and maintenance activities and the frequency at which those activities will be performed. The activities shall include, at a minimum, all of the following:*

    *a. Long–term care activities specified under s. NR 514.06 (11).*

    *b. Maintaining the integrity and effectiveness of the final cover system, including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion or other events, and preventing run–on and run–off from eroding or otherwise damaging the final cover.*

    *c. Maintaining the effectiveness of the leachate collection and removal system and operating the leachate collection and removal system in accordance with the requirements under s. NR 504.12 (3) (a). d. Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with ch. NR 507 and the sampling plan approval.*

2. *The name, address, telephone number, and email address of the person or office to contact about the facility during long– term care.*

3. *A description of the planned uses of the property during long–term care. Post–closure uses may not disturb the integrity of the final cover, liner, or any other component of the landfill, or the function of the monitoring systems unless approved in writing by the department. A written request for approval as part of the plan of operation submittal or a modification shall include a demonstration that disturbance of the final cover, liner, or other component of the containment system, including any removal of CCR, will not increase the potential threat to human health or the environment. The demonstration shall be certified by a professional engineer in accordance with s. NR 500.05 (4) (a)."*

A written long–term care plan that complies with NR 514.07 (10)(d) is in place for Phase 1, Modules 1 through 6 and Phase 2, Modules 10 and 11. The amended written long–term care plan is included in Appendix C4.

### 4.1.1.5 Compliance With NR 514.07 (10)(e)

NR 514.07 (10)(e)

*"The long–term care plan under par. (d) may be modified in accordance with s. NR 514.04 (6). The owner or operator shall modify the long–term care plan whenever there is a change in the operation of the CCR landfill that would substantially affect the written long–term care plan in effect; or after long–term care activities have commenced, when unanticipated events necessitate a revision of the written long–term care plan. The modification shall be submitted to*

*the department in writing at least 60 days prior to a planned change in the operation of the CCR landfill, or no later than 60 days after an unanticipated event requires the need to revise an existing long–term care plan. If a written long–term care plan is revised after long–term care activities have commenced for a CCR landfill, the owner or operator shall submit the modification request to the department no later than 30 days following the triggering event."*

Any modification of the written long–term care plan will be submitted to the department in writing in compliance with NR 514.07 (10)(e).

# 5.0 GROUNDWATER MONITORING NETWORK DEMONSTRATION

## 5.1 GROUNDWATER MONITORING NETWORK DEMONSTRATION UNDER NR 514.045 (1)(h)

NR 514.045 (1)(h)

*"A demonstration that the CCR groundwater monitoring system complies with the requirements under s. NR 507.15 (3), including documentation of the design, installation, and development of any CCR wells."*

To be provided in an addendum to this report, per discussions with the WDNR.

# 6.0 UPDATED SAMPLING PLAN

## 6.1 UPDATED SAMPLING PLAN UNDER NR 514.045 (1)(g)

NR 514.045 (1)(i)

*"An updated sampling plan that addresses the requirements under s. NR 507.15 (3)."*

To be provided in an addendum to this report, per discussions with the WDNR.

# 7.0 ADDENDUM DOCUMENTS

## 7.1 LEACHATE/SURFACE WATER POND

A pond abandonment strategy is in progress and will be submitted as an addendum to this Plan. This will include sequencing for filling the pond and adjustments to surrounding infrastructure.

## 7.2 PHASE 1, MODULES 5 AND 6 HAUL ROAD

Development of a permanent haul road in Modules 5 and 6 is in progress and will be submitted as an addendum to this Plan. The permanent haul road will be on the final cover system of Modules 5 and 6 and will provide future access during the post-closure period of the landfill.

## 7.3 CARE AND MAINTANCE OF LEACHATE COLLECTION SYSTEM TANKS AND PUMPS

Condition 6 of the July 28, 2022 conditional plan of operation approval modification for the 10-year update, states that "WPL shall submit an operation plan, which addresses the care and maintenance of the tanks and pumps, by February 1, 2023. The plan shall also address the means to monitor the tank and manholes secondary containment systems." The pumps for the leachate collection system have yet to be installed and the other infrastructure elements (tanks and manholes) are not planned to be constructed in the near future. An operational plan to address this condition may be submitted as an addendum to this Plan.

## 7.4 MODULE 12 LINER DESIGN

Condition 8 of the July 28, 2022 conditional plan of operation approval modification for the 10-year update, states that "WPL shall submit the design for the construction of Module 12 liner or submit a proposal for removal of the liner runout from Module 11 and timing of construction of the north berm for Module 11, by February 1, 2023." Evaluation of the need for construction of Module 12 is still in progress. The Module 12 liner design may be submitted as an addendum to this Plan once a decision is made.

## 7.5 GROUNDWATER MONITORING NETWORK DEMONSTRATION

The groundwater monitoring network demonstration under NR 514.045 (1)(h) will be provided as an addendum to this plan.

## 7.6 UPDATED SAMPLING PLAN

The updated sampling plan under NR 514.045 (1)(h) will be provided as an addendum to this plan.

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# Table 1

## CCR Landfill Plan of Operation Modification for Initial Permitting Checklist

**Table 1.**
**Coal Combustion Residual (CCR) Landfill Plan of Operation Modification for Initial Permitting Checklist**
**Section NR 514.045, Wis. Adm. Code**
**Wisconsin Power and Light Company - Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222260.00**

| REGULATORY REQUIREMENTS | COMPLETE? | | | LOCATION | COMMENTS |
|---|---|---|---|---|---|
| | Y | N | NA | | |
| **NR 514.045(1)(a) Does the submittal meet the requirements under s. NR 500.05, including the certifications required under s. NR 500.05(4)?** | | | | | |
| NR 500.05 GENERAL SUBMITTAL REQUIREMENTS. | | | | | |
| (1) Has payment of the review fee of $30,500 been received?<br>Note: The department sends an invoice to the facility contact upon receipt of the submittal. Payment is due within 30 days of receipt of the invoice. | | | | | |
| (2) Has a cover letter detailing the desired action been submitted? | | | | Cover Letter | |
| (3) Have the appropriate number of written and electronic copies been submitted to the department? | | | | N/A | |
| (4) Are the report and plan sheets submitted under the seals and certifications of a licensed professional engineer and professional geologist? | | | | | |
| (5) Technical Procedures: | | | | | |
| Were all test procedures specified in the report? | | | | N/A | |
| Were all technical procedures used to investigate the facility current standard procedures? | | | | N/A | |
| Were explanations and reasons given for deviations from any current standard method? | | | | N/A | |
| (6) Do all maps, plan sheets, drawings, isometrics, cross-sections, figures, photographs and tables meet the following requirements? | | | | | |
| (a) No larger than 32 inches by 44 inches and no smaller than 8 ½ inches x 11 inches.<br>Note: Section NR 514.045, Wis. Adm. Code requires engineering plans be drawn on standard 24 inch by 36-inch plan sheets. | | | | Figures 1 - 8 | |
| (b) Appropriate scale to show all required detail in sufficient clarity. | | | | Figures 1 - 8 | |
| (c) __numbered __legends for all symbols<br>__referenced in the narrative __horizontal & vertical scales<br>__titled __drafting and origination dates | | | | Figures 1 - 8 | |
| (d) Use uniform scales. | | | | Figures 1 - 8 | |
| (e) Contain a north arrow. | | | | Figures 1 - 8 | |
| (f) Use mean sea level as the basis for all elevations. | | | | Figures 1 - 8 | |
| (g) Contain a survey grid based on monuments established in the field and which utilize a coordinate system and datum, such as state plane coordinates, Universal Transverse Mercator (UTM), or Wisconsin Transverse Mercator. | | | | Figures 1 - 8 | |
| (h) Show original topography and a grid system shown on the plan sheets that show construction, operation, and closure topography. | | | | Figures 1 - 8 | |
| (i) Any cross-sections:<br>__Show survey grid locations,<br>__Reference major plan sheets,<br>__Include a reduced diagram of plan view showing cross-section location. | | | | N/A | |
| (7) A table of contents listing all sections of the submittal. | | | | Report Table of Contents | |
| (8) An appendix listing the following:<br>__names of all references __all raw data<br>__testing and sampling procedures __calculations | | | | Report Appendicies | |
| **NR 514.045(1)(b) Does the submittal include a demonstration that all phases of the CCR landfill meet the performance criteria under s. NR 504.04(4)(a), (b), and (c)?** | | | | | |
| NR 504.04(4) PERFORMANCE STANDARDS. Will the proposed landfill cause the following: | | | | | |
| (a) A significant adverse impact on wetlands?<br>__yes __no<br>Has a practicable alternatives analysis and a wetland functional values analysis been completed in accordance with ch. NR 103, if a wetland will be affected by the proposed landfill or any noncommercial soil borrow source activity?<br>Note: See DNR wetland regulation website (https://dnr.wisconsin.gov/topic/Wetlands/permits) to help determine if a wetland permit may be needed per s. 281.36, Stats. | | | | Report Section 2.1.1 | |
| (b) A take of an endangered or threatened species in accordance with s. 29.604, Stats?<br>__yes __no | | | | Report Section 2.1.2 | |
| (c) A detrimental effect on any surface water?<br>__yes __no<br>Note: Exemptions are not granted. | | | | Report Section 2.1.3 | |
| For new CCR landfills or a lateral expansion of a CCR landfill, if the landfill failed to make the demonstration showing compliance with the criteria above, has the landfill ceased placing CCR in the CCR landfill per NR 514.045(5)(b)? | | | | N/A | |
| **NR 514.045(1)(c) Does the submittal include a demonstration that all phases of the CCR landfill meet the locational criteria under s. NR 504.04(3)(g), (h), and (i)?** | | | | | |
| NR 504.04(3) LOCATIONAL CRITERIA. Are the proposed limits of filling within: | | | | | |
| (g) 200 feet of a fault that has had displacement in Holocene time?<br>__yes __no<br>__If yes, was an exemption requested? | | | | Report Section 2.2.1 | |
| (h) Seismic impact zones?<br>__yes __no<br>__If yes, was an exemption requested? | | | | Report Section 2.2.2 | |
| (i) Unstable areas?<br>__yes __no<br>__If yes, was an exemption requested? | | | | Report Section 2.2.3 | |
| For new CCR landfills or a lateral expansion of a CCR landfill, if the landfill failed to make the demonstration showing compliance with the criteria above, has the landfill ceased placing CCR in the CCR landfill per NR 514.045(5)(b)? | | | | N/A | |
| **NR 514.045(1)(c) (continued) Does the demonstration for unstable areas address all of the following factors, at a minimum, when determining whether an area is unstable:** | | | | | |
| 1. On-site or local soil conditions that may result in significant differential settling. | | | | Report Section 2.2.4 | |
| 2. On-site or local geologic or geomorphologic features. | | | | Report Section 2.2.5 | |
| 3. On-site or local human-made features or events both surface and subsurface. | | | | Report Section 2.2.6 | |

**Table 1.**
**Coal Combustion Residual (CCR) Landfill Plan of Operation Modification for Initial Permitting Checklist**
**Section NR 514.045, Wis. Adm. Code**
**Wisconsin Power and Light Company - Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222260.00**

| REGULATORY REQUIREMENTS | COMPLETE? | | | LOCATION | COMMENTS |
|---|---|---|---|---|---|
| | Y | N | NA | | |
| For existing CCR landfills that do not comply with the location criteria for unstable areas specified above, has the owner or operator, within 6 months of the determination, done the following per NR 514.045(5)(a):<br>__ceased placing CCR and non-CCR waste streams into the CCR landfill<br>__closed the CCR landfill in accordance with the requirements under s. NR 506.083<br>Note: This timeframe does not apply if the owner or operator complies with the alternative closure procedures under s. NR 506.083 (7). | | | | N/A | |
| **NR 514.045(1)(d) Does the submittal include a demonstration that the facility or practices near floodplains will not cause the following effects:** | | | | | |
| __Restrict the flow of the regional flood<br>__Reduce the temporary water storage capacity of the floodplain<br>__Result in washout of solid waste so as to pose a hazard to human life, wildlife, or land or water resources.<br>Note: NR 504.04(3)(c) also requires no person may establish, construct, operate, maintain, or permit the use of property for a landfill where the limits of filling are or would be within a floodplain. | | | | Report Section 2.3.1 | |
| For new CCR landfills or a lateral expansion of a CCR landfill, if the landfill failed to make the demonstration showing compliance with the criteria above, has the landfill ceased placing CCR in the CCR landfill per NR 514.045 (5)(b)? | | | | N/A | |
| **NR 514.045(1)(e) Does the submittal include a demonstration that the facility or practices will not result in the destruction or adverse modifications of the critical habitat of endangered or threatened species as identified in s. NR 27.03(1)?** | | | | Report Section 2.4.1 | |
| For new CCR landfills or a lateral expansion of a CCR landfill, if the landfill failed to make the demonstration showing compliance with the criteria above, has the landfill ceased placing CCR in the CCR landfill per NR 514.045 (5)(b)? | | | | N/A | |
| **NR 514.045(1)(f) Does the submittal include a demonstration that the CCR landfill design meets requirements under s. NR 504.12 or an alternate design under s. NR 504.10? Does the demonstration include a design report, engineering drawings, and calculations?**<br>Note: Complete NR 504.12 and if applicable NR 504.10 (for an alternate design) of the NR 504 Design and Construction Criteria Completeness Checklist. | | | | Report Section 3.0 | |
| For new CCR landfills or a lateral expansion of a CCR landfill, if the landfill failed to make the demonstration showing compliance with NR 504.12 and NR 504.10 (for an alternate design), has the landfill ceased placing CCR in the CCR landfill per NR 514.045(5)(b)? | | | | N/A | |
| **NR 514.045(1)(g) Does the submittal include all of the plans required under s. NR 514.07(10)?** | | | | | |
| NR 514.07(10) PLAN OF OPERATION. Does the submittal include all of the following: | | | | | |
| (a) A CCR fugitive dust control plan in accordance with all of the following: | | | | | |
| 1. The plan shall identify and describe the CCR fugitive dust control measures the owner will use to minimize CCR from becoming airborne at the facility. The owner shall select and include in the CCR fugitive dust control plan the CCR fugitive dust control measures that are most appropriate for site conditions, along with an explanation. See s. NR 514.07 (10)(a)1. for control measure examples. | | | | Appendix C1, Measures for Controlling Fugitive Dust | |
| 2. The plan shall include procedures to wet CCR with water to a moisture content that will prevent wind dispersal, but will not result in free liquids. In lieu of water, wetting of CCR may be accomplished with an appropriate chemical dust suppression agent. | | | | Appendix C1, Procedure for Conditioning CCR Prior to Placement | |
| 3. The plan shall include a description of the procedures the owner will follow to periodically assess the effectiveness of the control plan. At a minimum, the assessment shall include a visual inspection at least every 7 days, unless the CCR landfill is inactive, and all areas are covered by intermediate or final cover. | | | | Appendix C1, Visual Inspections | |
| 4. The plan shall be modified in accordance with s. NR 514.04 (6) whenever there is a change in conditions that may substantially affect the plan of operation. | | | | Appendix C1, Procedure for Periodic Review of CCR Fugitive Dust Control Plan | |
| 5. The plan shall address the preparation of an annual fugitive dust control report in accordance with s. NR 506.20 (3)(a). | | | | Appendix C1, Procedure for Periodic Review of CCR Fugitive Dust Control Plan | |
| (b) A run-on and run-off control system plan that includes all of the following: | | | | | |
| 1. A run-on and run-off control system designed in accordance with the requirements under s. NR 504.12 (2). | | | | Appendix C2, Section 2.0 | |
| 2. Plan sheets depicting the location of run-on and run-off control features, detail drawings, and supporting engineering calculations. | | | | Appendix C2, Figures and Appendix A | |
| 3. Construction procedures and a schedule for construction. | | | | Appendix C2, Section 2.3 | |
| 4. Modification every 5 years from the date of the most recent plan approval or whenever there is a change in conditions that may substantially affect the written plan in effect. The modification shall be requested by the owner in accordance with s. NR 514.04 (6) prior to the 5-year deadline. | | | | Appendix C2, Section 4.0 | |
| (c) A written closure plan in accordance with all requirements under NR 514.06 (10) and all of the following: | | | | | |
| 1. A narrative description of how the CCR landfill will be closed, including a description of the steps necessary to close the CCR unit at any point during the active life of the CCR unit, consistent with recognized and generally accepted good engineering practices. | | | | Appendix C3, Section 2.0 | |
| 2. A description of the final cover system, designed in accordance with s. NR 504.07, and the methods and procedures to be used to install the final cover.<br>Note: Complete NR 504.07 of the NR 504 Design and Construction Criteria Completeness Checklist. | | | | Appendix C3, Section 3.0 | |
| 3. A demonstration, including a narrative discussion, of how final closure will meet the performance standards under s. NR 506.083 (6). | | | | Appendix C3, Section 3.0 | |
| 4. An estimate of the maximum volume in cubic yards of CCR that will be disposed on-site over the active life of the CCR landfill. | | | | Appendix C3, Section 4.0 | |
| 5. An estimate of the largest area of the CCR landfill that will require a final cover at any time during the CCR landfill's active life. | | | | Appendix C3, Section 5.0 | |

**Table 1.**
**Coal Combustion Residual (CCR) Landfill Plan of Operation Modification for Initial Permitting Checklist**
**Section NR 514.045, Wis. Adm. Code**
**Wisconsin Power and Light Company - Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222260.00**

| REGULATORY REQUIREMENTS | COMPLETE? | | | LOCATION | COMMENTS |
|---|---|---|---|---|---|
| | Y | N | NA | | |
| 6. A schedule for completion of all closure activities, including an estimate of the year in which all closure activities for the CCR landfill will be completed. | | | | Appendix C3, Section 6.0 and 7.0 | |
| 7. The plan shall be modified in accordance with s. NR 514.04 (6) whenever there is a change in conditions that may substantially affect the written closure plan or unanticipated events necessitate a revision of the written closure plan. | | | | Appendix C3, Section 9.0 | |
| 8. If closure of the CCR landfill will be accomplished through removal of CCR from the CCR landfill, the closure plan shall be modified and approved by the department prior to implementation in accordance with s. NR 514.04 (6). | | | | N/A | |
| (d) A written long-term care plan that addresses all of the following: | | | | | |
| 1. A description of the monitoring and maintenance activities and the frequency at which those activities will be performed. The activities shall include, at a minimum, all of the following:<br>___Long-term care activities specified under s. NR 514.06 (11).<br>___Maintaining the integrity and effectiveness of the final cover system, including making repairs as necessary.<br>___Maintaining the effectiveness of the leachate collection and removal system and operating the leachate collection and removal system in accordance with the requirements under s. NR 504.12 (3) (a).<br>___Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with ch. NR 507 and the sampling plan approval. | | | | Appendix C4, Section 2.0 | |
| 2. The name, address, telephone number, and email address of the person or office to contact about the facility during long-term care. | | | | Appendix C4, Section 3.0 | |
| 3. A description of the planned uses of the property during long-term care. Post- closure uses may not disturb the integrity of the final cover, liner, or other component of the landfill, or function of the monitoring systems unless approved in writing by the department. A written request for approval as part of the plan of operation submittal or a modification shall include a demonstration that disturbance of any part of the CCR landfill will not increase the potential threat to human health or the environment. | | | | Appendix C4, Section 4.0 | |
| **NR 514.045(1) (h) Does the submittal include a demonstration that the CCR groundwater monitoring system complies with the requirements under s. NR 507.15(3), including documentation of the design, installation, and development of any CCR wells?** | | | | | |
| NR 507.15(3) CCR LANDFILLS. In addition to the detection groundwater monitoring system required under s. NR 507.19, the CCR landfill owner shall submit a plan establishing a separate CCR groundwater monitoring system for the purpose of monitoring groundwater quality in the uppermost aquifer. The plan shall be submitted with the plan of operation modification for initial permitting in accordance with s. NR 514.045 or in the feasibility report under ch. NR 512. The plan shall include all of the following: | | | | To be provided in an addendum | |
| (a) Does the monitoring system consist of a sufficient number of CCR monitoring wells, installed at appropriate locations and depths? | | | | To be provided in an addendum | |
| Are the CCR wells adequate to yield groundwater samples from the uppermost aquifer that accurately represent upgradient groundwater quality that has not been affected by leakage from CCR landfill and downgradient groundwater quality passing the waste boundary of the CCR landfill? | | | | To be provided in an addendum | |
| Are the downgradient monitoring wells installed to ensure detection of groundwater contamination in the uppermost aquifer, including all known or suspected contaminant pathways? | | | | To be provided in an addendum | |
| (b) Has the number, spacing, and depths of monitoring wells that are part of the CCR groundwater monitoring system plan based upon site-specific technical information that includes the following?<br>___Aquifer thickness<br>___Groundwater flow rate<br>___Groundwater flow direction, including seasonal and temporal fluctuations in groundwater flow | | | | To be provided in an addendum | |
| Does the monitoring system consider the saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials comprising the uppermost aquifer and materials comprising the confining unit defining the lower boundary of the uppermost aquifer, including thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities, and effective porosities? | | | | To be provided in an addendum | |
| (c) Does the monitoring system plan include the minimum number of monitoring wells necessary to meet performance standards specified under (a) based on the site- specific information specified under (b).? | | | | To be provided in an addendum | |
| 1. Does the groundwater monitoring system plan contain a minimum of one upgradient and 3 downgradient monitoring wells to be designated as CCR wells? | | | | To be provided in an addendum | |
| 2. Does the groundwater monitoring system contain additional monitoring wells as necessary to accurately represent the background groundwater quality in the uppermost aquifer that has not been affected by leakage from the CCR landfill and the quality of groundwater passing the waste boundary of the CCR landfill? | | | | To be provided in an addendum | |
| (d) Have the monitoring wells been designed and installed in accordance with NR 507.06 and regularly inspected in accordance with NR 507.13? | | | | To be provided in an addendum | |
| (e) Has the documentation of the design, installation, development, and decommissioning of all wells and measurement/sampling devices been performed in accordance with NR 507.14 and NR 141, where applicable? This includes submission of all required forms to the department in the timeframes specified. | | | | To be provided in an addendum | |
| **NR 514.045 (i) Does the submittal include an updated sampling plan that addresses the requirements under s. NR 507.15(3)?** | | | | | |
| NR 507.15(3) CCR LANDFILLS. Does the sampling plan address all of the following: | | | | | |
| (f) A sampling plan, which includes the CCR groundwater monitoring system, in accordance with s. NR 507.16 and the requirements under s. NR 140.16. Note: Complete NR 507.16(1) below. | | | | To be provided in an addendum | |
| Does the sampling plan include consistent sampling and analysis procedures designed to ensure the production of monitoring results that provide an accurate representation of groundwater results that provide an accurate representation of groundwater quality in the uppermost aquifer at the upgradient and downgradient CCR wells and that provide a characterization of leachate quality generated by the CCR landfill? | | | | To be provided in an addendum | |
| (g) Does the sampling plan include sampling and analytical methods that are appropriate for groundwater sampling and that accurately measure all required monitoring parameters under ch. NR 507, Appendix I in groundwater samples? | | | | To be provided in an addendum | |
| Does the sampling plan specify the CCR landfill owner or operator obtain and analyze samples in accordance with the sampling plan and the requirements under s. NR 507.17? | | | | To be provided in an addendum | |

**Table 1.**
**Coal Combustion Residual (CCR) Landfill Plan of Operation Modification for Initial Permitting Checklist**
**Section NR 514.045, Wis. Adm. Code**
**Wisconsin Power and Light Company - Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222260.00**

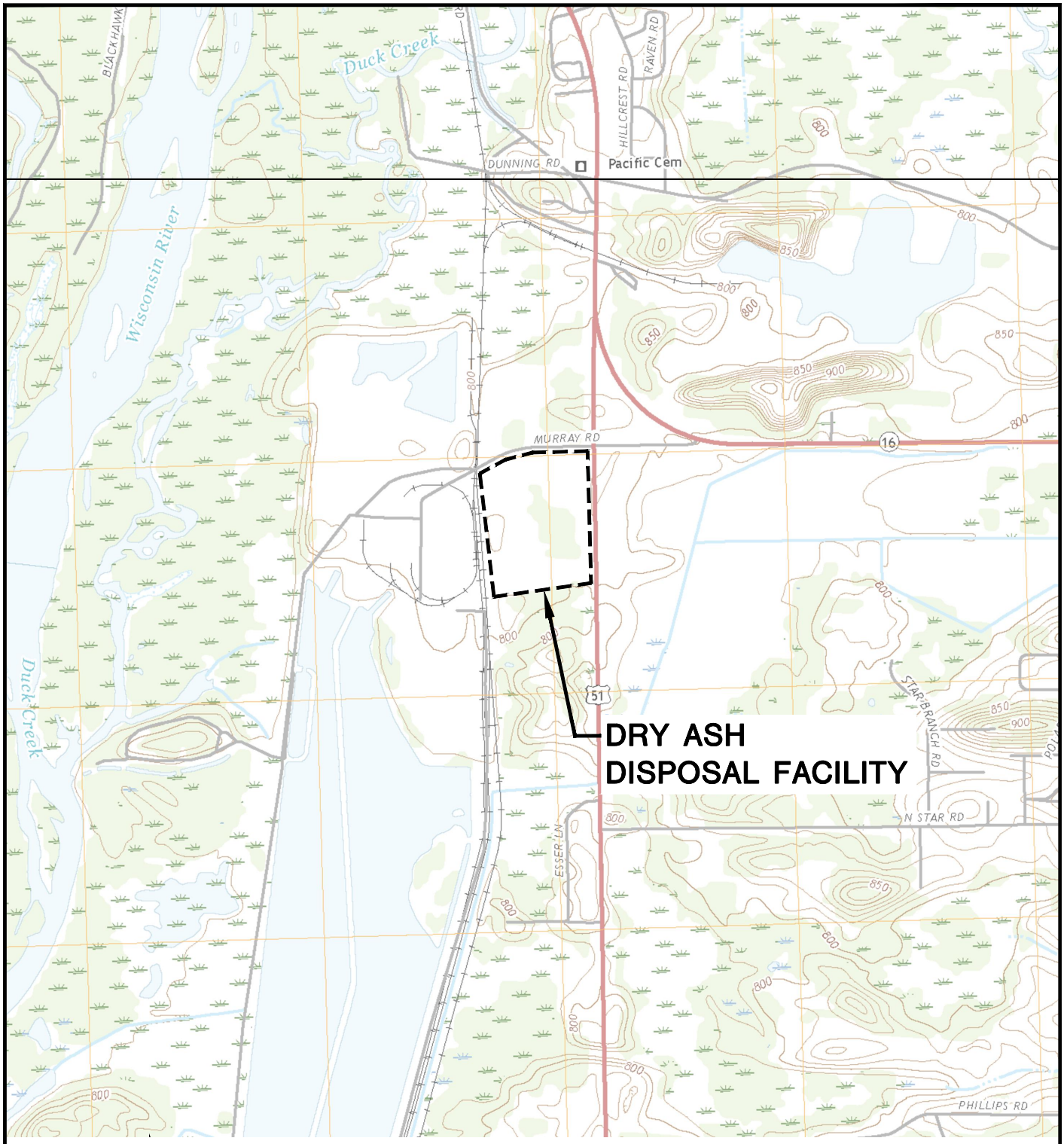
| REGULATORY REQUIREMENTS | COMPLETE? | | | LOCATION | COMMENTS |
|---|---|---|---|---|---|
| | Y | N | NA | | |
| (h) In addition to the field measurements required under s. NR 507.17(1), does the plan include measurement of the groundwater elevations in each CCR well immediately prior to purging, each time groundwater is sampled. | | | | To be provided in an addendum | |
| Does the plan include determination of the rate and direction of groundwater flow each time groundwater is sampled and reporting the result to the department in accordance with s. NR 507.26? | | | | To be provided in an addendum | |
| Does the plan include that groundwater elevations in wells that monitor the same CCR landfill be measured within a timeframe short enough to avoid temporal variations in groundwater flow that could preclude accurate determination of groundwater flow rate and direction? | | | | To be provided in an addendum | |
| (i) Has the owner/operator established baseline groundwater quality levels for each CCR monitoring well in accordance with NR 507.18 for each CCR well and for each of the constituents required under ch. NR 507 Appendix I, Table 1A and the sampling plan? | | | | To be provided in an addendum | |
| (j) Has the owner/operator measured the total recoverable metal concentrations when measuring groundwater quality for each CCR monitoring well? | | | | To be provided in an addendum | |
| Does measurement of total recoverable metals include both the particulate fraction and dissolved fraction of metals in natural waters? To ensure this, groundwater samples from CCR wells may not be field filtered prior to analysis. | | | | To be provided in an addendum | |
| (k) Does the plan specify the owner/operator notify the department in writing within 60 days of completing sampling and analysis at any CCR well when a groundwater standard at the point of standards application has been attained or exceeded in accordance with s. NR 507.30? | | | | To be provided in an addendum | |
| (L) Does the plan specify the owner/operator conduct detection groundwater monitoring at all CCR monitoring wells in accordance with NR 507.19 and all of the following? | | | | To be provided in an addendum | |
| Does detection groundwater monitoring include groundwater monitoring for all constituents appropriate for CCR wells as listed under ch. NR 507 Appendix I, Table 1A and additional parameters as required by the department. | | | | To be provided in an addendum | |
| 1. Is the minimum monitoring frequency semi-annual for detection groundwater monitoring? | | | | To be provided in an addendum | |
| Has baseline groundwater quality been established at each CCR monitoring well in accordance with s. NR 507.18? This includes collection of a minimum of 8 independent groundwater quality samples for each CCR well, analyzed for constituents' approval for CCR landfills as listed under ch. NR 507 Appendix I, Tables 1A and 3 and additional parameters as required by the department. | | | | To be provided in an addendum | |
| 2. Does the plan specify the number and methodology of groundwater quality samples be collected and analyzed for each CCR well during subsequent sampling events consistent with the approved sampling plan? | | | | To be provided in an addendum | |
| Does the plan specify the CCR landfill owner or operator inform the department in accordance with s. NR 507.26 of any CCR well that purges dry, is damaged or obstructed, or in any way is rendered such that a sample was unable to be collected from the well during a scheduled sampling event and does the plan specify the owner or operator propose remedial actions to correct the problem prior to the next sampling event? | | | | To be provided in an addendum | |
| 3. Does the plan specify the owner or operator of the CCR landfill notify the department and respond in accordance with s. NR 507.30 when a groundwater standard at the point of standards application has been attained or exceeded at any CCR well? This includes the establishment of an assessment monitoring program meeting the requirements under s. NR 508.06, unless the exceedance is determined by the department to be from a source other than the CCR landfill, or that the groundwater standard exceedance resulted from error in sampling, analysis, or natural variation in background groundwater quality in accordance with s. NR 508.06(2)(f)2. | | | | To be provided in an addendum | |
| 4. Does the plan specify the point of standards application for a groundwater quality exceedance at a CCR well, the horizontal distance for the design management zone under s. NR 140.22(3)(a) for a CCR landfill is 0 feet from the waste boundary and may not be expanded by the department under s. NR 140.22(3)(b)? The waste boundary includes the horizontal space taken up by any liner, dike or other barrier designed to contain CCR waste. | | | | To be provided in an addendum | |
| (m) Does the plan specify the owner or operator of the CCR landfill prepare an annual groundwater monitoring and corrective action report for submittal to the department, placement in the written operating record and position g on the publicly accessible internet site under s. NR 506.17(2) and (3) no later than January 31 of the year following the calendar year a groundwater monitoring system has been approved by the department, and annually thereafter? | | | | To be provided in an addendum | |
| Does the plan specify that the annual report document the status of the groundwater monitoring and any corrective action implemented at the CCR landfill, summarize key activities completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year? | | | | To be provided in an addendum | |
| Does the plan specify the annual groundwater monitoring and corrective action report contain, at a minimum the information included in ss. NR 507.15(3)(m) 1. – 5. | | | | To be provided in an addendum | |
| NR 507.16(1) SAMPLING PLAN. Does the sampling plan include the following information: | | | | | |
| (a) An 8 1/2 by 11 inch site map showing locations of all sample points and devices. An 11 by 17 inch site map may be included if clarity is compromised using the 8 1/2 by 11 inch size. Different symbols shall be used to differentiate types of monitoring devices such as groundwater monitoring wells, collection lysimeters and gas monitoring wells. Each sample point shall be labeled. | | | | To be provided in an addendum | |
| (b) A sample schedule, including all of the following:<br>1. The months that each sample point is to be sampled.<br>2. The sampling period, as designated by the department.<br>3. The list of parameters that are to be analyzed for in the sample from each monitoring device during each month that sampling occurs. | | | | To be provided in an addendum | |
| (c) Procedures for field measurements, including all of the following:<br>1. The order in which wells should be sampled if the groundwater has been impacted by regulated or other activities.<br>2. The procedures and type of equipment used to measure water level elevations.<br>3. The procedures and type of equipment used to measure temperature, pH, conductivity and procedures to determine turbidity, odor and color. | | | | To be provided in an addendum | |
| (d) Procedures for purging wells, including all of the following:<br>1. Procedures to purge wells prior to collecting samples.<br>2. Procedures for determining the volume of water to be removed from each well.<br>3. The type of equipment used to purge wells.<br>4. The rate of flow while purging, when applicable.<br>5. Procedures to clean purging equipment between wells.<br>6. The amount of time required between purging and sampling. | | | | To be provided in an addendum | |

**Table 1.**
**Coal Combustion Residual (CCR) Landfill Plan of Operation Modification for Initial Permitting Checklist**
**Section NR 514.045, Wis. Adm. Code**
**Wisconsin Power and Light Company - Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222260.00**

| REGULATORY REQUIREMENTS | COMPLETE? | | | LOCATION | COMMENTS |
|---|---|---|---|---|---|
| | Y | N | NA | | |
| (e) Procedures for obtaining samples from wells, including all of the following:<br>___1. Procedures and type of equipment used to retrieve samples.<br>___2. Volume of sample required for analysis.<br>___3. Procedures and type of equipment to filter samples, including when to filter and when not to filter samples, if applicable.<br>___4. The rate of flow when sampling, when applicable.<br>___5. Procedures and type of equipment to physically and chemically preserve samples.<br>___6. Procedures to clean sampling equipment following sampling of one well and prior to sampling the next well. | | | | To be provided in an addendum | |
| (f) Procedures for establishing field quality assurance and quality control, including all of the following:<br>___1. Field blank, duplicate sample and trip blank procedures.<br>___2. The frequency at which the field blanks, duplicate samples and trip blanks will be collected or processed. | | | | To be provided in an addendum | |
| (g) Special procedures to sample water supply wells. | | | | To be provided in an addendum | |
| (h) Special procedures to sample leachate headwells and other devices. | | | | To be provided in an addendum | |
| (i) Chain of custody procedures, including persons responsible for sampling and methods for transporting samples to the laboratory. | | | | To be provided in an addendum | |

# Figures


1 Site Location Map
2 CCR Landfill Location
3 Base Grade and Leachate Collection System Details
4 Base Grade and Leachate Collection System Details
5 Base Grades and Leachate Collection System
6 Subbase Grades
7 Final Grade Details
8 Final Grades




N

POYNETTE QUADRANGLE
WISCONSIN–COLUMBIA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
2018
SCALE: 1" = 2,000'

| | | | |
|---|---|---|---|
| CLIENT | WISCONSIN POWER AND LIGHT COMPANY<br>COLUMBIA ENERGY CENTER<br>W8375 MURRAY ROAD<br>PARDEEVILLE, WI 53954 | SITE | PLAN OF OPERATION MODIFICATION REQUEST<br>COLUMBIA DRY ASH DISPOSAL FACILITY<br>TOWN OF PACIFIC, WISCONSIN |

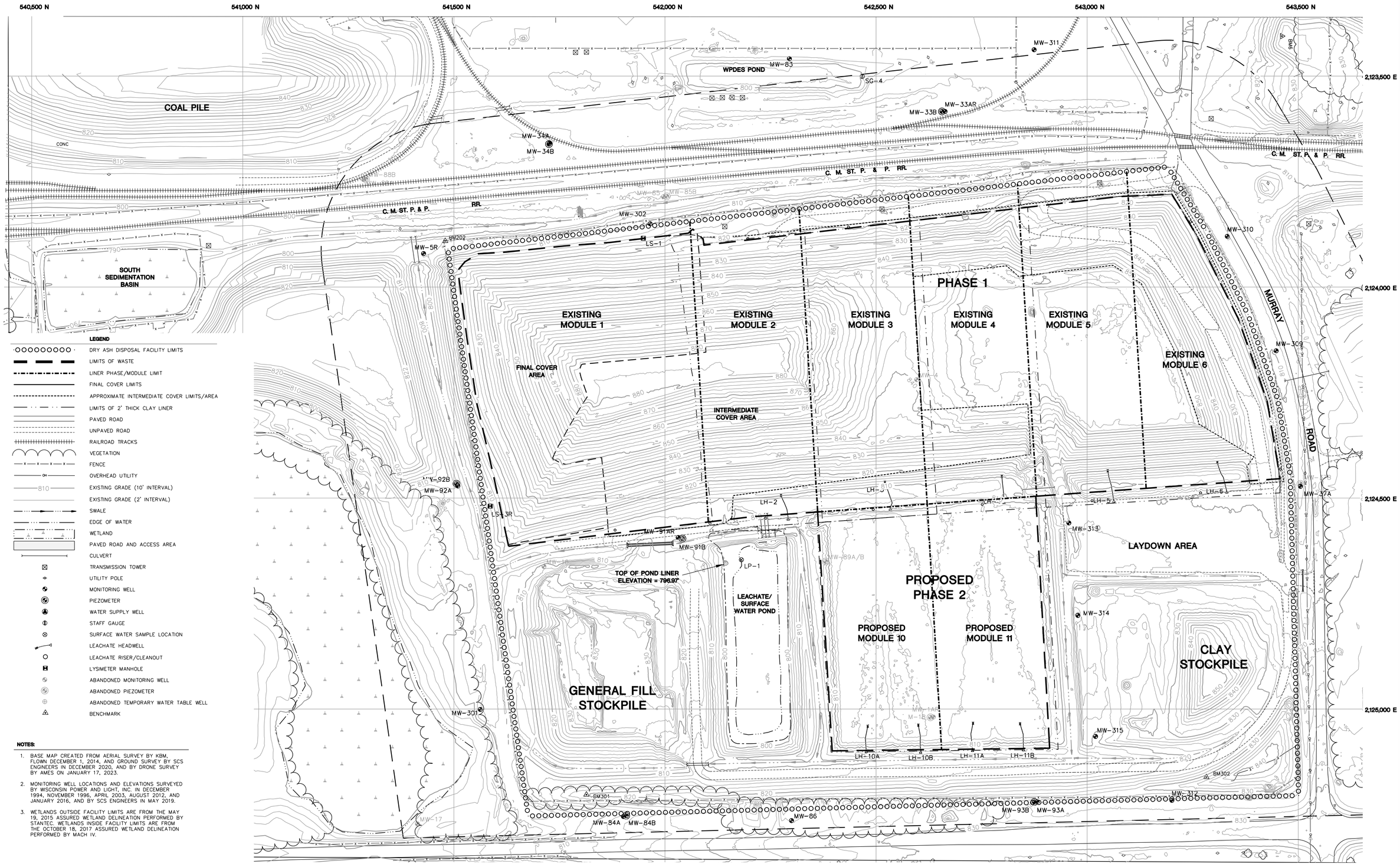
SITE LOCATION MAP

| | | | |
|---|---|---|---|
| PROJECT NO. | 25222157.00 | DRAWN BY: | KP |
| DRAWN: | 08/02/2022 | CHECKED BY: | PEG |
| REVISED: | 12/12/2022 | APPROVED BY: | PEG 01/31/2023 |

ENGINEER
SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

FIGURE
1

I:\25222260.00\Drawings\Figure 1_Site Location.dwg, 1/31/2023 1:28:35 PM




**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- APPROXIMATE INTERMEDIATE COVER LIMITS/AREA
- LIMITS OF 2' THICK CLAY LINER
- PAVED ROAD
- UNPAVED ROAD
- RAILROAD TRACKS
- VEGETATION
- FENCE
- OVERHEAD UTILITY
- EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- PAVED ROAD AND ACCESS AREA
- CULVERT
- TRANSMISSION TOWER
- UTILITY POLE
- MONITORING WELL
- PIEZOMETER
- WATER SUPPLY WELL
- STAFF GAUGE
- SURFACE WATER SAMPLE LOCATION
- LEACHATE HEADWELL
- LEACHATE RISER/CLEANOUT
- LYSIMETER MANHOLE
- ABANDONED MONITORING WELL
- ABANDONED PIEZOMETER
- ABANDONED TEMPORARY WATER TABLE WELL
- BENCHMARK

**NOTES:**

1. BASE MAP CREATED FROM AERIAL SURVEY BY KBM, FLOWN DECEMBER 1, 2014, AND GROUND SURVEY BY SCS ENGINEERS IN DECEMBER 2020, AND BY DRONE SURVEY BY AMES ON JANUARY 17, 2023.
2. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY WISCONSIN POWER AND LIGHT, INC. IN DECEMBER 1994, NOVEMBER 1996, APRIL 2003, AUGUST 2012, AND JANUARY 2016, AND BY SCS ENGINEERS IN MAY 2019.
3. WETLANDS OUTSIDE FACILITY LIMITS ARE FROM THE MAY 19, 2015 ASSURED WETLAND DELINEATION PERFORMED BY STANTEC. WETLANDS INSIDE FACILITY LIMITS ARE FROM THE OCTOBER 18, 2017 ASSURED WETLAND DELINEATION PERFORMED BY MACH IV.

100 0 100

SCALE: 1" = 100'

N

| | |
|---|---|
| PROJECT NO. | 25222260.00 |
| DRAWN: | 08/02/2022 |
| REVISED: | 12/12/2022 |
| DRAWN BY: | KP |
| CHECKED BY: | PEG |
| APPROVED BY: | PEG 01/31/2023 |

CLIENT

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WI 53954

ENGINEER

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

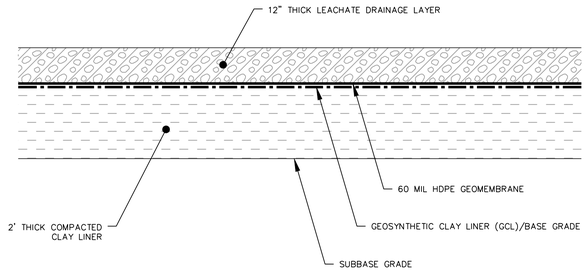
SITE

PLAN OF OPERATION MODIFICATION REQUEST
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

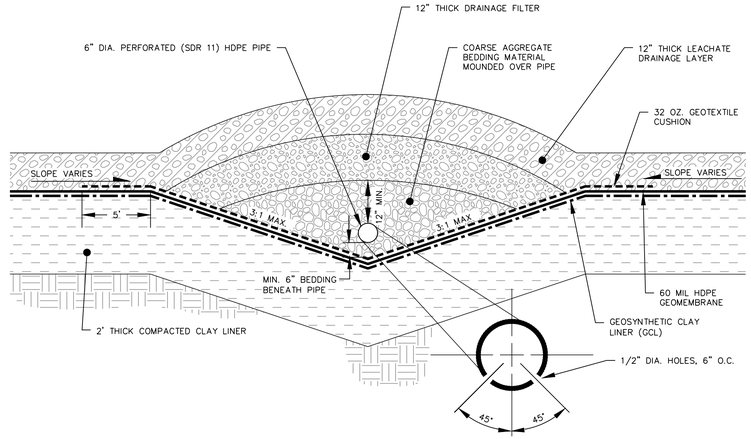
CCR LANDFILL LOCATION

FIGURE

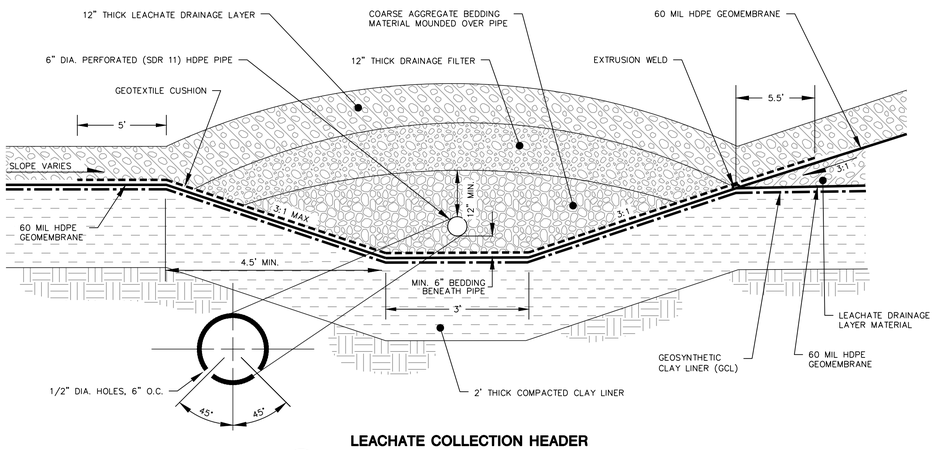
2



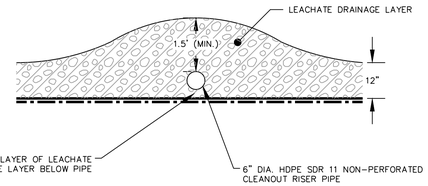

**1/3 COMPOSITE LINER SYSTEM**
SCALE: 1" = 2'

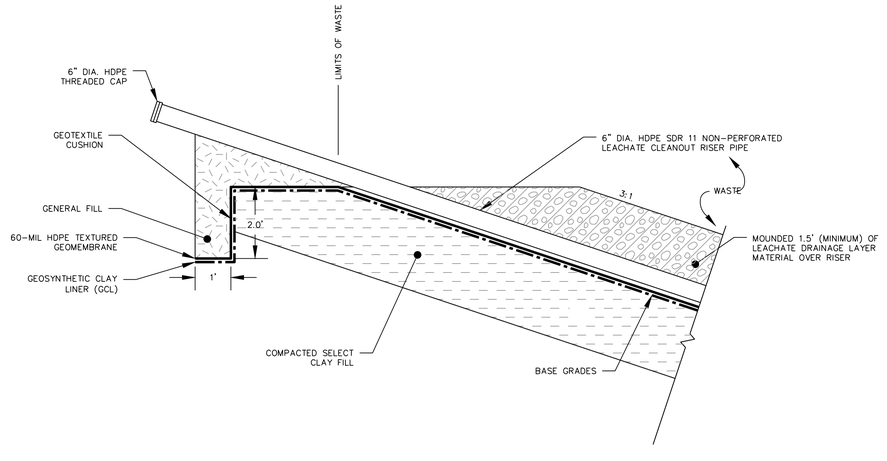



**2/3 LEACHATE COLLECTION LINE (EAST-WEST)**
NOT TO SCALE




**3/3 LEACHATE COLLECTION HEADER (NORTH-SOUTH)**
NOT TO SCALE




**4/3 LEACHATE CLEANOUT**
NOT TO SCALE

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

| | |
|---|---|
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| CHECKED BY: | PEG |
| APPROVED BY: | PEG 01/31/2023 |

| | |
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COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WI 53954

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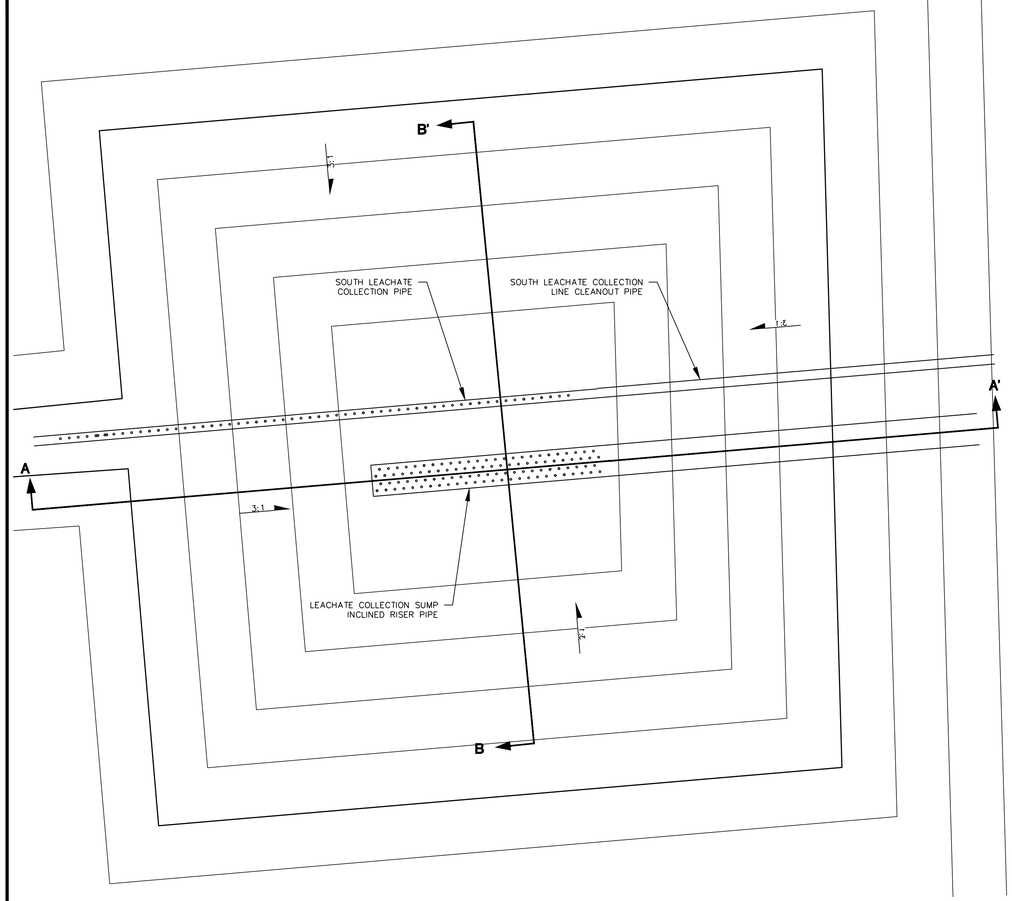
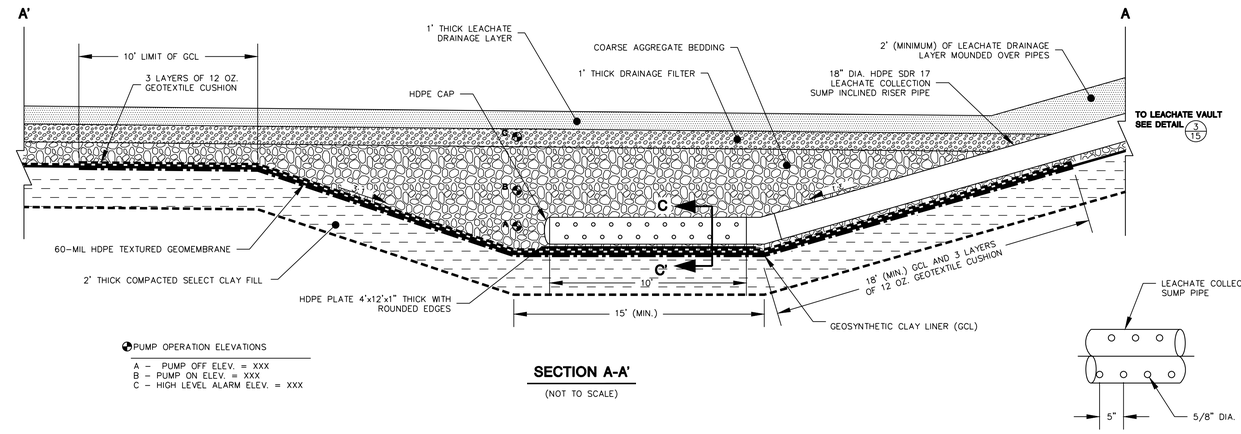
PLAN OF OPERATION MODIFICATION REQUEST
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SITE

# BASE GRADE AND LEACHATE COLLECTION SYSTEM DETAILS

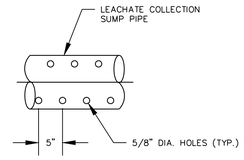
FIGURE
3



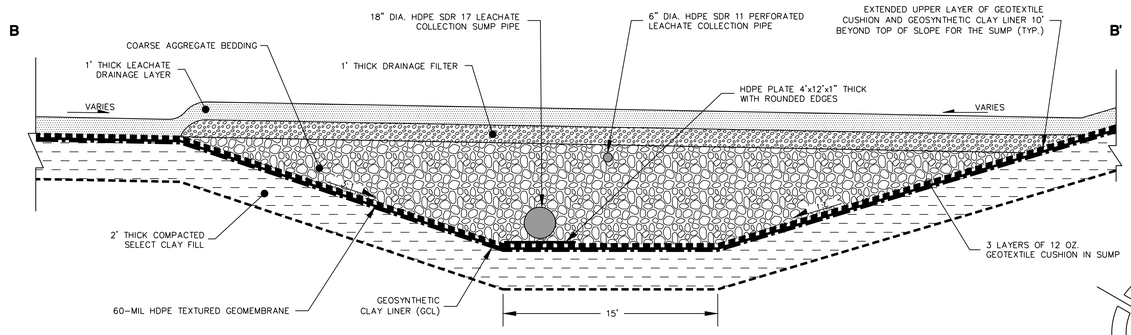

**SECTION A-A'**

(NOT TO SCALE)



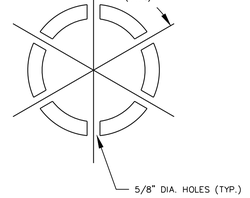

**LEACHATE COLLECTION SUMP PERFORATION**

(NOT TO SCALE)




**SECTION B-B'**

(NOT TO SCALE)




**SECTION C-C'**

(NOT TO SCALE)

NOTES:

1. DETAIL IS OF THE MODULE 11 SUMP, THE MODULE 10 SUMP IS SIMILAR.
2. ALL 90° ELBOWS ON LEACHATE PIPING CONSIST OF LONG SWEEP ELBOWS OR TWO 45° ELBOWS.

**1/4 LEACHATE COLLECTION SUMP**

SCALE: 1" = 4'

DRAWN BY: KP/MT
CHECKED BY: PEG
APPROVED BY: PEG 01/31/2023

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REVISED: 12/21/2022

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PARDEEVILLE, WI 53954

ENGINEER
SCS ENGINEERS
2830 DARY DRIVE MADISON, WI 53718-6751
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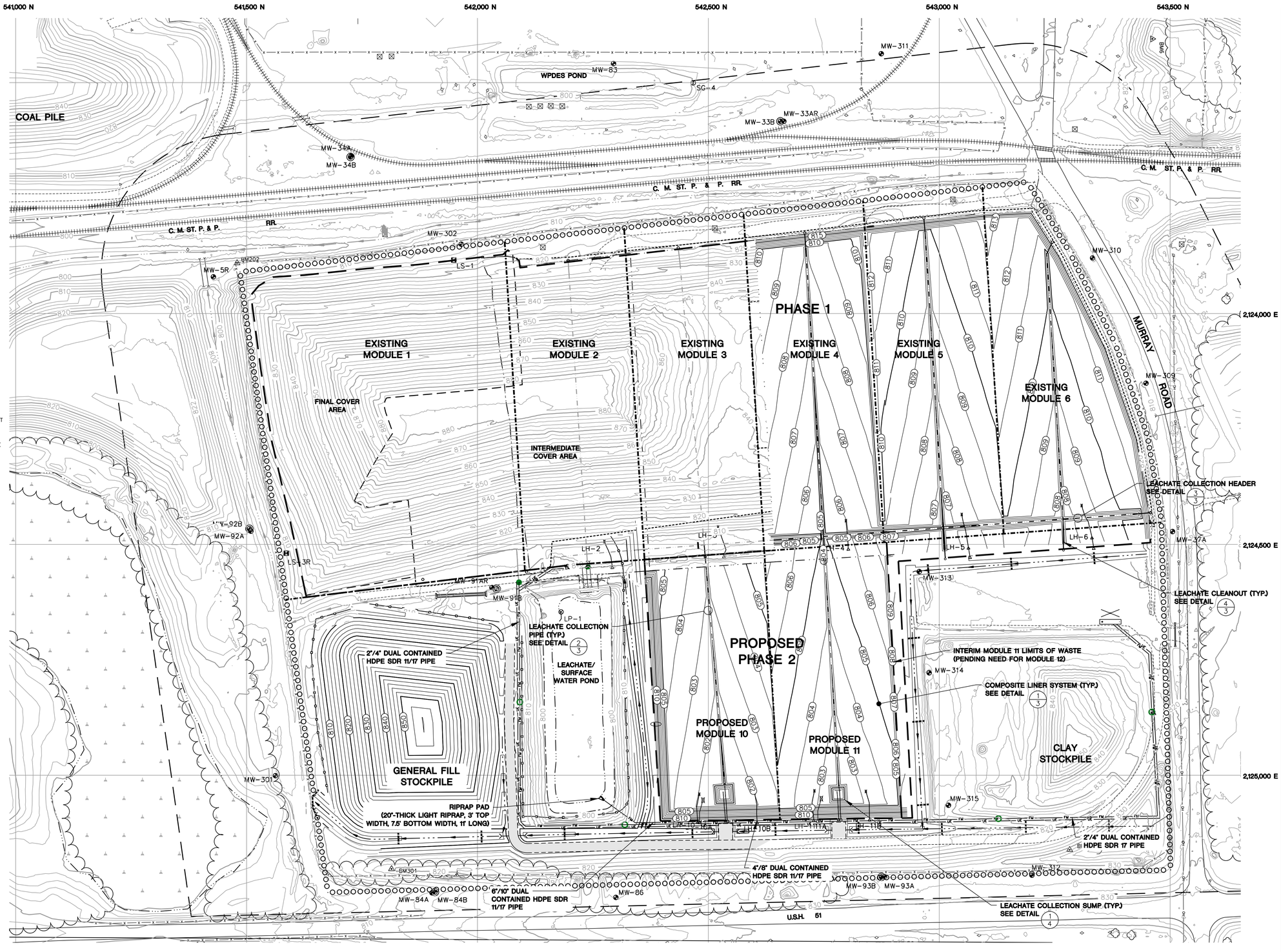
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

BASE GRADE AND LEACHATE COLLECTION SYSTEM DETAILS

FIGURE
4




**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- APPROXIMATE INTERMEDIATE COVER LIMITS/AREA
- LIMITS OF CONSTRUCTED 2' THICK CLAY LINER
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- FENCE
- 810 EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- 800 PROPOSED GRADE (10' INTERVAL)
- 802 PROPOSED GRADE (2' INTERVAL)
- PROPOSED SWALE
- PROPOSED CULVERT
- 6" DIAMETER PERFORATED SDR 11 HDPE LEACHATE COLLECTION LINE
- 6" DIAMETER SOLID SDR 11 HDPE PIPE
- PROPOSED LEACHATE COLLECTION SYSTEM CLEANOUT
- PROPOSED INCLINED RISER PIPE AND LEACHATE VAULT
- PROPOSED LEACHATE MANHOLE SUMP
- PROPOSED LEACHATE FORCEMAIN CLEANOUT MANHOLE
- FM PROPOSED LEACHATE FORCEMAIN
- UE PROPOSED UNDERGROUND ELECTRIC
- PROPOSED SILT FENCE/FILTER SOCK
- PROPOSED STRAW BALE DITCH CHECK

**NOTES:**

1. SEE FIGURE 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. LEACHATE COLLECTION LINE CUTTING AND CAPPING TO OCCUR AFTER WDNR APPROVAL OF MODULE 10 AND 11 LINER CONSTRUCTION.
3. MODULE 2 AND 3 LEACHATE MANHOLES TO BE INSTALLED DURING FINAL CLOSURE ACTIVITIES.

N

100 0 100

SCALE: 1" = 100'

| | |
|---|---|
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| CHECKED BY: | PEG |
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ENGINEER

PLAN OF OPERATION MODIFICATION REQUEST
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SITE

BASE GRADES AND LEACHATE COLLECTION SYSTEM

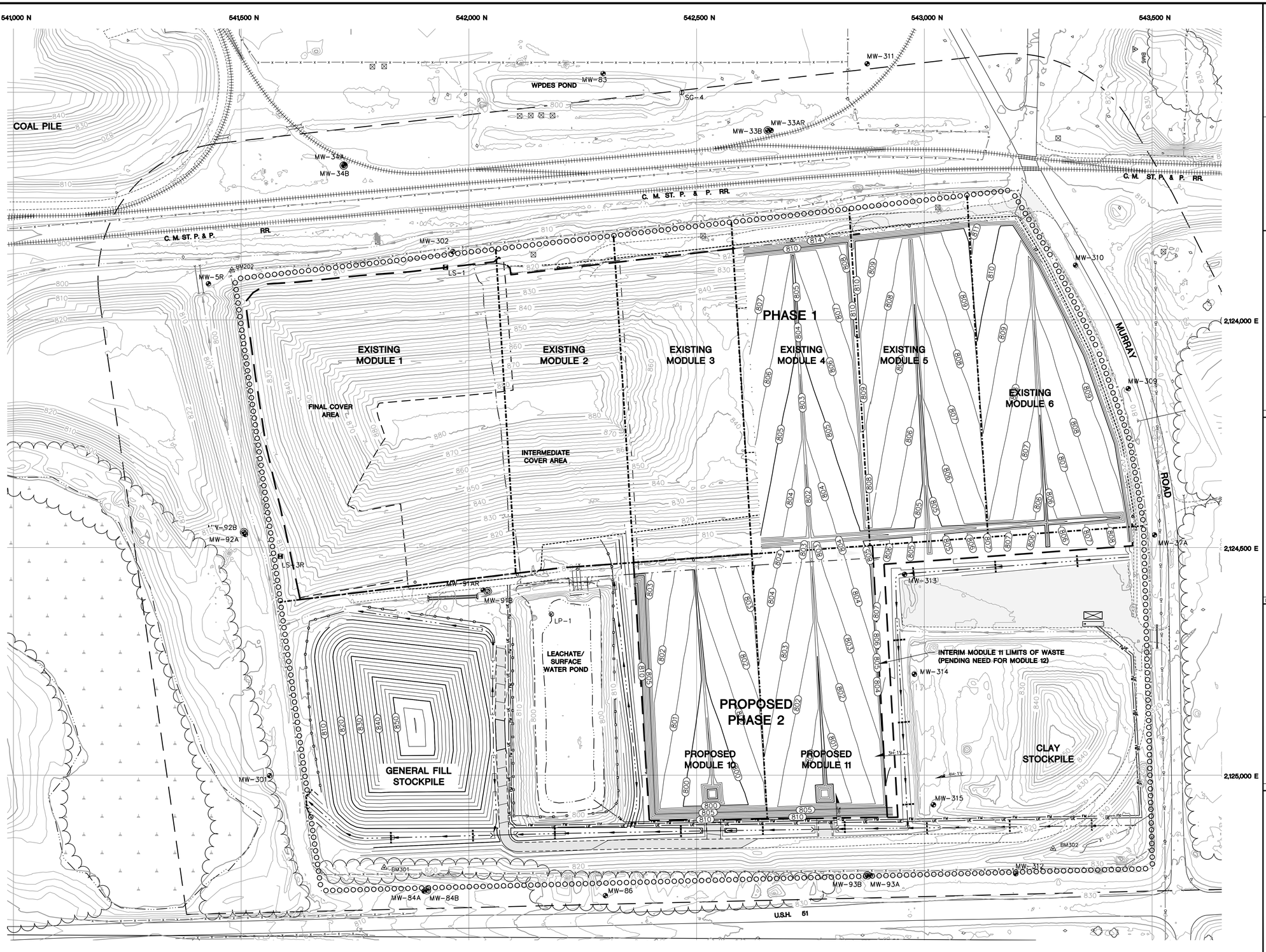
FIGURE 5

**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- APPROXIMATE INTERMEDIATE COVER LIMITS/AREA
- LIMITS OF CONSTRUCTED 2' THICK CLAY LINER
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- FENCE
- 810 EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- 800 PROPOSED GRADE (10' INTERVAL)
- 802 PROPOSED GRADE (2' INTERVAL)
- PROPOSED PERIMETER ROAD
- PROPOSED SWALE
- PROPOSED CULVERT
- PROPOSED SILT FENCE/FILTER SOCK
- PROPOSED STRAW BALE DITCH CHECK

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.




N

100 0 100

SCALE: 1" = 100'

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|---|---|
| PROJECT NO. | 25222260.00 |
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| CHECKED BY: | PEG |
| APPROVED BY: | PEG 01/31/2023 |

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ENGINEER: SCS ENGINEERS
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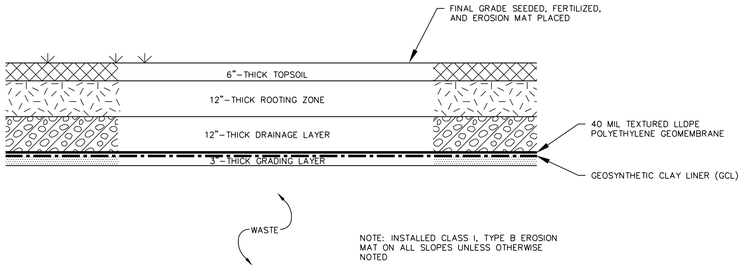
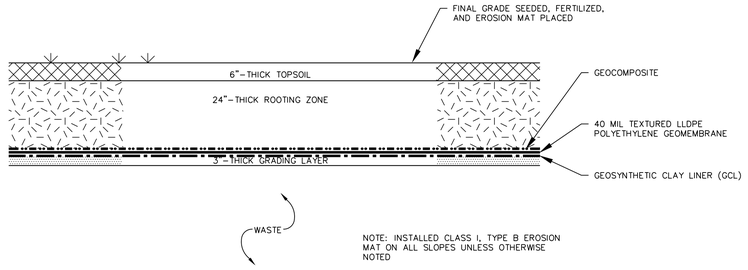
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SUBBASE GRADES

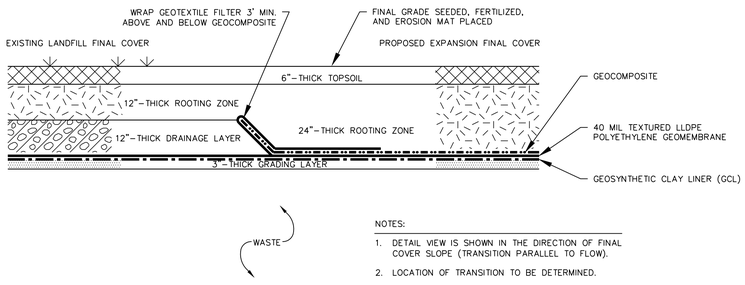
FIGURE 6




**1/7 FINAL COVER (SAND DRAINAGE LAYER)**
SCALE: 1" = 2'

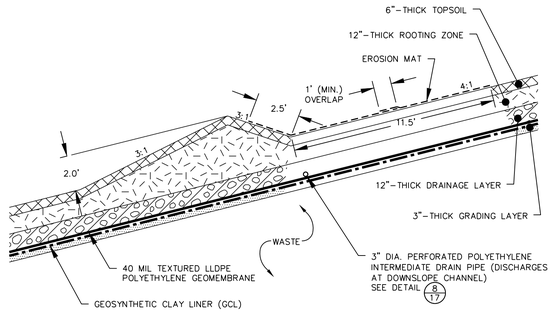



**2/7 FINAL COVER (GEOCOMPOSITE DRAINAGE LAYER)**
SCALE: 1" = 2'

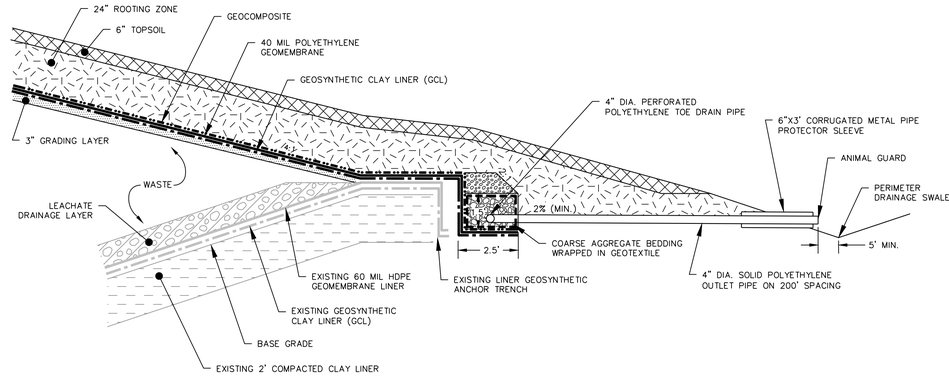



NOTES:
1. DETAIL VIEW IS SHOWN IN THE DIRECTION OF FINAL COVER SLOPE (TRANSITION PARALLEL TO FLOW).
2. LOCATION OF TRANSITION TO BE DETERMINED.

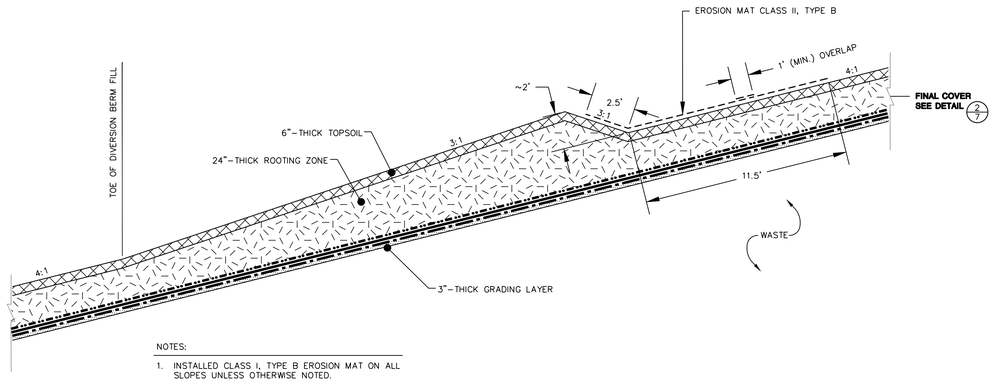
**3/7 FINAL COVER TRANSITION FROM SAND TO GEOCOMPOSITE**
SCALE: 1" = 2'




**4/7 TYPICAL DIVERSION BERM AND INTERMEDIATE DRAIN PIPE (SAND DRAINAGE LAYER)**
SCALE: 1" = 4'

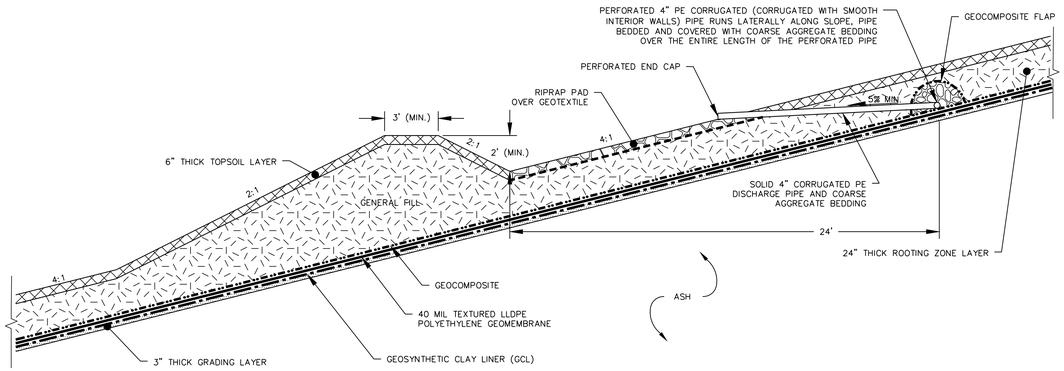



**5/7 FINAL COVER TO LINER TIE-IN AND TOE DRAIN**
SCALE: 1" = 3'




NOTES:
1. INSTALLED CLASS I, TYPE B EROSION MAT ON ALL SLOPES UNLESS OTHERWISE NOTED.

**6/7 FINAL COVER DIVERSION BERM**
SCALE: 1" = 4'




**7/7 HIGH CAPACITY GEOCOMPOSITE DRAIN**
SCALE: 1" = 4'

| | |
|---|---|
| DRAWN BY: | KP/MT |
| CHECKED BY: | PEG |
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PHONE: (608) 224-2830

ENGINEER

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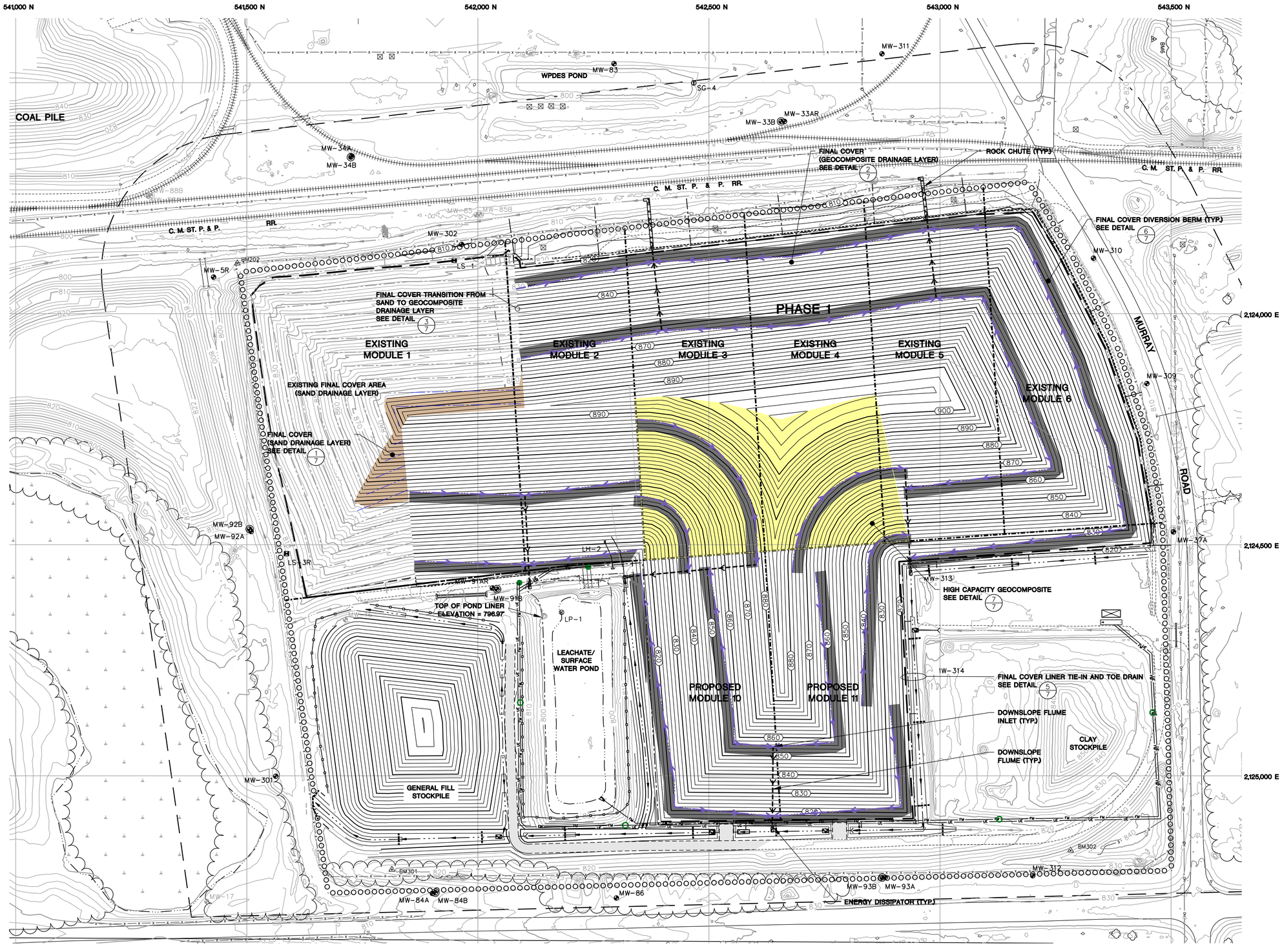
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SITE

FINAL COVER DETAILS

FIGURE
7




**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- FINAL COVER INTERMEDIATE/TOE DRAIN
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- FENCE
- EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- PROPOSED GRADE (10' INTERVAL)
- PROPOSED GRADE (2' INTERVAL)
- PROPOSED PERIMETER ROAD
- PROPOSED SWALE
- PROPOSED CULVERT
- PROPOSED LEACHATE COLLECTION SYSTEM CLEANOUT
- PROPOSED LEACHATE VAULT
- PROPOSED LEACHATE FORCEMAIN
- PROPOSED UNDERGROUND ELECTRIC
- PROPOSED FINAL COVER INTERMEDIATE/TOE DRAIN
- PROPOSED DIVERSION BERM
- PROPOSED DOWNSLOPE FLUME
- PROPOSED ENERGY DISSIPATOR
- PROPOSED RIPRAP
- PROPOSED SILT FENCE/FILTER SOCK
- PROPOSED STRAW BALE DITCH CHECK

**NOTES:**

1. SEE FIGURE 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. INSTALL NON-CHANNEL EROSION MAT ON ALL RESTORED SLOPES GREATER OR EQUAL TO 5:1 OR AS NOTED.
3. INSTALL CHANNEL EROSION MAT IN THE PROPOSED SWALE.
4. PROTECT EXISTING MONITORING WELLS AND STRUCTURES DURING CONSTRUCTION TO BE REPLACED AT CONTRACTOR'S COST IF DAMAGED.

N

100 0 100

SCALE: 1" = 100'

| | |
|---|---|
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SITE

FINAL GRADES

FIGURE
8

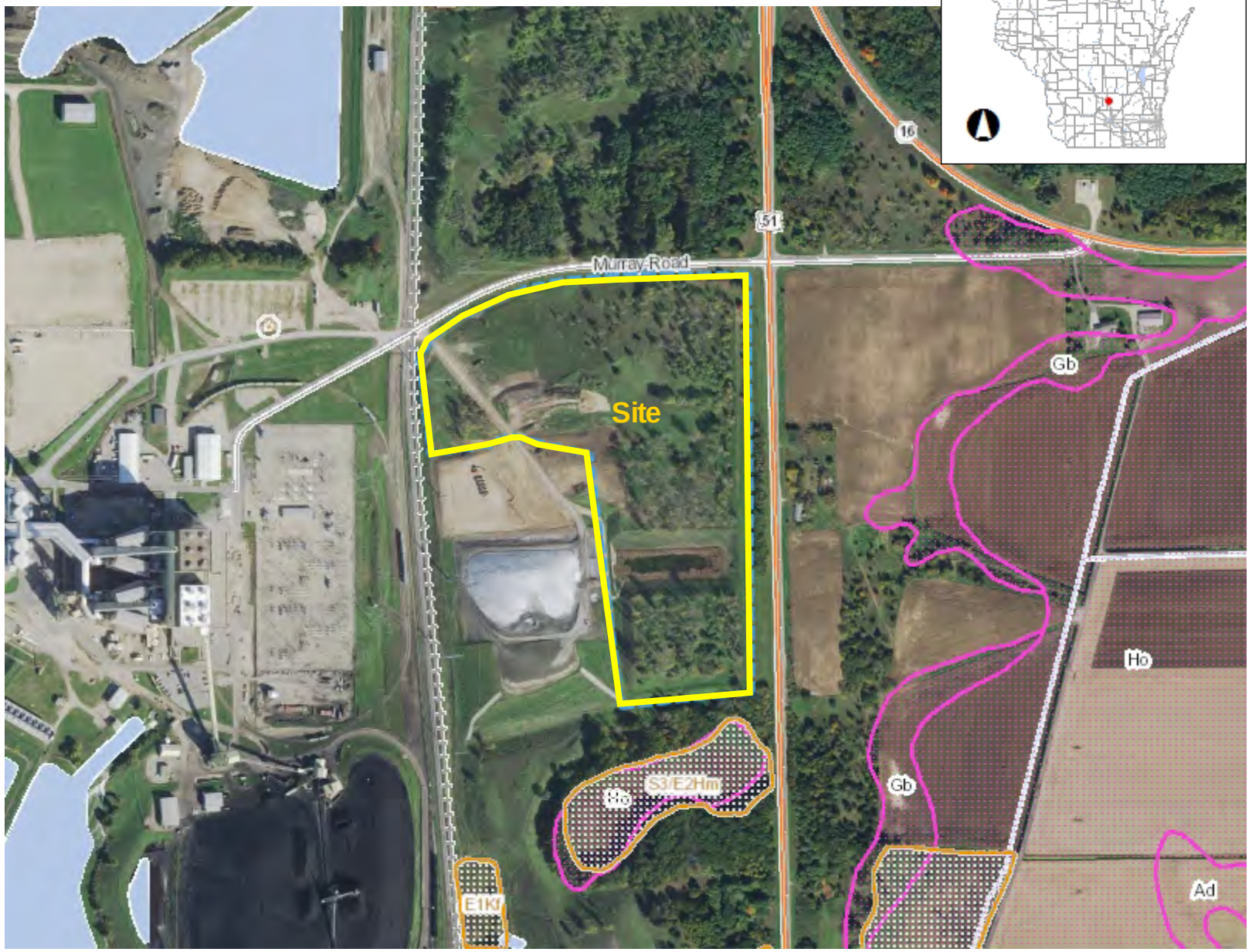
# Appendix A

# Performance and Location Criteria

# Appendix A1

# Wetland Delineation Maps

# Surface Water Data Viewer Map



## Legend

- **Wetland Class Points**
  - Dammed pond
  - Excavated pond
  - Filled excavated pond
  - Filled/drained wetland
  - Wetland too small to delineate
- **Filled Points**
- **Wetland Class Areas**
  - Wetland
  - Upland
- **Filled Areas**
- **NRCS Wetspots**
- **Wetland Indicators**
- **Municipality**
- **State Boundaries**
- **County Boundaries**
- **Major Roads**
  - Interstate Highway
  - State Highway
  - US Highway
- **County and Local Roads**
  - County HWY
  - Local Road
- **Railroads**
- **Tribal Lands**
- **Rivers and Streams**
- **Intermittent Streams**
- **Lakes and Open water**

0.3 0 0.13 0.3 Miles

NAD_1983_HARN_Wisconsin_TM

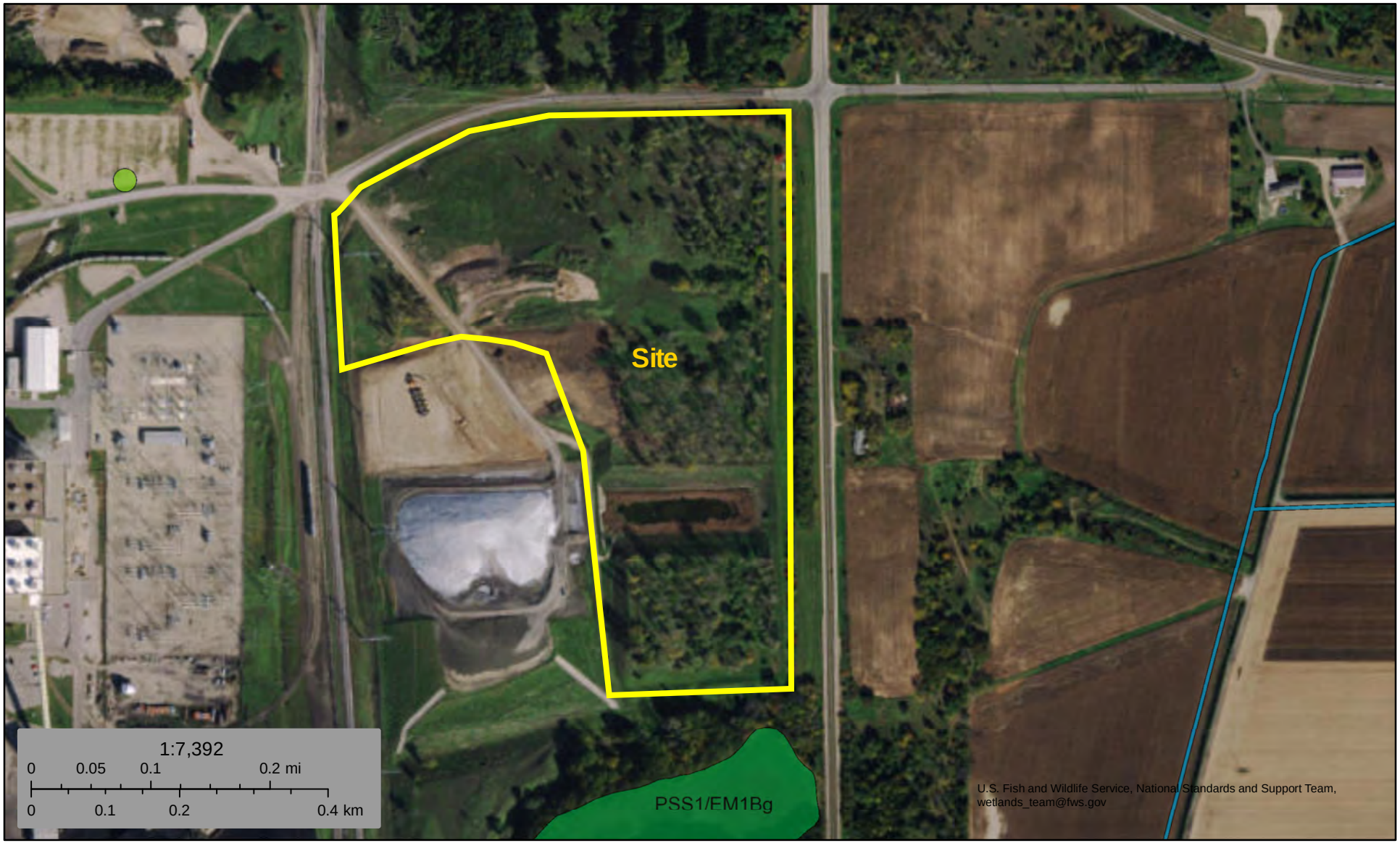
1: 7,920

DISCLAIMER: The information shown on these maps has been obtained from various sources, and are of varying age, reliability and resolution. These maps are not intended to be used for navigation, nor are these maps an authoritative source of information about legal land ownership or public access. No warranty, expressed or implied, is made regarding accuracy, applicability for a particular use, completeness, or legality of the information depicted on this map. For more information, see the DNR Legal Notices web page: http://dnr.wi.gov/legal/

## Notes

U.S. Fish and Wildlife Service
National Wetlands Inventory

# Wetlands




September 25, 2017

**Wetlands**

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

**State of Wisconsin**
**DEPARTMENT OF NATURAL RESOURCES**
**3911 Fish Hatchery Rd.**
**Fitchburg, WI, 53711**

**Tony Evers, Governor**
**Preston D. Cole, Secretary**
**Telephone 608-266-2621**
**Toll Free 1-888-936-7463**
**TTY Access via relay - 711**

03/15/2022

Jeff Maxted
4902 N Biltmore Lane
Madison, WI 53718

EXE-SC-2022-11-00802

RE: Artificial Wetland Exemption Determination for an area described as Wetlands 1, 2, and active coal combustion residual surface impoundments (purple colored on map) located at T12N R9E S27 in the Town of PACIFIC, Columbia County.

Dear Mr. Maxted:

This letter is in response to your request for an artificial wetland exemption determination for the above mentioned wetlands.

According to 281.36 (4n), State Statutes, a landscape feature where hydrophytic vegetation may be present as a result of human modification to the landscape or hydrology and for which no definitive evidence exists showing a prior wetland or stream history before August 1, 1991, may be exempt from state wetland regulations. The following types of artificial wetlands cannot be exempted from state wetland regulation: 1) a wetland that serves as a fish spawning area or that is passage to a fish spawning area and 2) a wetland created as a result of a wetland mitigation requirement. In addition, DNR must also consider whether the artificial wetland is providing significant flood protection to adjacent or downstream properties and infrastructure, and/or significant water quality functions to adjacent or downstream water bodies.

The Department reviewed the following materials to aid in our exemption determination:
The request narrative.
Historic Maps, including the Original Land Survey Plat, Bordner Survey, the USGS topographic Quad map from 1962 and 1984, and soil mapping.
Aerial photographs, including the 1937/8 era photograph, a pre-construction aerial photograph, and a post-construction photograph.
Site photographs that show different angles and views of the wetland.

Below is a summary of our findings:

**Request Narrative**
According to the request narrative the basis for a determination of artificial wetlands is that wetland characteristics formed within areas lacking a history of wetland land cover. This is due to the construction of CCRSIs in the CCRSI area, and the excavation/construction of a PVC-lined leachate and stormwater runoff collection basin and grading in the landfill area.

**Historic Map Review**
Original Land Survey Plat. The original land survey indicates inconclusive maps and notes along the WI River.
The Bordner survey indicates cropland including oak, hickory woodland.
The 1962 and 1984 USGS Quad map indicates no wetlands.
The 1913 soil survey maps indicate no wetlands.

**Aerial Photograph Review**
The 1937/38 aerial photograph shows farm field.
The 1972-74 aerial photographs show mass grading.

**Site Photographs**

The site photographs show the ponds and conveyance features.

**Conclusion:**
Based upon the information provided above, the wetland identified as Wetlands 1, 2 and active coal combustion residual surface impoundments (purple colored on map) lacked a wetland history prior to August 1, 1991, and fulfills all artificial wetland exemption standards. Therefore, Wetlands 1, 2, and active coal combustion residual surface impoundments (purple colored) are exempt from state wetland regulations.

This letter describes DNR's decision regarding the jurisdictional status of Wetlands 1, 2, and active coal combustion residual surface impoundments (purple colored on map) and are only valid for state jurisdictional purposes. For decisions regarding the federal jurisdictional status of Wetlands 1 and 2, you will need to contact the U.S. Army Corps of Engineers.

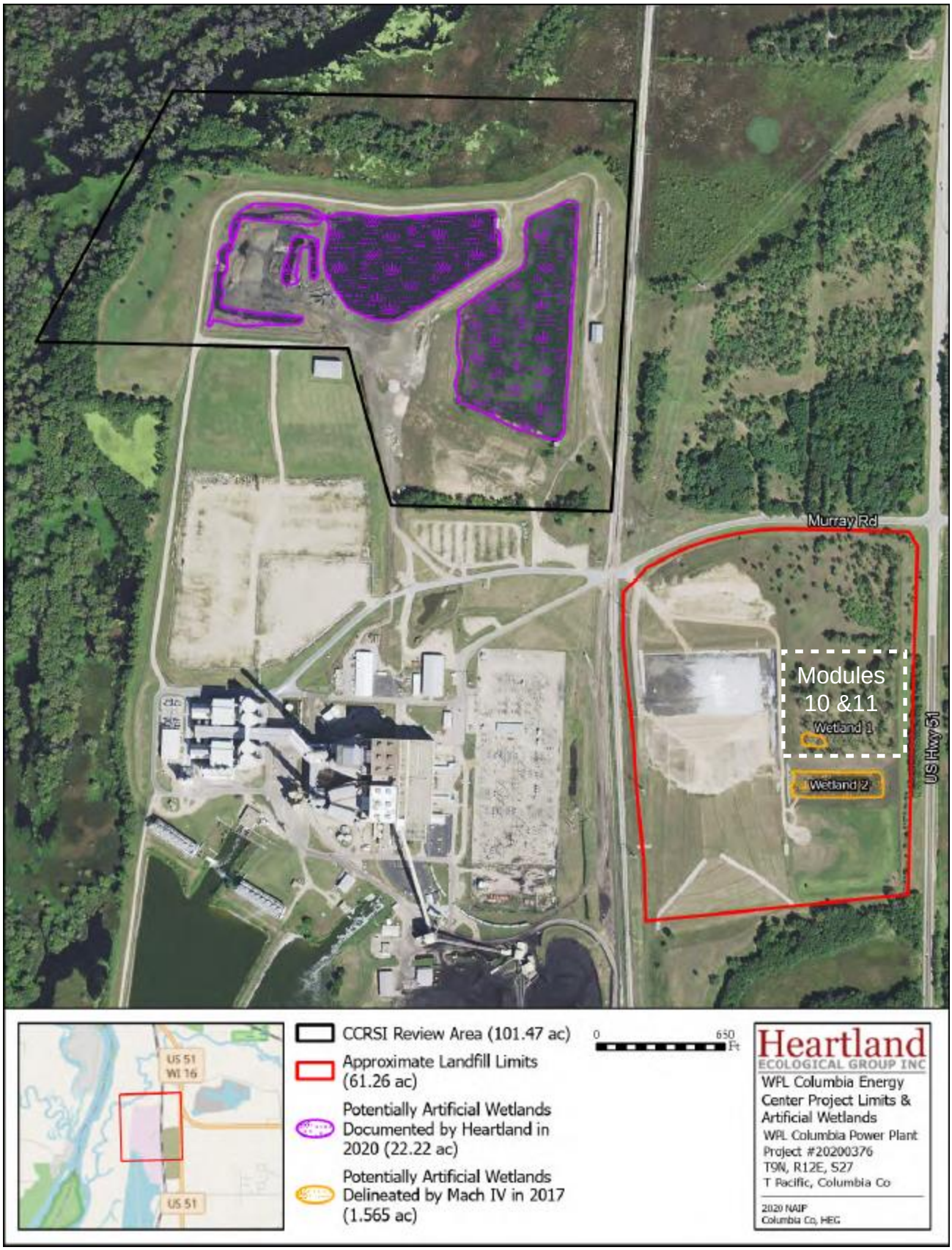
If you have any questions, please call me at (608) 228-4067 or email Allen.Ramminger@wisconsin.gov

Sincerely,

Allen Ramminger
Water Management Specialist

Copy to:

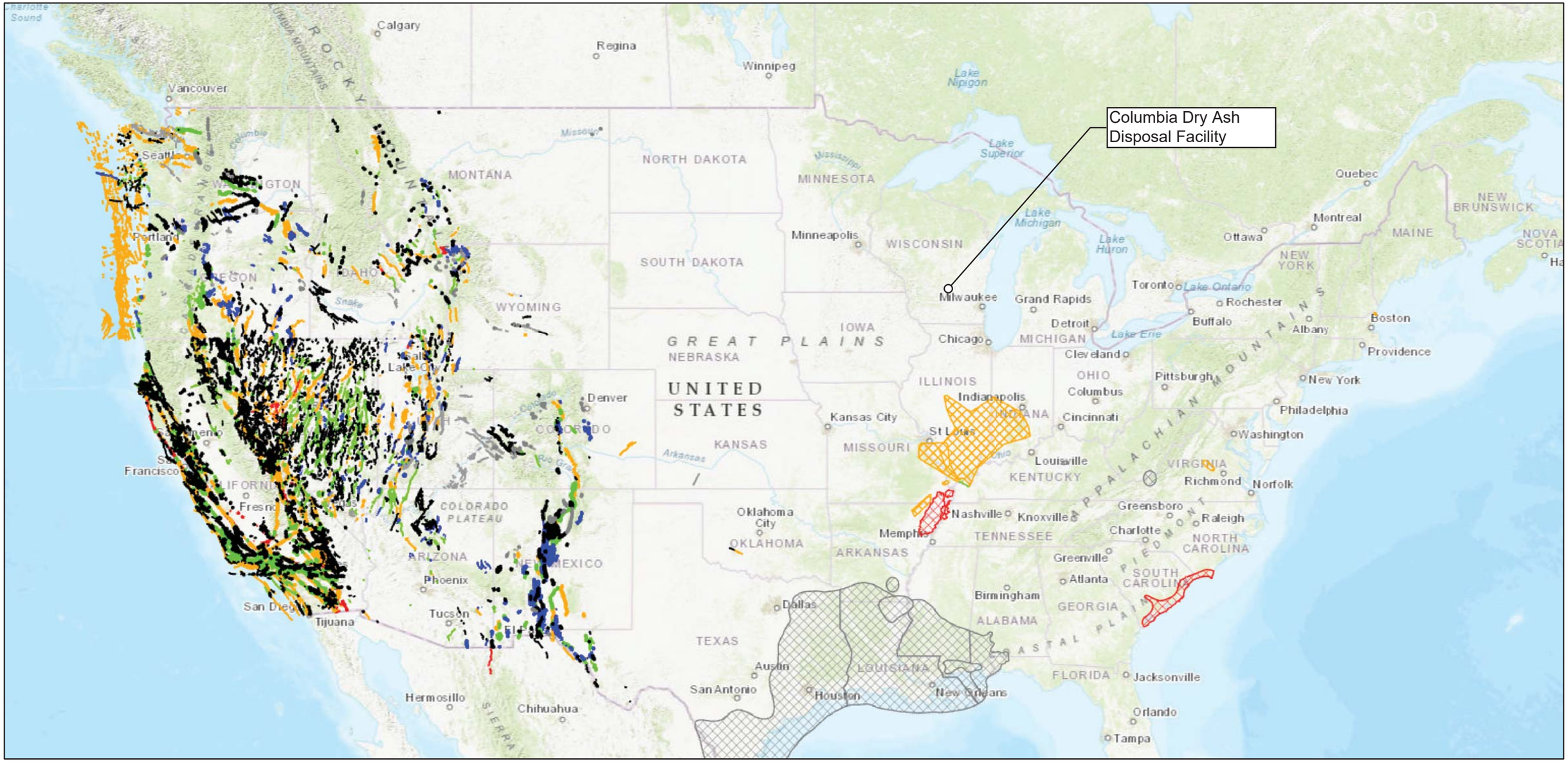
USACE Project Manager
Water Management Specialist
County Zoning Administrator
Consultant


Murray Rd
Modules
10 &11
Wetland 1
Wetland 2
US Hwy 51
US 51
WI 16
US 51
CCRSI Review Area (101.47 ac)
Approximate Landfill Limits
(61.26 ac)
Potentially Artificial Wetlands
Documented by Heartland in
2020 (22.22 ac)
Potentially Artificial Wetlands
Delineated by Mach IV in 2017
(1.565 ac)
0
650
Ft
Heartland
ECOLOGICAL GROUP INC
WPL Columbia Energy
Center Project Limits &
Artificial Wetlands
WPL Columbia Power Plant
Project #20200376
T9N, R12E, S27
T Pacific, Columbia Co
2020 NAIP
Columbia Co, HEG

# Appendix A2

# Fault Location Map

# U.S. Geological Survey Quaternary Faults




6/4/2021, 2:28:44 PM

Fault Areas

- Class B
- historic
- late Quaternary
- latest Quaternary
- middle and late Quaternary

National Database

- Historic (< 150 years), well constrained location
- Historic (< 150 years), moderately constrained location
- Historic (< 150 years), inferred location
- Latest Quaternary (<15,000 years), well constrained location
- Latest Quaternary (<15,000 years), moderately constrained location
- Latest Quaternary (<15,000 years), inferred location
- Late Quaternary (< 130,000 years), well constrained location
- Late Quaternary (< 130,000 years), moderately contrained location
- Late Quaternary (< 130,000 years), inferred location
- Middle and late Quaternary (< 750,000 years), well constrained location
- Middle and late Quaternary (< 750,000 years), moderately constrained location
- Middle and late Quaternary (< 750,000 years), inferred location
- Undifferentiated Quaternary (< 1.6 million years), well constrained location
- Undifferentiated Quaternary (< 1.6 million years), moderately constrained location
- Undifferentiated Quaternary (< 1.6 million years), inferred location

1:18,489,298

0 170 340 680 mi

0 265 530 1,060 km

Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

Source - https://www.usgs.gov/natural-hazards/earthquake-hazards/faults?qt-science_support_page_related_con=4#qt-science_support_page_related_con

USGS

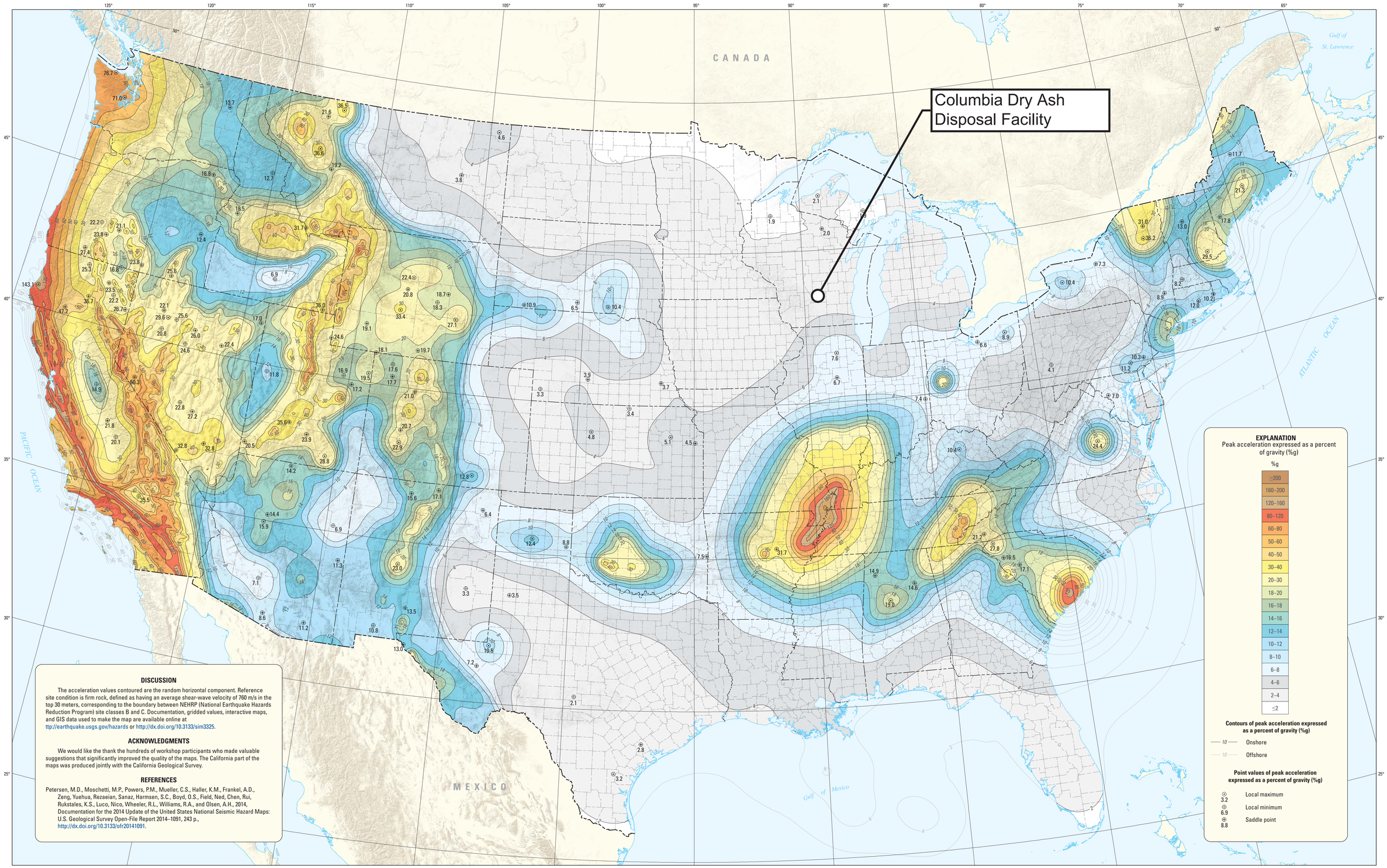
USGS | Esri, HERE, Garmin, FAO, NOAA, USGS, EPA |

# Appendix A3

# Seismic Hazard Map

U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3325
Sheet 2 of 6




## DISCUSSION

The acceleration values contoured are the random horizontal component. Reference site condition is firm rock, defined as having an average shear-wave velocity of 760 m/s in the top 30 meters, corresponding to the boundary between NEHRP (National Earthquake Hazards Reduction Program) site classes B and C. Documentation, gridded values, interactive maps, and GIS data used to make the map are available online at ttp://earthquake.usgs.gov/hazards or http://dx.doi.org/10.3133/sim3325.

## ACKNOWLEDGMENTS

We would like the thank the hundreds of workshop participants who made valuable suggestions that significantly improved the quality of the maps. The California part of the maps was produced jointly with the California Geological Survey.

## REFERENCES

Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 Update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p., http://dx.doi.org/10.3133/ofr20141091.

SCALE 1:7 000 000

100 0 100 200 300 400 500 600 700 800 900 1000 MILES

100 0 100 200 300 400 500 600 700 800 900 1000 KILOMETERS

Shaded relief base from Esri Inc., 2008, Data and Maps
All other base map data from Esri Inc., 1993, Digital Chart of the World
United States County base map from the U.S. Geological Survey National Atlas, available at http://nationalatlas.gov/

Projection: Albers equal-area conic
Standard parallels 29.5°N. and 45.5°N., central meridian 95°W

Digital data prepared with ArcGIS 10.1 running under Windows 7

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For more information concerning this publication, contact:
Center Director, USGS Geologic Hazards Science Center
Box 25046, Mail Stop 966
Denver, CO 80225
(303) 273-8579

Or visit the Geologic Hazards Science Center Web site at:
http://geohazards.cr.usgs.gov/.

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# Seismic-Hazard Maps for the Conterminous United States, 2014

## Peak Horizontal Acceleration with 2 Percent Probability of Exceedance in 50 Years

By

Mark D. Petersen,[1] Morgan P. Moschetti,[1] Peter M. Powers,[1] Charles S. Mueller,[1] Kathleen M. Haller,[1]Arthur D. Frankel,[1] Yuehua Zeng,[1] Sanaz Rezaeian,[1] Stephen C. Harmsen,[1] Oliver S. Boyd,[1] Edward H. Field,[1] Rui Chen,[2] Nicolas Luco,[1]Russell L. Wheeler,[1] Robert A. Williams,[1] Anna H. Olsen,[1] and Kenneth S. Rukstales[1]

2015

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[2]California Geological Survey, Sacramento, Calif.

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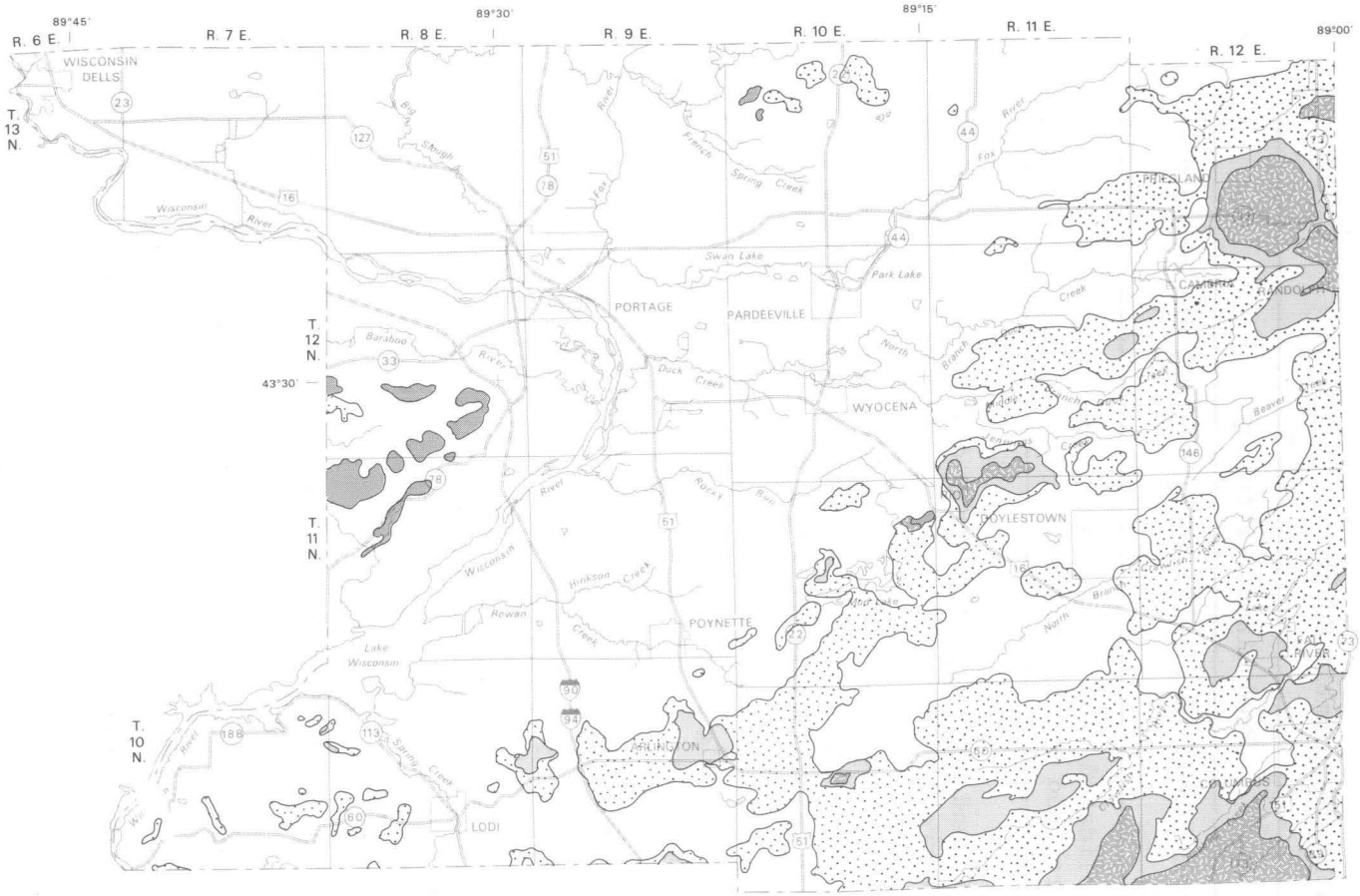
Suggested citation: Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, E.H., Chen, Rui, Luco, Nicolas, Wheeler, R.L., Williams, R.A., Olsen, A.H., and Rukstales, K.S., 2015, Seismic-hazard maps for the conterminous United States, 2014: U.S. Geological Survey Scientific Investigations Map 3325, 6 sheets, scale 1:7,000,000, http://dx.doi.org/10.3133/sim3325.

# Appendix A4

# Site Description and Geologic Summary

Attachment A4.1




Geology by L. C. Trotta (1976)

0 2 4 6 8 10 MILES

0 2 4 6 8 10 KILOMETERS

EXPLANATION

Galena Dolomite, Decorah, and Platteville Formations, undifferentiated
*Mostly dolomite*

St. Peter Sandstone
*Mostly sandstone*

Prairie du Chien Group
*Mostly dolomite*

ORDOVICIAN

Trempleau Formation and Franconia, Galesville, Eau Claire, and Mount Simon Sandstones, undifferentiated
*Mostly sandstone, some shale, siltstone and dolomite*

CAMBRIAN

Crystalline Rock
*Mostly quartzite and rhyolite*

PRECAMBRIAN

**Figure 2. Bedrock geology.**

# Site Description and Geologic Summary

## Site Information

The COL dry ash disposal facility encompasses 62.5 acres, and is located in an industrial and agricultural area with scattered private residences. The site location is Section 27, T12N, R9E, in the town of Pacific, located in Columbia County, Wisconsin. The facility is bounded by U.S. Highway 51 to the east and railroad tracks to the west. Murray Road is located to the north and wetlands are located to the south of the facility.

## Regional Geology

Columbia County glacial geology consists mostly of glacial drift. Glacial sediments from the Green Bay Lobe were deposit during the Wisconsin Glaciation (Harr et. al, 1978). Underling the glacial drift is a mix of dolomite and sandstone from the Ordovician. The Ordovician units: Prairie du Chien Group (mostly dolomite), St. Peter Sandstone, as well as the Platteville and Decorah Formation, and the Galena Dolomite (Galena-Platteville unit) underlay the glacial sediments present in Columbia County (Harr et. al, 1978). In many parts of the county, the Prairie du Chien Group was eroded away and the St. Peter Sandstone overlies Cambrian Sandstone. A bedrock geology map and stratigraphic column are provided in Attachment A4.1 and A4.2.

A map of karst and shallow carbonate bedrock in Wisconsin, like the bedrock geology map from Harr et. al, (1978), shows karst structures and shallow carbonate bedrock are found within Columbia County (Bradbury, 2009); however, the karst geology identified is not located at or near the COL dry ash disposal facility (Attachment A4.3).

The COL dry ash disposal facility is located within the area of the county where Ordovician St Peter sandstone bedrock underlies the glacial drift present at the surface (Appendices A6 and A7). Karst features were not observed in boreholes at COL ADF, and the Wisconsin Geological and Natural History Survey (WGNH) did not identify the site as an area with potential karst structures.

## Previous Geologic Investigations

The disposal facility area was investigated by Warzyn Engineering prior to construction by performing approximately 12 borings within and adjacent to the facility footprint. Eleven of the borings were instrumented with groundwater monitoring wells. The borings extended to depths of up to 100 feet. Split spoon samples were collected. Laboratory soil testing included grain size analysis, Atterberg limits, and organic content by loss on ignition. The boring locations and geologic cross sections are shown in Appendix A6.

Based on the results of the subsurface investigations performed prior to disposal facility construction, the soils below the liner system within the facility footprint consist primarily of medium dense to very dense sands underlain by sandstone bedrock.

## References

Harr, C.A., L.C. Trotta, and R.G. Borman, 1978, "Ground-Water Resources and Geology of Columbia County, Wisconsin," University of Wisconsin-Extension Geological and Natural History Survey Information Circular Number 37, 1978.

Bradbury, K. R., "Karst and Shallow Carbonate Bedrock in Wisconsin." University of Wisconsin-Extension Geological and Natural History Survey, Factsheet 02, 2009.

Warzyn Engineering, Inc., 1978, Feasibility Study, Proposed Fly Ash and/or Scrubber Sludge Disposal Facility – Columbia Site, Wisconsin Power and Light Company, Town of Pacific, Columbia County, WI, January 1978.

Attachment A4.2

Table 1.--Stratigraphy of Columbia County

| System | Rock unit | Predominant lithology |
|---|---|---|
| QUATERNARY | Holocene deposits | Unconsolidated clay, silt, sand, gravel, and organic matter. |
| | Pleistocene deposits | Unconsolidated clay, silt, sand, gravel, cobbles, boulders, and organic matter. |
| ORDOVICIAN | Galena Dolomite, Decorah Formation, and Platteville Formation, undifferentiated | Dolomite and some slightly shaly dolomite, light-gray to blue-gray. |
| | St. Peter Sandstone | Sandstone, dolomitic in some places, shaly at base in some places, white, light-gray, or pink, fine- to medium-grained. |
| | Prairie du Chien Group | Dolomite, tan, gray, or white; some sandstone and sandy dolomite. |
| CAMBRIAN | Trempealeau Formation | Sandstone, dolomitic, very fine- to medium-grained; dolomite interbedded with siltstone, light-gray. |
| | Franconia Sandstone | Sandstone, dolomitic, very fine- to medium-grained; siltstone, dolomitic. |
| | Galesville, Eau Claire, and Mount Simon Sandstones, undifferentiated | Sandstone, light-gray, fine- to coarse-grained, mostly medium grained. |
| PRECAMBRIAN | Precambrian rocks, undifferentiated | Crystalline rocks, mostly quartzite and rhyolite. |

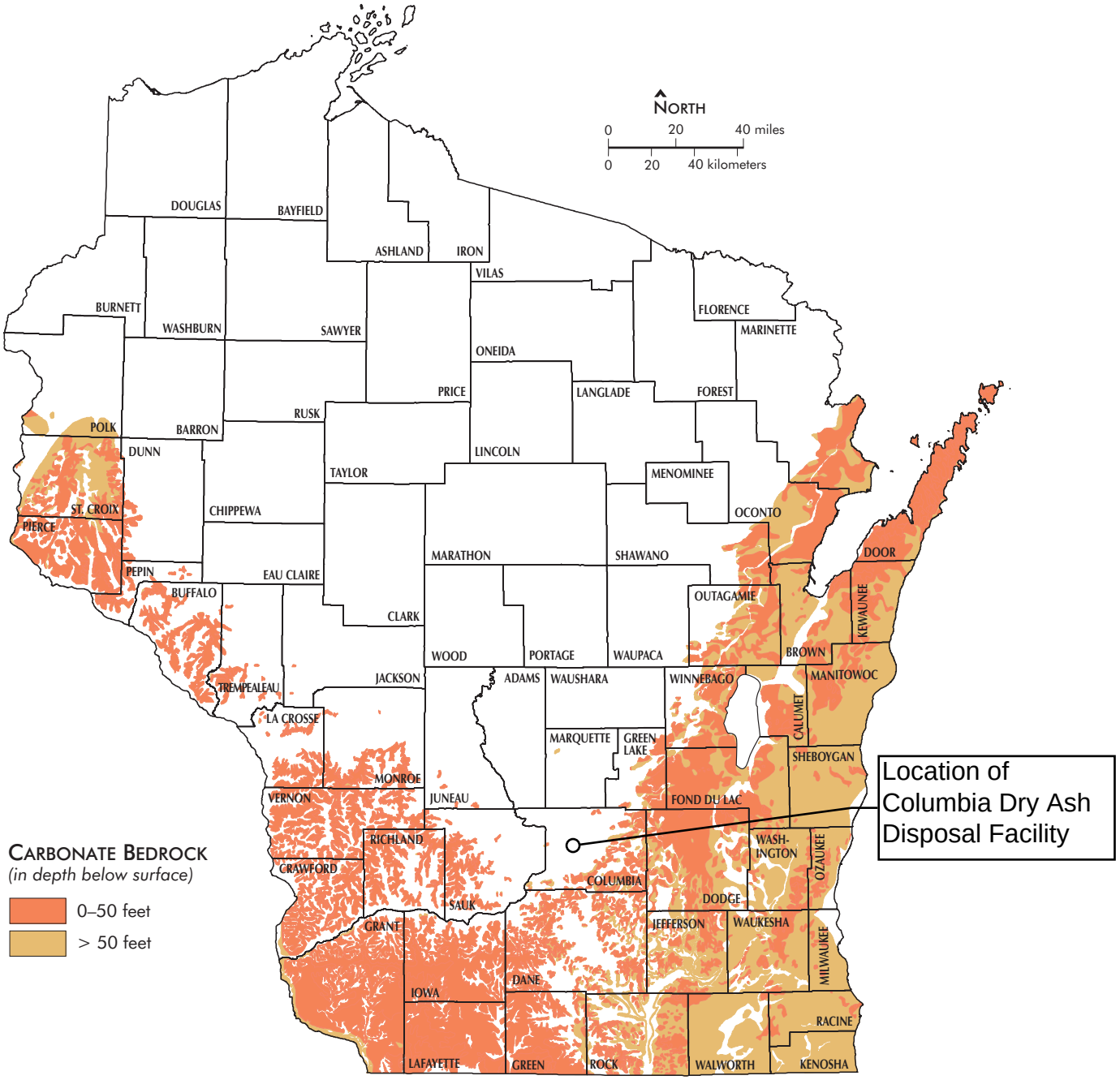
Attachment A4.3

# Karst and shallow carbonate bedrock in Wisconsin

**Wisconsin Geological and Natural History Survey**

Factsheet 02 | 2009

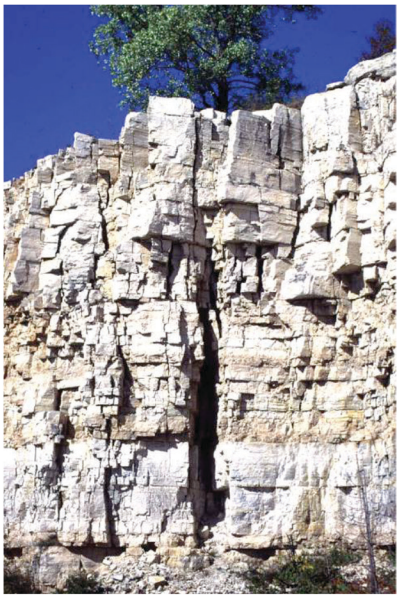
*Areas with carbonate bedrock within 50 feet of the land surface are particularly vulnerable to groundwater contamination.*




UW Extension
University of Wisconsin-Extension

**Wisconsin Geological and Natural History Survey** 3817 Mineral Point Road • Madison, Wisconsin 53705-5100
Tel 608.263.7389 • Fax 608.262.8086 • WisconsinGeologicalSurvey.org

**Director and State Geologist:** James M. Robertson



*Fracturing and bedding in an exposure of carbonate bedrock near Sturgeon Bay in Door County.*

# Karst and shallow carbonate bedrock in Wisconsin

**Wisconsin Geological and Natural History Survey**

Factsheet 02 | 2009

**Carbonate bedrock**, rock formations composed primarily of limestone or dolomite, underlie the southern third of Wisconsin in a V-shaped belt (see map on other side). These rocks are commonly fractured, with the fractures providing primary pathways for groundwater movement.

Carbonate rocks are soluble, and percolating surface water can enlarge fractures to form conduits, caves, and sinkholes that are the hallmarks of a **karst** system and its related karst landscape.

In Wisconsin, karst landscapes are direct evidence of underlying shallow, fractured carbonate bedrock. But the lack of classic karst features in a landscape does not mean that shallow fractured carbonate bedrock is absent, or that the groundwater is potentially any less vulnerable to contamination.

## Carbonate bedrock and groundwater contamination

Carbonate formations are important aquifers in Wisconsin. These aquifers supply water for homes, farms, cities, industries, and other human uses as well as maintaining water levels in lakes and wetlands and flows in streams and springs.

Carbonate aquifers are exceptionally vulnerable to contamination for two reasons:

- Groundwater flow in fractured rocks and karst systems can be extremely rapid—tens to hundreds of feet per day.
- Carbonate rocks are poor at filtering or otherwise removing contaminants.

## Some site-specific questions to ask about carbonate aquifers

Carbonate aquifers are particularly vulnerable where overlying soils are thin or absent. There are numerous examples of groundwater contamination of carbonate aquifers in such settings in Wisconsin. Consequently, land-use activities in areas of carbonate rock must be carefully managed to avoid the release of contaminants to groundwater.

Types of questions to ask:

- Is carbonate bedrock present in the subsurface?
- How deeply is it buried? In other words, what is the thickness of the overlying material?
- What is the nature of the overlying material? For example, what is its origin, composition, grain size, etc?

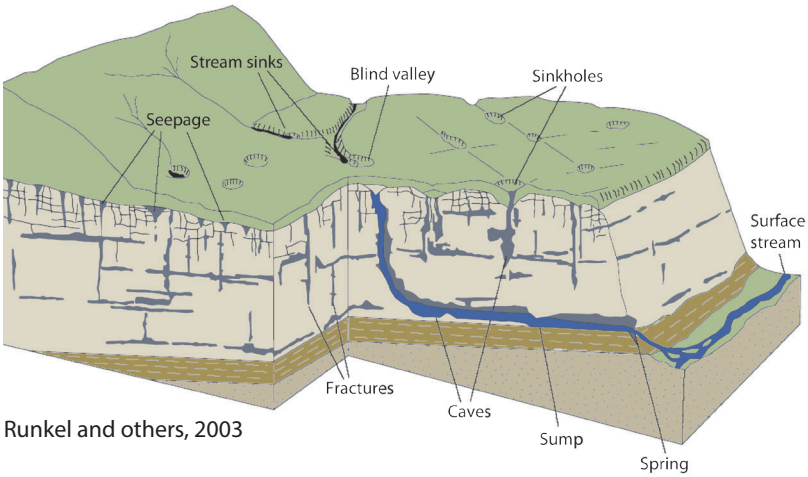
Water- and land-use management plans in areas with carbonate bedrock should always address these sorts of questions as they seek to protect groundwater quantity and quality.

**For more information, contact**

*Kenneth R. Bradbury, Ph.D.*
*Wisconsin Geological and Natural History Survey*
*608.263.7921, krbradbu@wisc.edu*

UW Extension
University of Wisconsin-Extension

**Typical features of a karst sytem and landscape: Seepages, sinkholes, caves, fractures, springs, and stream sinks.**




Runkel and others, 2003

# Appendix A5

# Liquefaction and Settlement Potential Evaluation

# Liquefaction and Settlement Potential Evaluation

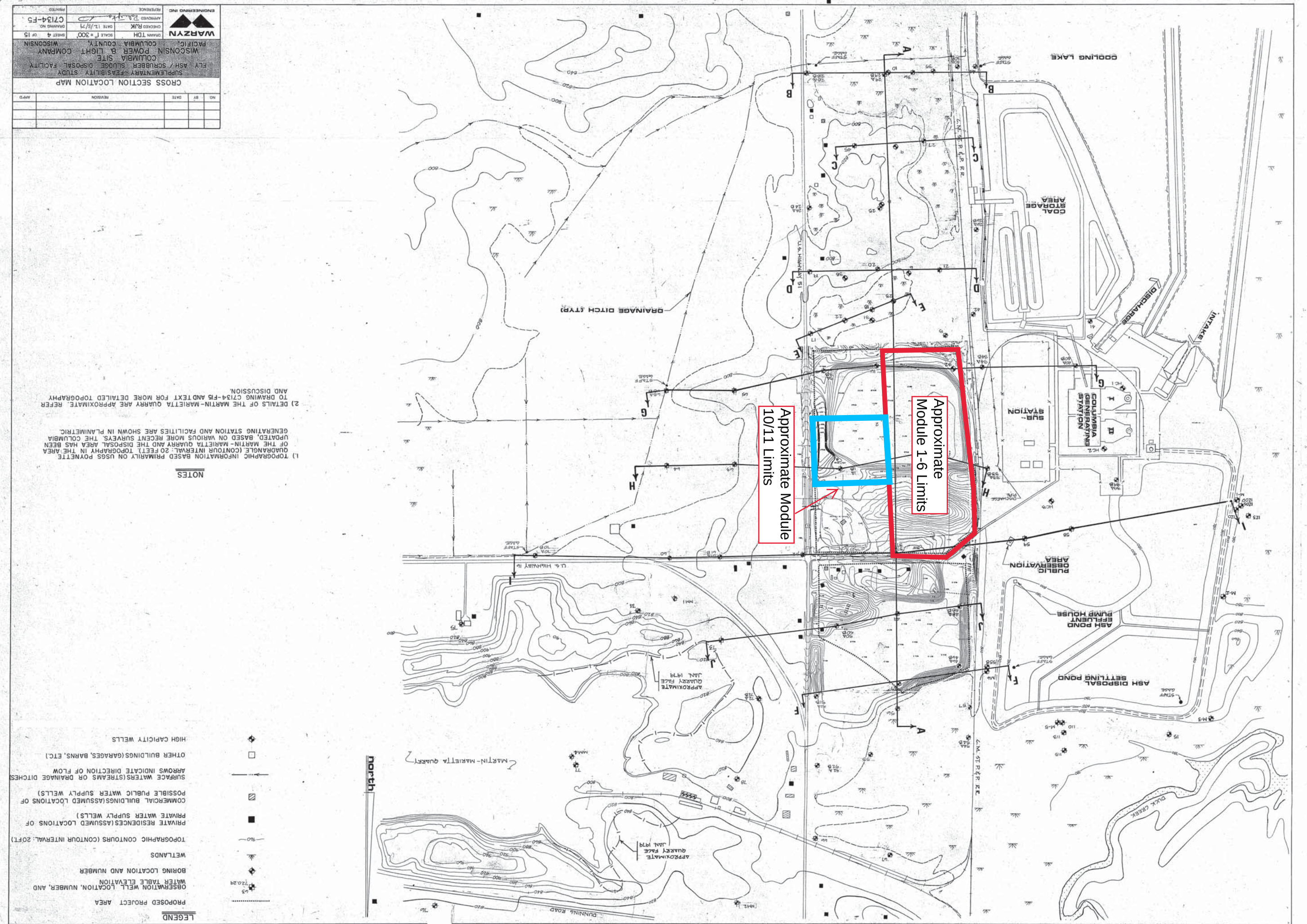
Based on the results of the site investigation borings and laboratory soil test results, the disposal facility soils are not subject to liquefaction or settlement concerns for the performance of the disposal facility.

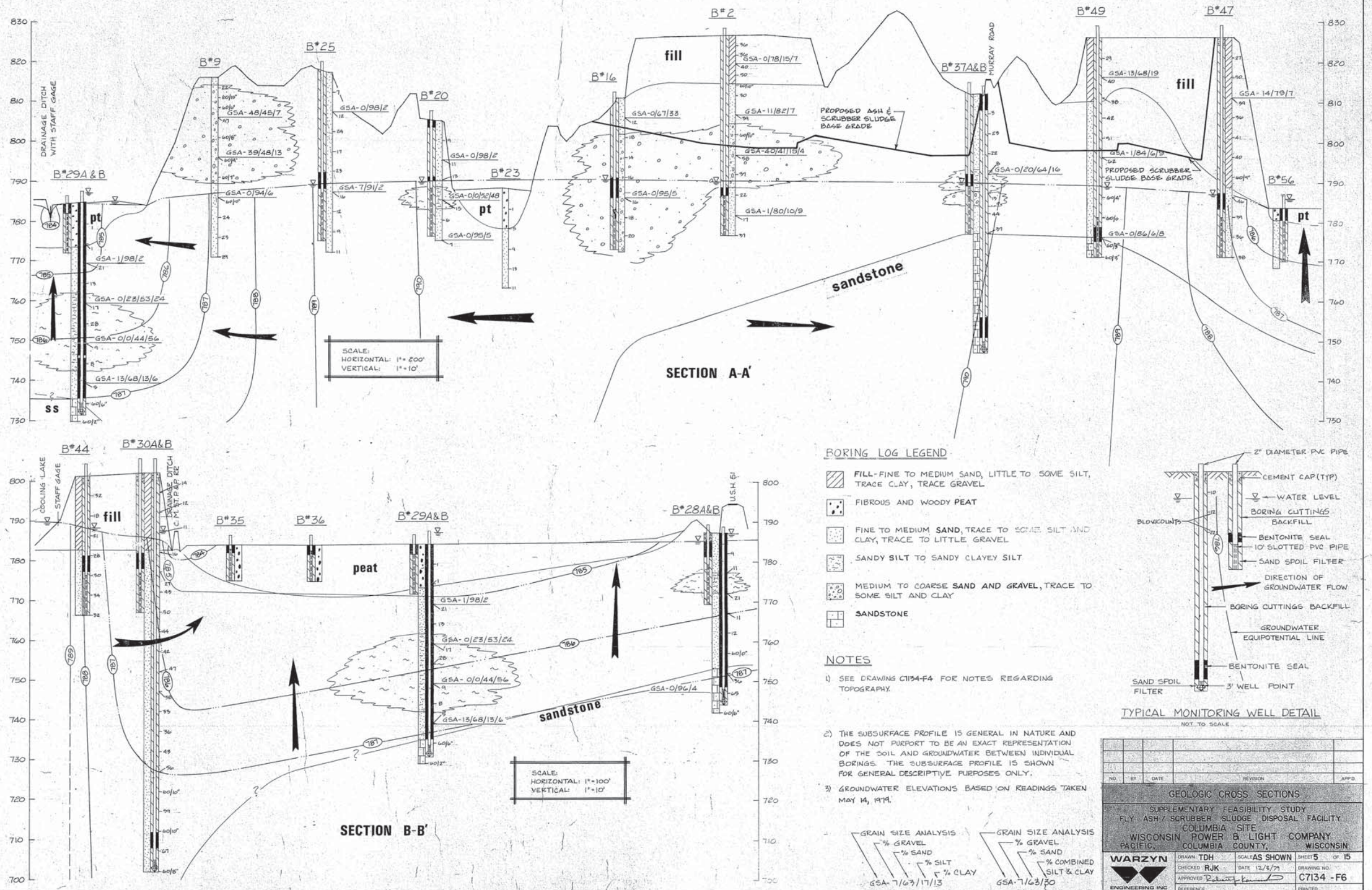
Liquefaction is the process by which a saturated, loose, cohesionless soil influenced by external forces can suddenly loses its shear strength and behave as a fluid. The external forces result from ground motion from an earthquake. The disposal facility site soils consist primarily of sand. Borings show that the sands are medium dense to very dense rather than loose so liquefaction is not a concern given the low magnitude of maximum ground accelerations expected in the area; see Appendix A3.

Settlement below a disposal facility can be a concern if the facility is underlain by extensive soft, fine-grained soils. Soft soils are subject to consolidation settlement depending on the load over the soft soils. The disposal facility soils consist of medium dense to very dense sands that are not subject to consolidation settlement so settlement is not a concern at the disposal facility.

# Appendix A6

# Geologic Cross Sections


Approximate Module 10/11 Limits
Approximate Module 1-6 Limits
COOLING LAKE
DISCHARGE
INTAKE
COAL STORAGE AREA
COLUMBIA GENERATING STATION
SUB-STATION
ASH DISPOSAL SETTLING POND
ASH POND EFFLUENT PUMP HOUSE
PUBLIC OBSERVATION AREA
DRAINAGE DITCH (TYP)
U.S. HIGHWAY 51
APPROXIMATE QUARRY FACE JAN. 1974
MARTIN-MARIETTA QUARRY?
DUNNING ROAD
DUCK CREEK
north
LEGEND
PROPOSED PROJECT AREA
OBSERVATION WELL LOCATION, NUMBER, AND WATER TABLE ELEVATION
BORING LOCATION AND NUMBER
WETLANDS
TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL: 20FT)
PRIVATE RESIDENCES (ASSUMED LOCATIONS OF PRIVATE WATER SUPPLY WELLS)
COMMERCIAL BUILDINGS (ASSUMED LOCATIONS OF POSSIBLE PUBLIC WATER SUPPLY WELLS)
SURFACE WATERS (STREAMS OR DRAINAGE DITCHES) ARROWS INDICATE DIRECTION OF FLOW
OTHER BUILDINGS (GARAGES, BARNS, ETC.)
HIGH CAPICITY WELLS
NOTES
1.) TOPOGRAPHIC INFORMATION BASED PRIMARILY ON USGS POYNETTE QUADRANGLE (CONTOUR INTERVAL: 20 FEET). TOPOGRAPHY IN THE AREA OF THE MARTIN-MARIETTA QUARRY AND THE DISPOSAL AREA HAS BEEN UPDATED, BASED ON VARIOUS MORE RECENT SURVEYS. THE COLUMBIA GENERATING STATION AND FACILITIES ARE SHOWN IN PLANIMETRIC.
2) DETAILS OF THE MARTIN-MARIETTA QUARRY ARE APPROXIMATE. REFER TO DRAWING C7134-F6 AND TEXT FOR MORE DETAILED TOPOGRAPHY AND DISCUSSION.
CROSS SECTION LOCATION MAP
SUPPLEMENTARY FEASIBILITY STUDY
FLY ASH / SCRUBBER SLUDGE DISPOSAL FACILITY
COLUMBIA SITE
WISCONSIN POWER & LIGHT COMPANY
PACIFIC, COLUMBIA COUNTY, WISCONSIN
NO. BY DATE REVISION APP'D
WARZYN ENGINEERING INC
DRAWN TDH SCALE 1" = 300' SHEET 4 OF 15
CHECKED RJK DATE 12/3/79 DRAWING NO. C7134-F5
APPROVED
REFERENCE
PRINTED




## BORING LOG LEGEND

- **FILL** - FINE TO MEDIUM SAND, LITTLE TO SOME SILT, TRACE CLAY, TRACE GRAVEL
- FIBROUS AND WOODY **PEAT**
- FINE TO MEDIUM **SAND**, TRACE TO SOME SILT AND CLAY, TRACE TO LITTLE GRAVEL
- SANDY **SILT** TO SANDY CLAYEY **SILT**
- MEDIUM TO COARSE **SAND AND GRAVEL**, TRACE TO SOME SILT AND CLAY
- **SANDSTONE**

## NOTES

1) SEE DRAWING C7134-F4 FOR NOTES REGARDING TOPOGRAPHY.

2) THE SUBSURFACE PROFILE IS GENERAL IN NATURE AND DOES NOT PURPORT TO BE AN EXACT REPRESENTATION OF THE SOIL AND GROUNDWATER BETWEEN INDIVIDUAL BORINGS. THE SUBSURFACE PROFILE IS SHOWN FOR GENERAL DESCRIPTIVE PURPOSES ONLY.

3) GROUNDWATER ELEVATIONS BASED ON READINGS TAKEN MAY 14, 1979.

GRAIN SIZE ANALYSIS
% GRAVEL
% SAND
% SILT
% CLAY
GSA-7/63/17/13

GRAIN SIZE ANALYSIS
% GRAVEL
% SAND
% COMBINED SILT & CLAY
GSA-7/63/30



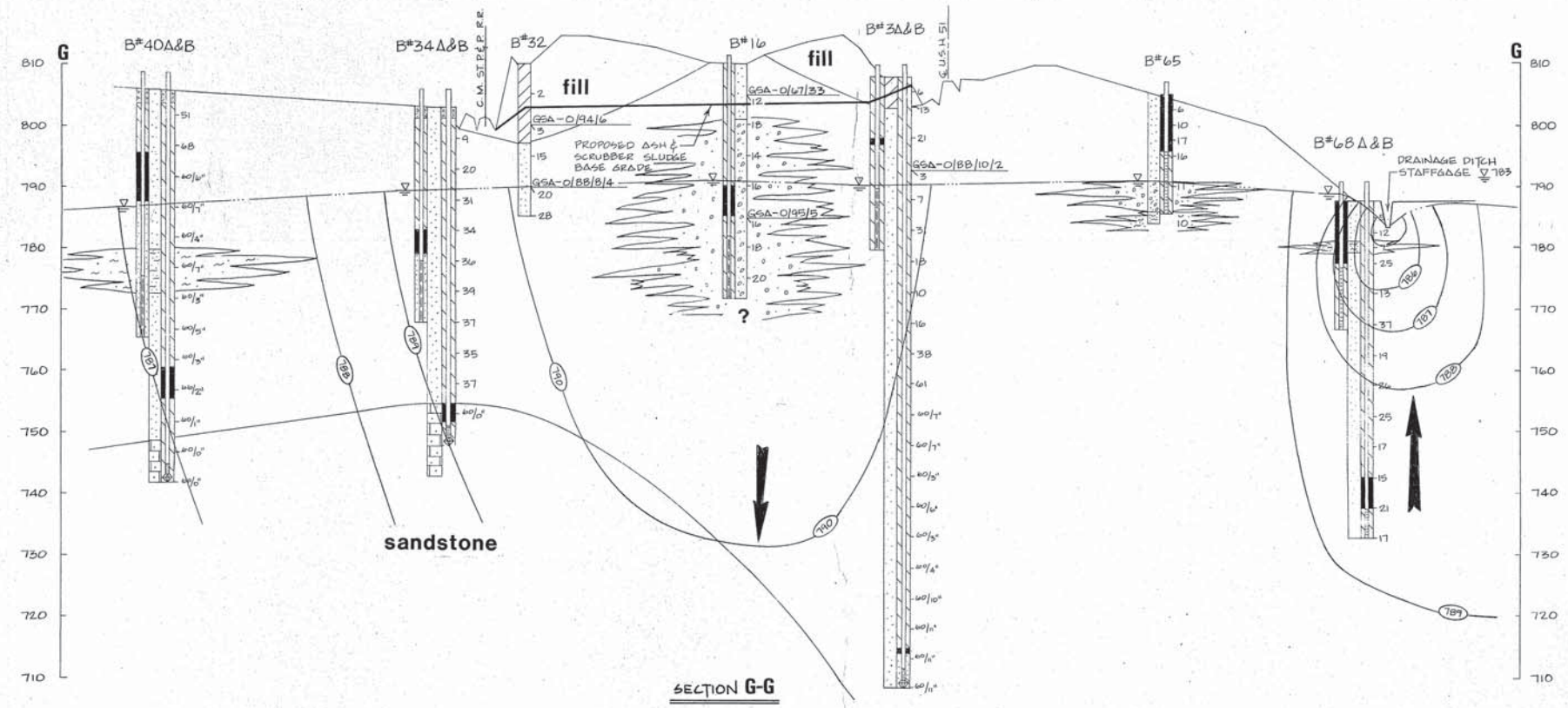

TYPICAL MONITORING WELL DETAIL
NOT TO SCALE

| NO. | BY | DATE | REVISION | APP'D |
|---|---|---|---|---|

GEOLOGIC CROSS SECTIONS
SUPPLEMENTARY FEASIBILITY STUDY
FLY ASH / SCRUBBER SLUDGE DISPOSAL FACILITY
COLUMBIA SITE
WISCONSIN POWER & LIGHT COMPANY
PACIFIC, COLUMBIA COUNTY, WISCONSIN

WARZYN ENGINEERING INC.

| | | | |
|---|---|---|---|
| DRAWN: TDH | SCALE: AS SHOWN | SHEET 5 | OF 15 |
| CHECKED RJK | DATE 12/5/79 | DRAWING NO. | |
| APPROVED | | C7134 -F6 | |
| REFERENCE | | PRINTED | |




SCALE:
VERTICAL: 1"=10'
HORIZONTAL: 1"=200'

NOTES

1) REFER TO DRAWING C7134-F5 FOR NOTES AND LEGEND

| NO. | BY | DATE | REVISION | APP'D |
|---|---|---|---|---|
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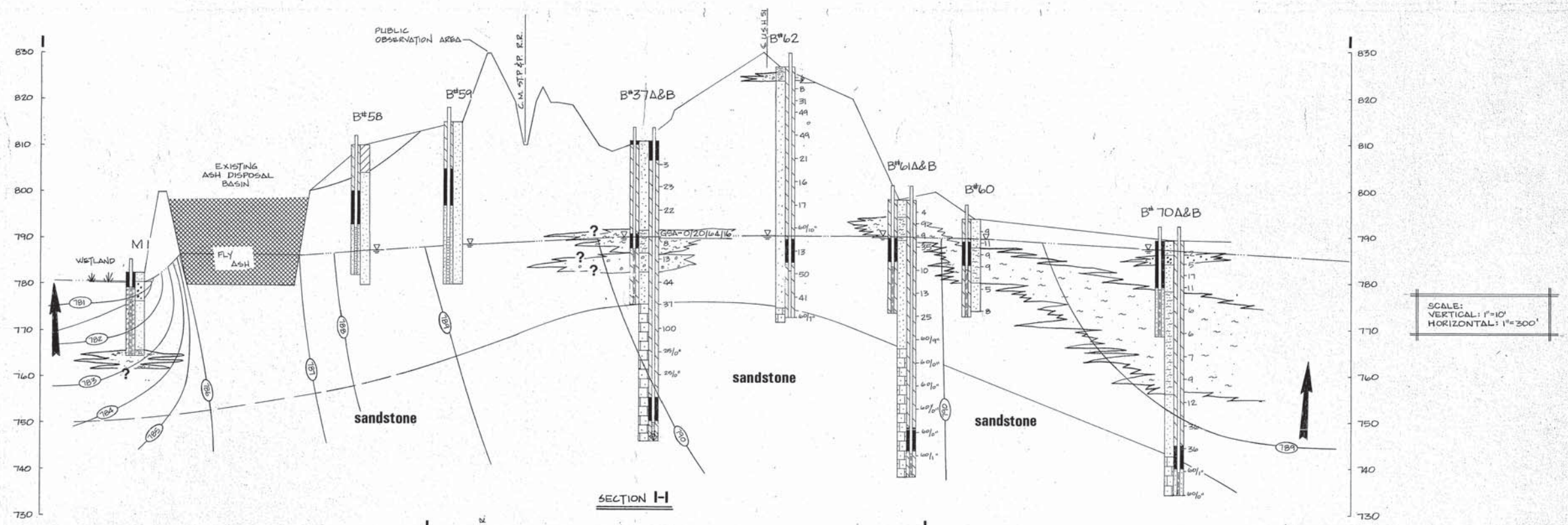
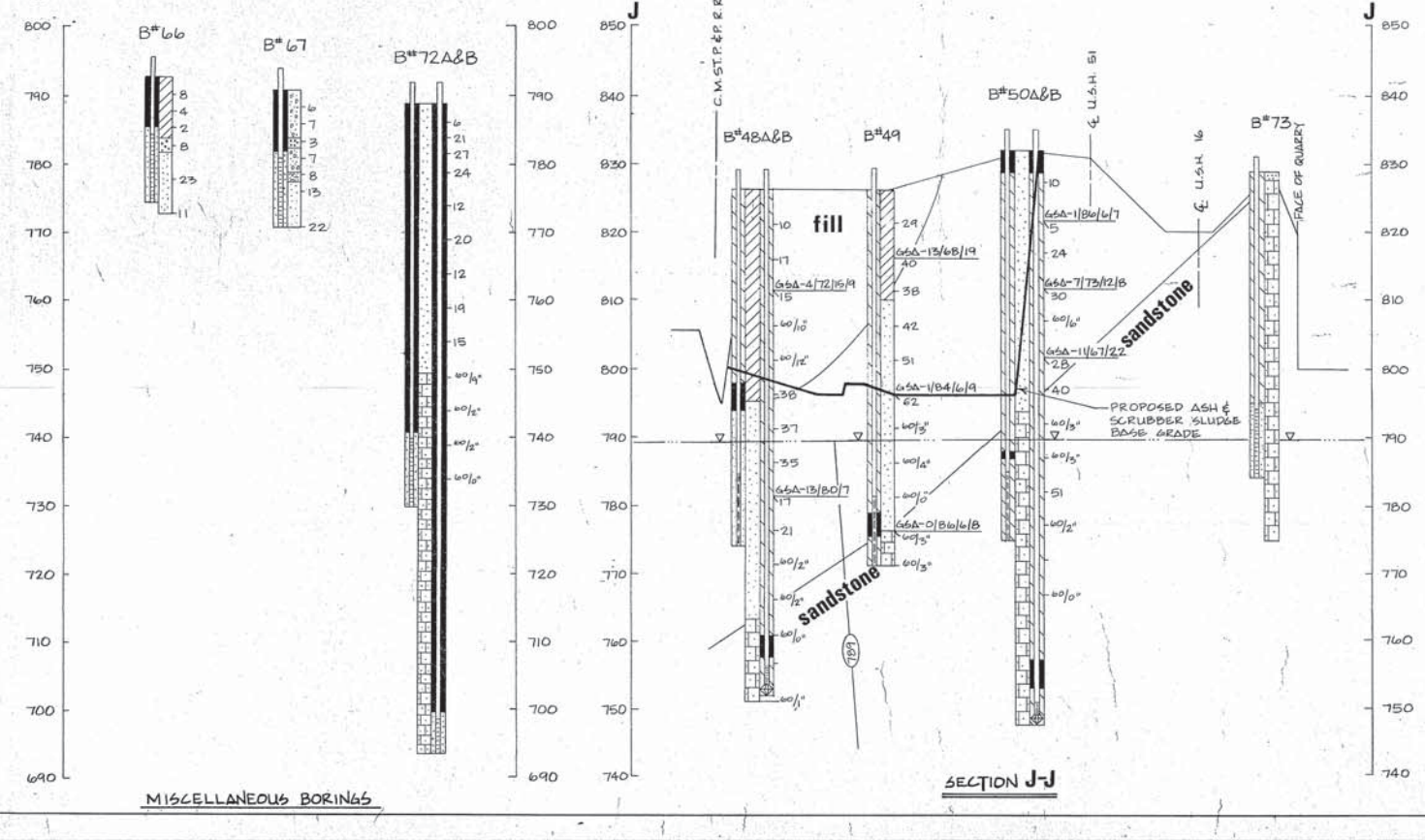
GEOLOGIC CROSS SECTIONS

SUPPLEMENTARY FEASIBILITY STUDY
FLY ASH / SCRUBBER SLUDGE DISPOSAL FACILITY
COLUMBIA SITE
WISCONSIN POWER & LIGHT COMPANY
PACIFIC, COLUMBIA COUNTY, WISCONSIN

WARZYN ENGINEERING INC.

| | | | |
|---|---|---|---|
| DRAWN TDH | SCALE AS SHOWN | SHEET 7 | OF 15 |
| CHECKED RJK | DATE 12/3/79 | DRAWING NO. | |
| APPROVED | | C7134 -F8 | |
| REFERENCE | | PRINTED | |




NOTES

1.) REFER TO DRAWING C7134-F5 FOR NOTES AND LEGEND.

| NO. | BY | DATE | REVISION | APP'D |
|---|---|---|---|---|
| | | | | |

GEOLOGIC CROSS SECTIONS

SUPPLEMENTARY FEASIBILITY STUDY
FLY ASH / SCRUBBER SLUDGE DISPOSAL FACILITY
COLUMBIA SITE
WISCONSIN POWER & LIGHT COMPANY
PACIFIC, COLUMBIA COUNTY, WISCONSIN

WARZYN ENGINEERING INC

| | | | |
|---|---|---|---|
| DRAWN TDH | SCALE AS SHOWN | SHEET 8 OF 15 | |
| CHECKED RJK | DATE 12/3/79 | DRAWING NO. C7134-F9 | |
| APPROVED [signature] | | | |
| REFERENCE | | PRINTED | |

# Appendix A7

# Slope Stability Analysis

May 10, 2022
File No. 25220183.00

TECHNICAL MEMORANDUM

ANALYSIS BY: Brandon Suchomel

REVIEWED BY: Deb Nelson
Phil Gearing

SUBJECT: Slope Stability Analyses
Plan of Operation 2022 Update
Columbia Dry Ash Disposal Facility

## PURPOSE

The purposes of the slope stability analyses were to evaluate:

- The interim 3H:1V waste slope in Module 5 at the highest waste grade (Interim Waste Filling Stage 2).
- The interim 4H:1V east waste slope in Module 4/Module 11 at the highest waste grade (Interim Waste Filling Stage 3).
- The final 4H:1V final cover slope Module 4/Module 11 at the highest final cover grade.

## CONCLUSION

The attached results confirm that the interim waste slopes will be stable during the construction and operation of the disposal facility modules and that the final grade slope will be stable post-closure of the disposal facility.

## APPROACH

SCS Engineers (SCS) evaluated the waste mass slope stability of the interim slope of Module 5 during interim waste filling stage 2 and the waste mass slope stability of the interim slope of Module 4/Module 11 during the interim waste filling stage 3 at the most critical/highest waste grade cross-sections. The Module 5 interim 3H:1V waste slope analyzed is the eastern filling face with a maximum waste fill height of approximately 63 feet above the base grade corresponding to a peak elevation of approximately 870 feet above mean sea level. The Module 4/Module 11 interim 4H:1V waste slope analyzed is at the eastern filling face with a maximum waste fill height of approximately 65 feet above the base grade corresponding to a peak elevation of approximately 870 feet above mean sea level. The interim waste slopes were evaluated for block failure and optimized circular failure.

SCS completed analysis for this waste slope by iteratively modifying the coal combustion residual (CCR) friction angle to determine the minimum friction angle required for a safety factor of 1.3. This calculated CCR friction angle was used in the other analyzed sections. The calculated CCR friction angle of 22.7 degrees is still conservative based on assumed published values of stabilized CCR in the range of 35 to 45 degrees (see Reference 7).

SCS evaluated the final grade slope stability of longest final cover slope at the most critical/highest final grade cross-section. The 4H:1V slope of analyzed is through the Module 4/Module 11 waste mass with a maximum waste fill height of approximately 101 feet above base grades corresponding to a peak elevation of approximately 908 feet above mean sea level. The final grade slope was evaluated for block failure and optimized circular failure.

## RESULTS

The calculated safety factors for each slope section and failure type are shown in the attached summary table.

SCS recommends a minimum safety factor of 1.3 for the interim waste slopes and 1.5 for the final grade slopes. The results indicate that the interim waste slopes and final grade slopes have acceptable minimum safety factors.

## REFERENCES

1. SCS Engineers, Columbia Dry Ash Disposal Facility, Module 3 Liner Construction, 2016, existing composite liner grades and material properties for geosynthetics.

2. SCS Engineers, Columbia Dry Ash Disposal Facility, 2018 Module 4 Liner Construction, 2018, existing composite liner grades and material properties for subbase, clay, and drainage layer.

3. SCS Engineers, Columbia Dry Ash Disposal Facility, Module 5-6 Liner Construction, 2021, existing composite liner grades and material properties for subbase, clay, and drainage layer.

4. SCS Engineers, Columbia Dry Ash Disposal Facility, Plan of Operation 2022 Update, 2022, Module 10-11 composite liner grades, interim waste filling stages, final grades.

5. TRI/Environmental, Interface Friction Test Results, 2016, for 2016 Module 3 Liner Construction.

6. TRI/Environmental, Consolidated-Undrained Triaxial Compression Test Results for FGD Material, 2015, material properties for CCR (SCS Project No. 25214049.00).

7. U.S. Department of Transportation, Federal Highway Administration, Recycled Materials, User Guidelines for Waste and Byproduct Materials in Pavement Construction.

8. Stabilization of FGD By-Products by Using Fly Ash, Cement, and Sialite, 2009 WOCA Conference.

9. Geo-Slope International, Ltd., GeoStudio 2016, Version 8.16.2.14053, Slope/W slope stability software.

## ASSUMPTIONS

- Sand drainage layer in each of the existing and future modules have the same properties.
- Geosynthetics installed for each of the module composite liners have the same properties.
- Clay material for each of the module composite liners have the same properties.
- CCR waste material will be the same in each of the existing and future modules.
- A waste fill slope of 3H:1V or 4H:1V is representative of the design interim waste slopes.
- The groundwater elevation will remain below the elevation at the base of the landfill liner system.
- The disposal facility will be operated to prevent development of liquid pressures, or seepage forces within the waste, and there will be no buildup of leachate above the top of the drainage layer.
- The disposal facility will be operated to prevent placement of weak layers of waste within the overall waste mass.
- Optimized circular and sliding block failure stability analyses are appropriate to evaluate the waste interim grade and final grade slope stability.
- Material properties are as shown in the table below, based on the indicated references and assumed values based on experience. Friction angles for soils are conservative assumed values based on soil type, published typical values, and SCS experience. The CCR friction angle is a calculated conservative value that is in line with assumed published values and the CCR unit weight is based on 2015 triaxial compression test results by TRI/Environmental for CCR.

Table 1. Material Properties Summary Table

| Material | Unit Weight (pcf) | Friction Angle (degrees) | Cohesion (psf) | Reference |
|---|---|---|---|---|
| Subbase | 120 | 30 | 0 | 1, 2, and 3 |
| Clay | 125 | 28 | 0 | 1, 2, and 3 |
| Geosynthetics | 58 | 24.3 | 0 | 5 |
| Drainage Layer | 115 | 30 | 0 | 2 and 3 |
| CCR | 86 | 22.7(1) | 0 | 6, 7, 8, and Calculation |
| Final Cover | 120 | 30 | 0 | 1, 2, 3, and 4 |

Notes: CCR friction angle iteratively calculated for minimum value for a safety factor of 1.3 for Module 5 interim 3H:1V analysis. Calculated CCR friction angle was used in the other analyzed sections.

Attachments: Calculations organized as follows:

- Factor of Safety Summary Table
- Cross Section Locations
- Slope/W Outputs

BSS/DLN/REO/PEG

I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\Tech Memo\Tech Memo_POO 2022 Update Stabtility Analysis_220510.docx

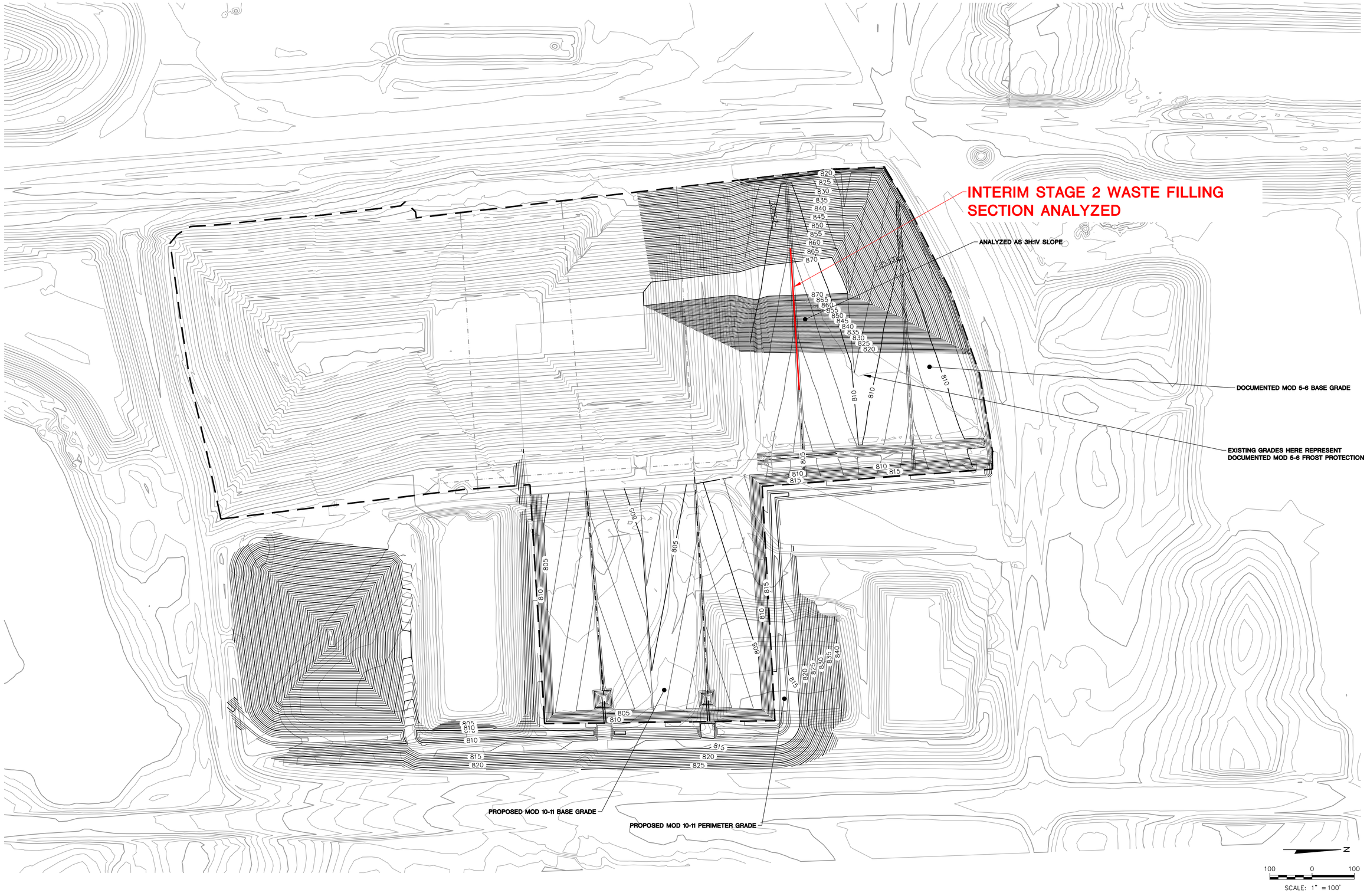
**Plan of Operation Update - Slope Stability Analysis**
**Factor of Safety Results Summary**
**Columbia Dry Ash Disposal Facility / SCS Project No. 25220183.00**

| Scenario Analyzed | Failure Type | Calculated Safety Factor | Recommended Minimum Safety Factor |
|---|---|---|---|
| **Interim Waste Stage 2 (Module 5 Interim 3H:1V Waste Slope)** | | | |
| 2-2_Optimized Circular_Forced Full Slope_FS=1.3 | Optimized Circular | 1.302[(1)] | 1.300 |
| 3_Block | Block | 1.579 | 1.300 |
| **Interim Waste Stage 3 (Module 4/Module 11 Interim 4H:1V Waste Slope)** | | | |
| 2-1_Optimized Circular_Forced Full Slope | Optimized Circular | 1.691 | 1.300 |
| 3_Block | Block | 2.063 | 1.300 |
| **Final Grade (Module 4/Module 11 4H:1V Final Cover Slope)** | | | |
| 2_Optimized Circular | Optimized Circular | 1.715 | 1.500 |
| 3_Block | Block | 2.143 | 1.500 |

Notes:
1. Coal combustion residual (CCR) friction angle iteratively calculated for minimum value for a safety factor of 1.3.

Updated by: BSS, 05/04/2022
Checked by: DLN, 05/05/2022

I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\Tech Memo\[A1_POO Slope Stability_FS Results Summary Table_220504.xlsx]FS Results Summary




| | |
|---|---|
| PROJECT NO. | 25220183.00 |
| DRAWN: | 04/01/2022 |
| REVISED: | 05/04/2022 |
| DRAWN BY: | BSS |
| CHECKED BY: | ?? |
| APPROVED BY: | |

CLIENT

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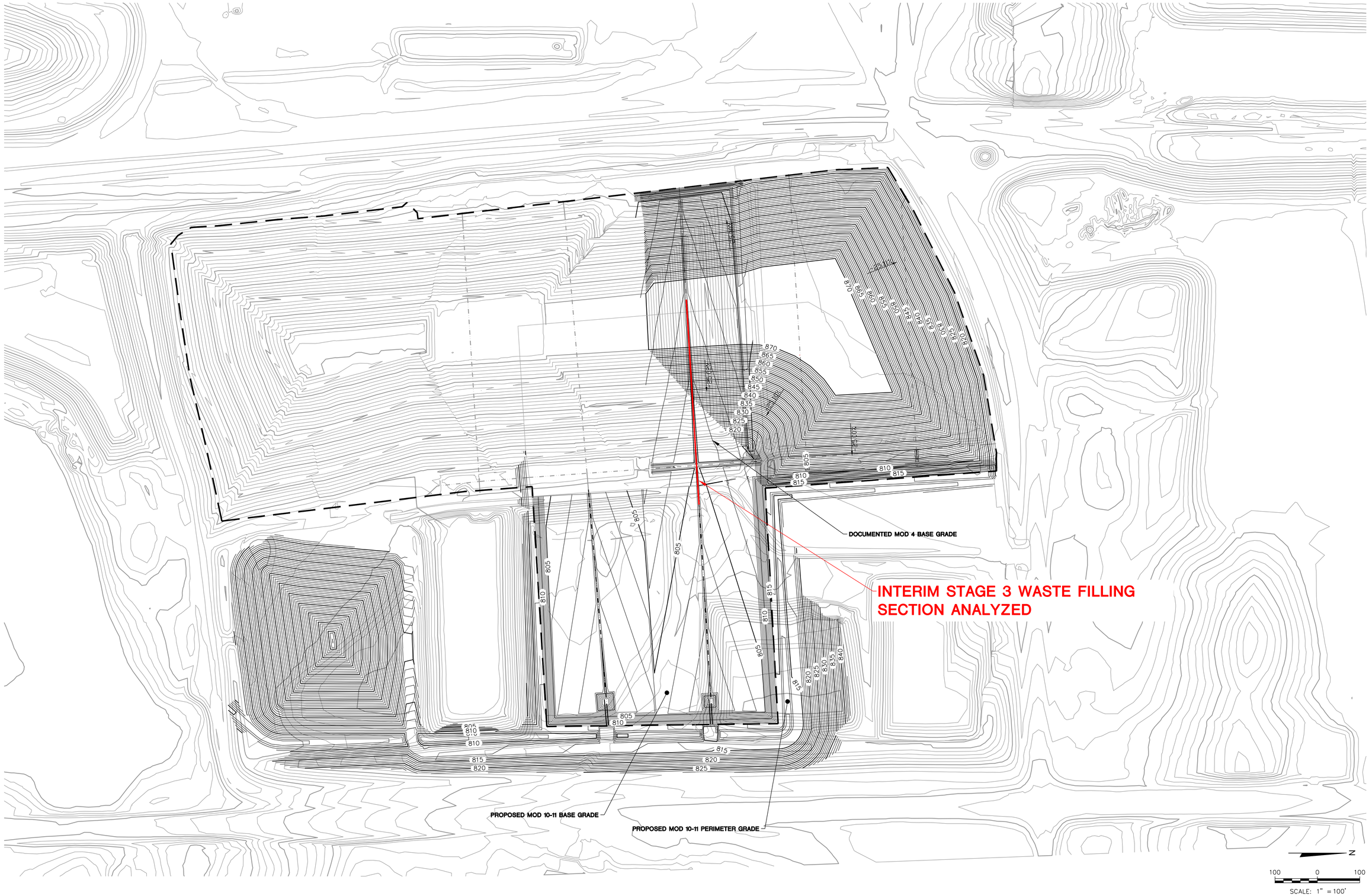
SITE

COLUMBIA DRY ASH DISPOSAL FACILITY

SLOPE STABILITY CROSS SECTION LOCATIONS
INTERIM FILLING STAGE 2

FIGURE

1 of 1




| | | | |
|---|---|---|---|
| PROJECT NO. | 25220183.00 | DRAWN BY: | BSS |
| DRAWN: | 04/01/2022 | CHECKED BY: | ?? |
| REVISED: | 05/04/2022 | APPROVED BY: | |

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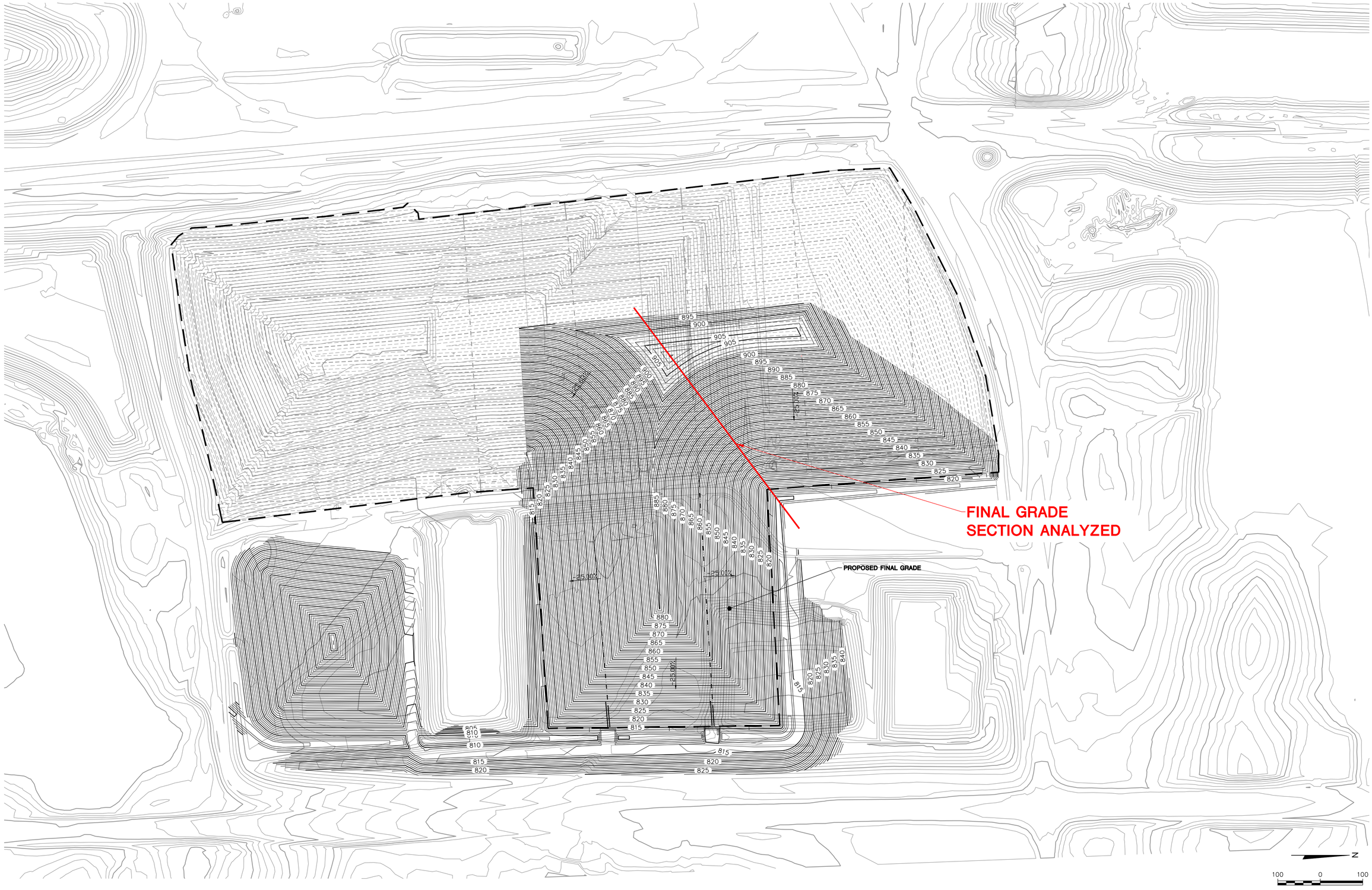
COLUMBIA DRY ASH DISPOSAL FACILITY

FIGURE

SLOPE STABILITY CROSS SECTION LOCATIONS
INTERIM FILLING STAGE 3

1 of 1

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|---|---|
| PROJECT NO. | 25220183.00 |
| DRAWN: | 04/01/2022 |
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| DRAWN BY: | BSS |
| CHECKED BY: | ?? |
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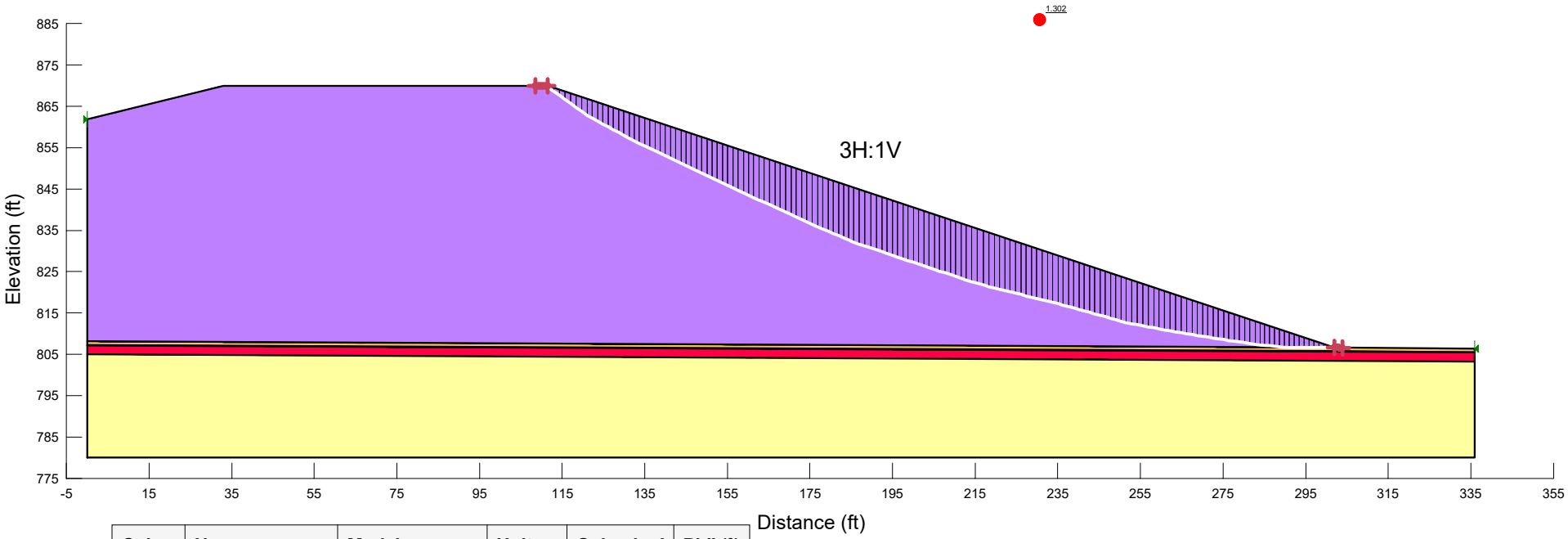
COLUMBIA DRY ASH DISPOSAL FACILITY

SLOPE STABILITY CROSS SECTION LOCATIONS
FINAL GRADE

FIGURE

1 of 1




| Color | Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|---|---|---|---|---|
| | CCR (Optimized Ciruclar FS=1.3) | Mohr-Coulomb | 86 | 0 | 22.7 |
| | Clay | Mohr-Coulomb | 125 | 0 | 28 |
| | Drainage Layer | Mohr-Coulomb | 115 | 0 | 30 |
| | Geosynthetics | Mohr-Coulomb | 58 | 0 | 24.3 |
| | Subbase | Mohr-Coulomb | 120 | 0 | 30 |

**Title: Columbia Mod 10-11 Interim Waste Stage 2**
**Name: 2-2_Optimized Circular_Forced Full Slope_FS=1.3**
**Method: Bishop**
**Last Edited By: Suchomel, Brandon**

**F of S: 1.302, F of S Rank (Analysis): 1 of 8,650 slip surfaces**
**Last Solved Date: 4/7/2022, Last Solved Time: 4:36:09 PM**

# 2-2_Optimized Circular_Forced Full Slope_FS=1.3

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## File Information

File Version: 8.16
Title: Columbia Mod 10-11 Interim Waste Stage 2
Created By: Suchomel, Brandon
Last Edited By: Suchomel, Brandon
Revision Number: 54
Date: 4/7/2022
Time: 4:35:53 PM
Tool Version: 8.16.3.14580
File Name: Columbia Mod 10-11 Interim Waste Stage 2.gsz
Directory: I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\
Last Solved Date: 4/7/2022
Last Solved Time: 4:36:08 PM

## Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

## Analysis Settings

### 2-2_Optimized Circular_Forced Full Slope_FS=1.3

Kind: SLOPE/W
Method: Bishop
Settings
    PWP Conditions Source: (none)
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 10
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Optimize Critical Slip Surface Location: Yes
    Critical Slip Surface Optimizations
        Maximum Iterations: 2,000
        Convergence Tolerance: 1e-007

Starting Points: 8
Ending Points: 16
Complete Passes per Insertion: 1

Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 150
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

# Materials

## Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

## Drainage Layer

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Geosynthetics

Model: Mohr-Coulomb
Unit Weight: 58 pcf
Cohesion': 0 psf
Phi': 24.3 °
Phi-B: 0 °

## Subbase

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## CCR (Optimized Ciruclar FS=1.3)

Model: Mohr-Coulomb
Unit Weight: 86 pcf
Cohesion': 0 psf
Phi': 22.7 °
Phi-B: 0 °

# Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (108.48, 870) ft
Left-Zone Right Coordinate: (111.54, 870) ft
Left-Zone Increment: 30
Right Projection: Range
Right-Zone Left Coordinate: (301.96, 806.59965) ft
Right-Zone Right Coordinate: (303.97, 806.58782) ft
Right-Zone Increment: 30
Radius Increments: 8

## Slip Surface Limits

Left Coordinate: (0, 861.8) ft
Right Coordinate: (335.9, 806.4) ft

## Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 0 | 780 |
| Point 2 | 335.9 | 780 |
| Point 3 | 0 | 805 |
| Point 4 | 335.9 | 803.3 |
| Point 5 | 0 | 807.1 |
| Point 6 | 335.9 | 805.4 |
| Point 7 | 0 | 808.1 |
| Point 8 | 335.9 | 806.4 |
| Point 9 | 0 | 861.8 |
| Point 10 | 33 | 870 |
| Point 11 | 111.6 | 870 |
| Point 12 | 305 | 805.6 |
| Point 13 | 301.9 | 806.6 |
| Point 14 | 0 | 807.2 |
| Point 15 | 305 | 805.7 |
| Point 16 | 335.9 | 805.5 |

## Regions

| | Material | Points | Area (ft²) |
|---|---|---|---|
| Region 1 | Subbase | 1,2,4,3 | 8,112 |
| Region 2 | Clay | 3,5,12,6,4 | 712.72 |
| Region 3 | CCR (Optimized Ciruclar FS=1.3) | 7,9,10,11,13 | 12,746 |
| Region 4 | Geosynthetics | 5,14,15,16,6,12 | 33.59 |
| Region 5 | Drainage Layer | 14,7,13,8,16,15 | 299.67 |

## Current Slip Surface

Slip Surface: 8,650
F of S: 1.302
Volume: 1,754.0514 ft³
Weight: 150,848.42 lbs
Resisting Moment: 15,727,122 lbs-ft

Activating Moment: 12,083,493 lbs-ft
F of S Rank (Analysis): 1 of 8,650 slip surfaces
F of S Rank (Query): 1 of 8,650 slip surfaces
Exit: (301.8996, 806.60013) ft
Entry: (111.00732, 870) ft
Radius: 95.822462 ft
Center: (282.35976, 1,073.0057) ft

## Slip Slices

| | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|
| Slice 1 | 111.30366 | 869.78663 | 0 | 14.901895 | 6.2335978 | 0 |
| Slice 2 | 112.27238 | 869.08913 | 0 | 47.970541 | 20.066512 | 0 |
| Slice 3 | 113.61713 | 868.12087 | 0 | 84.304041 | 35.265144 | 0 |
| Slice 4 | 114.96189 | 867.15261 | 0 | 120.63754 | 50.463777 | 0 |
| Slice 5 | 116.30665 | 866.18435 | 0 | 156.97104 | 65.662409 | 0 |
| Slice 6 | 117.6514 | 865.21609 | 0 | 193.30454 | 80.861041 | 0 |
| Slice 7 | 118.99616 | 864.24784 | 0 | 229.63804 | 96.059674 | 0 |
| Slice 8 | 120.34091 | 863.27958 | 0 | 265.97154 | 111.25831 | 0 |
| Slice 9 | 121.64885 | 862.45093 | 0 | 307.70165 | 128.71439 | 0 |
| Slice 10 | 122.91997 | 861.76189 | 0 | 327.15121 | 136.85031 | 0 |
| Slice 11 | 124.1911 | 861.07285 | 0 | 346.60077 | 144.98624 | 0 |
| Slice 12 | 125.46222 | 860.38381 | 0 | 366.05033 | 153.12217 | 0 |
| Slice 13 | 126.73334 | 859.69477 | 0 | 385.4999 | 161.2581 | 0 |
| Slice 14 | 128.00446 | 859.00573 | 0 | 404.94946 | 169.39403 | 0 |
| Slice 15 | 129.27559 | 858.31669 | 0 | 424.39902 | 177.52996 | 0 |
| Slice 16 | 130.54671 | 857.62765 | 0 | 443.84858 | 185.66588 | 0 |
| Slice 17 | 131.81132 | 856.98435 | 0 | 468.71531 | 196.06786 | 0 |
| Slice 18 | 133.06943 | 856.38679 | 0 | 482.02669 | 201.63613 | 0 |
| Slice 19 | 134.32754 | 855.78924 | 0 | 495.33807 | 207.2044 | 0 |
| Slice 20 | 135.58564 | 855.19168 | 0 | 508.64945 | 212.77267 | 0 |
| Slice 21 | 136.84375 | 854.59412 | 0 | 521.96083 | 218.34094 | 0 |
| Slice 22 | 138.10185 | 853.99656 | 0 | 535.27221 | 223.90922 | 0 |
| Slice 23 | 139.35996 | 853.39901 | 0 | 548.58359 | 229.47749 | 0 |
| Slice 24 | 140.61807 | 852.80145 | 0 | 561.89497 | 235.04576 | 0 |
| Slice 25 | 141.87617 | 852.20389 | 0 | 575.20635 | 240.61403 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 26 | 143.13428 | 851.60633 | 0 | 588.51773 | 246.1823 | 0 |
| Slice 27 | 144.39238 | 851.00878 | 0 | 601.82911 | 251.75057 | 0 |
| Slice 28 | 145.65049 | 850.41122 | 0 | 615.14049 | 257.31884 | 0 |
| Slice 29 | 146.90859 | 849.81366 | 0 | 628.45187 | 262.88711 | 0 |
| Slice 30 | 148.1667 | 849.2161 | 0 | 641.76325 | 268.45538 | 0 |
| Slice 31 | 149.42481 | 848.61854 | 0 | 655.07463 | 274.02365 | 0 |
| Slice 32 | 150.68291 | 848.02099 | 0 | 668.38601 | 279.59192 | 0 |
| Slice 33 | 151.94102 | 847.42343 | 0 | 681.69739 | 285.1602 | 0 |
| Slice 34 | 153.19913 | 846.82587 | 0 | 695.00877 | 290.72847 | 0 |
| Slice 35 | 154.45723 | 846.22831 | 0 | 708.32015 | 296.29674 | 0 |
| Slice 36 | 155.71534 | 845.63076 | 0 | 721.63153 | 301.86501 | 0 |
| Slice 37 | 156.97344 | 845.0332 | 0 | 734.94291 | 307.43328 | 0 |
| Slice 38 | 158.23155 | 844.43564 | 0 | 748.25429 | 313.00155 | 0 |
| Slice 39 | 159.48966 | 843.83808 | 0 | 761.56567 | 318.56982 | 0 |
| Slice 40 | 160.74776 | 843.24053 | 0 | 774.87705 | 324.13809 | 0 |
| Slice 41 | 162.00587 | 842.64297 | 0 | 788.18843 | 329.70636 | 0 |
| Slice 42 | 163.28072 | 842.05115 | 0 | 805.41636 | 336.91296 | 0 |
| Slice 43 | 164.57233 | 841.46506 | 0 | 817.1082 | 341.80376 | 0 |
| Slice 44 | 165.86394 | 840.87897 | 0 | 828.80004 | 346.69457 | 0 |
| Slice 45 | 167.15555 | 840.29289 | 0 | 840.49189 | 351.58537 | 0 |
| Slice 46 | 168.44716 | 839.7068 | 0 | 852.18373 | 356.47618 | 0 |
| Slice 47 | 169.73877 | 839.12071 | 0 | 863.87557 | 361.36698 | 0 |
| Slice 48 | 171.03038 | 838.53463 | 0 | 875.56742 | 366.25778 | 0 |
| Slice 49 | 172.32199 | 837.94854 | 0 | 887.25926 | 371.14859 | 0 |
| Slice 50 | 173.6136 | 837.36245 | 0 | 898.9511 | 376.03939 | 0 |
| Slice 51 | 174.90521 | 836.77636 | 0 | 910.64295 | 380.9302 | 0 |
| Slice | 176.19682 | 836.19028 | 0 | 922.33479 | 385.821 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 52 | | | | | | |
| Slice 53 | 177.48843 | 835.60419 | 0 | 934.02663 | 390.7118 | 0 |
| Slice 54 | 178.78004 | 835.0181 | 0 | 945.71848 | 395.60261 | 0 |
| Slice 55 | 180.04425 | 834.46978 | 0 | 966.36152 | 404.23778 | 0 |
| Slice 56 | 181.28106 | 833.95921 | 0 | 973.84146 | 407.36671 | 0 |
| Slice 57 | 182.51788 | 833.44863 | 0 | 981.32141 | 410.49564 | 0 |
| Slice 58 | 183.7547 | 832.93807 | 0 | 988.80136 | 413.62457 | 0 |
| Slice 59 | 184.99151 | 832.4275 | 0 | 996.2813 | 416.7535 | 0 |
| Slice 60 | 186.28858 | 831.93574 | 0 | 1,019.4282 | 426.43606 | 0 |
| Slice 61 | 187.64588 | 831.46281 | 0 | 1,021.0319 | 427.10689 | 0 |
| Slice 62 | 189.0032 | 830.98987 | 0 | 1,022.6355 | 427.77771 | 0 |
| Slice 63 | 190.3605 | 830.51694 | 0 | 1,024.2392 | 428.44853 | 0 |
| Slice 64 | 191.71782 | 830.04401 | 0 | 1,025.8428 | 429.11935 | 0 |
| Slice 65 | 193.03417 | 829.5952 | 0 | 1,031.2415 | 431.37765 | 0 |
| Slice 66 | 194.30958 | 829.17051 | 0 | 1,031.224 | 431.37034 | 0 |
| Slice 67 | 195.58499 | 828.74582 | 0 | 1,031.2065 | 431.36302 | 0 |
| Slice 68 | 196.8604 | 828.32113 | 0 | 1,031.189 | 431.35571 | 0 |
| Slice 69 | 198.13581 | 827.89645 | 0 | 1,031.1715 | 431.3484 | 0 |
| Slice 70 | 199.41122 | 827.47176 | 0 | 1,031.1541 | 431.34109 | 0 |
| Slice 71 | 200.68662 | 827.04707 | 0 | 1,031.1366 | 431.33377 | 0 |
| Slice 72 | 201.96203 | 826.62238 | 0 | 1,031.1191 | 431.32646 | 0 |
| Slice 73 | 203.23744 | 826.19769 | 0 | 1,031.1016 | 431.31915 | 0 |
| Slice 74 | 204.51285 | 825.77301 | 0 | 1,031.0841 | 431.31183 | 0 |
| Slice 75 | 205.78826 | 825.34832 | 0 | 1,031.0666 | 431.30452 | 0 |
| Slice 76 | 207.06366 | 824.92363 | 0 | 1,031.0492 | 431.29721 | 0 |
| Slice 77 | 208.33907 | 824.49894 | 0 | 1,031.0317 | 431.2899 | 0 |
| Slice 78 | 209.61448 | 824.07426 | 0 | 1,031.0142 | 431.28258 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 79 | 210.88989 | 823.64957 | 0 | 1,030.9967 | 431.27527 | 0 |
| Slice 80 | 212.1653 | 823.22488 | 0 | 1,030.9792 | 431.26796 | 0 |
| Slice 81 | 213.44071 | 822.80019 | 0 | 1,030.9618 | 431.26065 | 0 |
| Slice 82 | 214.78558 | 822.3828 | 0 | 1,041.5881 | 435.70573 | 0 |
| Slice 83 | 216.19992 | 821.9727 | 0 | 1,036.7818 | 433.69523 | 0 |
| Slice 84 | 217.61425 | 821.56259 | 0 | 1,031.9755 | 431.68472 | 0 |
| Slice 85 | 218.96492 | 821.1995 | 0 | 1,038.6881 | 434.49264 | 0 |
| Slice 86 | 220.25192 | 820.88343 | 0 | 1,029.7049 | 430.73488 | 0 |
| Slice 87 | 221.53892 | 820.56736 | 0 | 1,020.7216 | 426.97711 | 0 |
| Slice 88 | 222.82591 | 820.25128 | 0 | 1,011.7384 | 423.21935 | 0 |
| Slice 89 | 224.11291 | 819.93521 | 0 | 1,002.7552 | 419.46159 | 0 |
| Slice 90 | 225.39991 | 819.61913 | 0 | 993.77197 | 415.70382 | 0 |
| Slice 91 | 226.68691 | 819.30306 | 0 | 984.78875 | 411.94606 | 0 |
| Slice 92 | 227.97391 | 818.98699 | 0 | 975.80553 | 408.18829 | 0 |
| Slice 93 | 229.26091 | 818.67091 | 0 | 966.8223 | 404.43053 | 0 |
| Slice 94 | 230.54791 | 818.35484 | 0 | 957.83908 | 400.67277 | 0 |
| Slice 95 | 231.8349 | 818.03876 | 0 | 948.85585 | 396.915 | 0 |
| Slice 96 | 233.1219 | 817.72269 | 0 | 939.87263 | 393.15724 | 0 |
| Slice 97 | 234.4089 | 817.40662 | 0 | 930.88941 | 389.39947 | 0 |
| Slice 98 | 235.68854 | 817.07255 | 0 | 915.05172 | 382.77443 | 0 |
| Slice 99 | 236.96081 | 816.72049 | 0 | 909.38064 | 380.40216 | 0 |
| Slice 100 | 238.23309 | 816.36842 | 0 | 903.70957 | 378.0299 | 0 |
| Slice 101 | 239.50537 | 816.01636 | 0 | 898.03849 | 375.65764 | 0 |
| Slice 102 | 240.77764 | 815.6643 | 0 | 892.36742 | 373.28538 | 0 |
| Slice 103 | 242.04992 | 815.31224 | 0 | 886.69634 | 370.91311 | 0 |
| Slice 104 | 243.32219 | 814.96018 | 0 | 881.02526 | 368.54085 | 0 |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 105 | 244.59447 | 814.60811 | 0 | 875.35419 | 366.16859 | 0 |
| Slice 106 | 245.86675 | 814.25605 | 0 | 869.68311 | 363.79633 | 0 |
| Slice 107 | 247.13902 | 813.90399 | 0 | 864.01204 | 361.42406 | 0 |
| Slice 108 | 248.4113 | 813.55193 | 0 | 858.34096 | 359.0518 | 0 |
| Slice 109 | 249.68358 | 813.19986 | 0 | 852.66988 | 356.67954 | 0 |
| Slice 110 | 250.95585 | 812.8478 | 0 | 846.99881 | 354.30728 | 0 |
| Slice 111 | 252.25214 | 812.53777 | 0 | 856.00314 | 358.07387 | 0 |
| Slice 112 | 253.57244 | 812.26977 | 0 | 842.12775 | 352.26967 | 0 |
| Slice 113 | 254.89275 | 812.00176 | 0 | 828.25236 | 346.46547 | 0 |
| Slice 114 | 256.2161 | 811.74951 | 0 | 819.12328 | 342.64669 | 0 |
| Slice 115 | 257.54249 | 811.51301 | 0 | 802.41621 | 335.65797 | 0 |
| Slice 116 | 258.86888 | 811.27652 | 0 | 785.70914 | 328.66925 | 0 |
| Slice 117 | 260.19527 | 811.04002 | 0 | 769.00206 | 321.68053 | 0 |
| Slice 118 | 261.52166 | 810.80352 | 0 | 752.29499 | 314.69181 | 0 |
| Slice 119 | 262.84805 | 810.56702 | 0 | 735.58792 | 307.70309 | 0 |
| Slice 120 | 264.17444 | 810.33052 | 0 | 718.88084 | 300.71437 | 0 |
| Slice 121 | 265.50083 | 810.09403 | 0 | 702.17377 | 293.72565 | 0 |
| Slice 122 | 266.82722 | 809.85753 | 0 | 685.4667 | 286.73693 | 0 |
| Slice 123 | 268.1267 | 809.64225 | 0 | 673.0427 | 281.53986 | 0 |
| Slice 124 | 269.39927 | 809.44819 | 0 | 654.19403 | 273.65529 | 0 |
| Slice 125 | 270.67185 | 809.25414 | 0 | 635.34535 | 265.77072 | 0 |
| Slice 126 | 271.94442 | 809.06008 | 0 | 616.49668 | 257.88615 | 0 |
| Slice 127 | 273.217 | 808.86602 | 0 | 597.648 | 250.00157 | 0 |
| Slice 128 | 274.48957 | 808.67196 | 0 | 578.79932 | 242.117 | 0 |
| Slice 129 | 275.76215 | 808.47791 | 0 | 559.95065 | 234.23243 | 0 |
| Slice 130 | 277.03472 | 808.28385 | 0 | 541.10197 | 226.34786 | 0 |
| Slice | 278.3073 | 808.08979 | 0 | 522.2533 | 218.46329 | 0 |

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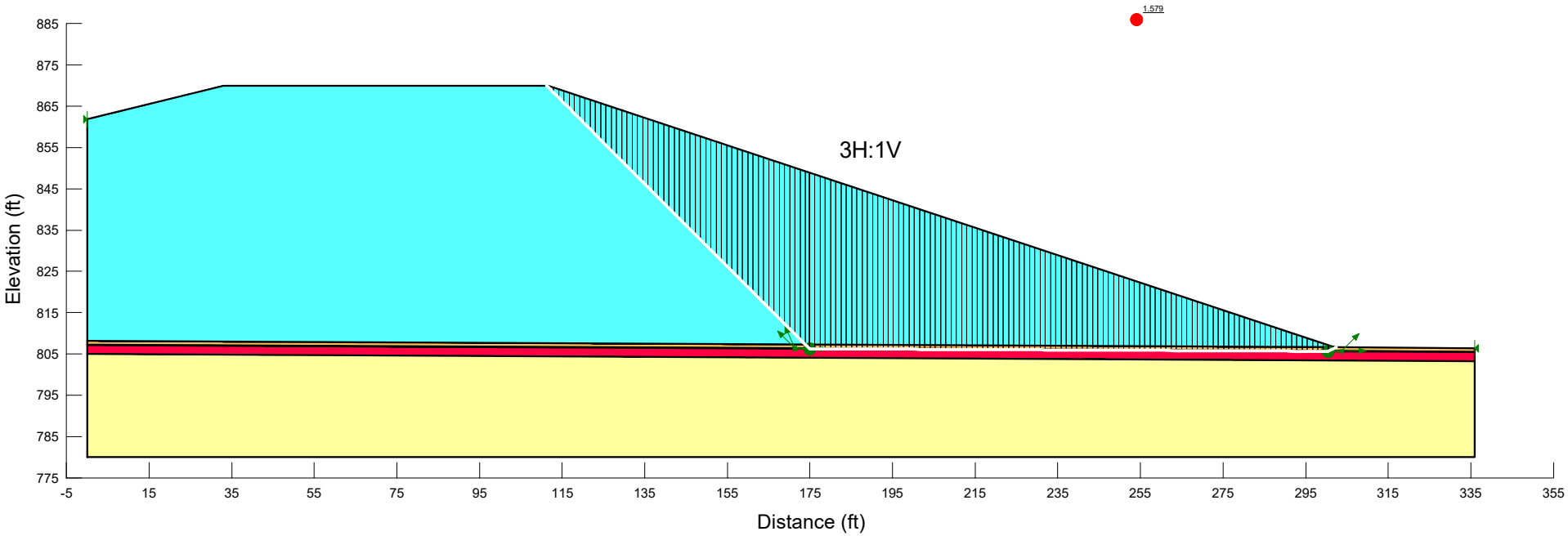
|---|---|---|---|---|---|---|
| 131 | | | | | | |
| Slice 132 | 279.57987 | 807.89573 | 0 | 503.40462 | 210.57871 | 0 |
| Slice 133 | 280.85245 | 807.70168 | 0 | 484.55595 | 202.69414 | 0 |
| Slice 134 | 282.12502 | 807.50762 | 0 | 465.70727 | 194.80957 | 0 |
| Slice 135 | 283.34622 | 807.34941 | 0 | 451.95442 | 189.05663 | 0 |
| Slice 136 | 284.51604 | 807.22705 | 0 | 429.7078 | 179.75067 | 0 |
| Slice 137 | 285.68586 | 807.10469 | 0 | 407.46119 | 170.44471 | 0 |
| Slice 138 | 286.85568 | 806.98234 | 0 | 385.21458 | 161.13875 | 0 |
| Slice 139 | 288.0255 | 806.85998 | 0 | 362.96796 | 151.83279 | 0 |
| Slice 140 | 289.19532 | 806.73762 | 0 | 340.72135 | 142.52683 | 0 |
| Slice 141 | 290.3862 | 806.67262 | 0 | 322.98961 | 135.10948 | 0 |
| Slice 142 | 291.59814 | 806.66499 | 0 | 288.9907 | 120.88743 | 0 |
| Slice 143 | 292.81007 | 806.65736 | 0 | 254.9918 | 106.66538 | 0 |
| Slice 144 | 294.02201 | 806.64973 | 0 | 220.99289 | 92.443328 | 0 |
| Slice 145 | 295.23395 | 806.6421 | 0 | 186.99398 | 78.221278 | 0 |
| Slice 146 | 296.44588 | 806.63447 | 0 | 152.99508 | 63.999227 | 0 |
| Slice 147 | 297.65782 | 806.62684 | 0 | 118.99617 | 49.777177 | 0 |
| Slice 148 | 298.86976 | 806.61921 | 0 | 84.997265 | 35.555126 | 0 |
| Slice 149 | 300.08169 | 806.61158 | 0 | 50.998359 | 21.333076 | 0 |
| Slice 150 | 301.29363 | 806.60395 | 0 | 16.999453 | 7.1110253 | 0 |




| Color | Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|---|---|---|---|---|
| | CCR | Mohr-Coulomb | 86 | 0 | 22.7 |
| | Clay | Mohr-Coulomb | 125 | 0 | 28 |
| | Drainage Layer | Mohr-Coulomb | 115 | 0 | 30 |
| | Geosynthetics | Mohr-Coulomb | 58 | 0 | 24.3 |
| | Subbase | Mohr-Coulomb | 120 | 0 | 30 |

**Title: Columbia Mod 10-11 Interim Waste Stage 2**
**Name: 3_Block**
**Method: Janbu**
**Last Edited By: Suchomel, Brandon**

**F of S: 1.579, F of S Rank (Analysis): 1 of 553,536 slip surfaces**
**Last Solved Date: 5/4/2022, Last Solved Time: 5:54:25 PM**

# 3_Block

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## File Information

File Version: 8.16
Title: Columbia Mod 10-11 Interim Waste Stage 2
Created By: Suchomel, Brandon
Last Edited By: Suchomel, Brandon
Revision Number: 59
Date: 5/4/2022
Time: 5:51:08 PM
Tool Version: 8.16.3.14580
File Name: Columbia Mod 10-11 Interim Waste Stage 2.gsz
Directory: I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\
Last Solved Date: 5/4/2022
Last Solved Time: 5:54:25 PM

## Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

## Analysis Settings

### 3_Block

Kind: SLOPE/W
Method: Janbu
Settings
    PWP Conditions Source: (none)
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 10
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Restrict Block Crossing: No
    Optimize Critical Slip Surface Location: No
    Tension Crack
        Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced

Number of Slices: 150
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

# Materials

## CCR

Model: Mohr-Coulomb
Unit Weight: 86 pcf
Cohesion': 0 psf
Phi': 22.7 °
Phi-B: 0 °

## Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

## Drainage Layer

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Geosynthetics

Model: Mohr-Coulomb
Unit Weight: 58 pcf
Cohesion': 0 psf
Phi': 24.3 °
Phi-B: 0 °

## Subbase

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

# Slip Surface Limits

Left Coordinate: (0, 861.8) ft
Right Coordinate: (335.9, 806.4) ft

# Slip Surface Block

Left Grid
Upper Left: (171.41, 806.37) ft
Lower Left: (171.41, 806.24) ft
Lower Right: (177.59, 806.22) ft

X Increments: 30
Y Increments: 3
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 5

Right Grid
Upper Left: (299.3, 805.73) ft
Lower Left: (299.3, 805.62) ft
Lower Right: (303.71, 805.6) ft
X Increments: 30
Y Increments: 3
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 5

## Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 0 | 780 |
| Point 2 | 335.9 | 780 |
| Point 3 | 0 | 805 |
| Point 4 | 335.9 | 803.3 |
| Point 5 | 0 | 807.1 |
| Point 6 | 335.9 | 805.4 |
| Point 7 | 0 | 808.1 |
| Point 8 | 335.9 | 806.4 |
| Point 9 | 0 | 861.8 |
| Point 10 | 33 | 870 |
| Point 11 | 111.6 | 870 |
| Point 12 | 305 | 805.6 |
| Point 13 | 301.9 | 806.6 |
| Point 14 | 0 | 807.2 |
| Point 15 | 305 | 805.7 |
| Point 16 | 335.9 | 805.5 |

## Regions

| | Material | Points | Area (ft²) |
|---|---|---|---|
| Region 1 | Subbase | 1,2,4,3 | 8,112 |
| Region 2 | Clay | 3,5,12,6,4 | 712.72 |
| Region 3 | CCR | 7,9,10,11,13 | 12,746 |
| Region 4 | Geosynthetics | 5,14,15,16,6,12 | 33.59 |
| Region 5 | Drainage Layer | 14,7,13,8,16,15 | 299.67 |

## Current Slip Surface

Slip Surface: 218,230
F of S: 1.579
Volume: 4,130.1925 ft³
Weight: 358,224.99 lbs

Resisting Force: 147,760.65 lbs
Activating Force: 93,577.095 lbs
F of S Rank (Analysis): 1 of 553,536 slip surfaces
F of S Rank (Query): 1 of 553,536 slip surfaces
Exit: (302.33287, 806.59745) ft
Entry: (111.184, 870) ft
Radius: 102.0734 ft
Center: (222.53102, 885.85064) ft

## Slip Slices

| | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|
| Slice 1 | 111.392 | 869.792 | 0 | 14.140131 | 5.9149449 | 0 |
| Slice 2 | 112.23621 | 868.94779 | 0 | 57.121324 | 23.894367 | 0 |
| Slice 3 | 113.50862 | 867.67538 | 0 | 114.80345 | 48.023322 | 0 |
| Slice 4 | 114.78103 | 866.40297 | 0 | 172.48557 | 72.152277 | 0 |
| Slice 5 | 116.05345 | 865.13055 | 0 | 230.16769 | 96.281232 | 0 |
| Slice 6 | 117.32586 | 863.85814 | 0 | 287.84982 | 120.41019 | 0 |
| Slice 7 | 118.59827 | 862.58573 | 0 | 345.53194 | 144.53914 | 0 |
| Slice 8 | 119.87069 | 861.31331 | 0 | 403.21406 | 168.6681 | 0 |
| Slice 9 | 121.1431 | 860.0409 | 0 | 460.89619 | 192.79705 | 0 |
| Slice 10 | 122.41552 | 858.76848 | 0 | 518.57831 | 216.92601 | 0 |
| Slice 11 | 123.68793 | 857.49607 | 0 | 576.26043 | 241.05496 | 0 |
| Slice 12 | 124.96034 | 856.22366 | 0 | 633.94256 | 265.18392 | 0 |
| Slice 13 | 126.23276 | 854.95124 | 0 | 691.62468 | 289.31287 | 0 |
| Slice 14 | 127.50517 | 853.67883 | 0 | 749.30681 | 313.44183 | 0 |
| Slice 15 | 128.77758 | 852.40642 | 0 | 806.98893 | 337.57078 | 0 |
| Slice 16 | 130.05 | 851.134 | 0 | 864.67105 | 361.69974 | 0 |
| Slice 17 | 131.32241 | 849.86159 | 0 | 922.35318 | 385.82869 | 0 |
| Slice 18 | 132.59482 | 848.58918 | 0 | 980.0353 | 409.95765 | 0 |
| Slice 19 | 133.86724 | 847.31676 | 0 | 1,037.7174 | 434.0866 | 0 |
| Slice 20 | 135.13965 | 846.04435 | 0 | 1,095.3995 | 458.21556 | 0 |
| Slice 21 | 136.41207 | 844.77193 | 0 | 1,153.0817 | 482.34451 | 0 |
| Slice 22 | 137.68448 | 843.49952 | 0 | 1,210.7638 | 506.47347 | 0 |
| Slice 23 | 138.95689 | 842.22711 | 0 | 1,268.4459 | 530.60242 | 0 |
| Slice 24 | 140.22931 | 840.95469 | 0 | 1,326.128 | 554.73138 | 0 |
| Slice | 141.50172 | 839.68228 | 0 | 1,383.8102 | 578.86033 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 25 | | | | | | |
| Slice 26 | 142.77413 | 838.40987 | 0 | 1,441.4923 | 602.98929 | 0 |
| Slice 27 | 144.04655 | 837.13745 | 0 | 1,499.1744 | 627.11824 | 0 |
| Slice 28 | 145.31896 | 835.86504 | 0 | 1,556.8565 | 651.2472 | 0 |
| Slice 29 | 146.59137 | 834.59263 | 0 | 1,614.5387 | 675.37615 | 0 |
| Slice 30 | 147.86379 | 833.32021 | 0 | 1,672.2208 | 699.50511 | 0 |
| Slice 31 | 149.1362 | 832.0478 | 0 | 1,729.9029 | 723.63406 | 0 |
| Slice 32 | 150.40862 | 830.77538 | 0 | 1,787.585 | 747.76302 | 0 |
| Slice 33 | 151.68103 | 829.50297 | 0 | 1,845.2672 | 771.89197 | 0 |
| Slice 34 | 152.95344 | 828.23056 | 0 | 1,902.9493 | 796.02093 | 0 |
| Slice 35 | 154.22586 | 826.95814 | 0 | 1,960.6314 | 820.14988 | 0 |
| Slice 36 | 155.49827 | 825.68573 | 0 | 2,018.3135 | 844.27884 | 0 |
| Slice 37 | 156.77068 | 824.41332 | 0 | 2,075.9956 | 868.40779 | 0 |
| Slice 38 | 158.0431 | 823.1409 | 0 | 2,133.6778 | 892.53674 | 0 |
| Slice 39 | 159.31551 | 821.86849 | 0 | 2,191.3599 | 916.6657 | 0 |
| Slice 40 | 160.58792 | 820.59608 | 0 | 2,249.042 | 940.79465 | 0 |
| Slice 41 | 161.86034 | 819.32366 | 0 | 2,306.7241 | 964.92361 | 0 |
| Slice 42 | 163.13275 | 818.05125 | 0 | 2,364.4063 | 989.05256 | 0 |
| Slice 43 | 164.40517 | 816.77883 | 0 | 2,422.0884 | 1,013.1815 | 0 |
| Slice 44 | 165.67758 | 815.50642 | 0 | 2,479.7705 | 1,037.3105 | 0 |
| Slice 45 | 166.94999 | 814.23401 | 0 | 2,537.4526 | 1,061.4394 | 0 |
| Slice 46 | 168.22241 | 812.96159 | 0 | 2,595.1348 | 1,085.5684 | 0 |
| Slice 47 | 169.49482 | 811.68918 | 0 | 2,652.8169 | 1,109.6973 | 0 |
| Slice 48 | 170.76723 | 810.41677 | 0 | 2,710.499 | 1,133.8263 | 0 |
| Slice 49 | 172.03965 | 809.14435 | 0 | 2,768.1811 | 1,157.9552 | 0 |
| Slice 50 | 173.31206 | 807.87194 | 0 | 2,825.8633 | 1,182.0842 | 0 |
| Slice 51 | 174.39608 | 806.78792 | 0 | 2,672.3431 | 1,542.878 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 52 | 174.87794 | 806.30606 | 0 | 2,868.8112 | 1,295.3179 | 0 |
| Slice 53 | 175.54616 | 806.26887 | 0 | 3,667.4758 | 1,655.9288 | 0 |
| Slice 54 | 176.81448 | 806.2626 | 0 | 3,631.7233 | 1,639.786 | 0 |
| Slice 55 | 178.08281 | 806.25633 | 0 | 3,595.9708 | 1,623.6431 | 0 |
| Slice 56 | 179.35113 | 806.25006 | 0 | 3,560.2183 | 1,607.5002 | 0 |
| Slice 57 | 180.61945 | 806.24379 | 0 | 3,524.4658 | 1,591.3573 | 0 |
| Slice 58 | 181.88778 | 806.23752 | 0 | 3,488.7133 | 1,575.2144 | 0 |
| Slice 59 | 183.1561 | 806.23125 | 0 | 3,452.9608 | 1,559.0716 | 0 |
| Slice 60 | 184.42442 | 806.22498 | 0 | 3,417.2082 | 1,542.9287 | 0 |
| Slice 61 | 185.69275 | 806.21871 | 0 | 3,381.4557 | 1,526.7858 | 0 |
| Slice 62 | 186.96107 | 806.21244 | 0 | 3,345.7032 | 1,510.6429 | 0 |
| Slice 63 | 188.22939 | 806.20617 | 0 | 3,309.9507 | 1,494.5001 | 0 |
| Slice 64 | 189.49772 | 806.1999 | 0 | 3,274.1982 | 1,478.3572 | 0 |
| Slice 65 | 190.76604 | 806.19363 | 0 | 3,238.4457 | 1,462.2143 | 0 |
| Slice 66 | 192.03436 | 806.18736 | 0 | 3,202.6932 | 1,446.0714 | 0 |
| Slice 67 | 193.30269 | 806.18109 | 0 | 3,166.9407 | 1,429.9285 | 0 |
| Slice 68 | 194.57101 | 806.17482 | 0 | 3,131.1881 | 1,413.7857 | 0 |
| Slice 69 | 195.83933 | 806.16856 | 0 | 3,095.4356 | 1,397.6428 | 0 |
| Slice 70 | 197.10766 | 806.16229 | 0 | 3,059.6831 | 1,381.4999 | 0 |
| Slice 71 | 198.37598 | 806.15602 | 0 | 3,023.9306 | 1,365.357 | 0 |
| Slice 72 | 199.6443 | 806.14975 | 0 | 2,988.1781 | 1,349.2141 | 0 |
| Slice 73 | 200.91263 | 806.14348 | 0 | 2,952.4256 | 1,333.0713 | 0 |
| Slice 74 | 202.18095 | 806.13721 | 0 | 2,916.6731 | 1,316.9284 | 0 |
| Slice 75 | 203.44927 | 806.13094 | 0 | 2,880.9205 | 1,300.7855 | 0 |
| Slice 76 | 204.7176 | 806.12467 | 0 | 2,845.168 | 1,284.6426 | 0 |
| Slice 77 | 205.98592 | 806.1184 | 0 | 2,809.4155 | 1,268.4997 | 0 |
| | | | | | | |

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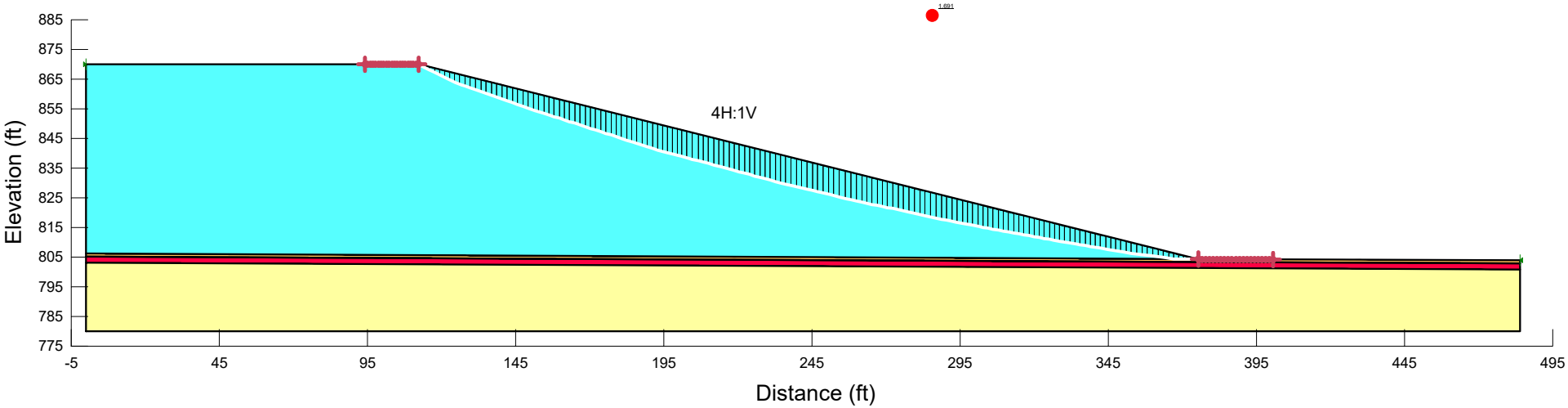
|---|---|---|---|---|---|---|
| Slice 78 | 207.25424 | 806.11213 | 0 | 2,773.663 | 1,252.3569 | 0 |
| Slice 79 | 208.52257 | 806.10586 | 0 | 2,737.9105 | 1,236.214 | 0 |
| Slice 80 | 209.79089 | 806.09959 | 0 | 2,702.158 | 1,220.0711 | 0 |
| Slice 81 | 211.05921 | 806.09332 | 0 | 2,666.4055 | 1,203.9282 | 0 |
| Slice 82 | 212.32754 | 806.08705 | 0 | 2,630.653 | 1,187.7854 | 0 |
| Slice 83 | 213.59586 | 806.08078 | 0 | 2,594.9004 | 1,171.6425 | 0 |
| Slice 84 | 214.86418 | 806.07452 | 0 | 2,559.1479 | 1,155.4996 | 0 |
| Slice 85 | 216.13251 | 806.06825 | 0 | 2,523.3954 | 1,139.3567 | 0 |
| Slice 86 | 217.40083 | 806.06198 | 0 | 2,487.6429 | 1,123.2138 | 0 |
| Slice 87 | 218.66915 | 806.05571 | 0 | 2,451.8904 | 1,107.071 | 0 |
| Slice 88 | 219.93747 | 806.04944 | 0 | 2,416.1379 | 1,090.9281 | 0 |
| Slice 89 | 221.2058 | 806.04317 | 0 | 2,380.3854 | 1,074.7852 | 0 |
| Slice 90 | 222.47412 | 806.0369 | 0 | 2,344.6328 | 1,058.6423 | 0 |
| Slice 91 | 223.74244 | 806.03063 | 0 | 2,308.8803 | 1,042.4994 | 0 |
| Slice 92 | 225.01077 | 806.02436 | 0 | 2,273.1278 | 1,026.3566 | 0 |
| Slice 93 | 226.27909 | 806.01809 | 0 | 2,237.3753 | 1,010.2137 | 0 |
| Slice 94 | 227.54741 | 806.01182 | 0 | 2,201.6228 | 994.07081 | 0 |
| Slice 95 | 228.81574 | 806.00555 | 0 | 2,165.8703 | 977.92793 | 0 |
| Slice 96 | 230.08406 | 805.99928 | 0 | 2,130.1178 | 961.78505 | 0 |
| Slice 97 | 231.35238 | 805.99301 | 0 | 2,094.3653 | 945.64217 | 0 |
| Slice 98 | 232.62071 | 805.98674 | 0 | 2,058.6127 | 929.49929 | 0 |
| Slice 99 | 233.88903 | 805.98047 | 0 | 2,022.8602 | 913.35641 | 0 |
| Slice 100 | 235.15735 | 805.97421 | 0 | 1,987.1077 | 897.21353 | 0 |
| Slice 101 | 236.42568 | 805.96794 | 0 | 1,951.3552 | 881.07066 | 0 |
| Slice 102 | 237.694 | 805.96167 | 0 | 1,915.6027 | 864.92778 | 0 |
| Slice 103 | 238.96232 | 805.9554 | 0 | 1,879.8502 | 848.7849 | 0 |
| Slice | 240.23065 | 805.94913 | 0 | 1,844.0977 | 832.64202 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 104 | | | | | | |
| Slice 105 | 241.49897 | 805.94286 | 0 | 1,808.3451 | 816.49914 | 0 |
| Slice 106 | 242.76729 | 805.93659 | 0 | 1,772.5926 | 800.35626 | 0 |
| Slice 107 | 244.03562 | 805.93032 | 0 | 1,736.8401 | 784.21338 | 0 |
| Slice 108 | 245.30394 | 805.92405 | 0 | 1,701.0876 | 768.0705 | 0 |
| Slice 109 | 246.57226 | 805.91778 | 0 | 1,665.3351 | 751.92762 | 0 |
| Slice 110 | 247.84059 | 805.91151 | 0 | 1,629.5826 | 735.78475 | 0 |
| Slice 111 | 249.10891 | 805.90524 | 0 | 1,593.8301 | 719.64187 | 0 |
| Slice 112 | 250.37723 | 805.89897 | 0 | 1,558.0775 | 703.49899 | 0 |
| Slice 113 | 251.64556 | 805.8927 | 0 | 1,522.325 | 687.35611 | 0 |
| Slice 114 | 252.91388 | 805.88643 | 0 | 1,486.5725 | 671.21323 | 0 |
| Slice 115 | 254.1822 | 805.88017 | 0 | 1,450.82 | 655.07035 | 0 |
| Slice 116 | 255.45053 | 805.8739 | 0 | 1,415.0675 | 638.92747 | 0 |
| Slice 117 | 256.71885 | 805.86763 | 0 | 1,379.315 | 622.78459 | 0 |
| Slice 118 | 257.98717 | 805.86136 | 0 | 1,343.5625 | 606.64172 | 0 |
| Slice 119 | 259.25549 | 805.85509 | 0 | 1,307.81 | 590.49884 | 0 |
| Slice 120 | 260.52382 | 805.84882 | 0 | 1,272.0574 | 574.35596 | 0 |
| Slice 121 | 261.79214 | 805.84255 | 0 | 1,236.3049 | 558.21308 | 0 |
| Slice 122 | 263.06046 | 805.83628 | 0 | 1,200.5524 | 542.0702 | 0 |
| Slice 123 | 264.32879 | 805.83001 | 0 | 1,164.7999 | 525.92732 | 0 |
| Slice 124 | 265.59711 | 805.82374 | 0 | 1,129.0474 | 509.78444 | 0 |
| Slice 125 | 266.86543 | 805.81747 | 0 | 1,093.2949 | 493.64156 | 0 |
| Slice 126 | 268.13376 | 805.8112 | 0 | 1,057.5424 | 477.49868 | 0 |
| Slice 127 | 269.40208 | 805.80493 | 0 | 1,021.7898 | 461.35581 | 0 |
| Slice 128 | 270.6704 | 805.79866 | 0 | 986.03733 | 445.21293 | 0 |
| Slice 129 | 271.93873 | 805.79239 | 0 | 950.28482 | 429.07005 | 0 |
| Slice 130 | 273.20705 | 805.78612 | 0 | 914.53231 | 412.92717 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 131 | 274.47537 | 805.77986 | 0 | 878.77979 | 396.78429 | 0 |
| Slice 132 | 275.7437 | 805.77359 | 0 | 843.02728 | 380.64141 | 0 |
| Slice 133 | 277.01202 | 805.76732 | 0 | 807.27476 | 364.49853 | 0 |
| Slice 134 | 278.28034 | 805.76105 | 0 | 771.52225 | 348.35565 | 0 |
| Slice 135 | 279.54867 | 805.75478 | 0 | 735.76974 | 332.21277 | 0 |
| Slice 136 | 280.81699 | 805.74851 | 0 | 700.01722 | 316.0699 | 0 |
| Slice 137 | 282.08531 | 805.74224 | 0 | 664.26471 | 299.92702 | 0 |
| Slice 138 | 283.35364 | 805.73597 | 0 | 628.5122 | 283.78414 | 0 |
| Slice 139 | 284.62196 | 805.7297 | 0 | 592.75968 | 267.64126 | 0 |
| Slice 140 | 285.89028 | 805.72343 | 0 | 557.00717 | 251.49838 | 0 |
| Slice 141 | 287.15861 | 805.71716 | 0 | 521.25466 | 235.3555 | 0 |
| Slice 142 | 288.42693 | 805.71089 | 0 | 485.50214 | 219.21262 | 0 |
| Slice 143 | 289.69525 | 805.70462 | 0 | 449.74963 | 203.06974 | 0 |
| Slice 144 | 290.96358 | 805.69835 | 0 | 413.99712 | 186.92687 | 0 |
| Slice 145 | 292.2319 | 805.69208 | 0 | 378.2446 | 170.78399 | 0 |
| Slice 146 | 293.50022 | 805.68581 | 0 | 342.49209 | 154.64111 | 0 |
| Slice 147 | 294.76855 | 805.67955 | 0 | 306.73958 | 138.49823 | 0 |
| Slice 148 | 296.03687 | 805.67328 | 0 | 270.98706 | 122.35535 | 0 |
| Slice 149 | 297.30519 | 805.66701 | 0 | 235.23455 | 106.21247 | 0 |
| Slice 150 | 298.57352 | 805.66074 | 0 | 199.48204 | 90.069593 | 0 |
| Slice 151 | 299.84184 | 805.65447 | 0 | 163.72952 | 73.926714 | 0 |
| Slice 152 | 300.54492 | 805.68645 | 0 | 166.29893 | 75.086847 | 0 |
| Slice 153 | 301.25692 | 806.04923 | 0 | 100.60907 | 58.086672 | 0 |
| Slice 154 | 302.11643 | 806.48718 | 0 | 15.767383 | 9.1033026 | 0 |




| Color | Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|---|---|---|---|---|
| | CCR | Mohr-Coulomb | 86 | 0 | 22.7 |
| | Clay | Mohr-Coulomb | 125 | 0 | 28 |
| | Drainage Layer | Mohr-Coulomb | 115 | 0 | 30 |
| | Geosynthetics | Mohr-Coulomb | 58 | 0 | 24.3 |
| | Subbase | Mohr-Coulomb | 120 | 0 | 30 |

**Title: Columbia Mod 10-11 Interim Waste Stage 3**
**Name: 2-1_Optimized Circular_Forced Full Slope**
**Method: Bishop**
**Last Edited By: Suchomel, Brandon**

**F of S: 1.691, F of S Rank (Analysis): 1 of 3,970 slip surfaces**
**Last Solved Date: 5/4/2022, Last Solved Time: 5:59:59 PM**

# 2-1_Optimized Circular_Forced Full Slope

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## File Information

File Version: 8.16
Title: Columbia Mod 10-11 Interim Waste Stage 3
Created By: Suchomel, Brandon
Last Edited By: Suchomel, Brandon
Revision Number: 50
Date: 5/4/2022
Time: 5:59:45 PM
Tool Version: 8.16.3.14580
File Name: Columbia Mod 10-11 Interim Waste Stage 3.gsz
Directory: I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\
Last Solved Date: 5/4/2022
Last Solved Time: 5:59:59 PM

## Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

## Analysis Settings

### 2-1_Optimized Circular_Forced Full Slope

Kind: SLOPE/W
Method: Bishop
Settings
    PWP Conditions Source: (none)
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 10
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Optimize Critical Slip Surface Location: Yes
    Critical Slip Surface Optimizations
        Maximum Iterations: 2,000
        Convergence Tolerance: 1e-007
        Starting Points: 8
        Ending Points: 16
        Complete Passes per Insertion: 1

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 150
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

# Materials

## CCR

Model: Mohr-Coulomb
Unit Weight: 86 pcf
Cohesion': 0 psf
Phi': 22.7 °
Phi-B: 0 °

## Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

## Drainage Layer

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Geosynthetics

Model: Mohr-Coulomb
Unit Weight: 58 pcf
Cohesion': 0 psf
Phi': 24.3 °
Phi-B: 0 °

## Subbase

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

# Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (94.1, 870) ft
Left-Zone Right Coordinate: (112.23, 870) ft
Left-Zone Increment: 20

Right Projection: Range
Right-Zone Left Coordinate: (375.32, 804.29919) ft
Right-Zone Right Coordinate: (400.59, 804.20629) ft
Right-Zone Increment: 20
Radius Increments: 8

## Slip Surface Limits

Left Coordinate: (0, 870) ft
Right Coordinate: (483.9, 803.9) ft

## Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 0 | 780 |
| Point 2 | 483.9 | 780 |
| Point 3 | 0 | 805.2 |
| Point 4 | 483.9 | 802.9 |
| Point 5 | 483.9 | 800.9 |
| Point 6 | 0 | 803.2 |
| Point 7 | 0 | 870 |
| Point 8 | 112.5 | 870 |
| Point 9 | 379.2 | 803.3 |
| Point 10 | 0 | 806.2 |
| Point 11 | 375.1 | 804.3 |
| Point 12 | 483.9 | 803.9 |
| Point 13 | 0 | 805.3 |
| Point 14 | 483.9 | 803 |
| Point 15 | 379.2 | 803.4 |

## Regions

| | Material | Points | Area ($ft^2$) |
|---|---|---|---|
| Region 1 | Subbase | 1,6,5,2 | 10,670 |
| Region 2 | Clay | 6,3,9,4,5 | 944.17 |
| Region 3 | Geosynthetics | 3,13,15,14,4,9 | 48.39 |
| Region 4 | Drainage Layer | 13,10,11,12,14,15 | 430.8 |
| Region 5 | CCR | 10,7,8,11 | 15,661 |

## Current Slip Surface

Slip Surface: 3,970
F of S: 1.691
Volume: 1,735.9578 $ft^3$
Weight: 149,292.37 lbs
Resisting Moment: 32,761,608 lbs-ft
Activating Moment: 19,375,797 lbs-ft
F of S Rank (Analysis): 1 of 3,970 slip surfaces
F of S Rank (Query): 1 of 3,970 slip surfaces
Exit: (375.08152, 804.30462) ft

Entry: (112.07755, 870) ft
Radius: 116.45652 ft
Center: (372.09783, 1,350.7512) ft

## Slip Slices

| | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|
| Slice 1 | 112.28878 | 869.89648 | 0 | 7.9403998 | 3.3215412 | 0 |
| Slice 2 | 113.34107 | 869.38075 | 0 | 31.358062 | 13.117361 | 0 |
| Slice 3 | 115.0232 | 868.55634 | 0 | 62.312587 | 26.06592 | 0 |
| Slice 4 | 116.70533 | 867.73193 | 0 | 93.267112 | 39.014478 | 0 |
| Slice 5 | 118.38746 | 866.90752 | 0 | 124.22164 | 51.963036 | 0 |
| Slice 6 | 120.06959 | 866.08311 | 0 | 155.17616 | 64.911595 | 0 |
| Slice 7 | 121.75172 | 865.2587 | 0 | 186.13069 | 77.860153 | 0 |
| Slice 8 | 123.43385 | 864.43429 | 0 | 217.08521 | 90.808711 | 0 |
| Slice 9 | 125.16346 | 863.70958 | 0 | 247.02114 | 103.33118 | 0 |
| Slice 10 | 126.94057 | 863.08457 | 0 | 261.29339 | 109.30139 | 0 |
| Slice 11 | 128.71767 | 862.45957 | 0 | 275.56565 | 115.27161 | 0 |
| Slice 12 | 130.49477 | 861.83457 | 0 | 289.8379 | 121.24182 | 0 |
| Slice 13 | 132.27188 | 861.20956 | 0 | 304.11016 | 127.21203 | 0 |
| Slice 14 | 134.04898 | 860.58456 | 0 | 318.38241 | 133.18225 | 0 |
| Slice 15 | 135.82609 | 859.95955 | 0 | 332.65466 | 139.15246 | 0 |
| Slice 16 | 137.60319 | 859.33455 | 0 | 346.92692 | 145.12267 | 0 |
| Slice 17 | 139.38029 | 858.70955 | 0 | 361.19917 | 151.09289 | 0 |
| Slice 18 | 141.1574 | 858.08454 | 0 | 375.47143 | 157.0631 | 0 |
| Slice 19 | 142.9345 | 857.45954 | 0 | 389.74368 | 163.03331 | 0 |
| Slice 20 | 144.71161 | 856.83453 | 0 | 404.01594 | 169.00353 | 0 |
| Slice 21 | 146.48871 | 856.20953 | 0 | 418.28819 | 174.97374 | 0 |
| Slice 22 | 148.26581 | 855.58453 | 0 | 432.56045 | 180.94395 | 0 |
| Slice 23 | 150.04292 | 854.95952 | 0 | 446.8327 | 186.91417 | 0 |
| Slice 24 | 151.80489 | 854.36508 | 0 | 462.02398 | 193.26882 | 0 |
| Slice 25 | 153.55174 | 853.8012 | 0 | 472.12555 | 197.49439 | 0 |
| Slice 26 | 155.29858 | 853.23732 | 0 | 482.22711 | 201.71997 | 0 |
| Slice 27 | 157.04543 | 852.67344 | 0 | 492.32868 | 205.94555 | 0 |

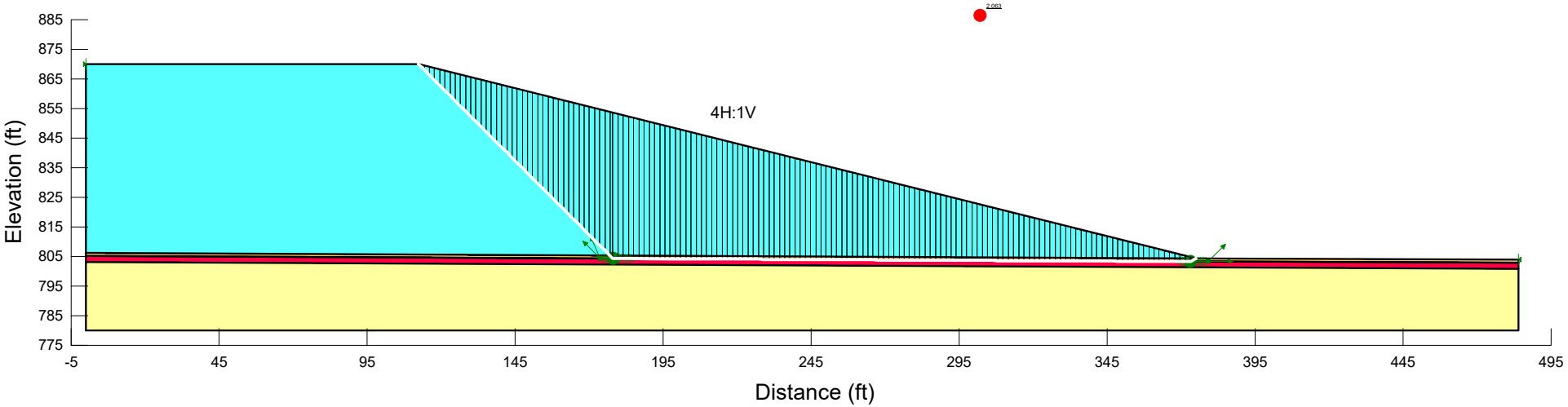
| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 28 | 158.79227 | 852.10956 | 0 | 502.43025 | 210.17112 | 0 |
| Slice 29 | 160.53912 | 851.54568 | 0 | 512.53181 | 214.3967 | 0 |
| Slice 30 | 162.28596 | 850.9818 | 0 | 522.63338 | 218.62228 | 0 |
| Slice 31 | 164.03281 | 850.41792 | 0 | 532.73495 | 222.84786 | 0 |
| Slice 32 | 165.77965 | 849.85404 | 0 | 542.83651 | 227.07343 | 0 |
| Slice 33 | 167.5265 | 849.29016 | 0 | 552.93808 | 231.29901 | 0 |
| Slice 34 | 169.27334 | 848.72628 | 0 | 563.03965 | 235.52459 | 0 |
| Slice 35 | 171.02019 | 848.1624 | 0 | 573.14121 | 239.75016 | 0 |
| Slice 36 | 172.76703 | 847.59852 | 0 | 583.24278 | 243.97574 | 0 |
| Slice 37 | 174.51388 | 847.03464 | 0 | 593.34435 | 248.20132 | 0 |
| Slice 38 | 176.26072 | 846.47076 | 0 | 603.44591 | 252.42689 | 0 |
| Slice 39 | 178.00757 | 845.90688 | 0 | 613.54748 | 256.65247 | 0 |
| Slice 40 | 179.75441 | 845.343 | 0 | 623.64905 | 260.87805 | 0 |
| Slice 41 | 181.50126 | 844.77912 | 0 | 633.75061 | 265.10362 | 0 |
| Slice 42 | 183.2481 | 844.21524 | 0 | 643.85218 | 269.3292 | 0 |
| Slice 43 | 184.99495 | 843.65136 | 0 | 653.95374 | 273.55478 | 0 |
| Slice 44 | 186.74179 | 843.08748 | 0 | 664.05531 | 277.78035 | 0 |
| Slice 45 | 188.48864 | 842.5236 | 0 | 674.15688 | 282.00593 | 0 |
| Slice 46 | 190.23548 | 841.95972 | 0 | 684.25844 | 286.23151 | 0 |
| Slice 47 | 191.98233 | 841.39584 | 0 | 694.36001 | 290.45708 | 0 |
| Slice 48 | 193.67524 | 840.89879 | 0 | 710.01929 | 297.0075 | 0 |
| Slice 49 | 195.31421 | 840.46857 | 0 | 711.64781 | 297.68873 | 0 |
| Slice 50 | 196.95319 | 840.03835 | 0 | 713.27633 | 298.36995 | 0 |
| Slice 51 | 198.59217 | 839.60812 | 0 | 714.90485 | 299.05118 | 0 |
| Slice 52 | 200.23115 | 839.1779 | 0 | 716.53337 | 299.7324 | 0 |
| Slice 53 | 201.87012 | 838.74768 | 0 | 718.16189 | 300.41362 | 0 |
| Slice | 203.64843 | 838.28605 | 0 | 720.41291 | 301.35525 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 54 | | | | | | |
| Slice 55 | 205.56608 | 837.79301 | 0 | 721.48539 | 301.80388 | 0 |
| Slice 56 | 207.39225 | 837.31305 | 0 | 721.33214 | 301.73977 | 0 |
| Slice 57 | 209.12696 | 836.84616 | 0 | 723.98333 | 302.84879 | 0 |
| Slice 58 | 210.86167 | 836.37927 | 0 | 726.63452 | 303.95781 | 0 |
| Slice 59 | 212.59638 | 835.91239 | 0 | 729.28571 | 305.06682 | 0 |
| Slice 60 | 214.33109 | 835.4455 | 0 | 731.9369 | 306.17584 | 0 |
| Slice 61 | 216.0658 | 834.97861 | 0 | 734.5881 | 307.28486 | 0 |
| Slice 62 | 217.80051 | 834.51172 | 0 | 737.23929 | 308.39387 | 0 |
| Slice 63 | 219.53522 | 834.04484 | 0 | 739.89048 | 309.50289 | 0 |
| Slice 64 | 221.26993 | 833.57795 | 0 | 742.54167 | 310.61191 | 0 |
| Slice 65 | 223.00463 | 833.11106 | 0 | 745.19286 | 311.72093 | 0 |
| Slice 66 | 224.73934 | 832.64418 | 0 | 747.84405 | 312.82994 | 0 |
| Slice 67 | 226.47405 | 832.17729 | 0 | 750.49524 | 313.93896 | 0 |
| Slice 68 | 228.20876 | 831.7104 | 0 | 753.14643 | 315.04798 | 0 |
| Slice 69 | 229.94347 | 831.24351 | 0 | 755.79762 | 316.15699 | 0 |
| Slice 70 | 231.67818 | 830.77663 | 0 | 758.44881 | 317.26601 | 0 |
| Slice 71 | 233.41289 | 830.30974 | 0 | 761.1 | 318.37503 | 0 |
| Slice 72 | 235.1476 | 829.84285 | 0 | 763.7512 | 319.48405 | 0 |
| Slice 73 | 236.91982 | 829.39551 | 0 | 769.91705 | 322.06328 | 0 |
| Slice 74 | 238.72955 | 828.96771 | 0 | 767.88747 | 321.21429 | 0 |
| Slice 75 | 240.53929 | 828.53991 | 0 | 765.85789 | 320.36529 | 0 |
| Slice 76 | 242.34902 | 828.11211 | 0 | 763.82831 | 319.5163 | 0 |
| Slice 77 | 244.15876 | 827.68431 | 0 | 761.79873 | 318.66731 | 0 |
| Slice 78 | 245.96849 | 827.25652 | 0 | 759.76915 | 317.81832 | 0 |
| Slice 79 | 247.77822 | 826.82872 | 0 | 757.73957 | 316.96933 | 0 |
| Slice 80 | 249.58796 | 826.40092 | 0 | 755.70999 | 316.12033 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 81 | 251.39769 | 825.97312 | 0 | 753.68041 | 315.27134 | 0 |
| Slice 82 | 253.24754 | 825.53553 | 0 | 751.57388 | 314.39017 | 0 |
| Slice 83 | 255.1375 | 825.08816 | 0 | 749.50415 | 313.52438 | 0 |
| Slice 84 | 257.02745 | 824.64079 | 0 | 747.43443 | 312.65859 | 0 |
| Slice 85 | 258.91741 | 824.19341 | 0 | 745.3647 | 311.79281 | 0 |
| Slice 86 | 260.80737 | 823.74604 | 0 | 743.29497 | 310.92702 | 0 |
| Slice 87 | 262.61573 | 823.34871 | 0 | 745.01303 | 311.6457 | 0 |
| Slice 88 | 264.34249 | 823.00144 | 0 | 738.07047 | 308.74157 | 0 |
| Slice 89 | 266.06925 | 822.65416 | 0 | 731.12791 | 305.83743 | 0 |
| Slice 90 | 267.796 | 822.30688 | 0 | 724.18534 | 302.93329 | 0 |
| Slice 91 | 269.52276 | 821.95961 | 0 | 717.24278 | 300.02915 | 0 |
| Slice 92 | 271.29595 | 821.58763 | 0 | 708.55328 | 296.39426 | 0 |
| Slice 93 | 273.11557 | 821.19094 | 0 | 703.77422 | 294.39513 | 0 |
| Slice 94 | 274.9352 | 820.79426 | 0 | 698.99516 | 292.39601 | 0 |
| Slice 95 | 276.75482 | 820.39757 | 0 | 694.2161 | 290.39688 | 0 |
| Slice 96 | 278.57444 | 820.00088 | 0 | 689.43703 | 288.39776 | 0 |
| Slice 97 | 280.39406 | 819.6042 | 0 | 684.65797 | 286.39863 | 0 |
| Slice 98 | 282.21369 | 819.20751 | 0 | 679.87891 | 284.39951 | 0 |
| Slice 99 | 284.03331 | 818.81083 | 0 | 675.09985 | 282.40038 | 0 |
| Slice 100 | 285.85293 | 818.41414 | 0 | 670.32079 | 280.40126 | 0 |
| Slice 101 | 287.67255 | 818.01745 | 0 | 665.54172 | 278.40213 | 0 |
| Slice 102 | 289.49218 | 817.62077 | 0 | 660.76266 | 276.40301 | 0 |
| Slice 103 | 291.3118 | 817.22408 | 0 | 655.9836 | 274.40388 | 0 |
| Slice 104 | 293.09319 | 816.86859 | 0 | 654.41264 | 273.74674 | 0 |
| Slice 105 | 294.83634 | 816.5543 | 0 | 644.38282 | 269.55117 | 0 |
| Slice 106 | 296.57151 | 816.23752 | 0 | 634.04049 | 265.22488 | 0 |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 107 | 298.2987 | 815.91827 | 0 | 624.75774 | 261.34183 | 0 |
| Slice 108 | 300.02589 | 815.59902 | 0 | 615.475 | 257.45877 | 0 |
| Slice 109 | 301.75308 | 815.27976 | 0 | 606.19225 | 253.57571 | 0 |
| Slice 110 | 303.48026 | 814.96051 | 0 | 596.9095 | 249.69265 | 0 |
| Slice 111 | 305.20745 | 814.64126 | 0 | 587.62675 | 245.8096 | 0 |
| Slice 112 | 306.93464 | 814.322 | 0 | 578.34401 | 241.92654 | 0 |
| Slice 113 | 308.66183 | 814.00275 | 0 | 569.06126 | 238.04348 | 0 |
| Slice 114 | 310.38901 | 813.6835 | 0 | 559.77851 | 234.16042 | 0 |
| Slice 115 | 312.1162 | 813.36425 | 0 | 550.49577 | 230.27737 | 0 |
| Slice 116 | 313.84339 | 813.04499 | 0 | 541.21302 | 226.39431 | 0 |
| Slice 117 | 315.57058 | 812.72574 | 0 | 531.93027 | 222.51125 | 0 |
| Slice 118 | 317.29776 | 812.40649 | 0 | 522.64752 | 218.62819 | 0 |
| Slice 119 | 319.02495 | 812.08723 | 0 | 513.36478 | 214.74514 | 0 |
| Slice 120 | 320.75214 | 811.76798 | 0 | 504.08203 | 210.86208 | 0 |
| Slice 121 | 322.47933 | 811.44873 | 0 | 494.79928 | 206.97902 | 0 |
| Slice 122 | 324.20393 | 811.14243 | 0 | 486.17056 | 203.36955 | 0 |
| Slice 123 | 325.92595 | 810.8491 | 0 | 474.82366 | 198.62304 | 0 |
| Slice 124 | 327.64797 | 810.55576 | 0 | 463.47676 | 193.87653 | 0 |
| Slice 125 | 329.36999 | 810.26243 | 0 | 452.12985 | 189.13001 | 0 |
| Slice 126 | 331.09201 | 809.9691 | 0 | 440.78295 | 184.3835 | 0 |
| Slice 127 | 332.81403 | 809.67576 | 0 | 429.43605 | 179.63699 | 0 |
| Slice 128 | 334.53605 | 809.38243 | 0 | 418.08915 | 174.89048 | 0 |
| Slice 129 | 336.25807 | 809.08909 | 0 | 406.74225 | 170.14397 | 0 |
| Slice 130 | 337.98009 | 808.79576 | 0 | 395.39534 | 165.39746 | 0 |
| Slice 131 | 339.70211 | 808.50242 | 0 | 384.04844 | 160.65094 | 0 |
| Slice 132 | 341.42413 | 808.20909 | 0 | 372.70154 | 155.90443 | 0 |
| Slice | 343.14615 | 807.91575 | 0 | 361.35464 | 151.15792 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 133 | | | | | | |
| Slice 134 | 344.86817 | 807.62242 | 0 | 350.00774 | 146.41141 | 0 |
| Slice 135 | 346.59019 | 807.32909 | 0 | 338.66084 | 141.6649 | 0 |
| Slice 136 | 348.31221 | 807.03575 | 0 | 327.31393 | 136.91838 | 0 |
| Slice 137 | 350.03423 | 806.74242 | 0 | 315.96703 | 132.17187 | 0 |
| Slice 138 | 351.79639 | 806.47788 | 0 | 304.26993 | 127.27887 | 0 |
| Slice 139 | 353.5987 | 806.24214 | 0 | 286.34431 | 119.78042 | 0 |
| Slice 140 | 355.40101 | 806.0064 | 0 | 268.4187 | 112.28197 | 0 |
| Slice 141 | 357.20332 | 805.77066 | 0 | 250.49308 | 104.78352 | 0 |
| Slice 142 | 359.00563 | 805.53491 | 0 | 232.56746 | 97.285077 | 0 |
| Slice 143 | 360.80794 | 805.29917 | 0 | 214.64184 | 89.786628 | 0 |
| Slice 144 | 362.61025 | 805.06343 | 0 | 196.71623 | 82.28818 | 0 |
| Slice 145 | 364.41256 | 804.82769 | 0 | 178.79061 | 74.789732 | 0 |
| Slice 146 | 366.21487 | 804.59195 | 0 | 160.86499 | 67.291283 | 0 |
| Slice 147 | 367.91257 | 804.45713 | 0 | 140.3953 | 58.728628 | 0 |
| Slice 148 | 369.50567 | 804.42324 | 0 | 109.19635 | 45.677822 | 0 |
| Slice 149 | 371.09877 | 804.38935 | 0 | 77.997391 | 32.627016 | 0 |
| Slice 150 | 372.69187 | 804.35546 | 0 | 46.798435 | 19.576209 | 0 |
| Slice 151 | 374.28497 | 804.32157 | 0 | 15.599478 | 6.5254031 | 0 |




| Color | Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|---|---|---|---|---|
| | CCR | Mohr-Coulomb | 86 | 0 | 22.7 |
| | Clay | Mohr-Coulomb | 125 | 0 | 28 |
| | Drainage Layer | Mohr-Coulomb | 115 | 0 | 30 |
| | Geosynthetics | Mohr-Coulomb | 58 | 0 | 24.3 |
| | Subbase | Mohr-Coulomb | 120 | 0 | 30 |

**Title: Columbia Mod 10-11 Interim Waste Stage 3**
**Name: 3_Block**
**Method: Janbu**
**Last Edited By: Suchomel, Brandon**

**F of S: 2.063, F of S Rank (Analysis): 1 of 147,456 slip surfaces**
**Last Solved Date: 5/4/2022, Last Solved Time: 6:00:41 PM**

# 3_Block

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## File Information

File Version: 8.16
Title: Columbia Mod 10-11 Interim Waste Stage 3
Created By: Suchomel, Brandon
Last Edited By: Suchomel, Brandon
Revision Number: 50
Date: 5/4/2022
Time: 5:59:45 PM
Tool Version: 8.16.3.14580
File Name: Columbia Mod 10-11 Interim Waste Stage 3.gsz
Directory: I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\
Last Solved Date: 5/4/2022
Last Solved Time: 6:00:41 PM

## Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

## Analysis Settings

### 3_Block

Kind: SLOPE/W
Method: Janbu
Settings
    PWP Conditions Source: (none)
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 10
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Restrict Block Crossing: No
    Optimize Critical Slip Surface Location: No
    Tension Crack
        Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced

Number of Slices: 150
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

# Materials

## CCR

Model: Mohr-Coulomb
Unit Weight: 86 pcf
Cohesion': 0 psf
Phi': 22.7 °
Phi-B: 0 °

## Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

## Drainage Layer

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Geosynthetics

Model: Mohr-Coulomb
Unit Weight: 58 pcf
Cohesion': 0 psf
Phi': 24.3 °
Phi-B: 0 °

## Subbase

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

# Slip Surface Limits

Left Coordinate: (0, 870) ft
Right Coordinate: (483.9, 803.9) ft

# Slip Surface Block

Left Grid
Upper Left: (173.66, 804.44) ft
Lower Left: (173.65, 804.32) ft
Lower Right: (184.43, 804.28) ft

X Increments: 15
Y Increments: 3
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 5

Right Grid
Upper Left: (369.03, 803.46) ft
Lower Left: (369.04, 803.34) ft
Lower Right: (379.14, 803.32) ft
X Increments: 15
Y Increments: 3
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 5

## Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 0 | 780 |
| Point 2 | 483.9 | 780 |
| Point 3 | 0 | 805.2 |
| Point 4 | 483.9 | 802.9 |
| Point 5 | 483.9 | 800.9 |
| Point 6 | 0 | 803.2 |
| Point 7 | 0 | 870 |
| Point 8 | 112.5 | 870 |
| Point 9 | 379.2 | 803.3 |
| Point 10 | 0 | 806.2 |
| Point 11 | 375.1 | 804.3 |
| Point 12 | 483.9 | 803.9 |
| Point 13 | 0 | 805.3 |
| Point 14 | 483.9 | 803 |
| Point 15 | 379.2 | 803.4 |

## Regions

| | Material | Points | Area (ft²) |
|---|---|---|---|
| Region 1 | Subbase | 1,6,5,2 | 10,670 |
| Region 2 | Clay | 6,3,9,4,5 | 944.17 |
| Region 3 | Geosynthetics | 3,13,15,14,4,9 | 48.39 |
| Region 4 | Drainage Layer | 13,10,11,12,14,15 | 430.8 |
| Region 5 | CCR | 10,7,8,11 | 15,661 |

## Current Slip Surface

Slip Surface: 52,648
F of S: 2.063
Volume: 6,571.6975 ft³
Weight: 569,769.11 lbs
Resisting Force: 243,018.44 lbs

Activating Force: 117,793.02 lbs
F of S Rank (Analysis): 1 of 147,456 slip surfaces
F of S Rank (Query): 1 of 147,456 slip surfaces
Exit: (375.01939, 804.32017) ft
Entry: (112.30933, 870) ft
Radius: 124.18106 ft
Center: (255.97976, 886.41996) ft

## Slip Slices

| | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|
| Slice 1 | 112.40467 | 869.90467 | 0 | 6.8170337 | 2.8516269 | 0 |
| Slice 2 | 113.3717 | 868.93763 | 0 | 60.372004 | 25.254156 | 0 |
| Slice 3 | 115.11511 | 867.19423 | 0 | 153.84788 | 64.355961 | 0 |
| Slice 4 | 116.85851 | 865.45082 | 0 | 247.32375 | 103.45777 | 0 |
| Slice 5 | 118.60191 | 863.70742 | 0 | 340.79962 | 142.55957 | 0 |
| Slice 6 | 120.34532 | 861.96402 | 0 | 434.2755 | 181.66138 | 0 |
| Slice 7 | 122.08872 | 860.22061 | 0 | 527.75137 | 220.76318 | 0 |
| Slice 8 | 123.83212 | 858.47721 | 0 | 621.22724 | 259.86499 | 0 |
| Slice 9 | 125.57553 | 856.73381 | 0 | 714.70312 | 298.96679 | 0 |
| Slice 10 | 127.31893 | 854.9904 | 0 | 808.17899 | 338.0686 | 0 |
| Slice 11 | 129.06233 | 853.247 | 0 | 901.65487 | 377.1704 | 0 |
| Slice 12 | 130.80574 | 851.5036 | 0 | 995.13074 | 416.27221 | 0 |
| Slice 13 | 132.54914 | 849.76019 | 0 | 1,088.6066 | 455.37401 | 0 |
| Slice 14 | 134.29254 | 848.01679 | 0 | 1,182.0825 | 494.47582 | 0 |
| Slice 15 | 136.03595 | 846.27339 | 0 | 1,275.5584 | 533.57762 | 0 |
| Slice 16 | 137.77935 | 844.52998 | 0 | 1,369.0342 | 572.67942 | 0 |
| Slice 17 | 139.52275 | 842.78658 | 0 | 1,462.5101 | 611.78123 | 0 |
| Slice 18 | 141.26616 | 841.04318 | 0 | 1,555.986 | 650.88303 | 0 |
| Slice 19 | 143.00956 | 839.29977 | 0 | 1,649.4619 | 689.98484 | 0 |
| Slice 20 | 144.75296 | 837.55637 | 0 | 1,742.9377 | 729.08664 | 0 |
| Slice 21 | 146.49637 | 835.81297 | 0 | 1,836.4136 | 768.18845 | 0 |
| Slice 22 | 148.23977 | 834.06956 | 0 | 1,929.8895 | 807.29025 | 0 |
| Slice 23 | 149.98317 | 832.32616 | 0 | 2,023.3653 | 846.39206 | 0 |
| Slice 24 | 151.72658 | 830.58276 | 0 | 2,116.8412 | 885.49386 | 0 |
| Slice 25 | 153.46998 | 828.83935 | 0 | 2,210.3171 | 924.59567 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 26 | 155.21338 | 827.09595 | 0 | 2,303.793 | 963.69747 | 0 |
| Slice 27 | 156.95679 | 825.35255 | 0 | 2,397.2688 | 1,002.7993 | 0 |
| Slice 28 | 158.70019 | 823.60914 | 0 | 2,490.7447 | 1,041.9011 | 0 |
| Slice 29 | 160.44359 | 821.86574 | 0 | 2,584.2206 | 1,081.0029 | 0 |
| Slice 30 | 162.187 | 820.12234 | 0 | 2,677.6965 | 1,120.1047 | 0 |
| Slice 31 | 163.9304 | 818.37893 | 0 | 2,771.1723 | 1,159.2065 | 0 |
| Slice 32 | 165.6738 | 816.63553 | 0 | 2,864.6482 | 1,198.3083 | 0 |
| Slice 33 | 167.41721 | 814.89213 | 0 | 2,958.1241 | 1,237.4101 | 0 |
| Slice 34 | 169.16061 | 813.14872 | 0 | 3,051.6 | 1,276.5119 | 0 |
| Slice 35 | 170.90401 | 811.40532 | 0 | 3,145.0758 | 1,315.6137 | 0 |
| Slice 36 | 172.64742 | 809.66192 | 0 | 3,238.5517 | 1,354.7155 | 0 |
| Slice 37 | 174.39082 | 807.91851 | 0 | 3,332.0276 | 1,393.8173 | 0 |
| Slice 38 | 176.13422 | 806.17511 | 0 | 3,425.5034 | 1,432.9191 | 0 |
| Slice 39 | 177.45332 | 804.85601 | 0 | 3,295.7974 | 1,902.8295 | 0 |
| Slice 40 | 178.81192 | 804.37175 | 0 | 4,204.9245 | 1,898.5962 | 0 |
| Slice 41 | 180.60202 | 804.33032 | 0 | 4,201.5161 | 1,897.0573 | 0 |
| Slice 42 | 182.35981 | 804.32121 | 0 | 4,164.5095 | 1,880.3481 | 0 |
| Slice 43 | 184.1176 | 804.31209 | 0 | 4,127.5028 | 1,863.639 | 0 |
| Slice 44 | 185.87539 | 804.30297 | 0 | 4,090.4962 | 1,846.9298 | 0 |
| Slice 45 | 187.63318 | 804.29386 | 0 | 4,053.4895 | 1,830.2207 | 0 |
| Slice 46 | 189.39097 | 804.28474 | 0 | 4,016.4828 | 1,813.5115 | 0 |
| Slice 47 | 191.14876 | 804.27562 | 0 | 3,979.4762 | 1,796.8024 | 0 |
| Slice 48 | 192.90655 | 804.2665 | 0 | 3,942.4695 | 1,780.0932 | 0 |
| Slice 49 | 194.66434 | 804.25739 | 0 | 3,905.4628 | 1,763.3841 | 0 |
| Slice 50 | 196.42213 | 804.24827 | 0 | 3,868.4562 | 1,746.6749 | 0 |
| Slice 51 | 198.17992 | 804.23915 | 0 | 3,831.4495 | 1,729.9658 | 0 |
| Slice | 199.93771 | 804.23004 | 0 | 3,794.4429 | 1,713.2566 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 52 | | | | | | |
| Slice 53 | 201.6955 | 804.22092 | 0 | 3,757.4362 | 1,696.5475 | 0 |
| Slice 54 | 203.45329 | 804.2118 | 0 | 3,720.4295 | 1,679.8383 | 0 |
| Slice 55 | 205.21108 | 804.20268 | 0 | 3,683.4229 | 1,663.1292 | 0 |
| Slice 56 | 206.96886 | 804.19357 | 0 | 3,646.4162 | 1,646.42 | 0 |
| Slice 57 | 208.72665 | 804.18445 | 0 | 3,609.4095 | 1,629.7109 | 0 |
| Slice 58 | 210.48444 | 804.17533 | 0 | 3,572.4029 | 1,613.0017 | 0 |
| Slice 59 | 212.24223 | 804.16622 | 0 | 3,535.3962 | 1,596.2926 | 0 |
| Slice 60 | 214.00002 | 804.1571 | 0 | 3,498.3895 | 1,579.5834 | 0 |
| Slice 61 | 215.75781 | 804.14798 | 0 | 3,461.3829 | 1,562.8743 | 0 |
| Slice 62 | 217.5156 | 804.13886 | 0 | 3,424.3762 | 1,546.1652 | 0 |
| Slice 63 | 219.27339 | 804.12975 | 0 | 3,387.3696 | 1,529.456 | 0 |
| Slice 64 | 221.03118 | 804.12063 | 0 | 3,350.3629 | 1,512.7469 | 0 |
| Slice 65 | 222.78897 | 804.11151 | 0 | 3,313.3562 | 1,496.0377 | 0 |
| Slice 66 | 224.54676 | 804.1024 | 0 | 3,276.3496 | 1,479.3286 | 0 |
| Slice 67 | 226.30455 | 804.09328 | 0 | 3,239.3429 | 1,462.6194 | 0 |
| Slice 68 | 228.06234 | 804.08416 | 0 | 3,202.3362 | 1,445.9103 | 0 |
| Slice 69 | 229.82013 | 804.07505 | 0 | 3,165.3296 | 1,429.2011 | 0 |
| Slice 70 | 231.57792 | 804.06593 | 0 | 3,128.3229 | 1,412.492 | 0 |
| Slice 71 | 233.33571 | 804.05681 | 0 | 3,091.3163 | 1,395.7828 | 0 |
| Slice 72 | 235.0935 | 804.04769 | 0 | 3,054.3096 | 1,379.0737 | 0 |
| Slice 73 | 236.85129 | 804.03858 | 0 | 3,017.3029 | 1,362.3645 | 0 |
| Slice 74 | 238.60908 | 804.02946 | 0 | 2,980.2963 | 1,345.6554 | 0 |
| Slice 75 | 240.36687 | 804.02034 | 0 | 2,943.2896 | 1,328.9462 | 0 |
| Slice 76 | 242.12466 | 804.01123 | 0 | 2,906.2829 | 1,312.2371 | 0 |
| Slice 77 | 243.88245 | 804.00211 | 0 | 2,869.2763 | 1,295.5279 | 0 |
| Slice 78 | 245.64024 | 803.99299 | 0 | 2,832.2696 | 1,278.8188 | 0 |

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|---|---|---|---|---|---|---|
| Slice 79 | 247.39803 | 803.98387 | 0 | 2,795.2629 | 1,262.1096 | 0 |
| Slice 80 | 249.15582 | 803.97476 | 0 | 2,758.2563 | 1,245.4005 | 0 |
| Slice 81 | 250.91361 | 803.96564 | 0 | 2,721.2496 | 1,228.6913 | 0 |
| Slice 82 | 252.6714 | 803.95652 | 0 | 2,684.243 | 1,211.9822 | 0 |
| Slice 83 | 254.42919 | 803.94741 | 0 | 2,647.2363 | 1,195.273 | 0 |
| Slice 84 | 256.18698 | 803.93829 | 0 | 2,610.2296 | 1,178.5639 | 0 |
| Slice 85 | 257.94477 | 803.92917 | 0 | 2,573.223 | 1,161.8547 | 0 |
| Slice 86 | 259.70256 | 803.92005 | 0 | 2,536.2163 | 1,145.1456 | 0 |
| Slice 87 | 261.46035 | 803.91094 | 0 | 2,499.2096 | 1,128.4364 | 0 |
| Slice 88 | 263.21814 | 803.90182 | 0 | 2,462.203 | 1,111.7273 | 0 |
| Slice 89 | 264.97593 | 803.8927 | 0 | 2,425.1963 | 1,095.0181 | 0 |
| Slice 90 | 266.73372 | 803.88359 | 0 | 2,388.1897 | 1,078.309 | 0 |
| Slice 91 | 268.49151 | 803.87447 | 0 | 2,351.183 | 1,061.5998 | 0 |
| Slice 92 | 270.2493 | 803.86535 | 0 | 2,314.1763 | 1,044.8907 | 0 |
| Slice 93 | 272.00709 | 803.85623 | 0 | 2,277.1697 | 1,028.1815 | 0 |
| Slice 94 | 273.76488 | 803.84712 | 0 | 2,240.163 | 1,011.4724 | 0 |
| Slice 95 | 275.52267 | 803.838 | 0 | 2,203.1563 | 994.76323 | 0 |
| Slice 96 | 277.28046 | 803.82888 | 0 | 2,166.1497 | 978.05408 | 0 |
| Slice 97 | 279.03825 | 803.81977 | 0 | 2,129.143 | 961.34493 | 0 |
| Slice 98 | 280.79604 | 803.81065 | 0 | 2,092.1363 | 944.63578 | 0 |
| Slice 99 | 282.55383 | 803.80153 | 0 | 2,055.1297 | 927.92663 | 0 |
| Slice 100 | 284.31162 | 803.79241 | 0 | 2,018.123 | 911.21749 | 0 |
| Slice 101 | 286.06941 | 803.7833 | 0 | 1,981.1164 | 894.50834 | 0 |
| Slice 102 | 287.8272 | 803.77418 | 0 | 1,944.1097 | 877.79919 | 0 |
| Slice 103 | 289.58499 | 803.76506 | 0 | 1,907.103 | 861.09004 | 0 |
| Slice 104 | 291.34277 | 803.75595 | 0 | 1,870.0964 | 844.38089 | 0 |
| | | | | | | |

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|---|---|---|---|---|---|---|
| Slice 105 | 293.10056 | 803.74683 | 0 | 1,833.0897 | 827.67174 | 0 |
| Slice 106 | 294.85835 | 803.73771 | 0 | 1,796.083 | 810.96259 | 0 |
| Slice 107 | 296.61614 | 803.72859 | 0 | 1,759.0764 | 794.25344 | 0 |
| Slice 108 | 298.37393 | 803.71948 | 0 | 1,722.0697 | 777.54429 | 0 |
| Slice 109 | 300.13172 | 803.71036 | 0 | 1,685.0631 | 760.83514 | 0 |
| Slice 110 | 301.88951 | 803.70124 | 0 | 1,648.0564 | 744.12599 | 0 |
| Slice 111 | 303.6473 | 803.69213 | 0 | 1,611.0497 | 727.41684 | 0 |
| Slice 112 | 305.40509 | 803.68301 | 0 | 1,574.0431 | 710.7077 | 0 |
| Slice 113 | 307.16288 | 803.67389 | 0 | 1,537.0364 | 693.99855 | 0 |
| Slice 114 | 308.92067 | 803.66477 | 0 | 1,500.0297 | 677.2894 | 0 |
| Slice 115 | 310.67846 | 803.65566 | 0 | 1,463.0231 | 660.58025 | 0 |
| Slice 116 | 312.43625 | 803.64654 | 0 | 1,426.0164 | 643.8711 | 0 |
| Slice 117 | 314.19404 | 803.63742 | 0 | 1,389.0097 | 627.16195 | 0 |
| Slice 118 | 315.95183 | 803.62831 | 0 | 1,352.0031 | 610.4528 | 0 |
| Slice 119 | 317.70962 | 803.61919 | 0 | 1,314.9964 | 593.74365 | 0 |
| Slice 120 | 319.46741 | 803.61007 | 0 | 1,277.9898 | 577.0345 | 0 |
| Slice 121 | 321.2252 | 803.60096 | 0 | 1,240.9831 | 560.32535 | 0 |
| Slice 122 | 322.98299 | 803.59184 | 0 | 1,203.9764 | 543.6162 | 0 |
| Slice 123 | 324.74078 | 803.58272 | 0 | 1,166.9698 | 526.90706 | 0 |
| Slice 124 | 326.49857 | 803.5736 | 0 | 1,129.9631 | 510.19791 | 0 |
| Slice 125 | 328.25636 | 803.56449 | 0 | 1,092.9564 | 493.48876 | 0 |
| Slice 126 | 330.01415 | 803.55537 | 0 | 1,055.9498 | 476.77961 | 0 |
| Slice 127 | 331.77194 | 803.54625 | 0 | 1,018.9431 | 460.07046 | 0 |
| Slice 128 | 333.52973 | 803.53714 | 0 | 981.93646 | 443.36131 | 0 |
| Slice 129 | 335.28752 | 803.52802 | 0 | 944.92979 | 426.65216 | 0 |
| Slice 130 | 337.04531 | 803.5189 | 0 | 907.92313 | 409.94301 | 0 |
| Slice | 338.8031 | 803.50978 | 0 | 870.91647 | 393.23386 | 0 |

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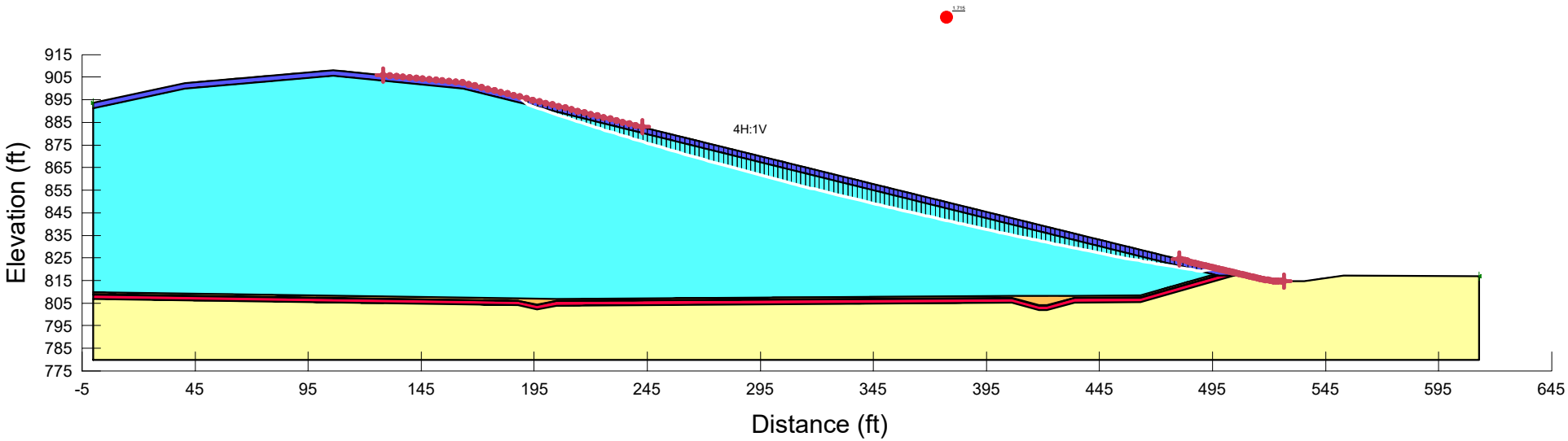
|---|---|---|---|---|---|---|
| 131 | | | | | | |
| Slice 132 | 340.56089 | 803.50067 | 0 | 833.9098 | 376.52471 | 0 |
| Slice 133 | 342.31868 | 803.49155 | 0 | 796.90314 | 359.81556 | 0 |
| Slice 134 | 344.07647 | 803.48243 | 0 | 759.89648 | 343.10642 | 0 |
| Slice 135 | 345.83426 | 803.47332 | 0 | 722.88981 | 326.39727 | 0 |
| Slice 136 | 347.59205 | 803.4642 | 0 | 685.88315 | 309.68812 | 0 |
| Slice 137 | 349.34984 | 803.45508 | 0 | 648.87649 | 292.97897 | 0 |
| Slice 138 | 351.10763 | 803.44596 | 0 | 611.86982 | 276.26982 | 0 |
| Slice 139 | 352.86542 | 803.43685 | 0 | 574.86316 | 259.56067 | 0 |
| Slice 140 | 354.62321 | 803.42773 | 0 | 537.8565 | 242.85152 | 0 |
| Slice 141 | 356.381 | 803.41861 | 0 | 500.84983 | 226.14237 | 0 |
| Slice 142 | 358.13879 | 803.4095 | 0 | 463.84317 | 209.43322 | 0 |
| Slice 143 | 359.89658 | 803.40038 | 0 | 426.83651 | 192.72407 | 0 |
| Slice 144 | 361.65437 | 803.39126 | 0 | 389.82984 | 176.01492 | 0 |
| Slice 145 | 363.41216 | 803.38214 | 0 | 352.82318 | 159.30577 | 0 |
| Slice 146 | 365.16995 | 803.37303 | 0 | 315.81652 | 142.59663 | 0 |
| Slice 147 | 366.92774 | 803.36391 | 0 | 278.80986 | 125.88748 | 0 |
| Slice 148 | 368.68553 | 803.35479 | 0 | 241.80319 | 109.17833 | 0 |
| Slice 149 | 370.44332 | 803.34568 | 0 | 204.79653 | 92.469178 | 0 |
| Slice 150 | 372.20111 | 803.33656 | 0 | 167.78987 | 75.760029 | 0 |
| Slice 151 | 373.17588 | 803.38085 | 0 | 162.70935 | 73.466091 | 0 |
| Slice 152 | 374.12637 | 803.86515 | 0 | 82.91754 | 47.872464 | 0 |
| Slice 153 | 375.00019 | 804.31039 | 0 | 1.398867 | 0.58515874 | 0 |




| Color | Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|---|---|---|---|---|
| | CCR | Mohr-Coulomb | 86 | 0 | 22.7 |
| | Clay | Mohr-Coulomb | 125 | 0 | 28 |
| | Drainage Layer | Mohr-Coulomb | 115 | 0 | 30 |
| | Final Cover | Mohr-Coulomb | 120 | 0 | 30 |
| | Geosynthetics | Mohr-Coulomb | 58 | 0 | 24.3 |
| | Subbase | Mohr-Coulomb | 120 | 0 | 30 |

**Title: Columbia Mod 10-11 Final Grade**
**Name: 2_Optimized Circular**
**Method: Bishop**
**Last Edited By: Suchomel, Brandon**

**F of S: 1.715, F of S Rank (Analysis): 1 of 15,130 slip surfaces**
**Last Solved Date: 5/4/2022, Last Solved Time: 6:09:49 PM**

# 2_Optimized Circular

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## File Information

File Version: 8.16
Title: Columbia Mod 10-11 Final Grade
Created By: Suchomel, Brandon
Last Edited By: Suchomel, Brandon
Revision Number: 76
Date: 5/4/2022
Time: 6:09:17 PM
Tool Version: 8.16.3.14580
File Name: Columbia Mod 10-11 Final Grade.gsz
Directory: I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\
Last Solved Date: 5/4/2022
Last Solved Time: 6:09:49 PM

## Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

## Analysis Settings

### 2_Optimized Circular

Kind: SLOPE/W
Method: Bishop
Settings
    PWP Conditions Source: (none)
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 10
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Optimize Critical Slip Surface Location: Yes
    Critical Slip Surface Optimizations
        Maximum Iterations: 2,000
        Convergence Tolerance: 1e-007
        Starting Points: 8
        Ending Points: 16
        Complete Passes per Insertion: 1

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 150
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

# Materials

## CCR

Model: Mohr-Coulomb
Unit Weight: 86 pcf
Cohesion': 0 psf
Phi': 22.7 °
Phi-B: 0 °

## Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

## Drainage Layer

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Geosynthetics

Model: Mohr-Coulomb
Unit Weight: 58 pcf
Cohesion': 0 psf
Phi': 24.3 °
Phi-B: 0 °

## Subbase

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Final Cover

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (128.23053, 906.01) ft
Left-Zone Right Coordinate: (242.77011, 883.007) ft
Left-Zone Increment: 40
Right Projection: Range
Right-Zone Left Coordinate: (480.36, 824.4345) ft
Right-Zone Right Coordinate: (526.61, 814.8) ft
Right-Zone Increment: 40
Radius Increments: 8

## Slip Surface Limits

Left Coordinate: (0, 893.8) ft
Right Coordinate: (613, 816.8) ft

## Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 0 | 808.8 |
| Point 2 | 187.7 | 806 |
| Point 3 | 196.4 | 804.2 |
| Point 4 | 205.1 | 805.9 |
| Point 5 | 406.3 | 807.2 |
| Point 6 | 418.1 | 803.9 |
| Point 7 | 421.7 | 803.9 |
| Point 8 | 433.9 | 807.3 |
| Point 9 | 463 | 807.5 |
| Point 10 | 497.4 | 817.3 |
| Point 11 | 0 | 806.8 |
| Point 12 | 187.7 | 804 |
| Point 13 | 196.4 | 802.2 |
| Point 14 | 205.1 | 803.9 |
| Point 15 | 406.3 | 805.2 |
| Point 16 | 418.1 | 801.9 |
| Point 17 | 421.7 | 801.9 |
| Point 18 | 433.9 | 805.3 |
| Point 19 | 463 | 805.5 |
| Point 20 | 504.6 | 817.3 |
| Point 21 | 0 | 809.8 |
| Point 22 | 187.7 | 807 |
| Point 23 | 205.1 | 806.9 |
| Point 24 | 406.3 | 808.2 |
| Point 25 | 433.9 | 808.3 |
| Point 26 | 463 | 808.5 |
| Point 27 | 494 | 817.3 |
| Point 28 | 0 | 891.3 |
| Point 29 | 40.4 | 900 |
| Point 30 | 106.1 | 905.7 |

| | | |
|---|---|---|
| Point 31 | 163.7 | 900 |
| Point 32 | 0 | 893.8 |
| Point 33 | 40.4 | 902.5 |
| Point 34 | 106.1 | 908.2 |
| Point 35 | 163.7 | 902.5 |
| Point 36 | 509.3 | 817.3 |
| Point 37 | 521.2 | 814.8 |
| Point 38 | 535.6 | 814.8 |
| Point 39 | 553.1 | 817.2 |
| Point 40 | 613 | 816.8 |
| Point 41 | 0 | 780 |
| Point 42 | 613 | 780 |
| Point 43 | 497 | 817.3 |
| Point 44 | 0 | 808.9 |
| Point 45 | 187.7 | 806.1 |
| Point 46 | 196.4 | 804.3 |
| Point 47 | 205.1 | 806 |
| Point 48 | 406.3 | 807.3 |
| Point 49 | 418.1 | 804 |
| Point 50 | 421.7 | 804 |
| Point 51 | 433.9 | 807.4 |
| Point 52 | 463 | 807.6 |

# Regions

| | Material | Points | Area (ft²) |
|---|---|---|---|
| Region 1 | Subbase | 41,11,12,13,14,15,16,17,18,19,20,36,37,38,39,40,42 | 16,750 |
| Region 2 | Clay | 11,1,2,3,4,5,6,7,8,9,10,20,19,18,17,16,15,14,13,12 | 1,002.9 |
| Region 3 | Geosynthetics | 1,44,45,46,47,48,49,50,51,52,43,10,9,8,7,6,5,4,3,2 | 49.96 |
| Region 4 | Drainage Layer | 44,21,22,23,24,25,26,27,43,52,51,50,49,48,47,46,45 | 512.68 |
| Region 5 | CCR | 21,28,29,30,31,10,43,27,26,25,24,23,22 | 31,970 |
| Region 6 | Final Cover | 28,32,33,34,35,36,20,10,31,30,29 | 1,333.3 |

# Current Slip Surface

Slip Surface: 15,130
F of S: 1.715
Volume: 2,057.5599 ft³
Weight: 205,107.91 lbs
Resisting Moment: 1.9773823e+008 lbs-ft
Activating Moment: 1.1529957e+008 lbs-ft
F of S Rank (Analysis): 1 of 15,130 slip surfaces
F of S Rank (Query): 1 of 15,130 slip surfaces
Exit: (496.40689, 820.47851) ft
Entry: (187.91178, 896.53112) ft
Radius: 135.32146 ft
Center: (884.20908, 3,149.1166) ft

## Slip Slices

| | X (ft) | Y (ft) | PWP | Base Normal Stress | Frictional Strength | Cohesive Strength |
|---|---|---|---|---|---|---|

| | | | (psf) | (psf) | (psf) | (psf) |
|---|---|---|---|---|---|---|
| Slice 1 | 188.94788 | 895.64148 | 0 | 59.043882 | 34.089001 | 0 |
| Slice 2 | 191.02008 | 893.8622 | 0 | 177.13165 | 102.267 | 0 |
| Slice 3 | 192.136 | 892.90403 | 0 | 255.19769 | 106.75151 | 0 |
| Slice 4 | 193.30095 | 892.46224 | 0 | 297.05904 | 124.26249 | 0 |
| Slice 5 | 195.47124 | 891.71573 | 0 | 313.92727 | 131.31862 | 0 |
| Slice 6 | 197.64153 | 890.96921 | 0 | 330.79551 | 138.37476 | 0 |
| Slice 7 | 199.81182 | 890.2227 | 0 | 347.66374 | 145.43089 | 0 |
| Slice 8 | 201.98211 | 889.47619 | 0 | 364.53198 | 152.48703 | 0 |
| Slice 9 | 204.1524 | 888.72967 | 0 | 381.40021 | 159.54317 | 0 |
| Slice 10 | 206.32269 | 887.98316 | 0 | 398.26845 | 166.5993 | 0 |
| Slice 11 | 208.45878 | 887.27447 | 0 | 415.11896 | 173.64802 | 0 |
| Slice 12 | 210.56069 | 886.60361 | 0 | 427.38749 | 178.78006 | 0 |
| Slice 13 | 212.6626 | 885.93275 | 0 | 439.65601 | 183.91209 | 0 |
| Slice 14 | 214.76451 | 885.2619 | 0 | 451.92453 | 189.04413 | 0 |
| Slice 15 | 216.86642 | 884.59104 | 0 | 464.19306 | 194.17616 | 0 |
| Slice 16 | 218.96833 | 883.92018 | 0 | 476.46158 | 199.3082 | 0 |
| Slice 17 | 221.07024 | 883.24932 | 0 | 488.7301 | 204.44023 | 0 |
| Slice 18 | 223.17215 | 882.57846 | 0 | 500.99863 | 209.57227 | 0 |
| Slice 19 | 225.27406 | 881.9076 | 0 | 513.26715 | 214.7043 | 0 |
| Slice 20 | 227.37597 | 881.23675 | 0 | 525.53567 | 219.83633 | 0 |
| Slice 21 | 229.47788 | 880.56589 | 0 | 537.8042 | 224.96837 | 0 |
| Slice 22 | 231.57979 | 879.89503 | 0 | 550.07272 | 230.1004 | 0 |
| Slice 23 | 233.66565 | 879.251 | 0 | 563.18804 | 235.58666 | 0 |
| Slice 24 | 235.73548 | 878.6338 | 0 | 571.84604 | 239.20838 | 0 |
| Slice 25 | 237.8053 | 878.0166 | 0 | 580.50403 | 242.83009 | 0 |
| Slice 26 | 239.87513 | 877.3994 | 0 | 589.16202 | 246.45181 | 0 |
| Slice 27 | 241.94495 | 876.7822 | 0 | 597.82001 | 250.07353 | 0 |
| Slice 28 | 244.01478 | 876.165 | 0 | 606.478 | 253.69524 | 0 |
| Slice 29 | 246.0846 | 875.5478 | 0 | 615.136 | 257.31696 | 0 |
| Slice 30 | 248.15443 | 874.9306 | 0 | 623.79399 | 260.93868 | 0 |

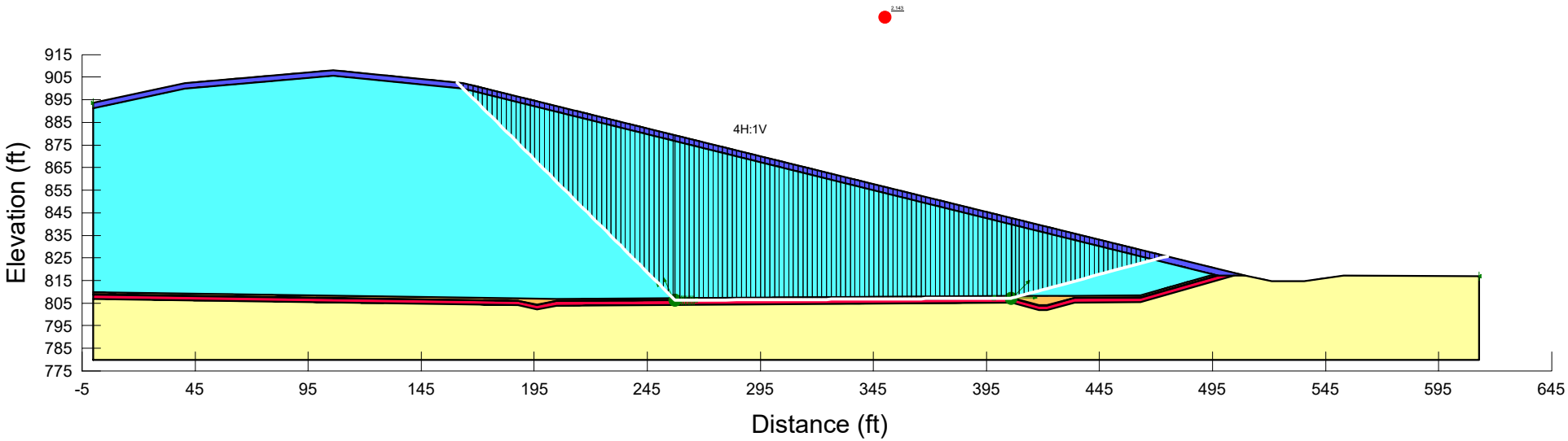
| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 31 | 250.22425 | 874.3134 | 0 | 632.45198 | 264.56039 | 0 |
| Slice 32 | 252.29407 | 873.6962 | 0 | 641.10997 | 268.18211 | 0 |
| Slice 33 | 254.3639 | 873.079 | 0 | 649.76797 | 271.80383 | 0 |
| Slice 34 | 256.43372 | 872.4618 | 0 | 658.42596 | 275.42554 | 0 |
| Slice 35 | 258.50355 | 871.8446 | 0 | 667.08395 | 279.04726 | 0 |
| Slice 36 | 260.57337 | 871.2274 | 0 | 675.74194 | 282.66898 | 0 |
| Slice 37 | 262.6432 | 870.6102 | 0 | 684.39994 | 286.29069 | 0 |
| Slice 38 | 264.76104 | 870.0051 | 0 | 694.99471 | 290.72258 | 0 |
| Slice 39 | 266.9269 | 869.4121 | 0 | 699.84528 | 292.75162 | 0 |
| Slice 40 | 269.09277 | 868.8191 | 0 | 704.69585 | 294.78066 | 0 |
| Slice 41 | 271.25863 | 868.2261 | 0 | 709.54641 | 296.80969 | 0 |
| Slice 42 | 273.42449 | 867.6331 | 0 | 714.39698 | 298.83873 | 0 |
| Slice 43 | 275.59036 | 867.0401 | 0 | 719.24755 | 300.86777 | 0 |
| Slice 44 | 277.67848 | 866.47383 | 0 | 724.38225 | 303.01566 | 0 |
| Slice 45 | 279.68887 | 865.9343 | 0 | 728.01062 | 304.53344 | 0 |
| Slice 46 | 281.69926 | 865.39476 | 0 | 731.63899 | 306.05122 | 0 |
| Slice 47 | 283.70965 | 864.85523 | 0 | 735.26736 | 307.569 | 0 |
| Slice 48 | 285.72004 | 864.31569 | 0 | 738.89573 | 309.08678 | 0 |
| Slice 49 | 287.73043 | 863.77616 | 0 | 742.5241 | 310.60456 | 0 |
| Slice 50 | 289.74082 | 863.23662 | 0 | 746.15247 | 312.12234 | 0 |
| Slice 51 | 291.75121 | 862.69709 | 0 | 749.78083 | 313.64012 | 0 |
| Slice 52 | 293.7616 | 862.15755 | 0 | 753.4092 | 315.1579 | 0 |
| Slice 53 | 295.77199 | 861.61802 | 0 | 757.03757 | 316.67568 | 0 |
| Slice 54 | 297.78237 | 861.07848 | 0 | 760.66594 | 318.19346 | 0 |
| Slice 55 | 299.79276 | 860.53895 | 0 | 764.29431 | 319.71124 | 0 |
| Slice 56 | 301.80315 | 859.99941 | 0 | 767.92268 | 321.22902 | 0 |
| Slice | 303.81354 | 859.45988 | 0 | 771.55105 | 322.7468 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 57 | | | | | | |
| Slice 58 | 305.82393 | 858.92034 | 0 | 775.17942 | 324.26458 | 0 |
| Slice 59 | 307.83432 | 858.38081 | 0 | 778.80779 | 325.78236 | 0 |
| Slice 60 | 309.84471 | 857.84127 | 0 | 782.43616 | 327.30014 | 0 |
| Slice 61 | 311.8551 | 857.30174 | 0 | 786.06453 | 328.81792 | 0 |
| Slice 62 | 313.86549 | 856.7622 | 0 | 789.6929 | 330.3357 | 0 |
| Slice 63 | 315.87588 | 856.22267 | 0 | 793.32127 | 331.85347 | 0 |
| Slice 64 | 317.93207 | 855.6982 | 0 | 799.58807 | 334.47494 | 0 |
| Slice 65 | 320.03408 | 855.18881 | 0 | 798.96026 | 334.21232 | 0 |
| Slice 66 | 322.13609 | 854.67942 | 0 | 798.33244 | 333.94969 | 0 |
| Slice 67 | 324.2381 | 854.17003 | 0 | 797.70462 | 333.68707 | 0 |
| Slice 68 | 326.3401 | 853.66064 | 0 | 797.07681 | 333.42445 | 0 |
| Slice 69 | 328.44211 | 853.15125 | 0 | 796.44899 | 333.16183 | 0 |
| Slice 70 | 330.54412 | 852.64185 | 0 | 795.82117 | 332.89921 | 0 |
| Slice 71 | 332.64613 | 852.13246 | 0 | 795.19336 | 332.63659 | 0 |
| Slice 72 | 334.74813 | 851.62307 | 0 | 794.56554 | 332.37397 | 0 |
| Slice 73 | 336.85014 | 851.11368 | 0 | 793.93772 | 332.11134 | 0 |
| Slice 74 | 338.95215 | 850.60429 | 0 | 793.30991 | 331.84872 | 0 |
| Slice 75 | 341.05416 | 850.0949 | 0 | 792.68209 | 331.5861 | 0 |
| Slice 76 | 343.08943 | 849.60487 | 0 | 792.40744 | 331.47121 | 0 |
| Slice 77 | 345.05798 | 849.13423 | 0 | 791.29902 | 331.00755 | 0 |
| Slice 78 | 347.02653 | 848.66358 | 0 | 790.19061 | 330.54389 | 0 |
| Slice 79 | 348.99507 | 848.19292 | 0 | 789.0822 | 330.08023 | 0 |
| Slice 80 | 350.96362 | 847.72227 | 0 | 787.97378 | 329.61657 | 0 |
| Slice 81 | 352.93216 | 847.25162 | 0 | 786.86537 | 329.15291 | 0 |
| Slice 82 | 354.90071 | 846.78098 | 0 | 785.75696 | 328.68925 | 0 |
| Slice 83 | 356.86926 | 846.31033 | 0 | 784.64854 | 328.22559 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 84 | 358.89006 | 845.83546 | 0 | 784.28138 | 328.07201 | 0 |
| Slice 85 | 360.96313 | 845.35638 | 0 | 781.76363 | 327.01881 | 0 |
| Slice 86 | 363.0362 | 844.87731 | 0 | 779.24588 | 325.96561 | 0 |
| Slice 87 | 365.10927 | 844.39823 | 0 | 776.72813 | 324.91241 | 0 |
| Slice 88 | 367.18234 | 843.91915 | 0 | 774.21037 | 323.85921 | 0 |
| Slice 89 | 369.2554 | 843.44007 | 0 | 771.69262 | 322.80602 | 0 |
| Slice 90 | 371.32847 | 842.96099 | 0 | 769.17487 | 321.75282 | 0 |
| Slice 91 | 373.40154 | 842.48192 | 0 | 766.65712 | 320.69962 | 0 |
| Slice 92 | 375.47461 | 842.00284 | 0 | 764.13936 | 319.64642 | 0 |
| Slice 93 | 377.52585 | 841.53663 | 0 | 762.36799 | 318.90544 | 0 |
| Slice 94 | 379.55527 | 841.08329 | 0 | 758.62269 | 317.33874 | 0 |
| Slice 95 | 381.58468 | 840.62994 | 0 | 754.87739 | 315.77205 | 0 |
| Slice 96 | 383.6141 | 840.1766 | 0 | 751.13208 | 314.20536 | 0 |
| Slice 97 | 385.64352 | 839.72326 | 0 | 747.38678 | 312.63866 | 0 |
| Slice 98 | 387.67293 | 839.26991 | 0 | 743.64148 | 311.07197 | 0 |
| Slice 99 | 389.70235 | 838.81657 | 0 | 739.89618 | 309.50528 | 0 |
| Slice 100 | 391.73177 | 838.36323 | 0 | 736.15088 | 307.93858 | 0 |
| Slice 101 | 393.76119 | 837.90989 | 0 | 732.40558 | 306.37189 | 0 |
| Slice 102 | 395.7906 | 837.45654 | 0 | 728.66028 | 304.8052 | 0 |
| Slice 103 | 397.82002 | 837.0032 | 0 | 724.91498 | 303.2385 | 0 |
| Slice 104 | 399.84944 | 836.54986 | 0 | 721.16968 | 301.67181 | 0 |
| Slice 105 | 401.87885 | 836.09651 | 0 | 717.42438 | 300.10512 | 0 |
| Slice 106 | 403.90827 | 835.64317 | 0 | 713.67908 | 298.53842 | 0 |
| Slice 107 | 405.93372 | 835.20322 | 0 | 710.95565 | 297.39919 | 0 |
| Slice 108 | 407.95521 | 834.77667 | 0 | 705.16772 | 294.97805 | 0 |
| Slice 109 | 409.9767 | 834.35013 | 0 | 699.37979 | 292.5569 | 0 |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 110 | 411.99819 | 833.92358 | 0 | 693.59187 | 290.13576 | 0 |
| Slice 111 | 414.04037 | 833.4998 | 0 | 688.2659 | 287.90786 | 0 |
| Slice 112 | 416.10325 | 833.07881 | 0 | 681.17935 | 284.94349 | 0 |
| Slice 113 | 418.16613 | 832.65781 | 0 | 674.0928 | 281.97913 | 0 |
| Slice 114 | 420.22901 | 832.23682 | 0 | 667.00625 | 279.01476 | 0 |
| Slice 115 | 422.29189 | 831.81582 | 0 | 659.9197 | 276.05039 | 0 |
| Slice 116 | 424.35477 | 831.39483 | 0 | 652.83315 | 273.08602 | 0 |
| Slice 117 | 426.41765 | 830.97383 | 0 | 645.7466 | 270.12165 | 0 |
| Slice 118 | 428.48053 | 830.55284 | 0 | 638.66005 | 267.15729 | 0 |
| Slice 119 | 430.54341 | 830.13184 | 0 | 631.5735 | 264.19292 | 0 |
| Slice 120 | 432.60629 | 829.71085 | 0 | 624.48695 | 261.22855 | 0 |
| Slice 121 | 434.66916 | 829.28985 | 0 | 617.4004 | 258.26418 | 0 |
| Slice 122 | 436.73204 | 828.86886 | 0 | 610.31385 | 255.29981 | 0 |
| Slice 123 | 438.79492 | 828.44786 | 0 | 603.2273 | 252.33545 | 0 |
| Slice 124 | 440.8578 | 828.02687 | 0 | 596.14075 | 249.37108 | 0 |
| Slice 125 | 442.92068 | 827.60587 | 0 | 589.0542 | 246.40671 | 0 |
| Slice 126 | 444.98356 | 827.18488 | 0 | 581.96765 | 243.44234 | 0 |
| Slice 127 | 447.04644 | 826.76388 | 0 | 574.8811 | 240.47798 | 0 |
| Slice 128 | 449.10932 | 826.34289 | 0 | 567.79455 | 237.51361 | 0 |
| Slice 129 | 451.1722 | 825.92189 | 0 | 560.708 | 234.54924 | 0 |
| Slice 130 | 453.23508 | 825.5009 | 0 | 553.62146 | 231.58487 | 0 |
| Slice 131 | 455.25753 | 825.11339 | 0 | 547.84698 | 229.16936 | 0 |
| Slice 132 | 457.23956 | 824.75938 | 0 | 536.83751 | 224.56399 | 0 |
| Slice 133 | 459.22159 | 824.40536 | 0 | 525.82804 | 219.95863 | 0 |
| Slice 134 | 461.20362 | 824.05135 | 0 | 514.81857 | 215.35327 | 0 |
| Slice 135 | 463.18565 | 823.69734 | 0 | 503.8091 | 210.74791 | 0 |
| Slice | 465.16768 | 823.34332 | 0 | 492.79962 | 206.14255 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 136 | | | | | | |
| Slice 137 | 467.14971 | 822.98931 | 0 | 481.79015 | 201.53719 | 0 |
| Slice 138 | 469.13453 | 822.64483 | 0 | 471.04949 | 197.04427 | 0 |
| Slice 139 | 471.12216 | 822.30988 | 0 | 458.32507 | 191.72153 | 0 |
| Slice 140 | 473.10978 | 821.97494 | 0 | 445.60064 | 186.39879 | 0 |
| Slice 141 | 475.09741 | 821.63999 | 0 | 432.87622 | 181.07605 | 0 |
| Slice 142 | 477.08503 | 821.30505 | 0 | 420.1518 | 175.7533 | 0 |
| Slice 143 | 479.07266 | 820.9701 | 0 | 407.42737 | 170.43056 | 0 |
| Slice 144 | 481.06028 | 820.63515 | 0 | 394.70295 | 165.10782 | 0 |
| Slice 145 | 483.0479 | 820.30021 | 0 | 381.97853 | 159.78508 | 0 |
| Slice 146 | 485.03553 | 819.96526 | 0 | 369.2541 | 154.46234 | 0 |
| Slice 147 | 487.02315 | 819.63032 | 0 | 356.52968 | 149.1396 | 0 |
| Slice 148 | 489.01078 | 819.29537 | 0 | 343.80526 | 143.81685 | 0 |
| Slice 149 | 491.07519 | 819.35375 | 0 | 315.06893 | 181.90513 | 0 |
| Slice 150 | 493.21107 | 819.80433 | 0 | 188.85259 | 109.03409 | 0 |
| Slice 151 | 495.34162 | 820.25378 | 0 | 62.950863 | 36.344698 | 0 |




| Color | Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|---|---|---|---|---|
| | CCR | Mohr-Coulomb | 86 | 0 | 22.7 |
| | Clay | Mohr-Coulomb | 125 | 0 | 28 |
| | Drainage Layer | Mohr-Coulomb | 115 | 0 | 30 |
| | Final Cover | Mohr-Coulomb | 120 | 0 | 30 |
| | Geosynthetics | Mohr-Coulomb | 58 | 0 | 24.3 |
| | Subbase | Mohr-Coulomb | 120 | 0 | 30 |

**Title: Columbia Mod 10-11 Final Grade**
**Name: 3_Block**
**Method: Janbu**
**Last Edited By: Suchomel, Brandon**

**F of S: 2.143, F of S Rank (Analysis): 1 of 65,536 slip surfaces**
**Last Solved Date: 5/4/2022, Last Solved Time: 6:10:13 PM**

# 3_Block

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## File Information

File Version: 8.16
Title: Columbia Mod 10-11 Final Grade
Created By: Suchomel, Brandon
Last Edited By: Suchomel, Brandon
Revision Number: 76
Date: 5/4/2022
Time: 6:09:17 PM
Tool Version: 8.16.3.14580
File Name: Columbia Mod 10-11 Final Grade.gsz
Directory: I:\25220183.00\Data and Calculations_Issued for Permitting POO Geotech Calculations\Slope Stability\
Last Solved Date: 5/4/2022
Last Solved Time: 6:10:13 PM

## Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

## Analysis Settings

### 3_Block

Kind: SLOPE/W
Method: Janbu
Settings
    PWP Conditions Source: (none)
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 10
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Restrict Block Crossing: No
    Optimize Critical Slip Surface Location: No
    Tension Crack
        Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced

Number of Slices: 150
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

# Materials

## CCR

Model: Mohr-Coulomb
Unit Weight: 86 pcf
Cohesion': 0 psf
Phi': 22.7 °
Phi-B: 0 °

## Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

## Drainage Layer

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Geosynthetics

Model: Mohr-Coulomb
Unit Weight: 58 pcf
Cohesion': 0 psf
Phi': 24.3 °
Phi-B: 0 °

## Subbase

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

## Final Cover

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

# Slip Surface Limits

Left Coordinate: (0, 893.8) ft
Right Coordinate: (613, 816.8) ft

# Slip Surface Block

Left Grid
- Upper Left: (256.72, 806.35) ft
- Lower Left: (256.72, 806.22) ft
- Lower Right: (266.56, 806.28) ft
- X Increments: 15
- Y Increments: 3
- Starting Angle: 115 °
- Ending Angle: 135 °
- Angle Increments: 3

Right Grid
- Upper Left: (398.42, 807.26) ft
- Lower Left: (398.42, 807.12) ft
- Lower Right: (406.38, 807.17) ft
- X Increments: 15
- Y Increments: 3
- Starting Angle: 0 °
- Ending Angle: 45 °
- Angle Increments: 3

# Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 0 | 808.8 |
| Point 2 | 187.7 | 806 |
| Point 3 | 196.4 | 804.2 |
| Point 4 | 205.1 | 805.9 |
| Point 5 | 406.3 | 807.2 |
| Point 6 | 418.1 | 803.9 |
| Point 7 | 421.7 | 803.9 |
| Point 8 | 433.9 | 807.3 |
| Point 9 | 463 | 807.5 |
| Point 10 | 497.4 | 817.3 |
| Point 11 | 0 | 806.8 |
| Point 12 | 187.7 | 804 |
| Point 13 | 196.4 | 802.2 |
| Point 14 | 205.1 | 803.9 |
| Point 15 | 406.3 | 805.2 |
| Point 16 | 418.1 | 801.9 |
| Point 17 | 421.7 | 801.9 |
| Point 18 | 433.9 | 805.3 |
| Point 19 | 463 | 805.5 |
| Point 20 | 504.6 | 817.3 |
| Point 21 | 0 | 809.8 |
| Point 22 | 187.7 | 807 |
| Point 23 | 205.1 | 806.9 |
| Point 24 | 406.3 | 808.2 |
| Point 25 | 433.9 | 808.3 |
| Point 26 | 463 | 808.5 |
| Point 27 | 494 | 817.3 |

| | | |
|---|---|---|
| Point 28 | 0 | 891.3 |
| Point 29 | 40.4 | 900 |
| Point 30 | 106.1 | 905.7 |
| Point 31 | 163.7 | 900 |
| Point 32 | 0 | 893.8 |
| Point 33 | 40.4 | 902.5 |
| Point 34 | 106.1 | 908.2 |
| Point 35 | 163.7 | 902.5 |
| Point 36 | 509.3 | 817.3 |
| Point 37 | 521.2 | 814.8 |
| Point 38 | 535.6 | 814.8 |
| Point 39 | 553.1 | 817.2 |
| Point 40 | 613 | 816.8 |
| Point 41 | 0 | 780 |
| Point 42 | 613 | 780 |
| Point 43 | 497 | 817.3 |
| Point 44 | 0 | 808.9 |
| Point 45 | 187.7 | 806.1 |
| Point 46 | 196.4 | 804.3 |
| Point 47 | 205.1 | 806 |
| Point 48 | 406.3 | 807.3 |
| Point 49 | 418.1 | 804 |
| Point 50 | 421.7 | 804 |
| Point 51 | 433.9 | 807.4 |
| Point 52 | 463 | 807.6 |

## Regions

| | Material | Points | Area (ft²) |
|---|---|---|---|
| Region 1 | Subbase | 41,11,12,13,14,15,16,17,18,19,20,36,37,38,39,40,42 | 16,750 |
| Region 2 | Clay | 11,1,2,3,4,5,6,7,8,9,10,20,19,18,17,16,15,14,13,12 | 1,002.9 |
| Region 3 | Geosynthetics | 1,44,45,46,47,48,49,50,51,52,43,10,9,8,7,6,5,4,3,2 | 49.96 |
| Region 4 | Drainage Layer | 44,21,22,23,24,25,26,27,43,52,51,50,49,48,47,46,45 | 512.68 |
| Region 5 | CCR | 21,28,29,30,31,10,43,27,26,25,24,23,22 | 31,970 |
| Region 6 | Final Cover | 28,32,33,34,35,36,20,10,31,30,29 | 1,333.3 |

## Current Slip Surface

Slip Surface: 18,298
F of S: 2.143
Volume: 12,851.682 ft³
Weight: 1,137,317.2 lbs
Resisting Force: 483,744.11 lbs
Activating Force: 225,710.24 lbs
F of S Rank (Analysis): 1 of 65,536 slip surfaces
F of S Rank (Query): 1 of 65,536 slip surfaces
Exit: (475.02664, 825.74934) ft
Entry: (160.86254, 902.78079) ft
Radius: 153.63542 ft
Center: (332.11038, 922.03865) ft

## Slip Slices

| | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|
| Slice 1 | 162.28127 | 901.36206 | 0 | 120.84936 | 69.772411 | 0 |
| Slice 2 | 164.75354 | 898.88979 | 0 | 312.2515 | 130.61763 | 0 |
| Slice 3 | 166.86063 | 896.7827 | 0 | 426.57116 | 178.43858 | 0 |
| Slice 4 | 168.96772 | 894.67562 | 0 | 540.89082 | 226.25953 | 0 |
| Slice 5 | 171.0748 | 892.56853 | 0 | 655.21047 | 274.08048 | 0 |
| Slice 6 | 173.18189 | 890.46145 | 0 | 769.53013 | 321.90143 | 0 |
| Slice 7 | 175.28897 | 888.35436 | 0 | 883.84978 | 369.72237 | 0 |
| Slice 8 | 177.39606 | 886.24727 | 0 | 998.16944 | 417.54332 | 0 |
| Slice 9 | 179.50315 | 884.14019 | 0 | 1,112.4891 | 465.36427 | 0 |
| Slice 10 | 181.61023 | 882.0331 | 0 | 1,226.8088 | 513.18522 | 0 |
| Slice 11 | 183.71732 | 879.92601 | 0 | 1,341.1284 | 561.00617 | 0 |
| Slice 12 | 185.82441 | 877.81893 | 0 | 1,455.4481 | 608.82711 | 0 |
| Slice 13 | 187.93149 | 875.71184 | 0 | 1,569.7677 | 656.64806 | 0 |
| Slice 14 | 190.03858 | 873.60475 | 0 | 1,684.0874 | 704.46901 | 0 |
| Slice 15 | 192.14566 | 871.49767 | 0 | 1,798.407 | 752.28996 | 0 |
| Slice 16 | 194.25275 | 869.39058 | 0 | 1,912.7267 | 800.11091 | 0 |
| Slice 17 | 196.35984 | 867.2835 | 0 | 2,027.0463 | 847.93185 | 0 |
| Slice 18 | 198.46692 | 865.17641 | 0 | 2,141.366 | 895.7528 | 0 |
| Slice 19 | 200.57401 | 863.06932 | 0 | 2,255.6857 | 943.57375 | 0 |
| Slice 20 | 202.6811 | 860.96224 | 0 | 2,370.0053 | 991.3947 | 0 |
| Slice 21 | 204.78818 | 858.85515 | 0 | 2,484.325 | 1,039.2156 | 0 |
| Slice 22 | 206.89527 | 856.74806 | 0 | 2,598.6446 | 1,087.0366 | 0 |
| Slice 23 | 209.00235 | 854.64098 | 0 | 2,712.9643 | 1,134.8575 | 0 |
| Slice 24 | 211.10944 | 852.53389 | 0 | 2,827.2839 | 1,182.6785 | 0 |
| Slice 25 | 213.21653 | 850.42681 | 0 | 2,941.6036 | 1,230.4994 | 0 |
| Slice 26 | 215.32361 | 848.31972 | 0 | 3,055.9232 | 1,278.3204 | 0 |
| Slice 27 | 217.4307 | 846.21263 | 0 | 3,170.2429 | 1,326.1413 | 0 |
| Slice 28 | 219.53779 | 844.10555 | 0 | 3,284.5626 | 1,373.9623 | 0 |
| Slice 29 | 221.64487 | 841.99846 | 0 | 3,398.8822 | 1,421.7832 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 30 | 223.75196 | 839.89137 | 0 | 3,513.2019 | 1,469.6042 | 0 |
| Slice 31 | 225.85905 | 837.78429 | 0 | 3,627.5215 | 1,517.4251 | 0 |
| Slice 32 | 227.96613 | 835.6772 | 0 | 3,741.8412 | 1,565.2461 | 0 |
| Slice 33 | 230.07322 | 833.57012 | 0 | 3,856.1608 | 1,613.067 | 0 |
| Slice 34 | 232.1803 | 831.46303 | 0 | 3,970.4805 | 1,660.888 | 0 |
| Slice 35 | 234.28739 | 829.35594 | 0 | 4,084.8002 | 1,708.7089 | 0 |
| Slice 36 | 236.39448 | 827.24886 | 0 | 4,199.1198 | 1,756.5299 | 0 |
| Slice 37 | 238.50156 | 825.14177 | 0 | 4,313.4395 | 1,804.3508 | 0 |
| Slice 38 | 240.60865 | 823.03468 | 0 | 4,427.7591 | 1,852.1718 | 0 |
| Slice 39 | 242.71574 | 820.9276 | 0 | 4,542.0788 | 1,899.9927 | 0 |
| Slice 40 | 244.82282 | 818.82051 | 0 | 4,656.3984 | 1,947.8137 | 0 |
| Slice 41 | 246.92991 | 816.71343 | 0 | 4,770.7181 | 1,995.6346 | 0 |
| Slice 42 | 249.03699 | 814.60634 | 0 | 4,885.0377 | 2,043.4556 | 0 |
| Slice 43 | 251.14408 | 812.49925 | 0 | 4,999.3574 | 2,091.2765 | 0 |
| Slice 44 | 253.25117 | 810.39217 | 0 | 5,113.6771 | 2,139.0975 | 0 |
| Slice 45 | 255.35825 | 808.28508 | 0 | 5,227.9967 | 2,186.9184 | 0 |
| Slice 46 | 256.85891 | 806.78443 | 0 | 5,009.3458 | 2,892.1472 | 0 |
| Slice 47 | 258.3866 | 806.30899 | 0 | 6,344.487 | 2,864.6457 | 0 |
| Slice 48 | 260.51276 | 806.28732 | 0 | 6,343.6373 | 2,864.2621 | 0 |
| Slice 49 | 262.60393 | 806.30064 | 0 | 6,298.1818 | 2,843.7381 | 0 |
| Slice 50 | 264.69511 | 806.31397 | 0 | 6,252.7263 | 2,823.2142 | 0 |
| Slice 51 | 266.78628 | 806.32729 | 0 | 6,207.2708 | 2,802.6902 | 0 |
| Slice 52 | 268.87746 | 806.34061 | 0 | 6,161.8153 | 2,782.1663 | 0 |
| Slice 53 | 270.96863 | 806.35394 | 0 | 6,116.3598 | 2,761.6423 | 0 |
| Slice 54 | 273.0598 | 806.36726 | 0 | 6,070.9043 | 2,741.1184 | 0 |
| Slice 55 | 275.15098 | 806.38059 | 0 | 6,025.4488 | 2,720.5945 | 0 |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 56 | 277.24215 | 806.39391 | 0 | 5,979.9933 | 2,700.0705 | 0 |
| Slice 57 | 279.33332 | 806.40723 | 0 | 5,934.5378 | 2,679.5466 | 0 |
| Slice 58 | 281.4245 | 806.42056 | 0 | 5,889.0823 | 2,659.0226 | 0 |
| Slice 59 | 283.51567 | 806.43388 | 0 | 5,843.6268 | 2,638.4987 | 0 |
| Slice 60 | 285.60685 | 806.44721 | 0 | 5,798.1713 | 2,617.9747 | 0 |
| Slice 61 | 287.69802 | 806.46053 | 0 | 5,752.7158 | 2,597.4508 | 0 |
| Slice 62 | 289.78919 | 806.47385 | 0 | 5,707.2603 | 2,576.9268 | 0 |
| Slice 63 | 291.88037 | 806.48718 | 0 | 5,661.8048 | 2,556.4029 | 0 |
| Slice 64 | 293.97154 | 806.5005 | 0 | 5,616.3493 | 2,535.8789 | 0 |
| Slice 65 | 296.06271 | 806.51383 | 0 | 5,570.8938 | 2,515.355 | 0 |
| Slice 66 | 298.15389 | 806.52715 | 0 | 5,525.4383 | 2,494.831 | 0 |
| Slice 67 | 300.24506 | 806.54047 | 0 | 5,479.9827 | 2,474.3071 | 0 |
| Slice 68 | 302.33623 | 806.5538 | 0 | 5,434.5272 | 2,453.7831 | 0 |
| Slice 69 | 304.42741 | 806.56712 | 0 | 5,389.0717 | 2,433.2592 | 0 |
| Slice 70 | 306.51858 | 806.58045 | 0 | 5,343.6162 | 2,412.7352 | 0 |
| Slice 71 | 308.60976 | 806.59377 | 0 | 5,298.1607 | 2,392.2113 | 0 |
| Slice 72 | 310.70093 | 806.60709 | 0 | 5,252.7052 | 2,371.6874 | 0 |
| Slice 73 | 312.7921 | 806.62042 | 0 | 5,207.2497 | 2,351.1634 | 0 |
| Slice 74 | 314.88328 | 806.63374 | 0 | 5,161.7942 | 2,330.6395 | 0 |
| Slice 75 | 316.97445 | 806.64707 | 0 | 5,116.3387 | 2,310.1155 | 0 |
| Slice 76 | 319.06562 | 806.66039 | 0 | 5,070.8832 | 2,289.5916 | 0 |
| Slice 77 | 321.1568 | 806.67371 | 0 | 5,025.4277 | 2,269.0676 | 0 |
| Slice 78 | 323.24797 | 806.68704 | 0 | 4,979.9722 | 2,248.5437 | 0 |
| Slice 79 | 325.33915 | 806.70036 | 0 | 4,934.5167 | 2,228.0197 | 0 |
| Slice 80 | 327.43032 | 806.71369 | 0 | 4,889.0612 | 2,207.4958 | 0 |
| Slice 81 | 329.52149 | 806.72701 | 0 | 4,843.6057 | 2,186.9718 | 0 |
| Slice | 331.61267 | 806.74033 | 0 | 4,798.1502 | 2,166.4479 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 82 | | | | | | |
| Slice 83 | 333.70384 | 806.75366 | 0 | 4,752.6947 | 2,145.9239 | 0 |
| Slice 84 | 335.79501 | 806.76698 | 0 | 4,707.2392 | 2,125.4 | 0 |
| Slice 85 | 337.88619 | 806.78031 | 0 | 4,661.7837 | 2,104.876 | 0 |
| Slice 86 | 339.97736 | 806.79363 | 0 | 4,616.3282 | 2,084.3521 | 0 |
| Slice 87 | 342.06854 | 806.80695 | 0 | 4,570.8727 | 2,063.8281 | 0 |
| Slice 88 | 344.15971 | 806.82028 | 0 | 4,525.4172 | 2,043.3042 | 0 |
| Slice 89 | 346.25088 | 806.8336 | 0 | 4,479.9617 | 2,022.7802 | 0 |
| Slice 90 | 348.34206 | 806.84692 | 0 | 4,434.5062 | 2,002.2563 | 0 |
| Slice 91 | 350.43323 | 806.86025 | 0 | 4,389.0506 | 1,981.7324 | 0 |
| Slice 92 | 352.5244 | 806.87357 | 0 | 4,343.5951 | 1,961.2084 | 0 |
| Slice 93 | 354.61558 | 806.8869 | 0 | 4,298.1396 | 1,940.6845 | 0 |
| Slice 94 | 356.70675 | 806.90022 | 0 | 4,252.6841 | 1,920.1605 | 0 |
| Slice 95 | 358.79792 | 806.91354 | 0 | 4,207.2286 | 1,899.6366 | 0 |
| Slice 96 | 360.8891 | 806.92687 | 0 | 4,161.7731 | 1,879.1126 | 0 |
| Slice 97 | 362.98027 | 806.94019 | 0 | 4,116.3176 | 1,858.5887 | 0 |
| Slice 98 | 365.07145 | 806.95352 | 0 | 4,070.8621 | 1,838.0647 | 0 |
| Slice 99 | 367.16262 | 806.96684 | 0 | 4,025.4066 | 1,817.5408 | 0 |
| Slice 100 | 369.25379 | 806.98016 | 0 | 3,979.9511 | 1,797.0168 | 0 |
| Slice 101 | 371.34497 | 806.99349 | 0 | 3,934.4956 | 1,776.4929 | 0 |
| Slice 102 | 373.43614 | 807.00681 | 0 | 3,889.0401 | 1,755.9689 | 0 |
| Slice 103 | 375.52731 | 807.02014 | 0 | 3,843.5846 | 1,735.445 | 0 |
| Slice 104 | 377.61849 | 807.03346 | 0 | 3,798.1291 | 1,714.921 | 0 |
| Slice 105 | 379.70966 | 807.04678 | 0 | 3,752.6736 | 1,694.3971 | 0 |
| Slice 106 | 381.80084 | 807.06011 | 0 | 3,707.2181 | 1,673.8731 | 0 |
| Slice 107 | 383.89201 | 807.07343 | 0 | 3,661.7626 | 1,653.3492 | 0 |
| Slice 108 | 385.98318 | 807.08676 | 0 | 3,616.3071 | 1,632.8253 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 109 | 388.07436 | 807.10008 | 0 | 3,570.8516 | 1,612.3013 | 0 |
| Slice 110 | 390.16553 | 807.1134 | 0 | 3,525.3961 | 1,591.7774 | 0 |
| Slice 111 | 392.2567 | 807.12673 | 0 | 3,479.9406 | 1,571.2534 | 0 |
| Slice 112 | 394.34788 | 807.14005 | 0 | 3,434.4851 | 1,550.7295 | 0 |
| Slice 113 | 396.43905 | 807.15338 | 0 | 3,389.0296 | 1,530.2055 | 0 |
| Slice 114 | 398.53023 | 807.1667 | 0 | 3,343.5741 | 1,509.6816 | 0 |
| Slice 115 | 400.6214 | 807.18002 | 0 | 3,298.1185 | 1,489.1576 | 0 |
| Slice 116 | 402.71257 | 807.19335 | 0 | 3,252.663 | 1,468.6337 | 0 |
| Slice 117 | 404.80375 | 807.20667 | 0 | 3,207.2075 | 1,448.1097 | 0 |
| Slice 118 | 406.00948 | 807.25625 | 0 | 3,364.1808 | 1,518.9859 | 0 |
| Slice 119 | 406.23482 | 807.31662 | 0 | 3,411.2113 | 1,969.4637 | 0 |
| Slice 120 | 407.11898 | 807.55353 | 0 | 3,361.7917 | 1,940.9313 | 0 |
| Slice 121 | 408.75694 | 807.99242 | 0 | 3,270.2285 | 1,888.0673 | 0 |
| Slice 122 | 410.60729 | 808.48822 | 0 | 3,108.7021 | 1,300.3983 | 0 |
| Slice 123 | 412.67002 | 809.04093 | 0 | 3,012.497 | 1,260.1548 | 0 |
| Slice 124 | 414.73275 | 809.59364 | 0 | 2,916.292 | 1,219.9114 | 0 |
| Slice 125 | 416.79548 | 810.14634 | 0 | 2,820.0869 | 1,179.6679 | 0 |
| Slice 126 | 418.85821 | 810.69905 | 0 | 2,723.8818 | 1,139.4244 | 0 |
| Slice 127 | 420.92094 | 811.25176 | 0 | 2,627.6767 | 1,099.181 | 0 |
| Slice 128 | 422.98367 | 811.80447 | 0 | 2,531.4717 | 1,058.9375 | 0 |
| Slice 129 | 425.0464 | 812.35717 | 0 | 2,435.2666 | 1,018.6941 | 0 |
| Slice 130 | 427.10913 | 812.90988 | 0 | 2,339.0615 | 978.45063 | 0 |
| Slice 131 | 429.17187 | 813.46259 | 0 | 2,242.8564 | 938.20717 | 0 |
| Slice 132 | 431.2346 | 814.01529 | 0 | 2,146.6514 | 897.96372 | 0 |
| Slice 133 | 433.29733 | 814.568 | 0 | 2,050.4463 | 857.72026 | 0 |
| Slice 134 | 435.36006 | 815.12071 | 0 | 1,954.2412 | 817.47681 | 0 |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Slice 135 | 437.42279 | 815.67342 | 0 | 1,858.0361 | 777.23335 | 0 |
| Slice 136 | 439.48552 | 816.22612 | 0 | 1,761.8311 | 736.9899 | 0 |
| Slice 137 | 441.54825 | 816.77883 | 0 | 1,665.626 | 696.74645 | 0 |
| Slice 138 | 443.61098 | 817.33154 | 0 | 1,569.4209 | 656.50299 | 0 |
| Slice 139 | 445.67371 | 817.88424 | 0 | 1,473.2158 | 616.25954 | 0 |
| Slice 140 | 447.73645 | 818.43695 | 0 | 1,377.0108 | 576.01608 | 0 |
| Slice 141 | 449.79918 | 818.98966 | 0 | 1,280.8057 | 535.77263 | 0 |
| Slice 142 | 451.86191 | 819.54237 | 0 | 1,184.6006 | 495.52917 | 0 |
| Slice 143 | 453.92464 | 820.09507 | 0 | 1,088.3955 | 455.28572 | 0 |
| Slice 144 | 455.98737 | 820.64778 | 0 | 992.19047 | 415.04227 | 0 |
| Slice 145 | 458.0501 | 821.20049 | 0 | 895.9854 | 374.79881 | 0 |
| Slice 146 | 460.11283 | 821.75319 | 0 | 799.78033 | 334.55536 | 0 |
| Slice 147 | 462.17556 | 822.3059 | 0 | 703.57525 | 294.3119 | 0 |
| Slice 148 | 464.23829 | 822.85861 | 0 | 607.37018 | 254.06845 | 0 |
| Slice 149 | 466.30102 | 823.41132 | 0 | 511.1651 | 213.82499 | 0 |
| Slice 150 | 468.36376 | 823.96402 | 0 | 414.96003 | 173.58154 | 0 |
| Slice 151 | 470.33371 | 824.49187 | 0 | 312.26526 | 180.28643 | 0 |
| Slice 152 | 472.21088 | 824.99486 | 0 | 187.35915 | 108.17186 | 0 |
| Slice 153 | 474.08805 | 825.49784 | 0 | 62.453052 | 36.057286 | 0 |

# Appendix A8

# Seepage Potential and Karst Condition Assessment

# Seepage Potential and Karst Condition Assessment

The disposal facility is designed and constructed to include storm water run-on and run-off management and leachate collection systems. The liner system is designed and constructed to be above the high groundwater level. There are currently no concerns that storm water, leachate, or groundwater movement will impact the stability of the landfill.

As noted in Appendix A4, karst features were not observed in the borings within and adjacent to the disposal facility. The borings encountered sandstone bedrock that is not subject to karst conditions. The Wisconsin map of karst and shallow carbonate bedrock in Appendix A4 indicates that karst structures are not located in or near the disposal facility.

# Appendix A9

# FEMA Flood Insurance Rate Map

NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 NORTH, RANGE 9 EAST.

## FLOOD HAZARD INFORMATION

**SEE FIS REPORT FOR ZONE DESCRIPTIONS AND INDEX MAP**

**THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT**

**HTTP://MSC.FEMA.GOV**

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A,V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes. *Zone X*

**OTHER AREAS**
- NO SCREEN — Areas Determined to be Outside the 0.2% Annual Chance Floodplain *Zone X*
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Accredited or Provisionally Accredited Levee, Dike, or Floodwall
- Non-accredited Levee, Dike, or Floodwall

**OTHER FEATURES**
- E 18.2 / 17.5 — Cross Sections with 1% Annual Chance Water Surface Elevation (BFE)
- 8 — Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 — Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

## NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Map Service Center at the number listed above.

For community and countywide map dates refer to the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in the community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Base map information shown on this FIRM was provided by the Wisconsin Regional Orthophotography Consortium (WROC). The aerial photography was acquired in the spring of 2010 to create 1":1000' scale digital orthophotos with 18-inch resolution.

## SCALE

N

**Map Projection:**
NAD 1983 HARN UTM Zone 16N;
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet 1:6,000

0 500 1,000 2,000 Feet

0 125 250 500 Meters

## PANEL LOCATOR

* PANEL NOT PRINTED

**NATIONAL FLOOD INSURANCE PROGRAM**
**FLOOD INSURANCE RATE MAP**

**COLUMBIA COUNTY, WISCONSIN**
AND INCORPORATED AREAS

PANEL 381 OF 620

FEMA

Panel Contains:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| COLUMBIA COUNTY | 550581 | 0381 | F |

**VERSION NUMBER**
2.2.2.1

**MAP NUMBER**
55021C0381F

**MAP REVISED**
May 16, 2016

# Appendix B

# Landfill Design Demonstration

# Appendix B1

# Storm Water Management Calculations for Post Closure Conditions

# Appendix B1.1

# 2000 Plan of Operation Update Storm Water Calculations

# SURFACE WATER MANAGEMENT CALCULATIONS
# COLUMBIA DRY ASH DISPOSAL FACILITY

## PURPOSE:

The purpose of the surface water runoff calculations is to demonstrate that the surface water control features incorporated into the proposed design will collect and transfer surface water from the landfill in a controlled manner and will minimize erosion. The surface water runoff calculations were performed for the western half (Phase 1) of the landfill, which this 10-year Plan of Operation Update report addresses.

## SITE GEOMETRY:

The surface water runoff from Phase 1 of the landfill will be routed to the existing South Sedimentation Basin. Diversion berms, downslope channels, and perimeter ditches are incorporated into the design to route the surface water to the southwestern corner of the landfill, where it is then routed to the South Sedimentation Basin. The South Sedimentation Basin was constructed during construction of Module 1 North. The south sedimentation pond discharges to a wetland area to the south of the pond.

## METHODOLOGIES:

The following methods and procedures were used to demonstrate that the proposed surface water control features will collect and transfer surface water in controlled manner and minimize erosion potential:

Hydrograph Generation

Peak stormwater flows for the 25-year, 24-hour and 100-year, 24-hour storm events were calculated using the Quick TR-55 computer model developed by the National Resources Conservation Service (NRCS) (formerly known as the Soil Conservation Service (SCS)). The Quick TR-55 methods for computing hydrographs are based on the methodologies presented in the Urban Hydrology for Small Watersheds manual. The Quick TR-55 model is designed to simulate the surface runoff response of a watershed to a precipitation event. Input parameters for the model include precipitation depth for a particular storm event, contributing drainage areas, runoff curve numbers, and time of concentration.

The time of concentration calculations combine overland flow time (i.e., sheet flow), shallow concentrated flow time, and channel flow time. Curve numbers for a specified drainage area were also calculated using the methodologies and tables presented in TR-55 (see **Reference** section at the end of this appendix).

Diversion Berm, Downslope Channels, and Perimeter Ditch Sizing

These control structures are sized to channel the peak storm runoff to the sedimentation basin while maintaining low enough velocities to limit the erosion potential. The proposed design allows storm water which comes into contact with the final cover to be routed by diversion berms and downslope channels to the perimeter ditches, which will then transport the water to the south sedimentation basin.

Diversion berm, downslope channels, and perimeter ditch locations and details are shown on the Plan Sheets. A portion of the perimeter ditch along the western side of the landfill was constructed as part of the construction of Module 1 North.

In conjunction with the graphical peak discharge methods as presented in TR-55, the Flowmaster computer modeling program was used to assist in the design of these control structures. This program allows the user to input the channel geometry, the slope of the channel, an estimated Manning's "n" value for the channel, and the peak flow in the channel. The program then determines the peak flow depth and the peak velocity for the given geometry of the control feature.

The diversion berms, downslope channels, and perimeter ditches were sized by calculating the peak flow each structure would have to manage in a worst-case design scenario (i.e., surface water runoff from the largest area of landfill final cover during the 25-year, 24-hour storm event). The drainage structure was modeled using the Flowmaster computer model to verify channel depth and velocity in the structure.

Sedimentation Pond Sizing

The sedimentation pond sizing process involved determining the proper ratio of surface area to flowrate that would allow a 15 micron particle size to settle out during a design storm event.

A table presented in the Erosion and Sediment Control Handbook (Goldman et al., 1986) provides the surface area-to-discharge ratios required to achieve settlement of the desired particle sizes (see the **Reference** section of this appendix).

The Pond Pack 6.0 computer program was used in conjunction with accepted formulas and engineering calculations to size the sedimentation basins. Calculations were performed to determine the performance of the basins as follows:

1. The inflow hydrograph for the basin was calculated as part of the hydrograph computations. The regulations require that sediment basins be sized for a 25-year, 6-hour storm event. Sediment basin calculations for the Alliant Columbia Ash Disposal Facility were based on the basin's peak discharge during the 25-year, 24-hour storm which equals or exceeds the basin inflow for average rainfall intensity of the 25-year, 6-hour storm.

2. Outlet structures were designed to provide the necessary detention of peak stormwater runoff from the final cover for the 25-year, 24-hour storm event.

3. The inflow hydrograph was routed through the sedimentation pond using the Pond Pack 6.0 program to determine the basin's peak water elevation and discharge during the 25-year, 24-hour storm.

4. The emergency spillways for the sedimentation basins were sized for the 100-year, 24-hour storm event.

## ASSUMPTIONS:

Summarized below are some of the major assumptions and data used in the computations:

1. Due to the presence of a drainage layer in the proposed landfill final cover, the soil for the landfill area was modeled between a Type B and C soil to account for greater water infiltration

through the cover. The final cover was modeled as a grassland in good condition, which resulted in a runoff curve number of 67.5.

2. SCS Type II storm was selected according to SCS storm distribution maps for the United States.

3. A 2-year, 24-hour storm event in the vicinity of the facility equates to 2.7 inches according to figures provided in TR-55.

4. A 25-year, 24-hour storm event in the vicinity of the facility equates to 4.7 inches according to precipitation data provided in TR-55.

5. A 100-year, 24-hour storm event in the vicinity of the facility equates to 5.9 inches according to precipitation data provided in TR-55.

6. Grass-lined berms and channels were designed for a maximum velocity of 4 feet per second (fps).

7. A Manning's "n" value of 0.045 was used to model a grass-lined berm or channel, as provided by the parameters set in the Flowmaster model.

8. Depths of channels were designed to be a minimum of 1 foot, with a minimum freeboard of 0.5 foot. Depths of diversion berms were designated to be a minimum of 2 feet, with a minimum of 0.5 foot of freeboard.

9. A 15-micron particle was targeted to be settled out of the water column. The 15-micron particle is classified as a medium-fine silt by the AASHTO Soil Classification System.

## SURFACE WATER MANAGEMENT CALCULATIONS (CONTINUED)
## COLUMBIA DRY ASH DISPOSAL FACILITY

**RESULTS:**

Based on the results of the surface water runoff computations presented in this appendix, the proposed surface water control features will adequately handle the runoff from a 25-year, 24-hour storm event while minimizing erosion. The drainage features will be constructed as shown on the Plan Sheets.

All diversion berms and perimeter ditches will maintain greater than 0.5 foot of freeboard during the design storm event. The sedimentation basins will settle out particles 15 microns and larger in diameter and will dewater in no less than three days. The detailed calculations are included with this appendix.

I:\1370\Reports\surface water calcs writeup.wpd

# Time of Concentration Calculations

File.... I:\1370\Columbia.ppk
Title... Landfill runoff to south basin

Landfill Area (1/2)

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Landfill runoff to south basin
---

Segment #1: Tc: TR-55 Sheet
Description: final cover slope

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .050000 | ft/ft |

Avg.Velocity .17 ft/sec

Segment #1 Time: .0989 hrs
---

Segment #2: Tc: TR-55 Sheet
Description: final cover slope

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .250000 | ft/ft |

Avg.Velocity .32 ft/sec

Segment #2 Time: .0520 hrs
---

Segment #3: Tc: TR-55 Shallow
Description: diversion berm

| | | |
|---|---|---|
| Hydraulic Length | 1530.00 | ft |
| Slope | .020000 | ft/ft |

Unpaved

Avg.Velocity 2.28 ft/sec

Segment #3 Time: .1863 hrs
---

Type.... Tc Calcs
Name.... LF TO S BASIN

File.... I:\1370\Columbia.ppk
Title... Landfill runoff to south basin

Landfill Area (2/2)

Segment #4: Tc: TR-55 Channel
Description: perimeter ditch

| | | |
|---|---|---|
| Flow Area | 32.0000 | sq.ft |
| Wetted Perimeter | 22.60 | ft |
| Hydraulic Radius | 1.42 | ft |
| Slope | .006000 | ft/ft |
| Mannings n | .0300 | |
| Hydraulic Length | 320.00 | ft |
| Avg.Velocity | 4.85 | ft/sec |

Segment #4 Time: .0183 hrs

---

==========
Total Tc: .3555 hrs
==========

West peripheral area leading to west perimeter ditch (1/2)

Type.... Tc Calcs
Name.... PERIPH TO S BASI

File.... I:\1370\COLUMBIA.PPK
Title... Peripheral area to south basin (area outside of LF leading to basin)

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Peripheral area to south basin (area outside of LF leading to basin)

Segment #1: Tc: TR-55 Sheet
Description: flow into ditch

| | |
|---|---|
| Mannings n | .1900 |
| Hydraulic Length | 10.00 ft |
| 2yr, 24hr P | 2.7000 in |
| Slope | .330000 ft/ft |
| Avg.Velocity | .25 ft/sec |

Segment #1 Time: .0111 hrs

Segment #2: Tc: TR-55 Channel
Description: flow along perimeter ditch

| | |
|---|---|
| Flow Area | 22.0000 sq.ft |
| Wetted Perimeter | 17.60 ft |
| Hydraulic Radius | 1.25 ft |
| Slope | .006000 ft/ft |
| Mannings n | .0300 |
| Hydraulic Length | 800.00 ft |
| Avg.Velocity | 4.46 ft/sec |

Segment #2 Time: .0498 hrs

Segment #3: Tc: TR-55 Channel
Description: flow along perimeter ditch

| | |
|---|---|
| Flow Area | 57.0000 sq.ft |
| Wetted Perimeter | 29.00 ft |
| Hydraulic Radius | 1.97 ft |
| Slope | .006000 ft/ft |
| Mannings n | .0300 |
| Hydraulic Length | 1010.00 ft |
| Avg.Velocity | 6.04 ft/sec |

Segment #3 Time: .0465 hrs

Type.... Tc Calcs
Name.... PERIPH TO S BASI

West peripheral area leading to west perimeter ditch (2/2)

File.... I:\1370\COLUMBIA.PPK
Title... Peripheral area to south basin (area outside of LF leading to basin)

==========
Total Tc: .1073 hrs
==========

Type.... Tc Calcs
Name.... E PERIPHERAL

Northeast peripheral area leading to east perimeter ditch (1/1)

File.... I:\1370\COLUMBIA.PPK
Title... Eastern peripheral area (north of leachate basin) leading to east ditch

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Eastern peripheral area (north of leachate basin) leading to east ditch
---

Segment #1: Tc: TR-55 Sheet

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 40.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .425000 | ft/ft |
| Avg.Velocity | .37 | ft/sec |

Segment #1 Time: .0304 hrs

---

Segment #2: Tc: TR-55 Sheet

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 260.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .023000 | ft/ft |
| Avg.Velocity | .17 | ft/sec |

Segment #2 Time: .4362 hrs

---

Segment #3: Tc: TR-55 Shallow

| | | |
|---|---|---|
| Hydraulic Length | 520.00 | ft |
| Slope | .014000 | ft/ft |
| Unpaved | | |
| Avg.Velocity | 1.91 | ft/sec |

Segment #3 Time: .0757 hrs

---

==========
Total Tc: .5423 hrs
==========

S/N: H0M0L0862791 BT 2, Inc
Pond Pack Ver: 8-01-98 (61) Compute Time: 14:58:36 Date: 08-29-2000

Type.... Tc Calcs
Name.... BASIN PERIPHERAL

Southeast/South peripheral area leading to south perimeter ditch (1/2)

File.... I:\1370\COLUMBIA.PPK
Title... South peripheral area to south perimeter ditch

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

South peripheral area to south perimeter ditch
---

Segment #1: Tc: TR-55 Sheet

| | |
|---|---|
| Mannings n | .1900 |
| Hydraulic Length | 300.00 ft |
| 2yr, 24hr P | 2.7000 in |
| Slope | .010000 ft/ft |
| Avg.Velocity | .12 ft/sec |

Segment #1 Time: .6825 hrs

---

Segment #2: Tc: TR-55 Shallow

| | |
|---|---|
| Hydraulic Length | 110.00 ft |
| Slope | .096000 ft/ft |
| Unpaved | |
| Avg.Velocity | 5.00 ft/sec |

Segment #2 Time: .0061 hrs

---

Segment #3: Tc: TR-55 Shallow

| | |
|---|---|
| Hydraulic Length | 550.00 ft |
| Slope | .022000 ft/ft |
| Unpaved | |
| Avg.Velocity | 2.39 ft/sec |

Segment #3 Time: .0638 hrs

---

Type.... Tc Calcs
Name.... BASIN PERIPHERAL

Southeast/South peripheral area leading to south perimeter ditch (2|2)

File.... I:\1370\COLUMBIA.PPK
Title... South peripheral area to south perimeter ditch

Segment #4: Tc: TR-55 Channel
Description: flow along south perimeter ditch

| | | |
|---|---|---|
| Flow Area | 100.0000 | sq.ft |
| Wetted Perimeter | 32.40 | ft |
| Hydraulic Radius | 3.09 | ft |
| Slope | .012000 | ft/ft |
| Mannings n | .0300 | |
| Hydraulic Length | 1030.00 | ft |
| Avg.Velocity | 11.53 | ft/sec |

Segment #4 Time: .0248 hrs

---

Total Tc: .7773 hrs

Equations used by PondPack to calculate Tc (1/2)

---

Tc Equations used...

---

==== SCS TR-55 Sheet Flow ==========

Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where: Tc = Time of concentration, hrs
n = Mannings n
Lf = Flow length, ft
P = 2yr, 24hr Rain depth, inches
Sf = Slope, ft/ft

==== SCS TR-55 Shallow Concentrated Flow ==========

Unpaved surface:
V = 16.1345 * (Sf**0.5)

Paved surface:
V = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where: V = Velocity, ft/sec
Sf = Slope, ft/ft
Tc = Time of concentration, hrs
Lf = Flow length, ft

Equations used by Pond Pack to calculate Tc (2/2)



==== SCS Channel Flow ==========

R = Aq / Wp
V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where: R = Hydraulic radius
Aq = Flow area, sq.ft.
Wp = Wetted perimeter, ft
V = Velocity, ft/sec
Sf = Slope, ft/ft
n = Mannings n
Tc = Time of concentration, hrs
Lf = Flow length, ft

# Hydrograph Generation

Type.... TR-55 Tabular Hyd.Input Data
Name.... TO SOUTH BASIN  Tag:  25

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir  = I:\1370\
HYG file = S BASIN.HYG  south basin 25

To South Basin
25-yr, 24-hr Storm
(1/2)

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

Total Area = 63.400 acres or .099063 sq.mi.
Peak Discharge = 69 cfs
WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| Landfill area | 29.600 | 67.5 | .4000 | .0000 | 4.70 | 1.63 | I.20 | .20 |
| W peripheral | 4.600 | 67.5 | .1000 | .0000 | 4.70 | 1.63 | I.20 | .20 |
| Basin area | 1.800 | 98.0 | .1000 | .0000 | 4.70 | 4.46 | I.01 | .10 |
| NE peripheral | 13.700 | 67.5 | .5000 | .0000 | 4.70 | 1.63 | I.20 | .20 |
| SE/S periphera | 13.700 | 67.5 | .7500 | .0000 | 4.70 | 1.63 | I.20 | .20 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | * Tt (hrs) | Rounded Values Tc (hrs) | * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| andfill area | .3600 | .0000 | .40 | .00 | Yes | -- |
| peripheral | .1000 | .0000 | ** | ** | Yes | -- |
| Basin area | .1000 | .0000 | ** | ** | No | Computed Ia/p < .1 |
| E peripheral | .5400 | .0000 | .50 | .00 | Yes | -- |
| E/S periphera | .7800 | .0000 | .75 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.
* Tc & Tt are available in the hydrograph tables.

Type.... TR-55 Tabular Hyd.Peaks
Name.... TO SOUTH BASIN Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir = I:\1370\
HYG file = S BASIN.HYG south basin 25

To South Basin
25-yr, 24-hr Storm
(2/2)

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| Landfill area | 40 | 12.3 |
| W peripheral | 11 | 12.1 |
| Basin area | 13 | 12.1 |
| NE peripheral | 17 | 12.4 |
| SE/S periphera | 13 | 12.6 |
| Composite Watershed | 69 | 12.4 |

To South Basin
100-yr, 24-hr

Type.... TR-55 Tabular Hyd.Input Data
Name.... TO SOUTH BASIN  Tag:  100

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir  = I:\1370\
HYG file = S BASIN.HYG  south basin 100

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
100yr, 24hr Rainfall Depth = 5.90 in

Total Area = 63.400 acres or .099063 sq.mi.
Peak Discharge = 110 cfs
WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| Landfill area | 29.600 | 67.5 | .4000 | .0000 | 5.90 | 2.50 | I.16 | .16 |
| W peripheral | 4.600 | 67.5 | .1000 | .0000 | 5.90 | 2.50 | I.16 | .16 |
| Basin area | 1.800 | 98.0 | .1000 | .0000 | 5.90 | 5.66 | I.01 | .10 |
| E peripheral | 13.700 | 67.5 | .5000 | .0000 | 5.90 | 2.50 | I.16 | .16 |
| SE/S periphera | 13.700 | 67.5 | .7500 | .0000 | 5.90 | 2.50 | I.16 | .16 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | * Tt (hrs) | Rounded Values Tc (hrs) | * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| andfill area | .3600 | .0000 | .40 | .00 | Yes | -- |
| W peripheral | .1000 | .0000 | ** | ** | Yes | -- |
| Basin area | .1000 | .0000 | ** | ** | No | Computed Ia/p < .1 |
| peripheral | .5400 | .0000 | .50 | .00 | Yes | -- |
| E/S periphera | .7800 | .0000 | .75 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.
* Tc & Tt are available in the hydrograph tables.

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir = I:\1370\
HYG file = S BASIN.HYG south basin 100

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
100yr, 24hr Rainfall Depth = 5.90 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| Landfill area | 65 | 12.3 |
| W peripheral | 18 | 12.1 |
| Basin area | 16 | 12.1 |
| NE peripheral | 27 | 12.4 |
| SE/S periphera | 21 | 12.6 |
| Composite Watershed | 110 | 12.4 |

# Diversion Berm, Downslope Swale, and Perimeter Ditch Sizing Calculations

Worst-case diversion Berm C1



Type.... Tc Calcs
Name.... WORSTCASE DIV BE

File.... I:\1370\COLUMBIA.PPK
Title... Tc for worst case diversion berm sizing calcs

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Tc for worst case diversion berm sizing calcs
---

Segment #1: Tc: TR-55 Sheet
Description: final cover slope - 25%

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 95.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .250000 | ft/ft |

Avg.Velocity .35 ft/sec

Segment #1 Time: .0751 hrs

---

Segment #2: Tc: TR-55 Shallow
Description: diversion berm

| | | |
|---|---|---|
| Hydraulic Length | 2090.00 | ft |
| Slope | .020000 | ft/ft |

Unpaved

Avg.Velocity 2.28 ft/sec

Segment #2 Time: .2544 hrs

---

==========
Total Tc: .3295 hrs
==========

Worst-case diversion berm



File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case diversion berm sizing calcs
HYG Dir  = I:\1370\
HYG file = NONE STORED  WORSTCASE DIV BE 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

Total Area = 4.600 acres or .007187 sq.mi.
Peak Discharge = 7 cfs

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| east side ph 1 | 4.600 | 67.5 | .3000 | .0000 | 4.70 | 1.63 | I.20 | .20 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | Input Values * Tt (hrs) | Rounded Values Tc (hrs) | Rounded Values * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| east side ph 1 | .3300 | .0000 | .30 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.

Worst-case diversion berm



Type.... TR-55 Tabular Hyd.Peaks
Name.... WORSTCASE DIV BE  Tag:  25

File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case diversion berm sizing calcs
HYG Dir  = I:\1370\
HYG file = NONE STORED  WORSTCASE DIV BE 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| east side ph 1 | 7 | 12.2 |
| Composite Watershed | 7 | 12.2 |

# Worksheet
## Worksheet for Triangular Channel

| Project Description | |
|---|---|
| Worksheet | Triangular Channe |
| Flow Element | Triangular Channe |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case diversion berm

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 020000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Discharge | 7.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.75 | ft |
| Flow Area | 2.0 | ft² |
| Wetted Perim | 5.47 | ft |
| Top Width | 5.25 | ft |
| Critical Depth | 0.76 | ft |
| Critical Slope | 0.019122 | ft/ft |
| Velocity | 3.55 | ft/s |
| Velocity Head | 0.20 | ft |
| Specific Energ | 0.95 | ft |
| Froude Numb | 1.02 | |
| Flow Type | Supercritical | |

Worst-case downslope channel



Type.... Tc Calcs
Name.... WORST CASE FLUME

File.... I:\1370\COLUMBIA.PPK
Title... Tc for worst case downslope flume sizing calcs

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Tc for worst case downslope flume sizing calcs
---

Segment #1: Tc: TR-55 Sheet
Description: final cover slope - 5%

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .050000 | ft/ft |

Avg.Velocity .17 ft/sec

Segment #1 Time: .0989 hrs
---

Segment #2: Tc: TR-55 Sheet
Description: final cover slope - 25%

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .250000 | ft/ft |

Avg.Velocity .32 ft/sec

Segment #2 Time: .0520 hrs
---

Segment #3: Tc: TR-55 Shallow
Description: diversion berm

| | | |
|---|---|---|
| Hydraulic Length | 1790.00 | ft |
| Slope | .020000 | ft/ft |
| Unpaved | | |

Avg.Velocity 2.28 ft/sec

Segment #3 Time: .2179 hrs
---

==========
Total Tc: .3688 hrs
==========

Worst-case downslope channel



File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case downslope flume sizing calcs
HYG Dir  = I:\1370\
HYG file = NONE STORED  WORST CASE FLUME 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

Total Area = 7.500 acres or .011719 sq.mi.
Peak Discharge = 10 cfs

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| To SE flume | 7.500 | 67.5 | .4000 | .0000 | 4.70 | 1.63 | I.20 | .20 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | Input Values * Tt (hrs) | Rounded Values Tc (hrs) | Rounded Values * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| To SE flume | .3700 | .0000 | .40 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.

Worst-case downslope channel



File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case downslope flume sizing calcs
HYG Dir = I:\1370\
HYG file = NONE STORED WORST CASE FLUME 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| To SE flume | 10 | 12.3 |
| Composite Watershed | 10 | 12.3 |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | downslope flume |
| Flow Element | Trapezoidal Cha |
| Method | Manning's Formı |
| Solve For | Channel Depth |

Worst-case downslope channel (SW channel)

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.040 | |
| Slope | 200000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 10.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.18 | ft |
| Flow Area | 1.9 | ft² |
| Wetted Perim | 11.16 | ft |
| Top Width | 11.10 | ft |
| Critical Depth | 0.30 | ft |
| Critical Slope | 0.035988 | ft/ft |
| Velocity | 5.17 | ft/s |
| Velocity Head | 0.41 | ft |
| Specific Energ | 0.60 | ft |
| Froude Numb | 2.18 | |
| Flow Type | Supercritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | worst-case west perimeter |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case west perimeter ditch

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 006000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 5.00 | ft |
| Discharge | 31.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.13 | ft |
| Flow Area | 9.5 | ft² |
| Wetted Perim | 12.17 | ft |
| Top Width | 11.80 | ft |
| Critical Depth | 0.88 | ft |
| Critical Slope | 0.015659 | ft/ft |
| Velocity | 3.26 | ft/s |
| Velocity Head | 0.16 | ft |
| Specific Energ | 1.30 | ft |
| Froude Numb | 0.64 | |
| Flow Type | Subcritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | worst-case east perimeter |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case east perimeter ditch

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 57.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.23 | ft |
| Flow Area | 16.9 | ft² |
| Wetted Perim | 17.79 | ft |
| Top Width | 17.39 | ft |
| Critical Depth | 0.91 | ft |
| Critical Slope | 0.014803 | ft/ft |
| Velocity | 3.38 | ft/s |
| Velocity Head | 0.18 | ft |
| Specific Energ | 1.41 | ft |
| Froude Numb | 0.61 | |
| Flow Type | Subcritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | worst case south perimeter |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case south perimeter ditch

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 012000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 70.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.08 | ft |
| Flow Area | 14.4 | ft² |
| Wetted Perim | 16.85 | ft |
| Top Width | 16.50 | ft |
| Critical Depth | 1.03 | ft |
| Critical Slope | 0.014316 | ft/ft |
| Velocity | 4.88 | ft/s |
| Velocity Head | 0.37 | ft |
| Specific Energ | 1.45 | ft |
| Froude Numb | 0.92 | |
| Flow Type | Subcritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | ditch from SW corner of LF to S |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Ditch from SW corner of Landfill to South Basin

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 006000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 15.00 | ft |
| Discharge | 69.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.07 | ft |
| Flow Area | 19.4 | ft² |
| Wetted Perim | 21.74 | ft |
| Top Width | 21.40 | ft |
| Critical Depth | 0.82 | ft |
| Critical Slope | 0.014896 | ft/ft |
| Velocity | 3.56 | ft/s |
| Velocity Head | 0.20 | ft |
| Specific Energ | 1.26 | ft |
| Froude Numb | 0.66 | |
| Flow Type | Subcritical | |


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# Basin Volume Computations

## POND VOLUME CALCULATIONS

Planimeter scale: 1.00 ft/in

| Elevation (ft) | Planimeter (sq.in) | Area (acres) | A1+A2+sqr(A1*A2) (acres) | Volume (ac-ft) | Volume Sum (ac-ft) |
|---|---|---|---|---|---|
| 789.00 | 62411.000 | 1.4328 | .0000 | .000 | .000 |
| 790.00 | 68355.000 | 1.5692 | 4.5014 | 1.500 | 1.500 |
| 792.00 | 74865.000 | 1.7187 | 4.9301 | 3.287 | 4.787 |
| 794.00 | 82150.000 | 1.8859 | 5.4049 | 3.603 | 8.390 |

## POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

# Outlet Structure Data

Type.... Outlet Input Data
Name.... SOUTH BASIN2

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

REQUESTED POND WS ELEVATIONS:

Min. Elev.= 789.50 ft
Increment = 1.00 ft
Max. Elev.= 794.00 ft

**********
OUTLET CONNECTIVITY
**********

---> Forward Flow Only (UpStream to DnStream)
<--- Reverse Flow Only (DnStream to UpStream)
<---> Forward and Reverse Both Allowed

| Structure | No. | | Outfall | E1, ft | E2, ft |
|---|---|---|---|---|---|
| Weir-Rectangular | e1 | ---> | TW | 793.000 | 794.000 |
| Stand Pipe | s1 | ---> | c1 | 791.000 | 794.000 |
| Orifice-Circular | o1 | ---> | c1 | 789.500 | 794.000 |
| Culvert-Circular | c1 | ---> | TW | 789.000 | 794.000 |

TW SETUP, DS Channel

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

OUTLET STRUCTURE INPUT DATA

| | | |
|---|---|---|
| Structure ID | = e1 | |
| Structure Type | = Weir-Rectangular | |
| # of Openings | = 1 | |
| Crest Elev. | = 793.00 | ft |
| Weir Length | = 10.00 | ft |
| Weir Coeff. | = 3.300000 | |

Weir TW effects (Use adjustment equation)

| | | |
|---|---|---|
| Structure ID | = s1 | |
| Structure Type | = Stand Pipe | |
| # of Openings | = 1 | |
| Invert Elev. | = 791.00 | ft |
| Diameter | = 2.5000 | ft |
| Orifice Area | = 4.9087 | sq.ft |
| Orifice Coeff. | = .600 | |
| Weir Length | = 7.85 | ft |
| Weir Coeff. | = 3.300 | |
| K, Submerged | = .000 | |
| K, Reverse | = 1.000 | |
| Kb,Barrel | = .000000 | (per ft of full flow) |
| Barrel Length | = .00 | ft |
| Mannings n | = .0000 | |

| | | |
|---|---|---|
| Structure ID | = o1 | |
| Structure Type | = Orifice-Circular | |
| # of Openings | = 72 | |
| Invert Elev. | = 789.50 | ft |
| Diameter | = .0400 | ft |
| Orifice Coeff. | = .600 | |

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

OUTLET STRUCTURE INPUT DATA

Structure ID = c1
Structure Type = Culvert-Circular
---

| | | | |
|---|---|---|---|
| No. Barrels | = | 1 | |
| Barrel Diameter | = | 1.2500 | ft |
| Upstream Invert | = | 789.00 | ft |
| Dnstream Invert | = | 788.50 | ft |
| Horiz. Length | = | 50.00 | ft |
| Barrel Length | = | 50.00 | ft |
| Barrel Slope | = | .01000 | ft/ft |

OUTLET CONTROL DATA...

| | | | |
|---|---|---|---|
| Mannings n | = | .0130 | |
| Ke | = | .9000 | (forward entrance loss) |
| Kb | = | .023225 | (per ft of full flow) |
| Kr | = | .9000 | (reverse entrance loss) |
| HW Convergence | = | .001 | +/- ft |

INLET CONTROL DATA...

| | | |
|---|---|---|
| Equation form | = | 1 |
| Inlet Control K | = | .0340 |
| Inlet Control M | = | 1.5000 |
| Inlet Control c | = | .05530 |
| Inlet Control Y | = | .5400 |
| T1 ratio (HW/D) | = | 1.258 |
| T2 ratio (HW/D) | = | 1.420 |
| Slope Factor | = | -.500 |

Use unsubmerged inlet control Form 1 equ. below T1 elev.
Use submerged inlet control Form 1 equ. above T2 elev.

In transition zone between unsubmerged and submerged inlet control, interpolate between flows at T1 & T2...
At T1 Elev = 790.57 ft ---> Flow = 4.80 cfs
At T2 Elev = 790.77 ft ---> Flow = 5.49 cfs

Structure ID = TW
Structure Type = TW SETUP, DS Channel
---
FREE OUTFALL CONDITIONS SPECIFIED

CONVERGENCE TOLERANCES...

| | | |
|---|---|---|
| Maximum Iterations | = | 30 |
| Min. TW tolerance | = | .01 ft |
| Max. TW tolerance | = | .01 ft |
| Min. HW tolerance | = | .01 ft |
| Max. HW tolerance | = | .01 ft |

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = e1 (Weir-Rectangular)
---
Upstream ID = (Pond Water Surface)
DNstream ID = TW (Pond Outfall)

| WS Elev,Device Q | | Tail Water | | Notes |
|---|---|---|---|---|
| WS Elev. ft | Q cfs | TW Elev Converge ft | +/-ft | Computation Messages |
| 789.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 790.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 791.00 | .00 | Free Outfall | | WS below an invert; no flow. |
| 791.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 792.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 793.00 | .00 | Free Outfall | | WS below an invert; no flow. |
| 793.50 | 11.67 | Free Outfall | | H=.50; Htw=.00; Qfree=11.67; |
| 794.00 | 33.00 | Free Outfall | | H=1.00; Htw=.00; Qfree=33.00; |

Type.... Individual Outlet Curves
Name.... SOUTH BASIN2

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = s1 (Stand Pipe)
---
Upstream ID = (Pond Water Surface)
DNstream ID = c1 (Culvert-Circular)

| Pond WS. Elev. ft | Device Q cfs | (into) HW HGL ft | Converge DS HGL ft | Next DS HGL ft | DS HGL Error +/-ft | Q SUM Error +/-cfs | DS Chan. TW ft | TW Error +/-ft |
|---|---|---|---|---|---|---|---|---|
| 789.50 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 790.50 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 791.00 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 791.50 | 7.06 | 791.50 | 791.50 | 791.50 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 792.50 | 8.78 | 792.50 | 792.50 | 792.50 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 793.00 | 9.52 | 793.00 | 793.00 | 793.00 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 793.50 | 10.21 | 793.50 | 793.50 | 793.50 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 794.00 | 10.86 | 794.00 | 794.00 | 794.00 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = o1 (Orifice-Circular)
---
Upstream ID = (Pond Water Surface)
DNstream ID = c1 (Culvert-Circular)

NUMBER OF OPENINGS = 72
EACH FLOW = SUM OF OPENINGS x FLOW FOR ONE OPENING

| Pond WS. Elev. ft | Device Q cfs | (into) HW HGL ft | Converge DS HGL ft | Next DS HGL ft | DS HGL Error +/-ft | Q SUM Error +/-cfs | DS Chan. TW ft | TW Error +/-ft |
|---|---|---|---|---|---|---|---|---|
| 789.50 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 790.50 | .43 | 790.50 | Free | 789.42 | .000 | .000 | Free Outfall | |
| | | H =.98 | | | | | | |
| 791.00 | .53 | 791.00 | Free | 789.47 | .000 | .000 | Free Outfall | |
| | | H =1.48 | | | | | | |
| 791.50 | .00 | 791.50 | 791.50 | 791.50 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 792.50 | .00 | 792.50 | 792.50 | 792.50 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 793.00 | .00 | 793.00 | 793.00 | 793.00 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 793.50 | .00 | 793.50 | 793.50 | 793.50 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 794.00 | .00 | 794.00 | 794.00 | 794.00 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = c1 (Culvert-Circular)
---
Mannings open channel maximum capacity: 6.95 cfs
UPstream ID's= s1, o1
DNstream ID = TW (Pond Outfall)

| Pond WS. Elev. ft | Device Q cfs | (into) HW HGL ft | Converge DS HGL ft | Next DS HGL ft | DS HGL Error +/-ft | Q SUM Error +/-cfs | DS Chan. TW ft | TW Error +/-ft |
|---|---|---|---|---|---|---|---|---|
| 789.50 | .00 | 789.00 | Free | Free | .000 | .000 | Free Outfall | |
| 790.50 | .43 | 789.42 | Free | Free | .000 | .000 | Free Outfall | |
| | | CRIT.DEPTH CONTROL | | Vh= .089ft | Dcr= .255ft | | CRIT.DEPTH | |
| 791.00 | .53 | 789.47 | Free | Free | .000 | .000 | Free Outfall | |
| | | CRIT.DEPTH CONTROL | | Vh= .100ft | Dcr= .283ft | | CRIT.DEPTH | |
| 791.50 | 7.06 | 791.50 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =2.50 | | | |
| 792.50 | 8.78 | 792.50 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =3.50 | | | |
| 793.00 | 9.52 | 793.00 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =4.00 | | | |
| 793.50 | 10.21 | 793.50 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =4.50 | | | |
| 794.00 | 10.86 | 794.00 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =5.00 | | | |

# Pond Routing Summary

South Basin
25-yr, 24-hr Storm

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

LEVEL POOL ROUTING SUMMARY

HYG Dir = I:\1370\
Inflow HYG file = SBASIN.HYG - south basin 25
Outflow HYG file = NONE STORED - SOUTH BASIN2 OUT 25

Pond Node Data = south basin
Pond Volume Data = south basin
Pond Outlet Data = south basin2

No Infiltration

INITIAL CONDITIONS

| | | |
|---|---|---|
| Starting WS Elev | = | 789.00 ft |
| Starting Volume | = | .000 ac-ft |
| Starting Outflow | = | .00 cfs |
| Starting Infiltr. | = | .00 cfs |
| Starting Total Qout | = | .00 cfs |
| Time Increment | = | .1000 hrs |

INFLOW/OUTFLOW HYDROGRAPH SUMMARY

| | | | | |
|---|---|---|---|---|
| Peak Inflow | = | 69.00 cfs | at | 12.4000 hrs |
| Peak Outflow | = | 7.94 cfs | at | 14.1000 hrs ← Peak discharge from basin |
| Peak Elevation | = | 792.01 ft ← Peak water elevation | | |
| Peak Storage | = | 4.805 ac-ft | | |

MASS BALANCE (ac-ft)

| | | |
|---|---|---|
| + Initial Vol | = | .000 |
| + HYG Vol IN | = | 8.872 |
| - Infiltration | = | .000 |
| - HYG Vol OUT | = | 8.101 |
| - Retained Vol | = | .769 |
| Unrouted Vol | = | -.001 ac-ft (.016% of Inflow Volume) |

WARNING: Inflow hydrograph truncated on left side.
WARNING: Outflow hydrograph truncated on right side.

BT² inc.

Sheet No.
Calc. No.
Rev. No.

Job No. 1370 Job Columbia Plan of Op Update By BLP Date 8/23/00

Client Alliant Subject Basin Calcs Chk'd. MRH Date 8-31-00

# Basin Particle Size Settling Capability

Basin required to settle out ≥ 15 micron (0.015 mm) particle for a 25-yr, 24-hr storm event.

From calculations, peak discharge from basin is 7.94 cfs and peak water elevation is 792.0 ft. The corresponding surface area of the basin at elevation 792.0 is 74,865 sf (see Basin Volume Computations Sectio

The surface area to discharge ratio is therefore

$$\frac{74,865 \text{ sf}}{7.94 \text{ cfs}} = 9,429 \text{ sf/cfs}$$

From the Erosion and Sediment Control Handbook, the required surface area to discharge ratio to settle out a 15 micron particle is 3,125 sf/cfs.

9,429 cfs/sf > 3,125 sf/cfs, therefore the basin is adequately sized to settle out a 15 micron particle

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (1/7)

POND ROUTED TOTAL OUTFLOW HYG...
HYG file =
HYG ID = SOUTH BASIN2 OUT
HYG Tag = 25

| | |
|---|---|
| Peak Discharge = | 7.94 cfs |
| Time to Peak = | 14.1000 hrs |
| HYG Volume = | 8.101 ac-ft |

WARNING: Hydrograph truncated on right side.

Basin dewatering time -
Begin discharge: 12.2
End discharge: 113.8 sa
Total discharge time: 101.6
or 4.2 days, whi
is greater than the
required minimum
of 3 days

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 11.0000 | .00 | .00 | .00 | .00 | .00 |
| 11.5000 | .00 | .00 | .00 | .00 | .00 |
| 12.0000 | .00 | .00 | .10 (Begin discharge) | .24 | .39 |
| 12.5000 | .48 | .92 | 3.82 | 6.00 | 7.14 |
| 13.0000 | 7.31 | 7.44 | 7.55 | 7.64 | 7.72 |
| 13.5000 | 7.78 | 7.83 | 7.87 | 7.90 | 7.92 |
| 14.0000 | 7.93 | 7.94 | 7.94 | 7.94 | 7.93 |
| 14.5000 | 7.92 | 7.91 | 7.90 | 7.89 | 7.87 |
| 15.0000 | 7.84 | 7.82 | 7.80 | 7.77 | 7.75 |
| 15.5000 | 7.73 | 7.71 | 7.68 | 7.66 | 7.63 |
| 16.0000 | 7.60 | 7.57 | 7.54 | 7.51 | 7.48 |
| 16.5000 | 7.45 | 7.42 | 7.40 | 7.37 | 7.34 |
| 17.0000 | 7.31 | 7.28 | 7.26 | 7.23 | 7.20 |
| 17.5000 | 7.18 | 7.15 | 7.13 | 7.10 | 7.08 |
| 18.0000 | 6.96 | 6.77 | 6.60 | 6.44 | 6.28 |
| 18.5000 | 6.14 | 6.00 | 5.88 | 5.76 | 5.65 |
| 19.0000 | 5.55 | 5.45 | 5.36 | 5.27 | 5.19 |
| 19.5000 | 5.12 | 5.01 | 4.89 | 4.77 | 4.66 |
| 20.0000 | 4.55 | 4.46 | 4.36 | 4.28 | 4.20 |
| 20.5000 | 4.12 | 4.05 | 3.99 | 3.92 | 3.87 |
| 21.0000 | 3.81 | 3.76 | 3.71 | 3.67 | 3.63 |
| 21.5000 | 3.59 | 3.55 | 3.51 | 3.48 | 3.45 |
| 22.0000 | 3.42 | 3.40 | 3.37 | 3.35 | 3.33 |
| 22.5000 | 3.31 | 3.29 | 3.24 | 3.16 | 3.09 |
| 23.0000 | 3.02 | 2.95 | 2.89 | 2.84 | 2.78 |
| 23.5000 | 2.74 | 2.69 | 2.65 | 2.61 | 2.57 |
| 24.0000 | 2.53 | 2.47 | 2.37 | 2.29 | 2.21 |
| 24.5000 | 2.13 | 2.06 | 1.99 | 1.93 | 1.87 |
| 25.0000 | 1.82 | 1.77 | 1.72 | 1.67 | 1.60 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (2/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 25.5000 | 1.50 | 1.40 | 1.32 | 1.23 | 1.15 |
| 26.0000 | 1.08 | 1.01 | .95 | .89 | .83 |
| 26.5000 | .78 | .73 | .69 | .64 | .60 |
| 27.0000 | .56 | .53 | .53 | .53 | .53 |
| 27.5000 | .53 | .53 | .53 | .53 | .53 |
| 28.0000 | .53 | .52 | .52 | .52 | .52 |
| 28.5000 | .52 | .52 | .52 | .52 | .52 |
| 29.0000 | .52 | .52 | .52 | .52 | .52 |
| 29.5000 | .52 | .52 | .52 | .52 | .52 |
| 30.0000 | .51 | .51 | .51 | .51 | .51 |
| 30.5000 | .51 | .51 | .51 | .51 | .51 |
| 31.0000 | .51 | .51 | .51 | .51 | .51 |
| 31.5000 | .51 | .51 | .51 | .51 | .50 |
| 32.0000 | .50 | .50 | .50 | .50 | .50 |
| 32.5000 | .50 | .50 | .50 | .50 | .50 |
| 33.0000 | .50 | .50 | .50 | .50 | .50 |
| 33.5000 | .50 | .50 | .50 | .50 | .49 |
| 34.0000 | .49 | .49 | .49 | .49 | .49 |
| 34.5000 | .49 | .49 | .49 | .49 | .49 |
| 35.0000 | .49 | .49 | .49 | .49 | .49 |
| 35.5000 | .49 | .49 | .49 | .49 | .48 |
| 36.0000 | .48 | .48 | .48 | .48 | .48 |
| 36.5000 | .48 | .48 | .48 | .48 | .48 |
| 37.0000 | .48 | .48 | .48 | .48 | .48 |
| 37.5000 | .48 | .48 | .48 | .48 | .48 |
| 38.0000 | .47 | .47 | .47 | .47 | .47 |
| 38.5000 | .47 | .47 | .47 | .47 | .47 |
| 39.0000 | .47 | .47 | .47 | .47 | .47 |
| 39.5000 | .47 | .47 | .47 | .47 | .47 |
| 40.0000 | .47 | .46 | .46 | .46 | .46 |
| 40.5000 | .46 | .46 | .46 | .46 | .46 |
| 41.0000 | .46 | .46 | .46 | .46 | .46 |
| 41.5000 | .46 | .46 | .46 | .46 | .46 |
| 42.0000 | .46 | .46 | .46 | .45 | .45 |
| 42.5000 | .45 | .45 | .45 | .45 | .45 |
| 43.0000 | .45 | .45 | .45 | .45 | .45 |
| 43.5000 | .45 | .45 | .45 | .45 | .45 |
| 44.0000 | .45 | .45 | .45 | .45 | .45 |
| 44.5000 | .44 | .44 | .44 | .44 | .44 |
| 45.0000 | .44 | .44 | .44 | .44 | .44 |
| 45.5000 | .44 | .44 | .44 | .44 | .44 |
| 46.0000 | .44 | .44 | .44 | .44 | .44 |
| 46.5000 | .44 | .44 | .44 | .43 | .43 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (3/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 47.0000 | .43 | .43 | .43 | .43 | .43 |
| 47.5000 | .43 | .43 | .43 | .43 | .43 |
| 48.0000 | .43 | .43 | .43 | .42 | .42 |
| 48.5000 | .42 | .42 | .42 | .42 | .42 |
| 49.0000 | .42 | .42 | .42 | .41 | .41 |
| 49.5000 | .41 | .41 | .41 | .41 | .41 |
| 50.0000 | .41 | .41 | .41 | .41 | .40 |
| 50.5000 | .40 | .40 | .40 | .40 | .40 |
| 51.0000 | .40 | .40 | .40 | .40 | .40 |
| 51.5000 | .39 | .39 | .39 | .39 | .39 |
| 52.0000 | .39 | .39 | .39 | .39 | .39 |
| 52.5000 | .39 | .38 | .38 | .38 | .38 |
| 53.0000 | .38 | .38 | .38 | .38 | .38 |
| 53.5000 | .38 | .38 | .38 | .37 | .37 |
| 54.0000 | .37 | .37 | .37 | .37 | .37 |
| 54.5000 | .37 | .37 | .37 | .37 | .37 |
| 55.0000 | .36 | .36 | .36 | .36 | .36 |
| 55.5000 | .36 | .36 | .36 | .36 | .36 |
| 56.0000 | .36 | .36 | .35 | .35 | .35 |
| 56.5000 | .35 | .35 | .35 | .35 | .35 |
| 57.0000 | .35 | .35 | .35 | .35 | .34 |
| 57.5000 | .34 | .34 | .34 | .34 | .34 |
| 58.0000 | .34 | .34 | .34 | .34 | .34 |
| 58.5000 | .34 | .34 | .33 | .33 | .33 |
| 59.0000 | .33 | .33 | .33 | .33 | .33 |
| 59.5000 | .33 | .33 | .33 | .33 | .33 |
| 60.0000 | .33 | .32 | .32 | .32 | .32 |
| 60.5000 | .32 | .32 | .32 | .32 | .32 |
| 61.0000 | .32 | .32 | .32 | .32 | .31 |
| 61.5000 | .31 | .31 | .31 | .31 | .31 |
| 62.0000 | .31 | .31 | .31 | .31 | .31 |
| 62.5000 | .31 | .31 | .31 | .30 | .30 |
| 63.0000 | .30 | .30 | .30 | .30 | .30 |
| 63.5000 | .30 | .30 | .30 | .30 | .30 |
| 64.0000 | .30 | .30 | .30 | .29 | .29 |
| 64.5000 | .29 | .29 | .29 | .29 | .29 |
| 65.0000 | .29 | .29 | .29 | .29 | .29 |
| 65.5000 | .29 | .29 | .29 | .28 | .28 |
| 66.0000 | .28 | .28 | .28 | .28 | .28 |
| 66.5000 | .28 | .28 | .28 | .28 | .28 |
| 67.0000 | .28 | .28 | .28 | .28 | .27 |
| 67.5000 | .27 | .27 | .27 | .27 | .27 |
| 68.0000 | .27 | .27 | .27 | .27 | .27 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (4/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 68.5000 | .27 | .27 | .27 | .27 | .27 |
| 69.0000 | .26 | .26 | .26 | .26 | .26 |
| 69.5000 | .26 | .26 | .26 | .26 | .26 |
| 70.0000 | .26 | .26 | .26 | .26 | .26 |
| 70.5000 | .26 | .26 | .25 | .25 | .25 |
| 71.0000 | .25 | .25 | .25 | .25 | .25 |
| 71.5000 | .25 | .25 | .25 | .25 | .25 |
| 72.0000 | .25 | .25 | .25 | .25 | .24 |
| 72.5000 | .24 | .24 | .24 | .24 | .24 |
| 73.0000 | .24 | .24 | .24 | .24 | .24 |
| 73.5000 | .24 | .24 | .24 | .24 | .24 |
| 74.0000 | .24 | .24 | .24 | .23 | .23 |
| 74.5000 | .23 | .23 | .23 | .23 | .23 |
| 75.0000 | .23 | .23 | .23 | .23 | .23 |
| 75.5000 | .23 | .23 | .23 | .23 | .23 |
| 76.0000 | .23 | .23 | .22 | .22 | .22 |
| 76.5000 | .22 | .22 | .22 | .22 | .22 |
| 77.0000 | .22 | .22 | .22 | .22 | .22 |
| 77.5000 | .22 | .22 | .22 | .22 | .22 |
| 78.0000 | .22 | .22 | .21 | .21 | .21 |
| 78.5000 | .21 | .21 | .21 | .21 | .21 |
| 79.0000 | .21 | .21 | .21 | .21 | .21 |
| 79.5000 | .21 | .21 | .21 | .21 | .21 |
| 80.0000 | .21 | .21 | .20 | .20 | .20 |
| 80.5000 | .20 | .20 | .20 | .20 | .20 |
| 81.0000 | .20 | .20 | .20 | .20 | .20 |
| 81.5000 | .20 | .20 | .20 | .20 | .20 |
| 82.0000 | .20 | .20 | .20 | .20 | .19 |
| 82.5000 | .19 | .19 | .19 | .19 | .19 |
| 83.0000 | .19 | .19 | .19 | .19 | .19 |
| 83.5000 | .19 | .19 | .19 | .19 | .19 |
| 84.0000 | .19 | .19 | .19 | .19 | .19 |
| 84.5000 | .19 | .19 | .18 | .18 | .18 |
| 85.0000 | .18 | .18 | .18 | .18 | .18 |
| 85.5000 | .18 | .18 | .18 | .18 | .18 |
| 86.0000 | .18 | .18 | .18 | .18 | .18 |
| 86.5000 | .18 | .18 | .18 | .18 | .18 |
| 87.0000 | .18 | .18 | .17 | .17 | .17 |
| 87.5000 | .17 | .17 | .17 | .17 | .17 |
| 88.0000 | .17 | .17 | .17 | .17 | .17 |
| 88.5000 | .17 | .17 | .17 | .17 | .17 |
| 89.0000 | .17 | .17 | .17 | .17 | .17 |
| 89.5000 | .17 | .17 | .17 | .16 | .16 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (5/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 90.0000 | .16 | .16 | .16 | .16 | .16 |
| 90.5000 | .16 | .16 | .16 | .16 | .16 |
| 91.0000 | .16 | .16 | .16 | .16 | .16 |
| 91.5000 | .16 | .16 | .16 | .16 | .16 |
| 92.0000 | .16 | .16 | .16 | .16 | .16 |
| 92.5000 | .15 | .15 | .15 | .15 | .15 |
| 93.0000 | .15 | .15 | .15 | .15 | .15 |
| 93.5000 | .15 | .15 | .15 | .15 | .15 |
| 94.0000 | .15 | .15 | .15 | .15 | .15 |
| 94.5000 | .15 | .15 | .15 | .15 | .15 |
| 95.0000 | .15 | .15 | .15 | .15 | .14 |
| 95.5000 | .14 | .14 | .14 | .14 | .14 |
| 96.0000 | .14 | .14 | .14 | .14 | .14 |
| 96.5000 | .14 | .14 | .14 | .14 | .14 |
| 97.0000 | .14 | .14 | .14 | .14 | .14 |
| 97.5000 | .14 | .14 | .14 | .14 | .14 |
| 98.0000 | .14 | .14 | .14 | .14 | .14 |
| 98.5000 | .14 | .13 | .13 | .13 | .13 |
| 99.0000 | .13 | .13 | .13 | .13 | .13 |
| 99.5000 | .13 | .13 | .13 | .13 | .13 |
| 100.0000 | .13 | .13 | .13 | .13 | .13 |
| 100.5000 | .13 | .13 | .13 | .13 | .13 |
| 101.0000 | .13 | .13 | .13 | .13 | .13 |
| 101.5000 | .13 | .13 | .13 | .13 | .12 |
| 102.0000 | .12 | .12 | .12 | .12 | .12 |
| 102.5000 | .12 | .12 | .12 | .12 | .12 |
| 103.0000 | .12 | .12 | .12 | .12 | .12 |
| 103.5000 | .12 | .12 | .12 | .12 | .12 |
| 104.0000 | .12 | .12 | .12 | .12 | .12 |
| 104.5000 | .12 | .12 | .12 | .12 | .12 |
| 105.0000 | .12 | .12 | .12 | .12 | .12 |
| 105.5000 | .12 | .11 | .11 | .11 | .11 |
| 106.0000 | .11 | .11 | .11 | .11 | .11 |
| 106.5000 | .11 | .11 | .11 | .11 | .11 |
| 107.0000 | .11 | .11 | .11 | .11 | .11 |
| 107.5000 | .11 | .11 | .11 | .11 | .11 |
| 108.0000 | .11 | .11 | .11 | .11 | .11 |
| 108.5000 | .11 | .11 | .11 | .11 | .11 |
| 109.0000 | .11 | .11 | .11 | .11 | .11 |
| 109.5000 | .11 | .10 | .10 | .10 | .10 |
| 110.0000 | .10 | .10 | .10 | .10 | .10 |
| 110.5000 | .10 | .10 | .10 | .10 | .10 |
| 111.0000 | .10 | .10 | .10 | .10 | .10 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (6/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 111.5000 | .10 | .10 | .10 | .10 | .10 |
| 112.0000 | .10 | .10 | .10 | .10 | .10 |
| 112.5000 | .10 | .10 | .10 | .10 | .10 |
| 113.0000 | .10 | .10 | .10 | .10 | .10 |
| 113.5000 | .10 | .10 | .10 | .10 End discharge | .09 |
| 114.0000 | .09 | .09 | .09 | .09 | .09 |
| 114.5000 | .09 | .09 | .09 | .09 | .09 |
| 115.0000 | .09 | .09 | .09 | .09 | .09 |
| 115.5000 | .09 | .09 | .09 | .09 | .09 |
| 116.0000 | .09 | .09 | .09 | .09 | .09 |
| 116.5000 | .09 | .09 | .09 | .09 | .09 |
| 117.0000 | .09 | .09 | .09 | .09 | .09 |
| 117.5000 | .09 | .09 | .09 | .09 | .09 |
| 118.0000 | .09 | .09 | .09 | .09 | .09 |
| 118.5000 | .09 | .09 | .09 | .08 | .08 |
| 119.0000 | .08 | .08 | .08 | .08 | .08 |
| 119.5000 | .08 | .08 | .08 | .08 | .08 |
| 120.0000 | .08 | .08 | .08 | .08 | .08 |
| 120.5000 | .08 | .08 | .08 | .08 | .08 |
| 121.0000 | .08 | .08 | .08 | .08 | .08 |
| 121.5000 | .08 | .08 | .08 | .08 | .08 |
| 122.0000 | .08 | .08 | .08 | .08 | .08 |
| 122.5000 | .08 | .08 | .08 | .08 | .08 |
| 123.0000 | .08 | .08 | .08 | .08 | .08 |
| 123.5000 | .08 | .08 | .08 | .08 | .08 |
| 124.0000 | .08 | .08 | .08 | .07 | .07 |
| 124.5000 | .07 | .07 | .07 | .07 | .07 |
| 125.0000 | .07 | .07 | .07 | .07 | .07 |
| 125.5000 | .07 | .07 | .07 | .07 | .07 |
| 126.0000 | .07 | .07 | .07 | .07 | .07 |
| 126.5000 | .07 | .07 | .07 | .07 | .07 |
| 127.0000 | .07 | .07 | .07 | .07 | .07 |
| 127.5000 | .07 | .07 | .07 | .07 | .07 |
| 128.0000 | .07 | .07 | .07 | .07 | .07 |
| 128.5000 | .07 | .07 | .07 | .07 | .07 |
| 129.0000 | .07 | .07 | .07 | .07 | .07 |
| 129.5000 | .07 | .07 | .07 | .07 | .07 |
| 130.0000 | .07 | .07 | .07 | .07 | .07 |
| 130.5000 | .07 | .06 | .06 | .06 | .06 |
| 131.0000 | .06 | .06 | .06 | .06 | .06 |
| 131.5000 | .06 | .06 | .06 | .06 | .06 |
| 132.0000 | .06 | .06 | .06 | .06 | .06 |
| 132.5000 | .06 | .06 | .06 | .06 | .06 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (7/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 133.0000 | .06 | .06 | .06 | .06 | .06 |
| 133.5000 | .06 | .06 | .06 | .06 | .06 |
| 134.0000 | .06 | .06 | .06 | .06 | .06 |
| 134.5000 | .06 | .06 | .06 | .06 | .06 |
| 135.0000 | .06 | .06 | .06 | .06 | .06 |
| 135.5000 | .06 | .06 | .06 | .06 | .06 |
| 136.0000 | .06 | .06 | .06 | .06 | .06 |
| 136.5000 | .06 | .06 | .06 | .06 | .06 |
| 137.0000 | .06 | .06 | .06 | .06 | .06 |
| 137.5000 | .06 | .06 | .06 | .06 | .05 |
| 138.0000 | .05 | .05 | .05 | .05 | .05 |
| 138.5000 | .05 | .05 | .05 | .05 | .05 |
| 139.0000 | .05 | .05 | .05 | .05 | .05 |
| 139.5000 | .05 | .05 | .05 | .05 | .05 |
| 140.0000 | .05 | .05 | .05 | .05 | .05 |
| 140.5000 | .05 | .05 | .05 | .05 | .05 |
| 141.0000 | .05 | .05 | .05 | .05 | .05 |
| 141.5000 | .05 | .05 | .05 | .05 | .05 |
| 142.0000 | .05 | .05 | .05 | .05 | .05 |
| 142.5000 | .05 | .05 | .05 | .05 | .05 |
| 143.0000 | .05 | .05 | .05 | .05 | .05 |
| 143.5000 | .05 | .05 | .05 | .05 | .05 |
| 144.0000 | .05 | .05 | .05 | .05 | .05 |
| 144.5000 | .05 | .05 | .05 | .05 | .05 |
| 145.0000 | .05 | .05 | .05 | .05 | .05 |
| 145.5000 | .05 | .05 | .05 | .05 | .05 |
| 146.0000 | .05 | .05 | .05 | .05 | .05 |
| 146.5000 | .05 | .05 | .04 | .04 | .04 |
| 147.0000 | .04 | .04 | .04 | .04 | .04 |
| 147.5000 | .04 | .04 | .04 | .04 | .04 |
| 148.0000 | .04 | .04 | .04 | .04 | .04 |
| 148.5000 | .04 | .04 | .04 | .04 | .04 |
| 149.0000 | .04 | .04 | .04 | .04 | .04 |
| 149.5000 | .04 | .04 | .04 | .04 | .04 |
| 150.0000 | .04 | .04 | .04 | .04 | .04 |
| 150.5000 | .04 | .04 | .04 | .04 | .04 |
| 151.0000 | .04 | .04 | .04 | .04 | .04 |
| 151.5000 | .04 | .04 | .04 | .04 | .04 |
| 152.0000 | .04 | .04 | .04 | .04 | .04 |
| 152.5000 | .04 | .04 | .04 | .04 | .04 |
| 153.0000 | .04 | .04 | .04 | .04 | .04 |
| 153.5000 | .04 | .04 | .04 | .04 | .04 |
| 154.0000 | .04 | .04 | .04 | .04 | .04 |

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin
100-yr, 24-hr storm

LEVEL POOL ROUTING SUMMARY

HYG Dir = I:\1370\
Inflow HYG file = SBASIN.HYG - south basin 100
Outflow HYG file = NONE STORED - SOUTH BASIN2 OUT 100

Pond Node Data = south basin
Pond Volume Data = south basin
Pond Outlet Data = south basin2

No Infiltration

INITIAL CONDITIONS

| | | |
|---|---|---|
| Starting WS Elev | = 789.00 | ft |
| Starting Volume | = .000 | ac-ft |
| Starting Outflow | = .00 | cfs |
| Starting Infiltr. | = .00 | cfs |
| Starting Total Qout | = .00 | cfs |
| Time Increment | = .1000 | hrs |

INFLOW/OUTFLOW HYDROGRAPH SUMMARY

| | | | | |
|---|---|---|---|---|
| Peak Inflow | = 110.00 cfs | at | 12.4000 hrs | |
| Peak Outflow | = 16.79 cfs | at | 13.7000 hrs | ← Peak discharge from basin |
| Peak Elevation | = 793.29 ft | ← Peak water elevation | | |
| Peak Storage | = 7.080 ac-ft | | | |

MASS BALANCE (ac-ft)

| | | |
|---|---|---|
| + Initial Vol | = | .000 |
| + HYG Vol IN | = | 13.207 |
| - Infiltration | = | .000 |
| - HYG Vol OUT | = | 12.435 |
| - Retained Vol | = | .770 |
| Unrouted Vol | = | -.001 ac-ft (.011% of Inflow Volume) |

WARNING: Inflow hydrograph truncated on left side.
WARNING: Outflow hydrograph truncated on right side.

# References

### Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute $T_t$:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

**Table 3-1.—Roughness coefficients (Manning's n) for sheet flow**

| Surface description | n[1] |
|---|---|
| Smooth surfaces (concrete, asphalt, gravel, or bare soil) | 0.011 |
| Fallow (no residue) | 0.05 |
| Cultivated soils: | |
| Residue cover ≤20% | 0.06 |
| Residue cover >20% | 0.17 |
| Grass: | |
| Short grass prairie | 0.15 |
| Dense grasses[2] | 0.24 |
| Bermudagrass | 0.41 |
| Range (natural) | 0.13 |
| Woods:[3] | |
| Light underbrush | 0.40 |
| Dense underbrush | 0.80 |

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

$T_t$ = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
$P_2$ = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

### Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

### Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

| Cover description | | Curve numbers for hydrologic soil group— | | | |
|---|---|---|---|---|---|
| Cover type | Hydrologic condition | A | B | C | D |
| Pasture, grassland, or range—continuous forage for grazing.[2] | Poor | 68 | 79 | 86 | 89 |
| | Fair | 49 | 69 | 79 | 84 |
| | Good | 39 | 61 | 74 | 80 |
| Meadow—continuous grass, protected from grazing and generally mowed for hay. | — | 30 | 58 | 71 | 78 |
| Brush—brush-weed-grass mixture with brush the major element.[3] | Poor | 48 | 67 | 77 | 83 |
| | Fair | 35 | 56 | 70 | 77 |
| | Good | 30[4] | 48 | 65 | 73 |
| Woods—grass combination (orchard or tree farm).[5] | Poor | 57 | 73 | 82 | 86 |
| | Fair | 43 | 65 | 76 | 82 |
| | Good | 32 | 58 | 72 | 79 |
| Woods.[6] | Poor | 45 | 66 | 77 | 83 |
| | Fair | 36 | 60 | 73 | 79 |
| | Good | 30[4] | 55 | 70 | 77 |
| Farmsteads—buildings, lanes, driveways, and surrounding lots. | — | 59 | 74 | 82 | 86 |

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
*Fair:* 50 to 75% ground cover and not heavily grazed.
*Good:* >75% ground cover and lightly or only occasionally grazed.

[3]*Poor:* <50% ground cover.
*Fair:* 50 to 75% ground cover.
*Good:* >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
*Fair:* Woods are grazed but not burned, and some forest litter covers the soil.
*Good:* Woods are protected from grazing, and litter and brush adequately cover the soil.

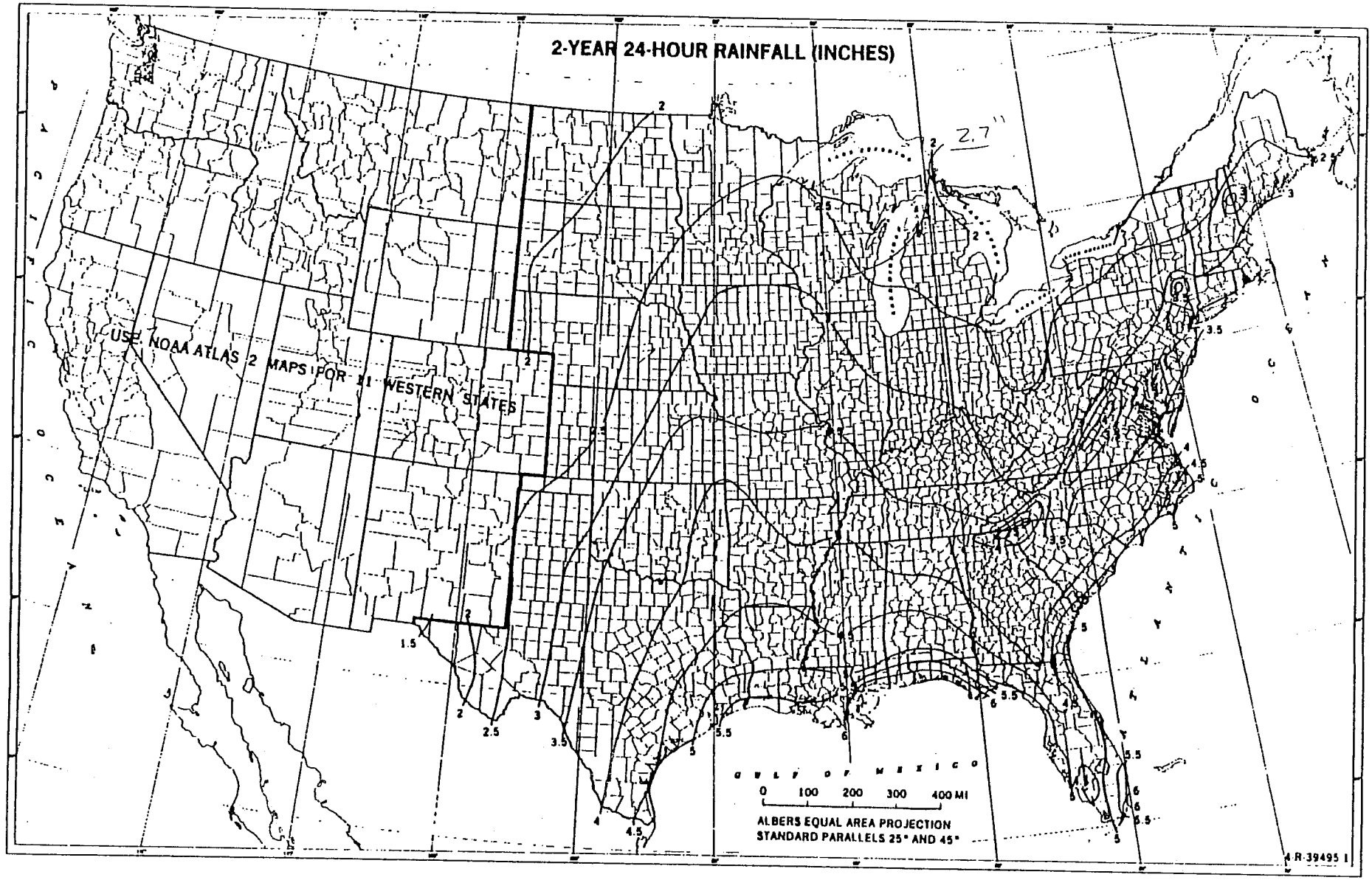



Figure B-3.—Two-year, 24-hour rainfall.

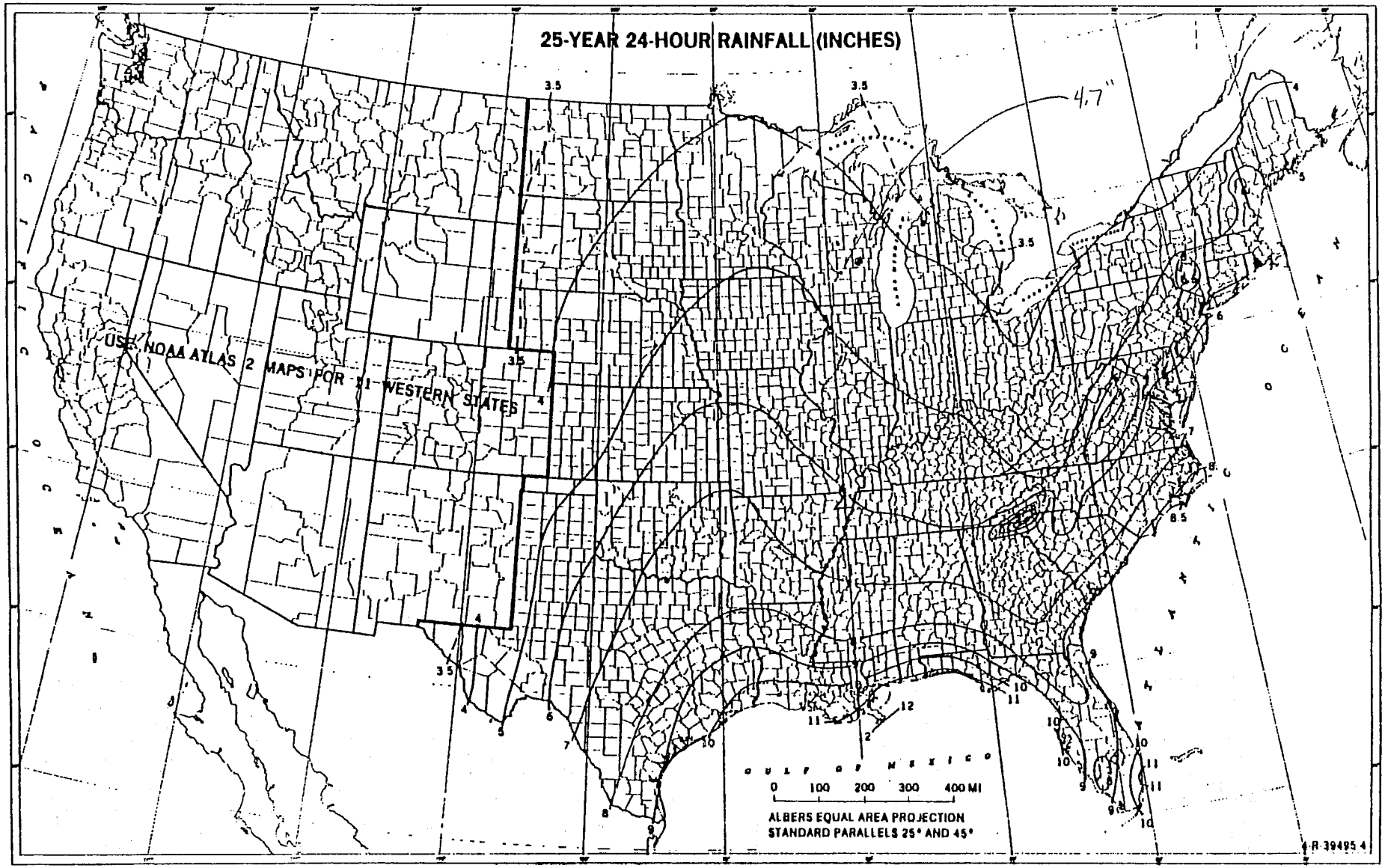



Figure B-6.—Twenty-five-year, 24-hour rainfall.

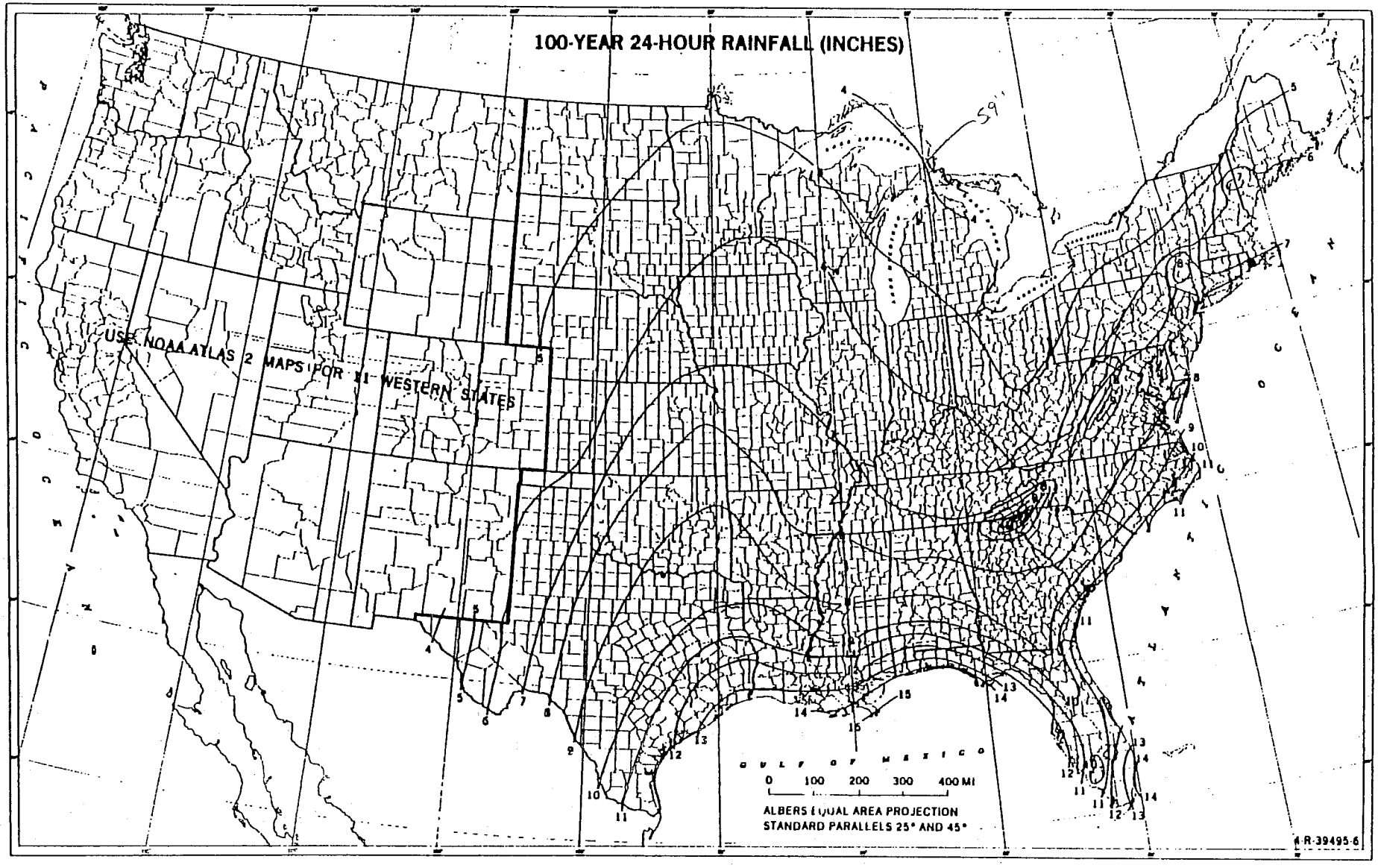



Figure B-8.—One-hundred-year, 24-hour rainfall.

TABLE 8.1 Surface Area Requirements of Sediment Traps and Basins

| Particle size, mm | Settling velocity, ft/sec (m/sec) | Surface area requirements, $ft^2$ per $ft^3$/sec discharge | ($m^2$ per $m^3$/sec discharge) |
|---|---|---|---|
| 0.5 (coarse sand) | 0.19 (0.058) | 6.3 | (20.7) |
| 0.2 (medium sand) | 0.067 (0.020) | 17.9 | (58.7) |
| 0.1 (fine sand) | 0.023 (0.0070) | 52.2 | (171.0) |
| 0.05 (coarse silt) | 0.0062 (0.0019) | 193.6 | (635.0) |
| 0.02 (medium silt) | 0.00096 (0.00029) | 1,250.0 | (4,101.0) |
| 0.01 (fine silt) | 0.00024 (0.000073) | 5,000.0 | (16,404.0) |
| 0.005 (clay) | 0.00006 (0.000018) | 20,000.0 | (65,617.0) |

0.015 <

→ Ave = 3,125 sf/cfs

weight composed of particles in the 0.01- to 0.02-mm range. A surface area 4 times larger would be needed to capture 5 percent more of this soil.

A balance between the cost-effectiveness of a certain basin size and the desire to capture fine particles must be achieved. It is desirable to capture the very small soil particles (clays and fine silts) because they cause turbidity and other water quality problems. However, Table 8.1 shows that a basin would have to be very large to capture particles smaller than 0.02 mm, particularly clay particles 0.005 mm and smaller. Because of the high cost of trapping very small particles, the authors recommend 0.02 as the design particle size for sediment basins except in areas with coarse soils, where a larger design particle may be used. The 0.02-mm particle is classified as a medium silt by the AASHTO soil classification system.

## 8.2d Basin Discharge Rate

The peak discharge, calculated by the rational or another approved method, is used to size the basin riser. During any major storm, a sediment basin should fill with water to the top of its riser and then discharge at the rate of inflow to the basin. A sediment basin is not designed with a large water storage volume as is a reservoir. If the inflow exceeds the design peak flow used to size the riser, the overflow should discharge down an emergency spillway.

## 8.2e Design Runoff Rate

In the equation for surface area of a sediment basin, the discharge rate $Q$ is a variable to be chosen by the designer. The above discussion of basin discharge rate shows that the discharge rate is, to a large extent, equal to the inflow. The riser is sized to handle the peak inflow to the basin. The authors suggest determining the surface area by the *average runoff of a 10-year, 6-hr storm* instead



of the peak flow. A substantial savings in size, and therefore cost, is obtained, and basin efficiency is not significantly decreased.

Consider a basin designed to capture the 0.02-mm particle at the average runoff rate. The average rainfall per hour is 17 percent of the total rainfall in a 6-hr storm (Sec. 4.1f). On a site with soils with a moderately high clay content, under ideal settling conditions this basin would retain about 62 percent of the eroded soil (i.e., 62 percent of the soil, by weight, is composed of 0.02-mm or larger particles).

If the surface area of this basin were instead designed for the peak flow, it would be roughly 3 times larger. According to data from the U.S. Bureau of Reclamation (10), 25 percent of the total rainfall in a 6-hr storm falls in a ½-hr period (Fig. 4.2). Since the rainfall intensity $i$ value is in units of inches (or millimeters) per hour, the peak flow can be calculated by using an $i$ value of 50 percent of the 6-hr total. Since basin surface area is directly proportional to the discharge rate ($A = 1.2Q/V_s$) and the peak discharge rate in a 6-hr storm is 2.9 times the average rate (50% = 2.9 × 17%), the surface area sized for the peak flow would be about 3 times the surface area sized for the average flow. The basin sized for the peak flow would capture, during most of the storm except the peak, particles with approximately one-third the settling velocity of the design particle. Since the 0.02-mm particle settles at 0.00096 ft/sec (0.00029 m/sec), particles with a settling velocity of 0.00032 ft/sec (0.000098 m/sec) would then be captured. These are approximately 0.01-mm particles.

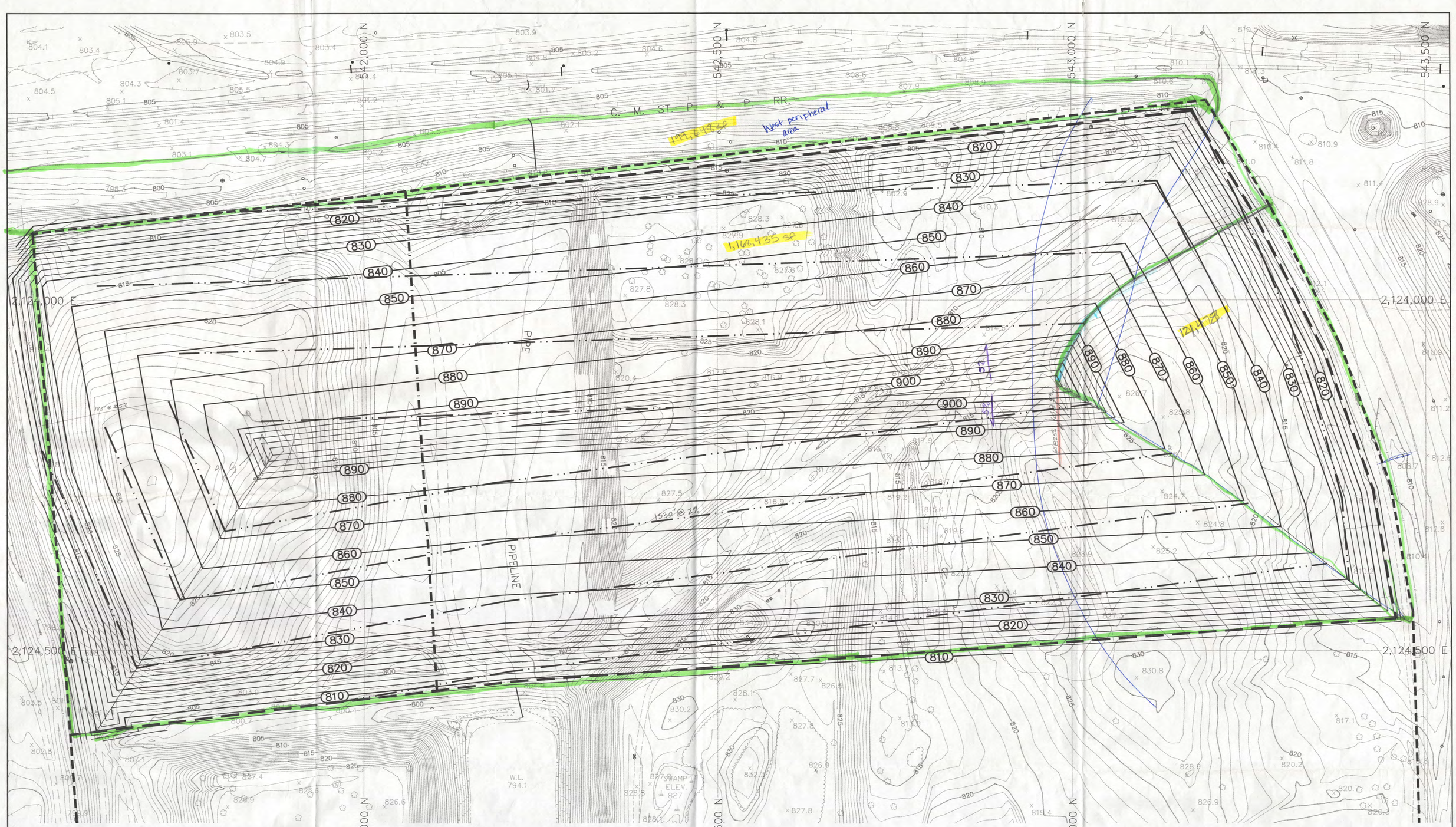
Suppose a basin on a site with clayey soils were sized by using the peak runoff rate. For the purpose of illustration, suppose the soil composition were typical of the San Francisco Bay Area as in the preceding example (62 percent of particles, by weight, greater than 0.02 mm and 5 percent, by weight, from 0.01 to 0.02 mm). A basin with a large surface area based on the peak runoff would capture the 0.01- to 0.02-mm particles as well as particles greater than 0.02 mm, or 67 percent of the eroded material. The basin efficiency would be increased 8 percent (5/62) by tripling the surface area. Thus it is generally much more cost-effective to size a basin by using the average runoff rather than the peak, and basin efficiency will not be significantly lower.

## 8.2f Settling Depth

If a basin is too shallow, water flowing rapidly through the basin may resuspend settled particles and decrease efficiency of capture. A similar problem occurs in grit-settling chambers at sewage treatment plants, where velocity must be controlled to prevent particle resuspension. An equation that describes scour in a grit chamber (2) is:

$$V_{scour} = \frac{1.486}{n} \times \left[ r^{1/6} \times k(S_s - 1) \times \frac{d}{304.8} \right]^{1/2}$$

Source: Goldman, S.J., et al. 1986. Erosion and Sediment Control Handbook. New York McGraw-Hill 1986




LEGEND

| | |
|---|---|
| PROPOSED LIMITS OF FILL | PAVED ROAD |
| APPROVED LIMITS OF FILL | UNPAVED ROAD |
| EXISTING SPOT ELEVATION | VEGETATION |
| EXISTING GRADES (5' INTERVAL) | RAILROAD TRACKS |
| EXISTING GRADES (1' INTERVAL) | FENCE |
| EDGE OF WATER | CULVERT |

Areas obtained from AutoCADD

60 0 60
SCALE: 1" = 60'

N

**PROPOSED FINAL GRADES**

PLAN OF OPERATION UPDATE
ALLIANT – COLUMBIA ASH DISPOSAL FACILITY
TOWN OF PACIFIC
COLUMBIA COUNTY, WISCONSIN

| | |
|---|---|
| PROJECT NO. 1370 | |
| DRAWN BY: RR/KP | |
| CHECKED BY: MRH | |
| DRAWN: 07/28/00 REVISED: 08/16/00 | |
| J:\1370\PO UPDATE\1370FG04.DWG | |

BT² inc.

SHEET 4 OF 8

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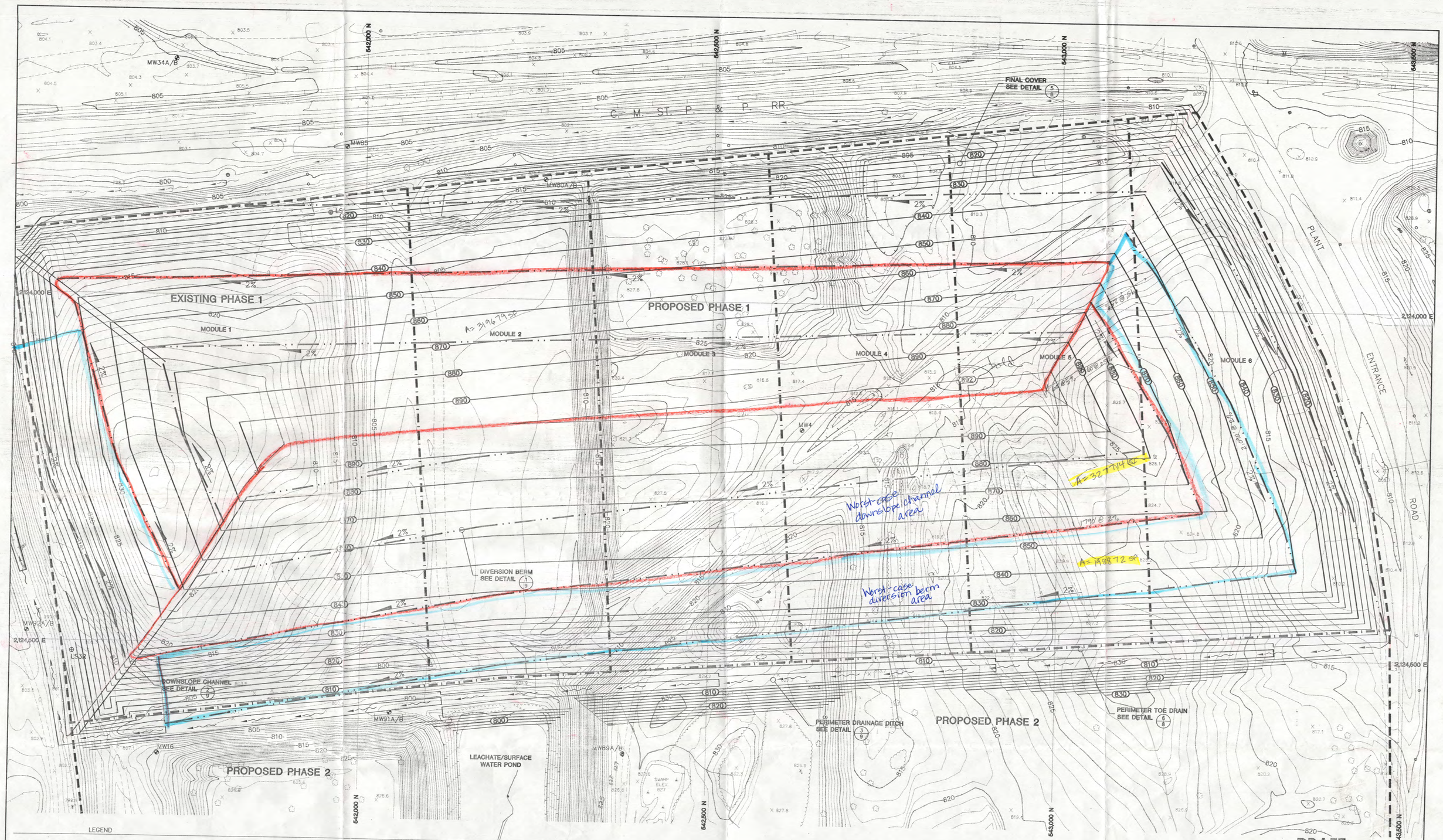


LEGEND

| | | |
|---|---|---|
| PHASE/MODULE LIMIT | PAVED ROAD | PROPOSED FINAL GRADES (5' INTERVAL) |
| APPROVED LIMITS OF FILL | UNPAVED ROAD | PROPOSED FINAL GRADES (1' INTERVAL) |
| EXISTING SPOT ELEVATION | VEGETATION | PROPOSED DIVERSION BERM |
| EXISTING GRADES (5' INTERVAL) | RAILROAD TRACKS | PROPOSED DOWNSLOPE CHANNEL |
| EXISTING GRADES (1' INTERVAL) | FENCE | DRAINAGE DITCH |
| EDGE OF WATER | CULVERT | |

Areas determined by planimeter

60 0 60
SCALE: 1" = 60'

N

DRAFT

**PROPOSED FINAL GRADES**

PLAN OF OPERATION UPDATE
ALLIANT – COLUMBIA ASH DISPOSAL FACILITY
TOWN OF PACIFIC
COLUMBIA COUNTY, WISCONSIN

| | |
|---|---|
| PROJECT NO. 1370 | BT² inc. |
| DRAWN BY: RR/KP | SHEET 4 OF 9 |
| CHECKED BY: MRH | |
| DRAWN: 07/28/00 REVISED: 08/25/00 | |
| J:\1370\PO UPDATE\1370FG04.DWG | |

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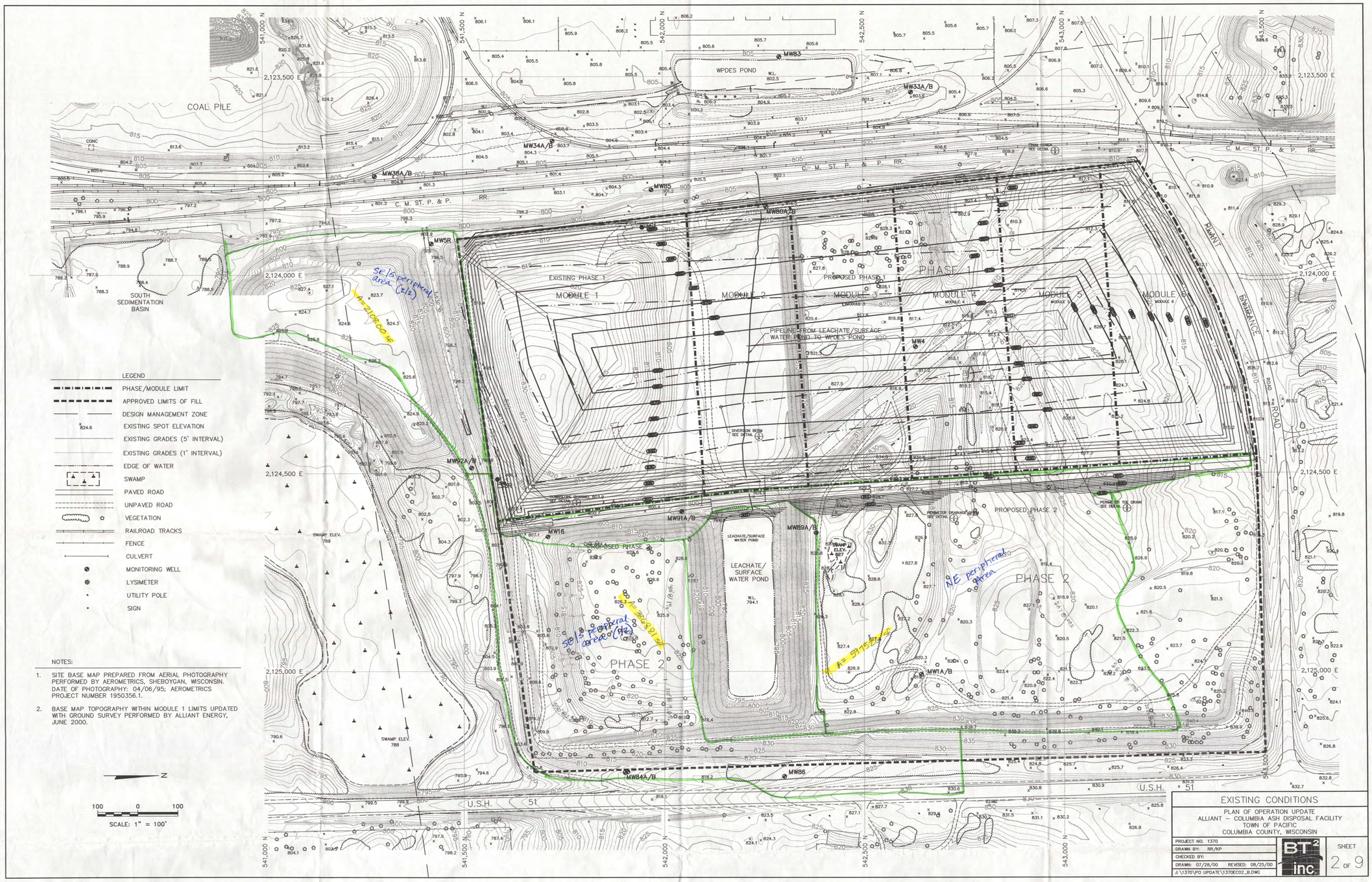


LEGEND

- PHASE/MODULE LIMIT
- APPROVED LIMITS OF FILL
- DESIGN MANAGEMENT ZONE
- EXISTING SPOT ELEVATION (824.6)
- EXISTING GRADES (5' INTERVAL)
- EXISTING GRADES (1' INTERVAL)
- EDGE OF WATER
- SWAMP
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- RAILROAD TRACKS
- FENCE
- CULVERT
- MONITORING WELL
- LYSIMETER
- UTILITY POLE
- SIGN

NOTES:

1. SITE BASE MAP PREPARED FROM AERIAL PHOTOGRAPHY PERFORMED BY AEROMETRICS, SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY: 04/06/95; AEROMETRICS PROJECT NUMBER 1950356.1.
2. BASE MAP TOPOGRAPHY WITHIN MODULE 1 LIMITS UPDATED WITH GROUND SURVEY PERFORMED BY ALLIANT ENERGY, JUNE 2000.

N

100 0 100

SCALE: 1" = 100'

# EXISTING CONDITIONS

PLAN OF OPERATION UPDATE
ALLIANT – COLUMBIA ASH DISPOSAL FACILITY
TOWN OF PACIFIC
COLUMBIA COUNTY, WISCONSIN

| | |
|---|---|
| PROJECT NO. 1370 | |
| DRAWN BY: RR/KP | |
| CHECKED BY: | |
| DRAWN: 07/28/00 REVISED: 08/25/00 | |
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BT² inc.

SHEET 2 OF 9

#1370 ON

# Appendix B1.2

# 2021 Leachate/Surface Water Pond Capacity Evaluation

March 10, 2021
File No. 25220183.00

Ms. Ann Bekta
Wisconsin Department of Natural Resources
2514 Morse Street
Janesville, WI 53545

Subject: Leachate/Surface Water Pond Capacity Evaluation
Dry Ash Disposal Facility – Columbia Energy Center
License #3025
Town of Pacific, Columbia County, Wisconsin

Dear Ms. Bekta:

On behalf of Wisconsin Power and Light Company (WPL), SCS Engineers (SCS) has prepared this leachate/surface water pond (pond) capacity evaluation in preparation for Phase 1, Module 5 (Module 5) and Module 6 (Module 6) liner construction at the dry ash disposal facility located at the Columbia Energy Center (Columbia) in the Town of Pacific, Wisconsin. This evaluation has been prepared in accordance with Condition No. 1 of the Rain Cover System Plan of Operation Approval Modification issued by Wisconsin Department of Natural Resources (WDNR) on June 6, 2018 (**Attachment A**). Construction of Module 5 and Module 6 is expected to begin in mid-2021 and be completed by the end of 2021.

## POND CAPACITY EVALUATION

A pond capacity evaluation was performed using storm water modeling. The evaluation demonstrates that the pond can accommodate a 25-year, 24-hour storm with up to 6.54 acres of open landfill area without overtopping. The model write-up and results are included in **Attachment B**. Based on this conclusion, WPL plans to manage pond levels using a similar approach implemented during construction and operation of Phase 1, Module 4 (Module 4). WPL proposes to use a rain cover in Module 5 and Module 6 to offset the required intermediate/final cover area necessary.

The evaluation was performed to determine the amount of open/contributing area in Modules 2, 3, 4, 5, and 6 that can be accommodated in the pond below the maximum lined pond limits (i.e., to elevation 796.97). The following scenarios were evaluated:

- Scenario 1 – 50 percent of Module 5 open (partially active); Module 6 and remaining 50 percent of Module 5 covered with a rain cover (**Figure 1, Attachment B**).
- Scenario 2 – 100 percent of Module 5 open (fully active); Module 6 covered with a rain cover (**Figure 2, Attachment B**).
- Scenario 3 – 50 percent of Module 6 open (partially active) (**Figure 3, Attachment B**).
- Scenario 4 – 100 percent of Module 6 open (fully active) (**Figure 4, Attachment B**).

**Figures 1** through **4** show the resulting general area requiring intermediate/final cover to achieve open landfill area for the scenarios modeled. The actual location of cover placement may vary

depending on coal combustion residual (CCR) grades, but the required additional intermediate/final cover area will be met.

## POND MANAGEMENT PLAN

While Module 5 and Module 6 are constructed and completed, water levels in the pond will be managed as outlined below:

### During Construction of Module 5 and Module 6, Through Installation of a Rain Cover Over a Frost Protection Layer

- Intermediate/final cover in Module 3 and Module 4.
  - Areas with existing intermediate/final cover will continue to be routed to the South Sedimentation Basin, reducing the volume discharging to the pond.
  - Intermediate cover will be placed on portions of Modules 3 and 4 if final waste grades are reached.

- Water level management in the pond.
  - The pond will be pumped dry and maintained by the site or Module 5 and Module 6 liner construction contractor:
    - At the start of Module 5 and Module 6 construction;
    - Following rain events during Module 5 and Module 6 construction; and
    - Following rain events during placement of the frost protection layer in Module 5 and Module 6.

    Note: During frost protection placement, there will be more than 6.54 acres of open landfill space; however, the pond will be able to accommodate a 10-year 24-hour storm (assuming a starting elevation of 6 inches of water in the pond). This transition period will last approximately 6 weeks or less and consist of the placement of approximately 50,000 cubic yards of frost protection material.

- Installation of a rain cover in Module 5 and Module 6.
  - A rain cover will be installed after the frost protection layer is placed in Module 5 and Module 6.
  - The rain cover will allow clean storm water to be diverted away from the leachate/contact water collection system prior to additional filling operations, reducing the volume discharging to the pond.

### During Subsequent Filling in Module 5

Filling in Module 5, beyond the frost protection layer, is expected to begin in early 2022. When filling commences, water levels will be managed as follows:

- Transition of disposal operations into Module 5.
  - WPL will remove a portion of the Module 5 rain cover only large enough to accommodate the transition of disposal operations in Module 5.

  - To the extent possible, in advance of the transition and during the transition, WPL may begin placing intermediate cover with internal resources in areas of Modules 3 and 4 where final or interim waste grades have been achieved.
  - WPL will continue installation of intermediate cover or begin the procurement of external resources (i.e., engineering and contractor assistance) to install final cover in Modules 3 and 4 once the transition of disposal operations into Module 5 is complete. WPL intends to monitor waste grades in Modules 3 and 4 using regular airspace surveys and GPS equipment to predict the timing of the transition as accurately as possible.
  - During the transition of disposal operations into Module 5, there may be more than 6.54 acres of open landfill space; however, the pond will be able to accommodate at least a 10-year 24-hour storm (assuming a starting elevation of 6 inches of water in the pond). The duration of this transition period will be as short as possible. The required timing of the transition in relation to the construction season may affect the duration of the transition.

- Placement of additional intermediate/final cover in Modules 3 and 4.
  - Following the complete transition of disposal operations into Module 5, WPL will focus on achieving the 6.54 acres of open landfill (if not already obtained) by placing additional intermediate/final cover in Modules 3 and 4 as described in the Pond Capacity Evaluation section above.
  - To maintain a maximum open area of 6.54 acres, WPL will place intermediate/final cover over a currently active area in Modules 3 and 4 that is equal to the area of the Module 5 rain cover they will remove. For example, 1.98 acres of intermediate/final cover will need to be installed if 50 percent of the rain cover were removed, and 4.03 acres of intermediate/final cover will need to be installed if 100 percent of the rain cover were removed.

- Water level management in the pond and staged removal of rain cover.
  - The rain cover may be removed in sections during additional waste filling, allowing portions of storm water in Module 5 to continue to be diverted from the pond.
  - Water levels will be managed by pumping to specified maximum starting elevations prior to the start of anticipated storm events. Operating level figures are attached to the pond evaluation in Attachment B for open scenarios of 50 percent and 100 percent of Module 5. Operating levels will be updated for actual removal areas.

## During Subsequent Filling in Module 6

Filling in Module 6, beyond the frost protection layer, is expected to begin in 2023. When filling commences, water levels will be managed as follows:

- Transition of disposal operations into Module 6.
  - WPL will remove a portion of the Module 6 rain cover only large enough to accommodate the transition of disposal operations in Module 6.
  - To the extent possible, in advance of the transition and during the transition, WPL may begin placing intermediate cover with internal resources in areas of Modules 4 and 5 where final or interim waste grades have been achieved.

  - WPL will continue installation of intermediate cover or begin the procurement of external resources (i.e., engineering and contractor assistance) to install final cover in Modules 4 and 5 once the transition of disposal operations into Module 6 is complete. WPL intends to monitor waste grades in Modules 4 and 5 using regular airspace surveys to predict the timing of the transition as accurately as possible.
  - During the transition of disposal operations into Module 6, there may be more than 6.54 acres of open landfill space; however, the pond will be able to accommodate at least a 10-year 24-hour storm (assuming a starting elevation of 6 inches of water in the pond). The duration of this transition period will be as short as possible. The required timing of the transition in relation to the construction season may affect the duration of the transition.

- Placement of additional intermediate/final cover in Modules 4 and 5.
  - Following the complete transition of disposal operations into Module 6, WPL will focus on achieving the 6.54 acres of open landfill by placing additional intermediate/ final cover in Modules 4 and 5 as described in the Pond Capacity Evaluation section above.
  - To maintain a maximum open area of 6.54 acres, WPL will place intermediate/final cover over a currently active area in Modules 4 and 5 that is equal to the area of the Module 6 rain cover they will remove. For example, 6.07 acres of intermediate/final cover will need to be installed if 50 percent of the rain cover were removed, and 7.97 acres of intermediate/final cover will need to be installed if 100 percent of the rain cover were removed. NOTE: The total areas of coverage are measured from current 2021 intermediate/final cover areas.

- Water level management in the pond and staged removal of rain cover.
  - The rain cover may be removed in sections during additional waste filling, allowing portions of storm water in Module 6 to continue to be diverted from the pond.
  - Water levels will be managed by pumping to specified maximum starting elevations prior to the start of anticipated storm events. Operating level figures are attached to the pond evaluation in **Attachment B** for open scenarios of 50 percent and 100 percent of Module 6. Operating levels will be updated for actual removal areas.

## PLAN MODIFICATION

A Plan of Operation Approval Modification (Plan Modification) to install a rain cover in Module 4 and future modules was provided on April 17, 2018, and approved on June 6, 2018 (**Attachment A**). The Plan Modification addressed installation, maintenance, and removal requirements for the rain cover. A preconstruction report will be submitted at a later date including geosynthetics material for Module 5 and Module 6 construction.

If you have any questions regarding the contents of this letter, please contact Jeff Maxted at 608.458.3853 or Phil Gearing at 608.216.7324.

Sincerely,

Phillip E. Gearing, PE
Project Manager
SCS Engineers

Mark R. Huber, PE
Project Director
SCS Engineers

RJG/AJR_jsn/PEG/MRH

cc: Jeff Maxted, Alliant Energy
Brian Clepper, WPL – Columbia Energy Center

Encl. Attachment A – WDNR Correspondence
Attachment B – Leachate/Surface Water Pond Capacity Evaluation

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Attachment A

WDNR Correspondence

**State of Wisconsin**
DEPARTMENT OF NATURAL RESOURCES
3911 Fish Hatchery Road
Fitchburg WI 53711-5397

Scott Walker, Governor
Daniel L. Meyer, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

June 6, 2018

File Ref: FID 111049180
Columbia County
Approval

Mr. Jeff Maxted
Alliant Energy Corporation
4902 North Biltmore Lane
Madison, WI 53718-2148

Subject: Rain Cover System, Plan of Operation Approval Modification, Dry Ash Disposal Facility, Columbia Energy Center License #3025

Dear Mr. Maxted:

The requested modification to your plan of operation for a rain cover system has been reviewed and approved. Please include the attached approval in the written operating record for the landfill as specified in s. NR 506.17, Wis. Adm. Code.

The proposed modification includes the installation and operation of a proposed rain cover system above the completed liner and leachate collection system at the Wisconsin Power and Light Company (WPL) Columbia dry ash disposal facility. The rain cover will allow WPL to divert clean storm water away from the leachate collection system. Diverting clean storm water will minimize the volume of leachate that is collected in the leachate/surface water pond.

If you have any questions regarding this letter, please contact Ann Bekta at ann.bekta@wisconsin.gov or (608)743-4845.

Sincerely,

Cynthia Moore
Waste and Materials Management Program Supervisor
South Central Region

c: Ann Bekta – DNR JSC
Adam Hogan – DNR SCR
Valerie Joosten – DNR NER
Eric Nelson – ENelson@scsengineers.com
Nate Sievers - NathanielSievers@alliantenergy.com

# PROJECT SUMMARY
# COLUMBIA DRY ASH DISPOSAL LANDFILL

## Background

During the construction of Phase 1, Module 2 it was discovered that the peak liner elevation of the existing leachate/surface water pond was at approximately 797 MSL instead of the design elevation of 798. Because of this, the new maximum allowable pond water level was set at 796.97 MSL. In the 2010 Plan of Operation Update the peak water elevation in the pond from a 25-year, 24-hour storm event when Module 3 is operating is 797.17 MSL, which is above the maximum allowable pond water level. Condition 1 of the Department's February 13, 2012 Phase 1, Module 2 liner construction documentation approval required an evaluation of the leachate/surface water pond capacity. The evaluation contained recommendations for a leachate management plan during Phase 1, Module 3 operation. Additional recommendations were discussed in a June 10, 2016 letter. It was determined that a combination of additional final and intermediate cover in Phase 1, Modules 1 and 2 and a rain cover system would maintain the pond water level below the maximum allowable level of 796.9 MSL.

Because the rain cover system for Phase 1, Module 3 was effective in keeping the levels of the pond below the maximum allowable level, WPL proposes to use the system in future modules.

## Rain Cover System

WPL is proposing to use rain covers to divert clean storm water away from the leachate collection system in newly constructed landfill cells at the Columbia Energy Center (Columbia) dry ash disposal facility. WPL will install rain covers over new liner and leachate collection systems or coal combustion residual (CCR) frost protection material, and the rain covers will remain in place until removal is needed to facilitate waste placement operations.

The rain covers will prevent storm water contact with leachate drainage layer material and frost protection material, which may both consist of CCR. The rain covers will collect clean, non-contact storm water that would otherwise be managed as leachate with the leachate collection system and allow WPL to divert that water to the perimeter drainage system.

The rain cover will be installed over the leachate drainage layer material, or frost protection layer, and anchored in a trench or with sand bags at the limits of the rain cover area. The rain cover will consist of a 12-mil polyethylene scrim reinforced polyethylene geomembrane. The 12-mil scrim reinforced polyethylene geomembrane material will be stitched together. A ballast system consisting of sandbags and rope installed on a grid over the scrim material will be used to protect the barrier layer from wind damage. The sand bag and rope ballast system will be installed on a grid over the scrim material. Sandbags will be installed on a 10-foot by 5-foot grid with ropes tied to the bags along the north-south lines. Sandbags used in the ballast system will be filled with a sand material and will not contain bottom ash.

When used, the rain cover will be terminated at a berm. The perimeter berms or temporary berms constructed within the limits of each module will be used to provide storm water containment. A berm will be constructed along the tie in or existing delineation berm between adjacent modules (i.e., existing and newly constructed). This berm will be constructed by grading the waste or general fill material in the existing module. The berm between adjacent modules is required to keep clean storm water on the rain cover and leachate off the rain cover. If interior berms are constructed for containment, the height will be determined based on storm water calculations to be performed prior to construction of each

module. The berm between adjacent modules will be at least 4 feet high, but will be no higher than the exterior perimeter berms. Outlets from the rain cover area will also be sized based on storm water calculations performed for each module where a rain cover is installed.

Non-contact storm water that accumulates on top of a rain cover will gravity drain or be pumped into the perimeter drainage swales. The perimeter drainage swales drain to the sedimentation basin located to the south of the landfill. Water collected on the rain cover will be visually inspected for evidence of leachate or contact water and other impacts before it is pumped into the perimeter drainage system. Evidence of leachate or contact water impacts may include a discoloration of the water, an accumulation of coal combustion residuals (CCR) at the collection point or signs of erosion along the limits of the rain cover where it abuts the active disposal area. The rain cover limits, including the berm and anchoring, will be inspected after all significant precipitation events (>0.5 inches) to ensure that leachate or contact water has not run onto the rain cover. In the event that leachate or contact water runs onto the rain cover, all water collected on the rain cover will be managed as leachate and hauled to the ash pond for disposal or used for dust control within the landfill limits of waste.

No CCR material will be placed on top of the rain cover. The rain cover will be removed in sections as filling operations proceed in each module. The rain cover will be cut at the limits of the operating area for CCR disposal and a new berm will be constructed at the rain cover limits to maintain flow to a new collection point. When removed, rain cover materials may be stored for reuse in future installations. The removed material may also be used for future repairs depending on the condition of material. Rain cover materials in poor condition after removal will be disposed offsite.

An updated Construction Quality Assurance (CQA) Plan that incorporates the rain cover will be included with the geosynthetics preconstruction report for future module construction. For future modules, the preconstruction report will also contain the storm water calculations performed to determine if a rain cover is needed. If a rain cover is required, the preconstruction report will contain the rain cover product identification, material properties, and installation recommendations from the manufacturer.

The installed limits of the rain cover will be surveyed and provided along with photographic documentation of the installation in the construction documentation report for each module, or as an addendum to the construction documentation report.

**BEFORE THE**
**STATE OF WISCONSIN**

**DEPARTMENT OF NATURAL RESOURCES**
**PLAN OF OPERATION APPROVAL MODIFICATION**
**FOR THE WISCONSIN POWER AND LIGHT (WPL)**
**COLUMBIA DRY ASH DISPOSAL LANDFILL (#03025)**

## FINDINGS OF FACT

The Department finds:

1. Wisconsin Power and Light (WPL) owns and operates a non-hazardous solid waste disposal facility located in Section 27, T12N, R9W, Town of Pacific, Columbia County, Wisconsin.

2. The Department conditionally approved a plan of operation for the facility on June 30, 1983. The plan of operation was updated on November 2, 2000 and January 28, 2011.

3. On April 19, 2018, Alliant Energy, on behalf of WPL, submitted a plan modification request to the Department for a rain cover system. The correct plan review fee of $1,650 was received by the Department on June 5, 2018.

4. The information submitted in connection with the modification request includes a report prepared by SCS Engineers, entitled "Plan Modification Rain Cover, Dry Ash Disposal Facility, Columbia Energy Center, Town of Pacific, Wisconsin" dated April 17, 2018 and was received by the Department on April 19, 2018.

5. Additional documents considered in connection with the modification request include documents supporting the following approvals:

    a. The Department's June 30, 1983 plan of operation approval.

    b. The Department's November 2, 2000 plan of operation update approval.

    c. The Department's January 28, 2011 plan of operation update approval.

    d. Alliant's February 24, 2016 leachate/surface water pond capacity evaluation.

    e. Alliant's June 10, 2016 letter containing additional information regarding the leachate/surface water pond capacity evaluation.

    f. The Department's July 1, 2016 plan of operation approval modification for a rain cover system.

    g. The Department files for the Columbia Energy Center Landfill #3025.

6. If the special conditions set forth below are complied with, the proposal will meet the requirements of chs. NR 500-538, Wis. Adm. Code.

## CONCLUSIONS OF LAW

1. The Department has authority under s. 289.30(6), Stats., to modify a plan of operation approval if the modification would not inhibit compliance with the applicable portions of chs. NR 500-538, Wis. Adm. Code.

2. The Department has authority to approve a plan of operation approval modification with special conditions if the conditions are needed to ensure compliance with chs. NR 500-538, Wis. Adm. Code.

3. The conditions of this approval are needed to ensure compliance with chs. NR 500-538, Wis. Adm. Code.

4. In accordance with the foregoing, the Department has the authority under s. 289.30, Stats., to issue the following conditional plan of operation approval modification.

## PLAN OF OPERATION MODIFICATION APPROVAL

The Department hereby approves the proposed modification to the plan of operation for the Wisconsin Power and Light Columbia Dry Ash Landfill to allow the use of a rain cover system, subject to chs. NR 500- 538, Wis. Adm. Code and the following:

1. For future modules, the preconstruction report shall contain the storm water calculations performed to determine if a rain cover is needed or not.

2. If a rain cover is required in a module, the preconstruction report shall contain the rain cover product identification, material properties, and installation recommendations from the manufacturer.

3. If a rain cover is required in a module, the installed limits of the rain cover shall be surveyed and provided along with photographic documentation of the installation in the construction documentation report for each module, or as an addendum to the construction documentation report.

The Department retains the right to require the submittal of additional information or to modify this approval at any time if, in the Department's opinion, further modifications are necessary. Unless specifically stated, the conditions of this approval modification do not supersede or replace any previous conditions of approval for this facility.

## NOTICE OF APPEAL RIGHTS

If you believe you have a right to challenge this decision made by the Department, you should know that Wisconsin statutes and administrative codes establish time periods and requirements for reviewing Department decisions.

To seek judicial review of the Department's decision, sections 227.52 and 227.53, Stats., establish criteria for filing a petition for judicial review. You have 30 days after the decision is mailed or otherwise served by the Department to file your petition with the appropriate circuit court and serve the petition on the Department. The petition shall name the Department of Natural Resources as the respondent.

Dated: June 6, 2018

DEPARTMENT OF NATURAL RESOURCES
For the Secretary

Cynthia Moore
Waste and Materials Management Program
South Central Region

Ann Bekta
Ann M. Bekta, P.E.
Waste Management Engineer
South Central Region

# Attachment B

# Leachate/Surface Water Pond Capacity Evaluation

| SCS ENGINEERS | | | | | |
|---|---|---|---|---|---|
| | | SHEET NO. | 1 | | |
| Job No. | 25220183.00 | CALC. NO. | | | |
| Job: | Columbia Energy Center | REV. NO. | | | |
| Client | WPL | BY | RJG | DATE | 02/10/21 |
| Subject | Module 5/6 - Leachate/Surface Water Pond Evaluation | CHK'D. | MH | DATE | 3/1/21 |

**Purpose:**
The purpose of the leachate/surface water pond evaluation is to determine the following based on the as-built leachate/surface water pond top of liner elevation of 796.97 (see Background section below):

- The amount of intermediate/final cover area required with Module 5 and 6 constructed in order to maintain the peak water elevation resulting from the 25-year, 24-hour storm event at the maximum allowable 796.97.
- Based on the amount of intermediate/final cover area determined from the above, determine the maximum starting water elevations in the leachate/surface water pond to accommodate 1, 2, 5, and 10-year, 24-hour storm events without overtopping.

**Background:**
- During construction of Module 2, the top of the leachate/surface water pond liner was determined to be at elevation 796.97.
- Previous calculations submitted to the WDNR on January 30, 2018, evaluated the leachate/surface water pond capacity based on the as-built pond liner elevation.
- A similar evaluation was performed for Module 3 and 4 construction that produced a chart of maximum leachate/surface water pond starting elevations vs. rainfall storage capacity.
- Portions of Modules 1, 2, and 3 currently have final or intermediate cover in place (see **Figure 1**).

**Approach:**
- Use the previously developed HydroCAD storm water model from Module 4 construction to model the below three scenarios.
    1. Scenario 1 –Assume a rain cover is in place over 50% of Module 5 and 100% of Module 6, resulting in the remaining 50% of Module 5 contributing to the leachate/surface water pond.
    2. Scenario 2 – Assume all of Module 5 is contributing to the leachate/surface water pond, while Module 6 is still under the rain cover.
    3. Scenario 3 – Assume a rain cover is in place over 50% of Module 6, resulting in 50% of Module 6 contributing to the leachate/surface water pond.
    4. Scenario 4 – Assume all of Module 6 is contributing to the leachate/surface water pond

**Assumptions:**
- Ash surfaces and intermediate cover areas were assumed to be impermeable (CN=98).
- The top of pond liner elevation is 796.97 (see Background section).
- Time of Concentration is 20 minutes for open areas.

**Results:**

1. Scenario 1 - with 50% of Module 5 contributing to the leachate/storm water pond:
   - The maximum allowable contributing area of landfill to the leachate/surface water pond is 4.47 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill (1.98 acres) would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 1** shows a conceptual 1.98 acres of additional cover, and **Figure 1a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

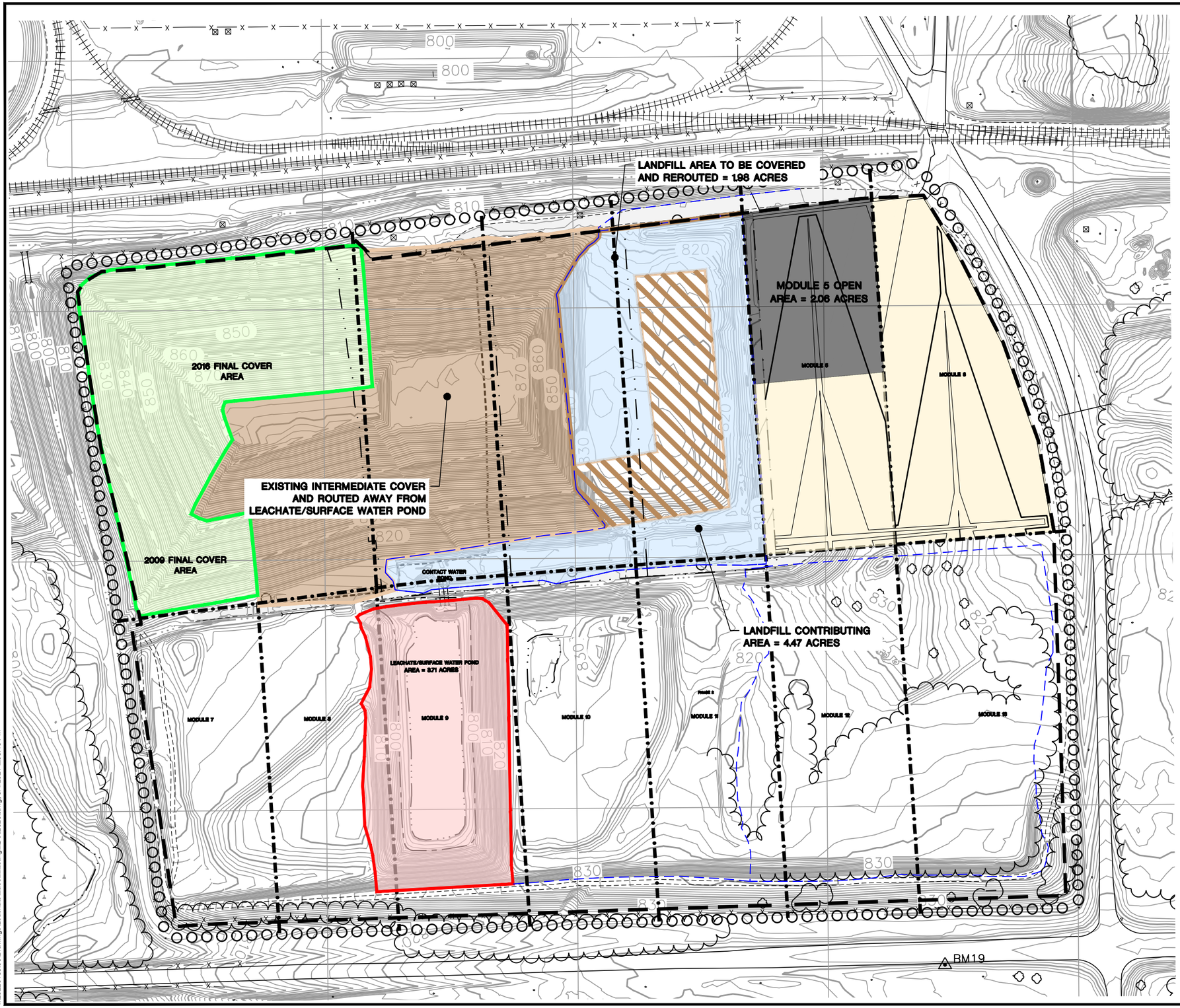
2. Scenario 2 - with 100% of Module 5 contributing to the leachate/storm water pond:
   - The maximum allowable contributing area of landfill to the leachate/surface water pond is 2.42 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill (4.03 acres) would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 2** shows a conceptual 4.03 acres of additional cover, and **Figure 2a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

3. Scenario 3 - with 50% of Module 6 contributing to the leachate/storm water pond:
   - The maximum allowable contributing area of landfill to the leachate/surface water pond is 4.64 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill (6.07 acres) would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 3** shows a conceptual 6.07 acres of additional cover, and **Figure 3a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

4. Scenario 4 - with 100% of Module 6 contributing to the leachate/storm water pond:
   - The maximum allowable contributing area of landfill to the leachate/surface water pond is 2.74 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill (7.97 acres) would need to be closed/covered with final or intermediate cover and routed away from the pond.

- **Figure 4** shows a conceptual 7.97 acres of additional cover, and **Figure 4a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

The HydroCAD reports for each scenario and storm event modeled are attached.




LEGEND

- DRY ASH DISPOSAL FACILITY LIMITS
- APPROVED LIMITS OF WASTE
- PROPOSED MODULE LIMIT
- EXISTING GRADE (2' CONTOUR)
- 690 EXISTING GRADE (10' CONTOUR)
- EDGE OF WATER (APPROXIMATE)
- EXISTING FINAL COVER AREA
- EXISTING INTERMEDIATE COVER AND ROUTED AWAY FROM POND
- LEACHATE/SURFACE WATER POND CONTRIBUTING AREA
- LANDFILL CONTRIBUTING AREA
- MODULE 5 CONTRIBUTING AREA
- AREA TO BE COVERED/REROUTED
- MODULE 5 AND 6 COVERED WITH RAIN COVER

N

200 0 200

SCALE: 1" = 200'

LEACHATE/SURFACE WATER POND EVALUATION
SCENARIO 1

FIGURE 1

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER
RJG
PG

SITE
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT
WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954
CLIENT LOGO IF AVAILABLE

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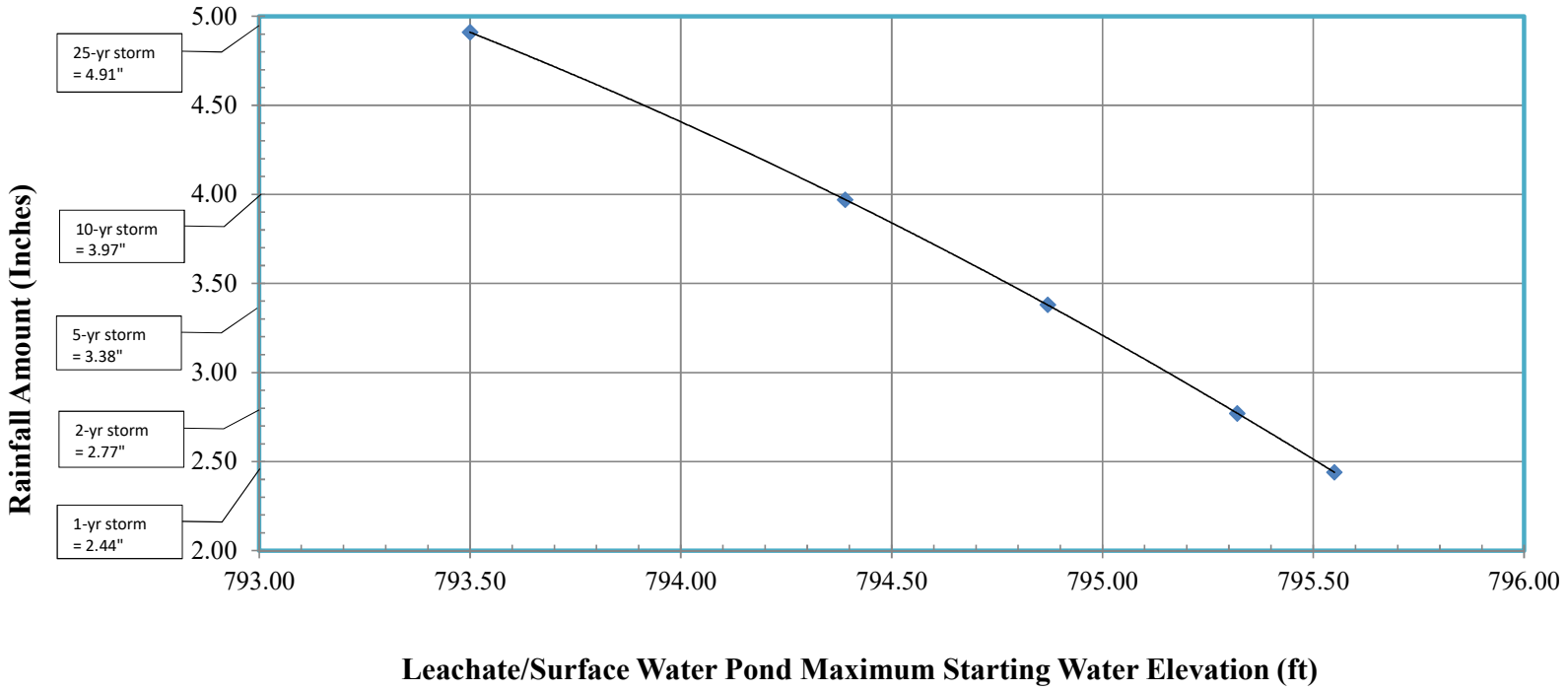
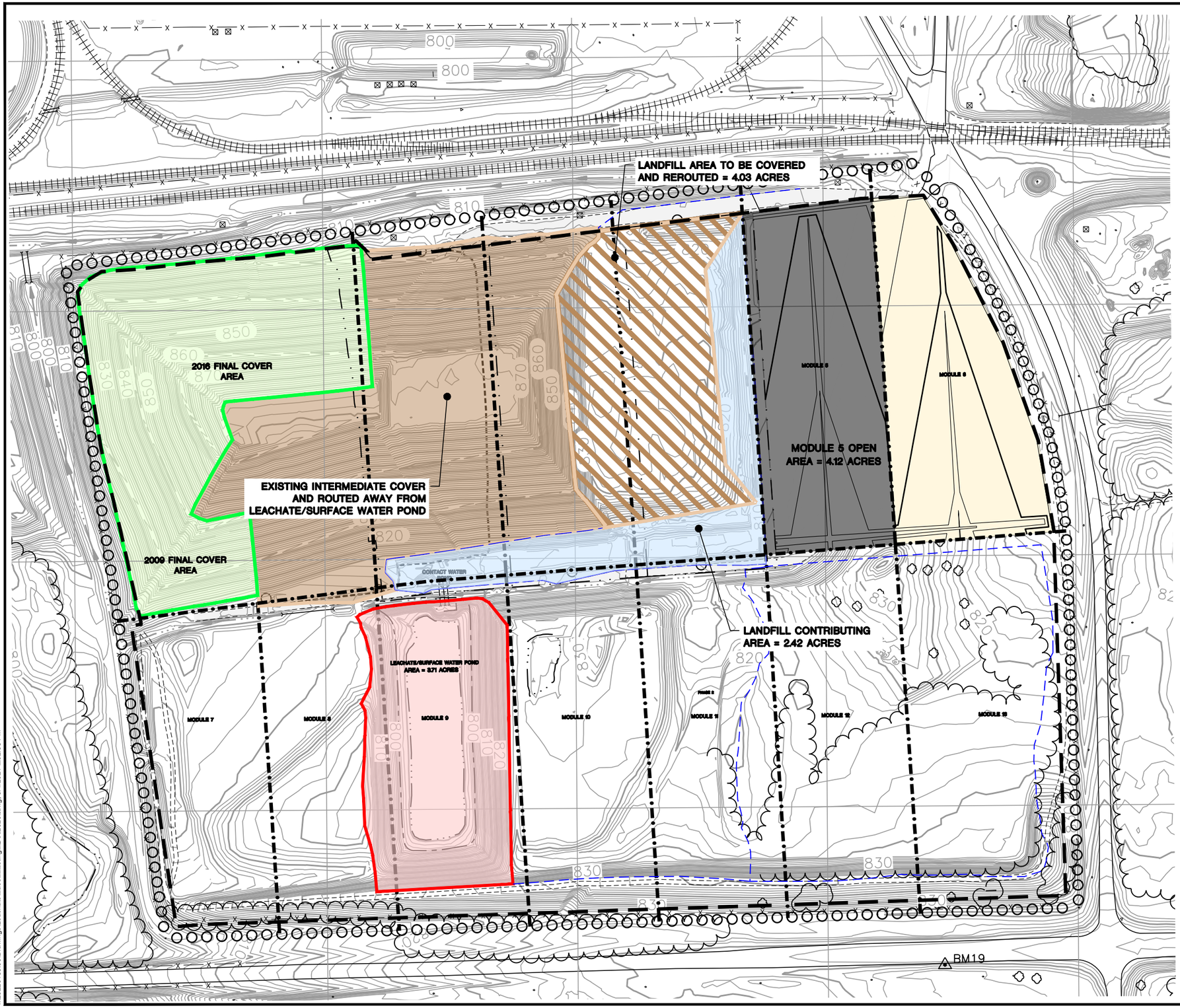
# Figure 1A
# Columbia Energy Center
# Scenario 1 - Module 5 50% Open
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (refer to Leachate/Surface Water Pond Evaluation figure dated 11/28/17):
   - Mod 5 open area = 50% of module = 2.06 acres.
   - Landfill open area = 4.47 acres (previously open/contributing area [6.45 acres] - required closure/rerouted area [1.98 acres]).
   - Leachate/Surface Water Pond Area, 3.71 acres.




LEGEND

- DRY ASH DISPOSAL FACILITY LIMITS
- APPROVED LIMITS OF WASTE
- PROPOSED MODULE LIMIT
- EXISTING GRADE (2' CONTOUR)
- 690 EXISTING GRADE (10' CONTOUR)
- EDGE OF WATER (APPROXIMATE)
- EXISTING FINAL COVER AREA
- EXISTING INTERMEDIATE COVER AND ROUTED AWAY FROM POND
- LEACHATE/SURFACE WATER POND CONTRIBUTING AREA
- LANDFILL CONTRIBUTING AREA
- MODULE 5 CONTRIBUTING AREA
- AREA TO BE COVERED/REROUTED
- MODULE 5 AND 6 COVERED WITH RAIN COVER

N

200 0 200

SCALE: 1" = 200'

LEACHATE/SURFACE WATER POND EVALUATION
SCENARIO 2

FIGURE 2

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER
RJG
PG

SITE
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT
WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954
CLIENT LOGO IF AVAILABLE

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| CHECKED BY: | |
| APPROVED BY: | |

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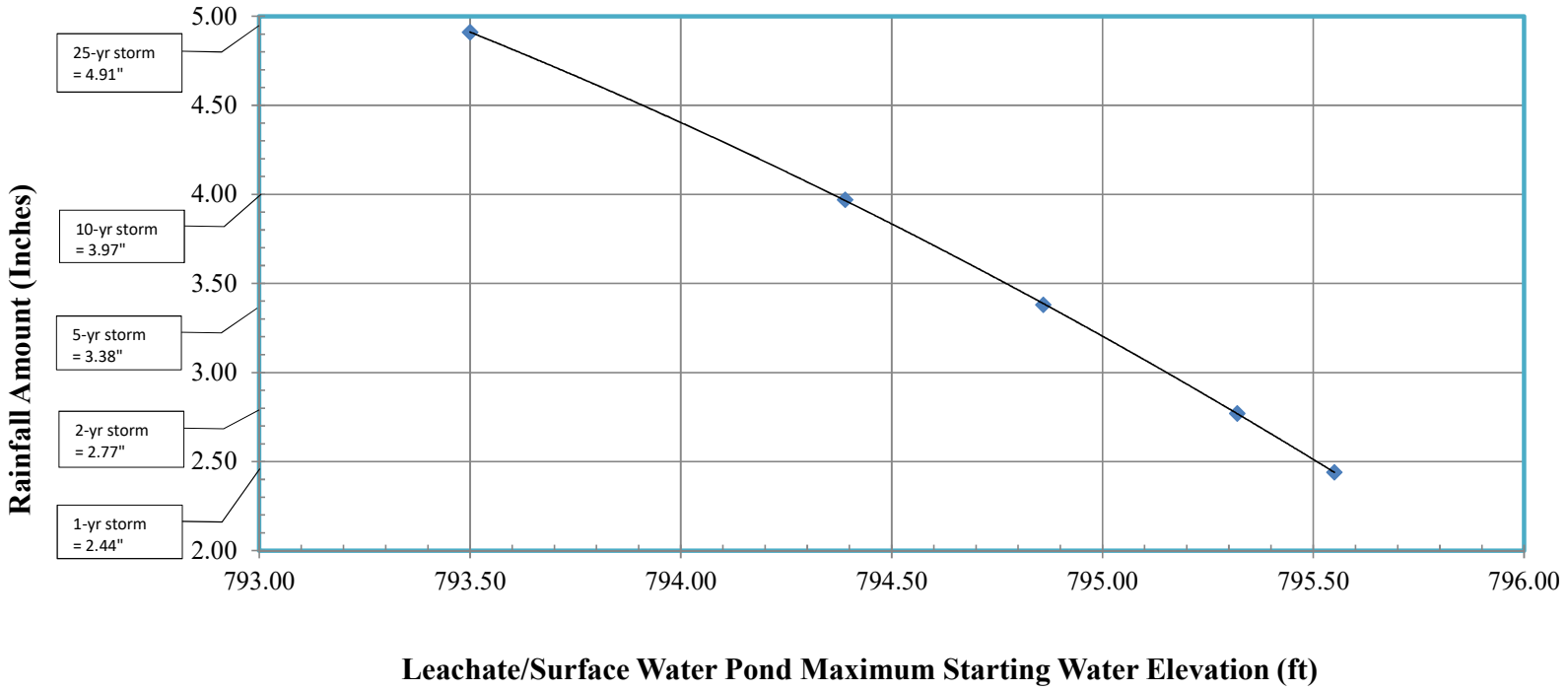
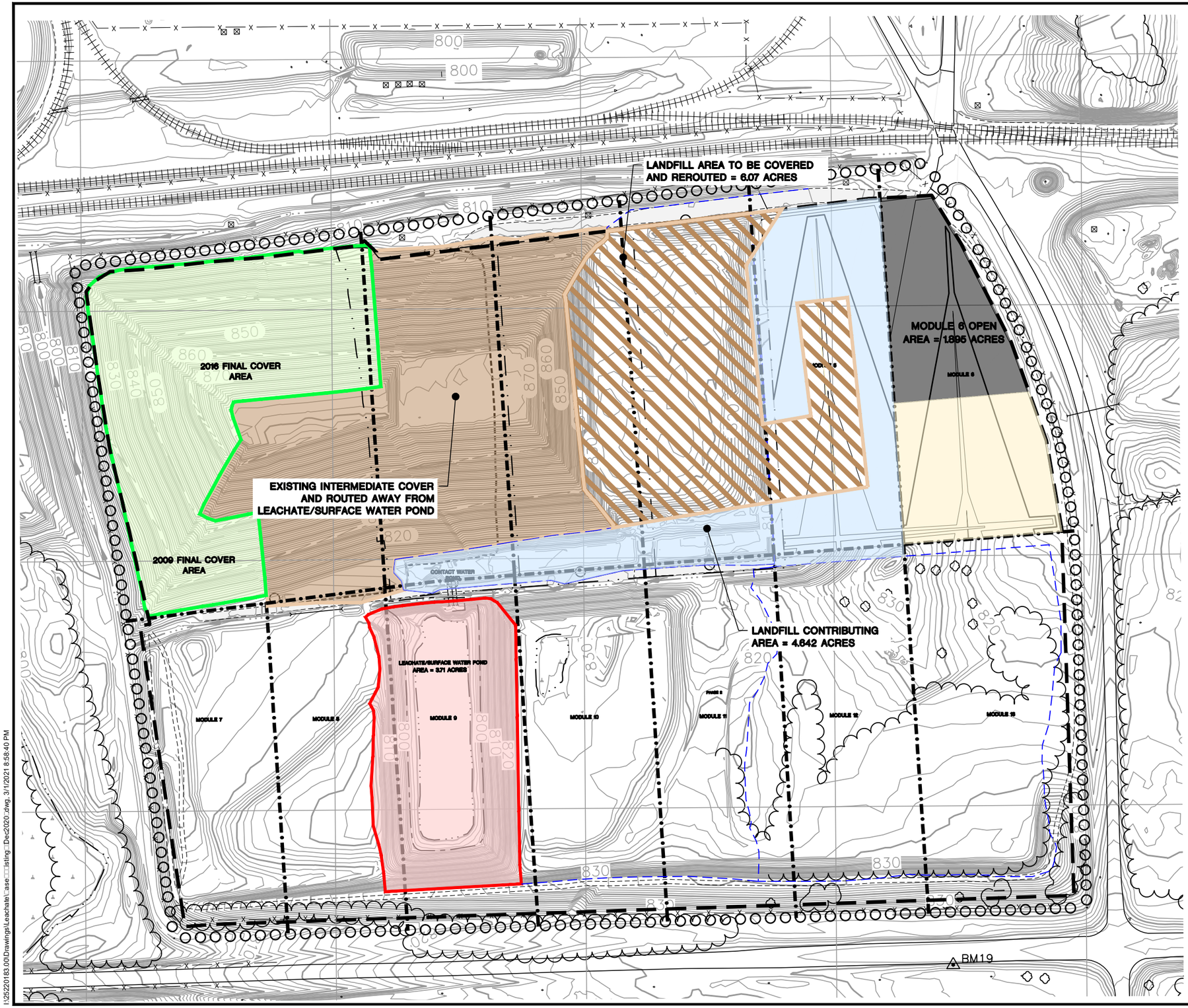
# Figure 2A
# Columbia Energy Center
# Scenario 2 - Module 5 100% Open
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (refer to Leachate/Surface Water Pond Evaluation figure dated 11/2/17):
   - Mod 5 open area = 100% of module = 4.12 acres.
   - Landfill open area = 2.42 acres (previously open/contributing area [ 6.45 acres] -require closure/rerouted area [ 4.03 acres]).
   - Leachate/Surface Water Pond Area, 3.71 acres.




LEGEND

- DRY ASH DISPOSAL FACILITY LIMITS
- APPROVED LIMITS OF WASTE
- PROPOSED MODULE LIMIT
- EXISTING GRADE (2' CONTOUR)
- 690 EXISTING GRADE (10' CONTOUR)
- EDGE OF WATER (APPROXIMATE)
- EXISTING FINAL COVER AREA
- EXISTING INTERMEDIATE COVER AND ROUTED AWAY FROM POND
- LEACHATE/SURFACE WATER POND CONTRIBUTING AREA
- LANDFILL CONTRIBUTING AREA
- MODULE 6 CONTRIBUTING AREA
- AREA TO BE COVERED/REROUTED
- MODULE 6 COVERED WITH RAIN COVER

N

200 0 200

SCALE: 1" = 200'

LEACHATE/SURFACE WATER POND EVALUATION
SCENARIO 3

FIGURE 3

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

RJG
PG

SITE

COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT LOGO IF AVAILABLE

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| APPROVED BY: | |

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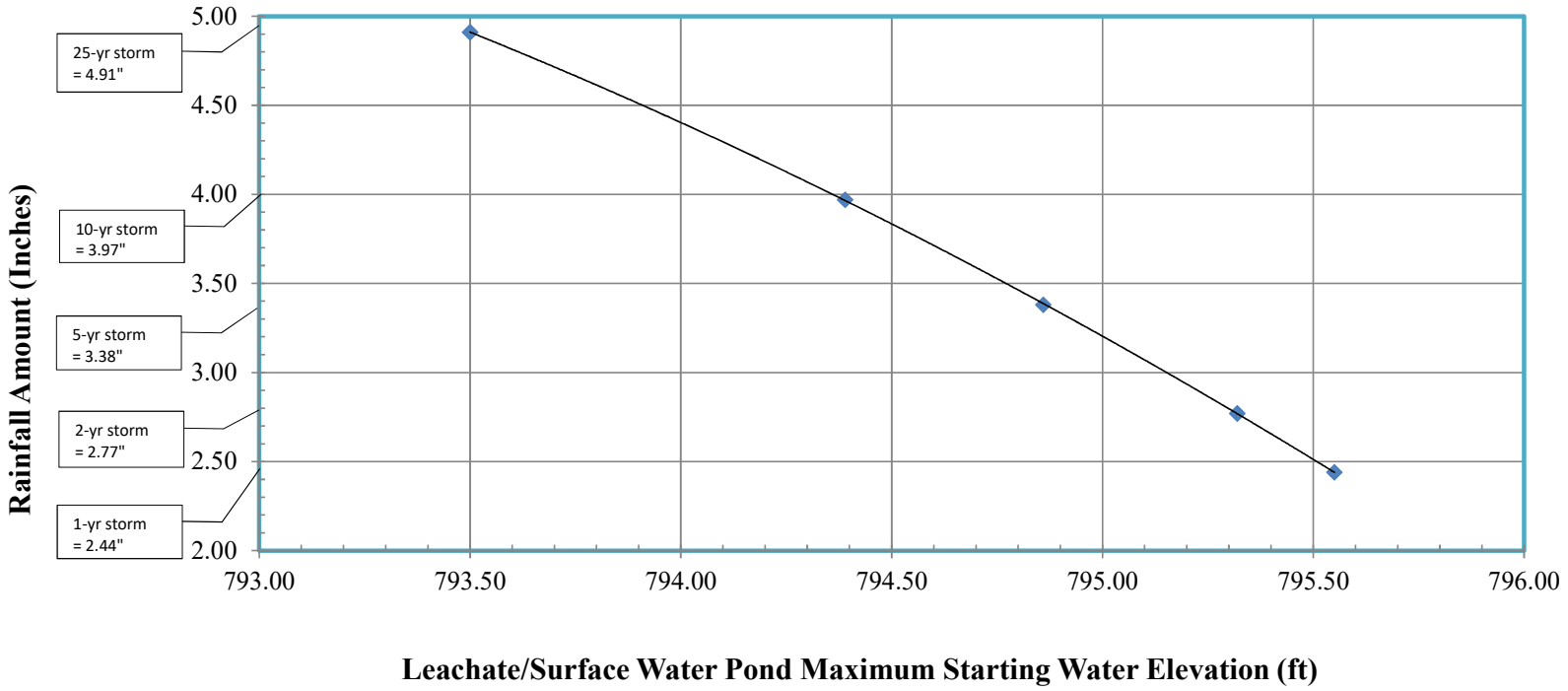
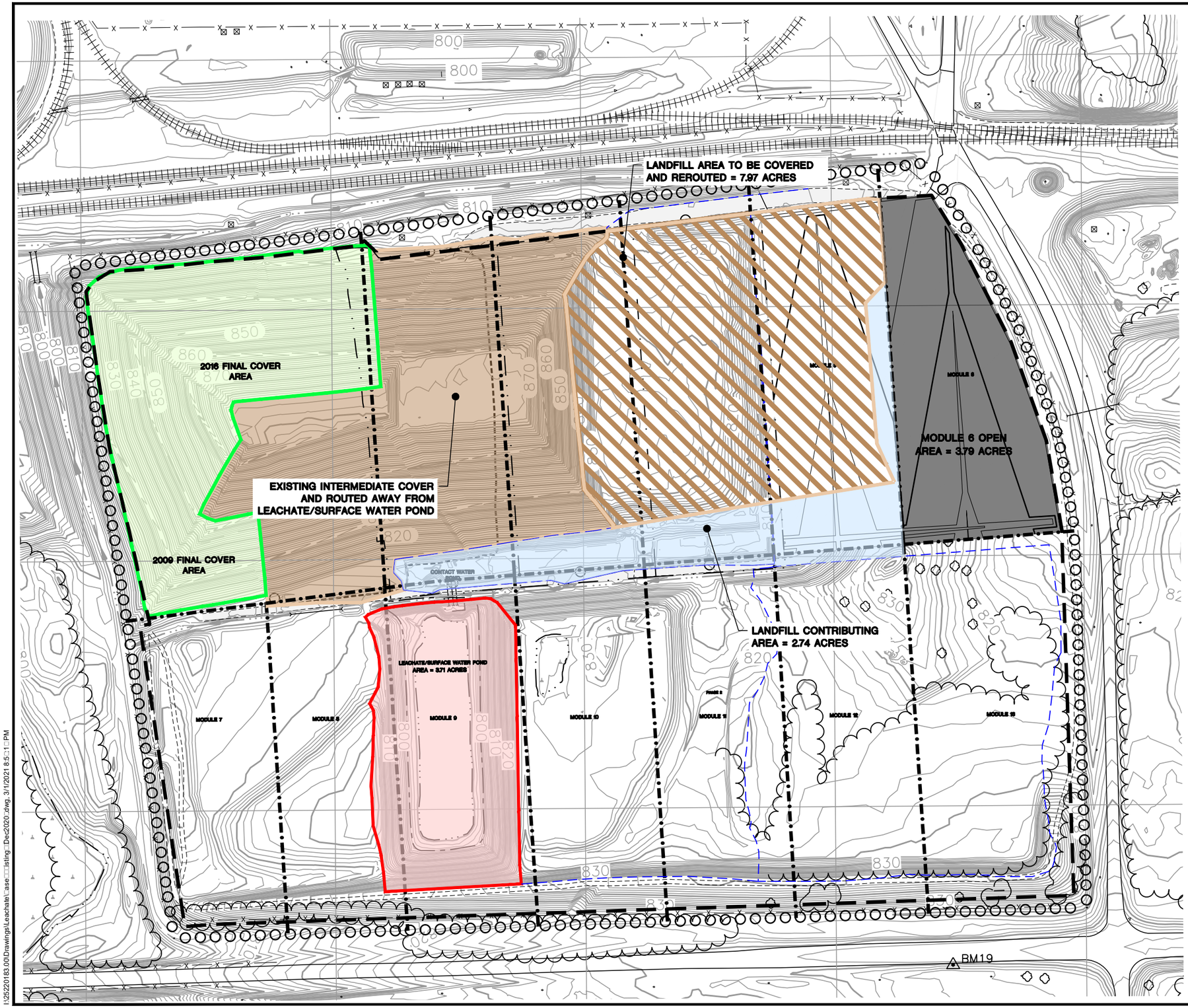
# Figure 3A
# Columbia Energy Center
# Scenario 3 - Module 6 50% Open
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (refer to Leachate/Surface Water Pond Evaluation figure dated 11/2/17):
   - Mod 6 open area = 50% of module = 1.895 acres.
   - Landfill open area = 4.64 acres (previously open/contributing area and Mod 5 [ 10.71 acres] -require closure/rerouted area [ 6.07 acres]).
   - Leachate/Surface Water Pond Area, 3.71 acres.




LEGEND

- DRY ASH DISPOSAL FACILITY LIMITS
- APPROVED LIMITS OF WASTE
- PROPOSED MODULE LIMIT
- EXISTING GRADE (2' CONTOUR)
- 690 EXISTING GRADE (10' CONTOUR)
- EDGE OF WATER (APPROXIMATE)
- EXISTING FINAL COVER AREA
- EXISTING INTERMEDIATE COVER AND ROUTED AWAY FROM POND
- LEACHATE/SURFACE WATER POND CONTRIBUTING AREA
- LANDFILL CONTRIBUTING AREA
- MODULE 6 CONTRIBUTING AREA
- AREA TO BE COVERED/REROUTED

N

200 0 200

SCALE: 1" = 200'

LEACHATE/SURFACE WATER POND EVALUATION
SCENARIO 4

SITE

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT

CLIENT LOGO IF AVAILABLE

COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

FIGURE 4

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

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| REVISED: | 03/01/21 |
| DRAWN BY: | RJG |
| CHECKED BY: | PG |
| APPROVED BY: | |

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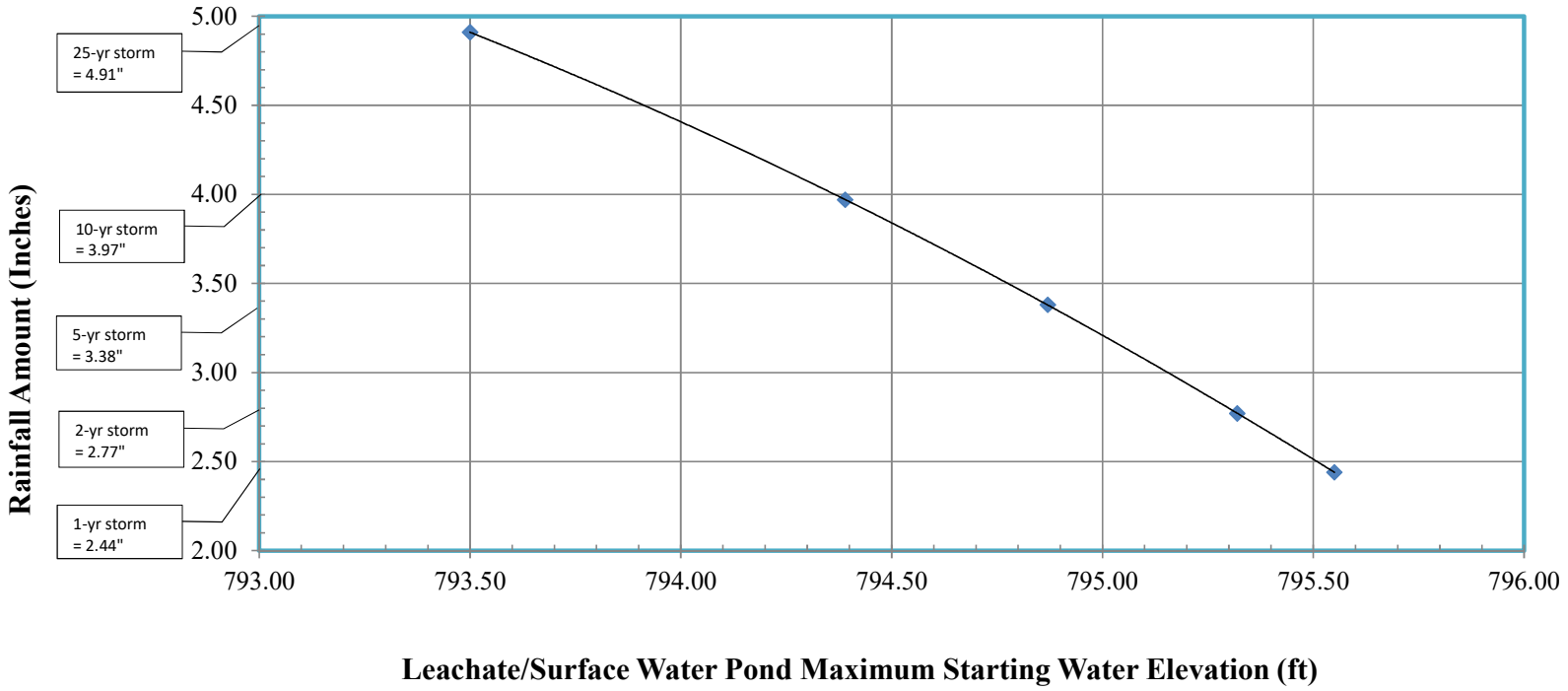
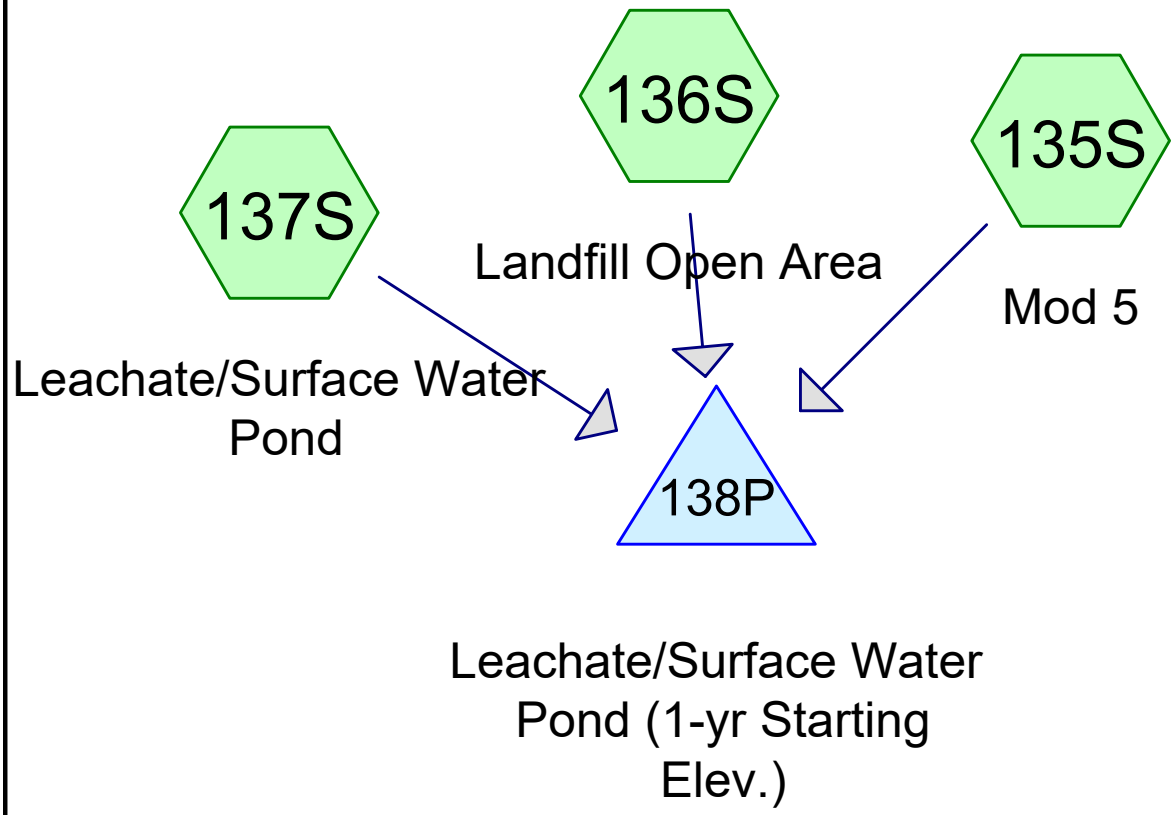
# Figure 4A
# Columbia Energy Center
# Scenario 3 - Module 6 50% Open
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (refer to Leachate/Surface Water Pond Evaluation figure dated 11/2/17):
   - Mod 6 open area = 100% of module = 3.79 acres.
   - Landfill open area = 2.74 acres (previously open/contributing area and Mod 5 [ 10.71 acres] -require closure/rerouted area [ 7.97 acres]).
   - Leachate/Surface Water Pond Area, 3.71 acres.

Scenario 1




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
HydroCAD® 10.00-25 s/n 05804 © 2019 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 135S: Mod 5** Runoff Area=2.060 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=4.11 cfs 0.380 af

**Subcatchment 136S: Landfill Open Area** Runoff Area=4.470 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=8.91 cfs 0.824 af

**Subcatchment 137S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.92 cfs 0.684 af

**Pond 138P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,576 cf Inflow=18.52 cfs 1.887 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 1.887 af Average Runoff Depth = 2.21"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 135S: Mod 5

Runoff = 4.11 cfs @ 12.29 hrs, Volume= 0.380 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.060 | 98 | Ash |
| | 2.060 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 136S: Landfill Open Area

Runoff = 8.91 cfs @ 12.29 hrs, Volume= 0.824 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.470 | 98 | Mod 4 Allowable Open Area |
| | 4.470 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 137S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.92 cfs @ 12.04 hrs, Volume= 0.684 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 138P: Leachate/Surface Water Pond (1-yr Starting Elev.)

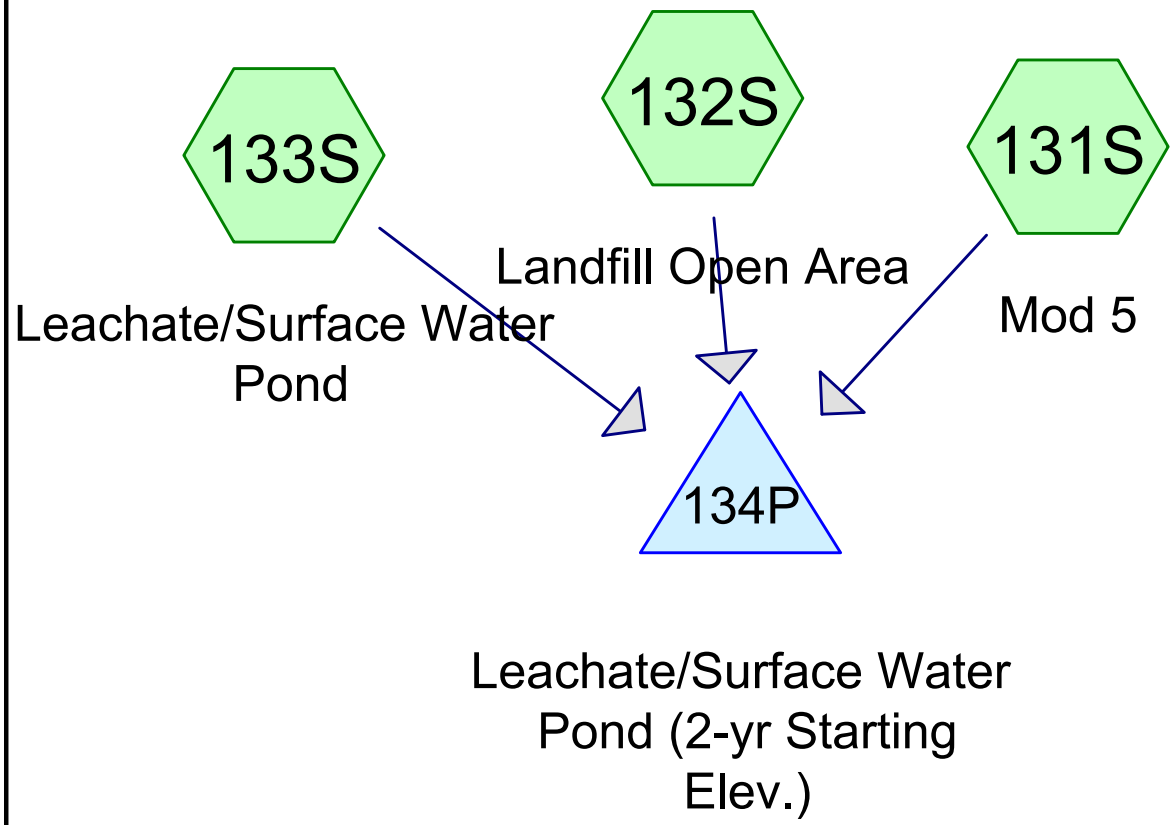
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 18.52 cfs @ 12.05 hrs, Volume= 1.887 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.55' Surf.Area= 53,339 sf Storage= 115,388 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,582 sf Storage= 197,576 cf (82,188 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (82,260 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 131S: Mod 5** Runoff Area=2.060 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=4.69 cfs 0.436 af

**Subcatchment 132S: Landfill Open Area** Runoff Area=4.470 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=10.17 cfs 0.946 af

**Subcatchment 133S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.73 cfs 0.785 af

**Pond 134P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,716 cf Inflow=21.13 cfs 2.167 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 2.167 af Average Runoff Depth = 2.54"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 131S: Mod 5

Runoff = 4.69 cfs @ 12.29 hrs, Volume= 0.436 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.060 | 98 | Ash |
| | 2.060 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 132S: Landfill Open Area

Runoff = 10.17 cfs @ 12.29 hrs, Volume= 0.946 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.470 | 98 | Mod 4 Allowable Open Area |
| | 4.470 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 133S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.73 cfs @ 12.04 hrs, Volume= 0.785 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 134P: Leachate/Surface Water Pond (2-yr Starting Elev.)

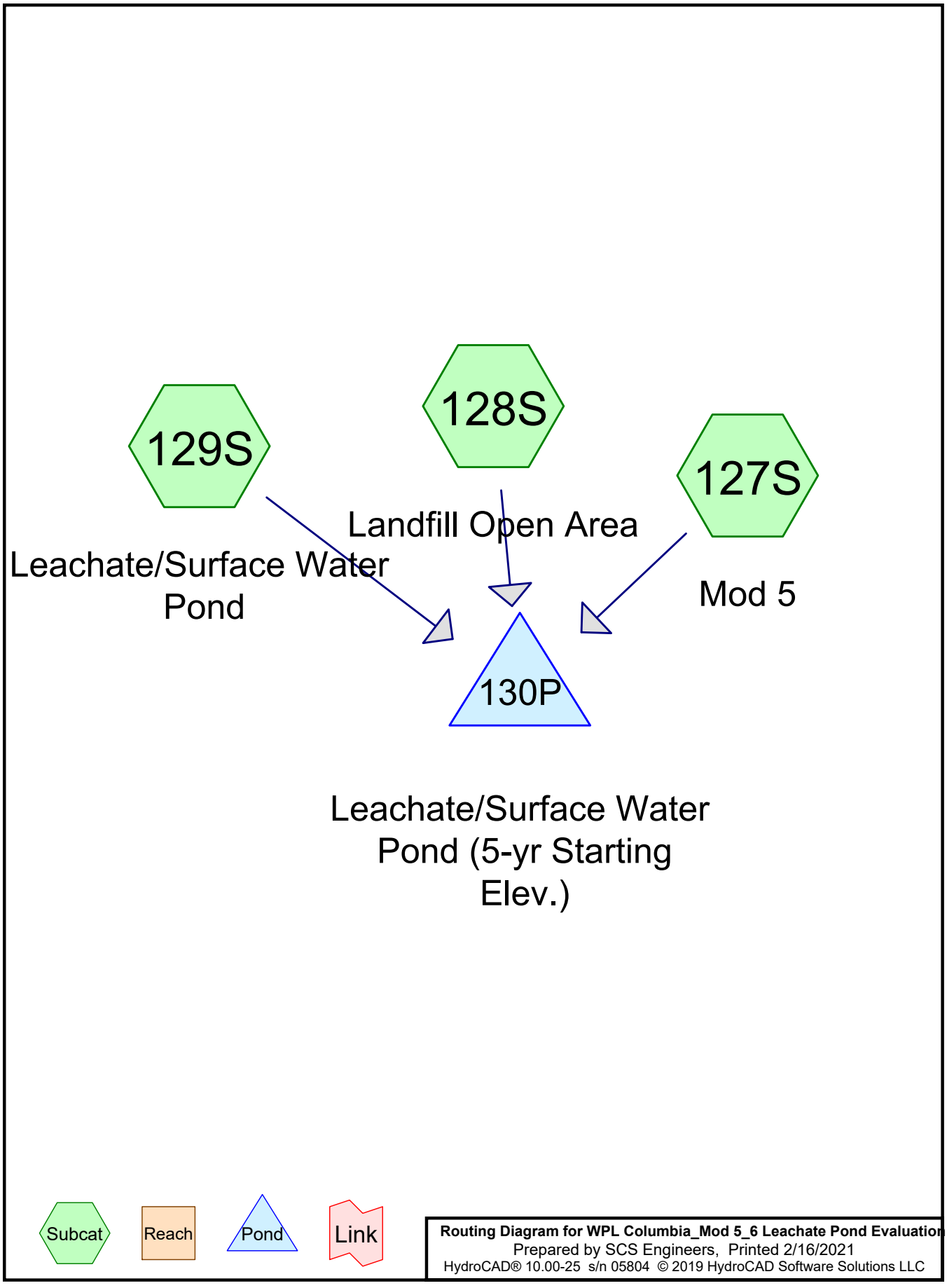
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 21.13 cfs @ 12.05 hrs, Volume= 2.167 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.32' Surf.Area= 51,527 sf Storage= 103,328 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,593 sf Storage= 197,716 cf (94,388 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (94,319 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 127S: Mod 5** Runoff Area=2.060 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=5.75 cfs 0.540 af

**Subcatchment 128S: Landfill Open Area** Runoff Area=4.470 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=12.48 cfs 1.172 af

**Subcatchment 129S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.06 cfs 0.973 af

**Pond 130P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,910 cf Inflow=25.94 cfs 2.685 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 2.685 af Average Runoff Depth = 3.15"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 127S: Mod 5

Runoff = 5.75 cfs @ 12.29 hrs, Volume= 0.540 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.060 | 98 | Ash |
| | 2.060 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 128S: Landfill Open Area

Runoff = 12.48 cfs @ 12.29 hrs, Volume= 1.172 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.470 | 98 | Mod 4 Allowable Open Area |
| | 4.470 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 129S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.06 cfs @ 12.04 hrs, Volume= 0.973 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 130P: Leachate/Surface Water Pond (5-yr Starting Elev.)

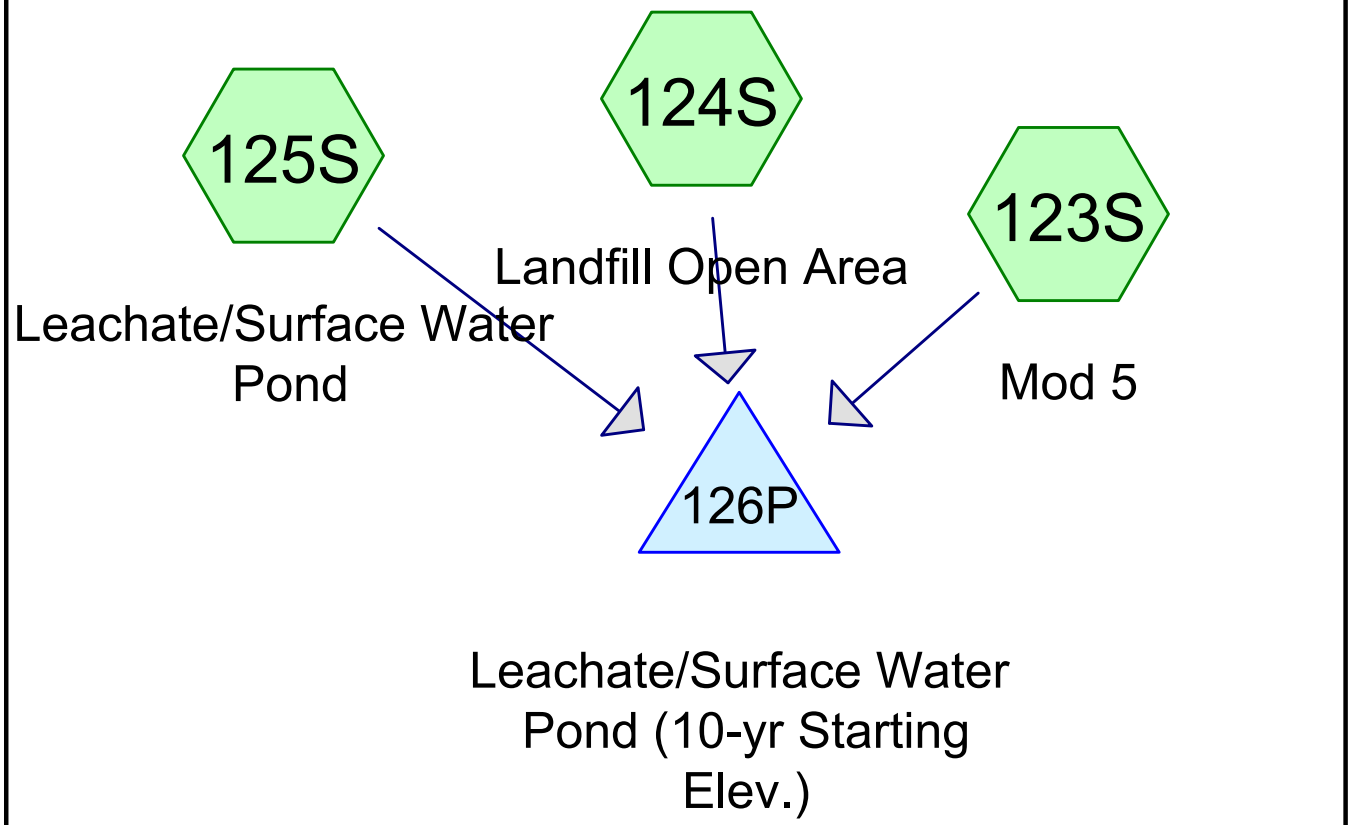
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 25.94 cfs @ 12.05 hrs, Volume= 2.685 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.87' Surf.Area= 47,981 sf Storage= 80,939 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,608 sf Storage= 197,910 cf (116,972 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (116,709 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 123S: Mod 5** Runoff Area=2.060 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=6.78 cfs 0.641 af

**Subcatchment 124S: Landfill Open Area** Runoff Area=4.470 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=14.70 cfs 1.391 af

**Subcatchment 125S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.27 cfs 1.155 af

**Pond 126P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,655 cf Inflow=30.59 cfs 3.187 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 3.187 af Average Runoff Depth = 3.74"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 123S: Mod 5

Runoff = 6.78 cfs @ 12.29 hrs, Volume= 0.641 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.060 | 98 | Ash |
| | 2.060 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 124S: Landfill Open Area

Runoff = 14.70 cfs @ 12.29 hrs, Volume= 1.391 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.470 | 98 | Mod 4 Allowable Open Area |
| | 4.470 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 125S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.27 cfs @ 12.04 hrs, Volume= 1.155 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 126P: Leachate/Surface Water Pond (10-yr Starting Elev.)

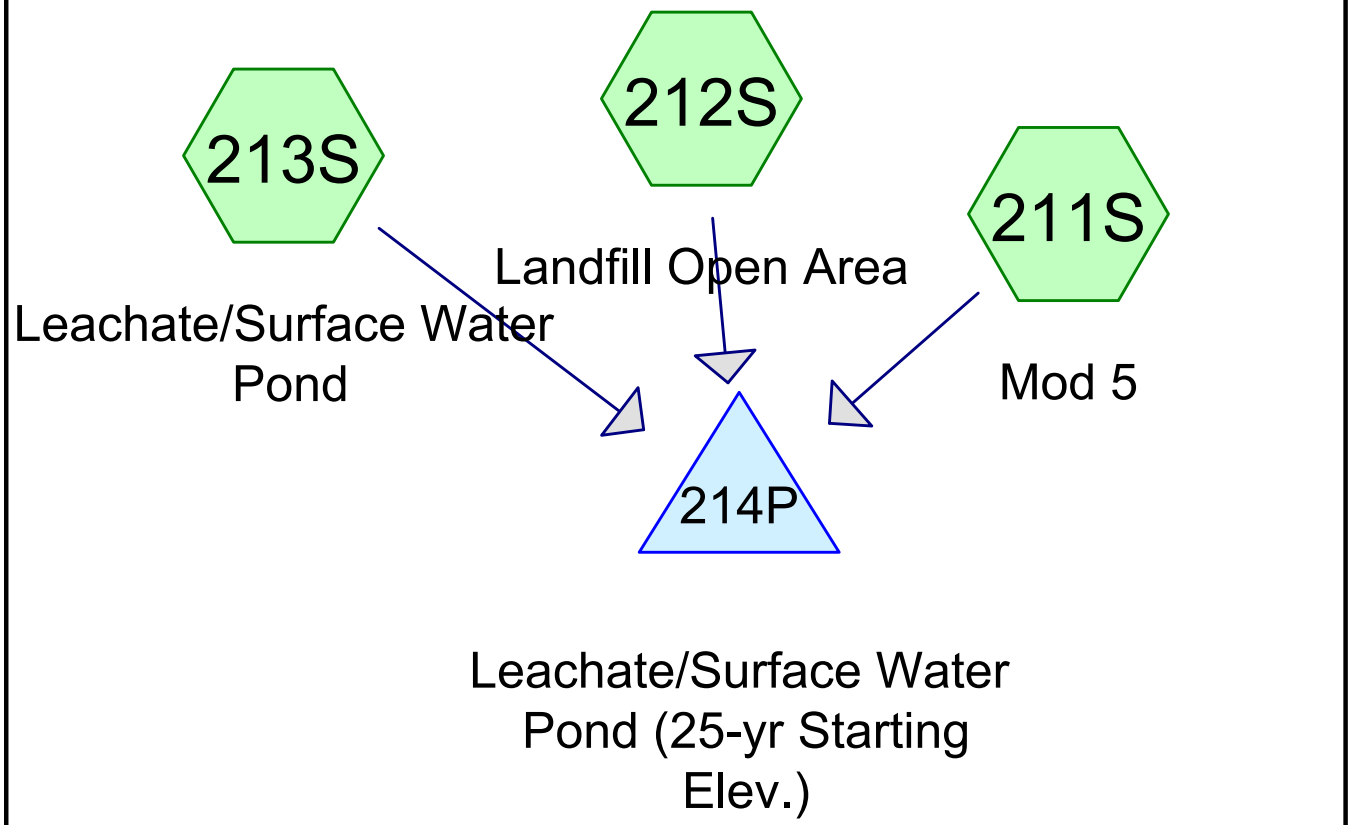
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 30.59 cfs @ 12.05 hrs, Volume= 3.187 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.39' Surf.Area= 44,199 sf Storage= 58,815 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,588 sf Storage= 197,655 cf (138,840 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (138,832 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation_210223**

Prepared by SCS Engineers, Printed 2/23/2021

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## Summary for Pond 214P: Leachate/Surface Water Pond (25-yr Starting Elev.)

Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 37.96 cfs @ 12.05 hrs, Volume= 3.988 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.50' Surf.Area= 31,107 sf Storage= 24,119 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,602 sf Storage= 197,830 cf (173,712 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (173,529 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |

## Summary for Subcatchment 211S: Mod 5

Runoff = 8.41 cfs @ 12.28 hrs, Volume= 0.802 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.060 | 98 | Ash |
| | 2.060 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 212S: Landfill Open Area

Runoff = 18.24 cfs @ 12.28 hrs, Volume= 1.741 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.470 | 98 | Mod 4 Allowable Open Area |
| | 4.470 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 213S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

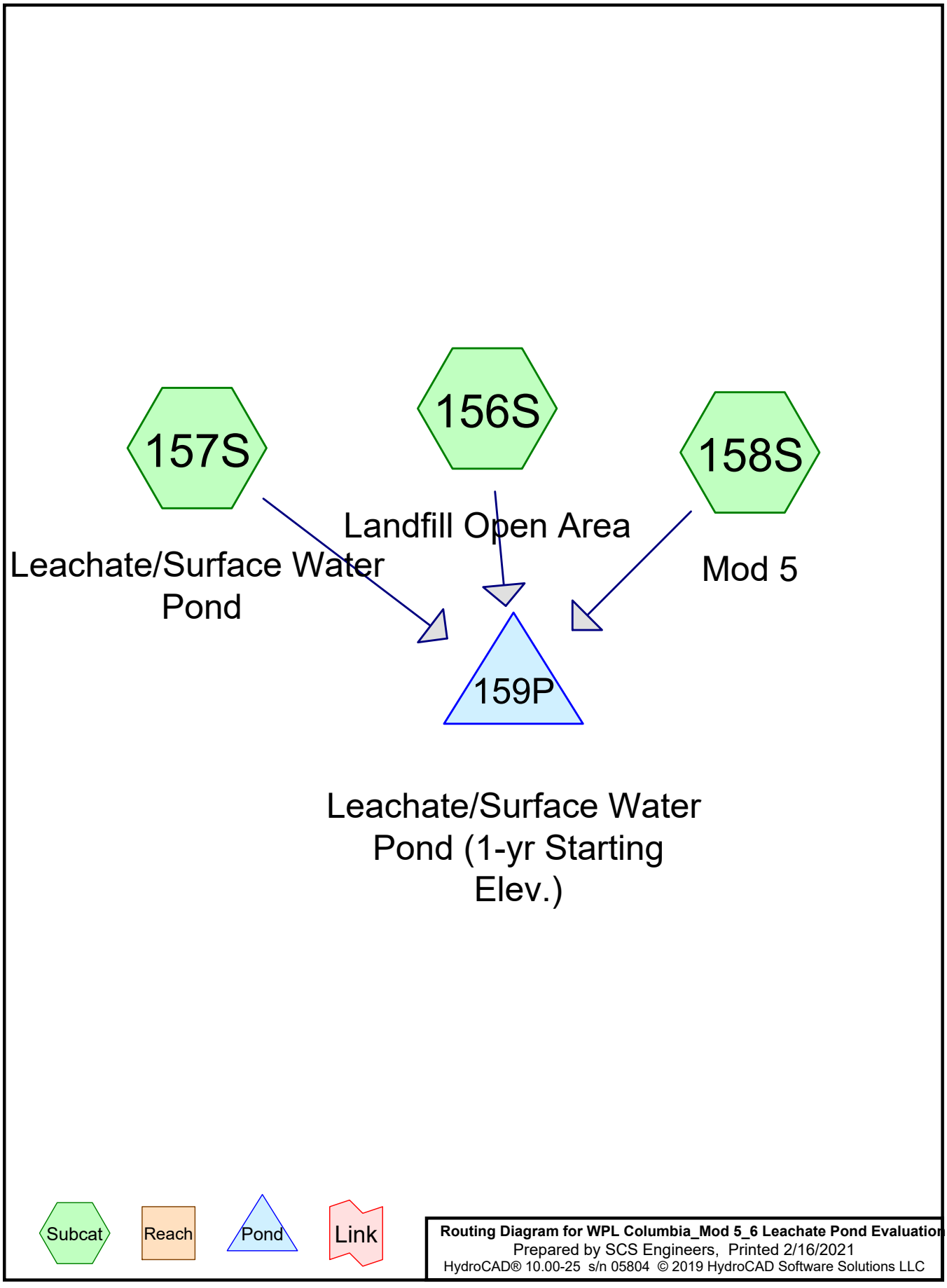
Runoff = 26.38 cfs @ 12.04 hrs, Volume= 1.445 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

Scenario 2




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 156S: Landfill Open Area** Runoff Area=2.417 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=4.82 cfs 0.445 af

**Subcatchment 157S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.92 cfs 0.684 af

**Subcatchment 158S: Mod 5** Runoff Area=4.120 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=8.22 cfs 0.759 af

**Pond 159P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,632 cf Inflow=18.52 cfs 1.888 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 1.888 af Average Runoff Depth = 2.21"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 156S: Landfill Open Area

Runoff = 4.82 cfs @ 12.29 hrs, Volume= 0.445 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.417 | 98 | Mod 4 Allowable Open Area |
| | 2.417 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 157S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.92 cfs @ 12.04 hrs, Volume= 0.684 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 158S: Mod 5

Runoff = 8.22 cfs @ 12.29 hrs, Volume= 0.759 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 159P: Leachate/Surface Water Pond (1-yr Starting Elev.)

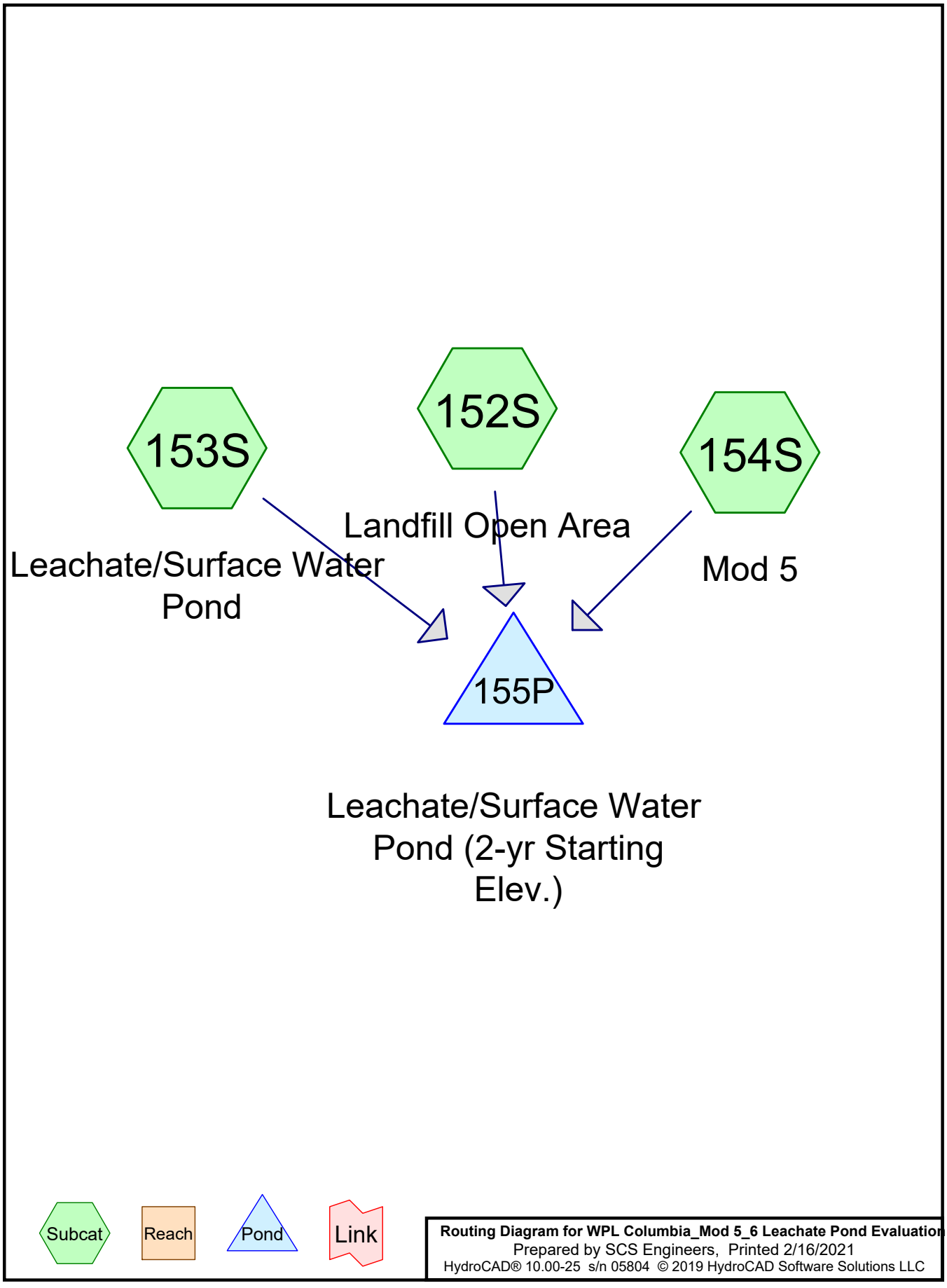
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 18.52 cfs @ 12.05 hrs, Volume= 1.888 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.55' Surf.Area= 53,339 sf Storage= 115,388 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,586 sf Storage= 197,632 cf (82,244 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (82,260 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 152S: Landfill Open Area** Runoff Area=2.417 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=5.50 cfs 0.511 af

**Subcatchment 153S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.73 cfs 0.785 af

**Subcatchment 154S: Mod 5** Runoff Area=4.120 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=9.37 cfs 0.872 af

**Pond 155P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,780 cf Inflow=21.14 cfs 2.168 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 2.168 af Average Runoff Depth = 2.54"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 152S: Landfill Open Area

Runoff = 5.50 cfs @ 12.29 hrs, Volume= 0.511 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.417 | 98 | Mod 4 Allowable Open Area |
| | 2.417 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 153S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.73 cfs @ 12.04 hrs, Volume= 0.785 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 154S: Mod 5

Runoff = 9.37 cfs @ 12.29 hrs, Volume= 0.872 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 155P: Leachate/Surface Water Pond (2-yr Starting Elev.)

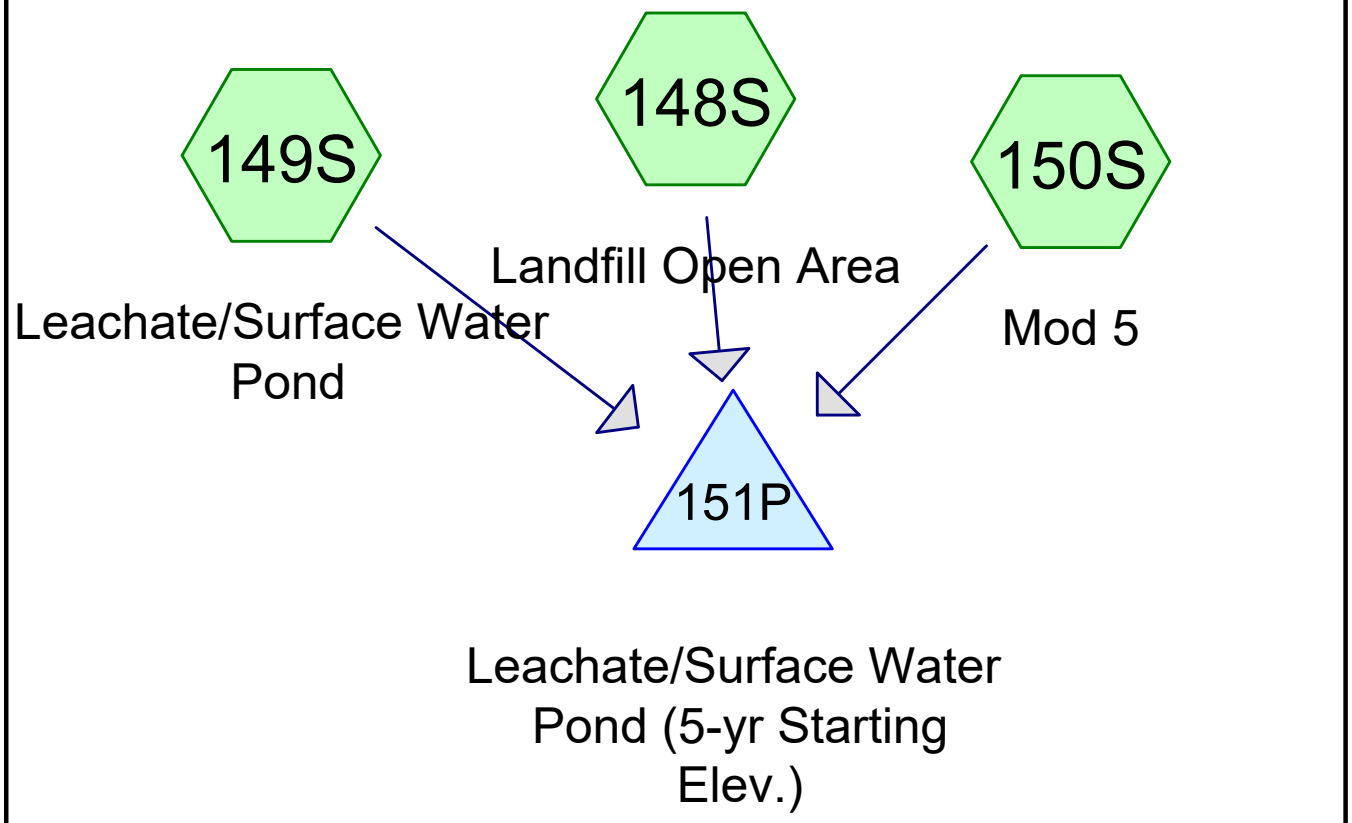
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 21.14 cfs @ 12.05 hrs, Volume= 2.168 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.32' Surf.Area= 51,527 sf Storage= 103,328 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,598 sf Storage= 197,780 cf (94,452 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (94,319 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 148S: Landfill Open Area** Runoff Area=2.417 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=6.75 cfs 0.634 af

**Subcatchment 149S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.06 cfs 0.973 af

**Subcatchment 150S: Mod 5** Runoff Area=4.120 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=11.50 cfs 1.080 af

**Pond 151P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,510 cf Inflow=25.95 cfs 2.687 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 2.687 af Average Runoff Depth = 3.15"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 148S: Landfill Open Area

Runoff = 6.75 cfs @ 12.29 hrs, Volume= 0.634 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.417 | 98 | Mod 4 Allowable Open Area |
| | 2.417 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 149S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.06 cfs @ 12.04 hrs, Volume= 0.973 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 150S: Mod 5

Runoff = 11.50 cfs @ 12.29 hrs, Volume= 1.080 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 151P: Leachate/Surface Water Pond (5-yr Starting Elev.)

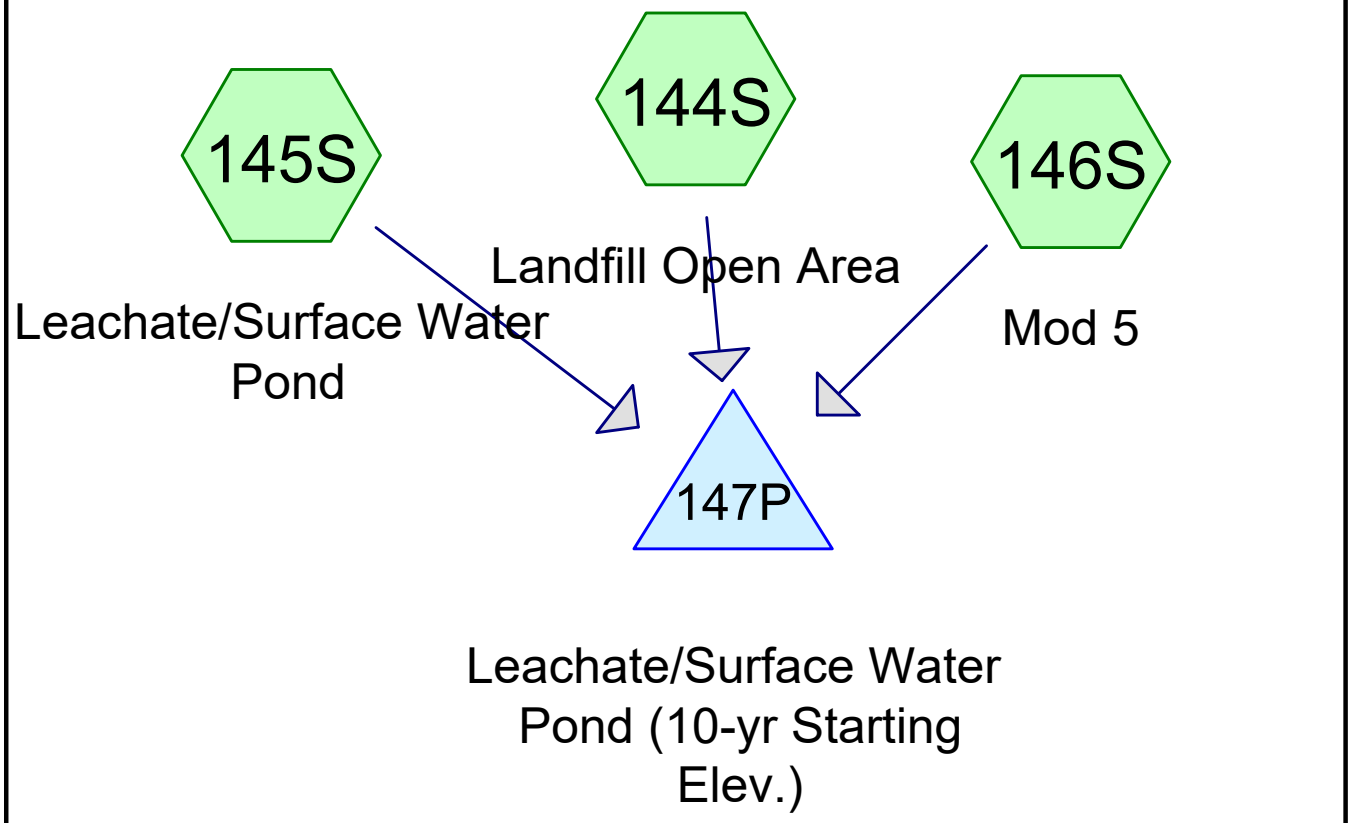
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 25.95 cfs @ 12.05 hrs, Volume= 2.687 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.86' Surf.Area= 47,902 sf Storage= 80,459 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,577 sf Storage= 197,510 cf (117,051 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (117,188 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 144S: Landfill Open Area** Runoff Area=2.417 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=7.95 cfs 0.752 af

**Subcatchment 145S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.27 cfs 1.155 af

**Subcatchment 146S: Mod 5** Runoff Area=4.120 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=13.55 cfs 1.282 af

**Pond 147P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,750 cf Inflow=30.60 cfs 3.190 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 3.190 af Average Runoff Depth = 3.74"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 144S: Landfill Open Area

Runoff = 7.95 cfs @ 12.29 hrs, Volume= 0.752 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.417 | 98 | Mod 4 Allowable Open Area |
| | 2.417 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 145S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.27 cfs @ 12.04 hrs, Volume= 1.155 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 146S: Mod 5

Runoff = 13.55 cfs @ 12.29 hrs, Volume= 1.282 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 147P: Leachate/Surface Water Pond (10-yr Starting Elev.)

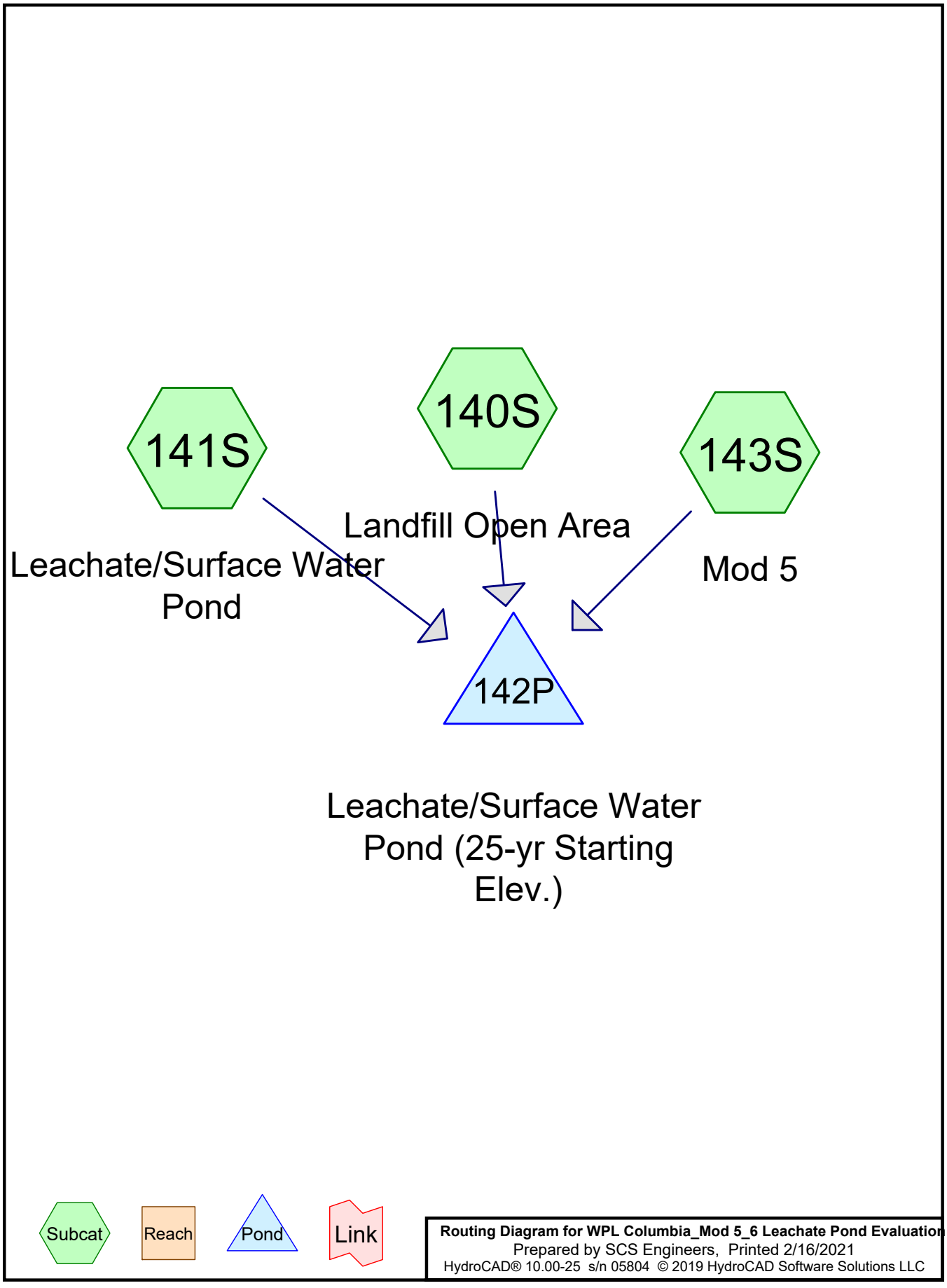
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 30.60 cfs @ 12.05 hrs, Volume= 3.190 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.39' Surf.Area= 44,199 sf Storage= 58,815 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,596 sf Storage= 197,750 cf (138,935 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (138,832 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |

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## Summary for Pond 142P: Leachate/Surface Water Pond (25-yr Starting Elev.)

Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 37.97 cfs @ 12.05 hrs, Volume= 3.991 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.50' Surf.Area= 31,107 sf Storage= 24,119 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,611 sf Storage= 197,949 cf (173,831 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (173,529 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |

## Summary for Subcatchment 140S: Landfill Open Area

Runoff = 9.86 cfs @ 12.28 hrs, Volume= 0.941 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.417 | 98 | Mod 4 Allowable Open Area |
| | 2.417 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 141S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.38 cfs @ 12.04 hrs, Volume= 1.445 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 143S: Mod 5

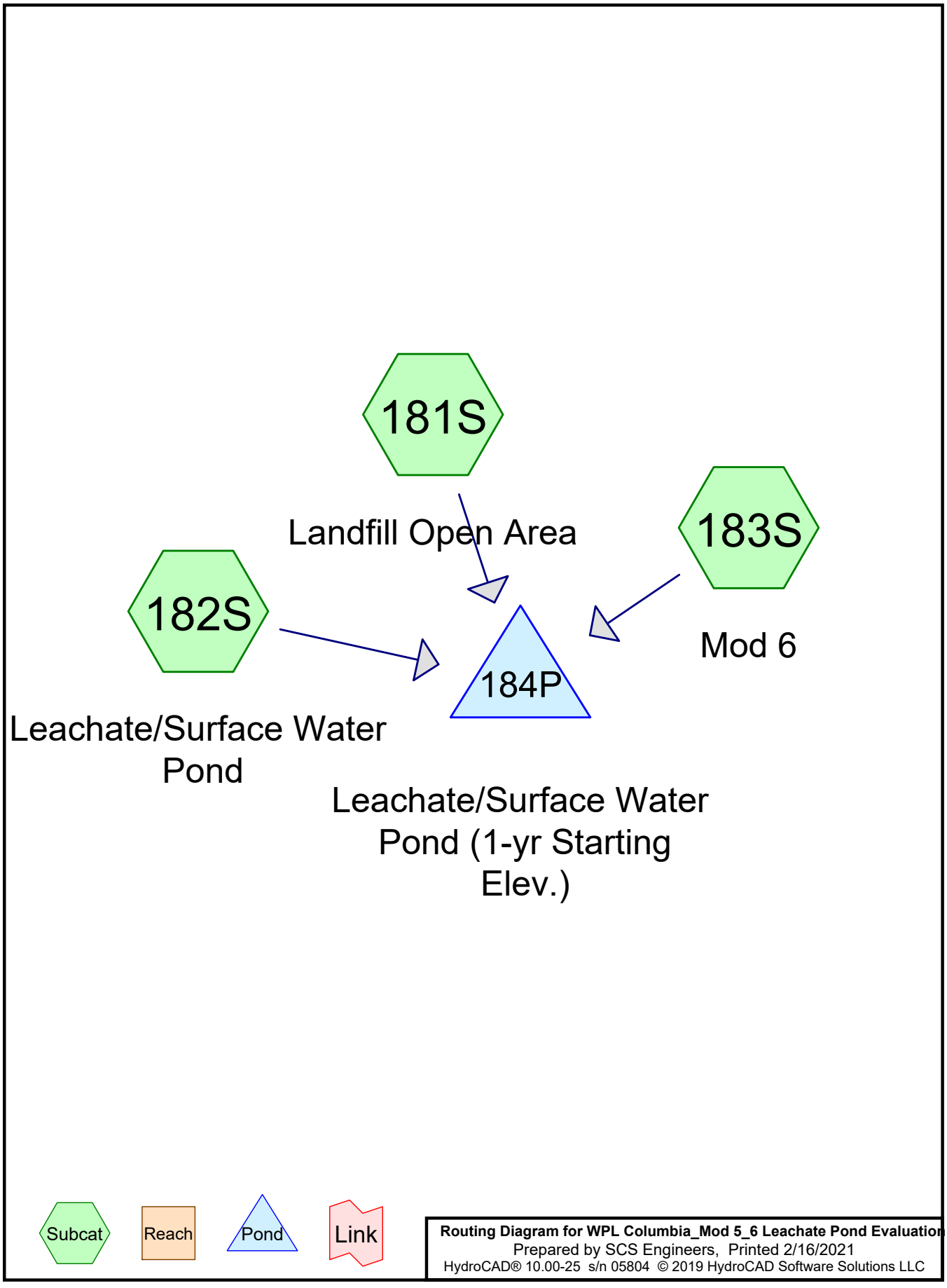
Runoff = 16.82 cfs @ 12.28 hrs, Volume= 1.605 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

Scenario 3




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 181S: Landfill Open Area** Runoff Area=4.642 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=9.26 cfs 0.855 af

**Subcatchment 182S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.92 cfs 0.684 af

**Subcatchment 183S: Mod 6** Runoff Area=1.895 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=3.78 cfs 0.349 af

**Pond 184P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,632 cf Inflow=18.52 cfs 1.888 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 1.888 af Average Runoff Depth = 2.21"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 181S: Landfill Open Area

Runoff = 9.26 cfs @ 12.29 hrs, Volume= 0.855 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.642 | 98 | Mod 4 Allowable Open Area |
| | 4.642 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 182S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.92 cfs @ 12.04 hrs, Volume= 0.684 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 183S: Mod 6

Runoff = 3.78 cfs @ 12.29 hrs, Volume= 0.349 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 1.895 | 98 | Ash |
| | 1.895 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 184P: Leachate/Surface Water Pond (1-yr Starting Elev.)

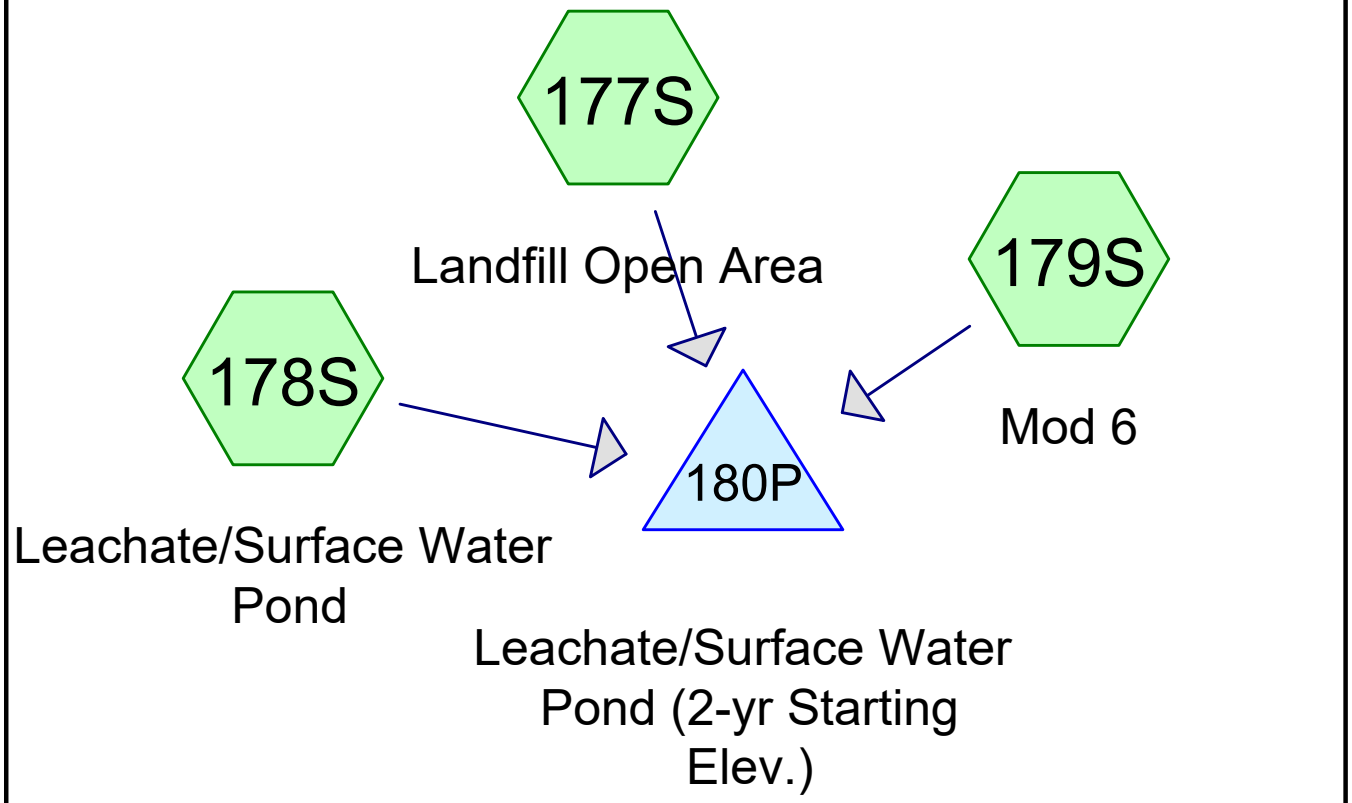
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 18.52 cfs @ 12.05 hrs, Volume= 1.888 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.55' Surf.Area= 53,339 sf Storage= 115,388 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,586 sf Storage= 197,632 cf (82,244 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (82,260 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 177S: Landfill Open Area** Runoff Area=4.642 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=10.56 cfs 0.982 af

**Subcatchment 178S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.73 cfs 0.785 af

**Subcatchment 179S: Mod 6** Runoff Area=1.895 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=4.31 cfs 0.401 af

**Pond 180P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,780 cf Inflow=21.14 cfs 2.168 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 2.168 af Average Runoff Depth = 2.54"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 177S: Landfill Open Area

Runoff = 10.56 cfs @ 12.29 hrs, Volume= 0.982 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.642 | 98 | Mod 4 Allowable Open Area |
| | 4.642 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 178S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.73 cfs @ 12.04 hrs, Volume= 0.785 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 179S: Mod 6

Runoff = 4.31 cfs @ 12.29 hrs, Volume= 0.401 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 1.895 | 98 | Ash |
| | 1.895 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 180P: Leachate/Surface Water Pond (2-yr Starting Elev.)

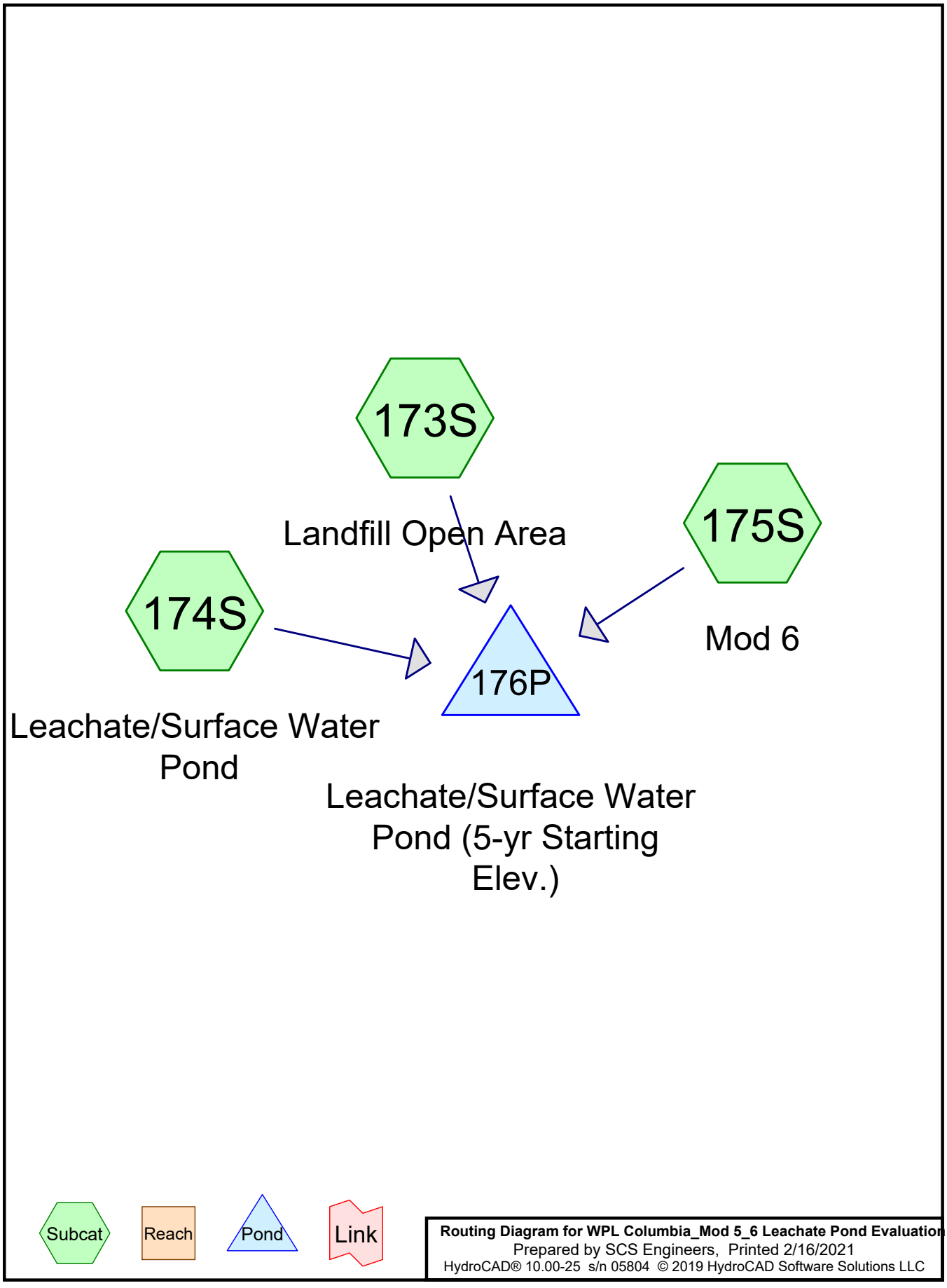
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 21.14 cfs @ 12.05 hrs, Volume= 2.168 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.32' Surf.Area= 51,527 sf Storage= 103,328 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,598 sf Storage= 197,780 cf (94,452 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (94,319 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 173S: Landfill Open Area** Runoff Area=4.642 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=12.96 cfs 1.217 af

**Subcatchment 174S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.06 cfs 0.973 af

**Subcatchment 175S: Mod 6** Runoff Area=1.895 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=5.29 cfs 0.497 af

**Pond 176P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,510 cf Inflow=25.95 cfs 2.687 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 2.687 af Average Runoff Depth = 3.15"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 173S: Landfill Open Area

Runoff = 12.96 cfs @ 12.29 hrs, Volume= 1.217 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.642 | 98 | Mod 4 Allowable Open Area |
| | 4.642 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 174S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.06 cfs @ 12.04 hrs, Volume= 0.973 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 175S: Mod 6

Runoff = 5.29 cfs @ 12.29 hrs, Volume= 0.497 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 1.895 | 98 | Ash |
| | 1.895 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 176P: Leachate/Surface Water Pond (5-yr Starting Elev.)

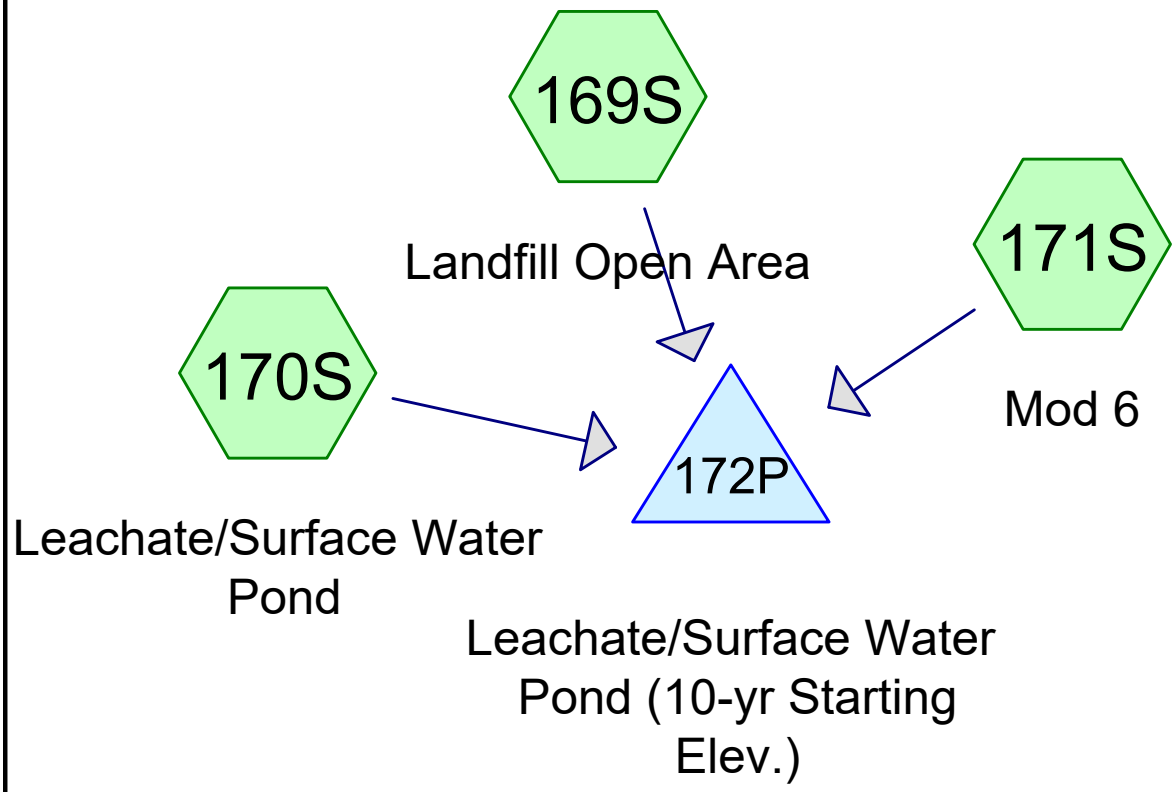
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 25.95 cfs @ 12.05 hrs, Volume= 2.687 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.86' Surf.Area= 47,902 sf Storage= 80,459 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,577 sf Storage= 197,510 cf (117,051 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (117,188 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 169S: Landfill Open Area** Runoff Area=4.642 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=15.27 cfs 1.445 af

**Subcatchment 170S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.27 cfs 1.155 af

**Subcatchment 171S: Mod 6** Runoff Area=1.895 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=6.23 cfs 0.590 af

**Pond 172P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,750 cf Inflow=30.60 cfs 3.190 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.247 ac Runoff Volume = 3.190 af Average Runoff Depth = 3.74"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.247 ac**

## Summary for Subcatchment 169S: Landfill Open Area

Runoff = 15.27 cfs @ 12.29 hrs, Volume= 1.445 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.642 | 98 | Mod 4 Allowable Open Area |
| | 4.642 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 170S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.27 cfs @ 12.04 hrs, Volume= 1.155 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 171S: Mod 6

Runoff = 6.23 cfs @ 12.29 hrs, Volume= 0.590 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 1.895 | 98 | Ash |
| | 1.895 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 172P: Leachate/Surface Water Pond (10-yr Starting Elev.)

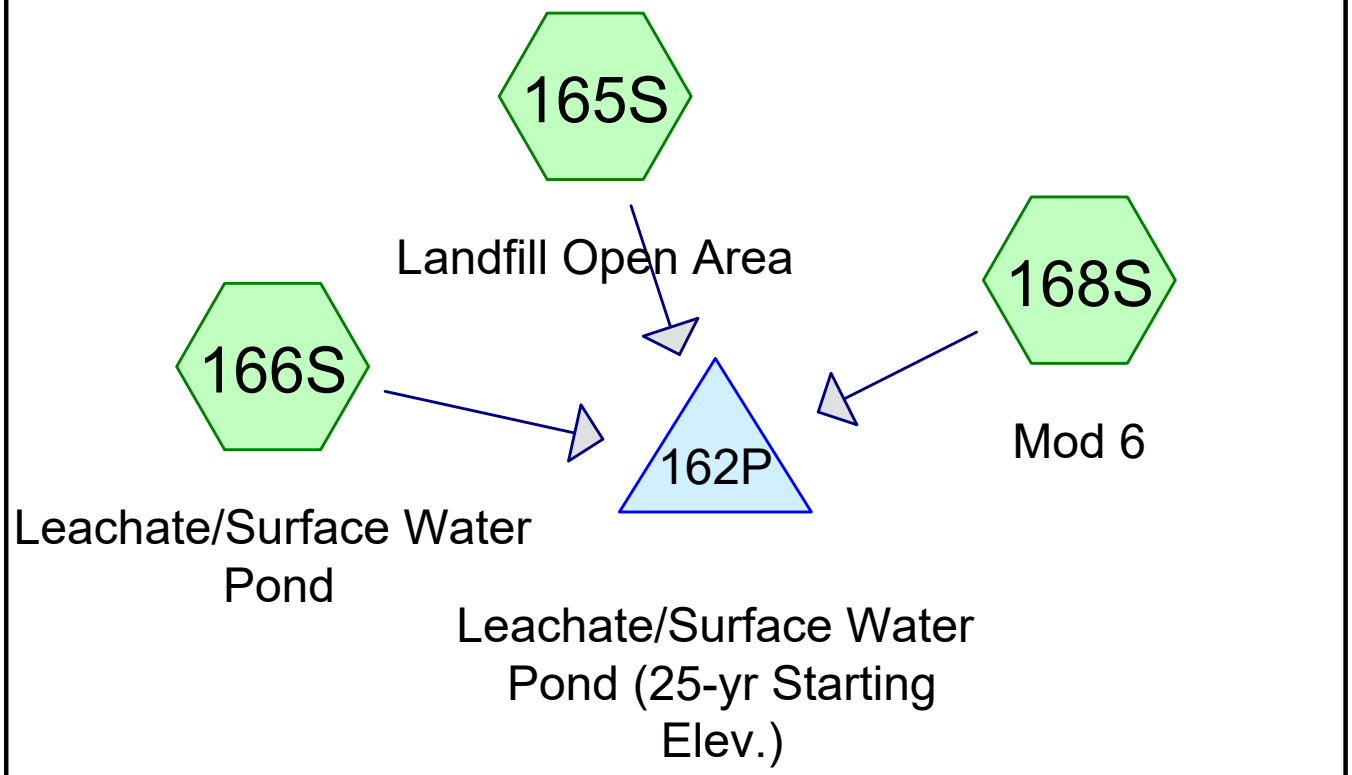
Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 30.60 cfs @ 12.05 hrs, Volume= 3.190 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.39' Surf.Area= 44,199 sf Storage= 58,815 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,596 sf Storage= 197,750 cf (138,935 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (138,832 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/16/2021
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## Summary for Pond 162P: Leachate/Surface Water Pond (25-yr Starting Elev.)

Inflow Area = 10.247 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 37.97 cfs @ 12.05 hrs, Volume= 3.991 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.50' Surf.Area= 31,107 sf Storage= 24,119 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,611 sf Storage= 197,949 cf (173,831 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (173,529 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |

## Summary for Subcatchment 165S: Landfill Open Area

Runoff = 18.95 cfs @ 12.28 hrs, Volume= 1.808 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.642 | 98 | Mod 4 Allowable Open Area |
| | 4.642 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 166S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.38 cfs @ 12.04 hrs, Volume= 1.445 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 168S: Mod 6

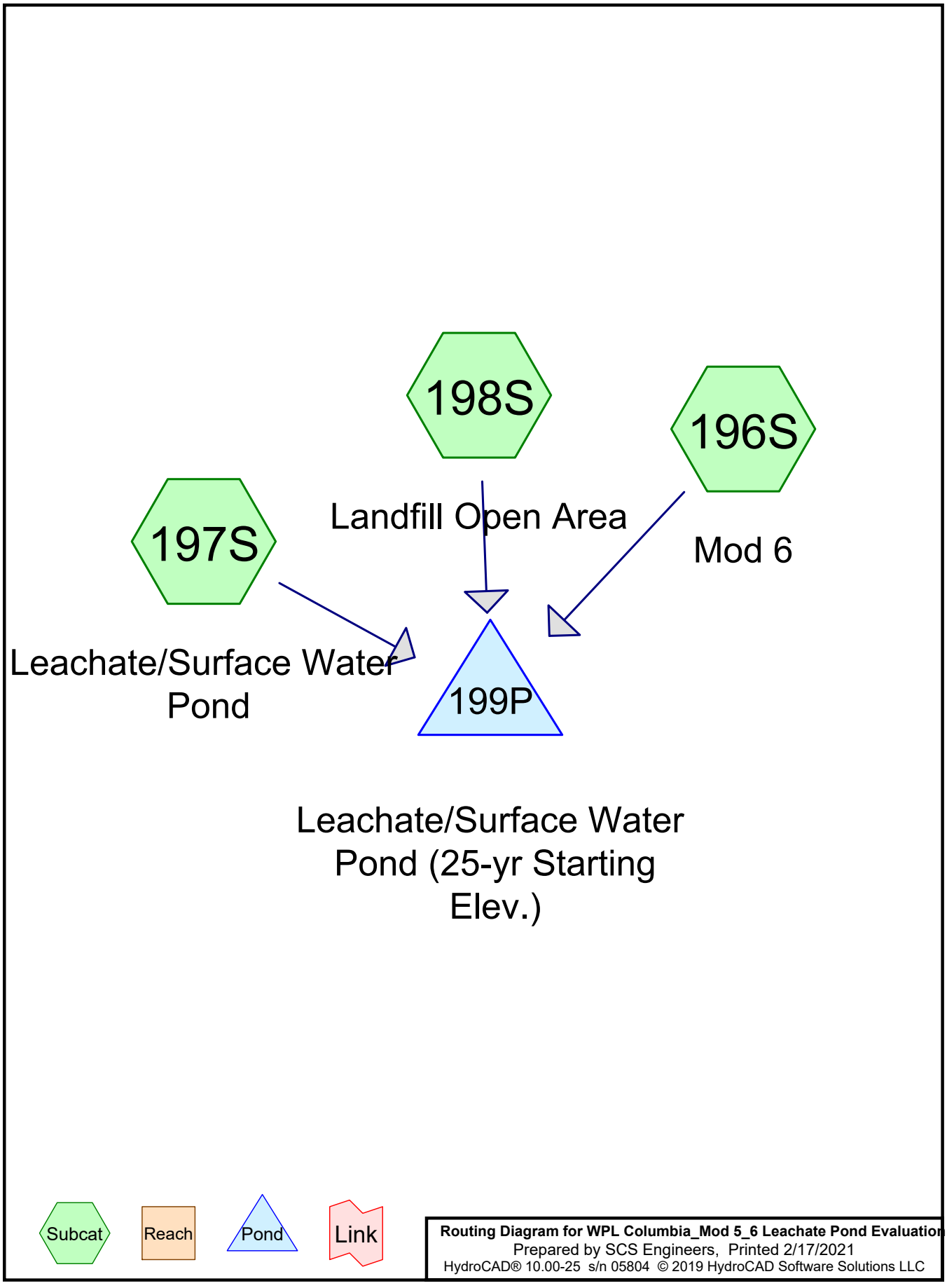
Runoff = 7.73 cfs @ 12.28 hrs, Volume= 0.738 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 1.895 | 98 | Ash |
| | 1.895 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

Scenario 4




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/17/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 196S: Mod 6** Runoff Area=3.790 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=7.56 cfs 0.698 af

**Subcatchment 197S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.92 cfs 0.684 af

**Subcatchment 198S: Landfill Open Area** Runoff Area=2.740 ac 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=5.46 cfs 0.505 af

**Pond 199P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,576 cf Inflow=18.52 cfs 1.887 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 1.887 af Average Runoff Depth = 2.21"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 196S: Mod 6

Runoff = 7.56 cfs @ 12.29 hrs, Volume= 0.698 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.790 | 98 | Ash |
| | 3.790 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 197S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.92 cfs @ 12.04 hrs, Volume= 0.684 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 198S: Landfill Open Area

Runoff = 5.46 cfs @ 12.29 hrs, Volume= 0.505 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.740 | 98 | Allowable Open Area |
| | 2.740 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 199P: Leachate/Surface Water Pond (25-yr Starting Elev.)

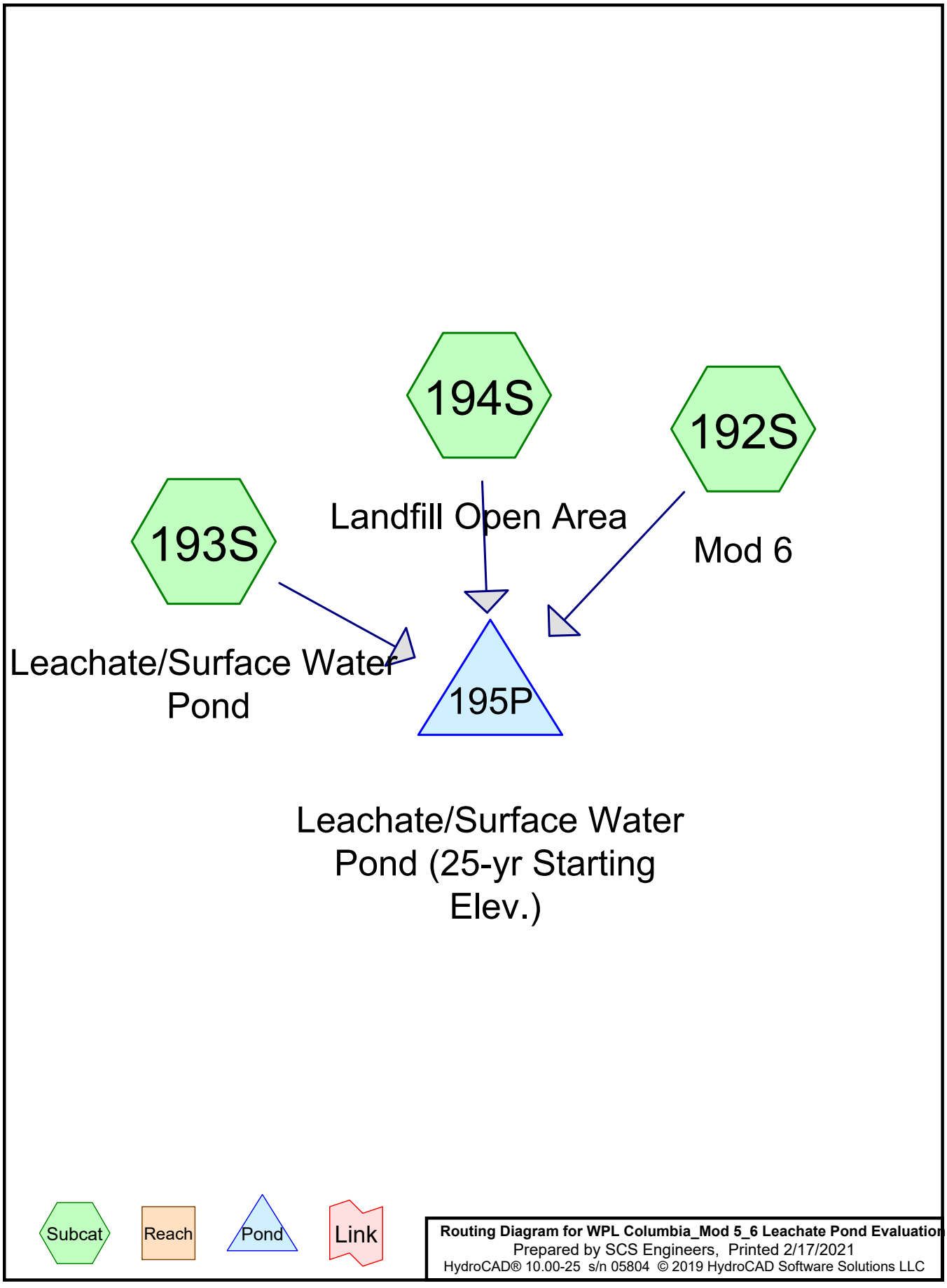
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 18.52 cfs @ 12.05 hrs, Volume= 1.887 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.55' Surf.Area= 53,339 sf Storage= 115,388 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,582 sf Storage= 197,576 cf (82,188 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (82,260 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/17/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 192S: Mod 6** Runoff Area=3.790 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=8.62 cfs 0.802 af

**Subcatchment 193S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.73 cfs 0.785 af

**Subcatchment 194S: Landfill Open Area** Runoff Area=2.740 ac 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=6.23 cfs 0.580 af

**Pond 195P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,716 cf Inflow=21.13 cfs 2.167 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 2.167 af Average Runoff Depth = 2.54"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 192S: Mod 6

Runoff = 8.62 cfs @ 12.29 hrs, Volume= 0.802 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.790 | 98 | Ash |
| | 3.790 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 193S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.73 cfs @ 12.04 hrs, Volume= 0.785 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 194S: Landfill Open Area

Runoff = 6.23 cfs @ 12.29 hrs, Volume= 0.580 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.740 | 98 | Allowable Open Area |
| | 2.740 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 195P: Leachate/Surface Water Pond (25-yr Starting Elev.)

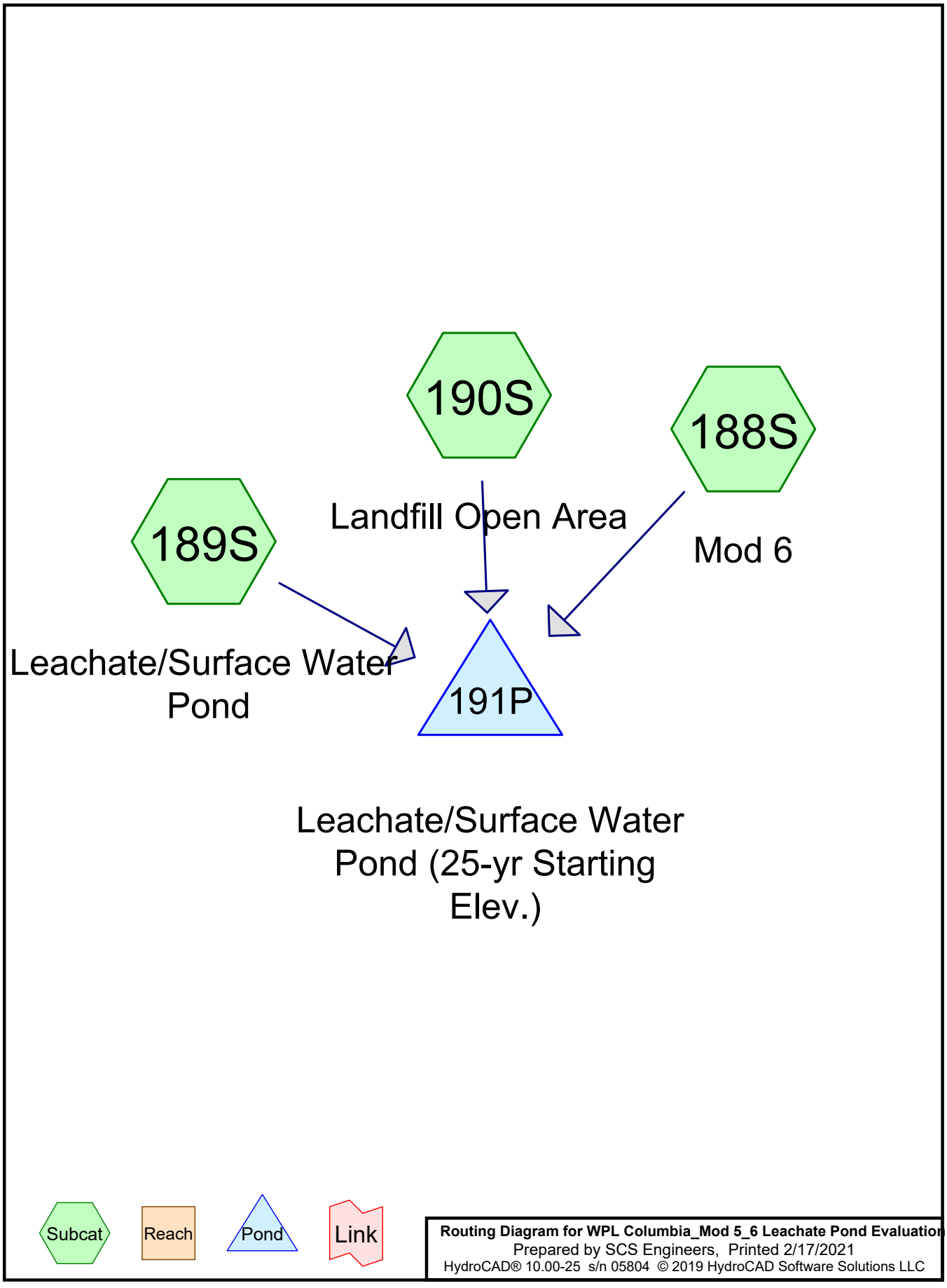
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 21.13 cfs @ 12.05 hrs, Volume= 2.167 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.32' Surf.Area= 51,527 sf Storage= 103,328 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,593 sf Storage= 197,716 cf (94,388 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (94,319 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/17/2021
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 188S: Mod 6** Runoff Area=3.790 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=10.58 cfs 0.994 af

**Subcatchment 189S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.06 cfs 0.973 af

**Subcatchment 190S: Landfill Open Area** Runoff Area=2.740 ac 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=7.65 cfs 0.719 af

**Pond 191P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,910 cf Inflow=25.94 cfs 2.685 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 2.685 af Average Runoff Depth = 3.15"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 188S: Mod 6

Runoff = 10.58 cfs @ 12.29 hrs, Volume= 0.994 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.790 | 98 | Ash |
| | 3.790 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 189S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.06 cfs @ 12.04 hrs, Volume= 0.973 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 190S: Landfill Open Area

Runoff = 7.65 cfs @ 12.29 hrs, Volume= 0.719 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.740 | 98 | Allowable Open Area |
| | 2.740 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 191P: Leachate/Surface Water Pond (25-yr Starting Elev.)

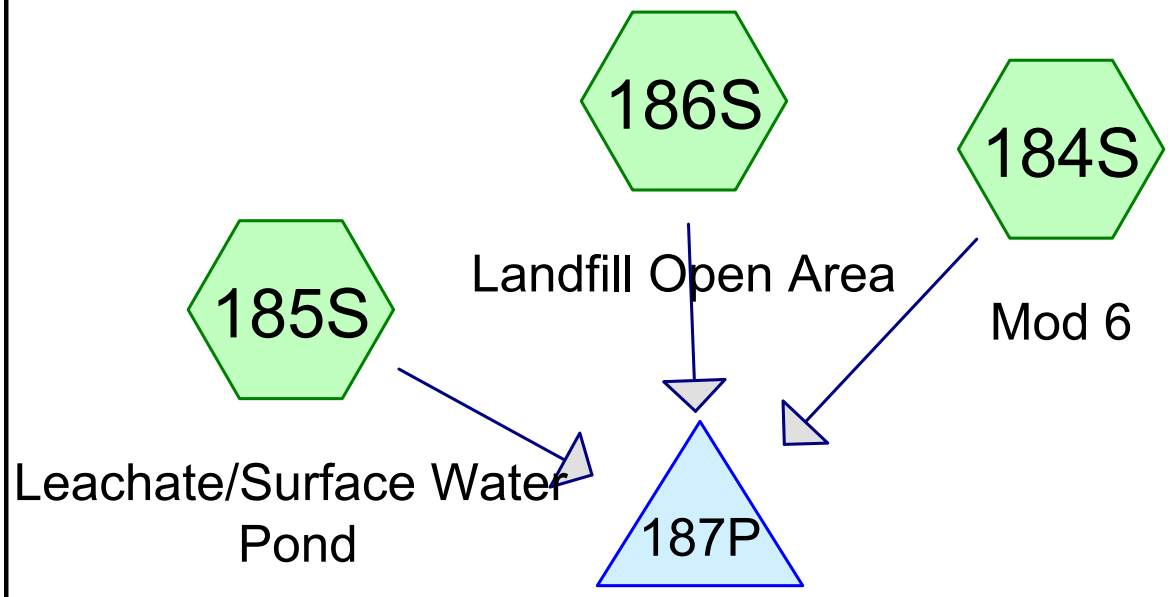
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 25.94 cfs @ 12.05 hrs, Volume= 2.685 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.87' Surf.Area= 47,981 sf Storage= 80,939 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,608 sf Storage= 197,910 cf (116,972 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (116,709 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
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Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 184S: Mod 6** Runoff Area=3.790 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=12.47 cfs 1.180 af

**Subcatchment 185S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.27 cfs 1.155 af

**Subcatchment 186S: Landfill Open Area** Runoff Area=2.740 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=9.01 cfs 0.853 af

**Pond 187P: Leachate/Surface Water** Peak Elev=796.97' Storage=197,655 cf Inflow=30.59 cfs 3.187 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 10.240 ac Runoff Volume = 3.187 af Average Runoff Depth = 3.74"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 10.240 ac**

## Summary for Subcatchment 184S: Mod 6

Runoff = 12.47 cfs @ 12.29 hrs, Volume= 1.180 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.790 | 98 | Ash |
| | 3.790 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 185S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.27 cfs @ 12.04 hrs, Volume= 1.155 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 186S: Landfill Open Area

Runoff = 9.01 cfs @ 12.29 hrs, Volume= 0.853 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.740 | 98 | Allowable Open Area |
| | 2.740 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 187P: Leachate/Surface Water Pond (25-yr Starting Elev.)

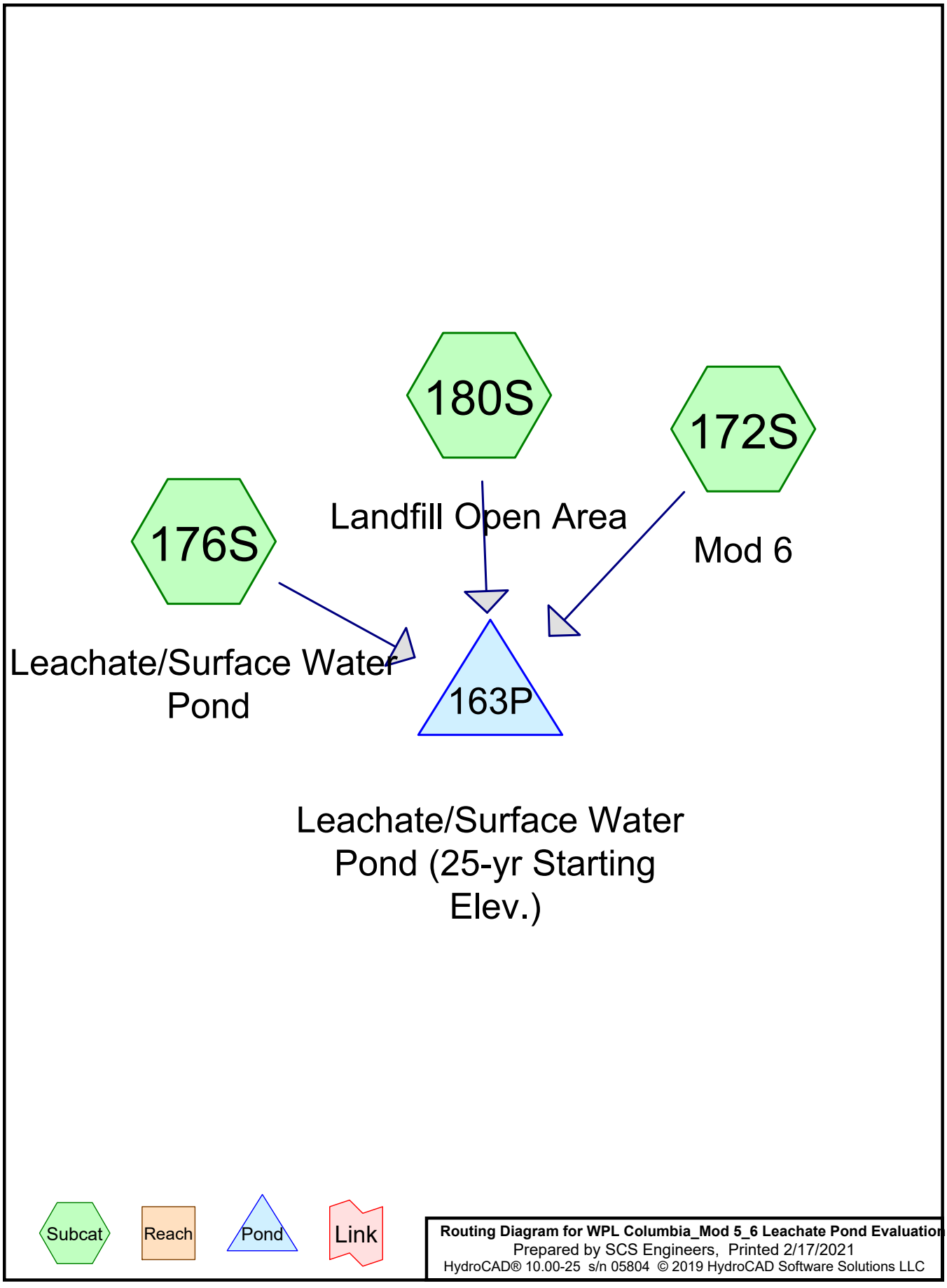
Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 30.59 cfs @ 12.05 hrs, Volume= 3.187 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.39' Surf.Area= 44,199 sf Storage= 58,815 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,588 sf Storage= 197,655 cf (138,840 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (138,832 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
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## Summary for Pond 163P: Leachate/Surface Water Pond (25-yr Starting Elev.)

Inflow Area = 10.240 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 37.96 cfs @ 12.05 hrs, Volume= 3.988 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.50' Surf.Area= 31,107 sf Storage= 24,119 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,602 sf Storage= 197,830 cf (173,712 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (173,529 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |

## Summary for Subcatchment 172S: Mod 6

Runoff = 15.47 cfs @ 12.28 hrs, Volume= 1.476 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.790 | 98 | Ash |
| | 3.790 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 176S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.38 cfs @ 12.04 hrs, Volume= 1.445 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 180S: Landfill Open Area

Runoff = 11.18 cfs @ 12.28 hrs, Volume= 1.067 af, Depth= 4.67"

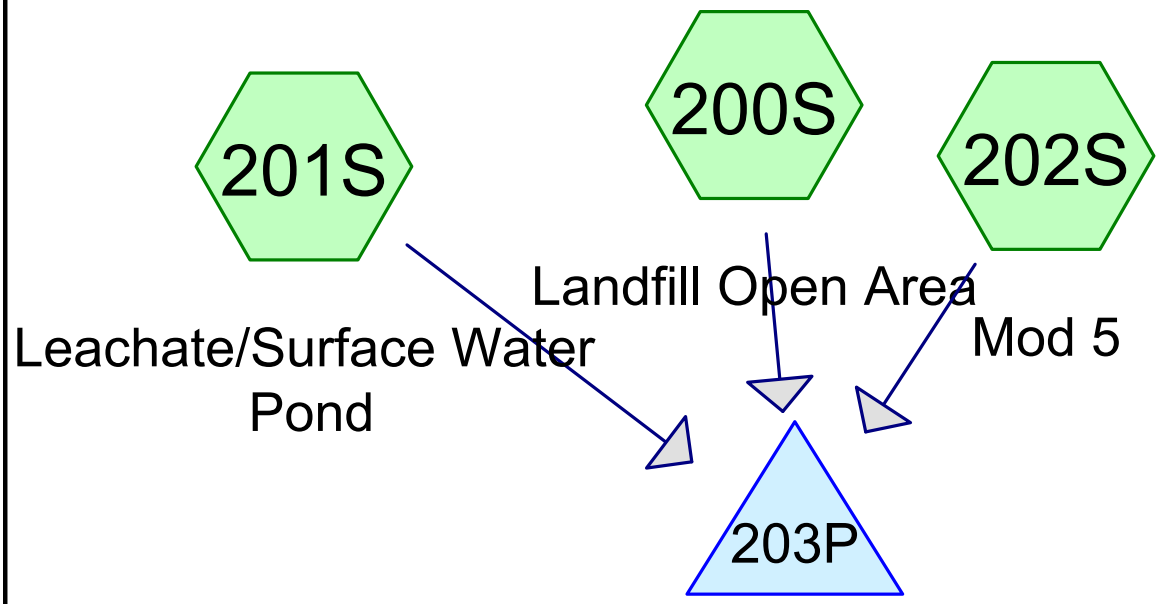
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.740 | 98 | Allowable Open Area |
| | 2.740 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

# Frost Protection Placement

# Base - Existing w/Mod 5 frost barrier construction




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/17/2021
HydroCAD® 10.00-25 s/n 05804 © 2019 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 200S: Landfill Open Area** Runoff Area=6.450 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=21.22 cfs 2.008 af

**Subcatchment 201S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.27 cfs 1.155 af

**Subcatchment 202S: Mod 5** Runoff Area=4.120 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=13.55 cfs 1.282 af

**Pond 203P: Leachate/Surface Water** Peak Elev=796.95' Storage=196,646 cf Inflow=39.08 cfs 4.445 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 14.280 ac Runoff Volume = 4.445 af Average Runoff Depth = 3.74"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 14.280 ac**

## Summary for Subcatchment 200S: Landfill Open Area

Runoff = 21.22 cfs @ 12.29 hrs, Volume= 2.008 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 6.450 | 98 | Mod 4 Open |
| | 6.450 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 201S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.27 cfs @ 12.04 hrs, Volume= 1.155 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 202S: Mod 5

Runoff = 13.55 cfs @ 12.29 hrs, Volume= 1.282 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 203P: Leachate/Surface Water Pond (6" Starting Elev.)

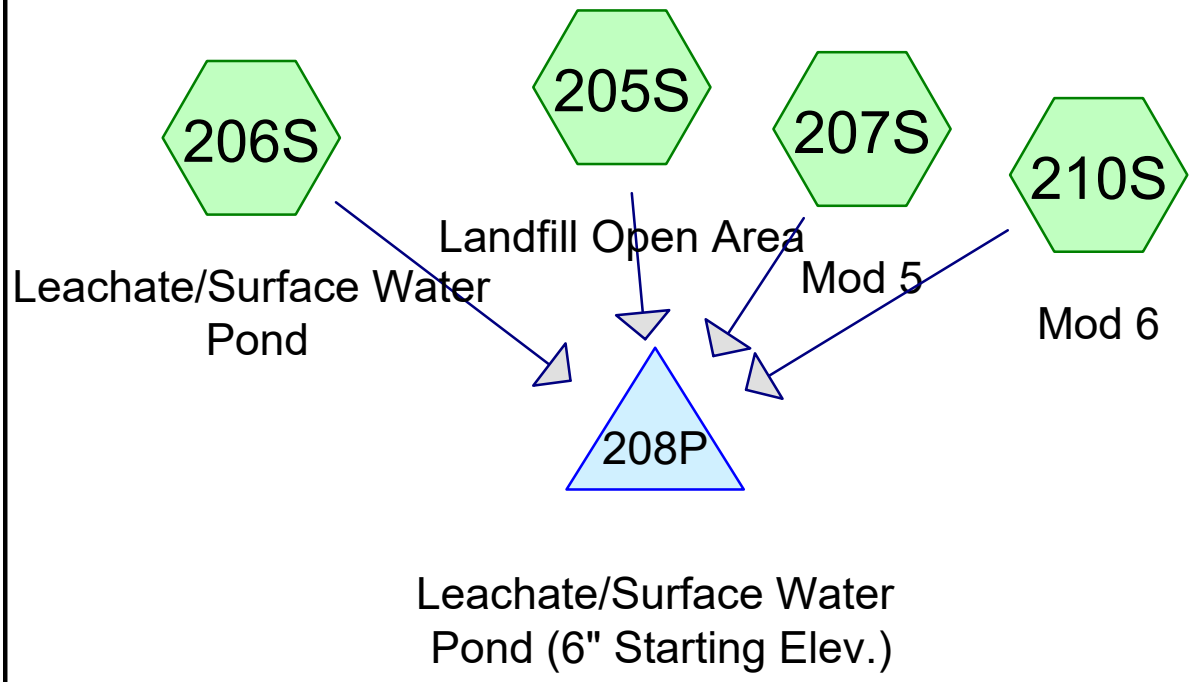
Inflow Area = 14.280 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 39.08 cfs @ 12.27 hrs, Volume= 4.445 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.95' @ 25.15 hrs Surf.Area= 61,509 sf Storage= 196,646 cf (193,616 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |




Subcat Reach Pond Link

**Routing Diagram for WPL Columbia_Mod 5_6 Leachate Pond Evaluation**
Prepared by SCS Engineers, Printed 2/23/2021
HydroCAD® 10.00-25 s/n 05804 © 2019 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 205S: Landfill Open Area** Runoff Area=6.450 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=21.22 cfs 2.008 af

**Subcatchment 206S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.27 cfs 1.155 af

**Subcatchment 207S: Mod 5** Runoff Area=4.120 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=13.55 cfs 1.282 af

**Subcatchment 210S: Mod 6** Runoff Area=3.790 ac 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=12.47 cfs 1.180 af

**Pond 208P: Leachate/Surface Water** Peak Elev=797.76' Storage=248,035 cf Inflow=51.51 cfs 5.625 af
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 18.070 ac Runoff Volume = 5.625 af Average Runoff Depth = 3.74"**
**0.00% Pervious = 0.000 ac 100.00% Impervious = 18.070 ac**

## Summary for Subcatchment 205S: Landfill Open Area

Runoff = 21.22 cfs @ 12.29 hrs, Volume= 2.008 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 6.450 | 98 | Mod 4 Open |
| | 6.450 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 206S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.27 cfs @ 12.04 hrs, Volume= 1.155 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 207S: Mod 5

Runoff = 13.55 cfs @ 12.29 hrs, Volume= 1.282 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 4.120 | 98 | Ash |
| | 4.120 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 210S: Mod 6

Runoff = 12.47 cfs @ 12.29 hrs, Volume= 1.180 af, Depth= 3.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.790 | 98 | Ash |
| | 3.790 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Pond 208P: Leachate/Surface Water Pond (6" Starting Elev.)

[58] Hint: Peaked 0.79' above defined flood level

Inflow Area = 18.070 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 51.51 cfs @ 12.28 hrs, Volume= 5.625 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 797.76' @ 25.15 hrs Surf.Area= 65,434 sf Storage= 248,035 cf (245,005 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 263,654 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |

# Appendix B1.3

# 2022 Leachate/Surface Water Pond Evaluation

| SCS ENGINEERS | | | | |
|---|---|---|---|---|
| | | SHEET NO. | 1 | |
| Job No. | 25220183.00 | CALC. NO. | | |
| Job: | Columbia Energy Center | REV. NO. | | |
| Client | WPL | BY | RJG | DATE 05/25/22 |
| Subject | Module 10/11 - Leachate/Surface Water Pond Evaluation | CHK'D. | MT | DATE 05/25/22 |

**Purpose:**
The purpose of the leachate/surface water pond evaluation is to determine the following based on the as-built leachate/surface water pond top of liner elevation of 796.97 (see Background section below):

- The maximum amount of open area during each filling phase in order to maintain the peak water elevation resulting from the 25-year, 24-hour storm event at the maximum allowable 796.97.
- The amount of open area allowable with pond closure filling in order to maintain the peak water elevation resulting from the 25-year, 24-hour storm event at the maximum allowable 796.97.
- Based on the amount of allowable open area determined from the above, determine the maximum starting water elevations in the leachate/surface water pond to accommodate 1, 2, 5, and 10-year, 24-hour storm events without overtopping.

**Background:**
- During construction of Module 2, the top of the leachate/surface water pond liner was determined to be at elevation 796.97.
- Previous calculations submitted to the WDNR on January 30, 2018, evaluated the leachate/surface water pond capacity based on the as-built pond liner elevation.
- A similar evaluation was performed for Module 3 and 4 construction and then Module 5 and 6 construction that produced a chart of maximum leachate/surface water pond starting elevations vs. rainfall storage capacity.
- Portions of Modules 1, 2, 3, and 4 currently have final or intermediate cover in place and Module 5 and 6 currently have rain cover (see **Figure 1 through 4**).
- Module 10 and 11 will be constructed in 2022.

**Approach:**
- Use the previously developed HydroCAD storm water model to model the below four filling scenarios.
    1. Filling Phase 0 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 1** for filling grades and contributing area
    2. Filling Phase 1 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 2** for filling grades and contributing area
    3. Filling Phase 2 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 3** for filling grades and contributing area.

4. Filling Phase 3 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 4** for filling grades and contributing area.
5. Filling Phase 4 – Assumes portions of Module 2, 3, 4, 5, 6, 10, and 11 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 5** for filling grades and contributing area.

**Assumptions:**

- Ash surfaces and intermediate cover areas were assumed to be impermeable (CN=98).
- The top of pond liner elevation is 796.97 (see Background section).
- Time of Concentration is 20 minutes for open areas.

**Results:**

1. Maximum allowable open area during filling and prior to permeter grade/Module 10 and 11 construction is 7.78 acres.

2. Maximum allowable open area during filling and after perimeter grades/Module 10 and 11 base grades are completed is 8.51 acres.

3. <u>Filling Phase 0:</u>
   - The contributing area of landfill to the leachate/surface water pond is 7.45 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 1** shows a proposed filling sequence, and **Figure 1a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.
4. <u>Filling Phase 1:</u>
   - The contributing area of landfill to the leachate/surface water pond is 7.78 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 2** shows a proposed filling sequence, and **Figure 2a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.
5. <u>Filling Phase 2:</u>
   - The contributing area of landfill to the leachate/surface water pond is 7.69 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.

- The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
- **Figure 3** shows a proposed filling sequence, and **Figure 3a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

6. Filling Phase 3:
   - The contributing area of landfill to the leachate/surface water pond is 7.64 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 4** shows a proposed filling sequence, and **Figure 4a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

7. Filling Phase 4:
   - The contributing area of landfill to the leachate/surface water pond is 8.44 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 5** shows a proposed filling sequence, and **Figure 5a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

The HydroCAD reports for the maximum open contributing area, each scenario modeled are attached.

**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- CONTACT WATER DRAINAGE
- SURFACE WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA 7.0 ACRES |
|---|---|---|
| 0 | | |
| 1 | | |
| 2 | | |
| 3 | | |
| TOTAL | | 7.0 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.

541,000 N | 541,500 N | 542,000 N | 542,500 N | 543,000 N | 543,500 N

2,123,500 E | 2,124,000 E | 2,124,500 E | 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

EXISTING FINAL COVER

EXISTING OPEN AREA

EXISTING INTERIM COVER

EXISTING RAIN COVER

DRAINAGE AREA = 7.45 ACRES

LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 3.71 ACRES

MURRAY ROAD

BM6

BM19

N

100 0 100

SCALE: 1" = 100'

U:\25220183.000\Drawings\Plan of Operation Update\FIG 5a - closure exhibit - half filling 5a - once stage 0 3 exhibits.dwg
05/20/2022 8:42:31 AM

SCS ENGINEERS
2830 DAIRY DRIVE, MADISON, WI 53718-6751
PHONE: (608) 224-2830

| | |
|---|---|
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |
| PROJECT NO. | 25220183.000 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/20/2022 |

CLIENT: WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WI 53954

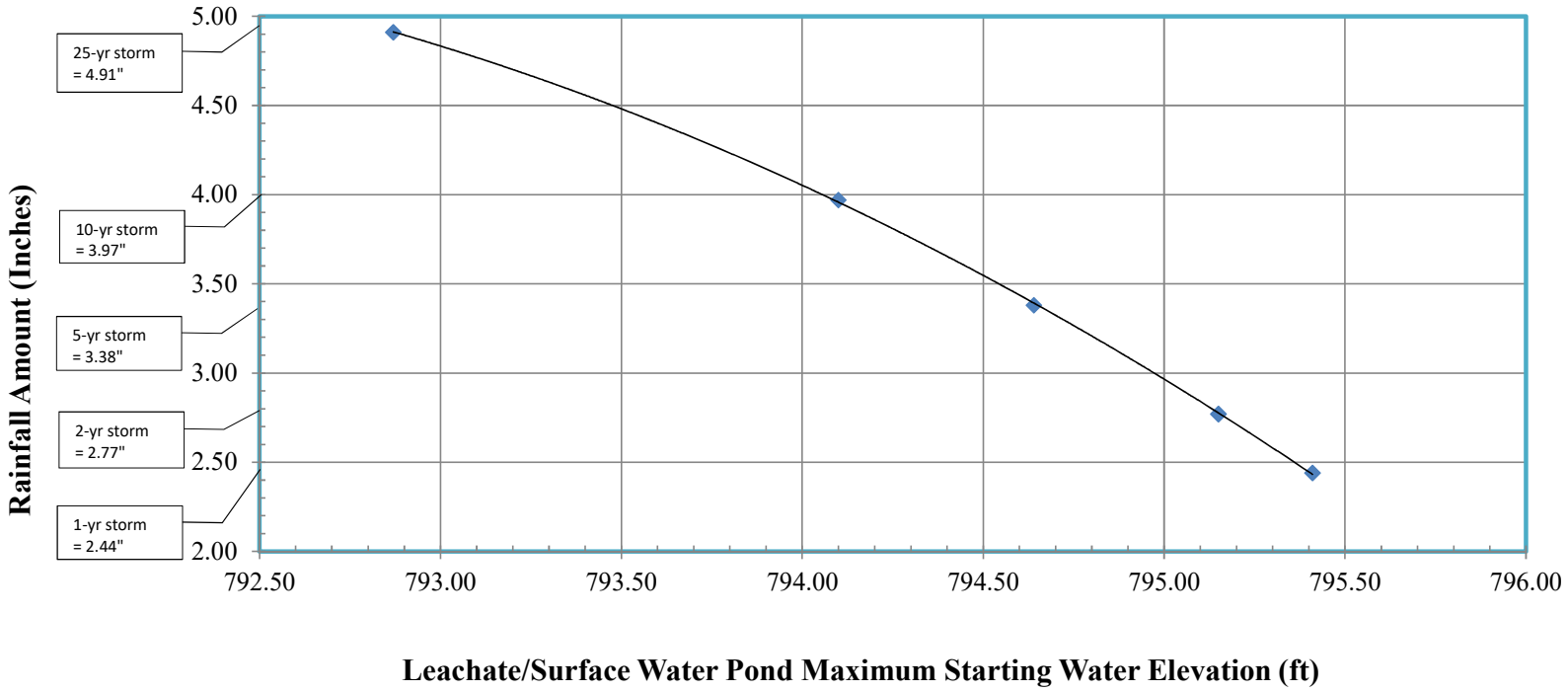
ENGINEER

SITE: PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

FIGURE: STAGE 0 – EXISTING CONDITIONS

1

# Figure 1A
# Columbia Energy Center
# Phase 0 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.46 acres.
   - Leachate/Surface Water Pond Area, 3.71 acres.
5. Maximum open area per HydroCAD model during filling is 7.78 acres.

I:\25220183.00\Data and Calculations\Leachate_Surface Water Pond Evaluation\Issued for Permitting_POO Update\

**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME 121,600 CY | ESTIMATED OPEN AREA 7.3 ACRES |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| TOTAL | 121,600 CY | 7.3 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.

N

100 0 100

SCALE: 1" = 100'

541,000 N 541,500 N 542,000 N 542,500 N 543,000 N 543,500 N

2,123,500 E 2,124,000 E 2,124,500 E 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

EXISTING FINAL COVER

INTERIM COVER

EXISTING INTERIM COVER

STAGE 1 ACTIVE AREA

EXISTING RAIN COVER

DRAINAGE AREA = 7.76 ACRES

NO BOTTOM ASH BEYOND MODULE LIMIT

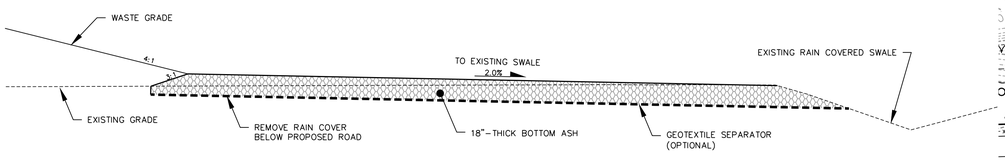
LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 3.71 ACRES

MURRAY ROAD

BM18

BM19




1/2 **40' WIDE HAUL ROAD**

SCALE: 1" = 5'

DRAWN BY: KP
CHECKED BY: PEG/MJT
APPROVED BY: MRH 05/25/2022

PROJECT NO. 25220183.00
DRAWN: 01/15/2022
REVISED: 05/11/2022

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 FORT ROAD
PARDEEVILLE, WI 53954

CLIENT

SGS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA COUNTY, WISCONSIN
TOWN OF PACIFIC, WISCONSIN

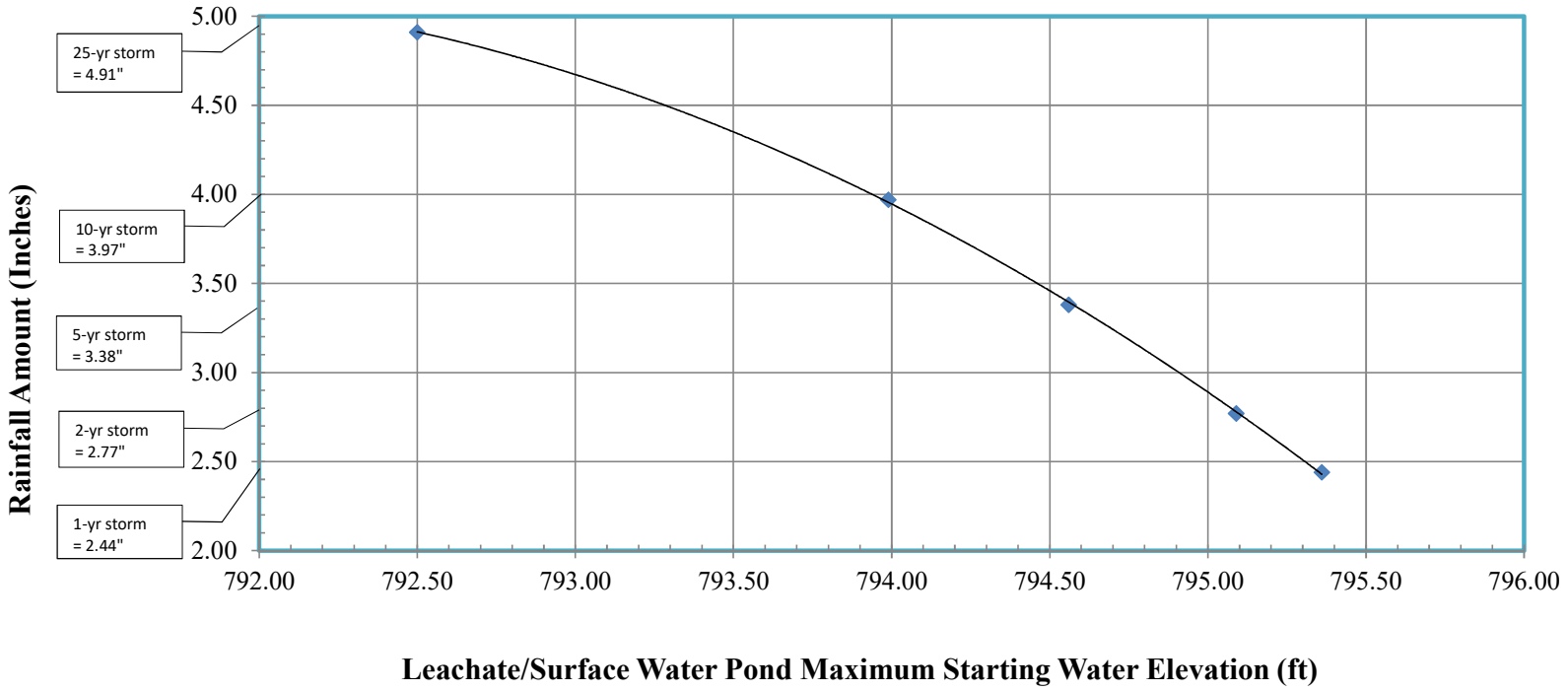
SITE

STAGE 1 – FILLING MODULES 5 AND 6

FIGURE 2

I:\25220183.00\Drawings\Plan of Operation Update\FIG Sht - Intrim and Final - Add Leachate Pond Sht - Intrim Stage 1.dwg
Apr 25, 2022 - 2:52:21pm

# Figure 2A
# Columbia Energy Center
# Phase 1 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.78 acres.
   - Leachate/Surface Water Pond Area, 3.71 acres.
5. Maximum open area per HydroCAD model during filling is 7.78 acres.

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**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- 840 — PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (10' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA |
|---|---|---|
| 1 | 121,600 CY | |
| 2 | 151,100 CY | 7.2 ACRES |
| 3 | | |
| 4 | | |
| TOTAL | 272,700 CY | 7.2 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.

N

100 0 100

SCALE: 1" = 100'

541,000 N | 541,500 N | 542,000 N | 542,500 N | 543,000 N | 543,500 N

2,123,500 E | 2,124,000 E | 2,124,500 E | 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

BM6

BM19

REMOVE CULVERT AFTER WEST SLOPE HAS INTERIM COVER

INTERIM COVER

INTERIM COVER BELOW OVERLAY TO BE REMOVED

EXISTING FINAL COVER

EXISTING INTERIM COVER

STAGE 2 ACTIVE AREA

TEMPORARY CONTACT WATER DIVERSION BERM (TYP.)

EXISTING RAIN COVER

DRAINAGE AREA = 7.69 ACRES

LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 2.98 ACRES

MODULE 10/11 LINER UNDER CONSTRUCTION

MURRAY ROAD

| | |
|---|---|
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/09/2022 |
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 FORT ROAD
PARDEEVILLE, WI 53954

CLIENT

SCS ENGINEERS
2830 DAIRY DRIVE, MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

SITE

STAGE 2 – FILLING MODULES 5 AND 6

FIGURE 3

I:\25220183.00\Drawings\Plan of Operation Update\FIG 3a - Annual Activities - with Another Filling Sq - ence Stage 2.dwg
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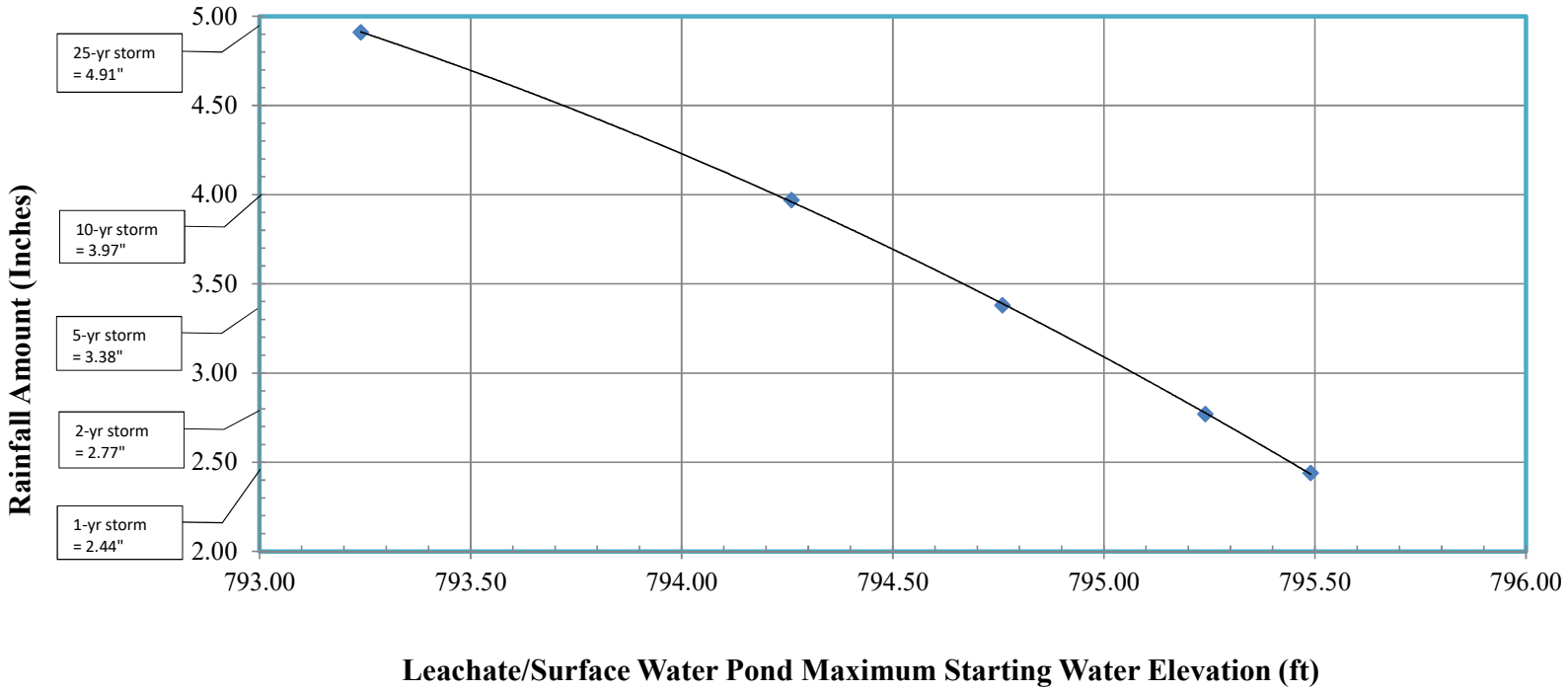
# Figure 3A
# Columbia Energy Center
# Phase 2 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.69 acres.
   - Leachate/Surface Water Pond Area, 2.98 acres.
5. Maximum open area per HydroCAD model during filling is 8.51 acres.

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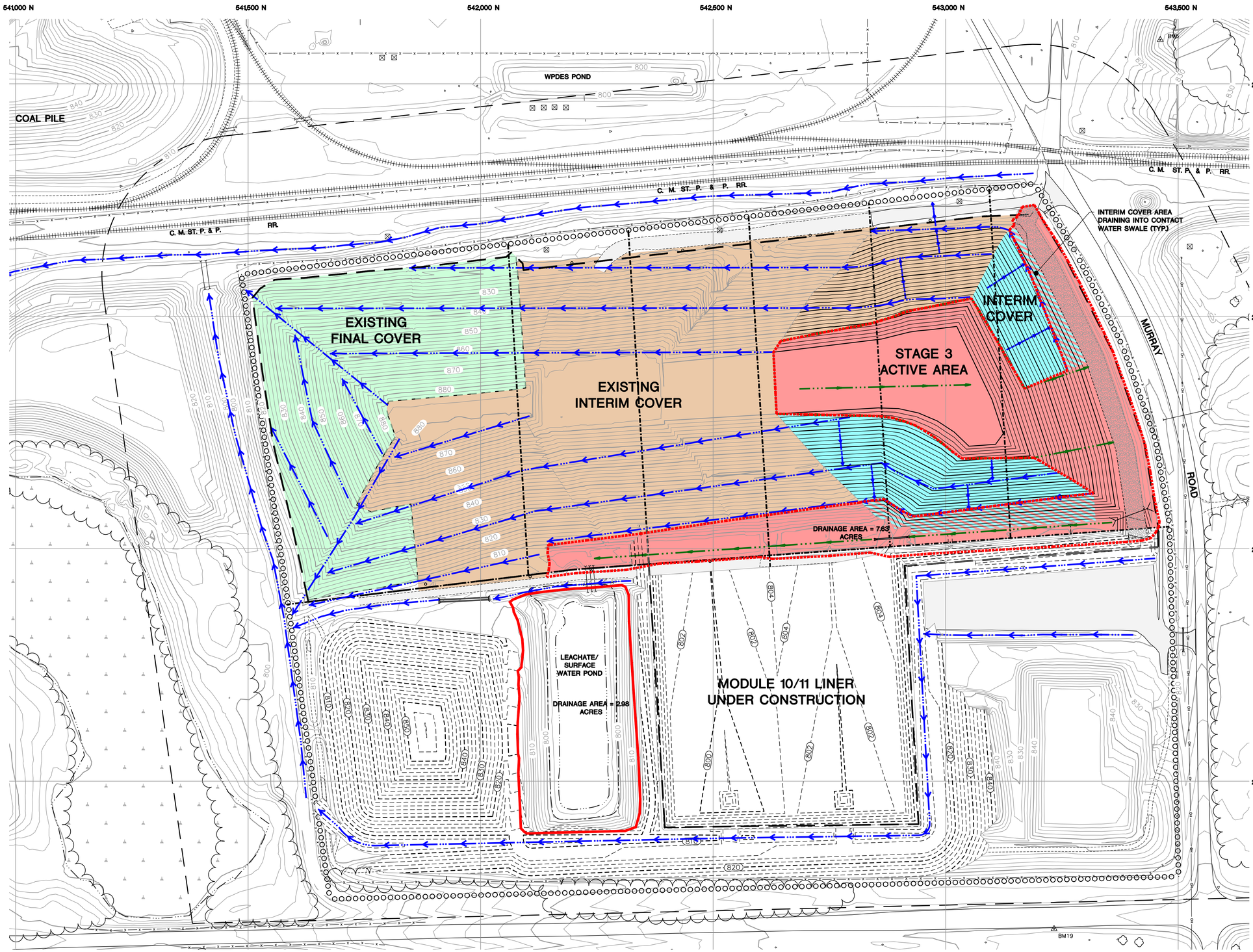
**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (10' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA |
|---|---|---|
| 1 | 121,600 CY | |
| 2 | 151,100 CY | |
| 3 | 107,300 CY | 7.2 ACRES |
| 4 | | |
| TOTAL | 380,000 CY | 7.2 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.




N

100 0 100

SCALE: 1" = 100'

| | |
|---|---|
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/09/2022 |

WISCONSIN POWER AND LIGHT COMPANY
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DRY ASH DISPOSAL FACILITY
COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

SITE

STAGE 3 – FILLING MODULES 5 AND 6

FIGURE

4

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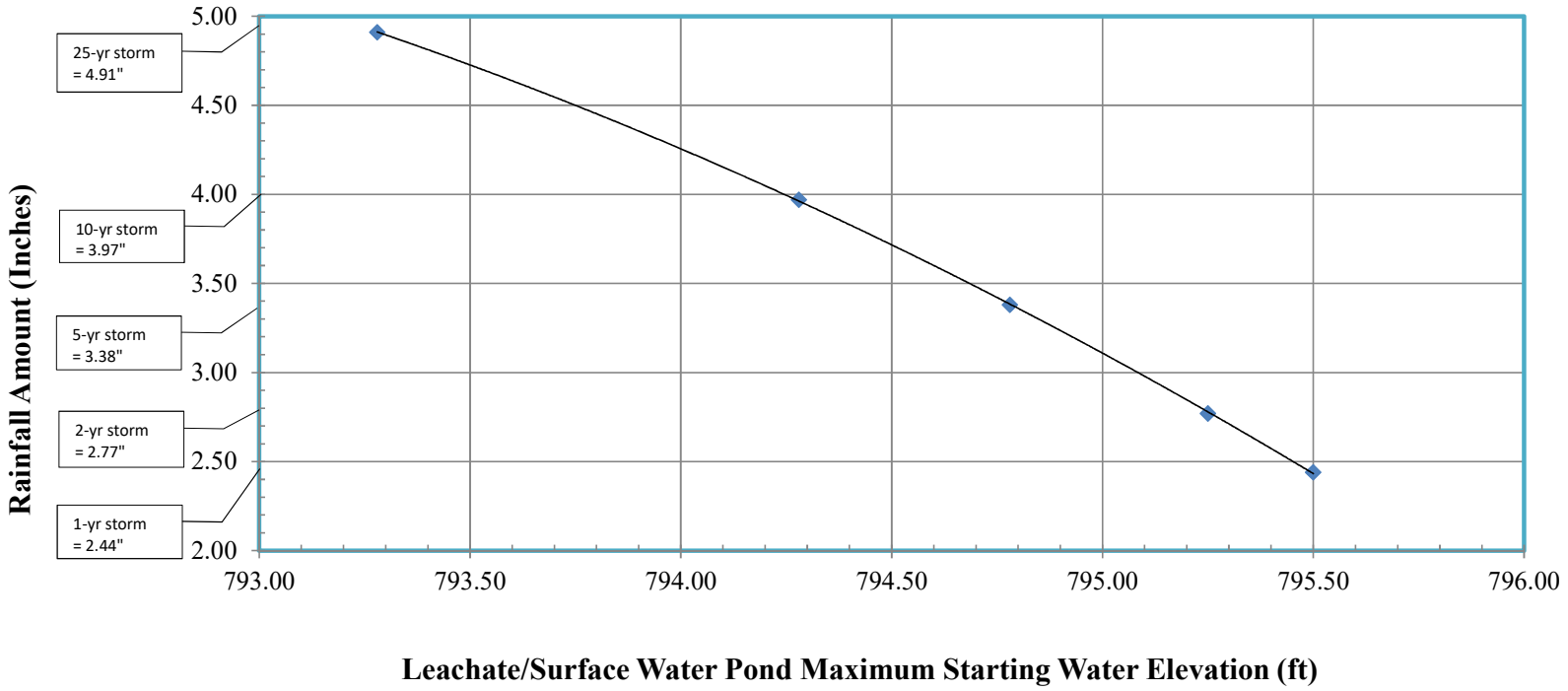
# Figure 4A
# Columbia Energy Center
# Phase 3 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.64 acres.
   - Leachate/Surface Water Pond Area, 2.98 acres.
5. Maximum open area per HydroCAD model during filling is 8.51 acres.

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**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- 840 — PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (10' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA |
|---|---|---|
| 1 | 121,600 CY | |
| 2 | 151,100 CY | |
| 3 | 107,300 CY | |
| 4 | 471,600 cy | 7.3 ACRES |
| TOTAL | 851,600 CY | 7.3 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.

N

100 0 100

SCALE: 1" = 100'

541,000 N 541,500 N 542,000 N 542,500 N 543,000 N 543,500 N

2,123,500 E 2,124,000 E 2,124,500 E 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

EXISTING FINAL COVER

EXISTING INTERIM COVER

INTERIM COVER

STAGE 4 ACTIVE AREA

DRAINAGE AREA = 8.44 ACRES

LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 2.98 ACRES

MODULE 10/11 LINER

PUMP CONTACT WATER TO LEACHATE POND

CONTACT WATER CULVERT TO BE REMOVED

TEMPORARY CONTACT WATER STORAGE AREA, USE WELL GRADED MATERAIL FOR 3' THICK FROST PROTECTION LAYER, NO CCR ABOVE FROST PROTECTION LAYER

MURRAY ROAD

BM19

PM6

| | |
|---|---|
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/11/2022 |

WISCONSIN POWER AND LIGHT COMPANY
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ENGINEER

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COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

SITE

STAGE 4 – FILLING MODULES 10 AND 11

FIGURE 5

I:\25220183.00\Drawings\Plan of Operation Update\Fill Sq - Annual Landfills - Cell Landfills\ Filling Sq - Annual Stage 4.dwg
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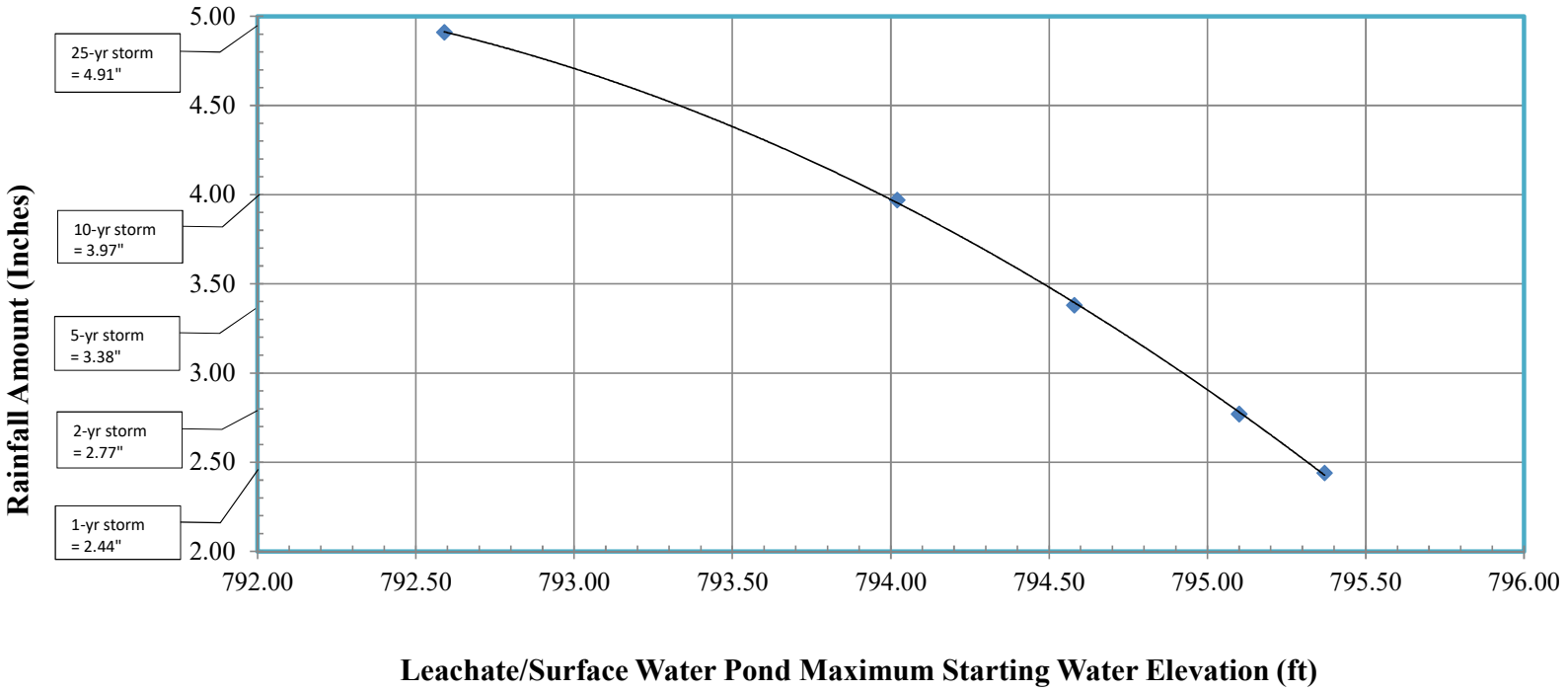
# Figure 5A
# Columbia Energy Center
# Phase 4 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 8.44 acres.
   - Leachate/Surface Water Pond Area, 2.98 acres.
5. Maximum open area per HydroCAD model during filling is 8.51 acres.

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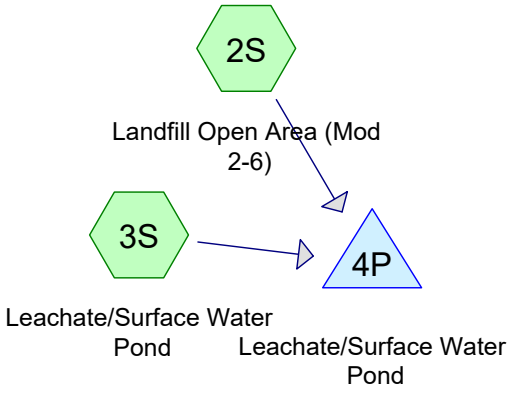
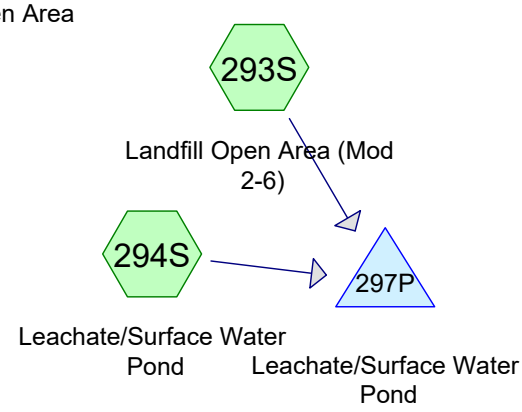
Maximum Open Area

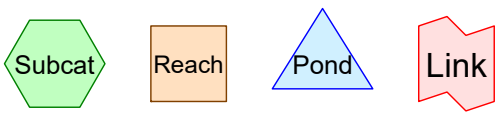



**Phase 0 Filling** **Phase 1 Filling**

**Phase 2 Filling** **Phase 3 Filling**

**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 2S: Landfill Open Area** Runoff Area=7.780 ac 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.75 cfs 3.030 af

**Subcatchment 3S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=26.38 cfs 1.445 af

**Subcatchment 293S: Landfill Open Area** Runoff Area=8.510 ac 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=34.73 cfs 3.314 af

**Subcatchment 294S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Pond 4P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,946 cf Inflow=40.23 cfs 4.475 af
Outflow=0.00 cfs 0.000 af

**Pond 297P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,946 cf Inflow=39.03 cfs 4.475 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 2S: Landfill Open Area (Mod 2-6)

Runoff = 31.75 cfs @ 12.28 hrs, Volume= 3.030 af, Depth= 4.67"
Routed to Pond 4P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 7.075 | 98 | Mod 2 - 6 Open Area |
| * | 0.705 | 98 | Access Road |
| | 7.780 | 98 | Weighted Average |
| | 7.780 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 3S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.38 cfs @ 12.04 hrs, Volume= 1.445 af, Depth= 4.67"
Routed to Pond 4P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 293S: Landfill Open Area (Mod 2-6)

Runoff = 34.73 cfs @ 12.28 hrs, Volume= 3.314 af, Depth= 4.67"
Routed to Pond 297P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 8.510 | 98 | Mod 2 - 11 Open Area |
| | 8.510 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 294S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 297P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 4P: Leachate/Surface Water Pond

Inflow Area = 11.490 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 40.23 cfs @ 12.06 hrs, Volume= 4.475 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,611 sf Storage= 197,946 cf (194,915 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 297P: Leachate/Surface Water Pond

Inflow Area = 11.490 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 39.03 cfs @ 12.27 hrs, Volume= 4.475 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,611 sf Storage= 197,946 cf (194,915 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

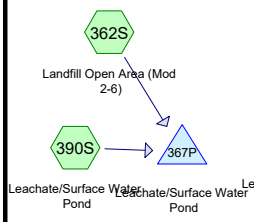
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

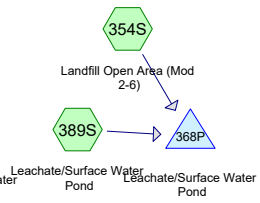
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**1-Year Storm Analysis**

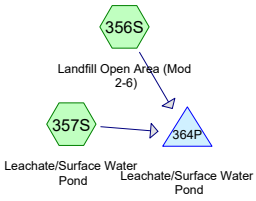
**Phase 0 Filling**



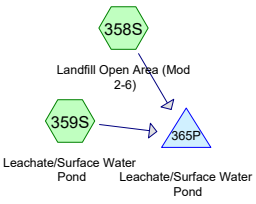

**Phase 1 Filling**



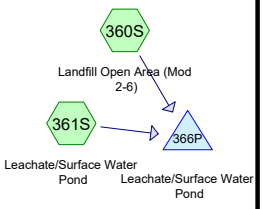

**Phase 2 Filling**

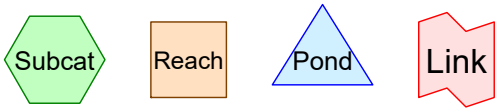



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 354S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=15.52 cfs 1.434 af

**Subcatchment 356S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=15.34 cfs 1.417 af

**Subcatchment 357S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=10.38 cfs 0.549 af

**Subcatchment 358S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=15.23 cfs 1.407 af

**Subcatchment 359S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=10.38 cfs 0.549 af

**Subcatchment 360S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=16.84 cfs 1.556 af

**Subcatchment 361S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=10.38 cfs 0.549 af

**Subcatchment 362S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=14.87 cfs 1.374 af

**Subcatchment 389S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.91 cfs 0.683 af

**Subcatchment 390S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.91 cfs 0.683 af

**Pond 364P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,850 cf Inflow=17.45 cfs 1.966 af
Outflow=0.00 cfs 0.000 af

**Pond 365P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,930 cf Inflow=17.34 cfs 1.956 af
Outflow=0.00 cfs 0.000 af

**Pond 366P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,593 cf Inflow=18.94 cfs 2.105 af
Outflow=0.00 cfs 0.000 af

**Pond 367P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,577 cf Inflow=19.31 cfs 2.056 af
Outflow=0.00 cfs 0.000 af

**Pond 368P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,611 cf Inflow=19.60 cfs 2.117 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 354S: Landfill Open Area (Mod 2-6)

Runoff = 15.52 cfs @ 12.29 hrs, Volume= 1.434 af, Depth= 2.21"
Routed to Pond 368P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 356S: Landfill Open Area (Mod 2-6)

Runoff = 15.34 cfs @ 12.29 hrs, Volume= 1.417 af, Depth= 2.21"
Routed to Pond 364P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 357S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.38 cfs @ 12.04 hrs, Volume= 0.549 af, Depth= 2.21"
Routed to Pond 364P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 358S: Landfill Open Area (Mod 2-6)

Runoff = 15.23 cfs @ 12.29 hrs, Volume= 1.407 af, Depth= 2.21"
Routed to Pond 365P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 359S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.38 cfs @ 12.04 hrs, Volume= 0.549 af, Depth= 2.21"
Routed to Pond 365P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 360S: Landfill Open Area (Mod 2-6)

Runoff = 16.84 cfs @ 12.29 hrs, Volume= 1.556 af, Depth= 2.21"
Routed to Pond 366P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 361S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.38 cfs @ 12.04 hrs, Volume= 0.549 af, Depth= 2.21"
Routed to Pond 366P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 362S: Landfill Open Area (Mod 2-6)

Runoff = 14.87 cfs @ 12.29 hrs, Volume= 1.374 af, Depth= 2.21"
Routed to Pond 367P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 389S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.91 cfs @ 12.04 hrs, Volume= 0.683 af, Depth= 2.21"
Routed to Pond 368P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 390S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.91 cfs @ 12.04 hrs, Volume= 0.683 af, Depth= 2.21"
Routed to Pond 367P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 364P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 17.45 cfs @ 12.27 hrs, Volume= 1.966 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.49' Surf.Area= 52,866 sf Storage= 112,201 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,604 sf Storage= 197,850 cf (85,648 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (85,446 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 365P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 17.34 cfs @ 12.27 hrs, Volume= 1.956 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.50' Surf.Area= 52,945 sf Storage= 112,730 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,610 sf Storage= 197,930 cf (85,199 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (84,917 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 366P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 18.94 cfs @ 12.27 hrs, Volume= 2.105 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.37' Surf.Area= 51,921 sf Storage= 105,914 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,593 cf (91,679 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (91,733 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 367P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 19.31 cfs @ 12.05 hrs, Volume= 2.056 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.41' Surf.Area= 52,236 sf Storage= 107,997 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,582 sf Storage= 197,577 cf (89,579 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (89,650 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 368P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 19.60 cfs @ 12.06 hrs, Volume= 2.117 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.36' Surf.Area= 51,842 sf Storage= 105,395 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,585 sf Storage= 197,611 cf (92,216 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (92,252 cf above start)

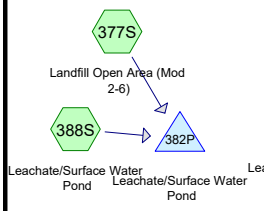
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

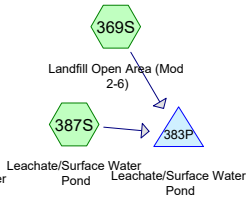
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## 2-Year Storm Analysis

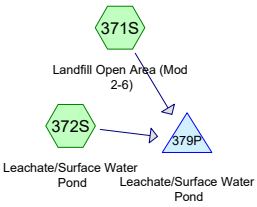
**Phase 0 Filling**



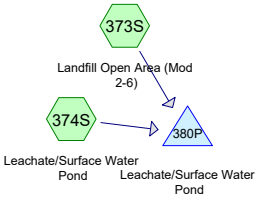

**Phase 1 Filling**



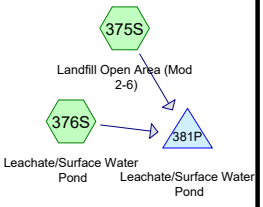

**Phase 2 Filling**

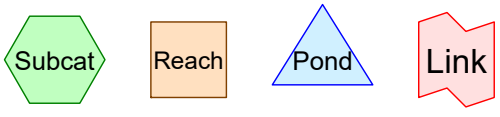



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 369S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=17.70 cfs 1.647 af

**Subcatchment 371S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=17.49 cfs 1.628 af

**Subcatchment 372S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=11.83 cfs 0.631 af

**Subcatchment 373S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=17.37 cfs 1.616 af

**Subcatchment 374S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=11.83 cfs 0.631 af

**Subcatchment 375S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=19.20 cfs 1.787 af

**Subcatchment 376S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=11.83 cfs 0.631 af

**Subcatchment 377S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=16.96 cfs 1.578 af

**Subcatchment 387S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.72 cfs 0.784 af

**Subcatchment 388S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.72 cfs 0.784 af

**Pond 379P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,593 cf Inflow=19.90 cfs 2.258 af
Outflow=0.00 cfs 0.000 af

**Pond 380P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,587 cf Inflow=19.77 cfs 2.246 af
Outflow=0.00 cfs 0.000 af

**Pond 381P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,471 cf Inflow=21.61 cfs 2.417 af
Outflow=0.00 cfs 0.000 af

**Pond 382P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,558 cf Inflow=22.04 cfs 2.362 af
Outflow=0.00 cfs 0.000 af

**Pond 383P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,589 cf Inflow=22.37 cfs 2.431 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 369S: Landfill Open Area (Mod 2-6)

Runoff = 17.70 cfs @ 12.29 hrs, Volume= 1.647 af, Depth= 2.54"
Routed to Pond 383P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 371S: Landfill Open Area (Mod 2-6)

Runoff = 17.49 cfs @ 12.29 hrs, Volume= 1.628 af, Depth= 2.54"
Routed to Pond 379P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 372S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 11.83 cfs @ 12.04 hrs, Volume= 0.631 af, Depth= 2.54"
Routed to Pond 379P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 373S: Landfill Open Area (Mod 2-6)

Runoff = 17.37 cfs @ 12.29 hrs, Volume= 1.616 af, Depth= 2.54"
Routed to Pond 380P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 374S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 11.83 cfs @ 12.04 hrs, Volume= 0.631 af, Depth= 2.54"
Routed to Pond 380P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 375S: Landfill Open Area (Mod 2-6)

Runoff = 19.20 cfs @ 12.29 hrs, Volume= 1.787 af, Depth= 2.54"
Routed to Pond 381P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 376S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 11.83 cfs @ 12.04 hrs, Volume= 0.631 af, Depth= 2.54"
Routed to Pond 381P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 377S: Landfill Open Area (Mod 2-6)

Runoff = 16.96 cfs @ 12.29 hrs, Volume= 1.578 af, Depth= 2.54"
Routed to Pond 382P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 387S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.72 cfs @ 12.04 hrs, Volume= 0.784 af, Depth= 2.54"
Routed to Pond 383P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 388S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.72 cfs @ 12.04 hrs, Volume= 0.784 af, Depth= 2.54"
Routed to Pond 382P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 379P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 19.90 cfs @ 12.27 hrs, Volume= 2.258 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.24' Surf.Area= 50,897 sf Storage= 99,231 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,593 cf (98,362 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (98,416 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 380P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 19.77 cfs @ 12.27 hrs, Volume= 2.246 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.25' Surf.Area= 50,975 sf Storage= 99,740 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,587 cf (97,847 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (97,907 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 381P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 21.61 cfs @ 12.27 hrs, Volume= 2.417 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.10' Surf.Area= 49,793 sf Storage= 92,183 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,574 sf Storage= 197,471 cf (105,288 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (105,464 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 382P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 22.04 cfs @ 12.05 hrs, Volume= 2.362 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.15' Surf.Area= 50,187 sf Storage= 94,682 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,581 sf Storage= 197,558 cf (102,876 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (102,965 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 383P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 22.37 cfs @ 12.06 hrs, Volume= 2.431 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.09' Surf.Area= 49,715 sf Storage= 91,685 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,589 cf (105,904 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (105,962 cf above start)

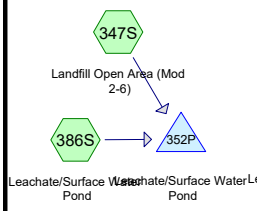
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

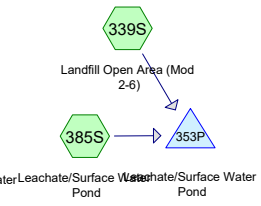
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**5-Year Storm Analysis**

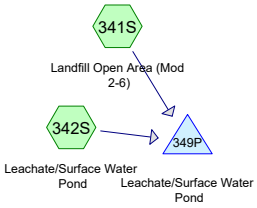
**Phase 0 Filling**



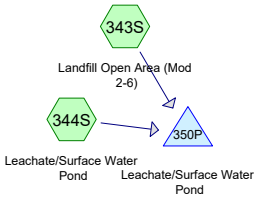

**Phase 1 Filling**



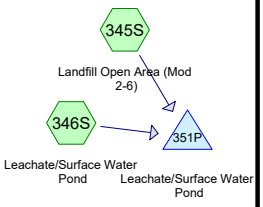

**Phase 2 Filling**

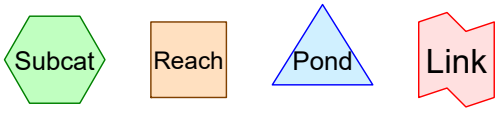



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 339S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=21.73 cfs 2.041 af

**Subcatchment 341S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=21.47 cfs 2.017 af

**Subcatchment 342S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=14.51 cfs 0.781 af

**Subcatchment 343S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=21.31 cfs 2.002 af

**Subcatchment 344S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=14.51 cfs 0.781 af

**Subcatchment 345S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=23.57 cfs 2.214 af

**Subcatchment 346S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=14.51 cfs 0.781 af

**Subcatchment 347S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=20.81 cfs 1.955 af

**Subcatchment 385S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.04 cfs 0.972 af

**Subcatchment 386S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.04 cfs 0.972 af

**Pond 349P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,605 cf Inflow=24.41 cfs 2.798 af
Outflow=0.00 cfs 0.000 af

**Pond 350P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,910 cf Inflow=24.26 cfs 2.784 af
Outflow=0.00 cfs 0.000 af

**Pond 351P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,834 cf Inflow=26.51 cfs 2.995 af
Outflow=0.00 cfs 0.000 af

**Pond 352P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,602 cf Inflow=27.07 cfs 2.927 af
Outflow=0.00 cfs 0.000 af

**Pond 353P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,686 cf Inflow=27.48 cfs 3.013 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 339S: Landfill Open Area (Mod 2-6)

Runoff = 21.73 cfs @ 12.29 hrs, Volume= 2.041 af, Depth= 3.15"
Routed to Pond 353P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 341S: Landfill Open Area (Mod 2-6)

Runoff = 21.47 cfs @ 12.29 hrs, Volume= 2.017 af, Depth= 3.15"
Routed to Pond 349P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 342S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.51 cfs @ 12.04 hrs, Volume= 0.781 af, Depth= 3.15"
Routed to Pond 349P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 343S: Landfill Open Area (Mod 2-6)

Runoff = 21.31 cfs @ 12.29 hrs, Volume= 2.002 af, Depth= 3.15"
Routed to Pond 350P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 344S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.51 cfs @ 12.04 hrs, Volume= 0.781 af, Depth= 3.15"
Routed to Pond 350P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 345S: Landfill Open Area (Mod 2-6)

Runoff = 23.57 cfs @ 12.29 hrs, Volume= 2.214 af, Depth= 3.15"
Routed to Pond 351P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 346S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.51 cfs @ 12.04 hrs, Volume= 0.781 af, Depth= 3.15"
Routed to Pond 351P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 347S: Landfill Open Area (Mod 2-6)

Runoff = 20.81 cfs @ 12.29 hrs, Volume= 1.955 af, Depth= 3.15"
Routed to Pond 352P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 385S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.04 cfs @ 12.04 hrs, Volume= 0.972 af, Depth= 3.15"
Routed to Pond 353P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 386S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.04 cfs @ 12.04 hrs, Volume= 0.972 af, Depth= 3.15"
Routed to Pond 352P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 349P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 24.41 cfs @ 12.27 hrs, Volume= 2.798 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.76' Surf.Area= 47,114 sf Storage= 75,708 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,584 sf Storage= 197,605 cf (121,897 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (121,939 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 350P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 24.26 cfs @ 12.27 hrs, Volume= 2.784 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.78' Surf.Area= 47,272 sf Storage= 76,652 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,608 sf Storage= 197,910 cf (121,257 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (120,995 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 351P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 26.51 cfs @ 12.27 hrs, Volume= 2.995 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.58' Surf.Area= 45,696 sf Storage= 67,355 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,602 sf Storage= 197,834 cf (130,479 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (130,292 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 352P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 27.07 cfs @ 12.05 hrs, Volume= 2.927 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.64' Surf.Area= 46,169 sf Storage= 70,111 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,584 sf Storage= 197,602 cf (127,491 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (127,536 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 353P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 27.48 cfs @ 12.06 hrs, Volume= 3.013 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

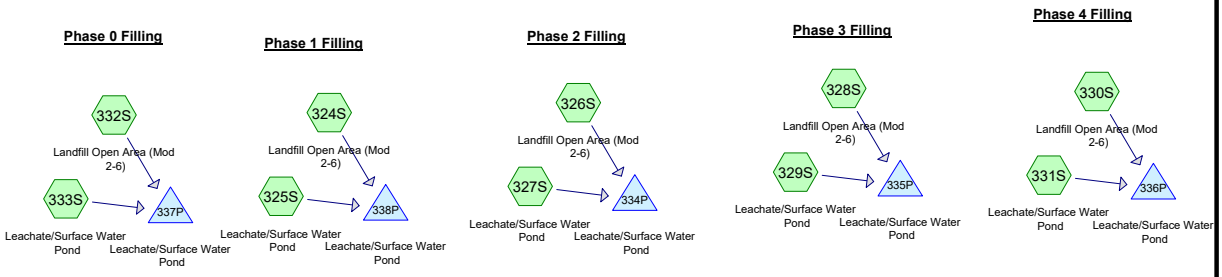
Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.56' Surf.Area= 45,539 sf Storage= 66,443 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,591 sf Storage= 197,686 cf (131,243 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (131,204 cf above start)

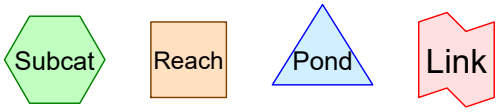
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**10-Year Storm Analysis**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 324S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=25.60 cfs 2.423 af

**Subcatchment 325S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.25 cfs 1.154 af

**Subcatchment 326S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=25.30 cfs 2.394 af

**Subcatchment 327S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=17.09 cfs 0.928 af

**Subcatchment 328S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=25.12 cfs 2.377 af

**Subcatchment 329S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=17.09 cfs 0.928 af

**Subcatchment 330S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=27.77 cfs 2.628 af

**Subcatchment 331S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=17.09 cfs 0.928 af

**Subcatchment 332S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=24.52 cfs 2.320 af

**Subcatchment 333S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.25 cfs 1.154 af

**Pond 334P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,822 cf Inflow=28.77 cfs 3.322 af
Outflow=0.00 cfs 0.000 af

**Pond 335P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,929 cf Inflow=28.58 cfs 3.304 af
Outflow=0.00 cfs 0.000 af

**Pond 336P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,874 cf Inflow=31.24 cfs 3.555 af
Outflow=0.00 cfs 0.000 af

**Pond 337P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,655 cf Inflow=31.91 cfs 3.474 af
Outflow=0.00 cfs 0.000 af

**Pond 338P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,547 cf Inflow=32.39 cfs 3.576 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 324S: Landfill Open Area (Mod 2-6)

Runoff = 25.60 cfs @ 12.29 hrs, Volume= 2.423 af, Depth= 3.74"
Routed to Pond 338P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 325S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.25 cfs @ 12.04 hrs, Volume= 1.154 af, Depth= 3.74"
Routed to Pond 338P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 326S: Landfill Open Area (Mod 2-6)

Runoff = 25.30 cfs @ 12.29 hrs, Volume= 2.394 af, Depth= 3.74"
Routed to Pond 334P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 327S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 17.09 cfs @ 12.04 hrs, Volume= 0.928 af, Depth= 3.74"
Routed to Pond 334P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 328S: Landfill Open Area (Mod 2-6)

Runoff = 25.12 cfs @ 12.29 hrs, Volume= 2.377 af, Depth= 3.74"
Routed to Pond 335P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 329S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 17.09 cfs @ 12.04 hrs, Volume= 0.928 af, Depth= 3.74"
Routed to Pond 335P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 330S: Landfill Open Area (Mod 2-6)

Runoff = 27.77 cfs @ 12.29 hrs, Volume= 2.628 af, Depth= 3.74"
Routed to Pond 336P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 331S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 17.09 cfs @ 12.04 hrs, Volume= 0.928 af, Depth= 3.74"
Routed to Pond 336P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 332S: Landfill Open Area (Mod 2-6)

Runoff = 24.52 cfs @ 12.29 hrs, Volume= 2.320 af, Depth= 3.74"
Routed to Pond 337P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 333S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.25 cfs @ 12.04 hrs, Volume= 1.154 af, Depth= 3.74"
Routed to Pond 337P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 334P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 28.77 cfs @ 12.27 hrs, Volume= 3.322 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.26' Surf.Area= 43,175 sf Storage= 53,136 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,601 sf Storage= 197,822 cf (144,686 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (144,511 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 335P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 28.58 cfs @ 12.27 hrs, Volume= 3.304 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.28' Surf.Area= 43,332 sf Storage= 54,001 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,610 sf Storage= 197,929 cf (143,927 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (143,646 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 336P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 31.24 cfs @ 12.27 hrs, Volume= 3.555 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.02' Surf.Area= 41,284 sf Storage= 43,001 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,605 sf Storage= 197,874 cf (154,873 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (154,646 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 337P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 31.91 cfs @ 12.05 hrs, Volume= 3.474 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.10' Surf.Area= 41,914 sf Storage= 46,329 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,588 sf Storage= 197,655 cf (151,326 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (151,318 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 338P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 32.39 cfs @ 12.06 hrs, Volume= 3.576 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.99' Surf.Area= 40,926 sf Storage= 41,767 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,580 sf Storage= 197,547 cf (155,781 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (155,880 cf above start)

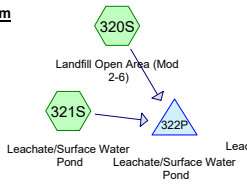
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

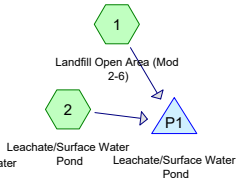
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**25-Year Storm Analysis**

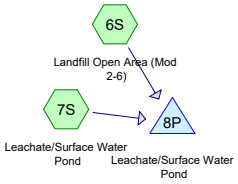
**Phase 0 Filling**



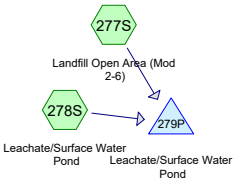

**Phase 1 Filling**



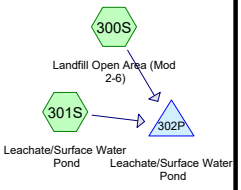

**Phase 2 Filling**

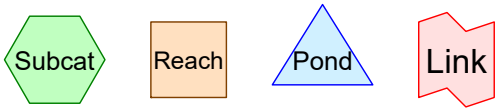



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 1: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.77 cfs 3.031 af

**Subcatchment 2: Leachate/Surface Water** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=26.35 cfs 1.443 af

**Subcatchment 6S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.39 cfs 2.995 af

**Subcatchment 7S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Subcatchment 277S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.16 cfs 2.974 af

**Subcatchment 278S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Subcatchment 300S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=34.46 cfs 3.288 af

**Subcatchment 301S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Subcatchment 320S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=30.43 cfs 2.903 af

**Subcatchment 321S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=26.35 cfs 1.443 af

**Pond 8P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,735 cf Inflow=35.69 cfs 4.156 af
Outflow=0.00 cfs 0.000 af

**Pond 279P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,837 cf Inflow=35.46 cfs 4.134 af
Outflow=0.00 cfs 0.000 af

**Pond 302P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,879 cf Inflow=38.75 cfs 4.448 af
Outflow=0.00 cfs 0.000 af

**Pond 322P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,831 cf Inflow=39.61 cfs 4.347 af
Outflow=0.00 cfs 0.000 af

**Pond P1: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,936 cf Inflow=40.21 cfs 4.474 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 1: Landfill Open Area (Mod 2-6)

Runoff = 31.77 cfs @ 12.28 hrs, Volume= 3.031 af, Depth= 4.67"
Routed to Pond P1 : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 2: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.35 cfs @ 12.04 hrs, Volume= 1.443 af, Depth= 4.67"
Routed to Pond P1 : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 6S: Landfill Open Area (Mod 2-6)

Runoff = 31.39 cfs @ 12.28 hrs, Volume= 2.995 af, Depth= 4.67"
Routed to Pond 8P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 7S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 8P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 277S: Landfill Open Area (Mod 2-6)

Runoff = 31.16 cfs @ 12.28 hrs, Volume= 2.974 af, Depth= 4.67"
Routed to Pond 279P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 278S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 279P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 300S: Landfill Open Area (Mod 2-6)

Runoff = 34.46 cfs @ 12.28 hrs, Volume= 3.288 af, Depth= 4.67"
Routed to Pond 302P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 301S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 302P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 320S: Landfill Open Area (Mod 2-6)

Runoff = 30.43 cfs @ 12.28 hrs, Volume= 2.903 af, Depth= 4.67"
Routed to Pond 322P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 321S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.35 cfs @ 12.04 hrs, Volume= 1.443 af, Depth= 4.67"
Routed to Pond 322P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 8P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 35.69 cfs @ 12.27 hrs, Volume= 4.156 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.24' Surf.Area= 25,898 sf Storage= 16,708 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,594 sf Storage= 197,735 cf (181,027 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (180,939 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 279P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 35.46 cfs @ 12.27 hrs, Volume= 4.134 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.28' Surf.Area= 26,699 sf Storage= 17,760 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,603 sf Storage= 197,837 cf (180,077 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (179,887 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 302P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 38.75 cfs @ 12.27 hrs, Volume= 4.448 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.59' Surf.Area= 12,873 sf Storage= 4,108 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,606 sf Storage= 197,879 cf (193,772 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (193,540 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 322P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 39.61 cfs @ 12.05 hrs, Volume= 4.347 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.87' Surf.Area= 18,484 sf Storage= 8,498 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,602 sf Storage= 197,831 cf (189,333 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (189,150 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond P1: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 40.21 cfs @ 12.06 hrs, Volume= 4.474 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,610 sf Storage= 197,936 cf (194,906 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

# Appendix B1.4

# 2022 Storm Water Management Calculations

**Storm Water Management Calculations**

**Purpose:**
The purpose of the storm water runoff calculations is to demonstrate that the existing storm water sedimentation basin and proposed storm water management features included in the Modules 10 and 11 Plan Modification Request can accommodate and safely convey the runoff from a 25-year, 24-hour storm event during post closure conditions.

Items addressed in these calculations:

- Sedimentation Basin
- Swales
- Culverts
- Diversion Berms
- Downslope Flumes & Energy Dissipaters
- Rock Chutes
- Discharge Aprons

The proposed storm water management conditions are shown on **Figure 1**.

The calculations support the capacity check of the following existing storm water management feature:

| Feature | Purpose | Design Method |
|---|---|---|
| Sedimentation Basin | To safely handle 25-year, 24-hour storm event without overtopping the 100-year, 24-hour emergency spillway. | HydroCAD runoff modeling |
| Swales | Convey storm water runoff from adjacent areas to Culvert C2 and offsite during post construction conditions | HydroCAD runoff modeling and Swale Calculation |
| Culverts | Convey storm water from the final cover perimeter swales during post construction conditions | HydroCAD runoff modeling and HY-8 Culvert Model |
| Diversion Berms | Reduce storm water runoff from long final cover slopes and to divert water to perimeter swales during post construction conditions | HydroCAD runoff modeling and Diversion Berm Calculations |
| Downslope Flumes & Energy Dissipators | Convey storm water from diversion berms down slope to discharge locations during post construction conditions | HydroCAD runoff modeling and Downslope Flume Calculations |
| Rock Chutes | Erosion protection and convey storm water from energy dissipators (Flume 1 and Flume 2) to existing swale during post construction conditions | HydroCAD runoff modeling and Rock Chute Calculation |
| Discharge Aprons | Erosion protection from culvert discharge at culverts | HydroCAD runoff modeling and Riprap Apron Calculation |

**Approach:**
Hydrograph Generation
HydroCAD was used to model the storm water management system and develop the hydrographs

using TR-20 methodologies. The model is designed to simulate the surface runoff response of a watershed to a precipitation event. Input parameters for the model include precipitation depth for the design storm events from NOAA ATLAS 14, contributing drainage areas, runoff curve numbers, and time of concentration.

Swale Sizing
The proposed swales were sized for the 25-year, 24-hour storm event. A spreadsheet based on Manning's equation was used to determine the depth of flow and velocity in the swales based on the swale geometry and peak flow in the swales (as determined by the Hydrograph Generation models).

Culvert Sizing
Culverts were sized for the 25-year, 24-hour storm event using the HY-8 computer model developed by the US Department of Transportation, Federal Highway Administration.

Diversion Berms
Diversion berms were sized for the 25-year, 24-hour storm event using the Manning's Equation to determine the depth of flow and velocity in the swale based on the swale geometry and peak flow for the storm event (as determined by the Hydrograph Generation Calculations).

Downslope Flumes and Energy Dissipaters Sizing
Flumes and energy dissipaters were sized for the 25-year, 24-hour storm event. Manning's equation and the orifice equation were used to size the flumes. Energy dissipaters were sized using tables from the reference book "Hydraulic Design of Energy Dissipaters for Culverts and Channels" US Department of Transportation, Federal Highway Administration, July 2006.

Rock Cute Sizing
Rock chutes were sized for the 25-year, 24-hour storm event. Rock Chutes were sized based on the flow to each culvert location. The Iowa NRCS Rock Chute Design spreadsheet was used to size the chute and riprap.

Discharge Apron Sizing
Riprap aprons were sized for the 25-year, 24-hour storm event using equations in Section 5.2 – Riprap Blanket of WisDOT FDM 13-35-5. The riprap aprons were sized based on the flow to the culvert location. The riprap sizing was used to size the riprap discharge apron.

Basin Sizing
Route the proposed construction and existing drainage runoff through the sedimentation basin to confirm the basin can handle the 25-year, 24-hour storm event. HydroCAD was used to model the runoff flow through the basin outfall (as determined by the Hydrograph Generation model).

**Key Assumptions:**

- Drainage areas and time of concentration flow paths are as shown on **Figure 1** for Post Construction Conditions.
- An MSE4 rainfall distribution was used based on NRCS Wisconsin rainfall distribution regions. The precipitation depth for the 25-year, 24-hour storm was assumed to be 4.91 inches, based on NOAA ATLAS 14 Point Precipitation Frequency Estimates (NOAA's National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server).

- Runoff curve numbers were based on tables presented in Urban Hydrology for Small Watersheds, and were assumed as follows and as listed in the modeling.

| Cover Type | CN |
|---|---|
| Final Cover | 69 – Pasture/grassland/range in good condition, hydrologic soil group (HSG) C/B (assumed mid value between each soil group) |
| Pasture, grassland or range | 39 – Pasture/grassland/range, Good, HSG A |
| Rain Cover | 98 – Rain Cover (plastic smooth material) |
| Pavement | 98 – impervious HSG A |
| Gravel | 96 – Gravel, HSG A |

- Type A soil group for non-disturbed areas outside the landfill as soils are loamy sand.
- Other assumptions are included with the calculations attached to this appendix.

**Results:**

Hydrograph Generation

The hydrograph modeling results for the 25-year and 100-year, 24-hour storm events are included in the Post Construction Conditions Hydrograph Generation section.

Basin Sizing

The existing sedimentation basin has the capacity to safely contain the 25-year, 24-hour storm event and safely pass the 100-year, 24-hour storm event through the emergency spillway. Refer to the Basin Sizing section.

Swale Sizing

The proposed swales will be constructed as shown on the Drawings. The swales have the capacity to safely convey the both the 25-year, 24-hour storm events and maintain a minimum 0.5 foot of freeboard. Refer to the Swale Sizing section.
Appropriate erosion control product was selected based on the velocities and shear stress in the swales. Refer to the Swale Sizing section below for the evaluation.

Culvert Sizing

Culverts will be as shown in the Drawings. The culverts have the capacity to safely convey the 25-year, 24-hour storm event. Refer to the Culvert Sizing Section for the detailed calculations.

Diversion Berm Sizing

The proposed final berms will be constructed as shown on the Drawings. The diversion berms will contain the runoff from the 25-year, 24-hour storm event. Refer to the Diversion Berm Design section.

Downslope Flume and Energy Dissipater Sizing

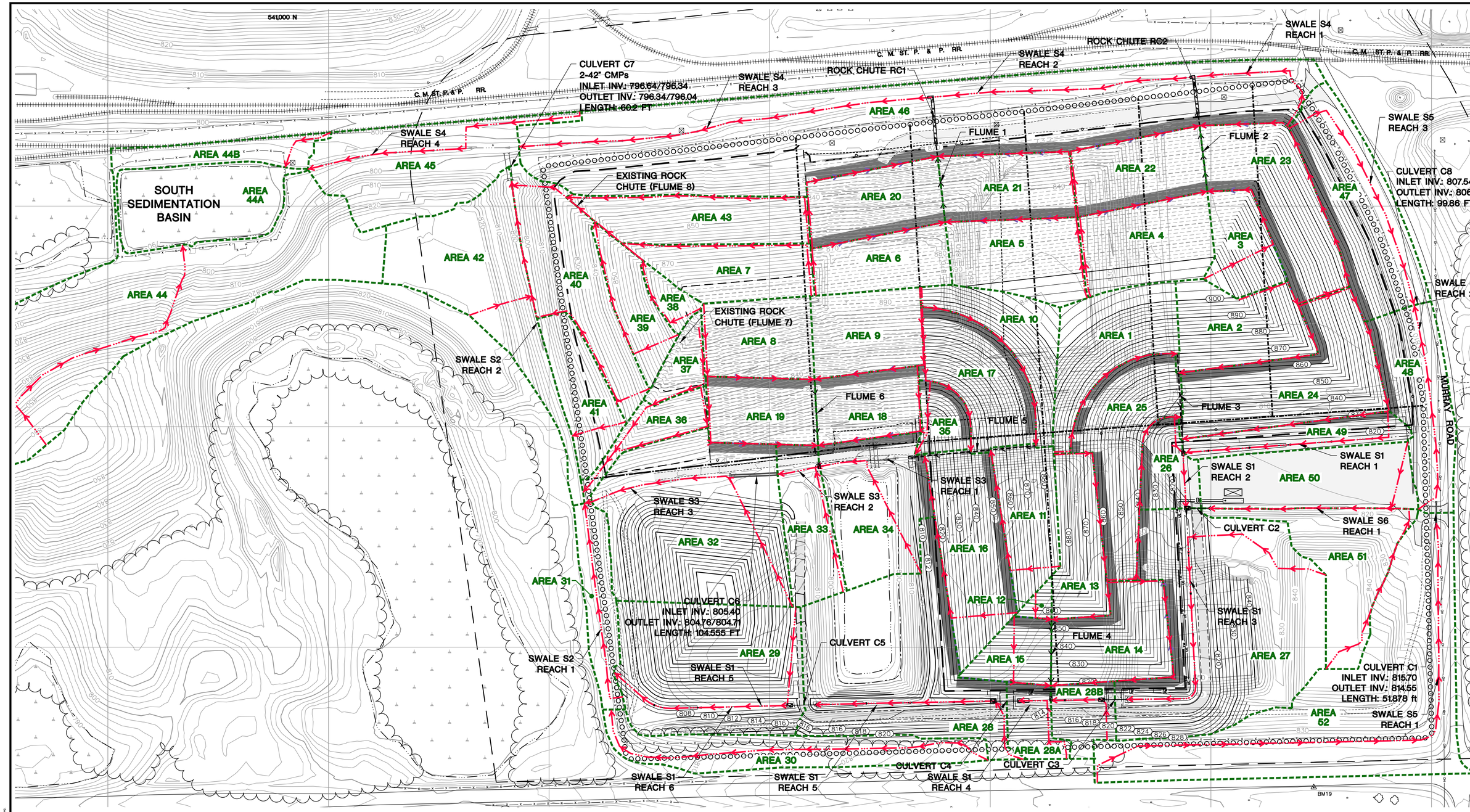
The downslope flumes and energy dissipaters will be constructed as shown on the Drawings. The downslope flumes are designed to contain the runoff from the 25-year, 24-hour storm event. Energy dissipaters at the bottom of the downslope flumes have been designed to handle the peak velocities. Refer to the Downslope Flume and Energy Dissipater Sizing section below for detailed calculations.

Rock Chute Sizing

The proposed rock chutes will be constructed as shown in the Drawings. The rock chutes will accommodate the runoff from the 25-year, 24-hour storm event. Refer to the Rock Chute Sizing section.

Discharge Apron Sizing

The proposed riprap aprons will be constructed as shown in the Drawings. The aprons will accommodate the runoff from the 25-year, 24-hour storm event. Refer to Discharge Apron Sizing for design calculations.




**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- APPROXIMATE INTERMEDIATE COVER LIMITS/AREA
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- FENCE
- 810 EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- 840 PROPOSED PHASE 1 FINAL GRADE (10' INTERVAL)
- PROPOSED PHASE 1 FINAL GRADE (2' INTERVAL)
- 840 PROPOSED GRADE (10' INTERVAL)
- PROPOSED GRADE (2' INTERVAL)
- PROPOSED PERIMETER ROAD
- PROPOSED SWALE
- PROPOSED CULVERT
- PROPOSED LEACHATE COLLECTION SYSTEM CLEANOUT
- PROPOSED LEACHATE VAULT
- FM PROPOSED LEACHATE FORCEMAIN
- UE PROPOSED UNDERGROUND ELECTRIC
- PROPOSED DIVERSION BERM
- PROPOSED DOWNSLOPE FLUME
- PROPOSED ENERGY DISSIPATOR
- PROPOSED RIPRAP
- DRAINAGE AREA DIVIDES
- FLOW PATH

**NOTES:**

1. SEE SHEET 2 OF PLAN OF OPERATION UPDATE (2022) PLAN SET FOR BASE MAP LEGEND ITEMS AND NOTES.
2. SWALE S4 REACHES ARE BETWEEN AREA BOUNDARY AND FLUMES IN AREA 45 AND 46.
3. FINAL SLOPES IN AREAS 27, 29, 32, 33, 34, AND 51 ARE ASSUMED DUE TO THESE AREAS BEING USED FOR STOCKPILES DURING CONSTRUCTION DURING THE LIFE OF THE DRY ASH DISPOSAL FACILITY.

N

100 0 100

SCALE: 1" = 100'

DRAWN BY: KP
CHECKED BY: RJG
APPROVED BY: MRH 05/25/2022

PROJECT NO. 25220183.00
DRAWN: 01/25/2022
REVISED: 05/02/2022

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

Wisconsin Power and Light Company

CLIENT

SCS ENGINEERS
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ENGINEER

PLAN OF OPERATION
2022 UPDATE
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

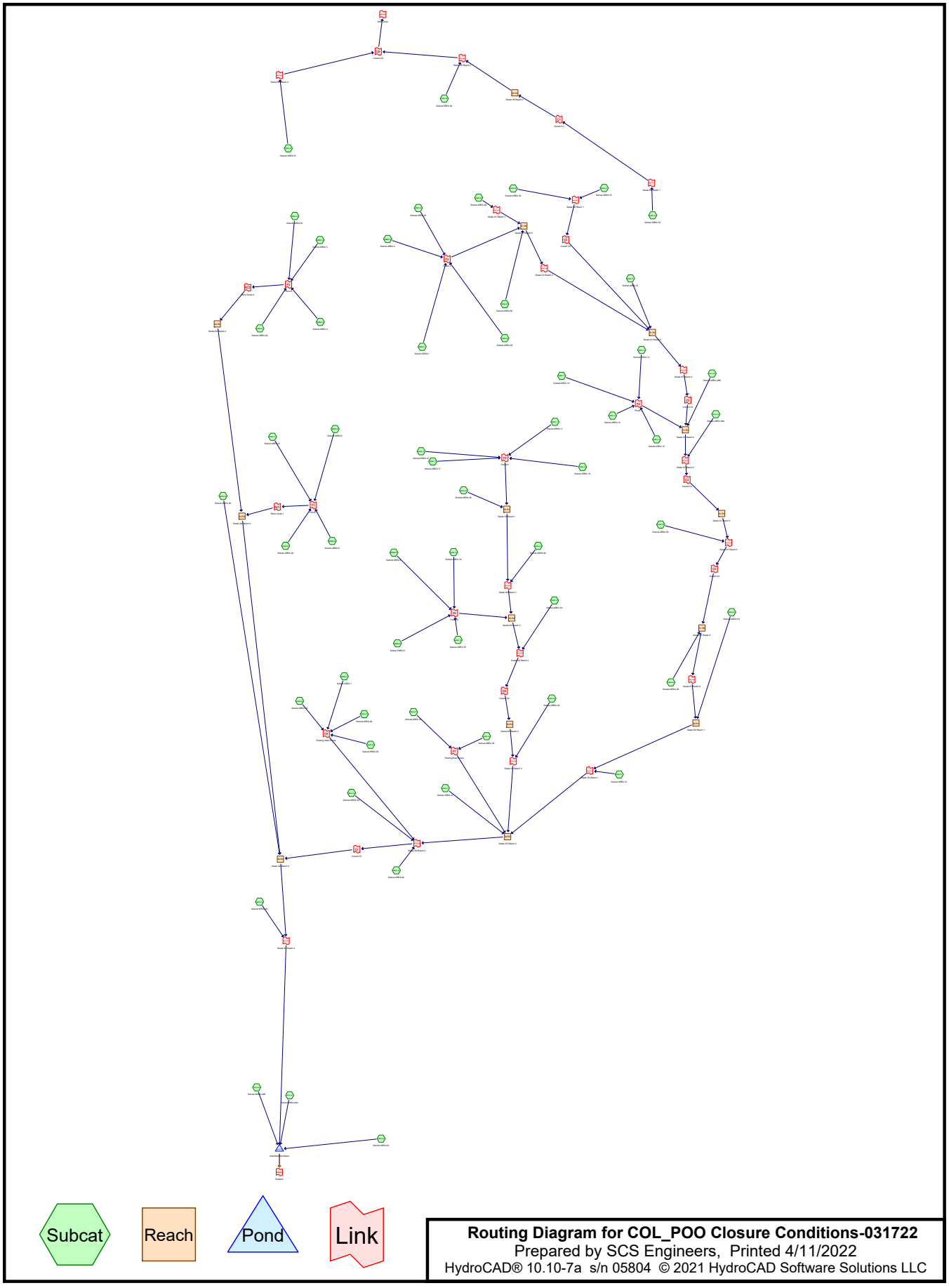
SITE

STORM WATER MODELING

FIGURE
1

Post Construction Conditions Hydrograph Generation

- 25-year, 24-hour Storm Event
- 100-year, 24-hour Storm Event




**Routing Diagram for COL_POO Closure Conditions-031722**
Prepared by SCS Engineers, Printed 4/11/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-40.00 hrs, dt=0.01 hrs, 4001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment AREA 1: Subcat AREA 1** Runoff Area=1.288 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=408' Tc=2.6 min CN=69 Runoff=4.58 cfs 0.203 af

**Subcatchment AREA 10: Subcat AREA 10** Runoff Area=0.914 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=500' Tc=3.2 min CN=69 Runoff=3.17 cfs 0.144 af

**Subcatchment AREA 11: Subcat AREA 11** Runoff Area=0.949 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=391' Tc=4.6 min CN=69 Runoff=3.10 cfs 0.150 af

**Subcatchment AREA 12: Subcat AREA 12** Runoff Area=0.098 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=92' Tc=2.5 min CN=69 Runoff=0.35 cfs 0.015 af

**Subcatchment AREA 13: Subcat AREA 13** Runoff Area=0.890 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=590' Tc=4.6 min CN=69 Runoff=2.91 cfs 0.140 af

**Subcatchment AREA 14: Subcat AREA 14** Runoff Area=1.145 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=625' Tc=5.1 min CN=69 Runoff=3.66 cfs 0.181 af

**Subcatchment AREA 15: Subcat AREA 15** Runoff Area=0.512 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=235' Tc=4.2 min CN=69 Runoff=1.71 cfs 0.081 af

**Subcatchment AREA 16: Subcat AREA 16** Runoff Area=1.510 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=522' Tc=4.9 min CN=69 Runoff=4.89 cfs 0.238 af

**Subcatchment AREA 17: Subcat AREA 17** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=386' Tc=4.7 min CN=69 Runoff=4.00 cfs 0.194 af

**Subcatchment AREA 18: Subcat AREA 18** Runoff Area=0.813 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=383' Tc=4.6 min CN=69 Runoff=2.66 cfs 0.128 af

**Subcatchment AREA 19: Subcat AREA 19** Runoff Area=0.847 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=394' Tc=4.6 min CN=69 Runoff=2.77 cfs 0.134 af

**Subcatchment AREA 2: Subcat AREA 2** Runoff Area=1.167 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=613' Tc=5.1 min CN=69 Runoff=3.73 cfs 0.184 af

**Subcatchment AREA 20: Subcat AREA 20** Runoff Area=1.054 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=453' Tc=4.7 min CN=69 Runoff=3.43 cfs 0.166 af

**Subcatchment AREA 21: Subcat AREA 21** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=448' Tc=4.7 min CN=69 Runoff=3.35 cfs 0.162 af

**Subcatchment AREA 22: Subcat AREA 22** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=448' Tc=4.7 min CN=69 Runoff=3.35 cfs 0.162 af

**Subcatchment AREA 23: Subcat AREA 23** Runoff Area=1.548 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=715' Tc=5.4 min CN=69 Runoff=4.89 cfs 0.244 af

**Subcatchment AREA 24: Subcat AREA 24** Runoff Area=1.952 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=889' Tc=5.8 min CN=69 Runoff=6.05 cfs 0.308 af

**Subcatchment AREA 25: Subcat AREA 25** Runoff Area=1.515 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=495' Tc=3.9 min CN=69 Runoff=5.13 cfs 0.239 af

**Subcatchment AREA 26: Subcat AREA 26** Runoff Area=0.518 ac 0.00% Impervious Runoff Depth=1.74"
Flow Length=216' Tc=4.1 min CN=67 Runoff=1.59 cfs 0.075 af

**Subcatchment AREA 27: Subcat AREA 27** Runoff Area=4.140 ac 0.00% Impervious Runoff Depth=0.55"
Flow Length=864' Tc=12.0 min CN=48 Runoff=1.68 cfs 0.191 af

**Subcatchment AREA 28: Subcat AREA 28** Runoff Area=142,960 sf 0.00% Impervious Runoff Depth=0.66"
Flow Length=573' Tc=9.1 min CN=50 Runoff=2.08 cfs 0.179 af

**Subcatchment AREA 28A: Subcat AREA 28A** Runoff Area=0.423 ac 0.00% Impervious Runoff Depth=0.60"
Flow Length=234' Tc=9.1 min CN=49 Runoff=0.23 cfs 0.021 af

**Subcatchment AREA 28B: Subcat AREA 28B** Runoff Area=0.476 ac 0.00% Impervious Runoff Depth=0.71"
Flow Length=211' Tc=4.5 min CN=51 Runoff=0.47 cfs 0.028 af

**Subcatchment AREA 29: Subcat AREA 29** Runoff Area=2.792 ac 0.00% Impervious Runoff Depth=0.22"
Flow Length=463' Tc=14.8 min CN=40 Runoff=0.16 cfs 0.050 af

**Subcatchment AREA 3: Subcat AREA 3** Runoff Area=0.717 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=409' Tc=6.3 min CN=69 Runoff=2.17 cfs 0.113 af

**Subcatchment AREA 30: Subcat AREA 30** Runoff Area=1.415 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=941' Slope=0.0260 '/' Tc=22.0 min CN=39 Runoff=0.06 cfs 0.021 af

**Subcatchment AREA 31: Subcat AREA 31** Runoff Area=0.698 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=481' Tc=4.4 min CN=39 Runoff=0.03 cfs 0.011 af

**Subcatchment AREA 32: Subcat AREA 32** Runoff Area=3.353 ac 0.00% Impervious Runoff Depth=0.46"
Flow Length=663' Tc=17.3 min CN=46 Runoff=0.81 cfs 0.128 af

**Subcatchment AREA 33: Subcat AREA 33** Runoff Area=38,914 sf 0.00% Impervious Runoff Depth=0.60"
Flow Length=377' Tc=16.0 min CN=49 Runoff=0.37 cfs 0.045 af

**Subcatchment AREA 34: Subcat AREA 34** Runoff Area=68,484 sf 0.00% Impervious Runoff Depth=0.37"
Flow Length=488' Tc=16.2 min CN=44 Runoff=0.25 cfs 0.049 af

**Subcatchment AREA 35: Subcat AREA 35** Runoff Area=0.375 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=174' Slope=0.2500 '/' Tc=4.2 min CN=69 Runoff=1.25 cfs 0.059 af

**Subcatchment AREA 36: Subcat AREA 36** Runoff Area=0.487 ac 0.00% Impervious Runoff Depth=1.82"
Flow Length=425' Tc=4.4 min CN=68 Runoff=1.54 cfs 0.074 af

**Subcatchment AREA 37: Subcat AREA 37** Runoff Area=0.344 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=510' Tc=4.6 min CN=69 Runoff=1.12 cfs 0.054 af

**Subcatchment AREA 38: Subcat AREA 38** Runoff Area=0.223 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=590' Tc=4.1 min CN=69 Runoff=0.75 cfs 0.035 af

**Subcatchment AREA 39: Subcat AREA 39** Runoff Area=0.656 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=642' Tc=5.3 min CN=69 Runoff=2.08 cfs 0.103 af

**Subcatchment AREA 4: Subcat AREA 4** Runoff Area=1.247 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=478' Tc=6.6 min CN=69 Runoff=3.74 cfs 0.197 af

**Subcatchment AREA 40: Subcat AREA 40** Runoff Area=1.618 ac 0.00% Impervious Runoff Depth=1.18"
Flow Length=699' Tc=5.2 min CN=59 Runoff=3.05 cfs 0.160 af

**Subcatchment AREA 41: Subcat AREA 41** Runoff Area=0.826 ac 0.00% Impervious Runoff Depth=1.12"
Flow Length=722' Tc=5.9 min CN=58 Runoff=1.40 cfs 0.077 af

**Subcatchment AREA 42: Subcat AREA 42** Runoff Area=2.177 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=415' Tc=9.1 min CN=39 Runoff=0.09 cfs 0.033 af

**Subcatchment AREA 43: Subcat AREA 43** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=778' Tc=5.9 min CN=69 Runoff=3.79 cfs 0.194 af

**Subcatchment AREA 44: Subcat AREA 44** Runoff Area=5.227 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=701' Tc=7.9 min CN=39 Runoff=0.22 cfs 0.079 af

**Subcatchment AREA 44A: Subcat AREA** Runoff Area=1.508 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=10.70 cfs 0.587 af

**Subcatchment AREA 44B: Subcat AREA 44B** Runoff Area=0.594 ac 0.00% Impervious Runoff Depth=0.66"
Flow Length=147' Slope=0.0544 '/' Tc=7.6 min CN=50 Runoff=0.41 cfs 0.032 af

**Subcatchment AREA 45: Subcat AREA 45** Runoff Area=2.001 ac 0.00% Impervious Runoff Depth=0.33"
Flow Length=681' Tc=21.9 min CN=43 Runoff=0.24 cfs 0.055 af

**Subcatchment AREA 46: Subcat AREA 46** Runoff Area=7.367 ac 0.36% Impervious Runoff Depth=1.18"
Flow Length=1,904' Tc=9.2 min CN=59 Runoff=11.31 cfs 0.727 af

**Subcatchment AREA 47: Subcat AREA 47** Runoff Area=79,132 sf 8.81% Impervious Runoff Depth=1.52"
Flow Length=582' Tc=9.1 min CN=64 Runoff=3.79 cfs 0.230 af

**Subcatchment AREA 48: Subcat AREA 48** Runoff Area=57,540 sf 11.76% Impervious Runoff Depth=1.32"
Flow Length=489' Tc=5.4 min CN=61 Runoff=2.79 cfs 0.145 af

**Subcatchment AREA 49: Subcat AREA 49** Runoff Area=0.691 ac 0.00% Impervious Runoff Depth=1.18"
Flow Length=522' Tc=4.3 min CN=59 Runoff=1.37 cfs 0.068 af

**Subcatchment AREA 5: Subcat AREA 5** Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=482' Tc=6.6 min CN=69 Runoff=3.58 cfs 0.188 af

**Subcatchment AREA 50: Subcat AREA 50** Runoff Area=1.482 ac 0.00% Impervious Runoff Depth=4.00"
Flow Length=570' Tc=3.4 min CN=92 Runoff=9.68 cfs 0.494 af

**Subcatchment AREA 51: Subcat AREA 51** Runoff Area=1.417 ac 0.00% Impervious Runoff Depth=0.22"
Flow Length=884' Tc=12.2 min CN=40 Runoff=0.08 cfs 0.025 af

**Subcatchment AREA 52: Subcat AREA 52** Runoff Area=197,330 sf 13.14% Impervious Runoff Depth=0.51"
Flow Length=1,294' Tc=6.3 min CN=47 Runoff=2.06 cfs 0.191 af

**Subcatchment AREA 6: Subcat AREA 6** Runoff Area=0.892 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=415' Tc=4.6 min CN=69 Runoff=2.92 cfs 0.141 af

**Subcatchment AREA 7: Subcat AREA 7** Runoff Area=1.017 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=833' Tc=5.8 min CN=69 Runoff=3.15 cfs 0.160 af

**Subcatchment AREA 8: Subcat AREA 8** Runoff Area=1.009 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=409' Tc=4.7 min CN=69 Runoff=3.29 cfs 0.159 af

**Subcatchment AREA 9: Subcat AREA 9** Runoff Area=1.047 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=426' Tc=4.8 min CN=69 Runoff=3.40 cfs 0.165 af

**Reach S1 R2: Swale S1 Reach 2** Avg. Flow Depth=0.76' Max Vel=2.58 fps Inflow=22.03 cfs 1.077 af
n=0.030 L=127.0' S=0.0055 '/' Capacity=140.64 cfs Outflow=21.68 cfs 1.077 af

**Reach S1 R3: Swale S1 Reach 3** Avg. Flow Depth=0.88' Max Vel=2.69 fps Inflow=31.44 cfs 1.788 af
n=0.030 L=578.0' S=0.0051 '/' Capacity=135.10 cfs Outflow=27.38 cfs 1.788 af

**Reach S1 R4: Swale S1 Reach 4** Avg. Flow Depth=0.94' Max Vel=3.19 fps Inflow=35.79 cfs 2.233 af
n=0.030 L=195.8' S=0.0066 '/' Capacity=154.36 cfs Outflow=35.20 cfs 2.233 af

**Reach S1 R5: Swale S1 Reach 5** Avg. Flow Depth=0.97' Max Vel=2.89 fps Inflow=35.39 cfs 2.255 af
n=0.030 L=411.6' S=0.0053 '/' Capacity=137.86 cfs Outflow=33.17 cfs 2.255 af

**Reach S1 R6: Swale S1 Reach 6** Avg. Flow Depth=0.97' Max Vel=2.87 fps Inflow=35.21 cfs 2.484 af
n=0.030 L=430.9' S=0.0052 '/' Capacity=136.28 cfs Outflow=33.18 cfs 2.484 af

**Reach S2 R1: Swale S2 Reach 1** Avg. Flow Depth=1.18' Max Vel=1.99 fps Inflow=33.19 cfs 2.506 af
n=0.030 L=472.0' S=0.0020 '/' Capacity=84.99 cfs Outflow=29.93 cfs 2.506 af

**Reach S2 R2: Swale S2 Reach 2** Avg. Flow Depth=0.98' Max Vel=3.41 fps Inflow=48.80 cfs 4.314 af
n=0.030 L=751.0' S=0.0069 '/' Capacity=182.04 cfs Outflow=46.24 cfs 4.314 af

**Reach S3 R1: Swale S3 Reach 1** Avg. Flow Depth=0.63' Max Vel=2.73 fps Inflow=16.31 cfs 0.785 af
n=0.030 L=215.0' S=0.0070 '/' Capacity=125.24 cfs Outflow=15.87 cfs 0.785 af

**Reach S3 R2: Swale S3 Reach 2** Avg. Flow Depth=1.75' Max Vel=3.61 fps Inflow=27.94 cfs 1.419 af
n=0.030 L=97.0' S=0.0070 '/' Capacity=71.57 cfs Outflow=27.78 cfs 1.419 af

**Reach S3 R3: Swale S3 Reach 3** Avg. Flow Depth=0.73' Max Vel=3.34 fps Inflow=27.86 cfs 1.464 af
n=0.030 L=353.0' S=0.0097 '/' Capacity=186.19 cfs Outflow=26.59 cfs 1.464 af

**Reach S4 R2: Swale S4 Reach 2** Avg. Flow Depth=0.46' Max Vel=2.23 fps Inflow=14.04 cfs 0.716 af
n=0.030 L=601.0' S=0.0069 '/' Capacity=174.20 cfs Outflow=11.87 cfs 0.716 af

**Reach S4 R3: Swale S4 Reach 3** Avg. Flow Depth=0.63' Max Vel=2.42 fps Inflow=23.93 cfs 1.374 af
n=0.030 L=946.0' S=0.0056 '/' Capacity=156.53 cfs Outflow=18.66 cfs 1.374 af

**Reach S4 R4: Swale S4 Reach 4** Avg. Flow Depth=1.27' Max Vel=4.35 fps Inflow=81.28 cfs 7.099 af
n=0.030 L=483.0' S=0.0082 '/' Capacity=427.66 cfs Outflow=80.05 cfs 7.099 af

**Reach S5 R2: Swale S5 Reach 2** Inflow=2.06 cfs 0.191 af
Outflow=2.06 cfs 0.191 af

**Pond Sed Pond: Sedimentation Basin** Peak Elev=791.59' Storage=137,326 cf Inflow=82.78 cfs 7.853 af
fs 5.880 af Primary=9.42 cfs 1.973 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=14.75 cfs 7.854 af

**Link C1: Culvert C1** Inflow=2.06 cfs 0.191 af
Primary=2.06 cfs 0.191 af

**Link C2: Culvert C2** Inflow=9.68 cfs 0.520 af
Primary=9.68 cfs 0.520 af

**Link C3: Culvert C3** Inflow=27.38 cfs 1.788 af
Primary=27.38 cfs 1.788 af

**Link C4: Culvert C4** Inflow=35.39 cfs 2.255 af
Primary=35.39 cfs 2.255 af

**Link C5: Culvert C5** Inflow=35.21 cfs 2.434 af
Primary=35.21 cfs 2.434 af

**Link C6: Culvert C6** Inflow=27.86 cfs 1.464 af
Primary=27.86 cfs 1.464 af

**Link C7: Culvert C7** Inflow=52.15 cfs 4.999 af
Primary=52.15 cfs 4.999 af

**Link C8: Culvert C8** Inflow=8.32 cfs 0.566 af
Primary=8.32 cfs 0.566 af

**Link F1: Flume 1** Inflow=13.17 cfs 0.658 af
Primary=13.17 cfs 0.658 af

**Link F2: Flume 2** Inflow=14.04 cfs 0.716 af
Primary=14.04 cfs 0.716 af

**Link F3: Flume 3** Inflow=19.08 cfs 0.934 af
Primary=19.08 cfs 0.934 af

**Link F4: Flume 4** Inflow=8.58 cfs 0.417 af
Primary=8.58 cfs 0.417 af

**Link F5: Flume 5** Inflow=15.06 cfs 0.725 af
Primary=15.06 cfs 0.725 af

**Link F6: Flume 6** Inflow=12.11 cfs 0.586 af
Primary=12.11 cfs 0.586 af

**Link F7: Existing East Flume** Inflow=2.66 cfs 0.128 af
Primary=2.66 cfs 0.128 af

**Link F8: Existing West Flume** Inflow=9.73 cfs 0.492 af
Primary=9.73 cfs 0.492 af

**Link North Area: North Area** Inflow=8.32 cfs 0.566 af
Primary=8.32 cfs 0.566 af

**Link RC1: Rock Chute 1** Inflow=13.17 cfs 0.658 af
Primary=13.17 cfs 0.658 af

**Link RC2: Rock Chute 2** Inflow=14.04 cfs 0.716 af
Primary=14.04 cfs 0.716 af

**Link Swale 1 R6: Swale S1 Reach 6** Inflow=33.18 cfs 2.484 af
Primary=33.18 cfs 2.484 af

**Link Swale S1 R1: Swale S1 Reach 1** Inflow=1.37 cfs 0.068 af
Primary=1.37 cfs 0.068 af

**Link Swale S1 R2: Swale S1 Reach 2** Inflow=21.68 cfs 1.077 af
Primary=21.68 cfs 1.077 af

**Link Swale S1 R3: Swale S1 Reach 3** Inflow=27.38 cfs 1.788 af
Primary=27.38 cfs 1.788 af

**Link Swale S1 R4: Swale S1 Reach 4** Inflow=35.39 cfs 2.255 af
Primary=35.39 cfs 2.255 af

**Link Swale S1 R5: Swale S1 Reach 5** Inflow=35.21 cfs 2.434 af
Primary=35.21 cfs 2.434 af

**Link Swale S2 R1: Swale S2 Reach 1** Inflow=29.95 cfs 2.516 af
Primary=29.95 cfs 2.516 af

**Link Swale S2 R2: Swale S2 Reach 2** Inflow=52.15 cfs 4.999 af
Primary=52.15 cfs 4.999 af

**Link Swale S3 R1: Swale S3 Reach 1** Inflow=15.88 cfs 0.833 af
Primary=15.88 cfs 0.833 af

**Link Swale S3 R2: Swale S3 Reach 2** Inflow=27.86 cfs 1.464 af
Primary=27.86 cfs 1.464 af

**Link Swale S3 R3: Swale S3 Reach 3** Inflow=26.70 cfs 1.592 af
Primary=26.70 cfs 1.592 af

**Link Swale S4 R4: Swale S4 Reach 4** Inflow=80.09 cfs 7.154 af
Primary=80.09 cfs 7.154 af

**Link Swale S5 R1: Swale S5 Reach 1** Inflow=2.06 cfs 0.191 af
Primary=2.06 cfs 0.191 af

**Link Swale S5 R2: Swale S5 Reach 2** Inflow=4.68 cfs 0.336 af
Primary=4.68 cfs 0.336 af

**Link Swale S5 R3: Swale S5 Reach 3** Inflow=3.79 cfs 0.230 af
Primary=3.79 cfs 0.230 af

**Link Swale S6 R1: Swale S6 Reach 1** Inflow=9.68 cfs 0.520 af
Primary=9.68 cfs 0.520 af

**Link Wetland: Wetland** Inflow=9.42 cfs 1.973 af
Primary=9.42 cfs 1.973 af

**Total Runoff Area = 82.060 ac Runoff Volume = 8.419 af Average Runoff Depth = 1.23"**
**97.02% Pervious = 79.615 ac 2.98% Impervious = 2.446 ac**

## Summary for Subcatchment AREA 1: Subcat AREA 1

Runoff = 4.58 cfs @ 12.11 hrs, Volume= 0.203 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.288 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.288 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.7 | 37 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.9 | 371 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.6 | 408 | Total | | | |

## Summary for Subcatchment AREA 10: Subcat AREA 10

Runoff = 3.17 cfs @ 12.11 hrs, Volume= 0.144 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.914 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.1 | 46 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 454 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.2 | 500 | Total | | | |

## Summary for Subcatchment AREA 11: Subcat AREA 11

Runoff = 3.10 cfs @ 12.12 hrs, Volume= 0.150 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.949 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.949 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 277 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 391 | Total | | | |

## Summary for Subcatchment AREA 12: Subcat AREA 12

Runoff = 0.35 cfs @ 12.11 hrs, Volume= 0.015 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.098 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.098 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 36 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.5 | 92 | Total | | | |

## Summary for Subcatchment AREA 13: Subcat AREA 13

Runoff = 2.91 cfs @ 12.12 hrs, Volume= 0.140 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.890 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.890 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.4 | 87 | 0.2500 | 0.42 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.2 | 503 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 590 | Total | | | |

## Summary for Subcatchment AREA 14: Subcat AREA 14

Runoff = 3.66 cfs @ 12.13 hrs, Volume= 0.181 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.145 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.145 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 27 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 498 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 625 | Total | | | |

## Summary for Subcatchment AREA 15: Subcat AREA 15

Runoff = 1.71 cfs @ 12.12 hrs, Volume= 0.081 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.512 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.512 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 85 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.2 | 235 | Total | | | |

## Summary for Subcatchment AREA 16: Subcat AREA 16

Runoff = 4.89 cfs @ 12.13 hrs, Volume= 0.238 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.510 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.510 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 372 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.9 | 522 | Total | | | |

## Summary for Subcatchment AREA 17: Subcat AREA 17

Runoff = 4.00 cfs @ 12.12 hrs, Volume= 0.194 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 63 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 223 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 386 | Total | | | |

## Summary for Subcatchment AREA 18: Subcat AREA 18

Runoff = 2.66 cfs @ 12.12 hrs, Volume= 0.128 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.813 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.813 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 48 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 235 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 383 | Total | | | |

## Summary for Subcatchment AREA 19: Subcat AREA 19

Runoff = 2.77 cfs @ 12.12 hrs, Volume= 0.134 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.847 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.847 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 244 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 394 | Total | | | |

## Summary for Subcatchment AREA 2: Subcat AREA 2

Runoff = 3.73 cfs @ 12.13 hrs, Volume= 0.184 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.167 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.167 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 495 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 613 | Total | | | |

## Summary for Subcatchment AREA 20: Subcat AREA 20

Runoff = 3.43 cfs @ 12.12 hrs, Volume= 0.166 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.054 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.054 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 303 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 453 | Total | | | |

## Summary for Subcatchment AREA 21: Subcat AREA 21

Runoff = 3.35 cfs @ 12.12 hrs, Volume= 0.162 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 22: Subcat AREA 22

Runoff = 3.35 cfs @ 12.12 hrs, Volume= 0.162 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 23: Subcat AREA 23

Runoff = 4.89 cfs @ 12.13 hrs, Volume= 0.244 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.548 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.548 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 591 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 715 | Total | | | |

## Summary for Subcatchment AREA 24: Subcat AREA 24

Runoff = 6.05 cfs @ 12.13 hrs, Volume= 0.308 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.952 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.952 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 765 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.8 | 889 | Total | | | |

## Summary for Subcatchment AREA 25: Subcat AREA 25

Runoff = 5.13 cfs @ 12.12 hrs, Volume= 0.239 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.515 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.515 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.8 | 67 | 0.2500 | 0.40 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 428 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.9 | 495 | Total | | | |

## Summary for Subcatchment AREA 26: Subcat AREA 26

Runoff = 1.59 cfs @ 12.12 hrs, Volume= 0.075 af, Depth= 1.74"
Routed to Reach S1 R2 : Swale S1 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.396 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.072 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.049 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 0.518 | 67 | Weighted Average |
| | 0.518 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 93 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 123 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.1 | 216 | Total | | | |

## Summary for Subcatchment AREA 27: Subcat AREA 27

Runoff = 1.68 cfs @ 12.25 hrs, Volume= 0.191 af, Depth= 0.55"
Routed to Reach S1 R3 : Swale S1 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.651 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 2.758 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.010 | 96 | Gravel surface, HSG A |
| | 0.295 | 96 | Gravel surface, HSG A |
| | 0.426 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 4.140 | 48 | Weighted Average |
| | 4.140 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.3 | 217 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 513 | 0.0051 | 4.23 | 135.28 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 12.0 | 864 | Total | | | |

## Summary for Subcatchment AREA 28: Subcat AREA 28

Runoff = 2.08 cfs @ 12.19 hrs, Volume= 0.179 af, Depth= 0.66"
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 30,267 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 100,859 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 11,834 | 96 | Gravel surface |
| | 142,960 | 50 | Weighted Average |
| | 142,960 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 5.9 | 78 | 0.0526 | 0.22 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 22 | 0.2500 | 0.32 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 23 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.6 | 410 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 573 | Total | | | |

## Summary for Subcatchment AREA 28A: Subcat AREA 28A

Runoff = 0.23 cfs @ 12.20 hrs, Volume= 0.021 af, Depth= 0.60"
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.035 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.257 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.075 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.010 | 96 | Gravel surface, HSG A |
| 0.046 | 96 | Gravel surface, HSG A |
| 0.423 | 49 | Weighted Average |
| 0.423 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 82 | 0.0334 | 0.19 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 34 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 13 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 67 | 0.0069 | 4.92 | 157.36 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 234 | Total | | | |

## Summary for Subcatchment AREA 28B: Subcat AREA 28B

Runoff = 0.47 cfs @ 12.13 hrs, Volume= 0.028 af, Depth= 0.71"
Routed to Reach S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.050 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.110 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.240 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.009 | 96 | Gravel surface, HSG A |
| 0.067 | 96 | Gravel surface, HSG A |
| 0.476 | 51 | Weighted Average |
| 0.476 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 58 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.6 | 20 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 115 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.5 | 211 | Total | | | |

## Summary for Subcatchment AREA 29: Subcat AREA 29

Runoff = 0.16 cfs @ 12.58 hrs, Volume= 0.050 af, Depth= 0.22"
Routed to Reach S1 R6 : Swale S1 Reach 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.056 | 96 | Gravel surface, HSG A |
| | 2.735 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Gravel surface |
| | 2.792 | 40 | Weighted Average |
| | 2.792 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 11.8 | 100 | 0.0150 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 100 | 0.0150 | 0.86 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 247 | 0.0052 | 4.27 | 136.60 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 5** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 14.8 | 463 | Total | | | |

## Summary for Subcatchment AREA 3: Subcat AREA 3

Runoff = 2.17 cfs @ 12.14 hrs, Volume= 0.113 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.717 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.717 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.9 | 44 | 0.1000 | 0.26 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 233 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 409 | Total | | | |

## Summary for Subcatchment AREA 30: Subcat AREA 30

Runoff = 0.06 cfs @ 13.18 hrs, Volume= 0.021 af, Depth= 0.18"
Routed to Reach S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.415 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.415 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 9.5 | 100 | 0.0260 | 0.18 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 194 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 9.6 | 647 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 22.0 | 941 | Total | | | |

## Summary for Subcatchment AREA 31: Subcat AREA 31

Runoff = 0.03 cfs @ 12.44 hrs, Volume= 0.011 af, Depth= 0.18"
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.698 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.698 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.8 | 447 | 0.0020 | 2.65 | 84.72 | **Trap/Vee/Rect Channel Flow, Swale 2 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.4 | 481 | Total | | | |

## Summary for Subcatchment AREA 32: Subcat AREA 32

Runoff = 0.81 cfs @ 12.38 hrs, Volume= 0.128 af, Depth= 0.46"
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.567 | 69 | Pasture/grassland/range, Fair, HSG B |
| 2.413 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.099 | 96 | Gravel surface, HSG A |
| 0.274 | 39 | Pasture/grassland/range, Good, HSG A |
| 3.353 | 46 | Weighted Average |
| 3.353 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.2 | 211 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 23 | 0.1740 | 2.92 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 329 | 0.0097 | 5.83 | 186.57 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 17.3 | 663 | Total | | | |

## Summary for Subcatchment AREA 33: Subcat AREA 33

Runoff = 0.37 cfs @ 12.32 hrs, Volume= 0.045 af, Depth= 0.60"
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 4,079 | 96 | Gravel surface, HSG A |
| | 1,422 | 96 | Gravel surface, HSG A |
| | 30,707 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 2,706 | 69 | Pasture/grassland/range, Fair, HSG A |
| | 38,914 | 49 | Weighted Average |
| | 38,914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.6 | 178 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.0 | 12 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 87 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 2** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.0 | 377 | Total | | | |

## Summary for Subcatchment AREA 34: Subcat AREA 34

Runoff = 0.25 cfs @ 12.43 hrs, Volume= 0.049 af, Depth= 0.37"
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 5,695 | 69 | Pasture/grassland/range, Fair, HSG B |
| 3,470 | 96 | Gravel surface, HSG A |
| 59,319 | 39 | Pasture/grassland/range, Good, HSG A |
| 68,484 | 44 | Weighted Average |
| 68,484 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 170 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 15 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 203 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 1** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.2 | 488 | Total | | | |

## Summary for Subcatchment AREA 35: Subcat AREA 35

Runoff = 1.25 cfs @ 12.12 hrs, Volume= 0.059 af, Depth= 1.89"
Routed to Reach S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.375 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.375 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 74 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 4.2 | 174 | Total | | | |

## Summary for Subcatchment AREA 36: Subcat AREA 36

Runoff = 1.54 cfs @ 12.12 hrs, Volume= 0.074 af, Depth= 1.82"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.470 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.016 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 0.487 | 68 | Weighted Average |
| | 0.487 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 90 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.7 | 201 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 134 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.4 | 425 | Total | | | |

## Summary for Subcatchment AREA 37: Subcat AREA 37

Runoff = 1.12 cfs @ 12.12 hrs, Volume= 0.054 af, Depth= 1.89"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.344 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.344 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 30 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 126 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 254 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.6 | 510 | Total | | | |

## Summary for Subcatchment AREA 38: Subcat AREA 38

Runoff = 0.75 cfs @ 12.12 hrs, Volume= 0.035 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.223 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.223 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 156 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.5 | 357 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.1 | 590 | Total | | | |

## Summary for Subcatchment AREA 39: Subcat AREA 39

Runoff = 2.08 cfs @ 12.13 hrs, Volume= 0.103 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.656 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.656 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 314 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 217 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.3 | 642 | Total | | | |

## Summary for Subcatchment AREA 4: Subcat AREA 4

Runoff = 3.74 cfs @ 12.14 hrs, Volume= 0.197 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.247 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.247 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 57 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 83 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 295 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 478 | Total | | | |

## Summary for Subcatchment AREA 40: Subcat AREA 40

Runoff = 3.05 cfs @ 12.13 hrs, Volume= 0.160 af, Depth= 1.18"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 1.079 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.539 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 1.618 | 59 | Weighted Average |
| | 1.618 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.8 | 237 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 70 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 315 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.2 | 699 | Total | | | |

## Summary for Subcatchment AREA 41: Subcat AREA 41

Runoff = 1.40 cfs @ 12.14 hrs, Volume= 0.077 af, Depth= 1.12"
Routed to Reach S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.520 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.306 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.826 | 58 | Weighted Average |
| 0.826 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 26 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 596 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.9 | 722 | Total | | | |

## Summary for Subcatchment AREA 42: Subcat AREA 42

Runoff = 0.09 cfs @ 12.55 hrs, Volume= 0.033 af, Depth= 0.18"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 2.177 | 39 | Pasture/grassland/range, Good, HSG A |
| 2.177 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 6.4 | 66 | 0.0303 | 0.17 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 49 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 266 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 415 | Total | | | |

## Summary for Subcatchment AREA 43: Subcat AREA 43

Runoff = 3.79 cfs @ 12.14 hrs, Volume= 0.194 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 6 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 541 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 131 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.9 | 778 | Total | | | |

## Summary for Subcatchment AREA 44: Subcat AREA 44

Runoff = 0.22 cfs @ 12.54 hrs, Volume= 0.079 af, Depth= 0.18"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 5.227 | 39 | Pasture/grassland/range, Good, HSG A |
| 5.227 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 4.5 | 75 | 0.0933 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.3 | 25 | 0.2500 | 0.33 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 10 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 381 | 0.0265 | 7.85 | 109.92 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=14.00' n= 0.030 Earth, grassed & winding |
| 0.8 | 162 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.5 | 48 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.9 | 701 | Total | | | |

## Summary for Subcatchment AREA 44A: Subcat AREA 44A

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.70 cfs @ 12.09 hrs, Volume= 0.587 af, Depth= 4.67"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.508 | 98 | Water Surface, HSG A |
| 1.508 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment AREA 44B: Subcat AREA 44B

Runoff = 0.41 cfs @ 12.17 hrs, Volume= 0.032 af, Depth= 0.66"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.479 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.115 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| | 0.594 | 50 | Weighted Average |
| | 0.594 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.1 | 100 | 0.0544 | 0.24 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 47 | 0.0544 | 1.63 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.6 | 147 | Total | | | |

## Summary for Subcatchment AREA 45: Subcat AREA 45

Runoff = 0.24 cfs @ 12.57 hrs, Volume= 0.055 af, Depth= 0.33"
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 0.000 | 0 | , HSG A |
| | 1.870 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.000 | 96 | Gravel surface, HSG A |
| | 0.130 | 96 | Gravel surface, HSG A |
| | 2.001 | 43 | Weighted Average |
| | 2.001 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 15.7 | 100 | 0.0074 | 0.11 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.7 | 169 | 0.0074 | 0.60 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 49 | 0.0800 | 1.98 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 363 | 0.0082 | 5.42 | 162.67 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 21.9 | 681 | Total | | | |

## Summary for Subcatchment AREA 46: Subcat AREA 46

Runoff = 11.31 cfs @ 12.18 hrs, Volume= 0.727 af, Depth= 1.18"
Routed to Reach S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 3.081 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.590 | 96 | Gravel surface, HSG B |
| | 3.264 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.017 | 98 | Paved parking, HSG A |
| | 0.009 | 98 | Paved parking, HSG A |
| | 0.378 | 96 | Gravel surface, HSG A |
| | 0.001 | 96 | Gravel surface, HSG A |
| | 0.026 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 7.367 | 59 | Weighted Average |
| | 7.340 | | 99.64% Pervious Area |
| | 0.027 | | 0.36% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.2 | 51 | 0.2500 | 0.38 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 16 | 0.2500 | 2.44 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.9 | 31 | 0.0050 | 0.58 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0650 | 1.78 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 5.6 | 1,759 | 0.0073 | 5.26 | 178.68 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 1** Bot.W=10.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.2 | 1,904 | Total | | | |

## Summary for Subcatchment AREA 47: Subcat AREA 47

Runoff = 3.79 cfs @ 12.17 hrs, Volume= 0.230 af, Depth= 1.52"
Routed to Link Swale S5 R3 : Swale S5 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 49,617 | 69 | Pasture/grassland/range, Fair, HSG B |
| 6,971 | 98 | Paved parking, HSG A |
| 1,619 | 96 | Gravel surface, HSG A |
| 20,925 | 39 | Pasture/grassland/range, Good, HSG A |
| 79,132 | 64 | Weighted Average |
| 72,161 | | 91.19% Pervious Area |
| 6,971 | | 8.81% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.1111 | 1.63 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.7 | 12 | 0.2500 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 28 | 0.0393 | 0.16 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 488 | 0.0024 | 2.40 | 52.81 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 3** Bot.W=0.00' D=2.00' Z= 5.0 & 6.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 582 | Total | | | |

## Summary for Subcatchment AREA 48: Subcat AREA 48

Runoff = 2.79 cfs @ 12.13 hrs, Volume= 0.145 af, Depth= 1.32"
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 24,597 | 69 | Pasture/grassland/range, Fair, HSG B |
| 24,117 | 39 | Pasture/grassland/range, Good, HSG A |
| 2,057 | 96 | Gravel surface, HSG A |
| 6,769 | 98 | Paved parking, HSG A |
| 57,540 | 61 | Weighted Average |
| 50,771 | | 88.24% Pervious Area |
| 6,769 | | 11.76% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 19 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.7 | 29 | 0.1667 | 0.29 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.1 | 441 | 0.0024 | 2.38 | 40.39 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 2** Bot.W=0.00' D=2.00' Z= 2.5 & 6.0 '/' Top.W=17.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 489 | Total | | | |

## Summary for Subcatchment AREA 49: Subcat AREA 49

Runoff = 1.37 cfs @ 12.12 hrs, Volume= 0.068 af, Depth= 1.18"
Routed to Link Swale S1 R1 : Swale S1 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.439 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.246 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.006 | 96 | Gravel surface, HSG A |
| 0.691 | 59 | Weighted Average |
| 0.691 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 59 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.8 | 463 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |

4.3 522 Total

## Summary for Subcatchment AREA 5: Subcat AREA 5

Runoff = 3.58 cfs @ 12.14 hrs, Volume= 0.188 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.195 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.195 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 59 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 41 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 85 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 297 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 482 | Total | | | |

## Summary for Subcatchment AREA 50: Subcat AREA 50

Runoff = 9.68 cfs @ 12.11 hrs, Volume= 0.494 af, Depth= 4.00"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.100 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.001 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.382 | 96 | Gravel surface, HSG A |
| 1.482 | 92 | Weighted Average |
| 1.482 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 100 | 0.0119 | 1.04 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0119 | 1.76 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.0 | 10 | 0.5000 | 4.95 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.4 | 413 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 3.4 | 570 | Total | | | |

## Summary for Subcatchment AREA 51: Subcat AREA 51

Runoff = 0.08 cfs @ 12.54 hrs, Volume= 0.025 af, Depth= 0.22"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.396 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.020 | 96 | Gravel surface, HSG A |
| 1.417 | 40 | Weighted Average |
| 1.417 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.2 | 302 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 53 | 0.0313 | 2.85 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 1.4 | 429 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 12.2 | 884 | Total | | | |

## Summary for Subcatchment AREA 52: Subcat AREA 52

Runoff = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Depth= 0.51"
Routed to Link Swale S5 R1 : Swale S5 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 169,213 | 39 | Pasture/grassland/range, Good, HSG A |
| 25,933 | 98 | Paved parking, HSG A |
| 2,184 | 96 | Gravel surface, HSG A |
| 197,330 | 47 | Weighted Average |
| 171,397 | | 86.86% Pervious Area |
| 25,933 | | 13.14% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 18 | 0.0050 | 0.52 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.4 | 21 | 0.1333 | 0.25 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.3 | 1,255 | 0.0096 | 4.82 | 125.20 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 1** Bot.W=0.00' D=2.00' Z= 6.0 & 7.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 1,294 | Total | | | |

## Summary for Subcatchment AREA 6: Subcat AREA 6

Runoff = 2.92 cfs @ 12.12 hrs, Volume= 0.141 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.892 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.892 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 7 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 308 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 415 | Total | | | |

## Summary for Subcatchment AREA 7: Subcat AREA 7

Runoff = 3.15 cfs @ 12.13 hrs, Volume= 0.160 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.017 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.017 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 419 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.4 | 296 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow,** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.8 | 833 | Total | | | |

## Summary for Subcatchment AREA 8: Subcat AREA 8

Runoff = 3.29 cfs @ 12.12 hrs, Volume= 0.159 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.009 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.009 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 66 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 243 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 409 | Total | | | |

## Summary for Subcatchment AREA 9: Subcat AREA 9

Runoff = 3.40 cfs @ 12.13 hrs, Volume= 0.165 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.047 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.047 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 250 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.8 | 426 | Total | | | |

## Summary for Reach S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 1.81" for 25-yr, 24-hr event
Inflow = 22.03 cfs @ 12.12 hrs, Volume= 1.077 af
Outflow = 21.68 cfs @ 12.13 hrs, Volume= 1.077 af, Atten= 2%, Lag= 0.5 min
Routed to Link Swale S1 R2 : Swale S1 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.58 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 0.69 fps, Avg. Travel Time= 3.1 min

Peak Storage= 1,066 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.76' , Surface Width= 14.08'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 140.64 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 127.0' Slope= 0.0055 '/'
Inlet Invert= 814.81', Outlet Invert= 814.11'

‡

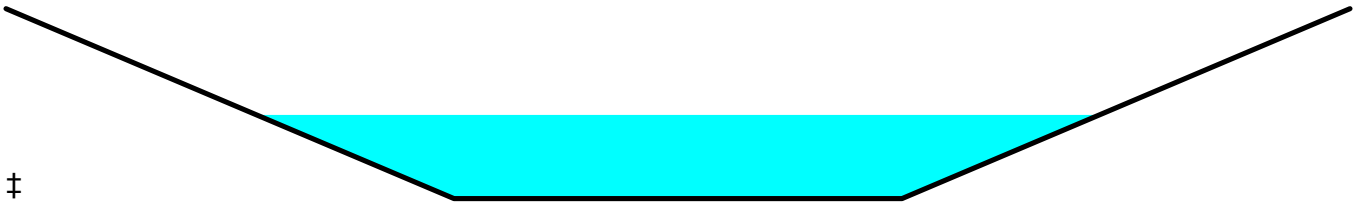
## Summary for Reach S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 1.51" for 25-yr, 24-hr event
Inflow = 31.44 cfs @ 12.12 hrs, Volume= 1.788 af
Outflow = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af, Atten= 13%, Lag= 1.6 min
Routed to Link Swale S1 R3 : Swale S1 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.69 fps, Min. Travel Time= 3.6 min
Avg. Velocity = 0.61 fps, Avg. Travel Time= 15.9 min

Peak Storage= 5,875 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.88' , Surface Width= 15.05'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 135.10 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 578.0' Slope= 0.0051 '/'
Inlet Invert= 814.11', Outlet Invert= 811.17'



‡

## Summary for Reach S1 R4: Swale S1 Reach 4

Inflow Area = 17.292 ac, 0.00% Impervious, Inflow Depth = 1.55" for 25-yr, 24-hr event
Inflow = 35.79 cfs @ 12.14 hrs, Volume= 2.233 af
Outflow = 35.20 cfs @ 12.15 hrs, Volume= 2.233 af, Atten= 2%, Lag= 0.7 min
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.19 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 0.70 fps, Avg. Travel Time= 4.6 min

Peak Storage= 2,163 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.94' , Surface Width= 15.52'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 154.36 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 195.8' Slope= 0.0066 '/'
Inlet Invert= 811.17', Outlet Invert= 809.87'

‡

## Summary for Reach S1 R5: Swale S1 Reach 5

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af
Outflow = 33.17 cfs @ 12.18 hrs, Volume= 2.255 af, Atten= 6%, Lag= 1.6 min
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.89 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 0.64 fps, Avg. Travel Time= 10.7 min

Peak Storage= 4,722 cf @ 12.18 hrs
Average Depth at Peak Storage= 0.97' , Surface Width= 15.73'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 137.86 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 411.6' Slope= 0.0053 '/'
Inlet Invert= 809.77', Outlet Invert= 807.59'

‡

## Summary for Reach S1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 1.25" for 25-yr, 24-hr event
Inflow = 35.21 cfs @ 12.18 hrs, Volume= 2.484 af
Outflow = 33.18 cfs @ 12.21 hrs, Volume= 2.484 af, Atten= 6%, Lag= 1.8 min
Routed to Link Swale 1 R6 : Swale S1 Reach 6

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.87 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 0.65 fps, Avg. Travel Time= 11.0 min

Peak Storage= 4,986 cf @ 12.21 hrs
Average Depth at Peak Storage= 0.97' , Surface Width= 15.78'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 136.28 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 430.9' Slope= 0.0052 '/'
Inlet Invert= 807.15', Outlet Invert= 804.92'

‡

## Summary for Reach S2 R1: Swale S2 Reach 1

Inflow Area = 25.203 ac, 0.00% Impervious, Inflow Depth = 1.19" for 25-yr, 24-hr event
Inflow = 33.19 cfs @ 12.21 hrs, Volume= 2.506 af
Outflow = 29.93 cfs @ 12.26 hrs, Volume= 2.506 af, Atten= 10%, Lag= 3.0 min
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.99 fps, Min. Travel Time= 4.0 min
Avg. Velocity = 0.45 fps, Avg. Travel Time= 17.6 min

Peak Storage= 7,099 cf @ 12.26 hrs
Average Depth at Peak Storage= 1.18' , Surface Width= 17.45'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 84.99 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 472.0' Slope= 0.0020 '/'
Inlet Invert= 802.25', Outlet Invert= 801.30'

‡

## Summary for Reach S2 R2: Swale S2 Reach 2

Inflow Area = 42.068 ac, 0.00% Impervious, Inflow Depth = 1.23" for 25-yr, 24-hr event
Inflow = 48.80 cfs @ 12.18 hrs, Volume= 4.314 af
Outflow = 46.24 cfs @ 12.25 hrs, Volume= 4.314 af, Atten= 5%, Lag= 4.2 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.41 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 0.75 fps, Avg. Travel Time= 16.7 min

Peak Storage= 10,190 cf @ 12.25 hrs
Average Depth at Peak Storage= 0.98' , Surface Width= 17.81'
Bank-Full Depth= 2.00' Flow Area= 36.0 sf, Capacity= 182.04 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 26.00'
Length= 751.0' Slope= 0.0069 '/'
Inlet Invert= 801.30', Outlet Invert= 796.10'

‡

## Summary for Reach S3 R1: Swale S3 Reach 1

Inflow Area = 4.976 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 16.31 cfs @ 12.12 hrs, Volume= 0.785 af
Outflow = 15.87 cfs @ 12.13 hrs, Volume= 0.785 af, Atten= 3%, Lag= 0.7 min
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.73 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 0.67 fps, Avg. Travel Time= 5.4 min

Peak Storage= 1,248 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 10.51'
Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 125.24 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 215.0' Slope= 0.0070 '/'
Inlet Invert= 807.58', Outlet Invert= 806.08'

‡

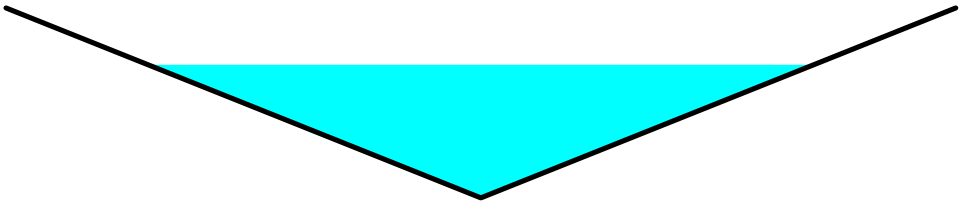
## Summary for Reach S3 R2: Swale S3 Reach 2

Inflow Area = 10.265 ac, 0.00% Impervious, Inflow Depth = 1.66" for 25-yr, 24-hr event
Inflow = 27.94 cfs @ 12.13 hrs, Volume= 1.419 af
Outflow = 27.78 cfs @ 12.13 hrs, Volume= 1.419 af, Atten= 1%, Lag= 0.3 min
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.61 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.31 fps, Avg. Travel Time= 1.2 min

Peak Storage= 745 cf @ 12.13 hrs
Average Depth at Peak Storage= 1.75' , Surface Width= 8.77'
Bank-Full Depth= 2.50' Flow Area= 15.6 sf, Capacity= 71.57 cfs

0.00' x 2.50' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.5 '/' Top Width= 12.50'
Length= 97.0' Slope= 0.0070 '/'
Inlet Invert= 806.08', Outlet Invert= 805.40'



## Summary for Reach S3 R3: Swale S3 Reach 3

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-yr, 24-hr event
Inflow = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af
Outflow = 26.59 cfs @ 12.15 hrs, Volume= 1.464 af, Atten= 5%, Lag= 1.0 min
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.34 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.88 fps, Avg. Travel Time= 6.7 min

Peak Storage= 2,810 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.73' , Surface Width= 13.83'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 186.19 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 353.0' Slope= 0.0097 '/'
Inlet Invert= 804.71', Outlet Invert= 801.30'

‡

## Summary for Reach S4 R2: Swale S4 Reach 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af
Outflow = 11.87 cfs @ 12.17 hrs, Volume= 0.716 af, Atten= 15%, Lag= 2.1 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.23 fps, Min. Travel Time= 4.5 min
Avg. Velocity = 0.55 fps, Avg. Travel Time= 18.3 min

Peak Storage= 3,193 cf @ 12.17 hrs
Average Depth at Peak Storage= 0.46' , Surface Width= 13.21'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 174.20 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 3.0 '/' Top Width= 24.00'
Length= 601.0' Slope= 0.0069 '/'
Inlet Invert= 806.43', Outlet Invert= 802.26'

‡

## Summary for Reach S4 R3: Swale S4 Reach 3

[62] Hint: Exceeded Reach S4 R2 OUTLET depth by 0.23' @ 12.28 hrs

Inflow Area = 8.711 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 23.93 cfs @ 12.14 hrs, Volume= 1.374 af
Outflow = 18.66 cfs @ 12.20 hrs, Volume= 1.374 af, Atten= 22%, Lag= 3.4 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.42 fps, Min. Travel Time= 6.5 min
Avg. Velocity = 0.57 fps, Avg. Travel Time= 27.9 min

Peak Storage= 7,289 cf @ 12.20 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 14.42'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 156.53 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 24.00'
Length= 946.0' Slope= 0.0056 '/'
Inlet Invert= 802.26', Outlet Invert= 796.96'

‡

## Summary for Reach S4 R4: Swale S4 Reach 4

[62] Hint: Exceeded Reach S4 R3 OUTLET depth by 0.67' @ 12.27 hrs

Inflow Area = 65.063 ac, 0.04% Impervious, Inflow Depth = 1.31" for 25-yr, 24-hr event
Inflow = 81.28 cfs @ 12.20 hrs, Volume= 7.099 af
Outflow = 80.05 cfs @ 12.23 hrs, Volume= 7.099 af, Atten= 2%, Lag= 1.7 min
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.35 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 0.97 fps, Avg. Travel Time= 8.3 min

Peak Storage= 8,890 cf @ 12.23 hrs
Average Depth at Peak Storage= 1.27' , Surface Width= 18.91'
Bank-Full Depth= 3.00' Flow Area= 61.5 sf, Capacity= 427.66 cfs

10.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 31.00'
Length= 483.0' Slope= 0.0082 '/'
Inlet Invert= 796.96', Outlet Invert= 793.00'

‡

## Summary for Reach S5 R2: Swale S5 Reach 2

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 0.51" for 25-yr, 24-hr event
Inflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af
Outflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Pond Sed Pond: Sedimentation Basin

[87] Warning: Oscillations may require smaller dt or Finer Routing (severity=42)

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 1.27" for 25-yr, 24-hr event
Inflow = 82.78 cfs @ 12.23 hrs, Volume= 7.853 af
Outflow = 14.75 cfs @ 13.29 hrs, Volume= 7.854 af, Atten= 82%, Lag= 64.1 min
Discarded = 5.33 cfs @ 13.29 hrs, Volume= 5.880 af
Primary = 9.42 cfs @ 13.29 hrs, Volume= 1.973 af
Routed to Link Wetland : Wetland
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link Wetland : Wetland
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link Wetland : Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Peak Elev= 791.59' @ 13.29 hrs Surf.Area= 63,986 sf Storage= 137,326 cf
Flood Elev= 794.00' Surf.Area= 75,797 sf Storage= 304,443 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 184.8 min ( 1,043.0 - 858.2 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 789.00' | 304,443 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 789.00 | 27,325 | 0 | 0 |
| 790.00 | 55,972 | 41,649 | 41,649 |
| 791.00 | 61,532 | 58,752 | 100,401 |
| 792.00 | 65,703 | 63,618 | 164,018 |
| 793.00 | 69,675 | 67,689 | 231,707 |
| 794.00 | 75,797 | 72,736 | 304,443 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 787.70' | **15.0" Round Culvert**<br>L= 40.0' RCP, mitered to conform to fill, Ke= 0.700<br>Inlet / Outlet Invert= 787.70' / 787.50' S= 0.0050 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 1.23 sf |
| #2 | Device 1 | 791.00' | **30.0" Horiz. Orifice/Grate** C= 0.600<br>Limited to weir flow at low heads |
| #3 | Device 1 | 790.50' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #4 | Device 1 | 790.00' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #5 | Device 1 | 789.00' | **0.5" Vert. Orifice/Grate X 14.00 columns**<br>X 6 rows with 6.0" cc spacing C= 0.600<br>Limited to weir flow at low heads |
| #6 | Secondary | 792.50' | **20.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #7 | Tertiary | 793.00' | **158.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #8 | Discarded | 789.00' | **3.600 in/hr Exfiltration over Surface area** |

**Discarded OutFlow** Max=5.33 cfs @ 13.29 hrs HW=791.59' (Free Discharge)
└**8=Exfiltration** (Exfiltration Controls 5.33 cfs)

**Primary OutFlow** Max=9.42 cfs @ 13.29 hrs HW=791.59' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 9.42 cfs @ 7.67 fps)
  ├**2=Orifice/Grate** (Passes < 11.59 cfs potential flow)
  ├**3=Orifice/Grate** (Passes < 0.07 cfs potential flow)
  ├**4=Orifice/Grate** (Passes < 0.08 cfs potential flow)
  └**5=Orifice/Grate** (Passes < 0.58 cfs potential flow)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=789.00' TW=0.00' (Dynamic Tailwater)
└**6=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

**Tertiary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=789.00' TW=0.00' (Dynamic Tailwater)
└**7=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

## Summary for Link C1: Culvert C1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 0.51" for 25-yr, 24-hr event
Inflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af
Primary = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S5 R2 : Swale S5 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C2: Culvert C2

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 2.15" for 25-yr, 24-hr event
Inflow = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af
Primary = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C3: Culvert C3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 1.51" for 25-yr, 24-hr event
Inflow = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af
Primary = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C4: Culvert C4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af
Primary = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R5 : Swale S1 Reach 5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C5: Culvert C5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af
Primary = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R6 : Swale S1 Reach 6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C6: Culvert C6

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-yr, 24-hr event
Inflow = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af
Primary = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R3 : Swale S3 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C7: Culvert C7

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 1.22" for 25-yr, 24-hr event
Inflow = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af
Primary = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C8: Culvert C8

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 0.89" for 25-yr, 24-hr event
Inflow = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af
Primary = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af, Atten= 0%, Lag= 0.0 min
Routed to Link North Area : North Area

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F1: Flume 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af
Primary = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC1 : Rock Chute 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F2: Flume 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af
Primary = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC2 : Rock Chute 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F3: Flume 3

Inflow Area = 5.923 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 19.08 cfs @ 12.12 hrs, Volume= 0.934 af
Primary = 19.08 cfs @ 12.12 hrs, Volume= 0.934 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F4: Flume 4

Inflow Area = 2.645 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 8.58 cfs @ 12.12 hrs, Volume= 0.417 af
Primary = 8.58 cfs @ 12.12 hrs, Volume= 0.417 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F5: Flume 5

Inflow Area = 4.601 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 15.06 cfs @ 12.12 hrs, Volume= 0.725 af
Primary = 15.06 cfs @ 12.12 hrs, Volume= 0.725 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R1 : Swale S3 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F6: Flume 6

Inflow Area = 3.717 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 12.11 cfs @ 12.12 hrs, Volume= 0.586 af
Primary = 12.11 cfs @ 12.12 hrs, Volume= 0.586 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F7: Existing East Flume

Inflow Area = 0.830 ac, 0.00% Impervious, Inflow Depth = 1.85" for 25-yr, 24-hr event
Inflow = 2.66 cfs @ 12.12 hrs, Volume= 0.128 af
Primary = 2.66 cfs @ 12.12 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F8: Existing West Flume

Inflow Area = 3.122 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 9.73 cfs @ 12.13 hrs, Volume= 0.492 af
Primary = 9.73 cfs @ 12.13 hrs, Volume= 0.492 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link North Area: North Area

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 0.89" for 25-yr, 24-hr event
Inflow = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af
Primary = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC1: Rock Chute 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af
Primary = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC2: Rock Chute 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af
Primary = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R2 : Swale S4 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale 1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 1.25" for 25-yr, 24-hr event
Inflow = 33.18 cfs @ 12.21 hrs, Volume= 2.484 af
Primary = 33.18 cfs @ 12.21 hrs, Volume= 2.484 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R1 : Swale S2 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R1: Swale S1 Reach 1

Inflow Area = 0.691 ac, 0.00% Impervious, Inflow Depth = 1.18" for 25-yr, 24-hr event
Inflow = 1.37 cfs @ 12.12 hrs, Volume= 0.068 af
Primary = 1.37 cfs @ 12.12 hrs, Volume= 0.068 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 1.81" for 25-yr, 24-hr event
Inflow = 21.68 cfs @ 12.13 hrs, Volume= 1.077 af
Primary = 21.68 cfs @ 12.13 hrs, Volume= 1.077 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 1.51" for 25-yr, 24-hr event
Inflow = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af
Primary = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af, Atten= 0%, Lag= 0.0 min
Routed to Link C3 : Culvert C3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R4: Swale S1 Reach 4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af
Primary = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af, Atten= 0%, Lag= 0.0 min
Routed to Link C4 : Culvert C4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R5: Swale S1 Reach 5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af
Primary = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af, Atten= 0%, Lag= 0.0 min
Routed to Link C5 : Culvert C5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R1: Swale S2 Reach 1

Inflow Area = 25.901 ac, 0.00% Impervious, Inflow Depth = 1.17" for 25-yr, 24-hr event
Inflow = 29.95 cfs @ 12.26 hrs, Volume= 2.516 af
Primary = 29.95 cfs @ 12.26 hrs, Volume= 2.516 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R2: Swale S2 Reach 2

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 1.22" for 25-yr, 24-hr event
Inflow = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af
Primary = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af, Atten= 0%, Lag= 0.0 min
Routed to Link C7 : Culvert C7

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R1: Swale S3 Reach 1

Inflow Area = 6.548 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 15.88 cfs @ 12.13 hrs, Volume= 0.833 af
Primary = 15.88 cfs @ 12.13 hrs, Volume= 0.833 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R2: Swale S3 Reach 2

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-yr, 24-hr event
Inflow = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af
Primary = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af, Atten= 0%, Lag= 0.0 min
Routed to Link C6 : Culvert C6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R3: Swale S3 Reach 3

Inflow Area = 14.511 ac, 0.00% Impervious, Inflow Depth = 1.32" for 25-yr, 24-hr event
Inflow = 26.70 cfs @ 12.15 hrs, Volume= 1.592 af
Primary = 26.70 cfs @ 12.15 hrs, Volume= 1.592 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S4 R4: Swale S4 Reach 4

Inflow Area = 67.064 ac, 0.04% Impervious, Inflow Depth = 1.28" for 25-yr, 24-hr event
Inflow = 80.09 cfs @ 12.23 hrs, Volume= 7.154 af
Primary = 80.09 cfs @ 12.23 hrs, Volume= 7.154 af, Atten= 0%, Lag= 0.0 min
Routed to Pond Sed Pond : Sedimentation Basin

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R1: Swale S5 Reach 1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 0.51" for 25-yr, 24-hr event
Inflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af
Primary = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Atten= 0%, Lag= 0.0 min
Routed to Link C1 : Culvert C1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R2: Swale S5 Reach 2

Inflow Area = 5.851 ac, 12.83% Impervious, Inflow Depth = 0.69" for 25-yr, 24-hr event
Inflow = 4.68 cfs @ 12.15 hrs, Volume= 0.336 af
Primary = 4.68 cfs @ 12.15 hrs, Volume= 0.336 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R3: Swale S5 Reach 3

Inflow Area = 1.817 ac, 8.81% Impervious, Inflow Depth = 1.52" for 25-yr, 24-hr event
Inflow = 3.79 cfs @ 12.17 hrs, Volume= 0.230 af
Primary = 3.79 cfs @ 12.17 hrs, Volume= 0.230 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S6 R1: Swale S6 Reach 1

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 2.15" for 25-yr, 24-hr event
Inflow = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af
Primary = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af, Atten= 0%, Lag= 0.0 min
Routed to Link C2 : Culvert C2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Wetland: Wetland

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 0.32" for 25-yr, 24-hr event
Inflow = 9.42 cfs @ 13.29 hrs, Volume= 1.973 af
Primary = 9.42 cfs @ 13.29 hrs, Volume= 1.973 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

Time span=0.00-40.00 hrs, dt=0.01 hrs, 4001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment AREA 1: Subcat AREA 1** Runoff Area=1.288 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=408' Tc=2.6 min CN=69 Runoff=7.63 cfs 0.342 af

**Subcatchment AREA 10: Subcat AREA 10** Runoff Area=0.914 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=500' Tc=3.2 min CN=69 Runoff=5.29 cfs 0.242 af

**Subcatchment AREA 11: Subcat AREA 11** Runoff Area=0.949 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=391' Tc=4.6 min CN=69 Runoff=5.21 cfs 0.251 af

**Subcatchment AREA 12: Subcat AREA 12** Runoff Area=0.098 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=92' Tc=2.5 min CN=69 Runoff=0.58 cfs 0.026 af

**Subcatchment AREA 13: Subcat AREA 13** Runoff Area=0.890 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=590' Tc=4.6 min CN=69 Runoff=4.89 cfs 0.236 af

**Subcatchment AREA 14: Subcat AREA 14** Runoff Area=1.145 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=625' Tc=5.1 min CN=69 Runoff=6.17 cfs 0.303 af

**Subcatchment AREA 15: Subcat AREA 15** Runoff Area=0.512 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=235' Tc=4.2 min CN=69 Runoff=2.86 cfs 0.136 af

**Subcatchment AREA 16: Subcat AREA 16** Runoff Area=1.510 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=522' Tc=4.9 min CN=69 Runoff=8.20 cfs 0.400 af

**Subcatchment AREA 17: Subcat AREA 17** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=386' Tc=4.7 min CN=69 Runoff=6.72 cfs 0.326 af

**Subcatchment AREA 18: Subcat AREA 18** Runoff Area=0.813 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=383' Tc=4.6 min CN=69 Runoff=4.47 cfs 0.215 af

**Subcatchment AREA 19: Subcat AREA 19** Runoff Area=0.847 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=394' Tc=4.6 min CN=69 Runoff=4.66 cfs 0.225 af

**Subcatchment AREA 2: Subcat AREA 2** Runoff Area=1.167 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=613' Tc=5.1 min CN=69 Runoff=6.28 cfs 0.309 af

**Subcatchment AREA 20: Subcat AREA 20** Runoff Area=1.054 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=453' Tc=4.7 min CN=69 Runoff=5.77 cfs 0.279 af

**Subcatchment AREA 21: Subcat AREA 21** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=448' Tc=4.7 min CN=69 Runoff=5.64 cfs 0.273 af

**Subcatchment AREA 22: Subcat AREA 22** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=448' Tc=4.7 min CN=69 Runoff=5.64 cfs 0.273 af

**Subcatchment AREA 23: Subcat AREA 23** Runoff Area=1.548 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=715' Tc=5.4 min CN=69 Runoff=8.23 cfs 0.410 af

**Subcatchment AREA 24: Subcat AREA 24** Runoff Area=1.952 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=889' Tc=5.8 min CN=69 Runoff=10.20 cfs 0.517 af

**Subcatchment AREA 25: Subcat AREA 25** Runoff Area=1.515 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=495' Tc=3.9 min CN=69 Runoff=8.59 cfs 0.402 af

**Subcatchment AREA 26: Subcat AREA 26** Runoff Area=0.518 ac 0.00% Impervious Runoff Depth=2.98"
Flow Length=216' Tc=4.1 min CN=67 Runoff=2.74 cfs 0.129 af

**Subcatchment AREA 27: Subcat AREA 27** Runoff Area=4.140 ac 0.00% Impervious Runoff Depth=1.28"
Flow Length=864' Tc=12.0 min CN=48 Runoff=5.63 cfs 0.442 af

**Subcatchment AREA 28: Subcat AREA 28** Runoff Area=142,960 sf 0.00% Impervious Runoff Depth=1.44"
Flow Length=573' Tc=9.1 min CN=50 Runoff=5.98 cfs 0.395 af

**Subcatchment AREA 28A: Subcat AREA 28A** Runoff Area=0.423 ac 0.00% Impervious Runoff Depth=1.36"
Flow Length=234' Tc=9.1 min CN=49 Runoff=0.71 cfs 0.048 af

**Subcatchment AREA 28B: Subcat AREA 28B** Runoff Area=0.476 ac 0.00% Impervious Runoff Depth=1.53"
Flow Length=211' Tc=4.5 min CN=51 Runoff=1.20 cfs 0.061 af

**Subcatchment AREA 29: Subcat AREA 29** Runoff Area=2.792 ac 0.00% Impervious Runoff Depth=0.69"
Flow Length=463' Tc=14.8 min CN=40 Runoff=1.21 cfs 0.161 af

**Subcatchment AREA 3: Subcat AREA 3** Runoff Area=0.717 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=409' Tc=6.3 min CN=69 Runoff=3.66 cfs 0.190 af

**Subcatchment AREA 30: Subcat AREA 30** Runoff Area=1.415 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=941' Slope=0.0260 '/' Tc=22.0 min CN=39 Runoff=0.43 cfs 0.074 af

**Subcatchment AREA 31: Subcat AREA 31** Runoff Area=0.698 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=481' Tc=4.4 min CN=39 Runoff=0.42 cfs 0.036 af

**Subcatchment AREA 32: Subcat AREA 32** Runoff Area=3.353 ac 0.00% Impervious Runoff Depth=1.13"
Flow Length=663' Tc=17.3 min CN=46 Runoff=3.11 cfs 0.315 af

**Subcatchment AREA 33: Subcat AREA 33** Runoff Area=38,914 sf 0.00% Impervious Runoff Depth=1.36"
Flow Length=377' Tc=16.0 min CN=49 Runoff=1.14 cfs 0.101 af

**Subcatchment AREA 34: Subcat AREA 34** Runoff Area=68,484 sf 0.00% Impervious Runoff Depth=0.98"
Flow Length=488' Tc=16.2 min CN=44 Runoff=1.20 cfs 0.128 af

**Subcatchment AREA 35: Subcat AREA 35** Runoff Area=0.375 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=174' Slope=0.2500 '/' Tc=4.2 min CN=69 Runoff=2.10 cfs 0.099 af

**Subcatchment AREA 36: Subcat AREA 36** Runoff Area=0.487 ac 0.00% Impervious Runoff Depth=3.08"
Flow Length=425' Tc=4.4 min CN=68 Runoff=2.62 cfs 0.125 af

**Subcatchment AREA 37: Subcat AREA 37** Runoff Area=0.344 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=510' Tc=4.6 min CN=69 Runoff=1.89 cfs 0.091 af

**Subcatchment AREA 38: Subcat AREA 38** Runoff Area=0.223 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=590' Tc=4.1 min CN=69 Runoff=1.25 cfs 0.059 af

**Subcatchment AREA 39: Subcat AREA 39** Runoff Area=0.656 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=642' Tc=5.3 min CN=69 Runoff=3.50 cfs 0.174 af

**Subcatchment AREA 4: Subcat AREA 4** Runoff Area=1.247 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=478' Tc=6.6 min CN=69 Runoff=6.31 cfs 0.331 af

**Subcatchment AREA 40: Subcat AREA 40** Runoff Area=1.618 ac 0.00% Impervious Runoff Depth=2.23"
Flow Length=699' Tc=5.2 min CN=59 Runoff=6.03 cfs 0.300 af

**Subcatchment AREA 41: Subcat AREA 41** Runoff Area=0.826 ac 0.00% Impervious Runoff Depth=2.13"
Flow Length=722' Tc=5.9 min CN=58 Runoff=2.84 cfs 0.147 af

**Subcatchment AREA 42: Subcat AREA 42** Runoff Area=2.177 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=415' Tc=9.1 min CN=39 Runoff=0.93 cfs 0.114 af

**Subcatchment AREA 43: Subcat AREA 43** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=778' Tc=5.9 min CN=69 Runoff=6.39 cfs 0.325 af

**Subcatchment AREA 44: Subcat AREA 44** Runoff Area=5.227 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=701' Tc=7.9 min CN=39 Runoff=2.38 cfs 0.273 af

**Subcatchment AREA 44A: Subcat AREA** Runoff Area=1.508 ac 100.00% Impervious Runoff Depth=6.35"
Tc=0.0 min CN=98 Runoff=14.38 cfs 0.798 af

**Subcatchment AREA 44B: Subcat AREA 44B** Runoff Area=0.594 ac 0.00% Impervious Runoff Depth=1.44"
Flow Length=147' Slope=0.0544 '/' Tc=7.6 min CN=50 Runoff=1.17 cfs 0.071 af

**Subcatchment AREA 45: Subcat AREA 45** Runoff Area=2.001 ac 0.00% Impervious Runoff Depth=0.90"
Flow Length=681' Tc=21.9 min CN=43 Runoff=1.16 cfs 0.150 af

**Subcatchment AREA 46: Subcat AREA 46** Runoff Area=7.367 ac 0.36% Impervious Runoff Depth=2.23"
Flow Length=1,904' Tc=9.2 min CN=59 Runoff=22.74 cfs 1.366 af

**Subcatchment AREA 47: Subcat AREA 47** Runoff Area=79,132 sf 8.81% Impervious Runoff Depth=2.69"
Flow Length=582' Tc=9.1 min CN=64 Runoff=6.90 cfs 0.408 af

**Subcatchment AREA 48: Subcat AREA 48** Runoff Area=57,540 sf 11.76% Impervious Runoff Depth=2.41"
Flow Length=489' Tc=5.4 min CN=61 Runoff=5.30 cfs 0.265 af

**Subcatchment AREA 49: Subcat AREA 49** Runoff Area=0.691 ac 0.00% Impervious Runoff Depth=2.23"
Flow Length=522' Tc=4.3 min CN=59 Runoff=2.68 cfs 0.128 af

**Subcatchment AREA 5: Subcat AREA 5** Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=482' Tc=6.6 min CN=69 Runoff=6.05 cfs 0.317 af

**Subcatchment AREA 50: Subcat AREA 50** Runoff Area=1.482 ac 0.00% Impervious Runoff Depth=5.65"
Flow Length=570' Tc=3.4 min CN=92 Runoff=13.35 cfs 0.698 af

**Subcatchment AREA 51: Subcat AREA 51** Runoff Area=1.417 ac 0.00% Impervious Runoff Depth=0.69"
Flow Length=884' Tc=12.2 min CN=40 Runoff=0.67 cfs 0.082 af

**Subcatchment AREA 52: Subcat AREA 52** Runoff Area=197,330 sf 13.14% Impervious Runoff Depth=1.20"
Flow Length=1,294' Tc=6.3 min CN=47 Runoff=7.48 cfs 0.454 af

**Subcatchment AREA 6: Subcat AREA 6** Runoff Area=0.892 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=415' Tc=4.6 min CN=69 Runoff=4.90 cfs 0.236 af

**Subcatchment AREA 7: Subcat AREA 7** Runoff Area=1.017 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=833' Tc=5.8 min CN=69 Runoff=5.31 cfs 0.269 af

**Subcatchment AREA 8: Subcat AREA 8** Runoff Area=1.009 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=409' Tc=4.7 min CN=69 Runoff=5.52 cfs 0.268 af

**Subcatchment AREA 9: Subcat AREA 9** Runoff Area=1.047 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=426' Tc=4.8 min CN=69 Runoff=5.71 cfs 0.278 af

**Reach S1 R2: Swale S1 Reach 2** Avg. Flow Depth=1.01' Max Vel=3.03 fps Inflow=37.51 cfs 1.827 af
n=0.030 L=127.0' S=0.0055 '/' Capacity=140.64 cfs Outflow=37.05 cfs 1.827 af

**Reach S1 R3: Swale S1 Reach 3** Avg. Flow Depth=1.18' Max Vel=3.17 fps Inflow=53.22 cfs 3.049 af
n=0.030 L=578.0' S=0.0051 '/' Capacity=135.10 cfs Outflow=47.76 cfs 3.049 af

**Reach S1 R4: Swale S1 Reach 4** Avg. Flow Depth=1.26' Max Vel=3.74 fps Inflow=62.37 cfs 3.811 af
n=0.030 L=195.8' S=0.0066 '/' Capacity=154.36 cfs Outflow=61.58 cfs 3.811 af

**Reach S1 R5: Swale S1 Reach 5** Avg. Flow Depth=1.31' Max Vel=3.42 fps Inflow=62.23 cfs 3.859 af
n=0.030 L=411.6' S=0.0053 '/' Capacity=137.86 cfs Outflow=59.21 cfs 3.859 af

**Reach S1 R6: Swale S1 Reach 6** Avg. Flow Depth=1.36' Max Vel=3.44 fps Inflow=65.66 cfs 4.415 af
n=0.030 L=430.9' S=0.0052 '/' Capacity=136.28 cfs Outflow=62.73 cfs 4.415 af

**Reach S2 R1: Swale S2 Reach 1** Avg. Flow Depth=1.65' Max Vel=2.39 fps Inflow=62.82 cfs 4.489 af
n=0.030 L=472.0' S=0.0020 '/' Capacity=84.99 cfs Outflow=57.87 cfs 4.489 af

**Reach S2 R2: Swale S2 Reach 2** Avg. Flow Depth=1.40' Max Vel=4.16 fps Inflow=95.28 cfs 7.736 af
n=0.030 L=751.0' S=0.0069 '/' Capacity=182.04 cfs Outflow=90.88 cfs 7.736 af

**Reach S3 R1: Swale S3 Reach 1** Avg. Flow Depth=0.85' Max Vel=3.26 fps Inflow=27.41 cfs 1.319 af
n=0.030 L=215.0' S=0.0070 '/' Capacity=125.24 cfs Outflow=26.88 cfs 1.319 af

**Reach S3 R2: Swale S3 Reach 2** Avg. Flow Depth=2.14' Max Vel=4.13 fps Inflow=47.52 cfs 2.432 af
n=0.030 L=97.0' S=0.0070 '/' Capacity=71.57 cfs Outflow=47.32 cfs 2.432 af

**Reach S3 R3: Swale S3 Reach 3** Avg. Flow Depth=0.98' Max Vel=3.94 fps Inflow=47.83 cfs 2.533 af
n=0.030 L=353.0' S=0.0097 '/' Capacity=186.19 cfs Outflow=46.22 cfs 2.533 af

**Reach S4 R2: Swale S4 Reach 2** Avg. Flow Depth=0.63' Max Vel=2.70 fps Inflow=23.68 cfs 1.204 af
n=0.030 L=601.0' S=0.0069 '/' Capacity=174.20 cfs Outflow=20.91 cfs 1.204 af

**Reach S4 R3: Swale S4 Reach 3** Avg. Flow Depth=0.89' Max Vel=2.94 fps Inflow=41.60 cfs 2.309 af
n=0.030 L=946.0' S=0.0056 '/' Capacity=156.53 cfs Outflow=34.31 cfs 2.309 af

**Reach S4 R4: Swale S4 Reach 4** Avg. Flow Depth=1.82' Max Vel=5.29 fps Inflow=159.67 cfs 12.653 af
n=0.030 L=483.0' S=0.0082 '/' Capacity=427.66 cfs Outflow=157.44 cfs 12.653 af

**Reach S5 R2: Swale S5 Reach 2** Inflow=7.48 cfs 0.454 af
Outflow=7.48 cfs 0.454 af

**Pond Sed Pond: Sedimentation Basin** Peak Elev=793.06' Storage=236,005 cf Inflow=164.77 cfs 13.946 af
.167 af Primary=11.35 cfs 4.914 af Secondary=22.50 cfs 1.762 af Tertiary=6.00 cfs 0.104 af Outflow=45.68 cfs 13.947 af

**Link C1: Culvert C1** Inflow=7.48 cfs 0.454 af
Primary=7.48 cfs 0.454 af

**Link C2: Culvert C2** Inflow=13.45 cfs 0.780 af
Primary=13.45 cfs 0.780 af

**Link C3: Culvert C3** Inflow=47.76 cfs 3.049 af
Primary=47.76 cfs 3.049 af

**Link C4: Culvert C4** Inflow=62.23 cfs 3.859 af
Primary=62.23 cfs 3.859 af

**Link C5: Culvert C5** Inflow=65.15 cfs 4.254 af
Primary=65.15 cfs 4.254 af

**Link C6: Culvert C6** Inflow=47.83 cfs 2.533 af
Primary=47.83 cfs 2.533 af

**Link C7: Culvert C7** Inflow=103.37 cfs 8.978 af
Primary=103.37 cfs 8.978 af

**Link C8: Culvert C8** Inflow=19.20 cfs 1.127 af
Primary=19.20 cfs 1.127 af

**Link F1: Flume 1** Inflow=22.19 cfs 1.105 af
Primary=22.19 cfs 1.105 af

**Link F2: Flume 2** Inflow=23.68 cfs 1.204 af
Primary=23.68 cfs 1.204 af

**Link F3: Flume 3** Inflow=32.10 cfs 1.570 af
Primary=32.10 cfs 1.570 af

**Link F4: Flume 4** Inflow=14.43 cfs 0.701 af
Primary=14.43 cfs 0.701 af

**Link F5: Flume 5** Inflow=25.31 cfs 1.219 af
Primary=25.31 cfs 1.219 af

**Link F6: Flume 6** Inflow=20.36 cfs 0.985 af
Primary=20.36 cfs 0.985 af

**Link F7: Existing East Flume** Inflow=4.50 cfs 0.216 af
Primary=4.50 cfs 0.216 af

**Link F8: Existing West Flume** Inflow=16.40 cfs 0.828 af
Primary=16.40 cfs 0.828 af

**Link North Area: North Area** Inflow=19.20 cfs 1.127 af
Primary=19.20 cfs 1.127 af

**Link RC1: Rock Chute 1** Inflow=22.19 cfs 1.105 af
Primary=22.19 cfs 1.105 af

**Link RC2: Rock Chute 2** Inflow=23.68 cfs 1.204 af
Primary=23.68 cfs 1.204 af

**Link Swale 1 R6: Swale S1 Reach 6** Inflow=62.73 cfs 4.415 af
Primary=62.73 cfs 4.415 af

**Link Swale S1 R1: Swale S1 Reach 1** Inflow=2.68 cfs 0.128 af
Primary=2.68 cfs 0.128 af

**Link Swale S1 R2: Swale S1 Reach 2** Inflow=37.05 cfs 1.827 af
Primary=37.05 cfs 1.827 af

**Link Swale S1 R3: Swale S1 Reach 3** Inflow=47.76 cfs 3.049 af
Primary=47.76 cfs 3.049 af

**Link Swale S1 R4: Swale S1 Reach 4** Inflow=62.23 cfs 3.859 af
Primary=62.23 cfs 3.859 af

**Link Swale S1 R5: Swale S1 Reach 5** Inflow=65.15 cfs 4.254 af
Primary=65.15 cfs 4.254 af

**Link Swale S2 R1: Swale S2 Reach 1** Inflow=58.13 cfs 4.525 af
Primary=58.13 cfs 4.525 af

**Link Swale S2 R2: Swale S2 Reach 2** Inflow=103.37 cfs 8.978 af
Primary=103.37 cfs 8.978 af

**Link Swale S3 R1: Swale S3 Reach 1** Inflow=27.22 cfs 1.447 af
Primary=27.22 cfs 1.447 af

**Link Swale S3 R2: Swale S3 Reach 2** Inflow=47.83 cfs 2.533 af
Primary=47.83 cfs 2.533 af

**Link Swale S3 R3: Swale S3 Reach 3** Inflow=47.45 cfs 2.848 af
Primary=47.45 cfs 2.848 af

**Link Swale S4 R4: Swale S4 Reach 4** Inflow=157.92 cfs 12.803 af
Primary=157.92 cfs 12.803 af

**Link Swale S5 R1: Swale S5 Reach 1** Inflow=7.48 cfs 0.454 af
Primary=7.48 cfs 0.454 af

**Link Swale S5 R2: Swale S5 Reach 2** Inflow=12.65 cfs 0.720 af
Primary=12.65 cfs 0.720 af

**Link Swale S5 R3: Swale S5 Reach 3** Inflow=6.90 cfs 0.408 af
Primary=6.90 cfs 0.408 af

**Link Swale S6 R1: Swale S6 Reach 1** Inflow=13.45 cfs 0.780 af
Primary=13.45 cfs 0.780 af

**Link Wetland: Wetland** Inflow=39.85 cfs 6.780 af
Primary=39.85 cfs 6.780 af

**Total Runoff Area = 82.060 ac Runoff Volume = 15.074 af Average Runoff Depth = 2.20"**
**97.02% Pervious = 79.615 ac 2.98% Impervious = 2.446 ac**

## Summary for Subcatchment AREA 1: Subcat AREA 1

Runoff = 7.63 cfs @ 12.11 hrs, Volume= 0.342 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.288 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.288 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.7 | 37 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.9 | 371 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.6 | 408 | Total | | | |

## Summary for Subcatchment AREA 10: Subcat AREA 10

Runoff = 5.29 cfs @ 12.11 hrs, Volume= 0.242 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.914 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.1 | 46 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 454 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.2 | 500 | Total | | | |

## Summary for Subcatchment AREA 11: Subcat AREA 11

Runoff = 5.21 cfs @ 12.12 hrs, Volume= 0.251 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.949 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.949 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 277 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 391 | Total | | | |

## Summary for Subcatchment AREA 12: Subcat AREA 12

Runoff = 0.58 cfs @ 12.11 hrs, Volume= 0.026 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.098 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.098 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 36 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.5 | 92 | Total | | | |

## Summary for Subcatchment AREA 13: Subcat AREA 13

Runoff = 4.89 cfs @ 12.12 hrs, Volume= 0.236 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.890 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.890 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.4 | 87 | 0.2500 | 0.42 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.2 | 503 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 590 | Total | | | |

## Summary for Subcatchment AREA 14: Subcat AREA 14

Runoff = 6.17 cfs @ 12.13 hrs, Volume= 0.303 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.145 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.145 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 27 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 498 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 625 | Total | | | |

## Summary for Subcatchment AREA 15: Subcat AREA 15

Runoff = 2.86 cfs @ 12.12 hrs, Volume= 0.136 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.512 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.512 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 85 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.2 | 235 | Total | | | |

## Summary for Subcatchment AREA 16: Subcat AREA 16

Runoff = 8.20 cfs @ 12.12 hrs, Volume= 0.400 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.510 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.510 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 372 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.9 | 522 | Total | | | |

## Summary for Subcatchment AREA 17: Subcat AREA 17

Runoff = 6.72 cfs @ 12.12 hrs, Volume= 0.326 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 63 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 223 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 386 | Total | | | |

## Summary for Subcatchment AREA 18: Subcat AREA 18

Runoff = 4.47 cfs @ 12.12 hrs, Volume= 0.215 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.813 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.813 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 48 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 235 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 383 | Total | | | |

## Summary for Subcatchment AREA 19: Subcat AREA 19

Runoff = 4.66 cfs @ 12.12 hrs, Volume= 0.225 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.847 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.847 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 244 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 394 | Total | | | |

## Summary for Subcatchment AREA 2: Subcat AREA 2

Runoff = 6.28 cfs @ 12.13 hrs, Volume= 0.309 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.167 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.167 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 495 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 613 | Total | | | |

## Summary for Subcatchment AREA 20: Subcat AREA 20

Runoff = 5.77 cfs @ 12.12 hrs, Volume= 0.279 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.054 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.054 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 303 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 453 | Total | | | |

## Summary for Subcatchment AREA 21: Subcat AREA 21

Runoff = 5.64 cfs @ 12.12 hrs, Volume= 0.273 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 22: Subcat AREA 22

Runoff = 5.64 cfs @ 12.12 hrs, Volume= 0.273 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 23: Subcat AREA 23

Runoff = 8.23 cfs @ 12.13 hrs, Volume= 0.410 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.548 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.548 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 591 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 715 | Total | | | |

## Summary for Subcatchment AREA 24: Subcat AREA 24

Runoff = 10.20 cfs @ 12.13 hrs, Volume= 0.517 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.952 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.952 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 765 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.8 | 889 | Total | | | |

## Summary for Subcatchment AREA 25: Subcat AREA 25

Runoff = 8.59 cfs @ 12.12 hrs, Volume= 0.402 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.515 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.515 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.8 | 67 | 0.2500 | 0.40 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 428 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.9 | 495 | Total | | | |

## Summary for Subcatchment AREA 26: Subcat AREA 26

Runoff = 2.74 cfs @ 12.12 hrs, Volume= 0.129 af, Depth= 2.98"
Routed to Reach S1 R2 : Swale S1 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.396 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.072 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.049 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 0.518 | 67 | Weighted Average |
| | 0.518 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 93 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 123 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.1 | 216 | Total | | | |

## Summary for Subcatchment AREA 27: Subcat AREA 27

Runoff = 5.63 cfs @ 12.22 hrs, Volume= 0.442 af, Depth= 1.28"
Routed to Reach S1 R3 : Swale S1 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.651 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 2.758 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.010 | 96 | Gravel surface, HSG A |
| | 0.295 | 96 | Gravel surface, HSG A |
| | 0.426 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 4.140 | 48 | Weighted Average |
| | 4.140 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.3 | 217 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 513 | 0.0051 | 4.23 | 135.28 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 12.0 | 864 | Total | | | |

## Summary for Subcatchment AREA 28: Subcat AREA 28

Runoff = 5.98 cfs @ 12.18 hrs, Volume= 0.395 af, Depth= 1.44"
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 30,267 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 100,859 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 11,834 | 96 | Gravel surface |
| | 142,960 | 50 | Weighted Average |
| | 142,960 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 5.9 | 78 | 0.0526 | 0.22 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 22 | 0.2500 | 0.32 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 23 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.6 | 410 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 573 | Total | | | |

## Summary for Subcatchment AREA 28A: Subcat AREA 28A

Runoff = 0.71 cfs @ 12.18 hrs, Volume= 0.048 af, Depth= 1.36"
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.035 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.257 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.075 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.010 | 96 | Gravel surface, HSG A |
| 0.046 | 96 | Gravel surface, HSG A |
| 0.423 | 49 | Weighted Average |
| 0.423 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 82 | 0.0334 | 0.19 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 34 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 13 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 67 | 0.0069 | 4.92 | 157.36 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 234 | Total | | | |

## Summary for Subcatchment AREA 28B: Subcat AREA 28B

Runoff = 1.20 cfs @ 12.13 hrs, Volume= 0.061 af, Depth= 1.53"
Routed to Reach S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.050 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.110 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.240 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.009 | 96 | Gravel surface, HSG A |
| 0.067 | 96 | Gravel surface, HSG A |
| 0.476 | 51 | Weighted Average |
| 0.476 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 58 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.6 | 20 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 115 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.5 | 211 | Total | | | |

## Summary for Subcatchment AREA 29: Subcat AREA 29

Runoff = 1.21 cfs @ 12.31 hrs, Volume= 0.161 af, Depth= 0.69"
Routed to Reach S1 R6 : Swale S1 Reach 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.056 | 96 | Gravel surface, HSG A |
| | 2.735 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Gravel surface |
| | 2.792 | 40 | Weighted Average |
| | 2.792 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 11.8 | 100 | 0.0150 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 100 | 0.0150 | 0.86 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 247 | 0.0052 | 4.27 | 136.60 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 5** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 14.8 | 463 | Total | | | |

## Summary for Subcatchment AREA 3: Subcat AREA 3

Runoff = 3.66 cfs @ 12.14 hrs, Volume= 0.190 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.717 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.717 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.9 | 44 | 0.1000 | 0.26 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 233 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 409 | Total | | | |

## Summary for Subcatchment AREA 30: Subcat AREA 30

Runoff = 0.43 cfs @ 12.46 hrs, Volume= 0.074 af, Depth= 0.63"
Routed to Reach S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.415 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.415 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 9.5 | 100 | 0.0260 | 0.18 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 194 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 9.6 | 647 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 22.0 | 941 | Total | | | |

## Summary for Subcatchment AREA 31: Subcat AREA 31

Runoff = 0.42 cfs @ 12.14 hrs, Volume= 0.036 af, Depth= 0.63"
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.698 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.698 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.8 | 447 | 0.0020 | 2.65 | 84.72 | **Trap/Vee/Rect Channel Flow, Swale 2 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.4 | 481 | Total | | | |

## Summary for Subcatchment AREA 32: Subcat AREA 32

Runoff = 3.11 cfs @ 12.31 hrs, Volume= 0.315 af, Depth= 1.13"
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.567 | 69 | Pasture/grassland/range, Fair, HSG B |
| 2.413 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.099 | 96 | Gravel surface, HSG A |
| 0.274 | 39 | Pasture/grassland/range, Good, HSG A |
| 3.353 | 46 | Weighted Average |
| 3.353 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.2 | 211 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 23 | 0.1740 | 2.92 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 329 | 0.0097 | 5.83 | 186.57 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 17.3 | 663 | Total | | | |

## Summary for Subcatchment AREA 33: Subcat AREA 33

Runoff = 1.14 cfs @ 12.28 hrs, Volume= 0.101 af, Depth= 1.36"
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 4,079 | 96 | Gravel surface, HSG A |
| | 1,422 | 96 | Gravel surface, HSG A |
| | 30,707 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 2,706 | 69 | Pasture/grassland/range, Fair, HSG A |
| | 38,914 | 49 | Weighted Average |
| | 38,914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.6 | 178 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.0 | 12 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 87 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 2** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.0 | 377 | Total | | | |

## Summary for Subcatchment AREA 34: Subcat AREA 34

Runoff = 1.20 cfs @ 12.30 hrs, Volume= 0.128 af, Depth= 0.98"
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 5,695 | 69 | Pasture/grassland/range, Fair, HSG B |
| 3,470 | 96 | Gravel surface, HSG A |
| 59,319 | 39 | Pasture/grassland/range, Good, HSG A |
| 68,484 | 44 | Weighted Average |
| 68,484 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 170 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 15 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 203 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 1** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.2 | 488 | Total | | | |

## Summary for Subcatchment AREA 35: Subcat AREA 35

Runoff = 2.10 cfs @ 12.12 hrs, Volume= 0.099 af, Depth= 3.18"
Routed to Reach S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.375 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.375 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 74 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 4.2 | 174 | Total | | | |

## Summary for Subcatchment AREA 36: Subcat AREA 36

Runoff = 2.62 cfs @ 12.12 hrs, Volume= 0.125 af, Depth= 3.08"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.470 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.016 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 0.487 | 68 | Weighted Average |
| | 0.487 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 90 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.7 | 201 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 134 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.4 | 425 | Total | | | |

## Summary for Subcatchment AREA 37: Subcat AREA 37

Runoff = 1.89 cfs @ 12.12 hrs, Volume= 0.091 af, Depth= 3.18"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.344 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.344 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 30 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 126 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 254 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.6 | 510 | Total | | | |

## Summary for Subcatchment AREA 38: Subcat AREA 38

Runoff = 1.25 cfs @ 12.12 hrs, Volume= 0.059 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.223 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.223 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 156 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.5 | 357 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.1 | 590 | Total | | | |

## Summary for Subcatchment AREA 39: Subcat AREA 39

Runoff = 3.50 cfs @ 12.13 hrs, Volume= 0.174 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.656 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.656 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 314 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 217 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.3 | 642 | Total | | | |

## Summary for Subcatchment AREA 4: Subcat AREA 4

Runoff = 6.31 cfs @ 12.14 hrs, Volume= 0.331 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.247 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.247 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 57 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 83 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 295 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 478 | Total | | | |

## Summary for Subcatchment AREA 40: Subcat AREA 40

Runoff = 6.03 cfs @ 12.13 hrs, Volume= 0.300 af, Depth= 2.23"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 1.079 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.539 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 1.618 | 59 | Weighted Average |
| | 1.618 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.8 | 237 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 70 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 315 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.2 | 699 | Total | | | |

## Summary for Subcatchment AREA 41: Subcat AREA 41

Runoff = 2.84 cfs @ 12.14 hrs, Volume= 0.147 af, Depth= 2.13"
Routed to Reach S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.520 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.306 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.826 | 58 | Weighted Average |
| 0.826 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 26 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 596 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.9 | 722 | Total | | | |

## Summary for Subcatchment AREA 42: Subcat AREA 42

Runoff = 0.93 cfs @ 12.22 hrs, Volume= 0.114 af, Depth= 0.63"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 2.177 | 39 | Pasture/grassland/range, Good, HSG A |
| 2.177 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 6.4 | 66 | 0.0303 | 0.17 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 49 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 266 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 415 | Total | | | |

## Summary for Subcatchment AREA 43: Subcat AREA 43

Runoff = 6.39 cfs @ 12.13 hrs, Volume= 0.325 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 6 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 541 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 131 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.9 | 778 | Total | | | |

## Summary for Subcatchment AREA 44: Subcat AREA 44

Runoff = 2.38 cfs @ 12.19 hrs, Volume= 0.273 af, Depth= 0.63"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 5.227 | 39 | Pasture/grassland/range, Good, HSG A |
| 5.227 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 4.5 | 75 | 0.0933 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.3 | 25 | 0.2500 | 0.33 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 10 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 381 | 0.0265 | 7.85 | 109.92 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=14.00' n= 0.030 Earth, grassed & winding |
| 0.8 | 162 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.5 | 48 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.9 | 701 | Total | | | |

## Summary for Subcatchment AREA 44A: Subcat AREA 44A

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.38 cfs @ 12.09 hrs, Volume= 0.798 af, Depth= 6.35"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.508 | 98 | Water Surface, HSG A |
| 1.508 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment AREA 44B: Subcat AREA 44B

Runoff = 1.17 cfs @ 12.16 hrs, Volume= 0.071 af, Depth= 1.44"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.479 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.115 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| | 0.594 | 50 | Weighted Average |
| | 0.594 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.1 | 100 | 0.0544 | 0.24 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 47 | 0.0544 | 1.63 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.6 | 147 | Total | | | |

## Summary for Subcatchment AREA 45: Subcat AREA 45

Runoff = 1.16 cfs @ 12.41 hrs, Volume= 0.150 af, Depth= 0.90"
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 0.000 | 0 | , HSG A |
| | 1.870 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.000 | 96 | Gravel surface, HSG A |
| | 0.130 | 96 | Gravel surface, HSG A |
| | 2.001 | 43 | Weighted Average |
| | 2.001 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 15.7 | 100 | 0.0074 | 0.11 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.7 | 169 | 0.0074 | 0.60 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 49 | 0.0800 | 1.98 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 363 | 0.0082 | 5.42 | 162.67 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 21.9 | 681 | Total | | | |

## Summary for Subcatchment AREA 46: Subcat AREA 46

Runoff = 22.74 cfs @ 12.17 hrs, Volume= 1.366 af, Depth= 2.23"
Routed to Reach S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 3.081 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.590 | 96 | Gravel surface, HSG B |
| | 3.264 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.017 | 98 | Paved parking, HSG A |
| | 0.009 | 98 | Paved parking, HSG A |
| | 0.378 | 96 | Gravel surface, HSG A |
| | 0.001 | 96 | Gravel surface, HSG A |
| | 0.026 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 7.367 | 59 | Weighted Average |
| | 7.340 | | 99.64% Pervious Area |
| | 0.027 | | 0.36% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.2 | 51 | 0.2500 | 0.38 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 16 | 0.2500 | 2.44 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.9 | 31 | 0.0050 | 0.58 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0650 | 1.78 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 5.6 | 1,759 | 0.0073 | 5.26 | 178.68 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 1** Bot.W=10.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.2 | 1,904 | Total | | | |

## Summary for Subcatchment AREA 47: Subcat AREA 47

Runoff = 6.90 cfs @ 12.17 hrs, Volume= 0.408 af, Depth= 2.69"
Routed to Link Swale S5 R3 : Swale S5 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 49,617 | 69 | Pasture/grassland/range, Fair, HSG B |
| 6,971 | 98 | Paved parking, HSG A |
| 1,619 | 96 | Gravel surface, HSG A |
| 20,925 | 39 | Pasture/grassland/range, Good, HSG A |
| 79,132 | 64 | Weighted Average |
| 72,161 | | 91.19% Pervious Area |
| 6,971 | | 8.81% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.1111 | 1.63 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.7 | 12 | 0.2500 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 28 | 0.0393 | 0.16 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 488 | 0.0024 | 2.40 | 52.81 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 3** Bot.W=0.00' D=2.00' Z= 5.0 & 6.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 582 | Total | | | |

## Summary for Subcatchment AREA 48: Subcat AREA 48

Runoff = 5.30 cfs @ 12.13 hrs, Volume= 0.265 af, Depth= 2.41"
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 24,597 | 69 | Pasture/grassland/range, Fair, HSG B |
| 24,117 | 39 | Pasture/grassland/range, Good, HSG A |
| 2,057 | 96 | Gravel surface, HSG A |
| 6,769 | 98 | Paved parking, HSG A |
| 57,540 | 61 | Weighted Average |
| 50,771 | | 88.24% Pervious Area |
| 6,769 | | 11.76% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 19 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.7 | 29 | 0.1667 | 0.29 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.1 | 441 | 0.0024 | 2.38 | 40.39 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 2** Bot.W=0.00' D=2.00' Z= 2.5 & 6.0 '/' Top.W=17.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 489 | Total | | | |

## Summary for Subcatchment AREA 49: Subcat AREA 49

Runoff = 2.68 cfs @ 12.12 hrs, Volume= 0.128 af, Depth= 2.23"
Routed to Link Swale S1 R1 : Swale S1 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.439 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.246 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.006 | 96 | Gravel surface, HSG A |
| 0.691 | 59 | Weighted Average |
| 0.691 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 59 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.8 | 463 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |

4.3 522 Total

## Summary for Subcatchment AREA 5: Subcat AREA 5

Runoff = 6.05 cfs @ 12.14 hrs, Volume= 0.317 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.195 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.195 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 59 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 41 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 85 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 297 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 482 | Total | | | |

## Summary for Subcatchment AREA 50: Subcat AREA 50

Runoff = 13.35 cfs @ 12.11 hrs, Volume= 0.698 af, Depth= 5.65"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.100 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.001 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.382 | 96 | Gravel surface, HSG A |
| 1.482 | 92 | Weighted Average |
| 1.482 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 100 | 0.0119 | 1.04 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0119 | 1.76 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.0 | 10 | 0.5000 | 4.95 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.4 | 413 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 3.4 | 570 | Total | | | |

## Summary for Subcatchment AREA 51: Subcat AREA 51

Runoff = 0.67 cfs @ 12.27 hrs, Volume= 0.082 af, Depth= 0.69"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.396 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.020 | 96 | Gravel surface, HSG A |
| 1.417 | 40 | Weighted Average |
| 1.417 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.2 | 302 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 53 | 0.0313 | 2.85 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 1.4 | 429 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 12.2 | 884 | Total | | | |

## Summary for Subcatchment AREA 52: Subcat AREA 52

Runoff = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Depth= 1.20"
Routed to Link Swale S5 R1 : Swale S5 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 169,213 | 39 | Pasture/grassland/range, Good, HSG A |
| 25,933 | 98 | Paved parking, HSG A |
| 2,184 | 96 | Gravel surface, HSG A |
| 197,330 | 47 | Weighted Average |
| 171,397 | | 86.86% Pervious Area |
| 25,933 | | 13.14% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 18 | 0.0050 | 0.52 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.4 | 21 | 0.1333 | 0.25 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.3 | 1,255 | 0.0096 | 4.82 | 125.20 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 1** Bot.W=0.00' D=2.00' Z= 6.0 & 7.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 1,294 | Total | | | |

## Summary for Subcatchment AREA 6: Subcat AREA 6

Runoff = 4.90 cfs @ 12.12 hrs, Volume= 0.236 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.892 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.892 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 7 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 308 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 415 | Total | | | |

## Summary for Subcatchment AREA 7: Subcat AREA 7

Runoff = 5.31 cfs @ 12.13 hrs, Volume= 0.269 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.017 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.017 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 419 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.4 | 296 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow,** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.8 | 833 | Total | | | |

## Summary for Subcatchment AREA 8: Subcat AREA 8

Runoff = 5.52 cfs @ 12.12 hrs, Volume= 0.268 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.009 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.009 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 66 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 243 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 409 | Total | | | |

## Summary for Subcatchment AREA 9: Subcat AREA 9

Runoff = 5.71 cfs @ 12.12 hrs, Volume= 0.278 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.047 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.047 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 250 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.8 | 426 | Total | | | |

## Summary for Reach S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 3.07" for 100-yr, 24-hr event
Inflow = 37.51 cfs @ 12.12 hrs, Volume= 1.827 af
Outflow = 37.05 cfs @ 12.12 hrs, Volume= 1.827 af, Atten= 1%, Lag= 0.4 min
Routed to Link Swale S1 R2 : Swale S1 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.03 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 0.80 fps, Avg. Travel Time= 2.7 min

Peak Storage= 1,553 cf @ 12.12 hrs
Average Depth at Peak Storage= 1.01' , Surface Width= 16.12'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 140.64 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 127.0' Slope= 0.0055 '/'
Inlet Invert= 814.81', Outlet Invert= 814.11'

‡

## Summary for Reach S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 2.58" for 100-yr, 24-hr event
Inflow = 53.22 cfs @ 12.12 hrs, Volume= 3.049 af
Outflow = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af, Atten= 10%, Lag= 1.5 min
Routed to Link Swale S1 R3 : Swale S1 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.17 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 0.70 fps, Avg. Travel Time= 13.8 min

Peak Storage= 8,716 cf @ 12.15 hrs
Average Depth at Peak Storage= 1.18' , Surface Width= 17.47'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 135.10 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 578.0' Slope= 0.0051 '/'
Inlet Invert= 814.11', Outlet Invert= 811.17'

‡

## Summary for Reach S1 R4: Swale S1 Reach 4

Inflow Area = 17.292 ac, 0.00% Impervious, Inflow Depth = 2.64" for 100-yr, 24-hr event
Inflow = 62.37 cfs @ 12.14 hrs, Volume= 3.811 af
Outflow = 61.58 cfs @ 12.15 hrs, Volume= 3.811 af, Atten= 1%, Lag= 0.6 min
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.74 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 0.81 fps, Avg. Travel Time= 4.0 min

Peak Storage= 3,220 cf @ 12.15 hrs
Average Depth at Peak Storage= 1.26' , Surface Width= 18.09'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 154.36 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 195.8' Slope= 0.0066 '/'
Inlet Invert= 811.17', Outlet Invert= 809.87'

‡

## Summary for Reach S1 R5: Swale S1 Reach 5

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 2.61" for 100-yr, 24-hr event
Inflow = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af
Outflow = 59.21 cfs @ 12.17 hrs, Volume= 3.859 af, Atten= 5%, Lag= 1.3 min
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.42 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 0.74 fps, Avg. Travel Time= 9.2 min

Peak Storage= 7,135 cf @ 12.17 hrs
Average Depth at Peak Storage= 1.31' , Surface Width= 18.48'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 137.86 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 411.6' Slope= 0.0053 '/'
Inlet Invert= 809.77', Outlet Invert= 807.59'

‡

## Summary for Reach S1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 2.23" for 100-yr, 24-hr event
Inflow = 65.66 cfs @ 12.17 hrs, Volume= 4.415 af
Outflow = 62.73 cfs @ 12.20 hrs, Volume= 4.415 af, Atten= 4%, Lag= 1.5 min
Routed to Link Swale 1 R6 : Swale S1 Reach 6

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.44 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 0.76 fps, Avg. Travel Time= 9.4 min

Peak Storage= 7,852 cf @ 12.20 hrs
Average Depth at Peak Storage= 1.36' , Surface Width= 18.86'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 136.28 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 430.9' Slope= 0.0052 '/'
Inlet Invert= 807.15', Outlet Invert= 804.92'

‡

## Summary for Reach S2 R1: Swale S2 Reach 1

Inflow Area = 25.203 ac, 0.00% Impervious, Inflow Depth = 2.14" for 100-yr, 24-hr event
Inflow = 62.82 cfs @ 12.20 hrs, Volume= 4.489 af
Outflow = 57.87 cfs @ 12.24 hrs, Volume= 4.489 af, Atten= 8%, Lag= 2.5 min
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.39 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 0.52 fps, Avg. Travel Time= 15.1 min

Peak Storage= 11,415 cf @ 12.24 hrs
Average Depth at Peak Storage= 1.65' , Surface Width= 21.24'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 84.99 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 472.0' Slope= 0.0020 '/'
Inlet Invert= 802.25', Outlet Invert= 801.30'

‡

## Summary for Reach S2 R2: Swale S2 Reach 2

Inflow Area = 42.068 ac, 0.00% Impervious, Inflow Depth = 2.21" for 100-yr, 24-hr event
Inflow = 95.28 cfs @ 12.17 hrs, Volume= 7.736 af
Outflow = 90.88 cfs @ 12.23 hrs, Volume= 7.736 af, Atten= 5%, Lag= 3.1 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.16 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 0.88 fps, Avg. Travel Time= 14.3 min

Peak Storage= 16,407 cf @ 12.23 hrs
Average Depth at Peak Storage= 1.40' , Surface Width= 21.20'
Bank-Full Depth= 2.00' Flow Area= 36.0 sf, Capacity= 182.04 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 26.00'
Length= 751.0' Slope= 0.0069 '/'
Inlet Invert= 801.30', Outlet Invert= 796.10'

‡

## Summary for Reach S3 R1: Swale S3 Reach 1

Inflow Area = 4.976 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 27.41 cfs @ 12.12 hrs, Volume= 1.319 af
Outflow = 26.88 cfs @ 12.13 hrs, Volume= 1.319 af, Atten= 2%, Lag= 0.6 min
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.26 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 0.77 fps, Avg. Travel Time= 4.7 min

Peak Storage= 1,774 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.85' , Surface Width= 11.40'
Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 125.24 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 215.0' Slope= 0.0070 '/'
Inlet Invert= 807.58', Outlet Invert= 806.08'

‡

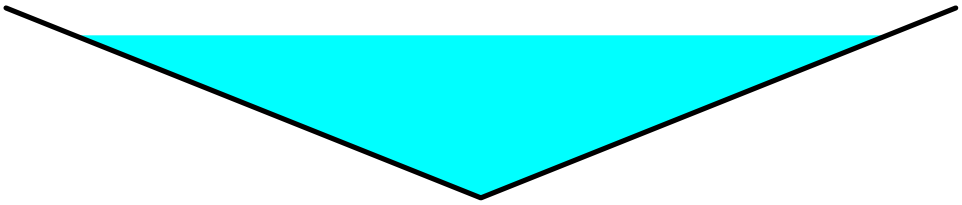
## Summary for Reach S3 R2: Swale S3 Reach 2

Inflow Area = 10.265 ac, 0.00% Impervious, Inflow Depth = 2.84" for 100-yr, 24-hr event
Inflow = 47.52 cfs @ 12.13 hrs, Volume= 2.432 af
Outflow = 47.32 cfs @ 12.13 hrs, Volume= 2.432 af, Atten= 0%, Lag= 0.3 min
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.13 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.45 fps, Avg. Travel Time= 1.1 min

Peak Storage= 1,111 cf @ 12.13 hrs
Average Depth at Peak Storage= 2.14' , Surface Width= 10.70'
Bank-Full Depth= 2.50' Flow Area= 15.6 sf, Capacity= 71.57 cfs

0.00' x 2.50' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.5 '/' Top Width= 12.50'
Length= 97.0' Slope= 0.0070 '/'
Inlet Invert= 806.08', Outlet Invert= 805.40'



## Summary for Reach S3 R3: Swale S3 Reach 3

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 2.72" for 100-yr, 24-hr event
Inflow = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af
Outflow = 46.22 cfs @ 12.15 hrs, Volume= 2.533 af, Atten= 3%, Lag= 0.9 min
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.94 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.02 fps, Avg. Travel Time= 5.8 min

Peak Storage= 4,140 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.98' , Surface Width= 15.86'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 186.19 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 353.0' Slope= 0.0097 '/'
Inlet Invert= 804.71', Outlet Invert= 801.30'

‡

## Summary for Reach S4 R2: Swale S4 Reach 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af
Outflow = 20.91 cfs @ 12.16 hrs, Volume= 1.204 af, Atten= 12%, Lag= 1.8 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.70 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 0.63 fps, Avg. Travel Time= 16.0 min

Peak Storage= 4,652 cf @ 12.16 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 14.44'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 174.20 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 3.0 '/' Top Width= 24.00'
Length= 601.0' Slope= 0.0069 '/'
Inlet Invert= 806.43', Outlet Invert= 802.26'

‡

## Summary for Reach S4 R3: Swale S4 Reach 3

[62] Hint: Exceeded Reach S4 R2 OUTLET depth by 0.32' @ 12.25 hrs

Inflow Area = 8.711 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 41.60 cfs @ 12.14 hrs, Volume= 2.309 af
Outflow = 34.31 cfs @ 12.18 hrs, Volume= 2.309 af, Atten= 18%, Lag= 2.7 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.94 fps, Min. Travel Time= 5.4 min
Avg. Velocity = 0.64 fps, Avg. Travel Time= 24.5 min

Peak Storage= 11,027 cf @ 12.18 hrs
Average Depth at Peak Storage= 0.89' , Surface Width= 16.22'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 156.53 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 24.00'
Length= 946.0' Slope= 0.0056 '/'
Inlet Invert= 802.26', Outlet Invert= 796.96'

‡

## Summary for Reach S4 R4: Swale S4 Reach 4

[62] Hint: Exceeded Reach S4 R3 OUTLET depth by 0.96' @ 12.25 hrs

Inflow Area = 65.063 ac, 0.04% Impervious, Inflow Depth = 2.33" for 100-yr, 24-hr event
Inflow = 159.67 cfs @ 12.19 hrs, Volume= 12.653 af
Outflow = 157.44 cfs @ 12.21 hrs, Volume= 12.653 af, Atten= 1%, Lag= 1.3 min
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.29 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.12 fps, Avg. Travel Time= 7.2 min

Peak Storage= 14,379 cf @ 12.21 hrs
Average Depth at Peak Storage= 1.82' , Surface Width= 22.73'
Bank-Full Depth= 3.00' Flow Area= 61.5 sf, Capacity= 427.66 cfs

10.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 31.00'
Length= 483.0' Slope= 0.0082 '/'
Inlet Invert= 796.96', Outlet Invert= 793.00'

‡

## Summary for Reach S5 R2: Swale S5 Reach 2

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 1.20" for 100-yr, 24-hr event
Inflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af
Outflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Pond Sed Pond: Sedimentation Basin

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 2.25" for 100-yr, 24-hr event
Inflow = 164.77 cfs @ 12.20 hrs, Volume= 13.946 af
Outflow = 45.68 cfs @ 12.70 hrs, Volume= 13.947 af, Atten= 72%, Lag= 30.2 min
Discarded = 5.84 cfs @ 12.70 hrs, Volume= 7.167 af
Primary = 11.35 cfs @ 12.70 hrs, Volume= 4.914 af
Routed to Link Wetland : Wetland
Secondary = 22.50 cfs @ 12.70 hrs, Volume= 1.762 af
Routed to Link Wetland : Wetland
Tertiary = 6.00 cfs @ 12.70 hrs, Volume= 0.104 af
Routed to Link Wetland : Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Peak Elev= 793.06' @ 12.70 hrs Surf.Area= 70,052 sf Storage= 236,005 cf
Flood Elev= 794.00' Surf.Area= 75,797 sf Storage= 304,443 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 169.7 min ( 1,014.6 - 845.0 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 789.00' | 304,443 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 789.00 | 27,325 | 0 | 0 |
| 790.00 | 55,972 | 41,649 | 41,649 |
| 791.00 | 61,532 | 58,752 | 100,401 |
| 792.00 | 65,703 | 63,618 | 164,018 |
| 793.00 | 69,675 | 67,689 | 231,707 |
| 794.00 | 75,797 | 72,736 | 304,443 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 787.70' | **15.0" Round Culvert**<br>L= 40.0' RCP, mitered to conform to fill, Ke= 0.700<br>Inlet / Outlet Invert= 787.70' / 787.50' S= 0.0050 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 1.23 sf |
| #2 | Device 1 | 791.00' | **30.0" Horiz. Orifice/Grate** C= 0.600<br>Limited to weir flow at low heads |
| #3 | Device 1 | 790.50' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #4 | Device 1 | 790.00' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #5 | Device 1 | 789.00' | **0.5" Vert. Orifice/Grate X 14.00 columns**<br>X 6 rows with 6.0" cc spacing C= 0.600<br>Limited to weir flow at low heads |
| #6 | Secondary | 792.50' | **20.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #7 | Tertiary | 793.00' | **158.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #8 | Discarded | 789.00' | **3.600 in/hr Exfiltration over Surface area** |

**Discarded OutFlow** Max=5.84 cfs @ 12.70 hrs HW=793.06' (Free Discharge)
└**8=Exfiltration** (Exfiltration Controls 5.84 cfs)

**Primary OutFlow** Max=11.35 cfs @ 12.70 hrs HW=793.06' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 11.35 cfs @ 9.25 fps)
  ├**2=Orifice/Grate** (Passes < 33.94 cfs potential flow)
  ├**3=Orifice/Grate** (Passes < 0.11 cfs potential flow)
  ├**4=Orifice/Grate** (Passes < 0.12 cfs potential flow)
  └**5=Orifice/Grate** (Passes < 0.91 cfs potential flow)

**Secondary OutFlow** Max=22.49 cfs @ 12.70 hrs HW=793.06' TW=0.00' (Dynamic Tailwater)
└**6=Broad-Crested Rectangular Weir** (Weir Controls 22.49 cfs @ 2.00 fps)

**Tertiary OutFlow** Max=5.99 cfs @ 12.70 hrs HW=793.06' TW=0.00' (Dynamic Tailwater)
└**7=Broad-Crested Rectangular Weir** (Weir Controls 5.99 cfs @ 0.62 fps)

## Summary for Link C1: Culvert C1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 1.20" for 100-yr, 24-hr event
Inflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af
Primary = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S5 R2 : Swale S5 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C2: Culvert C2

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 3.23" for 100-yr, 24-hr event
Inflow = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af
Primary = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C3: Culvert C3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 2.58" for 100-yr, 24-hr event
Inflow = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af
Primary = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C4: Culvert C4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 2.61" for 100-yr, 24-hr event
Inflow = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af
Primary = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R5 : Swale S1 Reach 5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C5: Culvert C5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 2.43" for 100-yr, 24-hr event
Inflow = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af
Primary = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R6 : Swale S1 Reach 6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C6: Culvert C6

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 2.72" for 100-yr, 24-hr event
Inflow = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af
Primary = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R3 : Swale S3 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C7: Culvert C7

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 2.20" for 100-yr, 24-hr event
Inflow = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af
Primary = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C8: Culvert C8

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 1.76" for 100-yr, 24-hr event
Inflow = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af
Primary = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af, Atten= 0%, Lag= 0.0 min
Routed to Link North Area : North Area

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F1: Flume 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af
Primary = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC1 : Rock Chute 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F2: Flume 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af
Primary = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC2 : Rock Chute 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F3: Flume 3

Inflow Area = 5.923 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 32.10 cfs @ 12.12 hrs, Volume= 1.570 af
Primary = 32.10 cfs @ 12.12 hrs, Volume= 1.570 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F4: Flume 4

Inflow Area = 2.645 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 14.43 cfs @ 12.12 hrs, Volume= 0.701 af
Primary = 14.43 cfs @ 12.12 hrs, Volume= 0.701 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F5: Flume 5

Inflow Area = 4.601 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 25.31 cfs @ 12.12 hrs, Volume= 1.219 af
Primary = 25.31 cfs @ 12.12 hrs, Volume= 1.219 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R1 : Swale S3 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F6: Flume 6

Inflow Area = 3.717 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 20.36 cfs @ 12.12 hrs, Volume= 0.985 af
Primary = 20.36 cfs @ 12.12 hrs, Volume= 0.985 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F7: Existing East Flume

Inflow Area = 0.830 ac, 0.00% Impervious, Inflow Depth = 3.12" for 100-yr, 24-hr event
Inflow = 4.50 cfs @ 12.12 hrs, Volume= 0.216 af
Primary = 4.50 cfs @ 12.12 hrs, Volume= 0.216 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F8: Existing West Flume

Inflow Area = 3.122 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 16.40 cfs @ 12.13 hrs, Volume= 0.828 af
Primary = 16.40 cfs @ 12.13 hrs, Volume= 0.828 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link North Area: North Area

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 1.76" for 100-yr, 24-hr event
Inflow = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af
Primary = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC1: Rock Chute 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af
Primary = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC2: Rock Chute 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af
Primary = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R2 : Swale S4 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale 1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 2.23" for 100-yr, 24-hr event
Inflow = 62.73 cfs @ 12.20 hrs, Volume= 4.415 af
Primary = 62.73 cfs @ 12.20 hrs, Volume= 4.415 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R1 : Swale S2 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R1: Swale S1 Reach 1

Inflow Area = 0.691 ac, 0.00% Impervious, Inflow Depth = 2.23" for 100-yr, 24-hr event
Inflow = 2.68 cfs @ 12.12 hrs, Volume= 0.128 af
Primary = 2.68 cfs @ 12.12 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 3.07" for 100-yr, 24-hr event
Inflow = 37.05 cfs @ 12.12 hrs, Volume= 1.827 af
Primary = 37.05 cfs @ 12.12 hrs, Volume= 1.827 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 2.58" for 100-yr, 24-hr event
Inflow = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af
Primary = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af, Atten= 0%, Lag= 0.0 min
Routed to Link C3 : Culvert C3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R4: Swale S1 Reach 4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 2.61" for 100-yr, 24-hr event
Inflow = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af
Primary = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af, Atten= 0%, Lag= 0.0 min
Routed to Link C4 : Culvert C4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R5: Swale S1 Reach 5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 2.43" for 100-yr, 24-hr event
Inflow = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af
Primary = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af, Atten= 0%, Lag= 0.0 min
Routed to Link C5 : Culvert C5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R1: Swale S2 Reach 1

Inflow Area = 25.901 ac, 0.00% Impervious, Inflow Depth = 2.10" for 100-yr, 24-hr event
Inflow = 58.13 cfs @ 12.24 hrs, Volume= 4.525 af
Primary = 58.13 cfs @ 12.24 hrs, Volume= 4.525 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R2: Swale S2 Reach 2

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 2.20" for 100-yr, 24-hr event
Inflow = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af
Primary = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af, Atten= 0%, Lag= 0.0 min
Routed to Link C7 : Culvert C7

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R1: Swale S3 Reach 1

Inflow Area = 6.548 ac, 0.00% Impervious, Inflow Depth = 2.65" for 100-yr, 24-hr event
Inflow = 27.22 cfs @ 12.13 hrs, Volume= 1.447 af
Primary = 27.22 cfs @ 12.13 hrs, Volume= 1.447 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R2: Swale S3 Reach 2

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 2.72" for 100-yr, 24-hr event
Inflow = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af
Primary = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af, Atten= 0%, Lag= 0.0 min
Routed to Link C6 : Culvert C6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R3: Swale S3 Reach 3

Inflow Area = 14.511 ac, 0.00% Impervious, Inflow Depth = 2.36" for 100-yr, 24-hr event
Inflow = 47.45 cfs @ 12.15 hrs, Volume= 2.848 af
Primary = 47.45 cfs @ 12.15 hrs, Volume= 2.848 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S4 R4: Swale S4 Reach 4

Inflow Area = 67.064 ac, 0.04% Impervious, Inflow Depth = 2.29" for 100-yr, 24-hr event
Inflow = 157.92 cfs @ 12.21 hrs, Volume= 12.803 af
Primary = 157.92 cfs @ 12.21 hrs, Volume= 12.803 af, Atten= 0%, Lag= 0.0 min
Routed to Pond Sed Pond : Sedimentation Basin

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R1: Swale S5 Reach 1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 1.20" for 100-yr, 24-hr event
Inflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af
Primary = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min
Routed to Link C1 : Culvert C1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R2: Swale S5 Reach 2

Inflow Area = 5.851 ac, 12.83% Impervious, Inflow Depth = 1.48" for 100-yr, 24-hr event
Inflow = 12.65 cfs @ 12.14 hrs, Volume= 0.720 af
Primary = 12.65 cfs @ 12.14 hrs, Volume= 0.720 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R3: Swale S5 Reach 3

Inflow Area = 1.817 ac, 8.81% Impervious, Inflow Depth = 2.69" for 100-yr, 24-hr event
Inflow = 6.90 cfs @ 12.17 hrs, Volume= 0.408 af
Primary = 6.90 cfs @ 12.17 hrs, Volume= 0.408 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S6 R1: Swale S6 Reach 1

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 3.23" for 100-yr, 24-hr event
Inflow = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af
Primary = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af, Atten= 0%, Lag= 0.0 min
Routed to Link C2 : Culvert C2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Wetland: Wetland

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 1.09" for 100-yr, 24-hr event
Inflow = 39.85 cfs @ 12.70 hrs, Volume= 6.780 af
Primary = 39.85 cfs @ 12.70 hrs, Volume= 6.780 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

Swale Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No: | 1 of 2 |
| | | Calc. No. | |
| | | Rev. No. | 0 |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Swale Sizing | Chk'd: MJT | Date: 4/5/22 |

**Purpose:**

To size the proposed swale along Module 10 and 11 to accommodate the 25-year, 24-hour storm event and determine required rolled erosion control product. To confirm capacity of existing swale during closure condition.

**References:**

1. WisDOT Facilities Development Manual Chapter 13, Section 30-15 - Grass Lined Channels.
2. Design of Roadside Channels with Flexible Linings, HEC-15, USDOT FHWA.
3. HydroCAD Report_POO Landfill Closure
4. Table 7E-5.01: Typical Rolled Erosion Control Product Properties and Uses, Iowa SUDAS Design and Specifications Manual.

**Approach:**

Use the HydroCAD Model results to obtain the peak flow during a 25-year, 24-hour storm event.

Use Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2 (from Reference #1) to size the swale for each design swale cross section. The WisDOT spreadsheet incorporates the design guidelines and equations described in "Design of Roadside Channels with Flexible Linings", HEC-15, USDOT FHWA (Reference #2).

Confirm the swale is stable and has enough capacity for the design flow rate.

Use Table 7E-5.01 (see Reference #4) to select appropriate erosion control mat based on shear stress and application.

**Assumptions:**

1. Swales geometry shown on the drawing set.

2. Assume the following parameters per Section 15.2 - Grass Lining Properties from Reference #1:
   Vegetation Retardance Class = C for Swales
   Vegetation Condition = Good
   Vegetation Growth Form = Turf
3. Assume cohesive soil type with ASTM Soil Class SC and a Plasticity Index (PI) of 16.

**Calculations:**

From the HydroCAD Report, the 25-year, 24-hour peak discharge rates in the swales are

| Swales: | 25-year | | 25-year | | 25-year |
|---|---|---|---|---|---|
| **Swale S1 Reach 1=** | 1.37 cfs | **Swale S2 Reach 2=** | 52.2 cfs | **Swale S4 Reach 4=** | 80.1 cfs |
| **Swale S1 Reach 2=** | 21.7 cfs | **Swale S3 Reach 1=** | 15.9 cfs | **Swale S5 Reach 1=** | 2.1 cfs |
| **Swale S1 Reach 3=** | 27.4 cfs | **Swale S3 Reach 2=** | 27.9 cfs | **Swale S5 Reach 2=** | 4.7 cfs |
| **Swale S1 Reach 4=** | 35.4 cfs | **Swale S3 Reach 3=** | 26.7 cfs | **Swale S5 Reach 3=** | 3.8 cfs |
| **Swale S1 Reach 5=** | 35.2 cfs | **Swale S4 Reach 1*=** | cfs | **Swale S6 Reach 1=** | 9.7 cfs |
| **Swale S1 Reach 6=** | 33.2 cfs | **Swale S4 Reach 2*=** | cfs | | |
| **Swale S2 Reach 1=** | 30.0 cfs | **Swale S4 Reach 3*=** | cfs | | |

Use max. flow from Swale S1 reaches to confirm swale works since slope is constant.

*Use full Swale S4 Reach 4 for swale flow in Swale S4 reaches.

Use the WisDOT Grass Swale Design Spreadsheet (Page 2) to determine the flow depth, velocity and shear stress in the swales.

**Results:**

The swales are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

The swales are stable at the design flow rates.

Use Class I, Type B erosion mat.

| ***Channel/Ditch Geometry*** | **Swale S1** | **Swale S1 Reach 1** | **Swale S1 Reach 2** | **Swale S1 Reach 3** | **Swale S1 Reach 4** | **Swale S1 Reach 5** | **Swale S1 Reach 6** | **Swale S2 Reach 1** | **Swale S2 Reach 2** | **Swale S3 Reach 1** | **Swale S3 Reach 2** | **Swale S3 Reach 3** | **Swale S4 Reach 1** | **Swale S4 Reach 2** | **Swale S4 Reach 3** | **Swale S4 Reach 4** | **Swale S5 Reach 1** | **Swale S5 Reach 2** | **Swale S5 Reach 3** | **Swale S6 Reach 1** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Channel Slope, $S_1$ (ft/ft) | **0.0055** | **0.0053** | **0.0055** | **0.0051** | **0.0069** | **0.0053** | **0.0084** | **0.0020** | **0.0069** | **0.0070** | **0.0070** | **0.0097** | **0.0155** | **0.0069** | **0.0056** | **0.0082** | **0.0096** | **0.0024** | **0.0024** | **0.0066** |
| Channel Bottom Width, B (ft) | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **10** | **8** | **8** | **0** | **10** | **10** | **10** | **10** | **0** | **0** | **0** | **8** |
| Channel Side Slope, $z_1$ | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **2** | **2** | **4** | **4** | **4** | **4** | **4** | **6** | **6** | **6** | **2.5** |
| Channel Side Slope, $z_2$ | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **2** | **2** | **4** | **3** | **3** | **3** | **3** | **7** | **2.5** | **2.5** | **2.5** |
| Flow Depth, d (ft) Solve iteratively | **1.59** | **0.37** | **1.30** | **1.47** | **1.46** | **1.61** | **1.32** | **2.18** | **1.61** | **1.07** | **1.39** | **1.81** | **1.42** | **1.97** | **2.13** | **1.85** | **0.67** | **1.51** | **1.41** | **0.85** |
| Safety Factor, SF | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** |
| ***Vegetation/Soil Parameters*** | | | | | | | | | | | | | | | | | | | | |
| Vegetation Retardance Class | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** |
| Vegetation Condition | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** |
| Vegetation Growth Form | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** |
| Soil Type | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** |
| $D_{75}$ (in) (Set at 0.00 for cohesive soils) | | | | | | | | | | | | | | | | | | | | |
| ASTM Soil Class | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** |
| Plasticity Index, PI | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** |
| ***Results Summary*** | | | | | | | | | | | | | | | | | | | | |
| Design Q ($ft^3/s$) | **35.4** | **1.4** | **21.7** | **27.4** | **35.4** | **35.2** | **33.2** | **30.0** | **52.2** | **15.9** | **27.9** | **26.7** | **80.1** | **80.1** | **80.1** | **80.1** | **2.1** | **4.7** | **3.8** | **9.7** |
| 1. Swales geometry shown on the drawing set | 35.4 | 1.4 | 22.1 | 27.4 | 35.4 | 35.2 | 33.5 | 29.8 | 52.5 | 16.0 | 28.0 | 27.1 | 79.6 | 80.5 | 79.5 | 81.6 | 2.1 | 4.7 | 3.8 | 9.6 |
| Difference Between Design & Calc. Flow (%) | 0.2% | 0.2% | 1.9% | 0.0% | 0.1% | 0.0% | 1.0% | -0.4% | 0.6% | 0.5% | 0.6% | 1.6% | -0.6% | 0.5% | -0.7% | 1.8% | 0.0% | -0.3% | 0.2% | -0.5% |
| **Stable (Yes or No)** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** |
| ***Channel Parameters*** | | | | | | | | | | | | | | | | | | | | |
| Vegetation Height, h (ft) | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| Grass Roughness Coefficient, $C_n$ | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 |
| Cover Factor, $C_f$ | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| Noncohesive Soil | | | | | | | | | | | | | | | | | | | | |
| Soil Grain Roughness, $\eta_1$ | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 |
| Permissible Soil Shear Stress, $\tau_o$ ($lb/ft^2$) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Cohesive Soil | | | | | | | | | | | | | | | | | | | | |
| Porosity, e | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Soil Coefficient 1, $c_1$ | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 |
| Soil Coefficient 2, $c_2$ | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 |
| Soil Coefficient 3, $c_3$ | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 |
| Soil Coefficient 4, $c_4$ | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 |
| Soil Coefficient 5, $c_5$ | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 |
| Soil Coefficient 6, $c_6$ | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 |
| Permissible Soil Shear Stress, $\tau_o$ ($lb/ft^2$) | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 |
| Total Permissible Shear Stress, $\tau_p$ ($lb/ft^2$) | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 |
| Cross Sectional Area, A ($ft^2$) | 22.832 | 3.453 | 17.160 | 20.404 | 20.206 | 23.248 | 17.530 | 36.450 | 26.468 | 10.850 | 14.984 | 13.104 | 21.257 | 33.283 | 37.179 | 30.479 | 2.874 | 9.690 | 8.449 | 8.606 |
| Wetted Perimeter, P (ft) | 21.11 | 11.01 | 18.72 | 20.12 | 20.04 | 21.28 | 18.88 | 25.98 | 23.28 | 12.79 | 14.22 | 14.93 | 20.35 | 24.35 | 25.52 | 23.48 | 8.75 | 13.25 | 12.37 | 12.58 |
| Hydraulic Radius, R (ft) | 1.082 | 0.314 | 0.917 | 1.014 | 1.008 | 1.093 | 0.928 | 1.403 | 1.137 | 0.849 | 1.054 | 0.878 | 1.045 | 1.367 | 1.457 | 1.298 | 0.329 | 0.731 | 0.683 | 0.684 |
| Top Width, T (ft) | 20.72 | 10.92 | 18.40 | 19.76 | 19.68 | 20.88 | 18.56 | 25.44 | 22.88 | 12.28 | 13.56 | 14.48 | 19.94 | 23.79 | 24.91 | 22.95 | 8.65 | 12.84 | 11.99 | 12.25 |
| Hydraulic Depth, D (ft) | 1.102 | 0.316 | 0.933 | 1.033 | 1.027 | 1.113 | 0.944 | 1.433 | 1.157 | 0.884 | 1.105 | 0.905 | 1.066 | 1.399 | 1.493 | 1.328 | 0.333 | 0.755 | 0.705 | 0.703 |
| Froude Number (Q design) | 0.261 | 0.125 | 0.235 | 0.233 | 0.305 | 0.253 | 0.347 | 0.121 | 0.325 | 0.276 | 0.314 | 0.383 | 0.639 | 0.360 | 0.309 | 0.409 | 0.219 | 0.098 | 0.094 | 0.235 |
| Channel Shear Stress, $\tau_o$ ($lb/ft^2$) | 0.37 | 0.10 | 0.31 | 0.32 | 0.43 | 0.36 | 0.49 | 0.18 | 0.49 | 0.37 | 0.46 | 0.53 | 1.01 | 0.59 | 0.51 | 0.66 | 0.20 | 0.11 | 0.10 | 0.28 |
| Actual Sheer Stress, $\tau_d$ ($lb/ft^2$) | 0.55 | 0.12 | 0.45 | 0.47 | 0.63 | 0.53 | 0.69 | 0.27 | 0.69 | 0.47 | 0.61 | 1.10 | 1.37 | 0.85 | 0.74 | 0.95 | 0.40 | 0.23 | 0.21 | 0.35 |
| Mannings n | 0.075 | 0.126 | 0.081 | 0.080 | 0.071 | 0.076 | 0.068 | 0.102 | 0.068 | 0.076 | 0.069 | 0.065 | 0.051 | 0.063 | 0.067 | 0.060 | 0.097 | 0.123 | 0.126 | 0.084 |
| Average Velocity, V (ft/s) | 1.55 | 0.40 | 1.26 | 1.34 | 1.75 | 1.51 | 1.89 | 0.82 | 1.97 | 1.46 | 1.86 | 2.04 | 3.77 | 2.41 | 2.15 | 2.63 | 0.72 | 0.48 | 0.45 | 1.12 |
| Calculated Flow, Q ($ft^3/s$) | 35.4 | 1.4 | 22.1 | 27.4 | 35.4 | 35.2 | 33.5 | 29.8 | 52.5 | 16.0 | 28.0 | 27.1 | 79.6 | 80.5 | 79.5 | 81.6 | 2.1 | 4.7 | 3.8 | 9.6 |
| Difference Between Design & Calc. Flow (%) | 0.2% | 0.2% | 1.9% | 0.0% | 0.1% | 0.0% | 1.0% | -0.4% | 0.6% | 0.5% | 0.6% | 1.6% | -0.6% | 0.5% | -0.7% | 1.8% | 0.0% | -0.3% | 0.2% | -0.5% |
| Effective Shear on Soil Surface, $\tau_e$ ($lb/ft^2$) | 0.002 | 0.000 | 0.002 | 0.002 | 0.003 | 0.002 | 0.004 | 0.001 | 0.004 | 0.002 | 0.003 | 0.007 | 0.014 | 0.005 | 0.004 | 0.007 | 0.001 | 0.000 | 0.000 | 0.001 |
| Total Permissible Shear on Veg., $\tau_{p,veg}$ ($lb/ft^2$) | 17.60 | 49.69 | 20.53 | 20.03 | 15.78 | 18.08 | 14.47 | 32.56 | 14.47 | 18.08 | 14.90 | 13.22 | 8.14 | 12.42 | 14.05 | 11.27 | 29.45 | 47.35 | 49.69 | 22.08 |
| Stable (Y or N) | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |

Source: Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2

## Non-Channel Erosion Mat
(1052)

Wisconsin Department of Natural Resources
Conservation Practice Standard

To differentiate applications Erosion mats are organized into three Classes of mats, which are further broken down into various Types.

A. **Class I**: A short-term duration (minimum of 6 months), light duty, organic mat with photodegradable plastic or biodegradable netting.

   1. **Type A** – Use on erodible slopes 2.5:1 or flatter.

   2. **Type B** – Double netted product for use on erodible slopes 2:1 or flatter.

B. **Class I, Urban**: A short-term duration (minimum of 6 months), light duty, organic erosion control mat for areas where mowing may be accomplished within two weeks after installation.

   1. **Urban, Type A** – Use on erodible soils with slopes 4:1 or flatter.

   2. **Urban, Type B** – A double netted product for use on slopes 2.5:1 or flatter.

C. **Class II**: A long-term duration (three years or greater), organic erosion control revegetative mat.

   1. **Type A** – Jute fiber only for use on slopes 2:1 or flatter for sod reinforcement.

   2. **Type B** – For use on slopes 2:1 or greater made with plastic or biodegradable net.

   3. **Type C** – A woven mat of 100% organic fibers for use on slopes 2:1 or flatter and in environmentally and biologically sensitive areas where plastic netting is inappropriate.

D. **Class III**: A permanent 100% synthetic ECRM or TRM. Either a soil stabilizer Type A or Class I, Type A or B erosion mat must be placed over the soil filled TRM.

   1. **Type A** – An ECRM for use on slopes 2:1 or flatter.

   2. **Type B or C** – A TRM for use on slopes 2:1 or flatter.

   3. **Type D** – A TRM for use on slopes 1:1 or flatter.

## Channel Erosion Mat
(1053)

Wisconsin Department of Natural Resources
Conservation Practice Standard

To differentiate applications WisDOT organizes erosion mats into three classes of mats, which are further broken down into various Types.

A. **Class I**: A short-term duration (minimum of 6 months), light duty, organic ECRM with plastic or biodegradable netting.

   1. **Type A** – Only suitable for slope applications, not channel applications.

   2. **Type B** – Double netted product for use in channels where the calculated (design) shear stress is 1.5 lbs/ft$^2$ or less.

B. **Class II**: A long-term duration (three years or greater), organic ECRM.

   1. **Type A** – Jute fiber only for use in channels to reinforce sod.

   2. **Type B** – For use in channels where the calculated (design) shear stress is 2.0 lbs/ft$^2$ or less. Made with plastic or biodegradable mat.

   3. **Type C** – A woven mat of 100% organic material for use in channels where the calculated (design) shear stress is 2.0 lbs/ft$^2$ or less. Applicable for use in environmentally sensitive areas where plastic netting is inappropriate.

C. **Class III**: A permanent 100% synthetic ECRM or TRM. Class I, Type B erosion mat or Class II, Type B or C erosion mat must be placed over a soil filled TRM.

   1. **Type A** – An ECRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft$^2$ or less.

   2. **Type B** – A TRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft$^2$ or less.

   3. **Type C** – A TRM for use in channels where the calculated (design) shear stress of 3.5 lbs/ft$^2$ or less.

   4. **Type D** – A TRM for use in channels where the calculated (design) shear stress of 5.0 lbs/ft$^2$ or less.

# Culvert Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| Sheet No: 1/7 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: COL - POO | By: RJG | Date: 4/7/22 |
| Client: WPL | Subject: Culvert Sizing | Chk'd: MJT | Date: |

**Purpose:**

To size the post closure culverts to accommodate the 25-year, 24-hour storm event.

**References:**

1. HY-8 7.40 Computer Model
2. HydroCAD Report_Post Construction and HydroCAD Report_Post Construction Temporary Culvert
3. Figure 1 - Storm Water Post Construction

**Approach:**

1. Create culvert crossing in HY-8 and input data from Reference #2 and #3.
2. Adjust diameter size and number of culverts in model until design flow does not over top berm/road crossing.

**Assumptions:**

1. Assume the tailwater channel data is a based on discharge swale or rock chute geometry (Reference #2).
2. Culverts are circular, PE Pipe with smooth interior, and with square edge with headwall.
3. Culvert elevatons,lengths, and slopes based on Figure 1 (Reference #3).
4. Roadwa data for crossing based on Figure 1 (Reference #3).
5. Discharge flows from HydroCAD report (Refence #2).

**Calculations:**

See attached HY-8 Model output reports.

**Results:**

The culverts are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

| Culvert | Dia. (ft) | # of Barrels | Upstream Invert (ft) | Downstream Invert (ft) | Slope (%) | Length (ft) |
|---|---|---|---|---|---|---|
| C1 | 2 | 1 | 815.70 | 814.55 | 2.22 | 52 |
| C2 | 1.5 | 2 | 814.40 | 814.20 | 0.49 | 41 |
| C3 | 2.5 | 2 | 811.17 | 811.16 | 0.02 | 50 |
| C4 | 2.5 | 2 | 809.87 | 809.74 | 0.26 | 50 |
| C5 | 2.5 | 2 | 807.57 | 807.15 | 0.84 | 50 |
| C6 | 2 | 2 | 805.40 | 804.76 | 0.61 | 105 |
| C7 | 3.5 | 2 | 796.64 | 796.34 | 0.50 | 60 |
| C8 | 2 | 1 | 807.54 | 806.81 | 0.73 | 100 |

# HY-8 Culvert Analysis Report _ Culvert C1

## Site Data - Culvert C1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 815.70 ft

Outlet Station: 51.88 ft

Outlet Elevation: 814.55 ft

Number of Barrels: 1

## Culvert Data Summary - Culvert C1

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Crossing Discharge Data

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

Minimum Flow: 2.06 cfs

Design Flow: 2.06 cfs

Maximum Flow: 7.48 cfs

## Tailwater Channel Data - Culvert C1

Tailwater Channel Option: Triangular Channel

Side Slope (H:V): 6.00 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0300

Channel Invert Elevation: 815.32 ft

## Table 1 - Culvert Summary Table: Culvert C1

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.06 | 2.06 | 816.37 | 0.670 | 0.0* | 1-JS1t | 0.321 | 0.498 | 1.127 | 0.357 | 1.129 | 2.695 |
| 2.60 | 2.60 | 816.46 | 0.758 | 0.031 | 1-JS1t | 0.361 | 0.562 | 1.160 | 0.390 | 1.378 | 2.857 |
| 3.14 | 3.14 | 816.54 | 0.838 | 0.070 | 1-JS1t | 0.396 | 0.619 | 1.188 | 0.418 | 1.616 | 2.995 |
| 3.69 | 3.69 | 816.61 | 0.912 | 0.108 | 1-JS1t | 0.428 | 0.672 | 1.214 | 0.444 | 1.847 | 3.117 |
| 4.23 | 4.23 | 816.68 | 0.982 | 0.145 | 1-JS1t | 0.459 | 0.722 | 1.237 | 0.467 | 2.072 | 3.226 |
| 4.77 | 4.77 | 816.76 | 1.058 | 0.182 | 1-S2n | 0.487 | 0.768 | 0.503 | 0.489 | 7.698 | 3.324 |
| 5.31 | 5.31 | 816.83 | 1.134 | 0.220 | 1-S2n | 0.515 | 0.813 | 0.533 | 0.509 | 7.895 | 3.415 |
| 5.85 | 5.85 | 816.91 | 1.206 | 0.258 | 1-S2n | 0.541 | 0.855 | 0.562 | 0.528 | 8.081 | 3.499 |
| 6.40 | 6.40 | 816.98 | 1.275 | 0.298 | 1-S2n | 0.566 | 0.895 | 0.590 | 0.546 | 8.262 | 3.577 |
| 6.94 | 6.94 | 817.04 | 1.342 | 0.338 | 1-S2n | 0.590 | 0.934 | 0.617 | 0.563 | 8.416 | 3.651 |
| 7.48 | 7.48 | 817.11 | 1.406 | 0.379 | 1-S2n | 0.614 | 0.972 | 0.643 | 0.579 | 8.566 | 3.720 |

* Full Flow Headwater elevation is below inlet invert.

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Straight Culvert

Inlet Elevation (invert): 815.70 ft, Outlet Elevation (invert): 814.55 ft

Culvert Length: 51.89 ft, Culvert Slope: 0.0222

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C1**

| Headwater Elevation (ft) | Total Discharge (cfs) | Culvert C1 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 816.37 | 2.06 | 2.06 | 0.00 | 1 |
| 816.46 | 2.60 | 2.60 | 0.00 | 1 |
| 816.54 | 3.14 | 3.14 | 0.00 | 1 |
| 816.61 | 3.69 | 3.69 | 0.00 | 1 |
| 816.68 | 4.23 | 4.23 | 0.00 | 1 |
| 816.76 | 4.77 | 4.77 | 0.00 | 1 |
| 816.83 | 5.31 | 5.31 | 0.00 | 1 |
| 816.91 | 5.85 | 5.85 | 0.00 | 1 |
| 816.98 | 6.40 | 6.40 | 0.00 | 1 |
| 817.04 | 6.94 | 6.94 | 0.00 | 1 |
| 817.11 | 7.48 | 7.48 | 0.00 | 1 |
| 819.06 | 22.61 | 22.61 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C2

## Site Data - C2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 814.40 ft

Outlet Station: 41.00 ft

Outlet Elevation: 814.20 ft

Number of Barrels: 2

## Culvert Data Summary - C2

Barrel Shape: Circular

Barrel Diameter: 1.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C2

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 814.10 ft

## Crossing Discharge Data

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

Minimum Flow: 9.68 cfs

Design Flow: 9.68 cfs

Maximum Flow: 13.45 cfs

## Table 1 - Culvert Summary Table: C2

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.68 | 9.68 | 815.67 | 1.271 | 0.199 | 1-S2n | 0.767 | 0.842 | 0.767 | 0.499 | 4.728 | 1.939 |
| 10.06 | 10.06 | 815.70 | 1.302 | 0.926 | 1-S2n | 0.786 | 0.858 | 0.786 | 0.510 | 4.769 | 1.963 |
| 10.43 | 10.43 | 815.73 | 1.333 | 0.966 | 1-S2n | 0.805 | 0.877 | 0.805 | 0.521 | 4.807 | 1.987 |
| 10.81 | 10.81 | 815.76 | 1.364 | 1.003 | 1-S2n | 0.824 | 0.893 | 0.824 | 0.531 | 4.842 | 2.010 |
| 11.19 | 11.19 | 815.79 | 1.395 | 1.041 | 1-S2n | 0.843 | 0.909 | 0.843 | 0.542 | 4.871 | 2.032 |
| 11.57 | 11.57 | 815.83 | 1.426 | 1.079 | 1-S2n | 0.863 | 0.924 | 0.863 | 0.552 | 4.899 | 2.053 |
| 11.94 | 11.94 | 815.86 | 1.457 | 1.117 | 1-S2n | 0.882 | 0.939 | 0.882 | 0.562 | 4.943 | 2.074 |
| 12.32 | 12.32 | 815.89 | 1.489 | 1.156 | 1-S2n | 0.902 | 0.954 | 0.902 | 0.572 | 4.973 | 2.095 |
| 12.70 | 12.70 | 815.92 | 1.521 | 1.196 | 5-S2n | 0.921 | 0.968 | 0.921 | 0.581 | 5.001 | 2.115 |
| 13.07 | 13.07 | 815.95 | 1.553 | 1.240 | 5-S2n | 0.941 | 0.987 | 0.941 | 0.591 | 5.028 | 2.134 |
| 13.45 | 13.45 | 815.99 | 1.586 | 1.281 | 5-S2n | 0.962 | 1.001 | 0.962 | 0.600 | 5.048 | 2.153 |

**********

Straight Culvert

Inlet Elevation (invert): 814.40 ft, Outlet Elevation (invert): 814.20 ft

Culvert Length: 41.00 ft, Culvert Slope: 0.0049

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C2**

| Headwater Elevation (ft) | Total Discharge (cfs) | C2 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 815.67 | 9.68 | 9.68 | 0.00 | 1 |
| 815.70 | 10.06 | 10.06 | 0.00 | 1 |
| 815.73 | 10.43 | 10.43 | 0.00 | 1 |
| 815.76 | 10.81 | 10.81 | 0.00 | 1 |
| 815.79 | 11.19 | 11.19 | 0.00 | 1 |
| 815.83 | 11.57 | 11.57 | 0.00 | 1 |
| 815.86 | 11.94 | 11.94 | 0.00 | 1 |
| 815.89 | 12.32 | 12.32 | 0.00 | 1 |
| 815.92 | 12.70 | 12.70 | 0.00 | 1 |
| 815.95 | 13.07 | 13.07 | 0.00 | 1 |
| 815.99 | 13.45 | 13.45 | 0.00 | 1 |
| 816.90 | 21.79 | 21.79 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C3

## Site Data - C3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 811.17 ft

Outlet Station: 50.00 ft

Outlet Elevation: 811.16 ft

Number of Barrels: 2

## Culvert Data Summary - C3

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C3

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 811.17 ft

## Crossing Discharge Data

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

Minimum Flow: 27.38 cfs

Design Flow: 27.38 cfs

Maximum Flow: 47.76 cfs

## Table 1 - Culvert Summary Table: C3

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.38 | 27.38 | 813.15 | 1.836 | 1.981 | 7-H2c | -1.000 | 1.245 | 1.245 | 0.886 | 5.607 | 2.677 |
| 29.42 | 29.42 | 813.23 | 1.918 | 2.064 | 7-H2c | -1.000 | 1.292 | 1.292 | 0.921 | 5.745 | 2.735 |
| 31.46 | 31.46 | 813.32 | 1.998 | 2.147 | 7-H2c | -1.000 | 1.339 | 1.339 | 0.954 | 5.878 | 2.789 |
| 33.49 | 33.49 | 813.40 | 2.077 | 2.228 | 7-H2c | -1.000 | 1.383 | 1.383 | 0.987 | 6.009 | 2.841 |
| 35.53 | 35.53 | 813.48 | 2.155 | 2.308 | 7-H2c | -1.000 | 1.427 | 1.427 | 1.018 | 6.137 | 2.891 |
| 37.57 | 37.46 | 813.55 | 2.229 | 2.384 | 7-H2c | -1.000 | 1.467 | 1.467 | 1.049 | 6.257 | 2.938 |
| 39.61 | 38.68 | 813.60 | 2.276 | 2.431 | 7-H2c | -1.000 | 1.492 | 1.492 | 1.078 | 6.332 | 2.983 |
| 41.65 | 39.64 | 813.64 | 2.312 | 2.468 | 7-H2c | -1.000 | 1.511 | 1.511 | 1.107 | 6.391 | 3.027 |
| 43.68 | 40.50 | 813.67 | 2.345 | 2.502 | 7-H2c | -1.000 | 1.528 | 1.528 | 1.135 | 6.443 | 3.068 |
| 45.72 | 41.26 | 813.70 | 2.374 | 2.531 | 7-H2c | -1.000 | 1.543 | 1.543 | 1.163 | 6.490 | 3.109 |
| 47.76 | 42.00 | 813.73 | 2.403 | 2.559 | 7-H2c | -1.000 | 1.557 | 1.557 | 1.189 | 6.534 | 3.148 |

**********

Straight Culvert

Inlet Elevation (invert): 811.17 ft, Outlet Elevation (invert): 811.16 ft

Culvert Length: 50.00 ft, Culvert Slope: 0.0002

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**Table 2 - Summary of Culvert Flows at Crossing: Culvert C3**

| Headwater Elevation (ft) | Total Discharge (cfs) | C3 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 813.15 | 27.38 | 27.38 | 0.00 | 1 |
| 813.23 | 29.42 | 29.42 | 0.00 | 1 |
| 813.32 | 31.46 | 31.46 | 0.00 | 1 |
| 813.40 | 33.49 | 33.49 | 0.00 | 1 |
| 813.48 | 35.53 | 35.53 | 0.00 | 1 |
| 813.55 | 37.57 | 37.46 | 0.02 | 10 |
| 813.60 | 39.61 | 38.68 | 0.85 | 6 |
| 813.64 | 41.65 | 39.64 | 1.94 | 5 |
| 813.67 | 43.68 | 40.50 | 3.15 | 5 |
| 813.70 | 45.72 | 41.26 | 4.38 | 4 |
| 813.73 | 47.76 | 42.00 | 5.71 | 4 |
| 813.55 | 37.37 | 37.37 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C4

## Site Data - C4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 809.87 ft

Outlet Station: 50.00 ft

Outlet Elevation: 809.74 ft

Number of Barrels: 2

## Culvert Data Summary - C4

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C4

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0070

Channel Manning's n: 0.0300

Channel Invert Elevation: 809.87 ft

## Crossing Discharge Data

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

Minimum Flow: 35.39 cfs

Design Flow: 35.39 cfs

Maximum Flow: 62.23 cfs

## Table 1 - Culvert Summary Table: C4

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 35.39 | 35.39 | 812.13 | 2.147 | 2.263 | 2-M2c | 1.660 | 1.424 | 1.424 | 0.929 | 6.128 | 3.252 |
| 38.07 | 38.07 | 812.24 | 2.249 | 2.365 | 2-M2c | 1.752 | 1.479 | 1.479 | 0.966 | 6.295 | 3.322 |
| 40.76 | 40.41 | 812.32 | 2.338 | 2.454 | 2-M2c | 1.837 | 1.526 | 1.526 | 1.002 | 6.438 | 3.389 |
| 43.44 | 41.81 | 812.38 | 2.392 | 2.507 | 7-M2c | 1.891 | 1.553 | 1.553 | 1.036 | 6.523 | 3.453 |
| 46.13 | 42.96 | 812.42 | 2.437 | 2.550 | 7-M2c | 1.938 | 1.575 | 1.575 | 1.069 | 6.593 | 3.513 |
| 48.81 | 44.01 | 812.46 | 2.478 | 2.589 | 7-M2c | 1.983 | 1.595 | 1.595 | 1.102 | 6.656 | 3.571 |
| 51.49 | 44.95 | 812.49 | 2.515 | 2.624 | 7-M2c | 2.027 | 1.613 | 1.613 | 1.133 | 6.713 | 3.627 |
| 54.18 | 45.85 | 812.53 | 2.550 | 2.658 | 7-M2c | 2.073 | 1.629 | 1.629 | 1.163 | 6.767 | 3.680 |
| 56.86 | 46.71 | 812.56 | 2.585 | 2.691 | 7-M2c | 2.121 | 1.645 | 1.645 | 1.193 | 6.819 | 3.731 |
| 59.55 | 47.53 | 812.59 | 2.617 | 2.721 | 7-M2c | 2.174 | 1.660 | 1.660 | 1.222 | 6.868 | 3.781 |
| 62.23 | 48.31 | 812.62 | 2.649 | 2.751 | 7-M2c | 2.500 | 1.674 | 1.674 | 1.250 | 6.915 | 3.828 |

**********

Straight Culvert

Inlet Elevation (invert): 809.87 ft, Outlet Elevation (invert): 809.74 ft

Culvert Length: 50.00 ft, Culvert Slope: 0.0026

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C4**

| Headwater Elevation (ft) | Total Discharge (cfs) | C4 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 812.13 | 35.39 | 35.39 | 0.00 | 1 |
| 812.24 | 38.07 | 38.07 | 0.00 | 1 |
| 812.32 | 40.76 | 40.41 | 0.26 | 9 |
| 812.38 | 43.44 | 41.81 | 1.56 | 6 |
| 812.42 | 46.13 | 42.96 | 3.08 | 5 |
| 812.46 | 48.81 | 44.01 | 4.75 | 5 |
| 812.49 | 51.49 | 44.95 | 6.46 | 4 |
| 812.53 | 54.18 | 45.85 | 8.25 | 4 |
| 812.56 | 56.86 | 46.71 | 10.10 | 4 |
| 812.59 | 59.55 | 47.53 | 11.98 | 4 |
| 812.62 | 62.23 | 48.31 | 13.89 | 4 |
| 812.30 | 39.78 | 39.78 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C5

## Site Data - C5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 807.57 ft

Outlet Station: 50.00 ft

Outlet Elevation: 807.15 ft

Number of Barrels: 2

## Culvert Data Summary - C5

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C5

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 807.59 ft

## Crossing Discharge Data

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

Minimum Flow: 35.21 cfs

Design Flow: 35.21 cfs

Maximum Flow: 65.15 cfs

## Table 1 - Culvert Summary Table: C5

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 35.21 | 35.21 | 809.70 | 2.133 | 1.411 | 1-S2n | 1.148 | 1.420 | 1.190 | 1.013 | 7.642 | 2.883 |
| 38.20 | 38.20 | 809.82 | 2.247 | 1.523 | 1-S2n | 1.203 | 1.482 | 1.248 | 1.058 | 7.801 | 2.952 |
| 41.20 | 41.20 | 809.93 | 2.362 | 1.638 | 1-S2n | 1.257 | 1.541 | 1.305 | 1.101 | 7.950 | 3.017 |
| 44.19 | 44.19 | 810.05 | 2.478 | 1.773 | 1-S2n | 1.311 | 1.598 | 1.360 | 1.142 | 8.093 | 3.079 |
| 47.19 | 47.19 | 810.17 | 2.596 | 1.912 | 5-S2n | 1.364 | 1.654 | 1.415 | 1.182 | 8.230 | 3.137 |
| 50.18 | 50.18 | 810.29 | 2.719 | 2.054 | 5-S2n | 1.417 | 1.707 | 1.470 | 1.220 | 8.362 | 3.193 |
| 53.17 | 53.17 | 810.42 | 2.846 | 2.199 | 5-S2n | 1.470 | 1.758 | 1.523 | 1.257 | 8.490 | 3.246 |
| 56.17 | 55.74 | 810.53 | 2.959 | 2.326 | 5-S2n | 1.516 | 1.800 | 1.569 | 1.294 | 8.595 | 3.296 |
| 59.16 | 57.10 | 810.59 | 3.021 | 2.395 | 5-S2n | 1.541 | 1.822 | 1.593 | 1.329 | 8.650 | 3.345 |
| 62.16 | 58.20 | 810.64 | 3.072 | 2.451 | 5-S2n | 1.561 | 1.839 | 1.613 | 1.363 | 8.693 | 3.391 |
| 65.15 | 59.19 | 810.69 | 3.118 | 2.501 | 5-S2n | 1.578 | 1.854 | 1.630 | 1.396 | 8.732 | 3.436 |

**********

Straight Culvert

Inlet Elevation (invert): 807.57 ft, Outlet Elevation (invert): 807.15 ft

Culvert Length: 50.00 ft, Culvert Slope: 0.0084

**********

## Table 24 - Summary of Culvert Flows at Crossing: Culvert C5

| Headwater Elevation (ft) | Total Discharge (cfs) | C5 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 809.70 | 35.21 | 35.21 | 0.00 | 1 |
| 809.82 | 38.20 | 38.20 | 0.00 | 1 |
| 809.93 | 41.20 | 41.20 | 0.00 | 1 |
| 810.05 | 44.19 | 44.19 | 0.00 | 1 |
| 810.17 | 47.19 | 47.19 | 0.00 | 1 |
| 810.29 | 50.18 | 50.18 | 0.00 | 1 |
| 810.42 | 53.17 | 53.17 | 0.00 | 1 |
| 810.53 | 56.17 | 55.74 | 0.36 | 10 |
| 810.59 | 59.16 | 57.10 | 1.98 | 6 |
| 810.64 | 62.16 | 58.20 | 3.88 | 5 |
| 810.69 | 65.15 | 59.19 | 5.92 | 5 |
| 810.50 | 55.08 | 55.08 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C6

## Site Data - C6

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 805.40 ft

Outlet Station: 104.56 ft

Outlet Elevation: 804.76 ft

Number of Barrels: 2

## Culvert Data Summary - C6

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Mitered to Conform to Slope

Inlet Depression: None

## Crossing Discharge Data

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

Minimum Flow: 27.86 cfs

Design Flow: 27.86 cfs

Maximum Flow: 47.83 cfs

## Tailwater Channel Data - Culvert C6

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0070

Channel Manning's n: 0.0300

Channel Invert Elevation: 804.56 ft

## Table 1 - Culvert Summary Table: C6

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.86 | 27.86 | 807.61 | 2.214 | 1.559 | 5-S2n | 1.263 | 1.344 | 1.263 | 0.769 | 6.666 | 3.141 |
| 29.86 | 29.86 | 807.76 | 2.362 | 1.734 | 5-S2n | 1.325 | 1.392 | 1.325 | 0.800 | 6.758 | 3.216 |
| 31.85 | 31.85 | 807.92 | 2.520 | 1.916 | 5-S2n | 1.390 | 1.439 | 1.391 | 0.831 | 6.829 | 3.287 |
| 33.85 | 33.85 | 808.09 | 2.689 | 2.105 | 5-S2n | 1.458 | 1.483 | 1.458 | 0.861 | 6.901 | 3.355 |
| 35.85 | 35.85 | 808.27 | 2.869 | 2.806 | 7-M2c | 1.531 | 1.525 | 1.525 | 0.890 | 6.973 | 3.420 |
| 37.84 | 37.84 | 808.46 | 3.061 | 2.896 | 7-M2c | 1.613 | 1.565 | 1.565 | 0.918 | 7.174 | 3.483 |
| 39.84 | 39.00 | 808.58 | 3.176 | 2.950 | 7-M2c | 1.669 | 1.587 | 1.587 | 0.946 | 7.293 | 3.543 |
| 41.84 | 39.67 | 808.64 | 3.245 | 2.982 | 7-M2c | 1.705 | 1.600 | 1.600 | 0.973 | 7.363 | 3.601 |
| 43.84 | 40.22 | 808.70 | 3.302 | 3.010 | 7-M2c | 1.740 | 1.610 | 1.610 | 0.999 | 7.421 | 3.656 |
| 45.83 | 40.73 | 808.76 | 3.356 | 3.038 | 7-M2c | 1.780 | 1.619 | 1.619 | 1.025 | 7.474 | 3.710 |
| 47.83 | 41.19 | 808.80 | 3.404 | 3.064 | 7-M2c | 2.000 | 1.627 | 1.627 | 1.051 | 7.523 | 3.762 |

**********

Straight Culvert

Inlet Elevation (invert): 805.40 ft, Outlet Elevation (invert): 804.76 ft

Culvert Length: 104.56 ft, Culvert Slope: 0.0061

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C6**

| Headwater Elevation (ft) | Total Discharge (cfs) | C6 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 807.61 | 27.86 | 27.86 | 0.00 | 1 |
| 807.76 | 29.86 | 29.86 | 0.00 | 1 |
| 807.92 | 31.85 | 31.85 | 0.00 | 1 |
| 808.09 | 33.85 | 33.85 | 0.00 | 1 |
| 808.27 | 35.85 | 35.85 | 0.00 | 1 |
| 808.46 | 37.84 | 37.84 | 0.00 | 1 |
| 808.58 | 39.84 | 39.00 | 0.80 | 8 |
| 808.64 | 41.84 | 39.67 | 2.13 | 6 |
| 808.70 | 43.84 | 40.22 | 3.56 | 5 |
| 808.76 | 45.83 | 40.73 | 5.07 | 5 |
| 808.80 | 47.83 | 41.19 | 6.62 | 5 |
| 808.50 | 38.24 | 38.24 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C7

## Site Data - C7

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 796.64 ft

Outlet Station: 60.20 ft

Outlet Elevation: 796.34 ft

Number of Barrels: 2

## Culvert Data Summary - C7

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C7

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0300

Channel Invert Elevation: 795.60 ft

## Crossing Discharge Data

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

Minimum Flow: 52.15 cfs

Design Flow: 52.15 cfs

Maximum Flow: 103.37 cfs

## Table 1 - Culvert Summary Table: C7

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52.15 | 52.15 | 799.12 | 2.228 | 2.484 | 2-M2c | 2.109 | 1.572 | 1.572 | 0.943 | 6.224 | 4.017 |
| 57.27 | 57.27 | 799.26 | 2.356 | 2.622 | 2-M2c | 2.247 | 1.651 | 1.651 | 0.992 | 6.414 | 4.133 |
| 62.39 | 62.39 | 799.40 | 2.481 | 2.756 | 2-M2c | 2.389 | 1.727 | 1.727 | 1.039 | 6.596 | 4.241 |
| 67.52 | 67.52 | 799.53 | 2.604 | 2.889 | 2-M2c | 2.539 | 1.800 | 1.800 | 1.084 | 6.773 | 4.342 |
| 72.64 | 72.64 | 799.66 | 2.725 | 3.019 | 2-M2c | 2.703 | 1.870 | 1.870 | 1.128 | 6.945 | 4.438 |
| 77.76 | 77.76 | 799.79 | 2.846 | 3.148 | 2-M2c | 2.898 | 1.938 | 1.938 | 1.170 | 7.112 | 4.528 |
| 82.88 | 82.88 | 799.92 | 2.966 | 3.277 | 2-M2c | 3.500 | 2.004 | 2.004 | 1.210 | 7.277 | 4.614 |
| 88.00 | 88.00 | 800.04 | 3.086 | 3.405 | 2-M2c | 3.500 | 2.067 | 2.067 | 1.250 | 7.439 | 4.696 |
| 93.13 | 93.13 | 800.17 | 3.207 | 3.534 | 7-M2c | 3.500 | 2.129 | 2.129 | 1.288 | 7.599 | 4.774 |
| 98.25 | 98.25 | 800.30 | 3.330 | 3.663 | 7-M2c | 3.500 | 2.189 | 2.189 | 1.324 | 7.758 | 4.849 |
| 103.37 | 103.37 | 800.43 | 3.454 | 3.794 | 7-M2c | 3.500 | 2.248 | 2.248 | 1.360 | 7.916 | 4.921 |

**********

Straight Culvert

Inlet Elevation (invert): 796.64 ft, Outlet Elevation (invert): 796.34 ft

Culvert Length: 60.20 ft, Culvert Slope: 0.0050

**********

## Table 15 - Summary of Culvert Flows at Crossing: Culvert C7

| Headwater Elevation (ft) | Total Discharge (cfs) | C7 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 799.12 | 52.15 | 52.15 | 0.00 | 1 |
| 799.26 | 57.27 | 57.27 | 0.00 | 1 |
| 799.40 | 62.39 | 62.39 | 0.00 | 1 |
| 799.53 | 67.52 | 67.52 | 0.00 | 1 |
| 799.66 | 72.64 | 72.64 | 0.00 | 1 |
| 799.79 | 77.76 | 77.76 | 0.00 | 1 |
| 799.92 | 82.88 | 82.88 | 0.00 | 1 |
| 800.04 | 88.00 | 88.00 | 0.00 | 1 |
| 800.17 | 93.13 | 93.13 | 0.00 | 1 |
| 800.30 | 98.25 | 98.25 | 0.00 | 1 |
| 800.43 | 103.37 | 103.37 | 0.00 | 1 |
| 802.50 | 162.85 | 162.85 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C8

## Site Data - C8

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 807.54 ft

Outlet Station: 99.86 ft

Outlet Elevation: 806.81 ft

Number of Barrels: 1

## Culvert Data Summary - C8

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

## Tailwater Channel Data - Culvert C8

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 12.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0560

Channel Manning's n: 0.0450

Channel Invert Elevation: 807.44 ft

## Crossing Discharge Data

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

Minimum Flow: 8.32 cfs

Design Flow: 8.32 cfs

Maximum Flow: 19.2 cfs

## Table 1 - Culvert Summary Table: C8

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.32 | 8.32 | 809.29 | 1.614 | 1.747 | 2-M2c | 1.344 | 1.028 | 1.028 | 0.230 | 5.117 | 2.797 |
| 9.41 | 9.41 | 809.43 | 1.751 | 1.891 | 2-M2c | 1.478 | 1.096 | 1.096 | 0.248 | 5.339 | 2.926 |
| 10.50 | 10.50 | 809.58 | 1.890 | 2.038 | 7-M2c | 1.639 | 1.160 | 1.160 | 0.264 | 5.553 | 3.045 |
| 11.58 | 11.58 | 809.74 | 2.033 | 2.199 | 7-M2c | 2.000 | 1.222 | 1.222 | 0.280 | 5.762 | 3.156 |
| 12.67 | 12.67 | 809.92 | 2.182 | 2.381 | 7-M2c | 2.000 | 1.280 | 1.280 | 0.295 | 5.968 | 3.260 |
| 13.76 | 13.76 | 810.22 | 2.338 | 2.679 | 7-M2c | 2.000 | 1.336 | 1.336 | 0.310 | 6.173 | 3.357 |
| 14.85 | 14.85 | 810.57 | 2.504 | 3.026 | 7-M2c | 2.000 | 1.389 | 1.389 | 0.324 | 6.378 | 3.451 |
| 15.94 | 15.94 | 810.93 | 2.679 | 3.391 | 7-M2c | 2.000 | 1.439 | 1.439 | 0.337 | 6.585 | 3.538 |
| 17.02 | 17.02 | 811.32 | 2.866 | 3.776 | 7-M2c | 2.000 | 1.487 | 1.487 | 0.351 | 6.796 | 3.622 |
| 18.11 | 18.11 | 811.72 | 3.066 | 4.183 | 7-M2c | 2.000 | 1.533 | 1.533 | 0.364 | 7.011 | 3.703 |
| 19.20 | 19.20 | 812.15 | 3.279 | 4.611 | 7-M2c | 2.000 | 1.576 | 1.576 | 0.376 | 7.231 | 3.780 |

**********

Straight Culvert

Inlet Elevation (invert): 807.54 ft, Outlet Elevation (invert): 806.81 ft

Culvert Length: 99.86 ft, Culvert Slope: 0.0073

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C8**

| Headwater Elevation (ft) | Total Discharge (cfs) | C8 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 809.29 | 8.32 | 8.32 | 0.00 | 1 |
| 809.43 | 9.41 | 9.41 | 0.00 | 1 |
| 809.58 | 10.50 | 10.50 | 0.00 | 1 |
| 809.74 | 11.58 | 11.58 | 0.00 | 1 |
| 809.92 | 12.67 | 12.67 | 0.00 | 1 |
| 810.22 | 13.76 | 13.76 | 0.00 | 1 |
| 810.57 | 14.85 | 14.85 | 0.00 | 1 |
| 810.93 | 15.94 | 15.94 | 0.00 | 1 |
| 811.32 | 17.02 | 17.02 | 0.00 | 1 |
| 811.72 | 18.11 | 18.11 | 0.00 | 1 |
| 812.15 | 19.20 | 19.20 | 0.00 | 1 |
| 812.40 | 19.87 | 19.87 | 0.00 | Overtopping |

Diversion Berm Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| Sheet No. | 1 of 5 | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: Columbia POO Update | By: RJG | Date: 2/15/22 |
| Client: WPL | Subject: Diversion Berm Spacing Calculation | Chk'd: MJT | Date: 4/1/22 |

**Purpose:**

Determine the spacing between diversion berms on the landfill final cover, with the goal of maintaining ≤ 3 ton/acre of soil loss along the final cover.

**References**

1. "Predicting Rainfall Erosion Losses," USDA Agriculture Handbook Number 537, 1978. (Figure 1 on Sheet 2 and Tables 10 and 13 on Sheet 4).
2. Erosion and Sediment Control Handbook," Goldman, Jackson, & Bursztynsky, 1986. (Table 5.5 on Sheet 5).
3. Rainfed retention probabilities computed for different cropping tillage systems. Agricultural Water Management, A.W. Mills & G.W. Thomas, 1985. Table 5.10 on Sheet 3)
4. Colombia Energy Center POO Update Drawings

**Approach:**

Use the Universal Soil Loss Equation (USLE) to determine diversion berm spacing. Longest flow length is 401 feet.

USLE Equation: $A = R * K * LS * C * P$

where: A = Average annual soil loss, tons/acre
R = Rainfall and runoff erosivity index
K = Soil erodibility factor, tons/acre
LS = Slope length and steepness factor
C = Cover management factor
P = Practice factor

or $LS = \frac{A}{R \times K \times C \times P}$

**Assumptions:**

| | | |
|---|---|---|
| A = | 3 | tons/acre |
| R = | 145 | see Figure 1 on Sheet 2 (Reference #1) |
| K = | 0.38 | see Table 5.10 on Sheet 3 for Loamy Very Fine Sand (Reference #3) |
| C = | 0.0064 | see Table 10 on Sheet 4, assuming 90% cover (Reference #1) |
| P = | 1.0 | assume no support practice used |

**Calculation:**

$$LS = \frac{A}{R \times K \times C \times P} = \frac{3}{145 \times 0.38 \times 0.0064 \times 1.0} = 8.51$$

From the LS Values Table (Sheet 5), based on the 4:1 final cover slope, the slope distance is between 200 and 250 feet.
Use linear interpolation between the LS values for 200 and 250 feet to determine the slope length value for the 4:1 slope.

| | | | | |
|---|---|---|---|---|
| Slope Length @ | 200 | ft | LS= | 8.33 |
| Slope Length @ | 250 | ft | LS= | 9.31 |

Slope length for the calculate LS factor = 209 ft

**Results:**

The maximum distance between diversion berms along the final cover to maintain less than 3 tons/acre soil loss is 209 ft.

SCS ENGINEERS

| | |
|---|---|
| Sheet No. | 2 of 5 |
| Calc. No. | |
| Rev. No. | |

| | | | |
|---|---|---|---|
| Job No. 25220183.00 | Job: Columbia POO Update | By: RJG | Date: 2/15/22 |
| Client: WPL | Subject: Diversion Berm Spacing Calculation | Chk'd: MJT | Date: 4/1/22 |

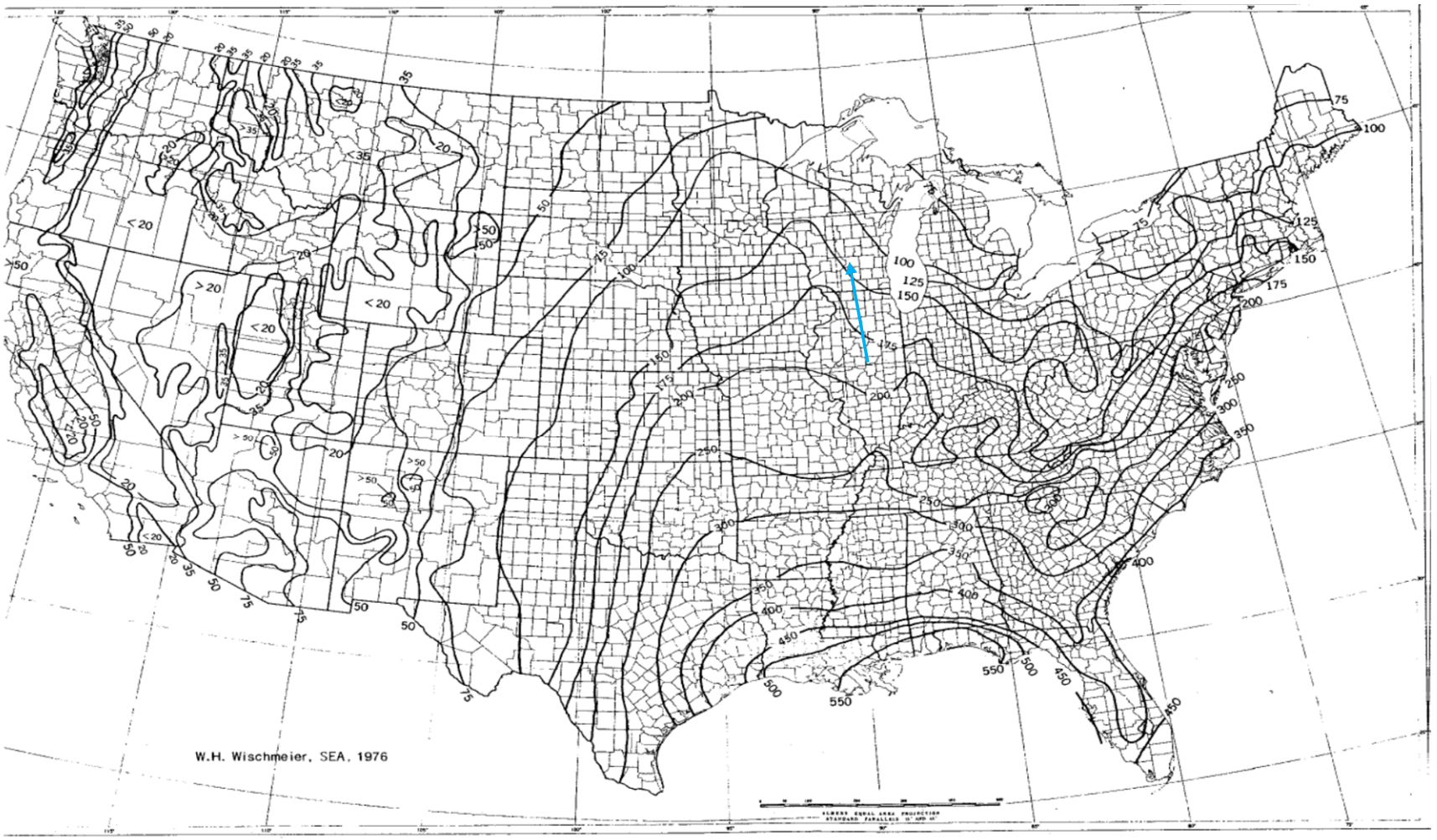



FIGURE 1.—Average annual values of the rainfall erosion index.

Source: "Predicting Rainfall Erosion Losses," USDA Agriculture Handbook Number 537, 1978.

**Table 5.10**. Soil Erodibility Factor $K_{fact}$ (after Stewart et al. 1975)[a]

| | $P_{om}$(%) | | |
|---|---|---|---|
| Textural Class | <0.5 | 2 | 4 |
| Sand | 0.05 | 0.03 | 0.02 |
| Fine sand | 0.16 | 0.14 | 0.10 |
| Very finesand | 0.42 | 0.36 | 0.28 |
| Loamy sand | 0.12 | 0.10 | 0.08 |
| Loamy finesand | 0.24 | 0.20 | 0.16 |
| Loamy veryfine sand | 0.44 | 0.38 | 0.30 |
| Sandy loam | 0.27 | 0.24 | 0.19 |
| Fine sandyloam | 0.35 | 0.30 | 0.24 |
| Very fine sandy loam | 0.47 | 0.41 | 0.33 |
| Loam | 0.38 | 0.34 | 0.29 |
| Silt loam | 0.48 | 0.42 | 0.33 |
| Silt | 0.60 | 0.52 | 0.42 |
| Sandy clayloam | 0.27 | 0.25 | 0.21 |
| Clay loam | 0.28 | 0.25 | 0.21 |
| Silty clayloam | 0.37 | 0.32 | 0.26 |
| Sandy clay | 0.14 | 0.13 | 0.12 |
| Silty clay | 0.25 | 0.23 | 0.19 |
| Clay | | 0.13-0.2 | |

(a) The values shown are estimated averages of broad ranges of specific soil values. When a texture is near the border line of two texture classes, use the average of the two $K_{fact}$ values.

In addition, the values shown are commensurate with the English units used in the cited reference (and as used in the source-term module input files). To obtain analagous values in the metric units used in this report, the above values should be multiplied by 1.292.

TABLE 10.—*Factor* **C** *for permanent pasture, range, and idle land*[1]

| Vegetative canopy | | | Cover that contacts the soil surface | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type and height[2] | Percent cover[3] | | Percent ground cover | | | | | |
| | | Type[4] | 0 | 20 | 40 | 60 | 80 | 95+ |
| No appreciable canopy | | G | 0.45 | 0.20 | 0.10 | 0.042 | 0.013 | 0.003 |
| | | W | .45 | .24 | .15 | .091 | .043 | .011 |
| Tall weeds or short brush with average drop fall height of 20 in | 25 | G | .36 | .17 | .09 | .038 | .013 | .003 |
| | | W | .36 | .20 | .13 | .083 | .041 | .011 |
| | 50 | G | .26 | .13 | .07 | .035 | .012 | .003 |
| | | W | .26 | .16 | .11 | .076 | .039 | .011 |
| | 75 | G | .17 | .10 | .06 | .032 | .011 | .003 |
| | | W | .17 | .12 | .09 | .068 | .038 | .011 |
| Appreciable brush or bushes, with average drop fall height of 6½ ft | 25 | G | .40 | .18 | .09 | .040 | .013 | .003 |
| | | W | .40 | .22 | .14 | .087 | .042 | .011 |
| | 50 | G | .34 | .16 | .08 | .038 | .012 | .003 |
| | | W | .34 | .19 | .13 | .082 | .041 | .011 |
| | 75 | G | .28 | .14 | .08 | .036 | .012 | .003 |
| | | W | .28 | .17 | .12 | .078 | .040 | .011 |
| Trees, but no appreciable low brush. Average drop fall height of 13 ft | 25 | G | .42 | .19 | .10 | .041 | .013 | .003 |
| | | W | .42 | .23 | .14 | .089 | .042 | .011 |
| | 50 | G | .39 | .18 | .09 | .040 | .013 | .003 |
| | | W | .39 | .21 | .14 | .087 | .042 | .011 |
| | 75 | G | .36 | .17 | .09 | .039 | .012 | .003 |
| | | W | .36 | .20 | .13 | .084 | .041 | .011 |

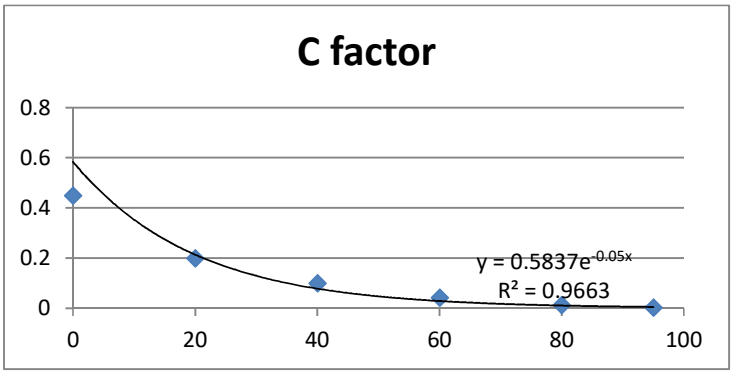
[1] The listed **C** values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in deep.
W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

Source: "Predicting Rainfall Erosion Losses," USDA Agriculture Handbook Number 537, 1978.




= 90 % cover
0.0065

**TABLE 5.5 LS Values* (10)**

| Slope ratio | Slope gradient s, % | LS values for following slope lengths l, ft (m) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 (3.0) | 20 (6.1) | 30 (9.1) | 40 (12.2) | 50 (15.2) | 60 (18.3) | 70 (21.3) | 80 (24.4) | 90 (27.4) | 100 (30.5) |
| | 0.5 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 |
| 100:1 | 1 | 0.08 | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 |
| | 2 | 0.10 | 0.12 | 0.14 | 0.15 | 0.16 | 0.17 | 0.18 | 0.19 | 0.19 | 0.20 |
| | 3 | 0.14 | 0.18 | 0.20 | 0.22 | 0.23 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 |
| | 4 | 0.16 | 0.21 | 0.25 | 0.28 | 0.30 | 0.33 | 0.35 | 0.37 | 0.38 | 0.40 |
| 20:1 | 5 | 0.17 | 0.24 | 0.29 | 0.34 | 0.38 | 0.41 | 0.45 | 0.48 | 0.51 | 0.53 |
| | 6 | 0.21 | 0.30 | 0.37 | 0.43 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 | 0.67 |
| | 7 | 0.26 | 0.37 | 0.45 | 0.52 | 0.58 | 0.64 | 0.69 | 0.74 | 0.78 | 0.82 |
| 12½:1 | 8 | 0.31 | 0.44 | 0.54 | 0.63 | 0.70 | 0.77 | 0.83 | 0.89 | 0.94 | 0.99 |
| | 9 | 0.37 | 0.52 | 0.64 | 0.74 | 0.83 | 0.91 | 0.98 | 1.05 | 1.11 | 1.17 |
| 10:1 | 10 | 0.43 | 0.61 | 0.75 | 0.87 | 0.97 | 1.06 | 1.15 | 1.22 | 1.30 | 1.37 |
| | 11 | 0.50 | 0.71 | 0.86 | 1.00 | 1.12 | 1.22 | 1.32 | 1.41 | 1.50 | 1.58 |
| 8:1 | 12.5 | 0.61 | 0.86 | 1.05 | 1.22 | 1.36 | 1.49 | 1.61 | 1.72 | 1.82 | 1.92 |
| | 15 | 0.81 | 1.14 | 1.40 | 1.62 | 1.81 | 1.98 | 2.14 | 2.29 | 2.43 | 2.56 |
| 6:1 | 16.7 | 0.96 | 1.36 | 1.67 | 1.92 | 2.15 | 2.36 | 2.54 | 2.72 | 2.88 | 3.04 |
| 5:1 | 20 | 1.29 | 1.82 | 2.23 | 2.58 | 2.88 | 3.16 | 3.41 | 3.65 | 3.87 | 4.08 |
| 4½:1 | 22 | 1.51 | 2.13 | 2.61 | 3.02 | 3.37 | 3.69 | 3.99 | 4.27 | 4.53 | 4.77 |
| 4:1 | 25 | 1.86 | 2.63 | 3.23 | 3.73 | 4.16 | 4.56 | 4.93 | 5.27 | 5.59 | 5.89 |
| | 30 | 2.51 | 3.56 | 4.36 | 5.03 | 5.62 | 6.16 | 6.65 | 7.11 | 7.54 | 7.95 |
| 3:1 | 33.3 | 2.98 | 4.22 | 5.17 | 5.96 | 6.67 | 7.30 | 7.89 | 8.43 | 8.95 | 9.43 |
| | 35 | 3.23 | 4.57 | 5.60 | 6.46 | 7.23 | 7.92 | 8.55 | 9.14 | 9.70 | 10.22 |
| 2⅔:1 | 40 | 4.00 | 5.66 | 6.93 | 8.00 | 8.95 | 9.80 | 10.59 | 11.32 | 12.00 | 12.65 |
| | 45 | 4.81 | 6.80 | 8.33 | 9.61 | 10.75 | 11.77 | 12.72 | 13.60 | 14.42 | 15.20 |
| 2:1 | 50 | 5.64 | 7.97 | 9.76 | 11.27 | 12.60 | 13.81 | 14.91 | 15.94 | 16.91 | 17.82 |
| | 55 | 6.48 | 9.16 | 11.22 | 12.96 | 14.48 | 15.87 | 17.14 | 18.32 | 19.43 | 20.48 |
| 1¾:1 | 57 | 6.82 | 9.64 | 11.80 | 13.63 | 15.24 | 16.69 | 18.03 | 19.28 | 20.45 | 21.55 |
| | 60 | 7.32 | 10.35 | 12.68 | 14.64 | 16.37 | 17.93 | 19.37 | 20.71 | 21.96 | 23.15 |
| 1½:1 | 66.7 | 8.44 | 11.93 | 14.61 | 16.88 | 18.87 | 20.67 | 22.32 | 23.87 | 25.31 | 26.68 |
| | 70 | 8.98 | 12.70 | 15.55 | 17.96 | 20.08 | 21.99 | 23.75 | 25.39 | 26.93 | 28.39 |
| | 75 | 9.78 | 13.83 | 16.94 | 19.56 | 21.87 | 23.95 | 25.87 | 27.66 | 29.34 | 30.92 |
| 1¼:1 | 80 | 10.55 | 14.93 | 18.28 | 21.11 | 23.60 | 25.85 | 27.93 | 29.85 | 31.66 | 33.38 |
| | 85 | 11.30 | 15.98 | 19.58 | 22.61 | 25.27 | 27.69 | 29.90 | 31.97 | 33.91 | 35.74 |
| | 90 | 12.02 | 17.00 | 20.82 | 24.04 | 26.88 | 29.44 | 31.80 | 34.00 | 36.06 | 38.01 |
| | 95 | 12.71 | 17.97 | 22.01 | 25.41 | 28.41 | 31.12 | 33.62 | 35.94 | 38.12 | 40.18 |
| 1:1 | 100 | 13.36 | 18.89 | 23.14 | 26.72 | 29.87 | 32.72 | 35.34 | 37.78 | 40.08 | 42.24 |

| Slope ratio | Slope gradient s, % | LS values for following slope lengths l, ft (m) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 150 (46) | 200 (61) | 250 (76) | 300 (91) | 350 (107) | 400 (122) | 450 (137) | 500 (152) | 600 (183) | 700 (213) | 800 (244) | 900 (274) | 1000 (305) | | | | | | | | | | |
| | 0.5 | 0.10 | 0.11 | 0.11 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | | | | | | | | | | |
| 100:1 | 1 | 0.14 | 0.14 | 0.15 | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.18 | 0.18 | 0.19 | 0.19 | 0.20 | | | | | | | | | | |
| | 2 | 0.23 | 0.25 | 0.26 | 0.28 | 0.29 | 0.30 | 0.32 | 0.33 | 0.34 | 0.36 | 0.37 | 0.39 | 0.40 | | | | | | | | | | |
| | 3 | 0.32 | 0.35 | 0.38 | 0.40 | 0.42 | 0.43 | 0.45 | 0.46 | 0.49 | 0.51 | 0.54 | 0.55 | 0.57 | | | | | | | | | | |
| | 4 | 0.47 | 0.53 | 0.58 | 0.62 | 0.66 | 0.70 | 0.73 | 0.76 | 0.82 | 0.87 | 0.92 | 0.96 | 1.00 | | | | | | | | | | |
| 20:1 | 5 | 0.66 | 0.76 | 0.85 | 0.93 | 1.00 | 1.07 | 1.13 | 1.20 | 1.31 | 1.42 | 1.51 | 1.60 | 1.69 | | | | | | | | | | |
| | 6 | 0.82 | 0.95 | 1.06 | 1.16 | 1.26 | 1.34 | 1.43 | 1.50 | 1.65 | 1.78 | 1.90 | 2.02 | 2.13 | | | | | | | | | | |
| | 7 | 1.01 | 1.17 | 1.30 | 1.43 | 1.54 | 1.65 | 1.75 | 1.84 | 2.02 | 2.18 | 2.33 | 2.47 | 2.61 | | | | | | | | | | |
| 12½:1 | 8 | 1.21 | 1.40 | 1.57 | 1.72 | 1.85 | 1.98 | 2.10 | 2.22 | 2.43 | 2.62 | 2.80 | 2.97 | 3.13 | | | | | | | | | | |
| | 9 | 1.44 | 1.66 | 1.85 | 2.03 | 2.19 | 2.35 | 2.49 | 2.62 | 2.87 | 3.10 | 3.32 | 3.52 | 3.71 | | | | | | | | | | |
| 10:1 | 10 | 1.68 | 1.94 | 2.16 | 2.37 | 2.56 | 2.74 | 2.90 | 3.06 | 3.35 | 3.62 | 3.87 | 4.11 | 4.33 | | | | | | | | | | |
| | 11 | 1.93 | 2.23 | 2.50 | 2.74 | 2.95 | 3.16 | 3.35 | 3.53 | 3.87 | 4.18 | 4.47 | 4.74 | 4.99 | | | | | | | | | | |
| 8:1 | 12.5 | 2.36 | 2.72 | 3.04 | 3.33 | 3.59 | 3.84 | 4.08 | 4.30 | 4.71 | 5.08 | 5.43 | 5.76 | 6.08 | | | | | | | | | | |
| | 15 | 3.13 | 3.62 | 4.05 | 4.43 | 4.79 | 5.12 | 5.43 | 5.72 | 6.27 | 6.77 | 7.24 | 7.68 | 8.09 | | | | | | | | | | |
| 6:1 | 16.7 | 3.72 | 4.30 | 4.81 | 5.27 | 5.69 | 6.08 | 6.45 | 6.80 | 7.45 | 8.04 | 8.60 | 9.12 | 9.62 | | | | | | | | | | |
| 5:1 | 20 | 5.00 | 5.77 | 6.45 | 7.06 | 7.63 | 8.16 | 8.65 | 9.12 | 9.99 | 10.79 | 11.54 | 12.24 | 12.90 | | | | | | | | | | |
| 4½:1 | 22 | 5.84 | 6.75 | 7.54 | 8.26 | 8.92 | 9.54 | 10.12 | 10.67 | 11.68 | 12.62 | 13.49 | 14.31 | 15.08 | | | | | | | | | | |
| 4:1 | 25 | 7.21 | 8.33 | 9.31 | 10.20 | 11.02 | 11.78 | 12.49 | 13.17 | 14.43 | 15.58 | 16.66 | 17.67 | 18.63 | | | | | | | | | | |
| | 30 | 9.74 | 11.25 | 12.57 | 13.77 | 14.88 | 15.91 | 16.87 | 17.78 | 19.48 | 21.04 | 22.49 | 23.86 | 25.15 | | | | | | | | | | |
| 3:1 | 33.3 | 11.55 | 13.34 | 14.91 | 16.33 | 17.64 | 18.86 | 20.00 | 21.09 | 23.10 | 24.95 | 26.67 | 28.29 | 29.82 | | | | | | | | | | |
| | 35 | 12.52 | 14.46 | 16.16 | 17.70 | 19.12 | 20.44 | 21.68 | 22.86 | 25.04 | 27.04 | 28.91 | 30.67 | 32.32 | | | | | | | | | | |
| 2⅔:1 | 40 | 15.50 | 17.89 | 20.01 | 21.91 | 23.67 | 25.30 | 26.84 | 28.29 | 30.99 | 33.48 | 35.79 | 37.96 | 40.01 | | | | | | | | | | |
| | 45 | 18.62 | 21.50 | 24.03 | 26.33 | 28.44 | 30.40 | 32.24 | 33.99 | 37.23 | 40.22 | 42.99 | 45.60 | 48.07 | | | | | | | | | | |
| 2:1 | 50 | 21.83 | 25.21 | 28.18 | 30.87 | 33.34 | 35.65 | 37.81 | 39.85 | 43.66 | 47.16 | 50.41 | 53.47 | 56.36 | | | | | | | | | | |
| | 55 | 25.09 | 28.97 | 32.39 | 35.48 | 38.32 | 40.97 | 43.45 | 45.80 | 50.18 | 54.20 | 57.94 | 61.45 | 64.78 | | | | | | | | | | |
| 1¾:1 | 57 | 26.40 | 30.48 | 34.08 | 37.33 | 40.32 | 43.10 | 45.72 | 48.19 | 52.79 | 57.02 | 60.96 | 64.66 | 68.15 | | | | | | | | | | |
| | 60 | 28.35 | 32.74 | 36.60 | 40.10 | 43.31 | 46.30 | 49.11 | 51.77 | 56.71 | 61.25 | 65.48 | 69.45 | 73.21 | | | | | | | | | | |
| 1½:1 | 66.7 | 32.68 | 37.74 | 42.19 | 46.22 | 49.92 | 53.37 | 56.60 | 59.66 | 65.36 | 70.60 | 75.47 | 80.05 | 84.38 | | | | | | | | | | |
| | 70 | 34.77 | 40.15 | 44.89 | 49.17 | 53.11 | 56.78 | 60.23 | 63.48 | 69.54 | 75.12 | 80.30 | 85.17 | 89.78 | | | | | | | | | | |
| | 75 | 37.87 | 43.73 | 48.89 | 53.56 | 57.85 | 61.85 | 65.60 | 69.15 | 75.75 | 81.82 | 87.46 | 92.77 | 97.79 | | | | | | | | | | |
| 1¼:1 | 80 | 40.88 | 47.20 | 52.77 | 57.81 | 62.44 | 66.75 | 70.80 | 74.63 | 81.76 | 88.31 | 94.41 | 100.13 | 105.55 | | | | | | | | | | |
| | 85 | 43.78 | 50.55 | 56.51 | 61.91 | 66.87 | 71.48 | 75.82 | 79.92 | 87.55 | 94.57 | 101.09 | 107.23 | 113.03 | | | | | | | | | | |
| | 90 | 46.55 | 53.76 | 60.10 | 65.84 | 71.11 | 76.02 | 80.63 | 84.99 | 93.11 | 100.57 | 107.51 | 114.03 | 120.20 | | | | | | | | | | |
| | 95 | 49.21 | 56.82 | 63.53 | 69.59 | 75.17 | 80.36 | 85.23 | 89.84 | 98.42 | 106.30 | 113.64 | 120.54 | 127.06 | | | | | | | | | | |
| 1:1 | 100 | 51.74 | 59.74 | 66.79 | 73.17 | 79.03 | 84.49 | 89.61 | 94.46 | 103.48 | 111.77 | 119.48 | 126.73 | 133.59 | | | | | | | | | | |

*Calculated from

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065\right)\left(\frac{l}{72.5}\right)^m$$

LS = topographic factor
$l$ = slope length, ft (m × 0.3048)
$s$ = slope steepness,
$m$ = exponent dependent upon slope steep
(0.2 for slopes < 1%, 0.3 for slopes 1 t
0.4 for slopes 3.5 to 4.5%, and
0.5 for slopes > 5%)

FROM "EROSION & SEDIMENT CONTROL HANDBOOK", Goldman, Jackson, + Bursztynsky, 1986

5.20

5.21

Source: Erosion and Sediment Control Handbook," Goldman, Jackson, & Bursztynsky, 1986.

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No: 1/2 | |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Project: Columbia Energy Center POO Update | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Diversion Berm Sizing | Chk'd: MJT | Date: 4/1/22 |

**Purpose:**

To size the post closure diversion berms on the final cover to accommodate the 25-year, 24-hour storm event.

**References:**

1. WisDOT Facilities Development Manual Chapter 13, Section 30-15 - Grass Lined Channels.
2. Design of Roadside Channels with Flexible Linings, HEC-15, USDOT FHWA.
3. HydroCAD Report_Post Construction

**Approach:**

Use the Post Closure HydroCAD Model results to obtain the peak flow during a 25-year, 24-hour storm event along the diversion berms.

Use Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2 (from Reference #1) to size the swale for each design swale cross section. The WisDOT spreadsheet incorporates the design guidelines and equations described in "Design of Roadside Channels with Flexible Linings", HEC-15, USDOT FHWA (Reference #2).

Confirm the swale is stable and has enough capacity for the design flow rate.

**Assumptions:**

1. Assume the channel geometry is a v-notch swale with one sideslope at 4:1 and one sideslope at 2:1 and a depth of 2.0 ft.
2. Assume 2.0% slope along the flowpath of the diversion swale.
3. Assume the following parameters per Section 15.2 - Grass Lining Properties from Reference #1:
   Vegetation Retardance Class = C for Swales
   Vegetation Condition = Good
   Vegetation Growth Form = Turf
4. Assume cohesive soil type with ASTM Soil Class SC and a Plasticity Index (PI) of 16.

**Calculations:**

From the HydroCAD Report, the peak flow rate along the diversion berms are as follows:

| Areas | | Areas | | Areas | | Areas | |
|---|---|---|---|---|---|---|---|
| 1 | 4.58 cfs | 8 | 3.29 cfs | 14 | 3.66 cfs | 20 | 3.43 cfs |
| 2 | 3.73 cfs | 9 | 3.40 cfs | 15 | 1.71 cfs | 21 | 3.35 cfs |
| 3 | 2.17 cfs | 10 | 3.17 cfs | 16 | 4.89 cfs | 22 | 3.35 cfs |
| 4 | 3.74 cfs | 11 | 3.10 cfs | 17 | 4.00 cfs | 23 | 4.89 cfs |
| 5 | 3.58 cfs | 12 | 0.35 cfs | 18 | 2.66 cfs | 24 | 6.05 cfs |
| 6 | 2.92 cfs | 13 | 2.91 cfs | 19 | 2.77 cfs | 25 | 5.13 cfs |

Use highest flow to confirm diversion berm functions.

Use the Grass Swale Design Spreadsheet (Page 2) to determine the flow depth, velocity and shear stress in the swales.

**Results:**

The diversion berms are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

The diversion berms are stable at the design flow rates. The design flow depth of 2.0 feet maintains at least 0.5 ft of freeboard during the 25-year, 24-hour storm event.

| ***Channel/Ditch Geometry*** | *Area 24* |
|---|---|
| Channel Slope, $S_o$ (ft/ft) | **0.02** |
| Channel Bottom Width, B (ft) | **0** |
| Channel Side Slope, $z_1$ | **4** |
| Channel Side Slope, $z_2$ | **2** |
| Flow Depth, d (ft) Solve iteratively | **1.00** |
| Safety Factor, SF | **1.0** |
| ***Vegetation/Soil Parameters*** | |
| Vegetation Retardance Class | **C** |
| Vegetation Condition | **good** |
| Vegetation Growth Form | **turf** |
| Soil Type | **cohesive** |
| $D_{75}$ (in) (Set at 0.00 for cohesive soils) | |
| ASTM Soil Class | **SC** |
| Plasticity Index, PI | **16** |
| ***Results Summary*** | |
| Design Q ($ft^3/s$) | **6.1** |
| Calculated Q ($ft^3/s$) | 6.1 |
| Difference Between Design & Calc. Flow (%) | 0.5% |
| **Stable (Yes or No)** | **YES** |
| ***Channel Parameters*** | |
| Vegetation Height, h (ft) | 0.67 |
| Grass Roughness Coefficient, $C_n$ | 0.238 |
| Cover Factor, $C_f$ | 0.90 |
| Noncohesive Soil | |
| Soil Grain Roughness, $n_s$ | 0.016 |
| Permissible Soil Shear Stress, $\tau_p$ ($lb/ft^2$) | N/A |
| Cohesive Soil | |
| Porosity, e | 0.35 |
| Soil Coefficient 1, $c_1$ | 1.0700 |
| Soil Coefficient 2, $c_2$ | 14.30 |
| Soil Coefficient 3, $c_3$ | 47.700 |
| Soil Coefficient 4, $c_4$ | 1.42 |
| Soil Coefficient 5, $c_5$ | -0.61 |
| Soil Coefficient 6, $c_6$ | 0.00010 |
| Permissible Soil Shear Stress, $\tau_p$ ($lb/ft^2$) | 0.080 |
| Total Permissible Shear Stress, $\tau_p$ ($lb/ft^2$) | 0.080 |
| Cross Sectional Area, A ($ft^2$) | 3.000 |
| Wetted Perimeter, P (ft) | 6.36 |
| Hydraulic Radius, R (ft) | 0.472 |
| Top Width, T (ft) | 6.00 |
| Hydraulic Depth, D (ft) | 0.500 |
| Froude Number (Q design) | 0.505 |
| Channel Shear Stress, $\tau_o$ ($lb/ft^2$) | 0.59 |
| Actual Sheer Stress, $\tau_d$ ($lb/ft^2$) | 1.25 |
| Mannings n | 0.063 |
| Average Velocity, V (ft/s) | 2.02 |
| Calculated Flow, Q ($ft^3/s$) | 6.1 |
| Difference Between Design & Calc. Flow (%) | 0.5% |
| Effective Shear on Soil Surface, $\tau_e$ ($lb/ft^2$) | 0.008 |
| Total Permissible Shear on Veg., $\tau_{p\,veg}$ ($lb/ft^2$) | 12.42 |
| Stable (Y or N) | YES |

Source: Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2

Downslope Flume & Energy Dissipater Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No: 1/3 | |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Downslope Pipe and Inlet Sizing | Chk'd: MJT | Date: 04/04/22 |

**Purpose:**

To size the downslope pipe and inlet to accommodate the 25-year, 24-hour storm event.

**References:**

1. HydroCAD Report_POO Landfill Closure

**Approach:**

Use the orifice equation to size the downslope pipe inlet. Size the inlet for the largest diversion berm flow rate and apply that inlet size to all downslope pipe inlets. Confirm the head (h) acting on the orifice will not overtop the diversion berm depth of 2.0 ft.

Use Manning's equation to size the downslope pipe based on the largest diversion berm flow rate.
Confirm the pipe has capacity for the design flow under open channel flow conditions.

**Assumptions:**

1. Orifice coefficient = 0.63
2. Assume the orifice head (h) acts on the centerline of the inlet pipe.
3. Manning's n = 0.012 (For smooth walled HDPE pipe: http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)
4. Size flumes under the vegetated cover condition.

**Calculations:**

Size the downslope pipe inlet:

From the HydroCAD report (Reference #1), the maximum 25-year, 24-hour flow along a diversion berm is 6.1 cfs
in HydroCAD model). Flume 3 Area 24

Orifice Equation: $Q = C * A * (2 * g * h)^{0.5}$

where: Q = flow rate (cfs) = 6.1 (From above)
C = orifice coefficient = 0.63 (See assumption #1)
A = orifice area (sf) = 1.77 (area of 18" diameter pipe) Actual Pipe Diameter = 18 inches
g = gravity ($ft/sec^2$)= 32.2
h = orifice head acting on centerline (ft)
$h = (Q/(C * A))^2/(2 * g)$ = 0.5 ft
Given Assumption #2, depth of flow along diversion berm = h + D/2/12 = 1.21 ft

**Results:**

Based on the inlet sizing calculation, an 18" diameter inlet will convey the stormwater runoff from the largest flow rate to a flume.

Based on the Manning's calculation for flow within the pipe, the 12" diameter downslope pipe will accommodate the design flow under open channel flow conditions. Although the flow for the downslope pipes can be handled by 12" dia. pipes, for ease of construction, all downslope pipes will be 18" dia.

**Calculations (Continued):**

The diversion swale depth of 2 ft is sufficient to prevent overtopping at the downslope pipe inlet locations. The depth of the diversion berm increases at the entrance of the down slope pipes due to mounding of the soil over the pipe.

Size the downslope flume pipe:

Use Manning's equation to size the downslope pipe.

Manning's Equation: $Q = (1.49/n) \times A \times R^{(2/3)} \times S^{(1/2)}$

where: Q = Flow Rate, cfs
n = Manning's Roughness Coefficient
A = Flow Area, sf
R = Hydraulic Radius, ft (= A/P)
S = Channel Slope, ft/ft

From the HydroCAD Report (Reference 1) , the peak discharge to each downslope flume resulting from a 25-year, 24-hour storm is as follows:

| **Flume 1** 3.58 cfs | | **Flume 2** 4.89 cfs | | **Flume 3** 6.05 cfs | | **Flume 4** 3.66 cfs | | **Flume 5** 4.89 cfs | |
|---|---|---|---|---|---|---|---|---|---|
| Area 5 | 3.58 | Area 3 | 2.17 | Area 1 | 4.58 | Area 12 | 0.35 | Area 10 | 3.17 |
| Area 6 | 2.92 | Area 4 | 3.74 | Area 2 | 3.73 | Area 13 | 2.91 | Area 11 | 3.10 |
| Area 20 | 3.43 | Area 22 | 3.35 | Area 24 | 6.05 | Area 14 | 3.66 | Area 16 | 4.89 |
| Area 21 | 3.35 | Area 23 | 4.89 | Area 25 | 5.13 | Area 15 | 1.71 | Area 17 | 4.00 |
| Total = | 13.28 | | 14.15 | | 19.49 | | 8.63 | | 15.16 |

| **Flume 6** 3.40 cfs | |
|---|---|
| Area 8 | 3.29 |
| Area 9 | 3.40 |
| Area 18 | 2.66 |
| Area 19 | 2.77 |
| Total = | 12.12 |

For flow rates < 20 cfs, assume a 12" diameter downslope flume:

Use 19.49 cfs to Flume 3 to check sizing (max flow to a flume that is < 20 cfs)

Design Criteria

Pipe Diameter (in) = D = 12

Pipe Slope (ft/ft) = S = 0.25

Manning's Roughness Coefficient = n = 0.012

See Downslope Flume 3 pipe flow calculator on Sheet 3

**Calculations (Continued):**

## Manning Formula Uniform Pipe Flow at Given Slope and Depth

**Inputs:**

| | | |
|---|---|---|
| Pipe Diameter, $d_o$ | 12.00 | in |
| Manning Roughness, n | 0.0120 | |
| Pressure slope (possibly equal to pipe slope), $S_o$ | 0.2500 | slope |
| Percent of (or ratio to) full depth (100% or 1 if flowing full) | 0.8290 | fraction |

**Results:**

| | | |
|---|---|---|
| Flow, Q | 19.4905 | ft^3/s |
| Velocity, v | 27.9991 | ft/s |
| Velocity head, hv | 12.1838 | ft |
| Flow Area, A | 0.6961 | ft^2 |
| Wetted Perimeter, P | 2.2890 | ft |
| Hydraulic Radius | 0.3041 | ft |
| Top Width, T | 0.7530 | ft |
| Froude Number, F | 5.21 | |
| Shear Stress (tractive force), τ | 12.9373 | psf |

**Calculations (Continued):**

## Manning Formula Uniform Pipe Flow at Given Slope and Depth

**Inputs:**

| | | |
|---|---|---|
| Pipe Diameter, $d_o$ | 18.00 | in |
| Manning Roughness, n | 0.0120 | |
| Pressure slope (possibly equal to pipe slope), $S_o$ | 0.2500 | slope |
| Percent of (or ratio to) full depth (100% or 1 if flowing full) | 0.4037 | fraction |

**Results:**

| | | |
|---|---|---|
| Flow, Q | 19.4983 | ft^3/s |
| Velocity, v | 29.1783 | ft/s |
| Velocity head, hv | 13.2317 | ft |
| Flow Area, A | 0.6682 | ft^2 |
| Wetted Perimeter, P | 2.0655 | ft |
| Hydraulic Radius | 0.3235 | ft |
| Top Width, T | 1.4719 | ft |
| Froude Number, F | 7.75 | |
| Shear Stress (tractive force), τ | 9.4502 | psf |

SCS ENGINEERS

| | | | |
|---|---|---|---|
| Sheet No. 1 of 7 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Energy Dissipator Sizing | Chk'd: MJT | Date: 4/1/22 |

**Purpose:**

To size an energy dissipator structure and riprap apron at the outlet of the downslope flume pipes.

**References:**

1. "Hydraulic Design of Energy Dissipators for Culverts and Channels," HEC-14, Third Edition, July 2006, USDOT FHWA.
2. Downslope Pipe and Inlet Sizing calculation (for pipe size, flow rate, and pipe velocity).
3. HydroCAD Model_POO Landfill Closure
4. Facilities Development Manual Chapter 13, Section 13-30 - Rock Riprap Lined Chutes.

**Approach:**

Use the downslope pipe outlet velocity to size an energy dissipator structure (USBR Type VI Impact Basin) following the design approach outlined in Section 9.4 of Reference #1.

Use Rock Chute Data Spreadsheet, FDM 13-30-30 Attachment 30.1 (from Reference #5) to design the rock chute.

For construction purposes use the maximum flow to size all dissipators and riprap apron.

**Assumptions:**

1. Riprap specific gravity = 2.65
2. From the HydroCAD Report, the 25-year, 24-hour peak discharge to each downslope flume is as follows:

| **Flume 1** 3.58 cfs | | **Flume 2** 4.89 cfs | | **Flume 3** 6.05 cfs | | **Flume 4** 3.66 cfs | | **Flume 5** 4.89 cfs | |
|---|---|---|---|---|---|---|---|---|---|
| Area 5 | 3.58 | Area 3 | 2.17 | Area 1 | 4.58 | Area 12 | 0.35 | Area 10 | 3.17 |
| Area 6 | 2.92 | Area 4 | 3.74 | Area 2 | 3.73 | Area 13 | 2.91 | Area 11 | 3.10 |
| Area 20 | 3.43 | Area 22 | 3.35 | Area 24 | 6.05 | Area 14 | 3.66 | Area 16 | 4.89 |
| Area 21 | 3.35 | Area 23 | 4.89 | Area 25 | 5.13 | Area 15 | 1.71 | Area 17 | 4.00 |
| Total = | 13.28 | | 14.15 | | 19.49 | | 8.63 | | 15.16 |

| **Flume 6** 3.40 cfs | |
|---|---|
| Area 8 | 3.29 |
| Area 9 | 3.40 |
| Area 18 | 2.66 |
| Area 19 | 2.77 |
| Total = | 12.12 |

Using Figure 9.14 (See Sheet 4), enter the Froude Number and the Energy from Step 2 to determine the from the downslope flume pipe and inlet sizing calculation.

**Results:**

The energy dissipator structures for the 18" dia. downslope flume pipes will consist of dissipator structures with widths ($W_B$) of 6 feet, with the remaining dimensions from Table 9.2 on Sheets 5 and 6.

Riprap at the Flume 3, 4, 5 and 6 energy dissipator outlets will consist of WisDOT Light Riprap (D50= 5.5 inches) (See Page 3). The riprap apron footprint will be based on the energy dissipator width and the outlet swale geometry.

Riprap at Flume 1 and 2 energy dissipator outlets will consist of WisDOT Light Riprap (D50= 5.8 and 3.6 inches). The riprap apron footprint will be 6 feet wide (based on rock chute calcs for RC1 and RC2) and extend down to the existing swale (Swale S4).

**Calculations:**

For 18" dia. downslope flume pipes

From Reference #2:

Flow rate (Q) = 19.5 cfs

Pipe velocity (V) = 8.9 ft/s

Flow area (A) = Q/V = 2.19 sf

Design procedure from pg. 9-40 of Reference #1:

Step 1: Compute the Equivalent Depth of Flow Entering Dissipator:

$Y_e = (A/2)^{1/2}$ where: Ye = Equivalent depth

A = Area (from above)

$Y_e$ = 1.05 ft

Step 2: Compute the Froude Number and the energy at the end of the pipe:

$Fr = V/[(g*Y_e)^{1/2}]$ where: Fr = Froude Number

V = Velocity (from above)

g = Gravity constant (32.2 ft/sec$^2$)

Fr = 1.5 $Y_e$ = Equivalent depth (from Step 1 above)

$H_o = Y_e + V^2/2g$ where: $H_o$ = Energy at the end of the pipe

$Y_e$ = Equivalent depth (from above)

V = Velocity (from above)

Ho = 2.3 ft g = Gravity constant (32.2 ft/sec$^2$)

Step 3: Determine $H_o/W_B$ and calculate the required width of the energy dissipator:

Using Figure 9.14 (See Sheet 4), enter the Froude Number and the Energy from Step 2 to determine the width of the energy dissipator.

From Figure 9.14, $H_o/W_B$ = 0.40

$W_B = H_o/(H_o/W_B)$ $W_B$ = 5.7 ft.

Use $W_B$ = 6.0 ft.

Step 4: Obtain the remaining energy dissipator dimensions from Table 9.2 from Reference #1 (see Sheets 5 and 6)

Step 5: Size the riprap at the structure outlet

From Reference #5, use Rock Chute Design spreadsheet (see Sheet 3)

# Rock Chute Design Data

(Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Revised for WisDOT 9/2010

**Project:** COL - POO Landfill Closure
**Designer:** RJG
**Date:** February 23, 2022

**County:** Columbia
**Checked by:** MJT
**Date:** 04/05/22

## Input Geometry:

| Upstream Channel | | Chute | | | Downstream Channel | |
|---|---|---|---|---|---|---|
| Bottom Width = | 6.0 ft. | Bottom Width = | 6.0 ft. | | Bottom Width = | 6.0 ft. |
| Side slopes = | 1.0 (m:1) | Factor of safety = | 1.20 (SF) | 1.2 Min | Side slopes = | 2.0 (m:1) |
| Mannings n value = | 0.012 | Side slopes = | 2.0 (z:1) | 2.0:1 max. | Mannings n value = | 0.030 |
| Bed slope = | 0.0001 ft./ft. | Bed slope = | 0.2500 ft./ft | 3.0:1 max. | Bed slope = | 0.0050 ft./ft. |
| Note: Use procedures 13-30-15 or 13-30-25 for upstream and downstream Mannings n | | Freeboard = | 1.0 ft. | | | |
| | | Outlet apron depth, d = | 1.0 ft. | | Base flow = | 0.0 cfs |

## Flow and Elevation Data:

Apron elev. --- Inlet = 818.0 ft. ------ Outlet 816.0 ft. --- ($H_{drop}$ = 1 ft.)

Degree of angularity = 1

$Q_{high}$ = Runoff from design storm
$Q_5$ = Runoff from a 5-year,24-hour storm

1 --> 50% angular, 50% rounded
2 --> 100 % rounded

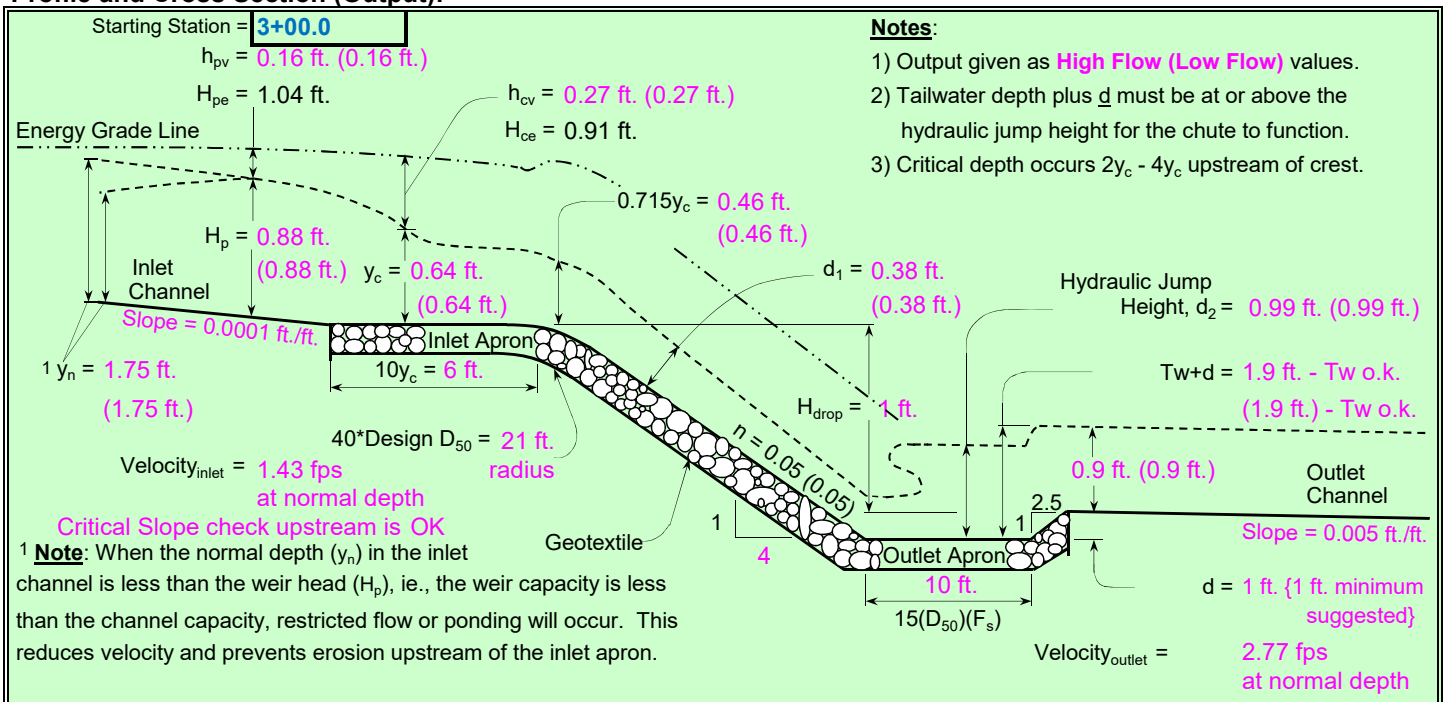
$Q_{high}$ = 19.5 cfs — High flow storm through chute → Tw (ft.) = **Program**

$Q_{low}$ = 19.5 cfs — Low flow storm through chute → Tw (ft.) = **Program**

**Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.

**Input tailwater (Tw)**: 0.25 1.20

## Profile and Cross Section (Output):

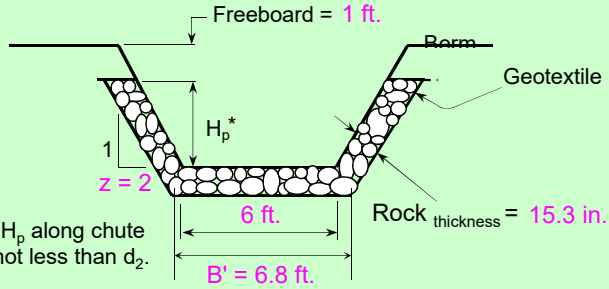



**Notes**:
1) Output given as **High Flow (Low Flow)** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.

[1] **Note**: When the normal depth ($y_n$) in the inlet channel is less than the weir head ($H_p$), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

## Profile Along Centerline of Chute

### Typical Cross Section




* Use $H_p$ along chute but not less than $d_2$.

| | | |
|---|---|---|
| | 2.9 cfs/ft. | Equivalent unit discharge |
| SF = | 1.20 | Factor of safety (multiplier) |
| $d_1$ = | 0.38 ft. | Normal depth in chute |
| n-value = | 0.05 | Manning's roughness coefficient |
| $D_{50}$(SF) = | 7.6 in. | Minimum Design $D_{50}$* |
| $2(D_{50})(SF)$ = | 15.3 in. | Rock chute thickness |
| Tw + d = | 1.9 ft. | Tailwater above outlet apron |
| $d_2$ = | 0.99 ft. | Hydraulic jump height |
| *** The outlet | will | function adequately |

### High Flow Storm Information

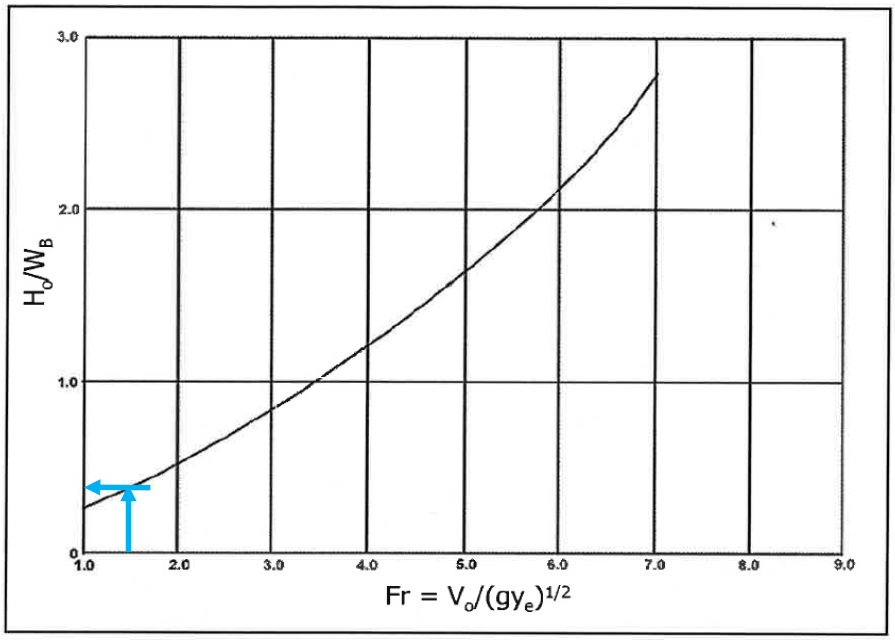



**Figure 9.14. Design Curve for USBR Type VI Impact Basin**

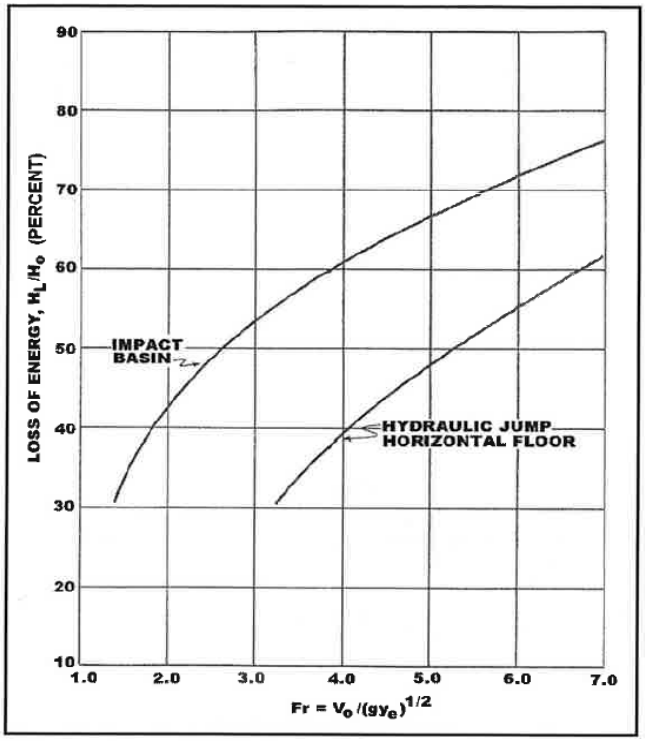



**Figure 9.15. Energy Loss of USBR Type VI Impact Basin versus Hydraulic Jump**

**Table 9.2 (CU). USBR Type VI Impact Basin Dimensions (ft) (AASHTO, 2005)**

| $W_B$ | $h_1$ | $h_2$ | $h_3$ | $h_4$ | L | $L_1$ | $L_2$ |
|---|---|---|---|---|---|---|---|
| 4. | 3.08 | 1.50 | 0.67 | 1.67 | 5.42 | 2.33 | 3.08 |
| 5. | 3.83 | 1.92 | 0.83 | 2.08 | 6.67 | 2.92 | 3.83 |
| 6. | 4.58 | 2.25 | 1.00 | 2.50 | 8.00 | 3.42 | 4.58 |
| 7. | 5.42 | 2.58 | 1.17 | 2.92 | 9.42 | 4.00 | 5.42 |
| 8. | 6.17 | 3.00 | 1.33 | 3.33 | 10.67 | 4.58 | 6.17 |
| 9. | 6.92 | 3.42 | 1.50 | 3.75 | 12.00 | 5.17 | 6.92 |
| 10. | 7.58 | 3.75 | 1.67 | 4.17 | 13.42 | 5.75 | 7.67 |
| 11. | 8.42 | 4.17 | 1.83 | 4.58 | 14.58 | 6.33 | 8.42 |
| 12. | 9.17 | 4.50 | 2.00 | 5.00 | 16.00 | 6.83 | 9.17 |
| 13. | 10.17 | 4.92 | 2.17 | 5.42 | 17.33 | 7.42 | 10.00 |
| 14. | 10.75 | 5.25 | 2.33 | 5.83 | 18.67 | 8.00 | 10.75 |
| 15. | 11.50 | 5.58 | 2.50 | 6.25 | 20.00 | 8.50 | 11.50 |
| 16. | 12.25 | 6.00 | 2.67 | 6.67 | 21.33 | 9.08 | 12.25 |
| 17. | 13.00 | 6.33 | 2.83 | 7.08 | 21.50 | 9.67 | 13.00 |
| 18. | 13.75 | 6.67 | 3.00 | 7.50 | 23.92 | 10.25 | 13.75 |
| 19. | 14.58 | 7.08 | 3.17 | 7.92 | 25.33 | 10.83 | 14.58 |
| 20. | 15.33 | 7.50 | 3.33 | 8.33 | 26.58 | 11.42 | 15.33 |

| $W_B$ | $W_1$ | $W_2$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ |
|---|---|---|---|---|---|---|---|
| 4. | 0.33 | 1.08 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 5. | 0.42 | 1.42 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 6. | 0.50 | 1.67 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 7. | 0.50 | 1.92 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 8. | 0.58 | 2.17 | 0.50 | 0.58 | 0.58 | 0.50 | 0.25 |
| 9. | 0.67 | 2.50 | 0.58 | 0.58 | 0.67 | 0.58 | 0.25 |
| 10. | 0.75 | 2.75 | 0.67 | 0.67 | 0.75 | 0.67 | 0.25 |
| 11. | 0.83 | 3.00 | 0.67 | 0.75 | 0.75 | 0.67 | 0.33 |
| 12. | 0.92 | 3.00 | 0.67 | 0.83 | 0.83 | 0.75 | 0.33 |
| 13. | 1.00 | 3.00 | 0.67 | 0.92 | 0.83 | 0.83 | 0.33 |
| 14. | 1.08 | 3.00 | 0.67 | 1.00 | 0.92 | 0.92 | 0.42 |
| 15. | 1.17 | 3.00 | 0.67 | 1.00 | 1.00 | 1.00 | 0.42 |
| 16. | 1.25 | 3.00 | 0.75 | 1.00 | 1.00 | 1.00 | 0.50 |
| 17. | 1.33 | 3.00 | 0.75 | 1.08 | 1.00 | 1.00 | 0.50 |
| 18. | 1.33 | 3.00 | 0.75 | 1.08 | 1.08 | 1.08 | 0.58 |
| 19. | 1.42 | 3.00 | 0.83 | 1.17 | 1.08 | 1.08 | 0.58 |
| 20. | 1.50 | 3.00 | 0.83 | 1.17 | 1.17 | 1.17 | 0.67 |

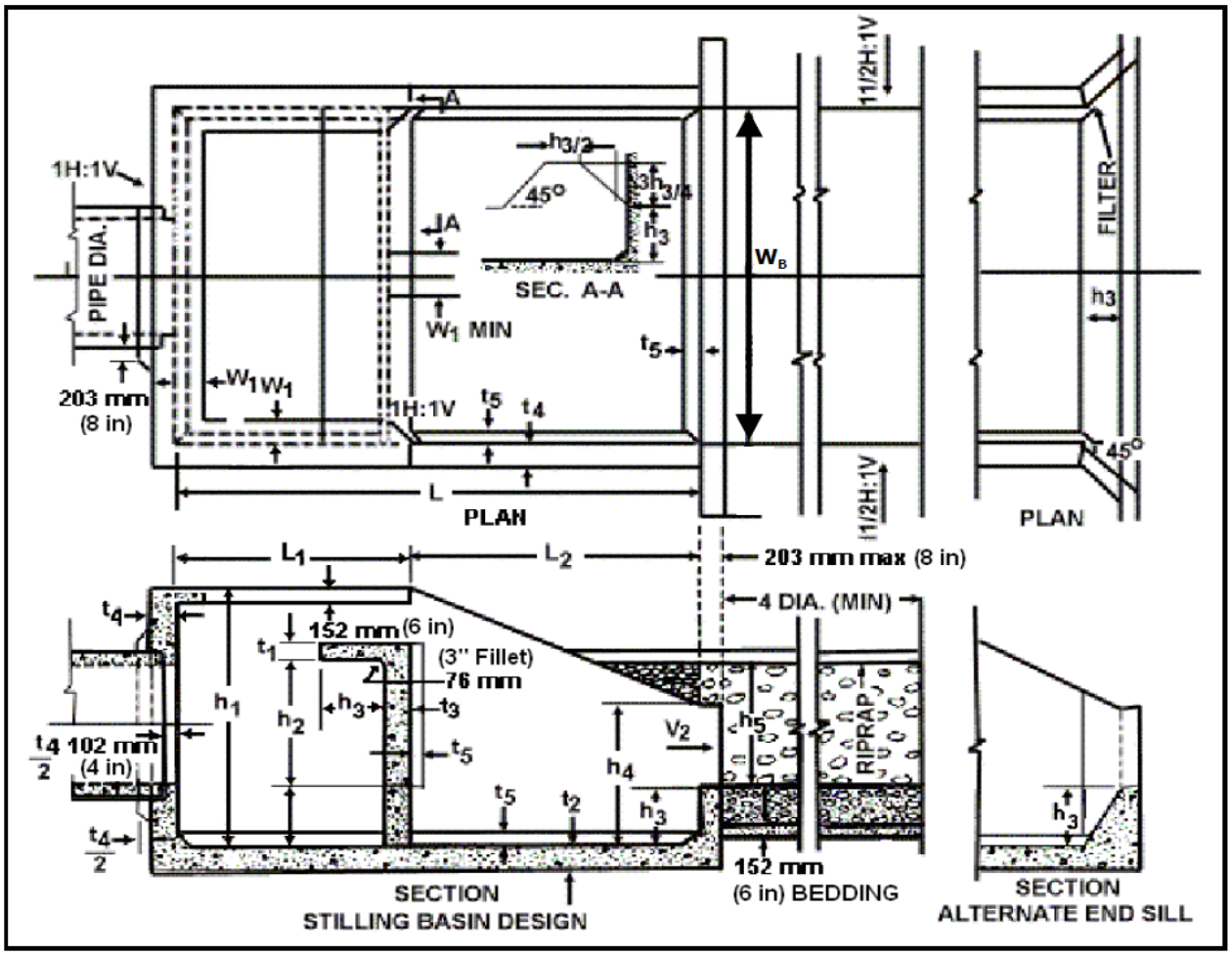



**Figure 9.13. USBR Type VI Impact Basin**

**Calculations (Continued):**

## Downslope Flume 3 - Velocity Calculator (Q = 19.49 cfs)

## Manning Formula Uniform Pipe Flow at Given Slope and Depth

**Inputs:**

| | | |
|---|---|---|
| Pipe Diameter, $d_o$ | 18 | in |
| Manning Roughness, n | 0.0120 | |
| Pressure slope | 0.2500 | slope |
| Percent of (or ratio to) full depth (100% or 1 if flowing full) | 0.4037 | fraction |

**Results:**

| | | |
|---|---|---|
| Flow, Q | 19.4983 | ft^3/s |
| Velocity, v | 8.8936 | m/s |
| Velocity head, hv | 4.0330 | m |
| Flow Area, A | 0.0621 | m^2 |
| Wetted Perimeter, P | 0.6296 | m |
| Hydraulic Radius | 0.0986 | m |
| Top Width, T | 0.4486 | m |
| Froude Number, F | 7.75 | |
| Shear Stress (tractive force), τ | 452.4774 | N/m^2 |

Version 2.0 (20 June 2017)

HawsEDC Calculators

Rock Chute

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| | | | |
|---|---|---|---|
| Sheet No: 1 of 4 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: COL - POO | By: RJG | Date: 4/11/22 |
| Client: WPL | Subject: Rock Chute Sizing & Riprap Size | Chk'd: MJT | Date: 4/13/22 |

**Purpose:**

To size the rock chutes to accommodate the 25-year, 24-hour storm event.

**References:**

1. Rock Chute Design Data spreadsheet Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998.
2. HydroCAD Report_Post Construction
3. Figure 1 - Storm Water Post Construction
4. Stable 25.1 Typical Particle Sizes of Native Sands at 75 Percent Passing (D75) from WisDOT Facilities. Development Manual (FDM).

**Approach:**

1. Enter Inlet Channel data based on culvert apron or swale geometry Reference #2 and #3.
2. Enter Chute data based on slope from Reference #3, start the width, Bw equal to inlet channel Bw.
3. Enter Outlet Channel data based on Reference #3, start the width, Bw equal to inlet channel Bw.
4. Enter drainage area, apron elevations, flow (Q), and rainfall.
5. Adjust Bw for Chute and Outlet Channel until spreadsheet shows the rock chute "will" function adequately.
6. Determine rip rap classification based on D50 weight per Reference #4.

**Assumptions:**

1. Assume side slopes of chute and outlet channel are 2:1.
2. Assume Factor of Safey is 1.2.
3. n-value is based on proposed conditions at the channel.
4. Assume Outlet apron depth, d is 1.0 ft.
5. Freeboard is 1.0 ft.
6. Use 25-year, 24-hour storm event flow (Reference #2) for $Q_{high}$ and $Q_{low}$.
7. Classification of riprap is based on weight (Reference #4).

**Calculations:**

See attached spreadsheet calcs for each rock chute.

**Results:**

The rock chutes are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

| Rock Chute | Width (ft) | Thickness (in) | Apron Width (ft) | Apron Length (ft) | $D_{50}$ (in) | WisDOT Rip Rap Classification |
|---|---|---|---|---|---|---|
| RC1 | 6 | 12 | 6 | 7 | 5.8 | Light Riprap Type R |
| RC2 | 6 | 8 | 6 | 5 | 3.6 | Light Riprap Type R |

# Rock Chute Design Data

(Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Revised for WisDOT 9/2010

**Project:** COL - POO Landfill Closure RC1 **County:** Columbia
**Designer:** RJG **Checked by:** MJT
**Date:** April 11, 2022 **Date:** 04/13/22

## Input Geometry:

| Upstream Channel | | Chute | | | Downstream Channel | |
|---|---|---|---|---|---|---|
| Bottom Width = | 6.0 ft. | Bottom Width = | 6.0 ft. | | Bottom Width = | 6.0 ft. |
| Side slopes = | 1.0 (m:1) | Factor of safety = | 1.20 (SF) | 1.2 Min | Side slopes = | 2.0 (m:1) |
| Mannings n value = | 0.012 | Side slopes = | 2.0 (z:1) | 2.0:1 max. | Mannings n value = | 0.030 |
| Bed slope = | 0.0001 ft./ft. | Bed slope = | 0.1967 ft./ft | 3.0:1 max. | Bed slope = | 0.0050 ft./ft. |
| Note: Use procedures 13-30-15 or 13-30-25 for upstream and downstream Mannings n | | Freeboard = | 1.0 ft. | | | |
| | | Outlet apron depth, d = | 1.0 ft. | | Base flow = | 0.0 cfs |

## Flow and Elevation Data:

Apron elev. --- Inlet = 822.8 ft. ---- Outlet 802.4 ft. --- ($H_{drop}$ = 19.4 ft.)

Degree of angularity = 1

$Q_{high}$ = Runoff from design storm
$Q_5$ = Runoff from a 5-year,24-hour storm

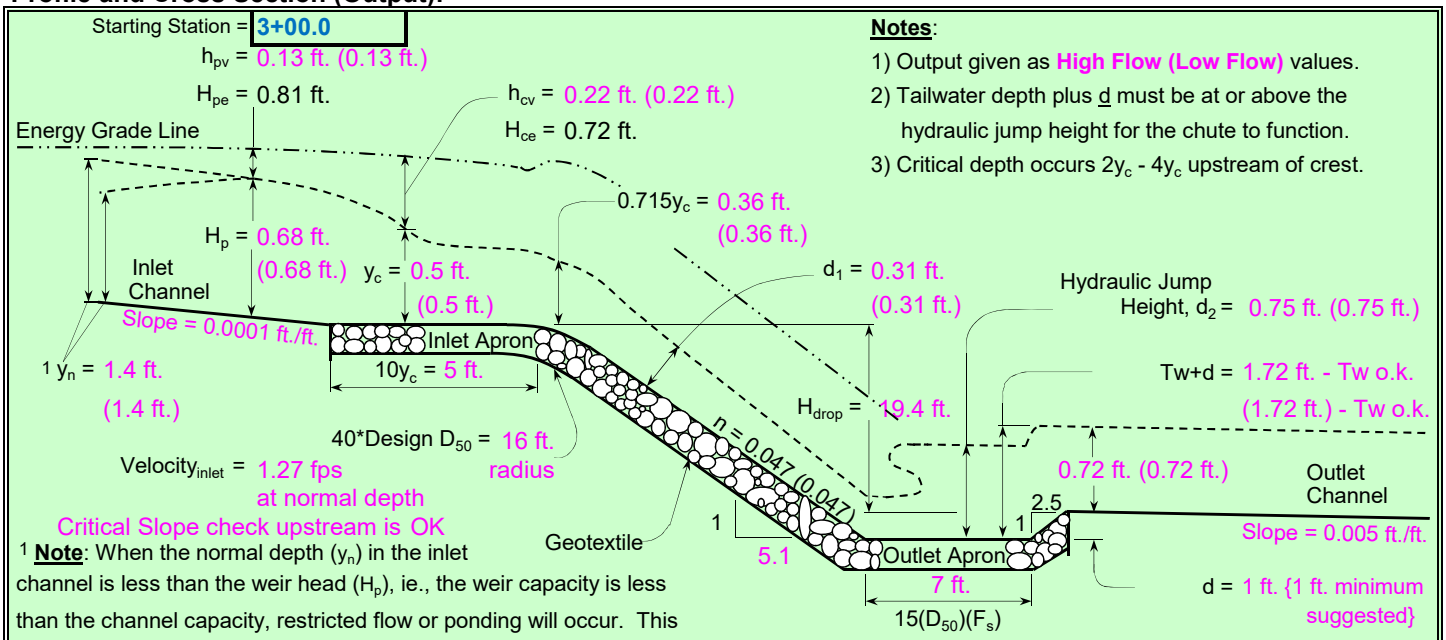
1 --> 50% angular, 50% rounded
2 --> 100 % rounded

$Q_{high}$ = 13.2 cfs High flow storm through chute → Tw (ft.) = Program
$Q_{low}$ = 13.2 cfs Low flow storm through chute → Tw (ft.) = Program

**Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.

**Input tailwater (Tw)**: 0.20 1.20

## Profile and Cross Section (Output):

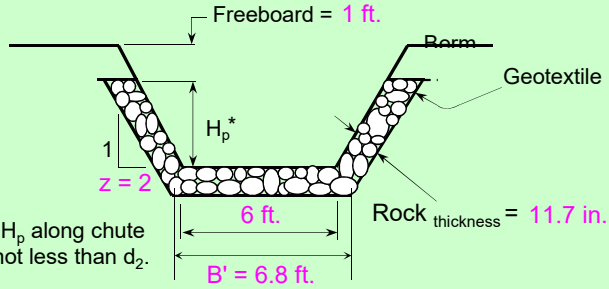



**Notes**:
1) Output given as **High Flow (Low Flow)** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.

[1] **Note**: When the normal depth ($y_n$) in the inlet channel is less than the weir head ($H_p$), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

## Profile Along Centerline of Chute

### Typical Cross Section




* Use $H_p$ along chute but not less than $d_2$.

| | | |
|---|---|---|
| | 2.01 cfs/ft. | Equivalent unit discharge |
| SF = | 1.20 | Factor of safety (multiplier) |
| $d_1$ = | 0.31 ft. | Normal depth in chute |
| n-value = | 0.047 | Manning's roughness coefficient |
| $D_{50}$(SF) = | 5.8 in. | Minimum Design $D_{50}$* |
| 2($D_{50}$)(SF) = | 11.7 in. | Rock chute thickness |
| Tw + d = | 1.72 ft. | Tailwater above outlet apron |
| $d_2$ = | 0.75 ft. | Hydraulic jump height |
| *** The outlet | will | function adequately |

### High Flow Storm Information

# Rock Chute Design Data

(Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Revised for WisDOT 9/2010

**Project:** COL - POO Landfill Closure RC2 **County:** Columbia
**Designer:** RJG **Checked by:** MJT
**Date:** April 11, 2022 **Date:** 04/13/22

## Input Geometry:

| Upstream Channel | | Chute | | | Downstream Channel | |
|---|---|---|---|---|---|---|
| Bottom Width = | 6.0 ft. | Bottom Width = | 6.0 ft. | | Bottom Width = | 6.0 ft. |
| Side slopes = | 1.0 (m:1) | Factor of safety = | 1.20 (SF) | 1.2 Min | Side slopes = | 2.0 (m:1) |
| Mannings n value = | 0.012 | Side slopes = | 2.0 (z:1) | 2.0:1 max. | Mannings n value = | 0.030 |
| Bed slope = | 0.0001 ft./ft. | Bed slope = | 0.0690 ft./ft | 3.0:1 max. | Bed slope = | 0.0050 ft./ft. |
| Note: Use procedures 13-30-15 or 13-30-25 for upstream and downstream Mannings n | | Freeboard = | 1.0 ft. | | | |
| | | Outlet apron depth, d = | 1.0 ft. | | Base flow = | 0.0 cfs |

## Flow and Elevation Data:

Apron elev. --- Inlet = 815.8 ft. ------ Outlet 808.4 ft. --- ($H_{drop}$ = 6.4 ft.)

Degree of angularity = 1

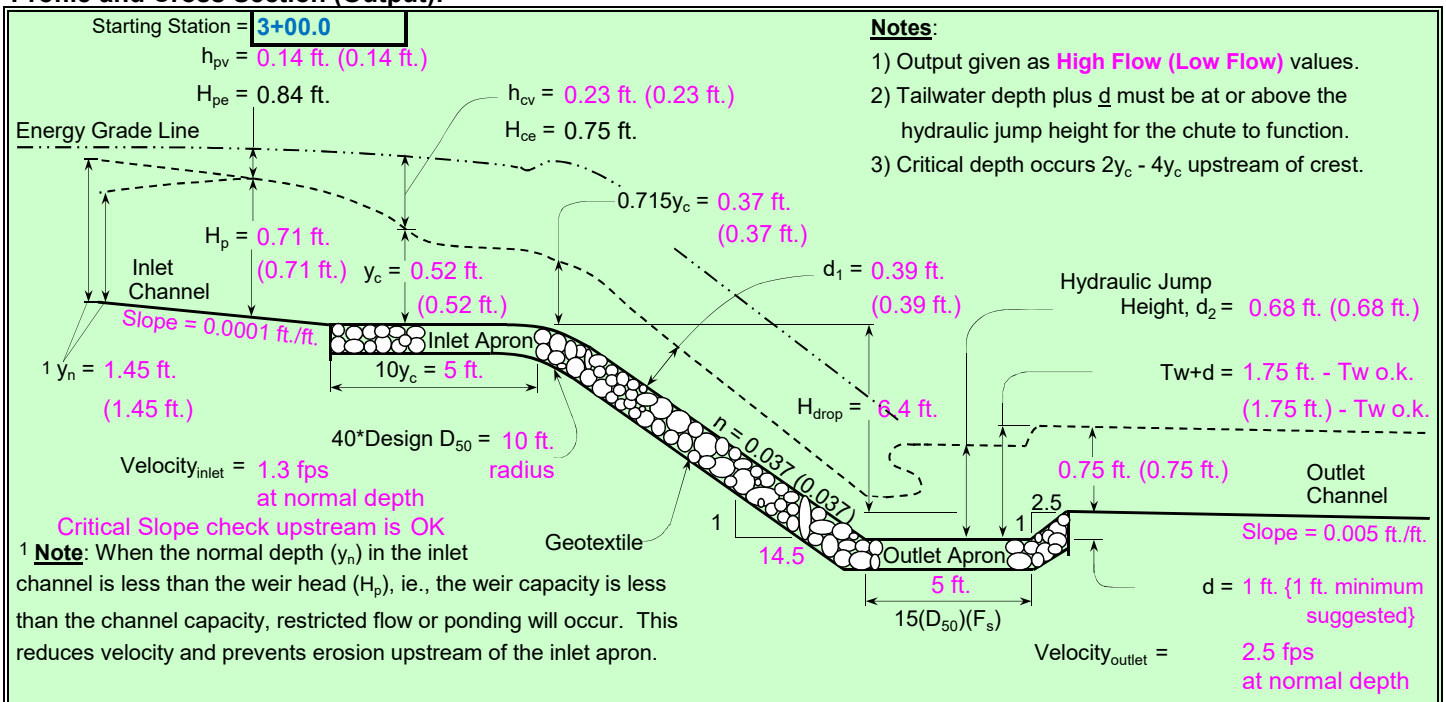
$Q_{high}$ = Runoff from design storm
$Q_5$ = Runoff from a 5-year,24-hour storm
1 --> 50% angular, 50% rounded
2 --> 100 % rounded

$Q_{high}$ = 14.0 cfs High flow storm through chute → Tw (ft.) = Program
$Q_{low}$ = 14.0 cfs Low flow storm through chute → Tw (ft.) = Program

**Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.

**Input tailwater (Tw)**: 0.07 1.20

## Profile and Cross Section (Output):

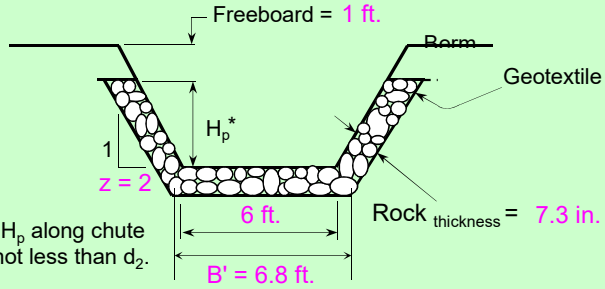



**Notes**:
1) Output given as **High Flow (Low Flow)** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.

[1] **Note**: When the normal depth ($y_n$) in the inlet channel is less than the weir head ($H_p$), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

## Profile Along Centerline of Chute

### Typical Cross Section




* Use $H_p$ along chute but not less than $d_2$.

| | | |
|---|---|---|
| | 2.14 cfs/ft. | Equivalent unit discharge |
| SF = | 1.20 | Factor of safety (multiplier) |
| $d_1$ = | 0.39 ft. | Normal depth in chute |
| n-value = | 0.037 | Manning's roughness coefficient |
| $D_{50}$(SF) = | 3.6 in. | Minimum Design $D_{50}$* |
| 2($D_{50}$)(SF) = | 7.3 in. | Rock chute thickness |
| Tw + d = | 1.75 ft. | Tailwater above outlet apron |
| $d_2$ = | 0.68 ft. | Hydraulic jump height |
| *** The outlet | will | function adequately |

### High Flow Storm Information

# Discharge Apron Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 2 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/21/22 |
| Client: WPL | Subject: Riprap Sizing at Culvert Outlet | Chk'd: MJT | Date: 4/5/22 |

**Purpose:**

To size the riprap apron dimensions at culvert C2, C3, C4, and C5 based on a 25-year, 24 hour storm event:

**References:**

1. "Energy Dissipators," Wisconsin Department of Transportation (WisDOT), Facilities Development Manual (FDM) 13-35-5.
2. Post Construction Condition HydroCAD Model.
3. "Rock Riprap Lined Channels," WisDOT FDM 13-30-25.
4. Culvert Sizing Calculation.
5. WisDOT FDM Chapter 13, Section 30 - Rock Riprap Lined Chutes

**Approach:**

Use the equations in Section 5.2 - Riprap Blanket of WisDOT FDM 13-35-5 (Energy Dissipators) to determine the average size of stone ($d_{50}$) and riprap apron length. Round up the calculated $d_{50}$ to the nearest WisDOT standard riprap size.

Use WisDOT FDM 13-35 Attachment 5.2 to determine the width of the riprap apron for discharges to a flat area. For discharges to channels, extend riprap across the channel bottom and up the sides.

**Assumptions:**

Assume riprap apron thickness (T) is 2 * $d_{50}$ to protect against washout and undercutting of the riprap.

Assume tailwater depth, TW = 0.40 * $D_o$

Assume max TW conditions for the riprap apron width.

Assume that when there are multiple culverts, the total discharge to the culverts is distributed evenly through each barrel.

**Calculation:**

From WisDOT Section 5.2 - Riprap Blanket:

$$d_{50}/D_o = 0.020\ (D_o/TW)\ (Q/D_o^{5/2})^{4/3}$$

$$L_{sp}/D_o = 1.7\ (Q/D_o^{5/2}) + 8$$

Or:

$$d_{50} = 0.02 \times (D_o/TW) \times (Q/D_o^{5/2})^{4/3} \times D_o$$

$$L_{sp} = (1.7\ (Q/D_o^{5/2}) + 8) \times D_o$$

where: $D_o$ = Diameter or width of culvert (ft)

Q = Flow rate (cfs) (discharge rate through culvert, from Worst Case Condition HydroCAD Model (Reference #2))

TW = Tail water depth (ft)

$d_{50}$ = Average size of stone (ft)

$L_{sp}$ = Length of stone protection (Apron Length) (ft)

| Location | Total Flow (Q, cfs) | Number of Pipes | $D_o$ (ft) | Q (cfs) | TW (ft) | $d_{50\ calculated}$ | $d_{50\ Design}$ | $L_{sp}$ |
|---|---|---|---|---|---|---|---|---|
| Culvert C2 | 9.68 | 2 | 1.5 | 4.8 | 0.60 | 0.16 | 0.83 | 16 |
| Culvert C3 | 27.38 | 2 | 2.5 | 13.7 | 1.00 | 0.19 | 0.83 | 26 |
| Culvert C4 | 35.39 | 2 | 2.5 | 17.7 | 1.00 | 0.27 | 0.83 | 28 |
| Culvert C5 | 35.21 | 2 | 2.5 | 17.6 | 1.00 | 0.27 | 0.83 | 28 |

**Results:**

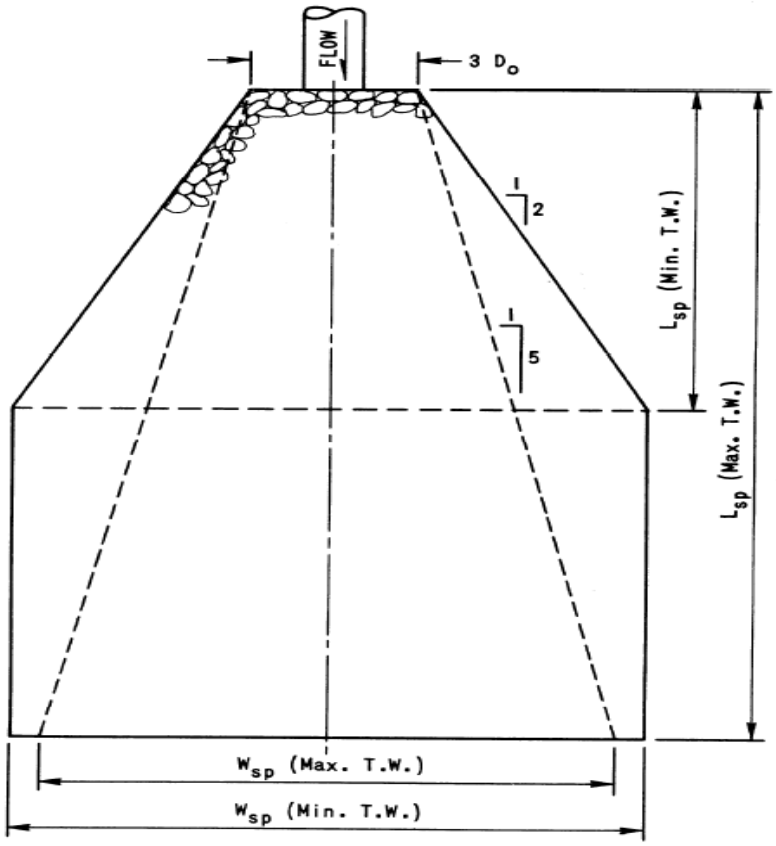
Below is a summary of the $d_{50}$ , thickness (T), and configuration of the riprap apron. Also refer to WisDOT FDM Attachment 5.2 (Sheet 2) for details on apron layout. Use WisDOT Light Riprap at culvert discharge.

| Location | $d_{50}$ (in)* | T (in) | $L_{sp}$ (ft) | $W_{sp}$ (ft) |
|---|---|---|---|---|
| Culvert C2 | 10.0 | 20 | 16 | See Note 1 |
| Culvert C3 | 10.0 | 20 | 26 | See Note 1 |
| Culvert C4 | 10.0 | 20 | 28 | See Note 1 |
| Culvert C5 | 10.0 | 20 | 28 | See Note 1 |

1. For discharges to channels, place riprap along channel bottom and up side of channel.

*Per Table 25.1 on Sheet 2 for standard WisDOT riprap sizes use Light Riprap.

*FDM 13-35 Attachment 5.2 Recommended Configuration of Riprap Blanket Subject to Maximum and Minimum Tail Waters*




RECOMMENDED CONFIGURATION OF RIPRAP BLANKET SUBJECT TO MAXIMUM AND MINIMUM TAILWATERS

Source: Miscellaneous paper H-72-5, "Practical Guidance for Estimating and Controlling Erosion at Culvert Outlets", U.S. Army Engineer Waterways Experiment Station, May, 1972.

***Table 25.1 Typical Particle Sizes of Native Sands at 75 Percent Passing ($D_{75}$)***

| Riprap Type | D50 (inches) | D50 (feet) | Riprap Thickness (in) | Geotextile Type |
|---|---|---|---|---|
| Select Crushed Material | 2.2 | 0.18 | 5 | Type R |
| Light Riprap | 10 | 0.83 | 12 | Type R |
| Medium Riprap | 12.5 | 1.04 | 18 | Type HR |
| Heavy Riprap | 16 | 1.33 | 24 | Type HR |
| Extra-Heavy Riprap | 20 | 1.67 | 30 | Type HR |

Source: Table 25.1 from WisDOT FDM.

# Appendix B2

# GCL Compatibility Test Results

GSE Environmental
19103 Gundle Rd
Houston, TX 77073
(832) 657-4857

November 23, 2015

**Phillip Gearing**
Geological Engineer

**SCS ENGINEERS**
2830 Dairy Drive
Madison, WI 53718
608.224.2830
Direct: 608.216.7324 • Cell: 608.316.5452
www.scsengineers.com

RE: **GSE CAR GCL Compatibility Test – Coal Ash Resistant**
**Alliant Energy – Columbia Energy Center**

Dear Mr. Phillip Gearing,

This letter summarizes the testing GSE performed on the coal combustion residual (CCR) samples that were supplied by Alliant Energy from their Columbia Energy Center. Alliant Energy supplied samples of dry fly ash from its operating coal-fired facility at Columbia Energy Center. The samples were used to generate a leachate for the GCL chemical compatibility testing. Based on the chemical constituents in the leachate, GSE selected the BentoLiner CAR GCL product for compatibility testing per ASTM D 6766 Scenario 2.

Leachate was derived by the following methods:

- The samples of CCR fly ash were received in buckets at the testing lab.
- The CCR fly ash samples were then leached with de-ionized water to produce sufficient leachate for the chemical compatibility testing using ASTM D 6141 procedure for generating a test liquid from a soil.
- The resulting leachate was analyzed for chemical constituents.
- GSE selected a polymer enhanced CAR (Coal Ash Resistant) Series Geosynthetic Clay Liner product deemed to be compatible based on chemical analysis of the leachate.
- JLT laboratories performed Hydraulic Conductivity testing per ASTM D6766 using the site generated leachates from above. GSE used scenario 2 which calls for permeation using the site specific leachate, not deionized water. This places the GCL with leachate as opposed to the deionized water prior to start of the compatibility test.
- The ASTM D 6766 Scenario 2 compatibility test for GCL ran uninterrupted for a period of 6 months. The test terminated at 6 months with test parameters and results listed below.
- The CAR GCL had a permeability of $3.4 \times 10^{-10}$ cm/s after 180 days of testing when tested against the site specific leachate produced from Columbia Energy Center ash. This value is greater (less permeable) than the GSE certified GCL permeability of $3 \times 10^{-9}$ cm/s.
- The CAR GCL meets or exceeds the Federal CCR Rule CCL Hydraulic Flux Equivalence (found in Section 40 CFR 257.70) per Table 1 below.

**Table 1: Hydraulic Equivalency Calculation GCL vs. CCL**

**Compacted Clay Liner Calculated Flux with 60 cm (2 ft.) Thickness**

| Compacted Clay Liner Thickness | thickness | water head | gradient | hydraulic conductivity | Flux |
|---|---|---|---|---|---|
| | T | H | i=(H/T)+1 | k | q =ki |
| | cm | cm | | cm/s | cm/s |
| ***CCL - 2 ft.*** | 60 | 30 | 1.50 | 1.0E-07 | 1.5E-07 |

**GCL Equivalency with GCL Thickness of 6 mm**

| GCL Type | thickness | water head | gradient | hydraulic conductivity | Flux |
|---|---|---|---|---|---|
| | T | H | i=(H/T)+1 | k | q =ki |
| | cm | cm | | cm/s | cm/s |
| ***GSE CAR BentoLiner GCL 6 mm thickness*** | 0.6 | 30 | 51.00 | 3.0E-9 | 1.5E-07 |

As required by the Federal CCR Rule, the liquid flow rate of BentoLiner CAR Series GCL, as manufactured by GSE Environmental, LLC, is less than the liquid flow rate for a 2-feet thick layer of compacted clay liner with a maximum hydraulic conductivity of 1E-7 cm/sec.

---

The purpose of this test is to demonstrate geosynthetic clay liner (GCL) liquid flow rate equivalency to compacted clay liner per Federal CCR Rule (published version posted to the US EPA website December 19, 2014). The Federal CCR Rule is found in Section 40 CFR 257.70.

GSE BentoLiner CAR NSL GCL is deemed chemically compatible with the leachate that will be encountered in the CCR waste management liner system at Columbia Energy Center.

Please review the results and contact me with any questions.

Respectfully,

Vincent Diviacchi
Technical Manager – Canada & Midwest USA
M: 832-657-4857
E: vdiviacchi@gseworld.com
W: www.gseworld.com

## SUMMARY OF FLEX WALL PERMEABILITY COMPATIBILITY TEST RESULTS

ASTM D-6766

| | | | | | |
|---|---|---|---|---|---|
| Client | : GSE | | Print Date | : 09/15/2015 | |
| Project | : Alliant Columbia FGD | | Job No. | : 15LR3160.01 | |
| Description | : No. 502194242 | | Tested By | : MLB/DB | |
| | : Lot 21101409 | | Checked By | : JBJr | |
| Permeant Fluid | : Lab Generated Leachate | | Panel No | : 20 | |
| Start Date : March 17, 2015 | Stop Date : September 1 | | Spec. Gravity | : 2.74 | Assumed |

### Physical Property Data

| | | | | | |
|---|---|---|---|---|---|
| Initial Height ( in ) | : | 0.29 | Final Height ( in ) | : | 0.32 |
| Initial Diameter ( in ) | : | 4.00 | Final Diameter ( in ) | : | 4.00 |
| Initial Wet Weight ( g ) | : | 41.50 | Final Wet Weight ( g ) | : | 84.40 |
| Wet Density ( pcf ) | : | 43.34 | Wet Density ( pcf ) | : | 79.89 |
| Moisture Content % | : | 9.60 | Moisture Content % | : | 148.20 |
| Dry Density ( pcf ) | : | 39.55 | Dry Density ( pcf ) | : | 32.19 |

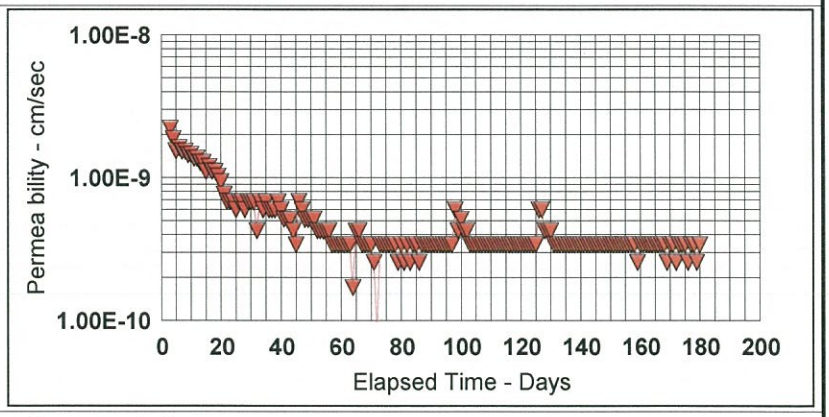
### Test Parameters

| | | | | | |
|---|---|---|---|---|---|
| Fluid | : | Lab Generated Leachate | **Average Effective** | | |
| Cell Pressure psi ) | : | 80.00 | **Confining Pressure (psi)** | : | 4.00 |
| Head Water psi ) | : | 77.00 | Gradient | : | 172.50 |
| Tail Water psi ) | : | 75.00 | **Eff Stress at Base (psi )** | : | 5 |

### Permeability Input Data

For Last Data Point

| | | | |
|---|---|---|---|
| Flow, Q | ( cc ) | : | 0.40 |
| Length, L | ( in ) | : | 0.32 |
| Area, A | ( sqin ) | : | 12.57 |
| **Head, h** | **( psi )** | : | **2.00** |
| Time, t | ( min ) | : | 1444.00 |
| Temp, T | ( Deg C ) | : | 18.7 |




### Computed Permeability

**PERMEABILITY, K =** 3.40E-010 ( cm/sec ) at 20 Degrees C

**Day 180** Total Inflow to Date : 103.5 cc

19103 Gundle Road
Houston, Texas 77073
O 281.443.8564
F 281.875.6010
TF 800.435.2008

5/18/2015

**Phillip Gearing**
Geological Engineer
**SCS ENGINEERS**
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Madison, WI 53718
608.224.2830
Direct: 608.216.7324 • Cell: 608.316.5452
www.scsengineers.com

**RE: GCL Compatibility Analysis**
**Alliant Energy – Columbia Power Plant in Wisconsin**

Dear Mr. Phillip Gearing,

As requested, the purpose of this correspondence is to confirm suitability of GSE geosynthetic clay liner (GCL) for FGD waste at the Alliant Energy Columbia Power Plant. This analysis is based on FGD being shipped to GSE for leaching. The leached solution was then analyzed for chemical constituents so GSE can assess the need and use of polymer enhancement in the GCL.

GCL is an active barrier system which relies on the swelling capacity of the sodium bentonite to decrease flow through the liner. Different chemical ions in the leachate can affect the GCL negatively and increase its permeability through cation exchange. GSE can modify our GCL products with polymers to resist this exchange and maintain the GCL impermeability.

Based on the chemical constituents identified in the Columbia Power Plant ash received by GSE, our CAR Series of GCL is recommended for use on site as an effective containment barrier.

GSE will run a permeability test per ASTM D 6766 Scenario 2 with the site specific leachate for an extended period of time. Ideally this time period will exceed 6 months so we have solid data to monitor the leachate interaction with the polymer enhanced GCL.

Should you wish to discuss or need additional information, please contact me at 832-657-4857.

Respectfully,

Vincent Diviacchi
Technical Manager – Midwest USA & Canada
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GSE ENVIRONMENTAL™

May 7, 2015

Vince Diviacchi
GSE Environmental
19103 Gundle Road
Houston, TX 77073

RE: Alliant Columbia FGD Leachate Analysis Summary for GCL Compatibility Test

Dear Mr. Diviacchi,

The ash that was sent to GSE was leached with Deionized water, and samples of the solution were sent to a third party lab for analysis. I have listed the key chemical constituents that will affect GCL performance in table below.

| Chemical Ions | Bottom Ash Leachate (mg/l) |
|---|---|
| Calcium | 1,000 |
| Magnesium | ND |
| Potassium | 110 |
| Sodium | 120 |
| Chlorides | 380 |
| Sulfates | 410 |
| pH | 12.5 |

*ND – Not Detected

Please feel free to contact me with any questions.

Thank You,

Jimmy Youngblood
GSE Technical Support Manager
(800) 435-2008 ext. 2523
jyoungblood@gseworld.com

JGY150007

# Appendix B3

# HELP Model

BT SQUARED
CIVIL & ENVIRONMENTAL ENGINEERING

| | | | |
|---|---|---|---|
| Sheet No. | 1 of 9 | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 4071 | Job: Columbia Plan of Operation Update | By: PEG | Date 10/28/2010 |
| Client: Wisconsin Power & Light | Subject: HELP Model Calculation | Chk'd: BLP | Date 10/28/2010 |

**Purpose:** To evaluate the effect of the most critical Module area and flow length for Phases 1 and 2 on the average leachate head levels on the landfill liner. The critical area is Module 13 in Phase 2. The other Modules have smaller areas and shorter drainage lengths.

**Approach:** Use the Hydrologic Evaluation of Landfill Performance (HELP) model to calculate the average leachate head.

**References:** 1.) HELP Model Version 3.07
2.) The Hydrolic Evaluation of Landfill Performance (HELP) Model, Engineering Documentation for Version 3.

**Assumptions:** Weather data obtained from Madison, Wisconsin.

| | | |
|---|---|---|
| Total Area of Module 13 = | 5.0 | acres |
| Slope of Liner System = | 2.0 | percent |
| Longest Drainage Length = | 185.0 | feet |

Layer 1 - Vertical Percolation Layer (Type 1)
HELP Default Waste Characteristics for High-Density Electric Plant Coal Fly Ash (30)
A waste thickness of 3 ft was assumed.

Layer 2 - Lateral Drainage Layer (Type 2)
HELP Default Waste Characteristics for High-Density Electric Plant Coal Bottom Ash (31)
Effective Saturated Hydraulic Conductivity was changed to tested value of 2.5 $x10^{-2}$ cm/s

Layer 3 - Flexible Membrane Liner (Type 4)
HELP Default Geosynthetic Material Characteristics for High Density Polyethylene Membrane (35)

Layer 4 - Barrier Soil Liner (Type 3)
HELP Default High Density Soils for Bentonite (17)

**Calculation:** Assumed properties of the liner system components and weather data were entered into the HELP model. The model was executed for a 15 year time frame. The HELP model output is attached.

The average head on the top of the HDPE geomembrane over the 15 years is 1.5 inches.
The average peak daily value for head on the geomembrane over 15 years is 7.2 inches.
The maximum head on top of the geomembrane over 15 years is 10.1 inches.

**Conclusion:** The proposed leachate collection system will maintain the average head on the liner below the required 1-foot.

**********
**********

**********
**********

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE

HELP MODEL VERSION 3.07 (1 NOVEMBER 1997)

DEVELOPED BY ENVIRONMENTAL LABORATORY

USAE WATERWAYS EXPERIMENT STATION

FOR USEPA RISK REDUCTION ENGINEERING LABORATORY

**********
**********

**********
**********

PRECIPITATION DATA FILE: I:\4071\CALCUL~1\HELP\DATA4.D4
TEMPERATURE DATA FILE: I:\4071\CALCUL~1\HELP\DATA7.D7
SOLAR RADIATION DATA FILE: I:\4071\CALCUL~1\HELP\DATA13.D13
EVAPOTRANSPIRATION DATA: I:\4071\CALCUL~1\HELP\DATA11.D11
SOIL AND DESIGN DATA FILE: I:\4071\CALCUL~1\HELP\CRITICAL.D10
OUTPUT DATA FILE: I:\4071\CALCUL~1\HELP\TEST1.OUT

TIME: 11:22 DATE: 10/28/2010

**********
**********

TITLE: COLUMBIA PLAN OF OPERATION UPDATE LEACHATE HEAD CALCULATION

**********
**********

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 30

| | | | |
|---|---|---|---|
| THICKNESS | = | 36.00 | INCHES |
| POROSITY | = | 0.5410 | VOL/VOL |
| FIELD CAPACITY | = | 0.1870 | VOL/VOL |
| WILTING POINT | = | 0.0470 | VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.3191 | VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.499999987000E-04 | CM/SEC |

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

| | | | |
|---|---|---|---|
| THICKNESS | = | 12.00 | INCHES |
| POROSITY | = | 0.5780 | VOL/VOL |
| FIELD CAPACITY | = | 0.0760 | VOL/VOL |
| WILTING POINT | = | 0.0250 | VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.0916 | VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.250000004000E-01 | CM/SEC |
| SLOPE | = | 2.00 | PERCENT |
| DRAINAGE LENGTH | = | 185.0 | FEET |

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

| | | | |
|---|---|---|---|
| THICKNESS | = | 0.04 | INCHES |
| POROSITY | = | 0.0000 | VOL/VOL |
| FIELD CAPACITY | = | 0.0000 | VOL/VOL |
| WILTING POINT | = | 0.0000 | VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.0000 | VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.199999996000E-12 | CM/SEC |
| FML PINHOLE DENSITY | = | 0.50 | HOLES/ACRE |
| FML INSTALLATION DEFECTS | = | 2.00 | HOLES/ACRE |
| FML PLACEMENT QUALITY | = | 3 - GOOD | |

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

| | | | |
|---|---|---|---|
| THICKNESS | = | 0.20 | INCHES |

| | | |
|---|---|---|
| POROSITY | = | 0.7500 VOL/VOL |
| FIELD CAPACITY | = | 0.7470 VOL/VOL |
| WILTING POINT | = | 0.4000 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.7500 VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.3000000003000E-08 CM/SEC |

## GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 73.00 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 0.0 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 5.000 | ACRES |
| EVAPORATIVE ZONE DEPTH | = | 8.0 | INCHES |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 3.878 | INCHES |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 4.328 | INCHES |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 0.376 | INCHES |
| INITIAL SNOW WATER | = | 0.000 | INCHES |
| INITIAL WATER IN LAYER MATERIALS | = | 12.737 | INCHES |
| TOTAL INITIAL WATER | = | 12.737 | INCHES |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | INCHES/YEAR |

## EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
MADISON WISCONSIN

| | | | |
|---|---|---|---|
| STATION LATITUDE | = | 43.13 | DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 0.00 | |
| START OF GROWING SEASON (JULIAN DATE) | = | 124 | |
| END OF GROWING SEASON (JULIAN DATE) | = | 279 | |
| EVAPORATIVE ZONE DEPTH | = | 8.0 | INCHES |
| AVERAGE ANNUAL WIND SPEED | = | 9.80 | MPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 74.00 | % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 68.00 | % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 74.00 | % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 77.00 | % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MADISON WISCONSIN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 1.11 | 1.02 | 2.15 | 3.10 | 3.34 | 3.89 |
| 3.75 | 3.82 | 3.06 | 2.24 | 1.83 | 1.53 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MADISON WISCONSIN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 15.60 | 20.50 | 31.20 | 45.80 | 57.00 | 66.30 |
| 70.60 | 68.50 | 60.10 | 49.50 | 35.10 | 22.40 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MADISON WISCONSIN
AND STATION LATITUDE = 43.13 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 15

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| PRECIPITATION | | | | | | |
| TOTALS | 0.98 | 0.97 | 2.10 | 3.13 | 3.38 | 4.46 |
| | 4.29 | 3.23 | 2.70 | 1.96 | 1.34 | 1.74 |
| STD. DEVIATIONS | 0.44 | 0.62 | 0.86 | 1.24 | 2.13 | 2.09 |
| | 1.70 | 1.71 | 1.11 | 0.61 | 0.70 | 0.85 |
| RUNOFF | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| EVAPOTRANSPIRATION | | | | | | |
| TOTALS | 0.402 | 0.411 | 0.543 | 2.578 | 2.946 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3.519 | | | | | | |
| | 3.934 | 2.761 | 1.924 | 1.775 | 0.961 | |
| 0.387 | | | | | | |
| STD. DEVIATIONS | 0.062 | 0.125 | 0.433 | 0.959 | 1.162 | |
| 1.434 | | | | | | |
| | 1.216 | 1.218 | 0.758 | 0.411 | 0.332 | |
| 0.118 | | | | | | |

LATERAL DRAINAGE COLLECTED FROM LAYER 2

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.3414 | 0.2706 | 0.2383 | 0.5824 | 1.4744 | |
| 1.2200 | | | | | | |
| | 1.0240 | 0.8998 | 0.6957 | 0.5561 | 0.4454 | |
| 0.4085 | | | | | | |
| STD. DEVIATIONS | 0.1748 | 0.1239 | 0.0960 | 0.5207 | 0.7942 | |
| 0.5444 | | | | | | |
| | 0.4877 | 0.5256 | 0.4057 | 0.3178 | 0.2080 | |
| 0.1697 | | | | | | |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 0.0000 | | | | | | |
| | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 0.0000 | | | | | | |
| STD. DEVIATIONS | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 0.0000 | | | | | | |
| | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 0.0000 | | | | | | |

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AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

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DAILY AVERAGE HEAD ON TOP OF LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 0.7190 | 0.6254 | 0.5018 | 1.2675 | 3.1053 | |
| 2.6551 | | | | | | |
| | 2.1568 | 1.8952 | 1.5141 | 1.1712 | 0.9694 | |
| 0.8604 | | | | | | |
| STD. DEVIATIONS | 0.3682 | 0.2794 | 0.2022 | 1.1332 | 1.6726 | |
| 1.1847 | | | | | | |
| | 1.0271 | 1.1070 | 0.8829 | 0.6694 | 0.4528 | |
| 0.3574 | | | | | | |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 15

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 30.28 | ( 5.206) | 549654.7 | 100.00 |
| RUNOFF | 0.000 | ( 0.0000) | 0.00 | 0.000 |
| EVAPOTRANSPIRATION | 22.141 | ( 3.3629) | 401853.31 | 73.110 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 2 | 8.15656 | ( 3.37153) | 148041.516 | 26.93355 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00019 | ( 0.00009) | 3.493 | 0.00064 |
| AVERAGE HEAD ON TOP OF LAYER 3 | 1.453 | ( 0.600) | | |
| CHANGE IN WATER STORAGE | -0.013 | ( 1.1178) | -243.71 | -0.044 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 15

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 4.26 | 77319.008 |
| RUNOFF | 0.000 | 0.0000 |
| DRAINAGE COLLECTED FROM LAYER 2 | 0.11095 | 2013.80457 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.000004 | 0.06510 |
| AVERAGE HEAD ON TOP OF LAYER 3 | 7.244 | |
| MAXIMUM HEAD ON TOP OF LAYER 3 | 10.173 | |
| LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN) | 55.0 FEET | |
| SNOW WATER | 4.51 | 81827.5312 |

| | |
|---|---|
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | 0.5410 |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | 0.0470 |

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 15

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 9.6571 | 0.2683 |
| 2 | 1.5771 | 0.1314 |
| 3 | 0.0000 | 0.0000 |
| 4 | 0.1500 | 0.7500 |
| SNOW WATER | 1.152 | |

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BT SQUARED
CIVIL & ENVIRONMENTAL ENGINEERING

| | | | |
|---|---|---|---|
| Sheet No. | 1 of 9 | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 4071 | Job: Columbia Plan of Operation Update | By: PEG | Date 10/28/2010 |
| Client: Wisconsin Power & Light | Subject: HELP Model Calculation | Chk'd: BLP | Date 10/28/2010 |

**Purpose:** To determine the required minimum hydraulic conductivity of the bottom ash drainage layer to maintain an average leachate head level on the geomembrane to less than 1 foot.

**Approach:** Use the Hydrologic Evaluation of Landfill Performance (HELP) model to calculate the average leachate head. Adjust the permeability of the drainage layer until the resulting head on the liner is approximately 1 foot.

**References:** 1.) HELP Model Version 3.07
2.) "The Hydrolic Evaluation of Landfill Performance (HELP) Model, Engineering Documentation for Version 3.

**Assumptions:** Weather data obtained from Madison, Wisconsin.

Total Area of Module 13 = 5.0 acres
Slope of Liner System = 2.0 percent
Longest Drainage Length = 185.0 feet

Layer 1 - Vertical Percolation Layer (Type 1)
HELP Default Waste Characteristics for High-Density Electric Plant Coal Fly Ash (30)
A waste thickness of 3 ft was assumed.

Layer 2 - Lateral Drainage Layer (Type 2)
HELP Default Waste Characteristics for High-Density Electric Plant Coal Bottom Ash (31)
Effective Saturated Hydraulic Conductivity was changed until the average leachate head was close to 1 foot.

Layer 3 - Flexible Membrane Liner (Type 4)
HELP Default Geosynthetic Material Characteristics for High Density Polyethylene Membrane (35)

Layer 4 - Barrier Soil Liner (Type 3)
HELP Default High Density Soils for Bentonite (17)

**Calculation:** Assumed properties of the liner system components and weather data were entered into the HELP model. The model was executed for a 15 year time frame. The HELP model output is attached.

The conductivity of the bottom ash at which the average head on top of the HDPE geomembrane over the 15 years is approximately 12 inches is $3.7 \times 10^{-3}$ cm/s

**Conclusion:** A hydraulic conductivity of $3.7 \times 10^{-3}$ cm/s for the bottom ash will be used in the specifications for the leachate drainage system construction.

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HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE

HELP MODEL VERSION 3.07 (1 NOVEMBER 1997)

DEVELOPED BY ENVIRONMENTAL LABORATORY

USAE WATERWAYS EXPERIMENT STATION

FOR USEPA RISK REDUCTION ENGINEERING LABORATORY

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PRECIPITATION DATA FILE: I:\4071\CALCUL~1\HELP\DATA4.D4
TEMPERATURE DATA FILE: I:\4071\CALCUL~1\HELP\DATA7.D7
SOLAR RADIATION DATA FILE: I:\4071\CALCUL~1\HELP\DATA13.D13
EVAPOTRANSPIRATION DATA: I:\4071\CALCUL~1\HELP\DATA11.D11
SOIL AND DESIGN DATA FILE: I:\4071\CALCUL~1\HELP\BOTTAS~1.D10
OUTPUT DATA FILE: I:\4071\CALCUL~1\HELP\TEST1.OUT

TIME: 13:19 DATE: 10/28/2010

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TITLE: COLUMBIA PLAN OF OPERATION UPDATE BOTTOM ASH CONDUCTIVITY

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE

COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 30

| | | | |
|---|---|---|---|
| THICKNESS | = | 36.00 | INCHES |
| POROSITY | = | 0.5410 | VOL/VOL |
| FIELD CAPACITY | = | 0.1870 | VOL/VOL |
| WILTING POINT | = | 0.0470 | VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.3191 | VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.499999987000E-04 | CM/SEC |

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

| | | | |
|---|---|---|---|
| THICKNESS | = | 12.00 | INCHES |
| POROSITY | = | 0.5780 | VOL/VOL |
| FIELD CAPACITY | = | 0.0760 | VOL/VOL |
| WILTING POINT | = | 0.0250 | VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.1693 | VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.370000000000E-02 | CM/SEC |
| SLOPE | = | 2.00 | PERCENT |
| DRAINAGE LENGTH | = | 185.0 | FEET |

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

| | | | |
|---|---|---|---|
| THICKNESS | = | 0.04 | INCHES |
| POROSITY | = | 0.0000 | VOL/VOL |
| FIELD CAPACITY | = | 0.0000 | VOL/VOL |
| WILTING POINT | = | 0.0000 | VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.0000 | VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.199999996000E-12 | CM/SEC |
| FML PINHOLE DENSITY | = | 0.50 | HOLES/ACRE |
| FML INSTALLATION DEFECTS | = | 2.00 | HOLES/ACRE |
| FML PLACEMENT QUALITY | = | 3 - GOOD | |

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

| | | | |
|---|---|---|---|
| THICKNESS | = | 0.20 | INCHES |
| POROSITY | = | 0.7500 | VOL/VOL |

| | | |
|---|---|---|
| FIELD CAPACITY | = | 0.7470 VOL/VOL |
| WILTING POINT | = | 0.4000 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.7500 VOL/VOL |
| EFFECTIVE SAT. HYD. COND. | = | 0.300000003000E-08 CM/SEC |

## GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 73.00 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 0.0 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 5.000 | ACRES |
| EVAPORATIVE ZONE DEPTH | = | 8.0 | INCHES |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 3.878 | INCHES |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 4.328 | INCHES |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 0.376 | INCHES |
| INITIAL SNOW WATER | = | 0.000 | INCHES |
| INITIAL WATER IN LAYER MATERIALS | = | 13.669 | INCHES |
| TOTAL INITIAL WATER | = | 13.669 | INCHES |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | INCHES/YEAR |

## EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
MADISON WISCONSIN

| | | | |
|---|---|---|---|
| STATION LATITUDE | = | 43.13 | DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 0.00 | |
| START OF GROWING SEASON (JULIAN DATE) | = | 124 | |
| END OF GROWING SEASON (JULIAN DATE) | = | 279 | |
| EVAPORATIVE ZONE DEPTH | = | 8.0 | INCHES |
| AVERAGE ANNUAL WIND SPEED | = | 9.80 | MPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 74.00 | % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 68.00 | % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 74.00 | % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 77.00 | % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MADISON WISCONSIN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 1.11 | 1.02 | 2.15 | 3.10 | 3.34 | 3.89 |
| 3.75 | 3.82 | 3.06 | 2.24 | 1.83 | 1.53 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MADISON WISCONSIN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 15.60 | 20.50 | 31.20 | 45.80 | 57.00 | 66.30 |
| 70.60 | 68.50 | 60.10 | 49.50 | 35.10 | 22.40 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MADISON WISCONSIN
AND STATION LATITUDE = 43.13 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 15

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| PRECIPITATION | | | | | | |
| TOTALS | 0.98 | 0.97 | 2.10 | 3.13 | 3.38 | 4.46 |
| | 4.29 | 3.23 | 2.70 | 1.96 | 1.34 | 1.74 |
| STD. DEVIATIONS | 0.44 | 0.62 | 0.86 | 1.24 | 2.13 | 2.09 |
| | 1.70 | 1.71 | 1.11 | 0.61 | 0.70 | 0.85 |
| RUNOFF | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| EVAPOTRANSPIRATION | | | | | | |
| TOTALS | 0.402 | 0.411 | 0.543 | 2.578 | 2.946 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3.519 | | | | | | |
| | 3.934 | 2.761 | 1.924 | 1.775 | 0.961 | |
| 0.387 | | | | | | |
| STD. DEVIATIONS | 0.062 | 0.125 | 0.433 | 0.959 | 1.162 | |
| 1.434 | | | | | | |
| | 1.216 | 1.218 | 0.758 | 0.411 | 0.332 | |
| 0.118 | | | | | | |

LATERAL DRAINAGE COLLECTED FROM LAYER 2

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.5915 | 0.5096 | 0.5218 | 0.5357 | 0.7327 | |
| 0.7471 | | | | | | |
| | 0.7756 | 0.7670 | 0.7185 | 0.7119 | 0.6619 | |
| 0.6555 | | | | | | |
| STD. DEVIATIONS | 0.2336 | 0.1960 | 0.1979 | 0.1970 | 0.1942 | |
| 0.1804 | | | | | | |
| | 0.1988 | 0.1997 | 0.1965 | 0.2100 | 0.2087 | |
| 0.2115 | | | | | | |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0002 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | |
| 0.0003 | | | | | | |
| | 0.0004 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | |
| 0.0002 | | | | | | |
| STD. DEVIATIONS | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | |
| 0.0003 | | | | | | |
| | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | |
| 0.0002 | | | | | | |

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AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

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DAILY AVERAGE HEAD ON TOP OF LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 9.5449 | 8.5281 | 7.6638 | 8.7552 | 13.1237 | |
| 14.1258 | | | | | | |
| | 14.6048 | 14.5199 | 13.9431 | 13.1631 | 12.3437 | |
| 11.1322 | | | | | | |
| STD. DEVIATIONS | 5.4346 | 4.3145 | 3.4099 | 4.6143 | 6.6383 | |
| 7.4800 | | | | | | |
| | 8.5318 | 8.3411 | 7.8508 | 7.4872 | 7.0064 | |
| 6.0237 | | | | | | |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 15

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 30.28 | ( 5.206) | 549654.7 | 100.00 |
| RUNOFF | 0.000 | ( 0.0000) | 0.00 | 0.000 |
| EVAPOTRANSPIRATION | 22.141 | ( 3.3629) | 401853.31 | 73.110 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 2 | 7.92858 | ( 2.04986) | 143903.781 | 26.18076 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00304 | ( 0.00225) | 55.220 | 0.01005 |
| AVERAGE HEAD ON TOP OF LAYER 3 | 11.787 | ( 5.511) | | |
| CHANGE IN WATER STORAGE | 0.212 | ( 2.3167) | 3842.32 | 0.699 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 15

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 4.26 | 77319.008 |
| RUNOFF | 0.000 | 0.0000 |
| DRAINAGE COLLECTED FROM LAYER 2 | 0.03793 | 688.50275 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.000044 | 0.79949 |
| AVERAGE HEAD ON TOP OF LAYER 3 | 37.157 | |
| MAXIMUM HEAD ON TOP OF LAYER 3 | 43.377 | |
| LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN) | 105.3 FEET | |
| SNOW WATER | 4.51 | 81827.5312 |

| | |
|---|---|
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | 0.5410 |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | 0.0470 |

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 15

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 9.6571 | 0.2683 |
| 2 | 5.8860 | 0.4905 |
| 3 | 0.0000 | 0.0000 |
| 4 | 0.1500 | 0.7500 |
| SNOW WATER | 1.152 | |

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# Appendix B4

# Pipe Strength Calculation

**Purpose:** To evaluate the pipe strength of 6-in. dia., SDR 11 HDPE leachate collection piping in the base system of the Columbia Dry Ash Disposal Facility Modules 10 and 11 using designed properties and parameters.

**Approach:** Use referenced formulas to determine the maximum height waste can be placed above the leachate piping and the specific physical pipe properties necessary to perform adequately.

**References:**
1. Plastics Pipe Institute, 2nd Edition Handbook of PE Pipe, Buried PE Pipe Design (Attachment 1)
2. ISCO Industries, Typical Physical Properties and Dimension Charts, www.isco-pipe.com (Attachment 2)
3. "Soil Reaction for Buried Flexible Pipe", Amster K. Howard, U.S. Bureau of Reclamation
4. Plan of Operation, Metro Landfill Western Expansion, Appendix F - "Report on Metro Landfill - Pipe Design", Watkins, 1989
5. U.S. Department of Transportation, Federal Highway Administration, Recycled Materials, Coal Ash User's Guide
6. "HDPE Leachate Collection Pipe Design by Fundamentals of Mechanics", Harrison and Watkins, 1996, Nineteenth International Madison Waste Conference.
7. SCS Engineers, Plan of Operation Update, Dry Ash Disposal Facility - Columbia Energy Center , Base / Final Grades Plan Sheets, April 2022

**Assumptions:**
1. Waste above the piping is assumed to be wet.
2. Wet waste unit weight is a conservative 135 pcf from research and typical project experience values.
3. Live loads are negligible above the piping. The maximum fill height over an 6-in SDR 11 HDPE pipe will be 104 feet for the current design.
4. Leachate collection pipes will be 6-in., SDR 11 HDPE in Modules 10 and 11.
5. Allowable compressive stress for HDPE pipe is 1,000 psi (Plastic Pipe Institute, Attachment 1).

**Calculations:** **Pipe Loading, $P_y$** $P_y = DL + LL$

**where,** $P_y$ = Pipe Load, lb/in²
$DL$ = Dead Load, lb/in²
$LL$ = Live Load, lb/in²

**Dead Load, *DL*** $DL = \frac{\gamma \cdot H}{144}$

**where,**

| | | | | | |
|---|---|---|---|---|---|
| $\gamma$ | = | Fill Unit Weight, lb/ft³ | = | **135** | (waste unit weight) |
| H | = | Height of cover, ft | = | **104** | (max. waste height) |
| DL | = | Dead Load, lb/in² | = | **98** | |

**In our case the live load = 0, due to limited live loads above the piping after placement.**

**So, $P_y$ = DL =** **98** lb/in²

**Assuming, 6 inch SDR 11 HDPE for leachate collection piping**

**Outer Diameter of Pipe (OD) =** **6.625** **in.** (From Attachment 2)

**Min. Pipe wall thickness (t) =** **0.602** **in.** (From Attachment 2)

**Calculations:** **Deflection**

**(cont.)** A deflection of 5 to 7.5% has become the standard for limiting deflection in flexible pipes. Based on Figure 7.16 in Uni-Bell (1991) and Watkins (1989) a vertical strain of greater than 5% will never be reached for flexible pipe bedded in compacted gravel, independent of vertical soil pressure. At 90% compaction the vertical strain will always be less than 2%. The height of fill over the pipe is not a factor when the pipe is well bedded in gravel. These findings are consistent for HDPE piping with the Harrison and Watkins (1996) paper.

## Wall Crushing

**where,** $\sigma$ = Compressive Stress, lb/in²
$T$ = Wall Thrust, lb/in
$A$ = Area of Pipe Wall, in²/in

$$\sigma = \frac{T}{A}$$

**Wall Thrust, *T***

$$T = \frac{P_y \cdot D_0}{2}$$

**SDR 11 HDPE Piping**

| | | | | | |
|---|---|---|---|---|---|
| **where,** | $P_y$ | = Vertical Fill Pressure lb/in² | = | **98** | (Previously Calculated) |
| | $D_0$ | = Outside Diameter, in | = | **6.625** | (SDR 11, 6-inch) |
| | **T** | = Wall Thrust, lb/in | = | **323** | |
| | **A** | = Area of Pipe Wall, in²/in | = | **0.602** | (Solid=Thickness) |

**So,** $\sigma$ = Compressive Stress, lb/in² = **536**

**Result:** The allowable compressive strength of HDPE pipe is approximately 1,000 psi, so the calculated compressive stress values are acceptable and wall crushing of the pipe will be avoided when the pipe is at least SDR 11, 6-inch diameter for the leachate collection pipe.

**Leachate Collection Piping Maximum Height - SDR 11 HDPE**

| | | | | | |
|---|---|---|---|---|---|
| **For** | $P_y$ | = Vertical Fill Pressure lb/in² | = | **182** | |
| | $D_0$ | = Outside Diameter, in | = | **6.625** | (SDR 11, 6-inch) |
| | **T** | = Wall Thrust, lb/in | = | **602** | |
| | **A** | = Area of Pipe Wall, in²/in | = | **0.602** | (Solid=Thickness) |

**So,** $\sigma$ = Compressive Stress, lb/in² = **1,000**

Maximum Height (feet) = Py*(144)/$\gamma$ = **194**

**Result:** The maximum height of fill above the 6-inch SDR 11 HDPE piping is 194 feet for a fill unit weight of 135 lb/ft³ to maintain the required minimum factor of safety against wall crushing. Wall crushing controls the maximum fill height that can be placed above the leachate collection pipes. The maximum fill height above the 6-inch diameter piping when Modules 10 and 11 are filled will be approximately 104 feet, which is lower than the maximum allowable fill height.

## Attachment 1

## From the Handbook of PE Pipe 2008, Second Edition by the Plastics Pipe Institute

### TABLE C.1
**Allowable Compressive Stress for 73°F (23°C)**

| | Pe Pipe Material Designation Code (1) | | | | | |
|---|---|---|---|---|---|---|
| | PE 2406 | | PE3408 | | PE 4710 | |
| | PE 2708 | | PE 3608 | | | |
| | | | PE 3708 | | | |
| | | | PE 3710 | | | |
| | | | PE 4708 | | | |
| | psi | MPa | psi | MPa | psi | MPa |
| Allowable Compressive Stress | 800 | 5.52 | 1000 | 6.90 | 1150 | 7.93 |

(1) See Chapter 5 for an explanation of the PE Pipe Material Designation Code.

## Attachment 2

## From the ISCO Product Catalog dated Q4 2020

IPS ASTM STANDARDS ISCO

For reference only. Actual dimensions may vary.
Solo para referencia. Las dimensiones reales pueden variar.

ASTM MATERIALS Materiales ASTM

# PE4710 HDPE PIPE SIZES IPS AND LARGE DIAMETER METRIC

## PE4710 Tamaños HDPE tuberías IPS y Diámetro Grande Métrico

| DR | | 11 | | | 13.5 | | | 15.5 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **PE4710** Pressure Rating Resistencia a la Presión | | 200 psi | | | 160 psi | | | 138 psi | | |
| Nom. OD DE Nominal (in) | Actual OD DE Actual (in) | Min Wall Espesor Mínimo de Pared (in) | Avg ID DI Promedio (in) | Weight Peso (lb/ft) | Min Wall Espesor Mínimo de Pared (in) | Avg ID DI Promedio (in) | Weight Peso (lb/ft) | Min Wall Espesor Mínimo de Pared (in) | Avg ID DI Promedio (in) | Weight Peso (lb/ft) |
| ¾" | 1.05 | 0.095 | 0.848 | 0.13 | --- | --- | --- | --- | --- | --- |
| 1" | 1.315 | 0.12 | 1.062 | 0.2 | --- | --- | --- | --- | --- | --- |
| 1¼" | 1.66 | 0.151 | 1.34 | 0.314 | --- | --- | --- | --- | --- | --- |
| 1½" | 1.9 | 0.173 | 1.534 | 0.411 | --- | --- | --- | --- | --- | --- |
| 2" | 2.375 | 0.216 | 1.917 | 0.642 | 0.176 | 2.002 | 0.534 | 0.153 | 2.05 | 0.47 |
| 3" | 3.5 | 0.318 | 2.825 | 1.395 | 0.259 | 2.95 | 1.16 | 0.226 | 3.021 | 1.02 |
| 4" | 4.5 | 0.409 | 3.633 | 2.31 | 0.333 | 3.793 | 1.92 | 0.29 | 3.885 | 1.687 |
| 5" | 5.563 | 0.506 | 4.491 | 3.523 | 0.412 | 4.689 | 2.928 | 0.359 | 4.802 | 2.58 |
| 6" | 6.625 | 0.602 | 5.348 | 4.93 | 0.491 | 5.585 | 4.152 | 0.427 | 5.719 | 3.656 |
| 8" | 8.625 | 0.784 | 6.963 | 8.47 | 0.639 | 7.271 | 7.04 | 0.556 | 7.445 | 6.197 |
| 10" | 10.75 | 0.977 | 8.678 | 13.16 | 0.796 | 9.062 | 10.932 | 0.694 | 9.28 | 9.626 |
| 12" | 12.75 | 1.159 | 10.293 | 18.51 | 0.944 | 10.748 | 15.38 | 0.823 | 11.006 | 13.53 |
| 14" | 14 | 1.273 | 11.302 | 22.32 | 1.037 | 11.801 | 18.54 | 0.903 | 12.085 | 16.31 |
| 16" | 16 | 1.455 | 12.916 | 29.15 | 1.185 | 13.487 | 24.22 | 1.032 | 13.812 | 21.3 |
| 18" | 18 | 1.636 | 14.531 | 36.89 | 1.333 | 15.173 | 30.651 | 1.161 | 15.538 | 26.95 |
| 20" | 20 | 1.818 | 16.145 | 45.541 | 1.481 | 16.859 | 37.84 | 1.29 | 17.265 | 33.28 |
| 22" | 22 | 2 | 17.76 | 55.105 | 1.63 | 18.545 | 45.79 | 1.419 | 18.991 | 39.712 |
| 24" | 24 | 2.182 | 19.375 | 65.58 | 1.778 | 20.231 | 54.49 | 1.548 | 20.717 | 47.92 |
| 26" | 26 | 2.364 | 20.989 | 77.44 | 1.926 | 21.917 | 64.261 | 1.677 | 22.444 | 56.532 |
| 28" | 28 | 2.545 | 22.604 | 89.785 | 2.074 | 23.603 | 74.522 | 1.806 | 24.17 | 65.563 |
| 30" | 30 | 2.727 | 24.218 | 103.076 | 2.222 | 25.289 | 85.543 | 1.935 | 25.897 | 75.264 |
| 32" | 32 | 2.909 | 25.833 | 117.285 | 2.37 | 26.975 | 97.324 | 2.065 | 27.623 | 85.672 |
| 34" | 34 | 3.091 | 27.447 | 132.411 | 2.519 | 28.661 | 109.905 | 2.194 | 29.35 | 96.714 |
| 36" | 36 | 3.273 | 29.062 | 148.454 | 2.667 | 30.347 | 123.208 | 2.323 | 31.076 | 108.424 |
| 42" | 42 | 3.818 | 33.906 | 202.039 | 3.111 | 35.404 | 167.675 | 2.71 | 36.255 | 147.568 |
| 48" | 48 | 4.364 | 38.749 | 278.27 | 3.556 | 40.461 | 216.74 | 3.097 | 41.435 | 192.774 |
| 54" | 54 | 4.909 | 43.59 | 352.14 | 4.00 | 45.75 | 286.94 | 3.484 | 46.614 | 243.921 |
| 1600mm/63" | 62.99 | --- | --- | --- | 4.667 | 53.107 | 390.58 | 4.065 | 54.383 | 340.15 |
| 1800mm | 70.87 | --- | --- | --- | 5.2* | 60.1* | Call | --- | --- | --- |
| 2000mm | 78.74 | --- | --- | --- | 5.8* | 66.8* | Call | --- | --- | --- |
| 2250mm | 88.58 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2500mm | 98.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2720mm | 107.1 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2800mm | 110.2 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 3000mm | 118.1 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 3500mm | 137.8 | --- | --- | --- | --- | --- | --- | --- | --- | --- |

1. Pressures are based on using water at 23°C (73°F).
2. Average inside diameter calculated using actual OD and minimum wall plus 6% for use in estimating fluid flows. Actual ID will vary.
3. Other piping sizes or DR's may be available upon request.
4. Standard Lengths:
   - 40' for 2"-24"
   - 50' for 26" and larger
   - Coils available for ¾ - 4" (6" by special order)

*DR 13.6

1. Las presiones están basadas en el uso de agua a 23°C (73°F).
2. El diámetro interno promedio calculado el diámetro externo real y la pared mínima más 6% para uso la estimación de flujos de fluidos. El diámetro interno real variará.
3. Otros tamaños o DR de tubería pueden estar disponibles bajo pedido.
4. Longitudes estándar
   - 40 pies para 2 -24 pulgadas
   - 50 pies para 26 pulgadas o mayores
   - Bobinas disponibles para ¾ a 4 pulgadas (6 pulgadas para pedidos especiales)

**Purpose:** To evaluate the pipe strength of 18-in. dia., SDR 17 HDPE sump riser piping in the base system of the Columbia Dry Ash Disposal Facility Modules 10 and 11 using designed properties and parameters.

**Approach:** Use referenced formulas to determine the maximum height waste can be placed above the sump riser piping and the specific physical pipe properties necessary to perform adequately.

**References:**


1. Plastics Pipe Institute, 2nd Edition Handbook of PE Pipe, Buried PE Pipe Design (Attachment 1)
2. ISCO Industries, Typical Physical Properties and Dimension Charts, www.isco-pipe.com (Attachment 2)
3. "Soil Reaction for Buried Flexible Pipe", Amster K. Howard, U.S. Bureau of Reclamation
4. Plan of Operation, Metro Landfill Western Expansion, Appendix F - "Report on Metro Landfill - Pipe Design", Watkins, 1989
5. U.S. Department of Transportation, Federal Highway Administration, Recycled Materials, Coal Ash User's Guide
6. "HDPE Leachate Collection Pipe Design by Fundamentals of Mechanics", Harrison and Watkins, 1996, Nineteenth International Madison Waste Conference.
7. SCS Engineers, Plan of Operation Update, Dry Ash Disposal Facility - Columbia Energy Center , Base / Final Grades Plan Sheets, April 2022


**Assumptions:**

1. Waste above the piping is assumed to be wet.
2. Wet waste unit weight is a conservative 135 pcf from research and typical project experience values.
3. Live loads are negligible above the piping. The maximum fill height over an 18-in SDR 17 HDPE pipe will be 35 feet for the current design.
4. Sump riser pipes will be 18-in., SDR 17 HDPE in Modules 10 and 11.
5. Allowable compressive stress for HDPE pipe is 1,000 psi (Plastic Pipe Institute, Attachment 1).

**Calculations:** **Pipe Loading, $P_y$** $P_y = DL + LL$

**where,** $P_y$ = Pipe Load, lb/in²
$DL$ = Dead Load, lb/in²
$LL$ = Live Load, lb/in²

**Dead Load, *DL*** $DL = \frac{\gamma \cdot H}{144}$

**where,**

| | | | | | |
|---|---|---|---|---|---|
| $\gamma$ | = | Fill Unit Weight, lb/ft$^3$ | = | **135** | (waste unit weight) |
| H | = | Height of cover, ft | = | **35** | (max. waste height) |
| DL | = | Dead Load, lb/in$^2$ | = | **33** | |

**In our case the live load = 0, due to limited live loads above the piping after placement.**

**So, $P_y$ = DL =** **33** lb/in$^2$

**Assuming, 18 inch SDR 17 HDPE for leachate sump riser piping**

**Outer Diameter of Pipe (OD) =** **18** **in.** (From Attachment 2)

**Min. Pipe wall thickness (t) =** **1.059** **in.** (From Attachment 2)

**Calculations:** **Deflection**

**(cont.)** A deflection of 5 to 7.5% has become the standard for limiting deflection in flexible pipes. Based on Figure 7.16 in Uni-Bell (1991) and Watkins (1989) a vertical strain of greater than 5% will never be reached for flexible pipe bedded in compacted gravel, independent of vertical soil pressure. At 90% compaction the vertical strain will always be less than 2%. The height of fill over the pipe is not a factor when the pipe is well bedded in gravel. These findings are consistent for HDPE piping with the Harrison and Watkins (1996) paper.

## Wall Crushing

**where,** $\sigma$ = Compressive Stress, lb/in²
$T$ = Wall Thrust, lb/in
$A$ = Area of Pipe Wall, in²/in

$$\sigma = \frac{T}{A}$$

**Wall Thrust, *T***

$$T = \frac{P_y \cdot D_0}{2}$$

**SDR 17 HDPE Piping**

| | | | | | |
|---|---|---|---|---|---|
| **where,** | $P_y$ | = Vertical Fill Pressure lb/in² | = | **33** | (Previously Calculated) |
| | $D_0$ | = Outside Diameter, in | = | **18.000** | (SDR 17, 18-inch) |
| | **T** | = Wall Thrust, lb/in | = | **295** | |
| | **A** | = Area of Pipe Wall, in²/in | = | **1.059** | (Solid=Thickness) |

**So,** $\sigma$ = Compressive Stress, lb/in² = **279**

**Result:** The allowable compressive strength of HDPE pipe is approximately 1,000 psi, so the calculated compressive stress values are acceptable and wall crushing of the pipe will be avoided when the pipe is at least SDR 17, 18-inch diameter for the sump riser pipe.

**Sump Riser Piping Maximum Height - SDR 17 HDPE**

| | | | | | |
|---|---|---|---|---|---|
| **For** | $P_y$ | = Vertical Fill Pressure lb/in² | = | **118** | |
| | $D_0$ | = Outside Diameter, in | = | **18.000** | (SDR 17, 18-inch) |
| | **T** | = Wall Thrust, lb/in | = | **1,059** | |
| | **A** | = Area of Pipe Wall, in²/in | = | **1.059** | (Solid=Thickness) |

**So,** $\sigma$ = Compressive Stress, lb/in² = **1,000**

Maximum Height (feet) = Py*(144)/$\gamma$ = **126**

**Result:** The maximum height of fill above the 18-inch SDR 17 HDPE piping is 126 feet for a fill unit weight of 135 lb/ft$^3$ to maintain the required minimum factor of safety against wall crushing. Wall crushing controls the maximum fill height that can be placed above the sump riser pipes. The maximum fill height above the 18-inch diameter piping when Modules 10 and 11 are filled will be approximately 35 feet, which is lower than the maximum allowable fill height.

## Attachment 1

## From the Handbook of PE Pipe 2008, Second Edition by the Plastics Pipe Institute

**TABLE C.1**
**Allowable Compressive Stress for 73°F (23°C)**

| | Pe Pipe Material Designation Code (1) | | | | | |
|---|---|---|---|---|---|---|
| | PE 2406 | | PE3408 | | PE 4710 | |
| | PE 2708 | | PE 3608 | | | |
| | | | PE 3708 | | | |
| | | | PE 3710 | | | |
| | | | PE 4708 | | | |
| | psi | MPa | psi | MPa | psi | MPa |
| Allowable Compressive Stress | 800 | 5.52 | 1000 | 6.90 | 1150 | 7.93 |

(1) See Chapter 5 for an explanation of the PE Pipe Material Designation Code.

## Attachment 2

## From the ISCO Product Catalog dated Q4 2020

ISCO ASTM STANDARDS IPS

For reference only. Actual dimensions may vary.
Solo para referencia. Las dimensiones reales pueden variar.

ASTM MATERIALS Materiales ASTM

# PE4710 HDPE PIPE SIZES IPS AND LARGE DIAMETER METRIC

PE4710 Tamaños HDPE tuberías IPS y Diámetro Grande Métrico

| DR | | 17 | | | 19 | | | 21 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **PE4710** Pressure Rating Resistencia a la Presión | | 125 psi | | | 111 psi | | | 100 psi | | |
| Nom. OD DE Nominal (in) | Actual OD DE Actual (in) | Min Wall Espesor Mínimo de Pared (in) | Avg ID DI Promedio (in) | Weight Peso (lb/ft) | Min Wall Espesor Mínimo de Pared (in) | Avg ID DI Promedio (in) | Weight Peso (lb/ft) | Min Wall Espesor Mínimo de Pared (in) | Avg ID DI Promedio (in) | Weight Peso (lb/ft) |
| ¾" | 1.05 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1" | 1.315 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1¼" | 1.66 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1½" | 1.9 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2" | 2.375 | 0.14 | 2.079 | 0.431 | --- | --- | --- | --- | --- | --- |
| 3" | 3.5 | 0.206 | 3.064 | 0.94 | --- | --- | --- | 0.167 | 3.147 | 0.757 |
| 4" | 4.5 | 0.265 | 3.939 | 1.55 | 0.237 | 3.998 | 1.39 | 0.214 | 4.046 | 1.27 |
| 5" | 5.563 | 0.327 | 4.869 | 2.36 | 0.293 | 4.942 | 2.12 | 0.265 | 5.001 | 1.94 |
| 6" | 6.625 | 0.39 | 5.799 | 3.36 | 0.349 | 5.886 | 3.01 | 0.315 | 5.956 | 2.75 |
| 8" | 8.625 | 0.507 | 7.549 | 5.69 | 0.454 | 7.663 | 5.1 | 0.411 | 7.754 | 4.662 |
| 10" | 10.75 | 0.632 | 9.409 | 8.834 | 0.566 | 9.551 | 7.92 | 0.512 | 9.665 | 7.242 |
| 12" | 12.75 | 0.75 | 11.16 | 12.43 | 0.671 | 11.327 | 11.14 | 0.607 | 11.463 | 10.19 |
| 14" | 14 | 0.824 | 12.254 | 14.983 | 0.737 | 12.438 | 13.43 | 0.667 | 12.587 | 12.282 |
| 16" | 16 | 0.941 | 14.005 | 19.57 | 0.842 | 14.215 | 17.54 | 0.762 | 14.385 | 16.042 |
| 18" | 18 | 1.059 | 15.755 | 24.77 | 0.947 | 15.992 | 22.2 | 0.857 | 16.183 | 20.304 |
| 20" | 20 | 1.176 | 17.506 | 30.58 | 1.053 | 17.768 | 27.41 | 0.952 | 17.981 | 25.07 |
| 22" | 22 | 1.294 | 19.256 | 37 | 1.158 | 19.545 | 33.162 | 1.048 | 19.779 | 30.33 |
| 24" | 24 | 1.412 | 21.007 | 44.031 | 1.263 | 21.322 | 39.47 | 1.143 | 21.577 | 36.1 |
| 26" | 26 | 1.529 | 22.758 | 51.856 | 1.368 | 23.099 | 46.701 | 1.238 | 23.375 | 42.486 |
| 28" | 28 | 1.647 | 24.508 | 60.154 | 1.474 | 24.876 | 54.189 | 1.333 | 25.173 | 49.266 |
| 30" | 30 | 1.765 | 26.259 | 69.068 | 1.579 | 26.653 | 62.196 | 1.429 | 26.971 | 56.585 |
| 32" | 32 | 1.882 | 28.009 | 78.557 | 1.684 | 28.429 | 70.755 | 1.524 | 28.77 | 64.37 |
| 34" | 34 | 2 | 29.76 | 88.7 | 1.789 | 30.206 | 79.865 | 1.619 | 30.568 | 72.657 |
| 36" | 36 | 2.118 | 31.511 | 99.457 | 1.895 | 31.983 | 89.571 | 1.714 | 32.366 | 81.446 |
| 42" | 42 | 2.471 | 36.762 | 135.372 | 2.211 | 37.314 | 121.925 | 2 | 37.76 | 110.874 |
| 48" | 48 | 2.824 | 42.014 | 176.813 | 2.526 | 42.644 | 159.198 | 2.286 | 43.154 | 144.833 |
| 54" | 54 | 3.176 | 47.266 | 223.713 | 2.842 | 47.975 | 201.502 | 2.571 | 48.549 | 183.253 |
| 1600mm/63" | 62.99 | 3.706 | 55.143 | 303.398 | 3.315 | 55.97 | 273.362 | 3 | 56.631 | 249.57 |
| 1800mm | 70.87 | 4.169 | 62.029 | Call | --- | --- | --- | 3.375 | 63.712 | Call |
| 2000mm | 78.74 | 4.632 | 68.921 | Call | --- | --- | --- | 3.75 | 70.791 | Call |
| 2250mm | 88.58 | 5.211 | 77.536 | Call | --- | --- | --- | 4.218 | 79.64 | Call |
| 2500mm | 98.43 | 5.79 | 86.151 | Call | --- | --- | --- | 4.687 | 88.489 | Call |
| 2720mm | 107.1 | --- | --- | --- | --- | --- | --- | 5.1 | 96.6 | Call |
| 2800mm | 110.2 | --- | --- | --- | --- | --- | --- | 5.3 | 99.4 | Call |
| 3000mm | 118.1 | --- | --- | --- | --- | --- | --- | 5.6 | 106.5 | Call |
| 3500mm | 137.8 | --- | --- | --- | --- | --- | --- | 6.6 | 124.3 | Call |

1. Pressures are based on using water at 23°C (73°F).
2. Average inside diameter calculated using actual OD and minimum wall plus 6% for use in estimating fluid flows. Actual ID will vary.
3. Other piping sizes or DR's may be available upon request.
4. Standard Lengths:
   - 40' for 2"-24"
   - 50' for 26" and larger
   - Coils available for ¾ - 4" (6" by special order)

1. Las presiones están basadas en el uso de agua a 23°C (73°F)
2. El diámetro interno promedio calculado el diámetro externo real y la pared mínima más 6% para uso la estimación de flujos de fluidos. El diámetro interno real variará.
3. Otros tamaños o DR de tubería pueden estar disponibles bajo pedido.
4. Longitudes estándar
   - 40 pies para 2 -24 pulgadas
   - 50 pies para 26 pulgadas o mayores
   - Bobinas disponibles para ¾ a 4 pulgadas (6 pulgadas para pedidos especiales)

# Appendix B5

# Liner Flow Rate Calculation

| SCS ENGINEERS | | Sheet No. 1 of 2 | |
|---|---|---|---|
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25217156.01 | Job: Columbia Ash Generation Landfill | By: BSS | Date: 1/29/18 |
| Client: Alliant | Subject: GCL Liner Equivalency | Chk'd: DN | Date: 1/29/18 |

**Purpose:** To determine that the liquid flow rate through a combined geosynthetic clay liner (GCL) and clay liner system is equivalent to just a clay liner.

**References:**
1. GSE Environmental, BentoLiner CAR-NWL35 GCL product specifications.
2. Columbia Energy Center, Construction Quality Assuracnce Plan, December 2017
3. JLT Laboratories, Inc., Fexible Wall Permeability Compatibility Test Results, September 2015
4. 40 CRF 257.70, Design criteria for new CCR landfills and any lateral expansion of a CCR landfill, 2017
5. Permeability of Stratifed Deposits, NPTEL website, December 2009

**Approach:** The following equation will be used to calcuate the flow rate per unit area (q) based on the liner thickness (H), hydaulic conductivity (k), and hydrualic head above the liner (h).

(Eq. 1) $$\frac{Q}{A} = q = k\left(\frac{h}{H} + 1\right)$$

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Where,

Q = flow rate (cubic centimeters/second);

A = surface area of the liner (squared centimeters);

q = flow rate per unit area (cubic centimeters/second/squared centimeter);

k = hydraulic conductivity of the liner (centimeters/second);

h = hydraulic head above the liner (centimeters); and

H = thickness of the liner (centimeters).

For the combined GCL and clay liner, an average hydraulic conductivity ($k_v$) will be calculated uing the following equation:

$$k_V = \frac{H}{\frac{H_1}{k_1} + \frac{H_2}{k_2} + \ldots\ldots\ldots\ldots\ldots}$$

Where $k_v$ is the average hydraulic conductvity tor the system, H is the total thickness of the combined liner system, $k_1$ and $k_2$ are the hydraulic conductivity of the clay liner and the GCL respectivitly, and $H_1$ and $H_2$ is the thickness of the clay liner and the GCL respectively.

**Assumptions:**
1. The clay liner hydraulic conducivity ($k_1$) is 1x10-7 cm/sec.
2. The hydraulic conductivity ($k_2$) for the GCL, 5x10-9 cm/sec was used based on the maximum allowable from the CQA Plan.
3. A hydraulic head (h) of 30 cm was assumed above the liner.
4. GCL thickness ($H_2$) of 0.74 cm was based on typical manufactured product thickness.

**Calculations:**

Calculation for clay liner

$H_1$ = 60.96 cm (2 ft x 30.48cm/ft = 60.96 cm)

h = 30 cm

$k_1$ = 1E-07 cm/sec

q = $k_1*(h/H_1 + 1)$ = 1.49E-07 cm/sec

Calculation for clay liner with a geosynthetic clay liner (GCL)

$H_2$ = 0.74 cm

h = 30 cm

$k_2$ = 5.00E-09 cm/sec

$H = H_1 + H_2$ = 61.70 cm

$k_v$ = $H / ((H_1/k_1) + (H_2/k_2))$ = 8.14E-08 cm/sec

q = $k_v*(h/H + 1)$ = 1.21E-07 cm/sec

| Clay Liner Flow Rate (cm/sec) | | Combined GCL and Clay Liner Flow Rate (cm/sec) |
|---|---|---|
| 1.49E-07 | > | 1.21E-07 |

**Conclusion:** A combined GCL and clay liner system has an equivalent or lower flow rate per unit area to just a clay liner.

# Appendix B6

# Water Levels

**Table 3. Groundwater Elevation - State Monitoring Program and CCR Well Network**
**Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222067.00**

| | Raw Data | MW-1AR | MW-4 | MW-5R | MW-33AR | MW-33BR | MW-34A | MW-34B | MW-37A | MW-83 | MW-84A | MW-84B | MW-86 | MW-91AR | MW-91B | MW-92A | MW-92B | MW-93A | MW-93B | MW-312 | LS-1 | LS-3R | LH-2 | LH-3 | LH-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Measurement Date** | | | | | | | | | | | | | | | | | | | | | | | | |
| | October 2, 2012 | 39.14 | 36.04 | 20.48 | 25.91 | 26.16 | 22.92 | 23.06 | 30.38 | dry | 30.44 | 30.32 | 40.98 | 24.94 | 24.55 | 23.98 | 24.35 | NI | NI | NI | 16.90 | 16.64 | dry | -- | -- |
| | April 15, 2013 | 37.11 | 35.72 | 19.35 | 24.13 | 24.25 | 21.21 | 21.26 | 29.17 | 23.47 | 28.45 | 28.50 | 39.57 | 23.89 | 23.44 | 22.72 | 23.07 | NI | NI | NI | 8.94 | dry | dry | -- | -- |
| | October 8, 2013 | | | | | | | | | | | | | 23.37 | 23.03 | 22.5 | 22.89 | NI | NI | NI | | | | -- | -- |
| | October 15, 2013 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 23.37 | 23.03 | 22.5 | 22.89 | NI | NI | NI | 9.15 | dry | (4) | -- | -- |
| | April 14, 2014 | 37.60 | 35.65 | 19.81 | 24.55 | 24.48 | 21.32 | 21.35 | 29.59 | 24.23 | 28.70 | 28.74 | 39.83 | 23.99 | 23.49 | 22.48 | 22.87 | NI | NI | NI | 9.61 | dry | 0.2 | -- | -- |
| | October 2-3, 2014 | 37.52 | 34.35 | 19.36 | 23.92 | 24.11 | 21.38 | 21.51 | 28.48 | dry | 29.04 | 29.08 | 39.60 | 23.56 | 23.17 | 22.72 | 23.08 | NI | NI | NI | 9.06 | dry | 0.3 | -- | -- |
| | April 13-14, 2015 | 38.59 | 36.11 | 20.19 | 25.28 | 25.65 | 22.30 | 22.10 | 30.17 | dry | 29.85 | 29.75 | 40.62 | 24.55 | 24.08 | 23.40 | 23.75 | NI | NI | NI | dry | 9.62 | dry | -- | -- |
| | October 6-7, 2015 | 38.27 | 35.30 | 19.72 | 24.61 | 25.06 | 21.90 | 22.03 | 29.38 | 24.31 | 29.48 | 29.5 | 40.13 | 24.14 | 23.75 | 23.27 | 23.65 | NI | NI | NI | broken | dry | 14.8 inches | -- | -- |
| | April 4-6, 2016 | 36.73 | aband | 18.42 | 23.00 | 23.32 | 20.32 | 20.38 | 28.28 | 22.53 | 27.91 | 28.00 | 38.90 | 22.98 | 22.50 | 21.86 | 22.20 | NI | NI | NI | broken | dry | 15.9" | -- | -- |
| | October 11-13, 2016 | 35.91 | aband | 17.44 | 20.93 | 21.93 | 19.50 | 19.73 | 26.64 | 21.15 | 27.06 | 27.15 | 37.83 | 21.86 | 21.64 | 20.79 | 21.16 | NI | NI | NI | 13.00 | dry | 0.8" | 1.4" | -- |
| | April 10-13, 2017 | 35.59 | aband | 17.31 | 21.90 | 22.40 | 19.65 | 19.77 | 26.70 | 21.73 | 27.12 | 27.20 | 37.83 | 21.79 | 21.42 | 20.57 | 20.81 | NI | NI | NI | 13.10 | dry | -0.3 | 1.4" | -- |
| | October 3-5, 2017 | 37.07 | aband | 18.78 | 23.78 | 24.17 | 21.28 | 21.42 | 28.18 | 23.67 | NM | 27.77 | 39.21 | 22.95 | 22.62 | 22.00 | 22.39 | NI | NI | NI | 13.26 | dry | NM | NM | -- |
| | October 9-10, 2017 | -- | aband | NM | NM | NM | NM | NM | NM | NM | 28.72 [6] | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | 1.4" [5] | 1.6" [5] | -- |
| | February 21, 2018 | 38.58 | aband | NM | NM | NM | NM | NM | NM | NM | -- | NM | NM | 24.35 | 23.99 | NM | NM | NI | NI | NI | NM | NM | NM | NM | -- |
| | April 23-25, 2018 | 38.56 | aband | 20.08 | 25.20 | 22.03 | 24.18 | 25.26 | 29.76 | 24.64 | 28.40 | 29.35 | 42.25 | 24.32 | 23.92 | 23.24 | 23.60 | NI | NI | NI | 13.26 | NM | NM | NM | -- |
| | October 23-25, 2018 | 34.30 | aband | 15.73 | 19.52 | 20.43 | 18.07 | 18.32 | 25.42 | 19.70 | 25.96 | 26.07 | 36.58 | 20.44 | 20.14 | 19.15 | 19.54 | NI | NI | NI | dry | 13.59 | 4.6 | 4 | -- |
| | April 1-4, 2019 | 35.50 | aband | 16.80 | 21.66 | 21.85 | 19.13 | 19.13 | 26.57 | 21.18 | 26.93 | 26.92 | 37.63 | 21.58 | 21.27 | 20.43 | 20.78 | NI | NI | NI | 13.51 | dry | 42.0 | 4 | 169 |
| | October 7-9, 2019 | 35.29 | aband | 16.21 | 20.03 | 20.75 | 18.03 | 18.31 | 26.27 | 19.06 | 26.49 | 26.53 | 37.35 | 21.25 | 20.83 | 19.84 | 20.24 | NI | NI | NI | 13.60 | dry | -0.1" | 11.7" | 13.1" |
| | May 27-28, 2020 | 35.63 | aband | 17.10 | 22.28 | 22.64 | 19.97 | 20.06 | 26.82 | 21.93 | 27.26 | 27.27 | 37.85 | 21.77 | 21.40 | 20.61 | 20.94 | NI | NI | NI | 13.62 | dry | -0.1 | 2.40 | 2.4 |
| | October 7-8, 2020 | 36.60 | aband | 17.68 | 22.38 | 22.94 | 20.25 | 20.37 | 27.52 | 22.24 | 28.18 | 28.20 | 38.69 | 22.48 | 22.12 | 21.62 | 22.03 | NI | NI | NI | 13.62 | dry | -0.1 | 2.70 | 2.4 |
| | February 25, 2021 | NM | aband | NM | NM | NM | 21.20 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | -0.1 | 2.70 | 2.6 |
| | April 14, 2021 | 44.43 | aband | 18.15 | 24.02 | 24.34 | 21.18 | 21.28 | 28.58 | 23.62 | 28.44 | 28.45 | 39.19 | 23.17 | 22.76 | 22.00 | 22.35 | NI | NI | NI | 13.71 | dry | -0.1" | 2.8" | 2.6" |
| | June 11, 2021 | NM | aband | NM | 24.10 | NM | 21.29 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NI | NI | NI | | | | | |
| | October 11-12, 14, 2021 | 38.08 | aband | 18.66 | 24.56 | 24.79 | 21.53 | 21.64 | 29.16 | 24.09 | 29.32 | 29.38 | 40.00 | 23.89 | 23.51 | 22.92 | 23.30 | NI | NI | NI | 13.71 | dry | | | |
| | October 17, 2021 | NM | aband | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | -0.1" | 3.1" | 2.8" |
| | April 1, 2022 | aband | aband | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | -"0.1" | 3.1" | 2.9" |
| | April 11-13, 2022 | aband | aband | 19.92 | 25.02 | 24.94 | 21.65 | 21.63 | 29.78 | 24.18 | 29.26 | 29.26 | 40.09 | 24.20 | 23.73 | 23.02 | 23.39 | 43.90 | 43.74 | 43.06 | 13.60 | dry | NM | NM | NM |
| | October 24-28, 2022 | aband | aband | 20.01 | 26.35 | 26.78 | 22.34 | 22.44 | 30.76 | dry | 29.71 | 29.72 | 40.41 | 24.39 | 23.98 | 23.42 | 23.79 | 44.15 | 44.95 | 43.29 | 13.78 | dry | NM | NM | NM |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dry Ash Facility (Facility ID #03025) | **Well Number** | **MW-1AR** | **MW-4** | **MW-5R** | **MW-33AR** | **MW-33BR** | **MW-34A** | **MW-34B** | **MW-37A** | **MW-83** | **MW-84A** | **MW-84B** | **MW-86** | **MW-91AR** | **MW-91B** | **MW-92A** | **MW-92B** | **MW-93A** | **MW-93B** | **MW-312** | **LS-1** | **LS-3R** | **LH-2** | **LH-3** | **LH-4** |
| | **Top of Casing Elevation (feet amsl)** | 822.55 | 819.74 | 805.44 | 808.29 | 808.39 | 805.95 | 806.05 | 813.04 | 807.96 | 814.28 | 814.26 | 824.79 | 809.03 | 808.45 | 808.47 | 808.41 | 827.89 | 827.71 | 826.79 | | | | | |
| | **Screen Length (ft)** | | | | | | | | | | | | | | | | | 10 | 5 | 10 | | | | | |
| | **Total Depth (ft from top of casing)** | 44.40 | 39.58 | 25.97 | 31.08 | 57.50 | 35.43 | 56.95 | 31.80 | 25.42 | 40.21 | 52.02 | 45.43 | 32.90 | 52.38 | 28.94 | 51.75 | 50.7 | 82.5 | 52.5 | 17.42 | 17.10 | 19.90 | | |
| | **Top of Well Screen Elevation (ft)** | 778.15 | 780.16 | 779.47 | 777.21 | 750.89 | 770.52 | 749.10 | 781.24 | 782.54 | 774.07 | 762.24 | 779.36 | 776.13 | 756.07 | 779.53 | 756.66 | 787.19 | 750.21 | 784.29 | NM | NM | NM | | |
| | **Measurement Date** | | | | | | | | | | | | | | | | | | | | | | | | |
| | October 2, 2012 | 783.41 | 783.70 | 784.96 | 782.38 | 782.23 | 783.03 | 782.99 | 782.66 | dry | 783.84 | 783.94 | 783.81 | 784.09 | 783.90 | 784.49 | 784.06 | NI | NI | NI | | | dry | -- | |
| | April 15, 2013 | 785.44 | 784.02 | 786.09 | 784.16 | 784.14 | 784.74 | 784.79 | 783.87 | 784.49 | 785.83 | 785.76 | 785.22 | 785.14 | 785.01 | 785.75 | 785.34 | NI | NI | NI | NM | dry | dry | -- | |
| | October 8, 2013 | | | | | | | | | | | | | 785.66 | 785.42 | 785.97 | 785.52 | NI | NI | NI | NM | NM | NM | -- | |
| | October 15, 2013 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 785.66 | 785.42 | 785.97 | 785.52 | NI | NI | NI | | | | -- | |
| | April 14, 2014 | 784.95 | 784.09 | 785.63 | 783.74 | 783.91 | 784.63 | 784.70 | 783.45 | 783.73 | 785.58 | 785.52 | 784.96 | 785.04 | 784.96 | 785.99 | 785.54 | NI | NI | NI | NM | dry | leachate depth = 0.2 in. | -- | |
| | October 2-3, 2014 | 785.03 | 785.39 | 786.08 | 784.37 | 784.28 | 784.57 | 784.54 | 784.56 | dry | 785.24 | 785.18 | 785.19 | 785.47 | 785.28 | 785.75 | 785.33 | NI | NI | NI | NM | dry | leachate depth = 0.3 in. | -- | |
| | April 13-14, 2015 | 783.96 | 783.63 | 785.25 | 783.01 | 782.74 | 783.65 | 783.95 | 782.87 | dry | 784.43 | 784.51 | 784.17 | 784.48 | 784.37 | 785.07 | 784.66 | NI | NI | NI | dry | -- | dry | -- | |
| | October 6-7, 2015 | 784.28 | 784.44 | 785.72 | 783.68 | 783.33 | 784.05 | 784.02 | 783.66 | dry | 784.80 | 784.76 | 784.66 | 784.89 | 784.70 | 785.20 | 784.76 | NI | NI | NI | broken | dry | leachate depth = 14.8 in. | -- | |
| | April 4-6, 2016 | 785.82 | aband | 787.02 | 785.29 | 785.07 | 785.63 | 785.67 | 784.76 | 785.43 | 786.37 | 786.26 | 785.89 | 786.05 | 785.95 | 786.61 | 786.21 | NI | NI | NI | broken | dry | 15.9" | -- | |
| | October 11-13, 2016 | 786.64 | aband | 788.00 | 787.36 | 786.46 | 786.45 | 786.32 | 786.40 | 786.81 | 787.22 | 787.11 | 786.96 | 787.17 | 786.81 | 787.68 | 787.25 | NI | NI | NI | liquid depth = 3.5' | dry | 0.8" | 1.4" | |
| | April 10-13, 2017 | 786.96 | aband | 788.13 | 786.39 | 785.99 | 786.30 | 786.28 | 786.34 | 786.23 | 787.16 | 787.06 | 786.96 | 787.24 | 787.03 | 787.90 | 787.60 | NI | NI | NI | liquid depth = 3.0' | dry | -0.3 | 1.4" | |
| | October 3-5, 2017 | 785.48 | aband | 786.66 | 784.51 | 784.22 | 784.67 | 784.63 | 784.86 | 784.29 | NM | 786.49 | 785.58 | 786.08 | 785.83 | 786.47 | 786.02 | NI | NI | NI | liquid depth = 2.7' | dry | NM | NM | |
| | October 9-10, 2017 | NM | aband | NM | NM | NM | NM | NM | NM | NM | 785.56 [6] | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | 1.4" [5] | 1.6" [5] | |
| | February 21, 2018 | 783.97 | aband | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 784.68 | 784.46 | NM | NM | NI | NI | NI | NM | NM | NM | NM | |
| | April 23-25, 2018 | 783.99 | aband | 785.36 | 783.09 | 786.36 | 781.77 | 780.79 | 783.28 | 783.32 | 785.88 | 784.91 | 782.54 | 784.71 | 784.53 | 785.23 | 784.81 | NI | NI | NI | liquid depth = 2.7' | NM | NM | NM | |
| | October 23-25, 2018 | 788.25 | aband | 789.71 | 788.77 | 787.96 | 787.88 | 787.73 | 787.62 | 788.26 | 788.32 | 788.19 | 788.21 | 788.59 | 788.31 | 789.32 | 788.87 | NI | NI | NI | dry | liquid depth = 2.4' | 4.6 | 4 | -- |
| | April 1-4, 2019 | 787.05 | aband | 788.64 | 786.63 | 786.54 | 786.82 | 786.92 | 786.47 | 786.78 | 787.35 | 787.34 | 787.16 | 787.45 | 787.18 | 788.04 | 787.63 | NI | NI | NI | liquid depth = 3.9' | dry | -- | -- | |
| | October 7-9, 2019 | 787.26 | aband | 789.23 | 788.26 | 787.64 | 787.92 | 787.74 | 786.77 | 788.90 | 787.79 | 787.73 | 787.44 | 787.78 | 787.62 | 788.63 | 788.17 | NI | NI | NI | liquid depth = 3.8' | dry | -0.1" | 11.7" | 13.1" |
| | May 27-28, 2020 | 786.92 | aband | 788.34 | 786.01 | 785.75 | 785.98 | 785.99 | 786.22 | 786.03 | 787.02 | 786.99 | 786.94 | 787.26 | 787.05 | 787.86 | 787.47 | NI | NI | NI | liquid depth = 3.8' | dry | -0.1 | 2.4 | 2.4 |
| | October 7-8, 2020 | 785.95 | aband | 787.76 | 785.91 | 785.45 | 785.70 | 785.68 | 785.52 | 785.72 | 786.10 | 786.06 | 786.10 | 786.55 | 786.33 | 786.85 | 786.38 | NI | NI | NI | liquid depth = 3.8' | dry | -0.1 | 2.7 | 2.4 |
| | February 25, 2021 | NM | aband | NM | NM | NM | 784.75 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | -0.1 | 2.7 | 2.6 |
| | April 14, 2021 | 778.12 | aband | 787.29 | 784.27 | 784.05 | 784.77 | 784.77 | 784.46 | c | 785.84 | 785.81 | 785.60 | 785.86 | 785.69 | 786.47 | 786.06 | NI | NI | NI | liquid depth = 3.7' | | -- | 0.233333333 | 0.216666667 |
| | June 11, 2021 | NM | aband | NM | 784.19 | NM | 784.66 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | NM | NM | NM |
| | October 11-12, 14, 2021 | 784.47 | adand | 786.78 | 783.73 | 783.60 | 784.42 | 784.41 | 783.88 | 783.87 | 784.96 | 784.88 | 784.79 | 785.14 | 784.94 | 785.55 | 785.11 | NI | NI | NI | liquid depth = 3.7' | -- | | | |
| | October 17, 2021 | NM | adand | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NI | NI | NI | NM | NM | -0.01 | 0.26 | 0.23 |
| | April 1, 2022 | aband | aband | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | -"0.1" | 3.1" | 2.9" |
| | April 11-13, 2022 | aband | adand | 785.52 | 783.27 | 783.45 | 784.30 | 784.42 | 783.26 | 783.78 | 785.02 | 785.00 | 784.70 | 784.83 | 784.72 | 785.45 | 785.02 | 783.99 | 783.97 | 783.73 | liquid depth = 3.8' | dry | NM | NM | NM |
| | October 24-28, 2022 | aband | aband | 785.43 | 781.94 | 781.61 | 783.61 | 783.61 | 782.28 | dry | 784.57 | 784.54 | 784.38 | 784.64 | 784.47 | 785.05 | 784.62 | 783.74 | 782.76 | 783.50 | liquid depth = 3.6' | dry | NM | NM | NM |
| | **Bottom of Well Elevation (ft)** | 778.15 | 780.16 | 779.47 | 777.21 | 750.89 | 770.52 | 749.10 | 781.24 | 782.54 | 774.07 | 762.24 | 779.36 | 776.13 | 756.07 | 779.53 | 756.66 | 777.19 | 745.21 | 774.29 | NM | NM | NM | NM | |

**Table 3. Groundwater Elevation - State Monitoring Program and CCR Well Network**
**Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222067.00**

| | Raw Data | M-3 | M-4R | MW-39A | MW-39B | MW-48A | MW-48B | MW-57 | MW-59 | MW-216R | MW-217 | MW-220RR | SG-1 | SG-2 | SG-3 | SG-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Measurement Date** | | | | | | | | | | | | | | | |
| | October 2, 2012 | 8.10 | 19.34 | 28.13 | 28.16 | 46.83 | 46.91 | 5.71 | 35.60 | 32.30 | 10.60 | 12.35 | 2.92 | 1.40 | dry | dry |
| | April 15, 2013 | 3.07 | 17.71 | 25.65 | 25.50 | 45.09 | 45.06 | 1.60 | 31.82 | 30.12 | 6.80 | 7.88 | (1) | NM[2] | dry | dry |
| | October 8, 2013 | 7.01 | 19.43 | NM | NM | 45.17 | 45.26 | NM | NM | 30.82 | 9.28 | 10.54 | (3) | 3.92 | (3) | dry |
| | October 15, 2013 | NM | NM | 26.68 | 26.69 | NM | NM | 3.82 | 31.99 | NM | NM | NM | NM | NM | NM | NM |
| | April 14, 2014 | 2.19 | 17.14 | 26.05 | 25.82 | 45.30 | 45.27 | 0.78 | 32.07 | 30.48 | 6.30 | 7.03 | 788.90 | NM | NM | NM |
| | October 1-3, 2014 | 7.07 | 18.55 | 26.20 | 26.18 | 44.81 | 44.90 | 3.97 | 31.93 | 30.42 | 8.92 | 9.87 | cannot read | dry | dry | dry |
| | April 13-14, 2015 | 5.15 | 19.27 | 26.85 | 26.82 | 46.06 | 46.02 | 3.48 | 32.65 | 31.28 | 8.21 | 9.48 | (1) | 3.55 | dry | dry |
| | October 6-7, 2015 | 7.57 | 19.98 | 26.65 | 26.69 | 45.76 | 45.83 | 4.47 | 32.23 | 31.03 | 9.6 | 10.64 | NM | 3.67 | dry | dry |
| | April 4-6, 2016 | 4.02 | 17.01 | 24.35 | 24.23 | 44.07 | 44.08 | 3.08 | 30.51 | 28.53 | 6.53 | 8.54 | From NS | 1.85 | dry | dry |
| | October 11-13, 2016 | 6.35 | 18.22 | 23.87 | 23.98 | 43.13 | 43.23 | 3.17 | 28.97 | 28.05 | 7.80 | 8.81 | From NS | 2.73 | dry | dry |
| | April 10-13, 2017 | 5.29 | 18.15 | 24.18 | 24.30 | 43.04 | 43.15 | 3.52 | 29.39 | 28.26 | 7.26 | 8.81 | From NS | 1.40 | dry | dry |
| | October 3-5, 2017 | 7.30 | 19.06 | 26.27 | 26.32 | 44.56 | 44.65 | 3.92 | 31.25 | 30.32 | 9.07 | 10.29 | From NS | 1.8 | dry | dry |
| | April 23-25, 2018 | 5.34 | 15.67 | 26.76 | 26.63 | 45.72 | 45.75 | 3.25 | 32.46 | 30.98 | 8.29 | 9.45 | From NS | above gauge | dry | dry |
| | October 23-25, 2018 | 5.28 | 17.63 | 22.50 | 22.62 | 41.74 | 41.85 | 2.81 | 27.75 | 26.72 | 6.65 | 8.38 | From NS | 2.00 | dry | dry |
| | April 1-4, 2019 | 2.55 | 16.66 | 23.34 | 23.19 | 42.30 | 42.39 | 1.02 | 28.09 | 27.68 | 5.22 | 7.44 | From BC | 0.65 | dry | dry |
| | October 7-9, 2019 | 2.90 | 15.45 | 22.52 | 22.48 | 42.18 | 42.19 | 1.00 | 28.80 | 27.14 | 5.54 | 7.48 | From BC | 0.05 | dry | dry |
| | May 27-29, 2020 | 6.43 | 18.37 | 24.50 | 24.58 | 43.12 | 43.25 | 3.18 | 29.59 | 28.61 | 8.14 | 9.01 | From BC | above gauge | dry | dry |
| | October 7-8 &17, 2020 | 6.81 | 18.36 | 24.88 | 24.86 | 43.83 | 43.88 | 3.46 | 30.05 | 29.11 | 8.49 | 9.41 | From BC | 1.93 | dry | NM |
| | April 12, 2021 | 5.93 | 19.76 | 25.96 | 25.85 | 44.73 | 44.76 | 3.50 | 31.40 | 30.24 | 8.40 | 9.41 | From BC | 1.80 | below gauge | dry |
| | October 11-12, 14, 2021 | 7.20 | 19.77 | 26.68 | 26.65 | 45.77 | 45.81 | 4.35 | 32.37 | 31.17 | 9.40 | 10.24 | From BC | 0.12 | dry | dry |
| | April 11-13, 2022 | 4.28 | 17.84 | 26.25 | 26.16 | 45.76 | 45.74 | NM | 32.49 | 30.81 | 7.62 | 9.07 | From BC | 0.60 | dry | dry |
| | June 3, 2022 | NM | NM | NM | NM | NM | NM | 4.16 | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 25, 26, 28, 2022 | 7.82 | 22.25 | 28.86 | 28.84 | 49.29 | 49.29 | 7.06 | 36.50 | 35.60 | 11.22 | 11.41 | NM | 0.04 | dry | dry |
| | | | | | | | | | | | | | | | | |
| | **Well Number** | **M-3** | **M-4R** | **MW-39A** | **MW-39B** | **MW-48A** | **MW-48B** | **MW-57** | **MW-59** | **MW-216R** | **MW-217** | **MW-220RR** | **SG-1** | **SG-2** | **SG-3** | **SG-4** |
| | **Top of Casing Elevation (feet amsl)** | 788.23 | 806.10 | 809.62 | 809.50 | 828.86 | 828.84 | 786.29 | 815.48 | 814.21 | 791.55 | 792.90 | 792.06 | 795.25 | 808.60 | 805.36 |
| Ash Pond Facility (Facility ID #02325) | **Screen Length (ft)** | | | | | | | | | | | | | | | |
| | **Total Depth (ft from top of casing)** | 16.90 | 25.55 | 34.80 | 76.07 | 51.88 | 75.80 | 14.40 | 38.50 | 37.85 | 37.37 | 18.96 | -- | -- | -- | -- |
| | **Top of Well Screen Elevation (ft)** | 771.33 | 780.55 | 774.82 | 733.43 | 776.98 | 753.04 | 771.89 | 776.98 | 776.36 | 754.18 | 773.94 | -- | -- | -- | -- |
| | **Measurement Date** | | | | | | | | | | | | | | | |
| | October 2, 2012 | 780.13 | 786.76 | 781.49 | 781.34 | 782.03 | 781.93 | 780.58 | 779.88 | 781.91 | 780.95 | 780.55 | 789.14 | 793.85 | dry | dry |
| | April 15, 2013 | 785.16 | 788.39 | 783.97 | 784.00 | 783.77 | 783.78 | 784.69 | 783.66 | 784.09 | 784.75 | 785.02 | 789.5[1] | NM | dry | dry |
| | October 8, 2013 | 781.22 | 786.67 | NM | NM | 783.69 | 783.58 | NM | NM | 783.39 | 782.27 | 782.36 | 789.5[1] | 791.33 | dry | dry |
| | October 15, 2013 | NM | NM | 782.94 | 782.81 | NM | NM | 782.47 | 783.49 | NM | NM | NM | NM | NM | NM | NM |
| | April 14, 2014 | 786.04 | 788.96 | 783.57 | 783.68 | 783.56 | 783.57 | 785.51 | 783.41 | 783.73 | 785.25 | 785.87 | 788.90 | dry | dry | dry |
| | October 1-3, 2014 | 781.16 | 787.55 | 783.42 | 783.32 | 784.05 | 783.94 | 782.32 | 783.55 | 783.79 | 782.63 | 783.03 | NM | dry | dry | dry |
| | April 13-14, 2015 | 783.08 | 786.83 | 782.77 | 782.68 | 782.80 | 782.82 | 782.81 | 782.83 | 782.93 | 783.34 | 783.42 | 789.3 | 791.70 | dry | dry |
| | October 6-7, 2015 | 780.66 | 786.12 | 782.97 | 782.81 | 783.10 | 783.01 | 781.82 | 783.25 | 783.18 | 781.95 | 782.26 | 788.48 | 791.58 | dry | dry |
| | April 4-6, 2016 | 784.21 | 789.09 | 785.27 | 785.27 | 784.79 | 784.76 | 783.21 | 784.97 | 785.68 | 785.02 | 784.36 | NM | 793.40 | dry | dry |
| | October 11-13, 2016 | 781.88 | 787.88 | 785.75 | 785.52 | 785.73 | 785.61 | 783.12 | 786.51 | 786.16 | 783.75 | 784.09 | 788.32 | 792.52 | dry | dry |
| | April 10-13, 2017 | 782.94 | 787.95 | 785.44 | 785.20 | 785.82 | 785.69 | 782.77 | 786.09 | 785.95 | 784.29 | 784.09 | 788.31 | 793.85 | dry | dry |
| | October 3-5, 2017 | 780.93 | 787.04 | 783.35 | 783.18 | 784.30 | 784.19 | 782.37 | 784.23 | 783.89 | 782.48 | 782.61 | 788.3 | 793.45 | dry | dry |
| | April 23-25, 2018 | 782.89 | 790.43 | 782.86 | 782.87 | 783.14 | 783.09 | 783.04 | 783.02 | 783.23 | 783.26 | 783.45 | 788.38 | >795.25 | dry | dry |
| | October 23-25, 2018 | 782.95 | 788.47 | 787.12 | 786.88 | 787.12 | 786.99 | 783.48 | 787.73 | 787.49 | 784.90 | 784.52 | 787.76 | 793.25 | dry | dry |
| | April 1-4, 2019 | 785.68 | 789.44 | 786.28 | 786.31 | 786.56 | 786.45 | 785.27 | 787.39 | 786.53 | 786.33 | 785.46 | 788.40 | 794.60 | dry | dry |
| | October 7-9, 2019 | 785.33 | 790.65 | 787.10 | 787.02 | 786.68 | 786.65 | 785.29 | 786.68 | 787.07 | 786.01 | 785.42 | 748.48 | 795.20 | dry | dry |
| | May 27-29, 2020 | 781.80 | 787.73 | 785.12 | 784.92 | 785.74 | 785.59 | 783.11 | 785.89 | 785.60 | 783.41 | 783.89 | 748.48 | >795.25 | dry | dry |
| | October 7-8 &17, 2020 | 781.42 | 787.74 | 784.74 | 784.64 | 785.03 | 784.96 | 782.83 | 785.43 | 785.10 | 783.06 | 783.49 | 788.34 | 793.32 | dry | NM |
| | April 12, 2021 | 782.30 | 786.34 | 783.66 | 783.65 | 784.13 | 784.08 | 782.79 | 784.08 | 783.97 | 783.15 | 783.49 | 788.03 | 793.45 | below gauge | dry |
| | October 11-12, 14, 2021 | 781.03 | 786.33 | 782.94 | 782.85 | 783.09 | 783.03 | 781.94 | 783.11 | 783.04 | 782.15 | 782.66 | 788.59 | 795.13 | dry | dry |
| | April 11-13, 2022 | 783.95 | 788.26 | 783.37 | 783.34 | 783.10 | 783.10 | NM | 782.99 | 783.40 | 783.93 | 783.83 | 788.4 | 794.65 | dry | dry |
| | June 3, 2022 | NM | NM | NM | NM | NM | NM | 782.13 | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 25, 26, 28, 2022 | 780.41 | 783.85 | 780.76 | 780.66 | 779.57 | 779.55 | 779.23 | 778.98 | 778.61 | 780.33 | 781.49 | NM | 795.21 | dry | dry |
| | **Bottom of Well Elevation (ft)** | 771.33 | 780.55 | 774.82 | 733.43 | 776.98 | 753.04 | 771.89 | 776.98 | 776.36 | 754.18 | 773.94 | -- | -- | -- | -- |

**Table 3. Groundwater Elevation - State Monitoring Program and CCR Well Network**
**Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222067.00**

| | Raw Data | MW-301 | MW-302 | MW-303 | MW-304 | MW-305 | M-4R | MW-33AR | MW-34A | MW-84A | MW-306 | MW-307 | MW-308 | MW-309 | MW-310 | MW-311 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Measurement Date** | | | | | | | | | | | | | | | |
| | December 21-22, 2015 | 21.33 | 28.22 | 27.41 | 19.29 | 17.36 | 18.52 | 24.52 | 22.45 | 28.97 | NI | NI | NI | NI | NI | NI |
| | April 4-5, 2016 | 20.11 | 27.19 | 26.04 | 17.34 | 16.71 | 17.01 | 23.00 | 20.32 | 27.91 | NI | NI | NI | NI | NI | NI |
| | July 7-8, 2016 | 20.58 | 26.72 | 26.92 | 18.06 | 17.06 | 18.67 | 23.10 | 20.90 | 28.39 | NI | NI | NI | NI | NI | NI |
| | July 28, 2016 | NM | NM | 27.17 | NM | NM | NM | NM | 21.09 | 28.67 | NI | NI | NI | NI | NI | NI |
| | October 11-13, 2016 | 19.25 | 25.24 | 25.34 | 17.24 | 16.54 | 18.22 | 20.93 | 19.50 | 27.06 | NI | NI | NI | NI | NI | NI |
| | December 29, 2016 | 19.52 | 25.95 | NM | NM | NM | NM | 22.63 | 20.23 | 27.65 | NI | NI | NI | NI | NI | NI |
| | January 25-26, 2017 | 19.62 | 26.11 | 26.24 | 16.08 | 16.96 | 16.46 | 22.41 | 19.97 | 27.58 | 22.13 | 21.53 | 21.17 | NI | NI | NI |
| | April 10 & 11, 2017 | 19.00 | 25.45 | 25.52 | 17.20 | 16.75 | 18.15 | 21.9 | 19.65 | 27.12 | 21.41 | 21.25 | 20.39 | NI | NI | NI |
| | June 6, 2017 | 18.64 | 24.63 | 25.03 | 16.84 | 16.53 | 18.27 | 21.02 | 19.29 | 26.65 | 20.78 | 20.82 | 20.44 | NI | NI | NI |
| | August 7-9, 2017 | 19.55 | 25.45 | 26.10 | 15.90 | 17.02 | 17.56 | 22.18 | 20.14 | 27.60 | 21.94 | 21.70 | 21.53 | NI | NI | NI |
| | October 23-24, 2017 | 21.00 | 27.06 | 27.60 | 16.45 | 18.18 | 18.10 | 24.16 | 21.45 | 28.96 | 23.66 | 22.10 | 22.73 | NI | NI | NI |
| | February 21, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 30.08 | 30.57 | 26.72 |
| | March 23, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 30.17 | 30.52 | 26.74 |
| | April 23-25, 2018 | 21.60 | 28.63 | 28.25 | 15.73 | 18.65 | 15.67 | 25.20 | 24.18 | 28.40 | 24.39 | 23.24 | 24.25 | 30.20 | 30.65 | 27.91 |
| | May 24, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | 21.84 | 21.80 | NM | 27.82 | 27.65 | 23.63 |
| | June 23, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 27.24 | 26.98 | 23.27 |
| | July 23, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 27.00 | 27.27 | 23.19 |
| | August 7, 2018 | 19.83 | NM | 26.32 | 17.17 | 17.76 | 18.47 | NM | NM | 27.73 | NM | NM | NM | NM | NM | NM |
| | August 22, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 27.73 | 28.22 | 24.28 |
| | September 21, 2018 | NM | 24.63 | 25.02 | NM | NM | NM | 20.39 | 18.94 | NM | NM | NM | NM | 26.19 | 26.38 | 22.08 |
| | October 22-24, 2018 | 17.91 | 23.84 | 24.01 | 16.37 | 16.28 | 17.63 | 19.52 | 18.07 | 25.96 | 19.97 | 20.32 | 19.09 | 25.28 | 25.44 | 21.10 |
| CCR Rule Wells | April 1-4, 2019 | 19.85 | 25.44 | 25.00 | 15.70 | 16.25 | 16.66 | 21.66 | 19.13 | 26.93 | 20.91 | 20.18 | 19.37 | 26.97 | 27.24 | 23.36 |
| | June 12, 2019 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 26.37 | NM |
| | June 19, 2019 | NM | NM | 24.71 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 7-9, 2019 | 18.42 | 24.69 | 24.50 | 15.01 | 15.96 | 15.45 | NM | NM | NM | 20.16 | 19.90 | 19.72 | 26.01 | 25.68 | 22.10 |
| | December 13, 2019 | NM | NM | NM | NM | NM | NM | NM | NM | NM | 20.60 | 21.21 | 20.47 | NM | NM | NM |
| | December 23, 2019 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 38.40 | NM |
| | January 17, 2020 | NM | NM | 25.94 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | February 3, 2020 | 19.65 | NM | -- | NM | NM | NM | NM | NM | 27.78 | 21.86 | 21.32 | 20.42 | NM | NM | NM |
| | May 27-29, 2020 | 19.12 | 25.71 | 25.96 | 16.12 | 18.54 | 18.37 | 22.28 | 19.97 | 27.26 | 21.86 | 21.54 | 20.62 | 27.29 | 27.81 | 23.89 |
| | June 30, 2020 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 27.09 | NM | NM |
| | August 6, 2020 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 27.34 | NM | NM |
| | October 7-8, 2020 | 20.36 | 26.26 | 26.36 | 16.90 | 18.36 | 18.36 | 22.38 | 20.25 | 28.18 | 22.24 | 22.18 | 21.22 | 27.80 | 28.06 | 23.91 |
| | December 11, 2020 | NM | NM | NM | NM | 18.13 | NM | NM | NM | NM | NM | NM | NM | 28.01 | 28.36 | NM |
| | February 25, 2021 | NM | NM | 27.25 | NM | 17.96 | NM | NM | 21.20 | NM | NM | NM | NM | NM | NM | NM |
| | April 12, 2021 | 20.39 | 27.23 | 27.45 | 17.43 | 18.21 | 19.76 | 24.02 | 21.18 | 28.44 | 23.31 | 22.68 | 21.35 | 28.98 | 29.38 | 25.59 |
| | June 11, 2021 | NM | NM | NM | NM | NM | NM | 24.10 | 21.29 | NM | NM | NM | NM | 29.07 | 29.57 | NM |
| | July 20, 2021 | NM | NM | 27.88 | NM | 17.93 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 11-12, 14, 2021 | 21.61 | 27.91 | 28.43 | 17.64 | 18.57 | 19.77 | 24.56 | 21.53 | 29.32 | 24.70 | 24.45 | 23.14 | 29.62 | 30.14 | 26.26 |
| | December 21, 2021 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 30.34 | NM | NM |
| | February 24, 2022 | NM | NM | 29.18 | NM | 19.83 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | April 11-13, 2022 | 21.45 | 28.58 | 28.12 | 17.22 | 18.45 | 17.84 | 25.02 | 21.65 | 29.26 | 24.52 | 23.57 | 22.71 | 30.13 | 30.43 | 26.70 |
| | July 27, 2022 | NM | NM | 28.45 | NM | 19.29 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 25-27, 2022 | 21.98 | 28.38 | 36.78 | 23.63 | 21.35 | 22.25 | 26.35 | 22.34 | 29.71 | 29.31 | 29.00 | 22.74 | 31.77 | 32.66 | 28.51 |
| | November 30, 2022 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 31.65 | 32.48 | 28.59 |
| | December 2, 2022 | 21.77 | 28.52 | NM | 21.45 | NM | NM | 26.38 | 22.24 | 29.52 | 29.11 | 27.35 | NM | NM | NM | NM |

**Table 3. Groundwater Elevation - State Monitoring Program and CCR Well Network**
**Columbia Dry Ash and Ash Pond Disposal Facilities / SCS Engineers Project #25222067.00**

| | Well Number | MW-301 | MW-302 | MW-303 | MW-304 | MW-305 | M-4R | MW-33AR | MW-34A | MW-84A | MW-306 | MW-307 | MW-308 | MW-309 | MW-310 | MW-311 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top of Casing Elevation (feet amsl) | 806.89 | 813.00 | 815.72 | 805.42 | 806.32 | 806.10 | 808.29 | 805.95 | 814.28 | 807.63 | 806.89 | 806.9 | 813.27 | 813.62 | 809.74 |
| | Screen Length (ft) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | Total Depth (ft from top of casing) | 29.40 | 33.6 | 35.80 | 25.7 | 25.6 | 39.58 | 31.08 | 35.43 | 40.21 | 27 | 26.5 | 28 | 37.67 | 38.41 | 36.19 |
| | Top of Well Screen Elevation (ft) | 787.49 | 789.40 | 785.72 | 789.72 | 790.72 | 776.52 | 787.21 | 780.52 | 784.07 | 790.63 | 790.39 | 788.90 | 785.60 | 785.21 | 783.55 |
| | Measurement Date | | | | | | | | | | | | | | | |
| | December 21-22, 2015 | 785.56 | 784.78 | 784.11 | 786.13 | 788.96 | 787.58 | 783.77 | 783.50 | 785.31 | NI | NI | NI | NI | NI | NI |
| | April 4-5, 2016 | 786.78 | 785.81 | 785.48 | 788.08 | 789.61 | 789.09 | 785.29 | 785.63 | 786.37 | -- | -- | -- | -- | -- | -- |
| | July 7-8, 2016 | 786.31 | 786.28 | 784.60 | 787.36 | 789.26 | 787.43 | 785.19 | 785.05 | 785.89 | -- | -- | -- | -- | -- | -- |
| | July 28, 2016 | NM | NM | 784.35 | NM | NM | NM | NM | 784.86 | 785.61 | -- | -- | -- | -- | -- | -- |
| | October 11-13, 2016 | 787.64 | 787.76 | 786.18 | 788.18 | 789.78 | 787.88 | 787.36 | 786.45 | 787.22 | -- | -- | -- | -- | -- | -- |
| | December 29, 2016 | 787.37 | 787.05 | NM | NM | NM | NM | 785.66 | 785.72 | 786.63 | -- | -- | -- | -- | -- | -- |
| | January 25-26, 2017 | 787.27 | 786.89 | 785.28 | 789.34 | 789.36 | 789.64 | 785.88 | 785.98 | 786.70 | 785.50 | 785.36 | 785.73 | -- | -- | -- |
| | April 10 & 11, 2017 | 787.89 | 787.55 | 786.00 | 788.22 | 789.57 | 787.95 | 786.39 | 786.30 | 787.16 | 786.22 | 785.64 | 786.51 | -- | -- | -- |
| | June 6, 2017 | 788.25 | 788.37 | 786.49 | 788.58 | 789.79 | 787.83 | 787.27 | 786.66 | 787.63 | 786.85 | 786.07 | 786.46 | -- | -- | -- |
| | August 7-9, 2017 | 787.34 | 787.55 | 785.42 | 789.52 | 789.30 | 788.54 | 786.11 | 785.81 | 786.68 | 785.69 | 785.19 | 785.37 | -- | -- | -- |
| | October 23-24, 2017 | 785.89 | 785.94 | 783.92 | 788.97 | 788.14 | 788.00 | 784.13 | 784.50 | 785.32 | 783.97 | 784.79 | 784.17 | -- | -- | -- |
| | February 21, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 783.19 | 783.05 | 783.02 |
| | March 23, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 783.10 | 783.10 | 783.00 |
| | April 23-25, 2018 | 785.29 | 784.37 | 783.27 | 789.69 | 787.67 | 790.43 | 783.09 | 781.77 | 785.88 | 783.24 | 783.65 | 782.65 | 783.07 | 782.97 | 781.83 |
| | May 24, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | 785.79 | 785.09 | NM | 785.45 | 785.97 | 786.11 |
| | June 23, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 786.03 | 786.64 | 786.47 |
| | July 23, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 786.27 | 786.35 | 786.55 |
| | August 7, 2018 | 787.06 | NM | 785.20 | 788.25 | 788.56 | 787.63 | NM | NM | 786.55 | NM | NM | NM | NM | NM | NM |
| | August 22, 2018 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 785.54 | 785.40 | 785.46 |
| | September 21, 2018 | NM | 788.37 | 786.50 | NM | NM | NM | 787.90 | 787.01 | NM | NM | NM | NM | 787.08 | 787.24 | 787.66 |
| CCR Rule Wells | October 22-24, 2018 | 788.98 | 789.16 | 787.51 | 789.05 | 790.04 | 788.47 | 788.77 | 787.88 | 788.32 | 787.66 | 786.57 | 787.81 | 787.99 | 788.18 | 788.64 |
| | April 1-4, 2019 | 787.04 | 787.56 | 786.52 | 789.72 | 790.07 | 789.44 | 786.63 | 786.82 | 787.35 | 786.72 | 786.71 | 787.53 | 786.30 | 786.38 | 786.38 |
| | June 12, 2019 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 787.25 | NM |
| | June 19, 2019 | NM | NM | 786.81 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 7-9, 2019 | 788.47 | 788.31 | 787.02 | 790.41 | 790.36 | 790.65 | NM | NM | NM | 787.47 | 786.99 | 787.18 | 787.26 | 787.94 | 787.64 |
| | December 13, 2019 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 787.03 | 785.68 | 786.43 | -- | -- | -- |
| | December 23, 2019 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 775.22 | -- |
| | January 17, 2020 | -- | -- | 785.58 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | February 3, 2020 | 787.24 | NM | NM | NM | NM | NM | NM | NM | 786.50 | 785.77 | 785.57 | 786.48 | NM | NM | NM |
| | May 27-29, 2020 | 787.77 | 787.29 | 785.56 | 789.30 | 787.78 | 787.73 | 786.01 | 785.98 | 787.02 | 785.77 | 785.35 | 786.28 | 785.98 | 785.81 | 785.85 |
| | June 30, 2020 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 786.18 | NM | NM |
| | August 6, 2020 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 785.93 | NM | NM |
| | October 7-8, 2020 | 786.53 | 786.74 | 785.16 | 788.52 | 787.96 | 787.74 | 785.91 | 785.70 | 786.10 | 785.39 | 784.71 | 785.68 | 785.47 | 785.56 | 785.83 |
| | December 11, 2020 | NM | NM | NM | NM | 788.19 | NM | NM | NM | NM | NM | NM | NM | 785.26 | 785.26 | NM |
| | February 25, 2021 | NM | NM | 784.27 | NM | 788.36 | NM | NM | 784.75 | NM | NM | NM | NM | NM | NM | NM |
| | April 12, 2021 | 786.50 | 785.77 | 784.07 | 787.99 | 788.11 | 786.34 | 784.27 | 784.77 | 785.84 | 784.32 | 784.21 | 785.55 | 784.29 | 784.24 | 784.15 |
| | June 11, 2021 | NM | NM | NM | NM | NM | NM | 784.19 | 784.66 | NM | NM | NM | NM | 784.20 | 784.05 | NM |
| | July 20, 2021 | NM | NM | 783.64 | NM | 788.39 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 11-12, 14, 2021 | 785.28 | 785.09 | 783.09 | 787.78 | 787.75 | 786.33 | 783.73 | 784.42 | 784.96 | 782.93 | 782.44 | 783.76 | 783.65 | 783.48 | 783.48 |
| | December 21, 2021 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 782.93 | NM | NM |
| | February 24, 2022 | NM | NM | 782.34 | NM | 786.49 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | April 11-13, 2022 | 785.44 | 784.42 | 783.40 | 788.20 | 787.87 | 788.26 | 783.27 | 784.30 | 785.02 | 783.11 | 783.32 | 784.19 | 783.14 | 783.19 | 783.04 |
| | July 27, 2022 | NM | NM | 783.07 | NM | 787.03 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM |
| | October 25-27, 2022 | 784.91 | 784.62 | 778.94 | 781.79 | 784.97 | 783.85 | 781.94 | 783.61 | 784.57 | 778.32 | 777.89 | 784.16 | 781.50 | 780.96 | 781.23 |
| | November 30, 2022 | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | NM | 781.62 | 781.14 | 781.15 |
| | December 2, 2022 | 785.12 | 784.48 | NM | 783.97 | NM | NM | 781.91 | 783.71 | 784.76 | 778.52 | 779.54 | NM | NM | NM | NM |
| | **Bottom of Well Elevation (ft)** | 777.49 | 779.40 | 775.72 | 779.72 | 780.72 | 766.52 | 777.21 | 770.52 | 774.07 | 780.63 | 780.39 | 778.90 | 775.60 | 775.21 | 773.55 |

Notes:
NM = not measured

Created by: MDB Date: 5/6/2013
Last revision by: JR Date: 12/13/2022
Checked by: RM Date: 12/23/2022

(1) The elevation for SG-1 is read off of the staff gauge (rather than measured from the top of the gauge).
(2) SG-2 could not be located during the April 2013 event.
(3) SG-3 could not be located during the October 2013 event. SG-1 could not be safely accessed during the October 2013 event.
(4) LH-2 measurements are given as leachate depth, measured by a transducer.
(5) LH-2 and LH-3 measurements were collected by WPL staff on October 9, 2017.
(6) The depth to water at MW-84A was not measured prior to purging for sampling during the October 3-5 sampling event. The level was allowed to return to static and was measured on 10/10/2017.
(7) BC = Brian Clepper; NS= Nate Sievers - Columbia Site employees.
(8) MW-303 was extended in 2022 due to regrading. Prior to October 2022, the TOC elevation was 811.52'. For events in October 2022 and later, the TOC elevation is 815.72'.

I:\25222260.00\Deliverables\Plan Modification\Appendices\B_Design Demonstration\[B7_wlstat_Columbia_2012-Dec 2022.xls]levels

# Appendix B7

# Final Cover Calculations

# Appendix B7.1

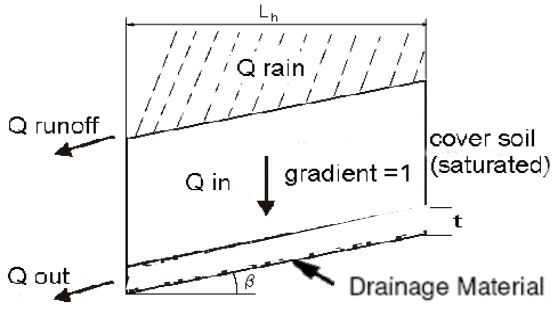
# Cover Unit Gradient for Existing Final Cover

**Purpose:** To determine the maximum length of slope that the final cover drainage layer (sand) can carry infiltrating water and remain stable.

**Approach:** Use the unit gradient method to determine the maximum slope length.

**References:**


1. Landfilldesign.com
2. "GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001
3. "Beyond a factor-of-safety value, i.e., the proabability of failure". GRI Newsletter/Report, Vol. 15, no. 3
4. "Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998
5. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J. P. Giroud, J. G. Zornberg and A. Zhao, Geosynthetics International, Vol. 7, Nos 4-5
6. "Lateral Drainage Design update - part 2". G. N. Richardson, J. P. Giroud and A. Zhao, Geotechnical Fabrics Report, March 2002
7. HELP Model "User's Guide", Table 4: Default Soil, Waste, and Geosynthetic Characteristics
8. SCS Engineers, Plan Modification Request/Plan of Operation Update, Dry Ash Disposal Facility, COL Energy Center, Final Grades Plan Sheet, May 2022


**With Darcy's Law:**

$$Q = k \times i \times A$$

Inflow of water in the Drainage Material

$$Q_{in} = k_{veg} \times i \times A = k_{veg} \times 1 \times L_h \times 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{drain} \times i \times A = k_{drain} \times t \times \sin\beta$$

This results in a required $k_{drain}$ of:

$$k_{drain} = \frac{k_{veg} \times L_h}{t \times \sin\beta} \times FS$$

**Assumptions:** 1. Soil hydraulic gradient $i$ = 1.0.

2. Top soil will be clay. Soil permeability is 4.2 x $10^{-5}$ cm/sec for a CL clay from HELP model user's guide.

3. Drainage Layer hydraulic gradient = sinβ where β=14˚ (4:1 horizontal/vertical final cover slope).

4. Maximum horizontal final cover slope length from crest to toe drain is 368 feet as shown in Module 1 on the final grades plan sheet.

5. The minimum hydraulic conductivity ($k_{drain,ave}$) is 1.0 x $10^{-2}$ cm/s for the sand.

6. Cover drainage layer thickness t = 1 foot.

**Calculation:** Constants

| | | | | | |
|---|---|---|---|---|---|
| $L_h$ | = | Drainage pipe spacing or length of slope measured horizontally | = | See Below | |
| $k_{veg}$ | = | Permeability of the vegetative supporting soil | = | 0.000042 | cm/sec |
| S | = | The liner's slope, **S** = tan **b** | = | 25% | b = 14˚ |
| $FS_{slope}$ | = | Minimum factor of safety against sliding, for drainage layer/geomembrane interface | = | 1.5 | |
| $\delta_{req'd}$ | = | Minimum interface friction angle = $\tan^{-1}$(FS*tan(b)) | = | 20.6 | degrees |

Determine the maximum slope length for the given minimum required drainage layer permeability

| $L_h$ (feet) | $L_h$ (meter) | $k_{drain, req}$ (cm/s) | |
|---|---|---|---|
| 30 | 9.1 | 7.69E-03 | Design |

**Conclusions:** The design has an intermediate pipe every 30 feet spaced evenly up the slope. The intermediate pipe spacing design with the sand material has a factor of safety of 1.95.

# Appendix B7.2

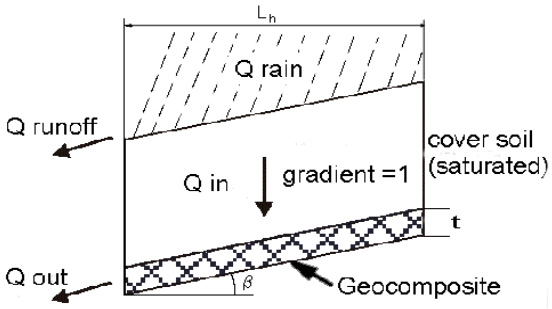
# Cover Unit Gradient for Alternative Final Cover

**Purpose:** To determine the geocomposite drainage requirements in the final cover where flow converges in the north and south corners of Modules 10 and 11so the final cover drainage geocomposite can carry infiltrating water and remain stable. Also to determine the recommended minimum interface friction angle for final cover stability.

**Approach:** Use the unit gradient method and flow path geometry to determine the geocomposite transmissivity required at locations within the converging flow area.

**References:**


1. Landfilldesign.com - Lateral Drainage System - Single Slope, Unit Gradient Method
2. "GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.
3. "Beyond a factor-of-safety value, i.e., the proabability of failure". GRI Newsletter/Report, Vol. 15, no. 3.
4. "Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.
5. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J. P. Giroud, J. G. Zornberg and A. Zhao, Geosynthetics International, Vol. 7, Nos 4-5.
6. "Lateral Drainage Design update - part 2". G. N. Richardson, J. P. Giroud and A. Zhao, Geotechnical Fabrics Report, March 2002.
7. Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International
8. SCS Engineers, Plan Modification Request/Plan of Operation Update, Dry Ash Disposal Facility, COL Energy Center, Final Grades Plan Sheet, April 2022
9. HELP Model "User's Guide" in conjunction with GRI report #19, pages 34-37 (Leachate Collection System)


**With Darcy's law:**

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin\beta$$

= θ*i*1 where θ = $k_{comp}$ * t (minimum allowable outflow to keep head within geocomposite)

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin\beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

**Assumptions:** 1. Soil hydraulic gradient $i$ = 1.0.

2. Top soil will be clay. Soil permeability is 4.2 x $10^{-5}$ cm/sec for a CL clay from HELP model user's guide.

3. Geocomposite hydraulic gradient = sinβ where β=14˚ (4:1 horizontal/vertical final cover slope).

4. Factor of safety and transmissivity reduction factors are from recommended values in GRI report #19 (Leachate collection system example) and HELP model "Users Guide"

5. Flow paths A-E and F-J are as shown on attached drawing. Assume circular arc with radius measured from the corner of the toe drain.

6. Intermediate drainage piping will be used at 3 locations along the slope in each area to divert flow from the drainage layer to the diversion berms and downslope flume.

**Calculation:** Constants

| | | | | | |
|---|---|---|---|---|---|
| $L_h$ | = | Drainage pipe spacing or length of slope measured horizontally | = | See Below | |
| $k_{veg}$ | = | Permeability of the vegetative supporting soil | = | 0.000042 | cm/sec |
| S | = | The liner's slope, **S** = tan **b** | = | 25% | b = 14˚ |
| $FS_{slope}$ | = | Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces | = | 1.5 | |
| $\delta_{req'd}$ | = | Minimum interface friction angle = $\tan^{-1}$(FS*tan(b)) | = | 20.6 | degrees |
| $FS_d$ | = | Overall factor of safety for drainage | = | 2.0 | |
| $RF_{in}$ | = | Intrusion Reduction Factor | = | 1.1 | |
| $RF_{cr}$ | = | Creep Reduction Factor | = | 1.2 | |
| $RF_{cc}$ | = | Chemical Clogging Reduction Factor | = | 1.1 | |
| $RF_{bc}$ | = | Biological Clogging Reduction Factor | = | 1.4 | |
| w | = | Geocomposite width at drainage outlet | | | |
| A | = | Final cover plan area upslope of geocomposite drainage outlet | | | |

Determine the maximum slope length for a given ultimate transmissivity

Min. $\Theta_{req}$ = A X $k_{veg}$ / ( w X sinβ )

For the outlet at the corner, use minimum 5 foot width and 2 foot width of geocomposite to connect the toe drain to drain the converging flow area:

| Area | A (sq. feet) | w (feet) | w (meter) | Min. $\Theta_{ult}$ ($m^2$/sec) | Proposed $\Theta_{ult}$ ($m^2$/sec) |
|---|---|---|---|---|---|
| 1 | 420 | 5 | 1.52 | 1.81E-04 | 1.00E-03 |
| 4 | 70 | 2 | 0.61 | 7.53E-05 | 1.00E-03 |

The toe drainage areas, Area 1 and Area 4, include only converging flow below the lowest intermediate drainage piping, as flow above this area is diverted. There are intermediate drainage pipes in Areas 1 and 4 which divert flow from the outlet corner to the downslope flume.

For converging flow in a circular arc, from radius R-top to radius R-bottom:

L = R-top - R-bottom

w-bot = w-top * (R-bot/R-top)

A = L* ( 1+ (R-bot/R-top))/2 (assuming unit width at top and trapezoid vs arc to simplify)

Θult-bot = (Θult calculated for L) * R-top/R-bot * ( 1+ (R-bot/R-top))/2

**Calculation: (Cont.)** For the southern convergence area, flow paths A-E, calculate Θult for selected R-bot values to determine appropriate geocomposite products as flow converges down the slope:

| Flow Path | R-top (feet) | R-bot (feet) | $L_h$ (feet) | $L_h$ (meters) | $\Theta_{ult}$ ($m^2$/sec) | Proposed $\Theta_{ult}$ ($m^2$/sec) |
|---|---|---|---|---|---|---|
| Area 1 | | | | | | |
| A1 | 138 | 26 | 112 | 34 | 7.57E-04 | 1.00E-03 |
| B1 | 132 | 24 | 108 | 32 | 7.34E-04 | 1.00E-03 |
| C1 | 129 | 23 | 106 | 32 | 7.47E-04 | 1.00E-03 |
| D1 | 126 | 21 | 105 | 32 | 7.91E-04 | 1.00E-03 |
| E1 | 122 | 20 | 102 | 31 | 7.77E-04 | 1.00E-03 |
| Area 2 | | | | | | |
| A2 | 306 | 138 | 168 | 51 | 5.79E-04 | 1.00E-03 |
| B2 | 294 | 132 | 162 | 49 | 5.58E-04 | 1.00E-03 |
| C2 | 286 | 129 | 157 | 47 | 5.34E-04 | 1.00E-03 |
| D2 | 278 | 126 | 152 | 46 | 5.21E-04 | 1.00E-03 |
| E2 | 270 | 122 | 148 | 45 | 5.11E-04 | 1.00E-03 |
| Area 3 | | | | | | |
| A3 | 328 | 306 | 22 | 6 | 4.39E-05 | 1.00E-03 |
| B3 | 357 | 294 | 63 | 19 | 1.49E-04 | 1.00E-03 |
| C3 | 419 | 286 | 133 | 40 | 3.48E-04 | 1.00E-03 |
| D3 | 319 | 278 | 41 | 12 | 9.10E-05 | 1.00E-03 |
| E3 | 285 | 270 | 15 | 4 | 2.91E-05 | 1.00E-03 |

**Conclusions:** For the southern area proposed design with intermediate slope outlets and a toe-of-slope drainage outlet, placement of geocomposite with the required transmissivities to the minimum lengths/areas shown in the table above and on the attached drawing will provide adequate drainage for the converging flow.

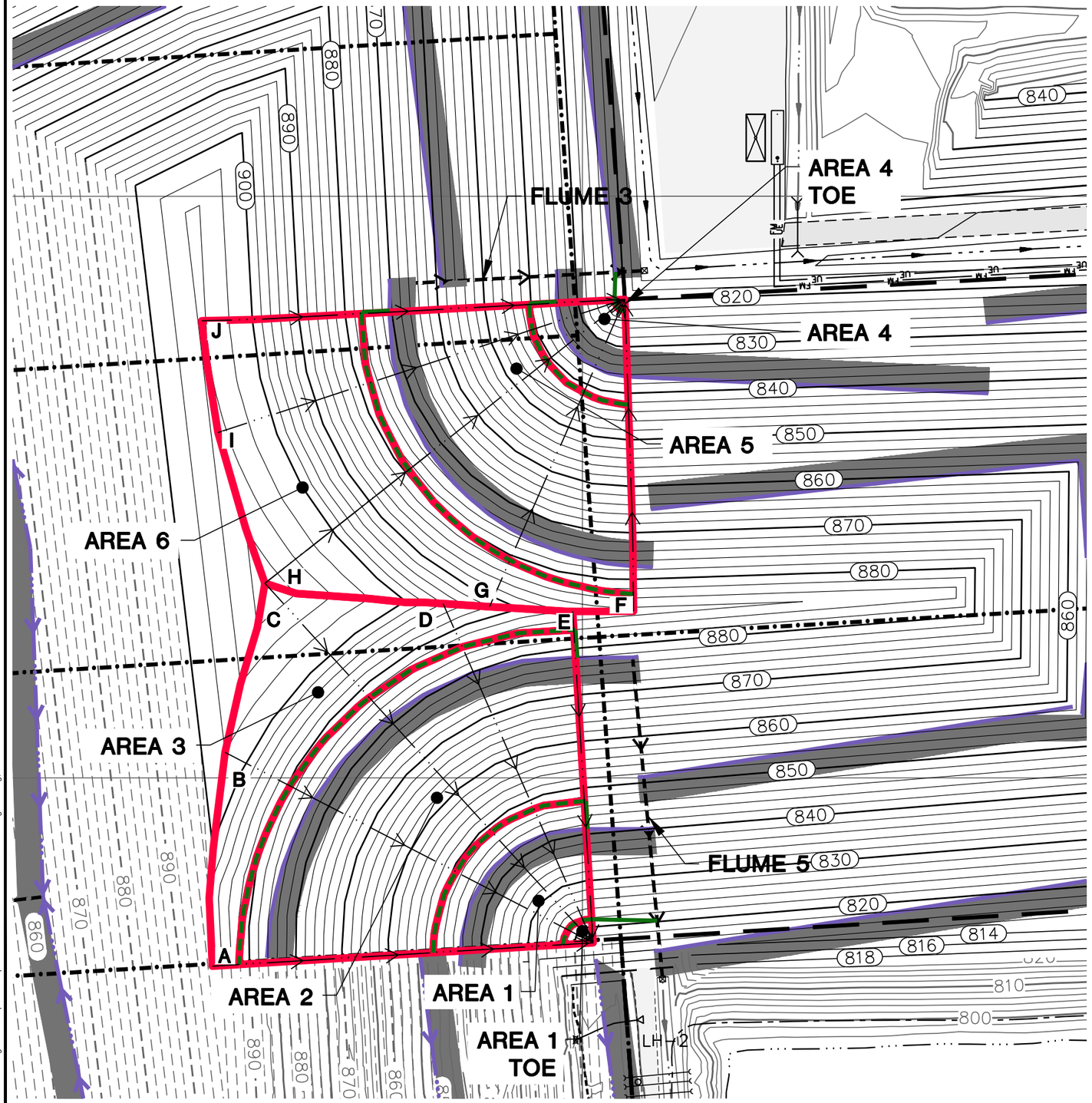
A minimum interface friction angle of 20.6 degrees for the geocomposite, geomembrane, and GCL interfaces is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.

**Calculation: (Cont.)** For the northern convergence area, flow paths F-J, calculate Θult for selected R-bot values to determine appropriate geocomposite products as flow converges down the slope:

| Flow Path | R-top (feet) | R-bot (feet) | $L_h$ (feet) | $L_h$ (meters) | $\Theta_{ult}$ ($m^2$/sec) | Proposed $\Theta_{ult}$ ($m^2$/sec) |
|---|---|---|---|---|---|---|
| Area 4 | | | | | | |
| F4 | 91 | 11 | 80 | 24 | 7.86E-04 | 1.00E-03 |
| G4 | 87 | 10 | 77 | 23 | 7.88E-04 | 1.00E-03 |
| H4 | 86 | 9 | 77 | 23 | 8.57E-04 | 1.00E-03 |
| I4 | 84 | 9 | 75 | 22 | 8.03E-04 | 1.00E-03 |
| J4 | 83 | 9 | 74 | 22 | 7.94E-04 | 1.00E-03 |
| Area 5 | | | | | | |
| F5 | 254 | 91 | 163 | 49 | 6.56E-04 | 1.00E-03 |
| G5 | 245 | 87 | 158 | 48 | 6.47E-04 | 1.00E-03 |
| H5 | 237 | 86 | 151 | 46 | 6.10E-04 | 1.00E-03 |
| I5 | 231 | 84 | 147 | 44 | 5.83E-04 | 1.00E-03 |
| J5 | 227 | 83 | 144 | 43 | 5.67E-04 | 1.00E-03 |
| Area 6 | | | | | | |
| F6 | 268 | 254 | 14 | 4 | 2.90E-05 | 1.00E-03 |
| G6 | 289 | 245 | 44 | 13 | 1.00E-04 | 1.00E-03 |
| H6 | 395 | 237 | 158 | 48 | 4.52E-04 | 1.00E-03 |
| I6 | 368 | 231 | 137 | 41 | 3.75E-04 | 1.00E-03 |
| J6 | 365 | 227 | 138 | 42 | 3.87E-04 | 1.00E-03 |

**Conclusions:** For the northern area proposed design with intermediate slope outlets and a toe-of-slope drainage outlet, placement of geocomposite with the required transmissivities to the minimum lengths/areas shown in the table above and on the attached drawing will provide adequate drainage for the converging flow.

A minimum interface friction angle of 20.6 degrees for the geocomposite, geomembrane, and GCL interfaces is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.




**LEGEND**

- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- 840 — PROPOSED PHASE 1 FINAL GRADE (10' INTERVAL)
- PROPOSED PHASE 1 FINAL GRADE (2' INTERVAL)
- 840 — PROPOSED GRADE (10' INTERVAL)
- PROPOSED GRADE (2' INTERVAL)
- PROPOSED PERIMETER ROAD
- PROPOSED SWALE
- PROPOSED CULVERT
- PROPOSED LEACHATE COLLECTION SYSTEM CLEANOUT
- PROPOSED LEACHATE VAULT
- FM — PROPOSED LEACHATE FORCEMAIN
- UE — PROPOSED UNDERGROUND ELECTRIC
- PROPOSED DIVERSION BERM
- PROPOSED DOWNSLOPE FLUME
- PROPOSED ENERGY DISSIPATOR
- PROPOSED RIPRAP
- CONVERGENCE FLOW PATH
- PERFORATED SUBSURFACE PIPING
- SOLID SUBSURFACE PIPING

N

10 0 10

SCALE: 1" = 10'

GEOTECHNICAL CALCULATION – FLOW CONVERGENCE

PLAN OF OPERATION
2022 UPDATE
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SITE

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT

FIGURE 1

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

| | |
|---|---|
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/25/2022 |
| REVISED: | 05/02/2022 |
| DRAWN BY: | KP/MJT |
| CHECKED BY: | DN |
| APPROVED BY: | |

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# Appendix B7.3

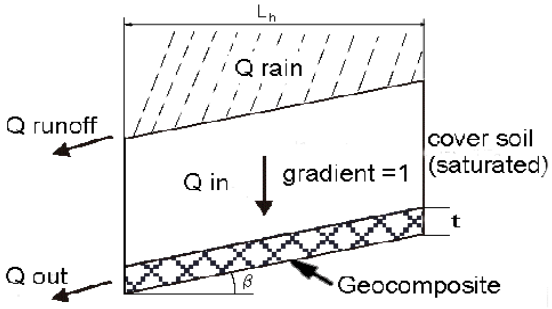
# Geocomposite Drainage Layer

**Purpose:** To determine the maximum length of slope that the final cover drainage geocomposite can carry infiltrating water and remain stable. Also determine the recommended minimum friction angle for final cover side slope stability. Note: This calculation does not include the flow convergence areas where a separate calculation is required.

**Approach:** Use the unit gradient method to determine the maximum slope length.

**References:**


1. Landfilldesign.com - Lateral Drainage System - Single Slope, Unit Gradient Method
2. "GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.
3. "Beyond a factor-of-safety value, i.e., the proabability of failure". GRI Newsletter/Report, Vol. 15, no. 3.
4. "Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.
5. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J. P. Giroud, J. G. Zornberg and A. Zhao, Geosynthetics International, Vol. 7, Nos 4-5.
6. "Lateral Drainage Design update - part 2". G. N. Richardson, J. P. Giroud and A. Zhao, Geotechnical Fabrics Report, March 2002.
7. Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International
8. SCS Engineers, Plan Modification Request/Plan of Operation Update, Dry Ash Disposal Facility, COL Energy Center, Final Grades Plan Sheet, May 2022
9. HELP Model "User's Guide" in conjunction with GRI report #19, pages 34-37 (Leachate Collection System)


**With Darcy's law:**

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin\beta \quad = \theta * i * 1 \text{ where } \theta = k_{comp} * t$$

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin\beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

**Assumptions:** 1. Soil hydraulic gradient $i$ = 1.0.

2. Top soil will be clay. Soil permeability is 4.2 x $10^{-5}$ cm/sec for a CL clay from HELP model user's guide.

3. Geocomposite hydraulic gradient = sinβ where β=14˚ (4:1 horizontal/vertical final cover slope).

4. Factor of safety and transmissivity reduction factors are from recommended values in GRI report #19 (Leachate collection system example) and HELP model "Users Guide"

5. Maximum horizontal final cover slope length from crest to toe drain is 397 feet as shown on Module 10 and 11 Final Grades plan sheet. This includes 58' of 10:1 slope length at the peak.

**Calculation:** Constants

| | | | | | |
|---|---|---|---|---|---|
| $L_h$ | = | Drainage pipe spacing or length of slope measured horizontally | = | See Below | |
| $k_{veg}$ | = | Permeability of the vegetative supporting soil | = | 0.000042 | cm/sec |
| S | = | The liner's slope, **S** = tan **b** | = | 25% | b = 14˚ |
| $FS_{slope}$ | = | Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces | = | 1.5 | |
| $\delta_{req'd}$ | = | Minimum interface friction angle = $\tan^{-1}$(FS*tan(b)) | = | 20.6 | degrees |
| $FS_d$ | = | Overall factor of safety for drainage | = | 2.0 | |
| $RF_{in}$ | = | Intrusion Reduction Factor | = | 1.1 | |
| $RF_{cr}$ | = | Creep Reduction Factor | = | 1.2 | |
| $RF_{cc}$ | = | Chemical Clogging Reduction Factor | = | 1.1 | |
| $RF_{bc}$ | = | Biological Clogging Reduction Factor | = | 1.4 | |

Determine the maximum slope length for a given ultimate transmissivity

| $\Theta_{ult}$ ($m^2$/sec) | $L_h$ (meter) | $L_h$ (feet) |
|---|---|---|
| 1.00E-03 | 141.7 | 465 |

Determine the ultimate transmissivity based on a given slope length

| $L_h$ (feet) | $L_h$ (meter) | $\Theta_{ult}$ ($m^2$/sec) | |
|---|---|---|---|
| 397 | 121.0 | 8.55E-04 | ~ Total slope length |
| 199 | 60.5 | 4.27E-04 | ~ 1/2 of total slope length |
| 132 | 40.3 | 2.85E-04 | ~ 1/3 of total slope length |

**Conclusions:** If no intermediate drainage outlets were constructed on the final cover, a minimum transmissivity of 8.55 x $10^{-4}$ $m^2$/sec would need to be obtained.

A minimum interface friction angle of 20.6 degrees between cover soil and geocomposite is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.

# Appendix B7.4

# GCL Cover Strength

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 1 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Dry Ash Disposal Facility | By: MJT | Date: 04/25/22 |
| Client: WPL | Subject: GCL Internal Shear on Final Cover | Chk'd: DLN | Date: 04/26/22 |

**Purpose:** Determine the maximum shear stress acting on a Geosynthetic Clay Liner (GCL) and the GCL internal shear strength required to provide a minimum slope stability safety factor (FS) of 1.5 for the final cover.

**Approach:** Use maximum shear stress formula and assumed values.

**References:** Design of GCL Barrier for Final Cover Side Slope Applications, Gregory N. Richardson, Ph.D., P.E., Geosynthetics '97-541

**Calculation:** The maximum shear stress acting on the GCL can be calculated as follows:

$$\tau_{act} = W_T \sin \beta$$

$$\beta = 14^\circ$$

$$W_T = \gamma \times h$$

Where: $\gamma$ = Soil Unit Weight = 120 pcf

$h$ = Cover Thickness = 2.5 ft

$$W_T = 300 \text{ psf}$$

$$\tau_{act} = 72.6 \text{ psf}$$

$$FS = \frac{\tau_{resist}}{\tau_{act}} = 1.5$$

$$\tau_{resist} = FS \times \tau_{act} = 1.5 \times 72.6 = 109 \text{ psf}$$

**Assumptions:** Slope angle, $\beta = 14^\circ$ (4:1 horizontal / vertical final cover slope)

Soil unit weight, $\gamma = 120$ pcf

**Conclusion:** For a total weight of the final cover system of 300 psf and a slope angle of 4:1, the maximum shear stress will be 72.6 psf. A minimum GCL internal shear strength of 109 psf is required to provide a slope stability safety factor of 1.5.

# Appendix C

# Operational Plans

# Appendix C1

# Fugitive Dust Control Plan

**Wisconsin Power and Light Company**

**Columbia Energy Center (COL)**

# Coal Combustion Residuals (CCR) Fugitive Dust Control Plan

**February 1, 2023**

The procedures in this plan apply to the following CCR units at this facility:

*CCR Surface Impoundments*

COL Primary Ash Pond

COL Secondary Ash Pond

*CCR Landfill*

COL Dry Ash Disposal Facility Module 1

COL Dry Ash Disposal Facility Module 2

COL Dry Ash Disposal Facility Module 3

COL Dry Ash Disposal Facility Module 4

COL Dry Ash Disposal Facility Module 5

COL Dry Ash Disposal Facility Module 6

COL Dry Ash Disposal Facility Module 10

COL Dry Ash Disposal Facility Module 11

**Coal Combustion Residuals (CCR) Fugitive Dust Control Plan for CCR Landfills**

February 1, 2023

## Purpose of CCR Fugitive Dust Control Plan

This plan describes the measures used to minimize fugitive CCR dust from facilities with CCR landfills[1], the procedure for logging citizen complaints involving CCR fugitive dust events, and the procedure for periodic review of this plan. This plan has been developed in accordance with 40 CFR 257.80(b) and NR 514.07(10)(a).

## Measures for Controlling Fugitive Dust

The following measures are appropriate for minimizing CCR from becoming airborne at this facility:

- Establishing and enforcing a vehicle speed limit of 10 mph or less. Reduced speeds minimize fugitive dust generated from vehicle traffic.
- Covering all open-bodied vehicles that are transporting CCR to minimize the generation of fugitive dust during transport of CCR.
- Minimizing fall distances when handling or transferring CCR. The facility uses best practices when handling CCR with end loaders, and other best management practices, to minimize the generation of fugitive dust.
- Promptly collecting CCR that is observed in vehicle loading/unloading areas to minimize the potential for CCR to become airborne.
- Applying water directly to CCR using a water truck or irrigation system. Moistened CCR is less likely to become airborne.
- Suspending CCR management activities, including placement of CCR, during excessively windy conditions to minimize CCR from becoming airborne.
- Placement of soil and/or vegetated cover to minimize exposure of CCR in inactive landfill areas to conditions that could lead to fugitive dust.

These measures are applicable to the CCR managed at this facility and appropriate for the conditions at this site because they are compatible with current operations and they effectively minimize the generation of fugitive dust.

## Procedure for Conditioning CCR Prior to Placement

CCR is routinely conditioned with water prior to placement to prevent wind dispersal. Conditioning of scrubber by-products occurs through the use of a pug mill within an enclosed building. Conditioning may also occur by wetting with a water truck as material is placed in the CCR landfill. Conditioning will not result in free liquids.

[1] "CCR" and "CCR landfill" are defined at 40 CFR 257.53 and NR 500.03.

## Procedure for Logging Citizen Complaints

Citizen complaints pertaining to fugitive dust will be managed in accordance with Alliant Corporate Policy ENV-107. Specifically, the complaint must be reported to Environmental Services (1) via phone call and (2) in writing by submitting a completed Environmental Incident Report to Environmental Services within 10 business days. Citizen complaints will be tracked within the Alliant Environmental Management Information System ("ENVIANCE").

## Visual Inspections

In accordance with NR 514.07(10)(a)(3), the owner/operator will perform visual inspections of the landfill surface at least every 7 days. If fugitive dust concerns are observed during the inspection, action will be taken to remedy the situation. Visual fugitive dust inspections will not be performed if the CCR disposal area is covered by intermediate or final cover and there is no potential for CCR to become airborne.

## Procedure for Periodic Review of CCR Fugitive Dust Control Plan

The CCR Fugitive Dust Control Plan will be reviewed annually, and updated as necessary, in conjunction with preparation of the Annual CCR Fugitive Dust Control Report [40 CFR 257.80(c) and NR 514.07(10)(a)(5)]. The Annual CCR Fugitive Dust Control Report will be included in the annual report in accordance with NR 506.20(3)(a) and include a description of the actions taken by the owner or operator to control CCR fugitive dust, a record of all citizen complaints, and a summary of any corrective measures taken.

During the periodic review, staff will evaluate each measure for controlling fugitive dust to ensure that it is still appropriate for minimizing CCR from becoming airborne at the facility, will verify that the procedures for conditioning CCR prior to landfilling and the procedure for logging complaints are sufficient, and will evaluate other operations changes at the facility to determine whether additional dust control measures should be added.

In accordance with NR 514.07(10)(a)(4), the CCR Fugitive Dust Control Plan will be modified in accordance with NR 514.04(6) whenever there is a change in conditions that may substantially affect the plan of operation.

***- END -***

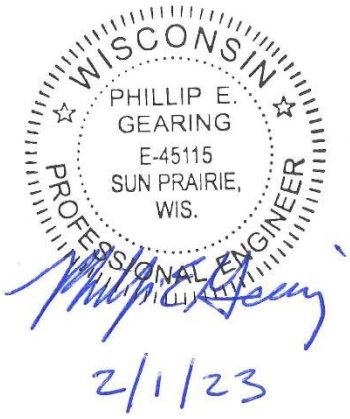
**P.E. Certification**

I, Phillip Gearing, hereby certify that I am a licensed professional engineer in the State of Wisconsin in accordance with the requirements of ch. A−E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A−E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code.

Specifically,

- This CCR Fugitive Dust Control Plan was prepared by me or under my direct supervision and meets the requirements of 40 CFR 257.80(b) and NR 514.07 (10)(a)

Signature




February 1, 2023
Date

License number E-45115

My license renewal date is July 31, 2024.

# Appendix C2

# Run-on and Run-off Control System Plan

# Run-On and Run-Off Control Plan Update – Phase 1, Modules 1 through 6 and Phase 2, Modules 10 and 11

Columbia Dry Ash Disposal Facility
Columbia Energy Center
W8375 Murray Road
Pardeeville, Wisconsin 53954

Prepared for:

Wisconsin Power and Light Company
Columbia Energy Center
W8375 Murray Road
Pardeeville, Wisconsin 53954

SCS ENGINEERS

25222260.00 | February 1, 2023

2830 Dairy Drive
Madison, WI 53718-6751
608-224-2830

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A2 – Leachate/Surface Water Pond Capacity Evaluation
A3 – 2022 Module 10 and 11 Design and South Sediment Basin Check

I:\25222260.00\Deliverables\Runon & Runoff Control Plan\230201_Run-On and Run-Off Control Plan Update.docx

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# PE CERTIFICATION

I, Phillip Gearing, hereby certify that I am a licensed professional engineer in the State of Wisconsin in accordance with the requirements of ch. A–E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A–E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code.

Specifically,

- This Run-On and Run-Off Control Plan Update was prepared by me or under my direct supervision and meets the requirements of 40 CFR 257.81(c) and NR 514.07(10)(b)

(signature) February 1, 2023 (date)

Phillip E. Gearing
(printed or typed name)

License number E-45115

My license renewal date is July 31, 2024.

Pages or sheets covered by this seal:

Run-On and Run-Off Control Plan Update – Phase 1, Modules 1 through 6 and Phase 2, Modules 10 and 11

Columbia Dry Ash Disposal Facility, Columbia Energy Center

W8375 Murray Road, Pardeeville, Wisconsin 53954

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# 1.0 INTRODUCTION AND PROJECT SUMMARY

The Columbia Dry Ash Disposal Facility includes an active coal combustion residual (CCR) landfill, which currently consists of the following modules, located in Phase 1 and Phase 2 of the facility.

- **Phase 1, Module 1** – This module has received final cover over completed outer sideslope areas that will no longer receive additional CCR; intermediate cover has been placed over remaining areas.
- **Phase 1, Module 2** – This module has received intermediate cover over a majority of the in-place CCR.
- **Phase 1, Module 3** – This module has received intermediate cover over a majority of the in-place CCR.
- **Phase 1, Module 4** – This module is currently being filled.
- **Phase 1, Module 5** – This module was constructed in 2021 and is approved by Wisconsin Department of Natural Resources (WDNR) to receive CCR.
- **Phase 1, Module 6** – This module was constructed in 2021 and is approved by WDNR to receive CCR.
- **Phase 2, Module 10** – Module 10 liner construction began in 2022. The new module will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for WDNR review in 2023.
- **Phase 2, Module 11** – Module 11 liner construction began in 2022. The new module will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for WDNR review in 2023.

Phase 1, Modules 1-3 were previously described as separate existing CCR landfills although they are contiguous and are managed as a single landfill by the facility and by the WDNR. WPL clarified that Modules 1-3 are one existing CCR landfill under the federal CCR Rule. Phase 1, Modules 4-6 are considered a new CCR landfill that initiated construction after October 19, 2015, and are therefore managed as a separate CCR unit under the federal CCR Rule even though they are contiguous to Modules 1-3. In addition, the new CCR landfill will include Phase 2, Modules 10 and 11, which is near completion and will begin receiving CCR in 2023 after full WDNR approval.

Phase 2, Modules 7-9 and 12-13 are permitted with the WDNR, but have not been developed. If developed, the units will also be part of the new CCR landfill, as defined at 40 CFR 257.53 and NR 500.03. Construction of additional modules is not currently planned prior to retirement of the Columbia Energy Center, which is currently scheduled to occur no later than June 1, 2026.

**Figure 1** shows the site location. **Figure 2** shows the run-on and run-off drainage areas.

On behalf of Wisconsin Power and Light Company (WPL), SCS Engineers (SCS) has prepared this Run-On and Run-Off Control Plan Update for the Columbia (COL) Dry Ash Disposal Facility in accordance with 40 CFR 257.81(c)(1) and NR 514.07(10)(b) as follows.

**40 CFR 257.81(c)(4).** *"The owner or operator of the CCR unit must prepare periodic run-on and run-off control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on*

*the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed a periodic run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).”*

NR 514.07(10)(b)(4). *“Modification every 5 years from the date of the most recent plan approval or whenever there is a change in conditions that may substantially affect the written plan in effect. The modification shall be requested by the owner or operator in accordance with s. NR 514.04 (6) prior to the 5-year deadline.”*

The initial Run-On and Run-Off Control Plan was completed in 2016, and updates were completed in 2018 prior to receipt of CCR in Phase 1, Module 4 and in 2021, prior to receipt of CCR in Phase 1, Modules 5 and 6.

## 1.1 PERIODIC PLAN UPDATES

The following items have been updated in this plan prior to receipt of CCR in Phase 2, Modules 10 and 11:

- Run-On and Run-Off Drainage Areas – Figure 2 has been updated to show topographic data for active landfill areas obtained during the most recent survey of the existing landfill in January 2023 and construction of Phase 2, Modules 10 and 11 in 2022. Additional intermediate cover has been placed in Modules 3, 4, 5, and 6 since the latest survey reducing the area contributing run-off as contact water. Modules 5 and 6 no longer have a temporary rain cover; however, rain cover may be used in the future to reduce the area contributing run-off as contact water (refer to Section 2.0). Additional intermediate cover will be added to active landfill areas as Modules 10 and 11 begin receiving CCR to maintain contributing run-off area.

- Storm Water Calculations – Additional storm water calculations were completed for Modules 10 and 11 as described in Section 2.0.

- Primary Ash Pond – The Primary Ash Pond will no longer accept contact water from the landfill. As needed, contact water will be transported to the plant for discharge through Outfall 003 rather than disposal at the Primary Ash Pond.

- No other changes impacting the run-on and run-off controls have been identified with this update.

- This update also incorporates the requirements of NR 514.07(10)(b), which became effective August 1, 2022.

# 2.0 RUN-ON AND RUN-OFF CONTROL PLAN

40 CFR 257.81(a). *“The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain:*

*(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm.”*

NR 514.07(10)(b). *“A run−on and run−off control system plan that includes all of the following:*

*(1) A run−on and run−off control system designed in accordance with the requirements under s. NR 504.12 (2)."*

NR 504.12 (2). *"An existing or new CCR landfill or any lateral expansion of a CCR landfill shall be designed, constructed, operated, and maintained with a run−off and run−on control system in accordance with the requirements under s. NR 504.09 (1) (f) and (g) and all of the following:*

*(a) A run−on control system shall prevent flow onto the active portion of the CCR landfill during the peak discharge from a 24−hour, 25−year storm."*

The entire facility has run-on and run-off control in place, as approved by the WDNR and further described below. Run-on is controlled by berms and swales around the perimeter of the landfill that divert storm water away from the landfill to a sedimentation basin.

40 CFR 257.81(a)(2) *"A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm."*

NR 504.12 (2)(b) *"A run−off control system from the active portion of the CCR landfill shall collect and control, at a minimum, the water volume resulting from a 24−hour, 25−year storm."*

Run-off from the active portions of the facility is handled as leachate and is collected by a leachate collection system and internal swales, which route the contact water run-off to the Leachate/Surface Water Pond. Modules 4-6 and all module fills going forward will have intermediate cover added to reduce contact water that is directed to the pond. The contact water in the basin is used for dust control or other actions within the active landfill or, if needed, is transported with a water wagon to the generating station where it may be discharged through Outfall 003 inside the plant in accordance with a Wisconsin Pollutant Discharge Elimination System (WPDES) permit.

Run-off from areas outside existing CCR units and areas of the existing CCR units where final or intermediate cover is in place is diverted into the perimeter drainage swales, which drain to the South Sedimentation Basin and a lower are north of the landfill. Intermediate swales/berms and downslope channels on the final cover help minimize erosion of the final cover and divert water to the perimeter drainage system, and ultimately to the on-site detention/sedimentation basin. Per 40 CFR 257.81(b), this is consistent with the surface water requirements under 40 CFR 257.3-3.

In addition to these controls, a temporary rain cover may be installed to limit leachate and contact water production when needed. Storm water collected on the rain cover will be diverted to perimeter swales. The rain cover will be removed in sections to accommodate waste placement. As the rain cover is removed, new diversion berms will be constructed to form the perimeter of a storm water containment area. The berms will prevent contact water from running onto the rain cover and will anchor or ballast the rain cover at the new limits. When the rain cover has been fully removed, run-off will be controlled by the limits of the developed modules, and all water inside the lined waste limits will be managed as contact water.

## 2.1 DESIGN CRITERIA

The storm water features described above are designed to handle run-on and run-off from a 25-year, 24-hour storm event, as required by 40 CFR 257.81(a)(1) and (2) and NR 504.12(2)(a) and (b). Storm water run-off calculations were updated in 2022. The calculations were performed assuming a 25-year, 24-hour precipitation depth of 4.91 inches, based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation data published in April 2013. The

detention/sedimentation basin and associated basin outlet structures are designed to safely pass run-off from a 100-year, 24-hour storm event.

Table 1. Storm Water Updates

| Year Conducted | Description of Update | Included in Appendix A |
|---|---|---|
| **Run-On and Run-Off** | | |
| 2000 | Run-on calculations performed as part of the 2000 Plan of Operation Update; performed assuming 25-year, 24-hour precipitation depth of 4.7 inches, based on Technical Paper-40 (TP-40) precipitation data published in May 1961. | Yes, Included in Appendix A |
| 2010 | Run-off calculations performed as part of the 2010 Plan of Operation Update; performed assuming 25-year, 24-hour precipitation depth of 4.7 inches, based on TP-40 precipitation data published in May 1961. | Superseded by Phase 1, Modules 5 & 6 |
| 2015 | Update to leachate/surface water pond calculations; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 1, Module 4 |
| 2016 | Update to run-on to a ditch along the north end of Module 3; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 1, Module 4 |
| 2016 | Calculations to evaluate installation of a rain cover in Module 3; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 1, Module 4 |
| 2017 | Update to leachate/surface water pond calculations with consideration of Phase 1, Module 4 construction; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 1, Modules 5 & 6 |
| 2018 | Calculations to evaluate installation of a rain cover in Module 4; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 1, Modules 5 & 6 |
| 2018 | Calculations to size swales and culverts to divert run-on as part of construction of Module 4, performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 1, Modules 5 & 6 |
| 2021 | Update to leachate/surface water pond calculations with consideration of Phase 1, Modules 5 and 6 construction; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 2, Modules 10 & 11 |
| 2021 | Calculations to size swales and culverts to divert run-on as part of construction of Modules 5 and 6, performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 2, Modules 10 & 11 |

| Year Conducted | Description of Update | Included in Appendix A |
|---|---|---|
| **Run-On and Run-Off** | | |
| 2021 | Calculations to confirm South Sedimentation Basin can handle storm water after construction of Modules 5 and 6, performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Superseded by Phase 2, Modules 10 & 11 |
| 2022 | Update to leachate/surface water pond calculations with consideration of Phase 2, Modules 10 and 11 construction; performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Yes, Included in Appendix A |
| 2022 | Calculations to size swales and culverts to divert run-on as part of construction of Modules 10 and 11, performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Yes, Included in Appendix A |
| 2022 | Calculations to confirm South Sedimentation Basin can handle storm water after construction of Modules 10 and 11, performed assuming 25-year, 24-hour precipitation depth of 4.9 inches, based on NOAA Atlas 14 precipitation data published in April 2013. | Yes, Included in Appendix A |

## 2.2 DESIGN WITH CALCULATIONS

Storm water management design calculations are contained in **Appendix A**, as required by 40 CFR 257.81(c)(1) and NR 514.07(10)(b)(2). As described in **Section 2.1**, the calculations from the 2000 Plan of Operation Update and the 2022 calculations describe the storm water management design and provide calculations showing that the run-on control system will prevent flow onto the active portion of the CCR units during the peak discharge from a 25-year, 24-hour storm. The 2022 calculations also describe the storm water management design and provide calculations showing that the run-off control system for the active portions of the CCR units will collect and control the water volume resulting from a 25-year, 24-hour storm. The calculations were performed by or overseen by a professional engineer licensed in the State of Wisconsin.

## 2.3 CONSTRUCTION

Existing storm water management features were constructed to site specifications with construction oversight directed by a professional engineer licensed in the State of Wisconsin. Construction documentation reports for the storm water management features were prepared, submitted to the WDNR, and approved by the WDNR. Any future construction features will have been previously approved.

# 3.0 CERTIFICATIONS

**40 CFR 257.81(c)(5).** *"The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section."*

Phillip Gearing, PE, a licensed profession engineer in the State of Wisconsin, has overseen the preparation of this Run-On and Run-Off Control Plan. A certification statement is provided on **page iii** of this plan.

# 4.0 RECORDKEEPING AND PERIODIC UPDATES

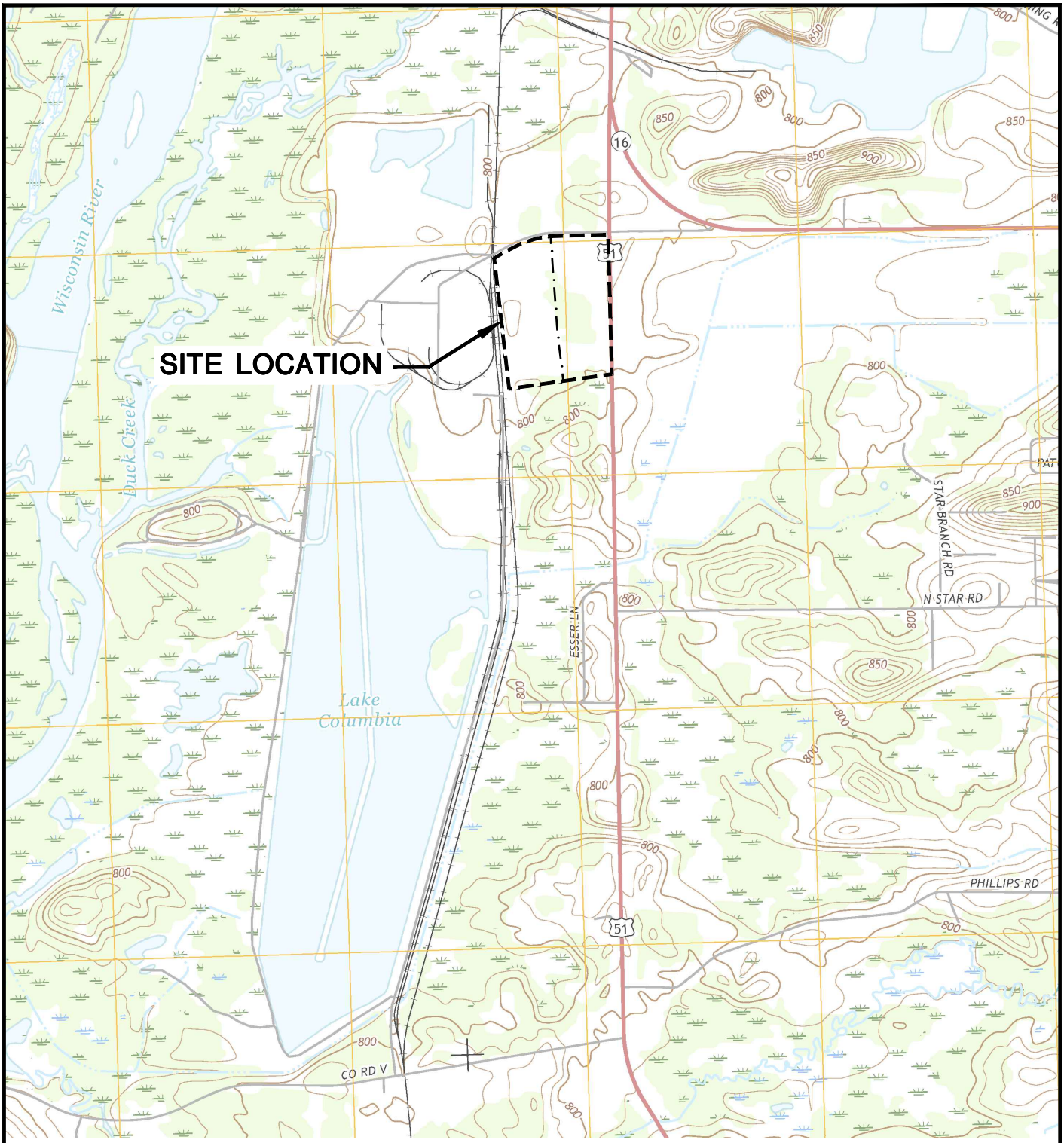
**40 CFR 257.81(d).** *"The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in section 257.105(g), the notification requirements specified in section 257.106(g), and the internet requirements specified in section 257.107(g)."*

This Run-On and Run-Off Control Plan, and all periodic plans, will be placed in the facility's operating record and on Alliant Energy's CCR Rule Compliance Data and Information website, as will all amendments. Periodic plan updates will be completed at least every 5 years per 40 CFR 257.81(c)(4) and NR 514.07(10)(b)(4).

WPL will notify the State Director when this Run-On and Run-Off Control Plan, and all subsequent updates, are available in the facility's operating record and on the facility's website per 40 CFR 257.105(g), 257.106(g), and 257.107(g) and NR 506.17(2) and (3).

# Figures

1 Site Location Map
2 Run-On and Run-Off Control Plan




N

POYNETTE QUADRANGLE
WISCONSIN–COLUMBIA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
2016
SCALE: 1" = 2,000'

| | | | |
|---|---|---|---|
| CLIENT | WISCONSIN POWER AND LIGHT<br>COLUMBIA ENERGY CENTER<br>W8375 MURRAY ROAD<br>PARDEEVILLE, WISCONSIN 53954 | SITE | RUN–ON AND RUN–OFF CONTROL PLAN<br>COLUMBIA DRY ASH DISPOSAL FACILITY<br>TOWN OF PACIFIC, WISCONSIN |

SITE LOCATION MAP

| | | | |
|---|---|---|---|
| PROJECT NO. | 25222260.00 | DRAWN BY: | AHB/RJG |
| DRAWN: | 08/09/16 | CHECKED BY: | PG |
| REVISED: | 07/16/21 | APPROVED BY: | PG 12/01/21 |

ENGINEER

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718–6751
PHONE: (608) 224–2830

FIGURE
1

I:\25222260.00\Drawings\Run-On Run-Off\1_Site Location.dwg, 1/10/2023 4:36:34 PM

DISCHARGE STRUCTURE

SW01

SOUTH SEDIMENTATION BASIN

C. M. ST. P. & P. RR.

WESTERN AREA DRAINS TO THE WEST AND SOUTH

SITE ENTRANCE

PLANT ENTRANCE ROAD

PHASE 1

MODULE 1

MODULE 2

MODULE 3

MODULE 4

MODULE 5

MODULE 6

FINAL COVER AREA DRAINS TO PERIMETER SWALES AND SOUTH SEDIMENTATION BASIN

INTERMEDIATE COVER AREA DRAINS TO PERIMETER SWALES AND SOUTH SEDIMENTATION BASIN

ACTIVE AREA DRAINS TO THE LEACHATE COLLECTION SYSTEM OR TO THE CONTACT WATER SWALE AND TO THE LEACHATE/SURFACE WATER POND

LEACHATE/ SURFACE WATER POND

PROPOSED PHASE 2

PROPOSED MODULE 10

PROPOSED MODULE 11

EASTERN AREA DRAINS TO SWALES AND SOUTH SEDIMENTATION BASIN

CLAY STOCKPILE

GENERAL FILL STOCKPILE

BM301

BM302

U.S.H. 51

LEGEND

- ASH DISPOSAL FACILITY LIMITS
- APPROVED LIMITS OF ASH FILL
- PHASE/MODULE LIMIT
- EXISTING GRADE (10' CONTOUR)
- EXISTING GRADE (2' CONTOUR)
- PAVED ROAD
- UNPAVED ROAD
- RAILROAD TRACKS
- VEGETATION
- FENCE
- SWALE
- EDGE OF WATER
- APPROXIMATE LIMITS OF EXISTING LEACHATE/SURFACE WATER POND LINER
- FINAL COVER LIMITS
- INTERMEDIATE COVER LIMITS
- CULVERT
- TRANSMISSION TOWER
- FINAL COVER DRAINAGE AREA
- INTERMEDIATE COVER DRAINAGE AREA
- ACTIVE DRAINAGE AREA

NOTES:

1. BASE MAP CREATED FROM AERIAL SURVEY BY KBM, FLOWN DECEMBER 1, 2014, AND GROUND SURVEY BY SCS ENGINEERS IN DECEMBER 2020, AND BY DRONE SURVEY BY AMES ON JANUARY 17, 2023.

N

200 0 200

SCALE: 1" = 200'

| | | | |
|---|---|---|---|
| PROJECT NO. | 25222260.00 | DRAWN BY: | RJG/KP/MJT |
| DRAWN: | 12/18/2017 | CHECKED BY: | PG |
| REVISED: | 01/25/2023 | APPROVED BY: | PG 01/31/23 |

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CLIENT

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

SITE

RUN-ON AND RUN-OFF CONTROL PLAN
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

RUN-ON AND RUN-OFF CONTROL PLAN

FIGURE 2

# Appendix A

# Storm Water Design Calculations

# Appendix A1

# 2000 Plan of Operations Update

# SURFACE WATER MANAGEMENT CALCULATIONS
# COLUMBIA DRY ASH DISPOSAL FACILITY

## PURPOSE:

The purpose of the surface water runoff calculations is to demonstrate that the surface water control features incorporated into the proposed design will collect and transfer surface water from the landfill in a controlled manner and will minimize erosion. The surface water runoff calculations were performed for the western half (Phase 1) of the landfill, which this 10-year Plan of Operation Update report addresses.

## SITE GEOMETRY:

The surface water runoff from Phase 1 of the landfill will be routed to the existing South Sedimentation Basin. Diversion berms, downslope channels, and perimeter ditches are incorporated into the design to route the surface water to the southwestern corner of the landfill, where it is then routed to the South Sedimentation Basin. The South Sedimentation Basin was constructed during construction of Module 1 North. The south sedimentation pond discharges to a wetland area to the south of the pond.

## METHODOLOGIES:

The following methods and procedures were used to demonstrate that the proposed surface water control features will collect and transfer surface water in controlled manner and minimize erosion potential:

Hydrograph Generation

Peak stormwater flows for the 25-year, 24-hour and 100-year, 24-hour storm events were calculated using the Quick TR-55 computer model developed by the National Resources Conservation Service (NRCS) (formerly known as the Soil Conservation Service (SCS)). The Quick TR-55 methods for computing hydrographs are based on the methodologies presented in the Urban Hydrology for Small Watersheds manual. The Quick TR-55 model is designed to simulate the surface runoff response of a watershed to a precipitation event. Input parameters for the model include precipitation depth for a particular storm event, contributing drainage areas, runoff curve numbers, and time of concentration.

The time of concentration calculations combine overland flow time (i.e., sheet flow), shallow concentrated flow time, and channel flow time. Curve numbers for a specified drainage area were also calculated using the methodologies and tables presented in TR-55 (see **Reference** section at the end of this appendix).

Diversion Berm, Downslope Channels, and Perimeter Ditch Sizing

These control structures are sized to channel the peak storm runoff to the sedimentation basin while maintaining low enough velocities to limit the erosion potential. The proposed design allows storm water which comes into contact with the final cover to be routed by diversion berms and downslope channels to the perimeter ditches, which will then transport the water to the south sedimentation basin.

Diversion berm, downslope channels, and perimeter ditch locations and details are shown on the Plan Sheets. A portion of the perimeter ditch along the western side of the landfill was constructed as part of the construction of Module 1 North.

In conjunction with the graphical peak discharge methods as presented in TR-55, the Flowmaster computer modeling program was used to assist in the design of these control structures. This program allows the user to input the channel geometry, the slope of the channel, an estimated Manning's "n" value for the channel, and the peak flow in the channel. The program then determines the peak flow depth and the peak velocity for the given geometry of the control feature.

The diversion berms, downslope channels, and perimeter ditches were sized by calculating the peak flow each structure would have to manage in a worst-case design scenario (i.e., surface water runoff from the largest area of landfill final cover during the 25-year, 24-hour storm event). The drainage structure was modeled using the Flowmaster computer model to verify channel depth and velocity in the structure.

Sedimentation Pond Sizing

The sedimentation pond sizing process involved determining the proper ratio of surface area to flowrate that would allow a 15 micron particle size to settle out during a design storm event.

A table presented in the Erosion and Sediment Control Handbook (Goldman et al., 1986) provides the surface area-to-discharge ratios required to achieve settlement of the desired particle sizes (see the **Reference** section of this appendix).

The Pond Pack 6.0 computer program was used in conjunction with accepted formulas and engineering calculations to size the sedimentation basins. Calculations were performed to determine the performance of the basins as follows:

1. The inflow hydrograph for the basin was calculated as part of the hydrograph computations. The regulations require that sediment basins be sized for a 25-year, 6-hour storm event. Sediment basin calculations for the Alliant Columbia Ash Disposal Facility were based on the basin's peak discharge during the 25-year, 24-hour storm which equals or exceeds the basin inflow for average rainfall intensity of the 25-year, 6-hour storm.

2. Outlet structures were designed to provide the necessary detention of peak stormwater runoff from the final cover for the 25-year, 24-hour storm event.

3. The inflow hydrograph was routed through the sedimentation pond using the Pond Pack 6.0 program to determine the basin's peak water elevation and discharge during the 25-year, 24-hour storm.

4. The emergency spillways for the sedimentation basins were sized for the 100-year, 24-hour storm event.

## ASSUMPTIONS:

Summarized below are some of the major assumptions and data used in the computations:

1. Due to the presence of a drainage layer in the proposed landfill final cover, the soil for the landfill area was modeled between a Type B and C soil to account for greater water infiltration

through the cover. The final cover was modeled as a grassland in good condition, which resulted in a runoff curve number of 67.5.

2. SCS Type II storm was selected according to SCS storm distribution maps for the United States.

3. A 2-year, 24-hour storm event in the vicinity of the facility equates to 2.7 inches according to figures provided in TR-55.

4. A 25-year, 24-hour storm event in the vicinity of the facility equates to 4.7 inches according to precipitation data provided in TR-55.

5. A 100-year, 24-hour storm event in the vicinity of the facility equates to 5.9 inches according to precipitation data provided in TR-55.

6. Grass-lined berms and channels were designed for a maximum velocity of 4 feet per second (fps).

7. A Manning's "n" value of 0.045 was used to model a grass-lined berm or channel, as provided by the parameters set in the Flowmaster model.

8. Depths of channels were designed to be a minimum of 1 foot, with a minimum freeboard of 0.5 foot. Depths of diversion berms were designated to be a minimum of 2 feet, with a minimum of 0.5 foot of freeboard.

9. A 15-micron particle was targeted to be settled out of the water column. The 15-micron particle is classified as a medium-fine silt by the AASHTO Soil Classification System.

## SURFACE WATER MANAGEMENT CALCULATIONS (CONTINUED)
## COLUMBIA DRY ASH DISPOSAL FACILITY

**RESULTS:**

Based on the results of the surface water runoff computations presented in this appendix, the proposed surface water control features will adequately handle the runoff from a 25-year, 24-hour storm event while minimizing erosion. The drainage features will be constructed as shown on the Plan Sheets.

All diversion berms and perimeter ditches will maintain greater than 0.5 foot of freeboard during the design storm event. The sedimentation basins will settle out particles 15 microns and larger in diameter and will dewater in no less than three days. The detailed calculations are included with this appendix.

I:\1370\Reports\surface water calcs writeup.wpd

# Time of Concentration Calculations

File.... I:\1370\Columbia.ppk
Title... Landfill runoff to south basin

Landfill Area (1/2)

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Landfill runoff to south basin
---

Segment #1: Tc: TR-55 Sheet
Description: final cover slope

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .050000 | ft/ft |

Avg.Velocity .17 ft/sec

Segment #1 Time: .0989 hrs
---

Segment #2: Tc: TR-55 Sheet
Description: final cover slope

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .250000 | ft/ft |

Avg.Velocity .32 ft/sec

Segment #2 Time: .0520 hrs
---

Segment #3: Tc: TR-55 Shallow
Description: diversion berm

| | | |
|---|---|---|
| Hydraulic Length | 1530.00 | ft |
| Slope | .020000 | ft/ft |

Unpaved

Avg.Velocity 2.28 ft/sec

Segment #3 Time: .1863 hrs
---

Type.... Tc Calcs
Name.... LF TO S BASIN

File.... I:\1370\Columbia.ppk
Title... Landfill runoff to south basin

Landfill Area (2/2)

Segment #4: Tc: TR-55 Channel
Description: perimeter ditch

| | | |
|---|---|---|
| Flow Area | 32.0000 | sq.ft |
| Wetted Perimeter | 22.60 | ft |
| Hydraulic Radius | 1.42 | ft |
| Slope | .006000 | ft/ft |
| Mannings n | .0300 | |
| Hydraulic Length | 320.00 | ft |
| Avg.Velocity | 4.85 | ft/sec |

Segment #4 Time: .0183 hrs

---

==========
Total Tc: .3555 hrs
==========

West peripheral area leading to west perimeter ditch (1/2)

Type.... Tc Calcs
Name.... PERIPH TO S BASI

File.... I:\1370\COLUMBIA.PPK
Title... Peripheral area to south basin (area outside of LF leading to basin)

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Peripheral area to south basin (area outside of LF leading to basin)

Segment #1: Tc: TR-55 Sheet
Description: flow into ditch

| | |
|---|---|
| Mannings n | .1900 |
| Hydraulic Length | 10.00 ft |
| 2yr, 24hr P | 2.7000 in |
| Slope | .330000 ft/ft |
| Avg.Velocity | .25 ft/sec |

Segment #1 Time: .0111 hrs

Segment #2: Tc: TR-55 Channel
Description: flow along perimeter ditch

| | |
|---|---|
| Flow Area | 22.0000 sq.ft |
| Wetted Perimeter | 17.60 ft |
| Hydraulic Radius | 1.25 ft |
| Slope | .006000 ft/ft |
| Mannings n | .0300 |
| Hydraulic Length | 800.00 ft |
| Avg.Velocity | 4.46 ft/sec |

Segment #2 Time: .0498 hrs

Segment #3: Tc: TR-55 Channel
Description: flow along perimeter ditch

| | |
|---|---|
| Flow Area | 57.0000 sq.ft |
| Wetted Perimeter | 29.00 ft |
| Hydraulic Radius | 1.97 ft |
| Slope | .006000 ft/ft |
| Mannings n | .0300 |
| Hydraulic Length | 1010.00 ft |
| Avg.Velocity | 6.04 ft/sec |

Segment #3 Time: .0465 hrs

Type.... Tc Calcs
Name.... PERIPH TO S BASI

West peripheral area leading to west perimeter ditch (2/2)

File.... I:\1370\COLUMBIA.PPK
Title... Peripheral area to south basin (area outside of LF leading to basin)

==========
Total Tc: .1073 hrs
==========

Type.... Tc Calcs
Name.... E PERIPHERAL

Northeast peripheral area leading to east perimeter ditch (1/1)

File.... I:\1370\COLUMBIA.PPK
Title... Eastern peripheral area (north of leachate basin) leading to east ditch

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Eastern peripheral area (north of leachate basin) leading to east ditch
---

Segment #1: Tc: TR-55 Sheet

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 40.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .425000 | ft/ft |
| Avg.Velocity | .37 | ft/sec |

Segment #1 Time: .0304 hrs

---

Segment #2: Tc: TR-55 Sheet

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 260.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .023000 | ft/ft |
| Avg.Velocity | .17 | ft/sec |

Segment #2 Time: .4362 hrs

---

Segment #3: Tc: TR-55 Shallow

| | | |
|---|---|---|
| Hydraulic Length | 520.00 | ft |
| Slope | .014000 | ft/ft |
| Unpaved | | |
| Avg.Velocity | 1.91 | ft/sec |

Segment #3 Time: .0757 hrs

---

==========
Total Tc: .5423 hrs
==========

S/N: H0M0L0862791 BT 2, Inc
Pond Pack Ver: 8-01-98 (61) Compute Time: 14:58:36 Date: 08-29-2000

Type.... Tc Calcs
Name.... BASIN PERIPHERAL

Southeast/South peripheral area leading to south perimeter ditch (1/2)

File.... I:\1370\COLUMBIA.PPK
Title... South peripheral area to south perimeter ditch

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

South peripheral area to south perimeter ditch
---

Segment #1: Tc: TR-55 Sheet

| | |
|---|---|
| Mannings n | .1900 |
| Hydraulic Length | 300.00 ft |
| 2yr, 24hr P | 2.7000 in |
| Slope | .010000 ft/ft |
| Avg.Velocity | .12 ft/sec |

Segment #1 Time: .6825 hrs

---

Segment #2: Tc: TR-55 Shallow

| | |
|---|---|
| Hydraulic Length | 110.00 ft |
| Slope | .096000 ft/ft |
| Unpaved | |
| Avg.Velocity | 5.00 ft/sec |

Segment #2 Time: .0061 hrs

---

Segment #3: Tc: TR-55 Shallow

| | |
|---|---|
| Hydraulic Length | 550.00 ft |
| Slope | .022000 ft/ft |
| Unpaved | |
| Avg.Velocity | 2.39 ft/sec |

Segment #3 Time: .0638 hrs

---

Type.... Tc Calcs
Name.... BASIN PERIPHERAL

Southeast/South peripheral area leading to south perimeter ditch (2|2)

File.... I:\1370\COLUMBIA.PPK
Title... South peripheral area to south perimeter ditch

Segment #4: Tc: TR-55 Channel
Description: flow along south perimeter ditch

| | | |
|---|---|---|
| Flow Area | 100.0000 | sq.ft |
| Wetted Perimeter | 32.40 | ft |
| Hydraulic Radius | 3.09 | ft |
| Slope | .012000 | ft/ft |
| Mannings n | .0300 | |
| Hydraulic Length | 1030.00 | ft |
| Avg.Velocity | 11.53 | ft/sec |

Segment #4 Time: .0248 hrs

---

Total Tc: .7773 hrs

Equations used by PondPack to calculate Tc (1/2)

---

Tc Equations used...

---

==== SCS TR-55 Sheet Flow ==========

Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where: Tc = Time of concentration, hrs
n = Mannings n
Lf = Flow length, ft
P = 2yr, 24hr Rain depth, inches
Sf = Slope, ft/ft

==== SCS TR-55 Shallow Concentrated Flow ==========

Unpaved surface:
V = 16.1345 * (Sf**0.5)

Paved surface:
V = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where: V = Velocity, ft/sec
Sf = Slope, ft/ft
Tc = Time of concentration, hrs
Lf = Flow length, ft

Equations used by Pond Pack to calculate Tc (2/2)



==== SCS Channel Flow ==========

R = Aq / Wp
V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where: R = Hydraulic radius
Aq = Flow area, sq.ft.
Wp = Wetted perimeter, ft
V = Velocity, ft/sec
Sf = Slope, ft/ft
n = Mannings n
Tc = Time of concentration, hrs
Lf = Flow length, ft

# Hydrograph Generation

Type.... TR-55 Tabular Hyd.Input Data
Name.... TO SOUTH BASIN  Tag:  25

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir  = I:\1370\
HYG file = S BASIN.HYG  south basin 25

To South Basin
25-yr, 24-hr Storm
(1/2)

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

Total Area = 63.400 acres or .099063 sq.mi.
Peak Discharge = 69 cfs
WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| Landfill area | 29.600 | 67.5 | .4000 | .0000 | 4.70 | 1.63 | I.20 | .20 |
| W peripheral | 4.600 | 67.5 | .1000 | .0000 | 4.70 | 1.63 | I.20 | .20 |
| Basin area | 1.800 | 98.0 | .1000 | .0000 | 4.70 | 4.46 | I.01 | .10 |
| NE peripheral | 13.700 | 67.5 | .5000 | .0000 | 4.70 | 1.63 | I.20 | .20 |
| SE/S periphera | 13.700 | 67.5 | .7500 | .0000 | 4.70 | 1.63 | I.20 | .20 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | * Tt (hrs) | Rounded Values Tc (hrs) | * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| andfill area | .3600 | .0000 | .40 | .00 | Yes | -- |
| peripheral | .1000 | .0000 | ** | ** | Yes | -- |
| Basin area | .1000 | .0000 | ** | ** | No | Computed Ia/p < .1 |
| E peripheral | .5400 | .0000 | .50 | .00 | Yes | -- |
| E/S periphera | .7800 | .0000 | .75 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.
* Tc & Tt are available in the hydrograph tables.

Type.... TR-55 Tabular Hyd.Peaks
Name.... TO SOUTH BASIN Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir = I:\1370\
HYG file = S BASIN.HYG south basin 25

To South Basin
25-yr, 24-hr Storm
(2/2)

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| Landfill area | 40 | 12.3 |
| W peripheral | 11 | 12.1 |
| Basin area | 13 | 12.1 |
| NE peripheral | 17 | 12.4 |
| SE/S periphera | 13 | 12.6 |
| Composite Watershed | 69 | 12.4 |

To South Basin
100-yr, 24-hr

Type.... TR-55 Tabular Hyd.Input Data
Name.... TO SOUTH BASIN  Tag:  100

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir  = I:\1370\
HYG file = S BASIN.HYG  south basin 100

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
100yr, 24hr Rainfall Depth = 5.90 in

Total Area = 63.400 acres or .099063 sq.mi.
Peak Discharge = 110 cfs
WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| Landfill area | 29.600 | 67.5 | .4000 | .0000 | 5.90 | 2.50 | I.16 | .16 |
| W peripheral | 4.600 | 67.5 | .1000 | .0000 | 5.90 | 2.50 | I.16 | .16 |
| Basin area | 1.800 | 98.0 | .1000 | .0000 | 5.90 | 5.66 | I.01 | .10 |
| E peripheral | 13.700 | 67.5 | .5000 | .0000 | 5.90 | 2.50 | I.16 | .16 |
| SE/S periphera | 13.700 | 67.5 | .7500 | .0000 | 5.90 | 2.50 | I.16 | .16 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | * Tt (hrs) | Rounded Values Tc (hrs) | * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| andfill area | .3600 | .0000 | .40 | .00 | Yes | -- |
| W peripheral | .1000 | .0000 | ** | ** | Yes | -- |
| Basin area | .1000 | .0000 | ** | ** | No | Computed Ia/p < .1 |
| peripheral | .5400 | .0000 | .50 | .00 | Yes | -- |
| E/S periphera | .7800 | .0000 | .75 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.
* Tc & Tt are available in the hydrograph tables.

File.... I:\1370\COLUMBIA.PPK
Title... Runoff to south basin
HYG Dir = I:\1370\
HYG file = S BASIN.HYG south basin 100

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
100yr, 24hr Rainfall Depth = 5.90 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| Landfill area | 65 | 12.3 |
| W peripheral | 18 | 12.1 |
| Basin area | 16 | 12.1 |
| NE peripheral | 27 | 12.4 |
| SE/S periphera | 21 | 12.6 |
| Composite Watershed | 110 | 12.4 |

# Diversion Berm, Downslope Swale, and Perimeter Ditch Sizing Calculations

Worst-case diversion Berm C1



Type.... Tc Calcs
Name.... WORSTCASE DIV BE

File.... I:\1370\COLUMBIA.PPK
Title... Tc for worst case diversion berm sizing calcs

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Tc for worst case diversion berm sizing calcs
---

Segment #1: Tc: TR-55 Sheet
Description: final cover slope - 25%

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 95.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .250000 | ft/ft |

Avg.Velocity .35 ft/sec

Segment #1 Time: .0751 hrs

---

Segment #2: Tc: TR-55 Shallow
Description: diversion berm

| | | |
|---|---|---|
| Hydraulic Length | 2090.00 | ft |
| Slope | .020000 | ft/ft |

Unpaved

Avg.Velocity 2.28 ft/sec

Segment #2 Time: .2544 hrs

---

==========
Total Tc: .3295 hrs
==========

Worst-case diversion berm



File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case diversion berm sizing calcs
HYG Dir  = I:\1370\
HYG file = NONE STORED  WORSTCASE DIV BE 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

Total Area = 4.600 acres or .007187 sq.mi.
Peak Discharge = 7 cfs

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| east side ph 1 | 4.600 | 67.5 | .3000 | .0000 | 4.70 | 1.63 | I.20 | .20 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | Input Values * Tt (hrs) | Rounded Values Tc (hrs) | Rounded Values * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| east side ph 1 | .3300 | .0000 | .30 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.

Worst-case diversion berm



Type.... TR-55 Tabular Hyd.Peaks
Name.... WORSTCASE DIV BE  Tag:  25

File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case diversion berm sizing calcs
HYG Dir  = I:\1370\
HYG file = NONE STORED  WORSTCASE DIV BE 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| east side ph 1 | 7 | 12.2 |
| Composite Watershed | 7 | 12.2 |

# Worksheet
## Worksheet for Triangular Channel

| Project Description | |
|---|---|
| Worksheet | Triangular Channe |
| Flow Element | Triangular Channe |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case diversion berm

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 020000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Discharge | 7.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.75 | ft |
| Flow Area | 2.0 | ft² |
| Wetted Perim | 5.47 | ft |
| Top Width | 5.25 | ft |
| Critical Depth | 0.76 | ft |
| Critical Slope | 0.019122 | ft/ft |
| Velocity | 3.55 | ft/s |
| Velocity Head | 0.20 | ft |
| Specific Energ | 0.95 | ft |
| Froude Numb | 1.02 | |
| Flow Type | Supercritical | |

Worst-case downslope channel



Type.... Tc Calcs
Name.... WORST CASE FLUME

File.... I:\1370\COLUMBIA.PPK
Title... Tc for worst case downslope flume sizing calcs

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Tc for worst case downslope flume sizing calcs
---

Segment #1: Tc: TR-55 Sheet
Description: final cover slope - 5%

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .050000 | ft/ft |

Avg.Velocity .17 ft/sec

Segment #1 Time: .0989 hrs
---

Segment #2: Tc: TR-55 Sheet
Description: final cover slope - 25%

| | | |
|---|---|---|
| Mannings n | .1900 | |
| Hydraulic Length | 60.00 | ft |
| 2yr, 24hr P | 2.7000 | in |
| Slope | .250000 | ft/ft |

Avg.Velocity .32 ft/sec

Segment #2 Time: .0520 hrs
---

Segment #3: Tc: TR-55 Shallow
Description: diversion berm

| | | |
|---|---|---|
| Hydraulic Length | 1790.00 | ft |
| Slope | .020000 | ft/ft |
| Unpaved | | |

Avg.Velocity 2.28 ft/sec

Segment #3 Time: .2179 hrs
---

==========
Total Tc: .3688 hrs
==========

Worst-case downslope channel



File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case downslope flume sizing calcs
HYG Dir  = I:\1370\
HYG file = NONE STORED  WORST CASE FLUME 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

Total Area = 7.500 acres or .011719 sq.mi.
Peak Discharge = 10 cfs

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| To SE flume | 7.500 | 67.5 | .4000 | .0000 | 4.70 | 1.63 | I.20 | .20 |

* Travel time from subarea outfall to composite watershed outfall point.
I -- Subarea where user specified interpolation between Ia/p tables.

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hrs) | Input Values * Tt (hrs) | Rounded Values Tc (hrs) | Rounded Values * Tt (hrs) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| To SE flume | .3700 | .0000 | .40 | .00 | Yes | -- |

* Travel time from subarea outfall to composite watershed outfall point.

Worst-case downslope channel



File.... I:\1370\COLUMBIA.PPK
Title... Hydrograph for worst-case downslope flume sizing calcs
HYG Dir = I:\1370\
HYG file = NONE STORED WORST CASE FLUME 25

TR-55 TABULAR HYDROGRAPH METHOD
TYPE II Distribution
25yr, 24hr Rainfall Depth = 4.70 in

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| To SE flume | 10 | 12.3 |
| Composite Watershed | 10 | 12.3 |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | downslope flume |
| Flow Element | Trapezoidal Cha |
| Method | Manning's Formı |
| Solve For | Channel Depth |

Worst-case downslope channel (SW channel)

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.040 | |
| Slope | 200000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 10.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.18 | ft |
| Flow Area | 1.9 | ft² |
| Wetted Perim | 11.16 | ft |
| Top Width | 11.10 | ft |
| Critical Depth | 0.30 | ft |
| Critical Slope | 0.035988 | ft/ft |
| Velocity | 5.17 | ft/s |
| Velocity Head | 0.41 | ft |
| Specific Energ | 0.60 | ft |
| Froude Numb | 2.18 | |
| Flow Type | Supercritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | worst-case west perimeter |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case west perimeter ditch

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 006000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 5.00 | ft |
| Discharge | 31.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.13 | ft |
| Flow Area | 9.5 | ft² |
| Wetted Perim | 12.17 | ft |
| Top Width | 11.80 | ft |
| Critical Depth | 0.88 | ft |
| Critical Slope | 0.015659 | ft/ft |
| Velocity | 3.26 | ft/s |
| Velocity Head | 0.16 | ft |
| Specific Energ | 1.30 | ft |
| Froude Numb | 0.64 | |
| Flow Type | Subcritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | worst-case east perimeter |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case east perimeter ditch

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 57.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.23 | ft |
| Flow Area | 16.9 | ft² |
| Wetted Perim | 17.79 | ft |
| Top Width | 17.39 | ft |
| Critical Depth | 0.91 | ft |
| Critical Slope | 0.014803 | ft/ft |
| Velocity | 3.38 | ft/s |
| Velocity Head | 0.18 | ft |
| Specific Energ | 1.41 | ft |
| Froude Numb | 0.61 | |
| Flow Type | Subcritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | worst case south perimeter |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Worst-case south perimeter ditch

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 012000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 70.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.08 | ft |
| Flow Area | 14.4 | ft² |
| Wetted Perim | 16.85 | ft |
| Top Width | 16.50 | ft |
| Critical Depth | 1.03 | ft |
| Critical Slope | 0.014316 | ft/ft |
| Velocity | 4.88 | ft/s |
| Velocity Head | 0.37 | ft |
| Specific Energ | 1.45 | ft |
| Froude Numb | 0.92 | |
| Flow Type | Subcritical | |


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# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | ditch from SW corner of LF to S |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

Ditch from SW corner of Landfill to South Basin

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 006000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 15.00 | ft |
| Discharge | 69.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.07 | ft |
| Flow Area | 19.4 | ft² |
| Wetted Perim | 21.74 | ft |
| Top Width | 21.40 | ft |
| Critical Depth | 0.82 | ft |
| Critical Slope | 0.014896 | ft/ft |
| Velocity | 3.56 | ft/s |
| Velocity Head | 0.20 | ft |
| Specific Energ | 1.26 | ft |
| Froude Numb | 0.66 | |
| Flow Type | Subcritical | |


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# Basin Volume Computations

## POND VOLUME CALCULATIONS

Planimeter scale: 1.00 ft/in

| Elevation (ft) | Planimeter (sq.in) | Area (acres) | A1+A2+sqr(A1*A2) (acres) | Volume (ac-ft) | Volume Sum (ac-ft) |
|---|---|---|---|---|---|
| 789.00 | 62411.000 | 1.4328 | .0000 | .000 | .000 |
| 790.00 | 68355.000 | 1.5692 | 4.5014 | 1.500 | 1.500 |
| 792.00 | 74865.000 | 1.7187 | 4.9301 | 3.287 | 4.787 |
| 794.00 | 82150.000 | 1.8859 | 5.4049 | 3.603 | 8.390 |

## POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

# Outlet Structure Data

Type.... Outlet Input Data
Name.... SOUTH BASIN2

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

REQUESTED POND WS ELEVATIONS:

Min. Elev.= 789.50 ft
Increment = 1.00 ft
Max. Elev.= 794.00 ft

**********
OUTLET CONNECTIVITY
**********

---> Forward Flow Only (UpStream to DnStream)
<--- Reverse Flow Only (DnStream to UpStream)
<---> Forward and Reverse Both Allowed

| Structure | No. | | Outfall | E1, ft | E2, ft |
|---|---|---|---|---|---|
| Weir-Rectangular | e1 | ---> | TW | 793.000 | 794.000 |
| Stand Pipe | s1 | ---> | c1 | 791.000 | 794.000 |
| Orifice-Circular | o1 | ---> | c1 | 789.500 | 794.000 |
| Culvert-Circular | c1 | ---> | TW | 789.000 | 794.000 |

TW SETUP, DS Channel

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

OUTLET STRUCTURE INPUT DATA

| | | |
|---|---|---|
| Structure ID | = e1 | |
| Structure Type | = Weir-Rectangular | |
| # of Openings | = 1 | |
| Crest Elev. | = 793.00 | ft |
| Weir Length | = 10.00 | ft |
| Weir Coeff. | = 3.300000 | |

Weir TW effects (Use adjustment equation)

| | | |
|---|---|---|
| Structure ID | = s1 | |
| Structure Type | = Stand Pipe | |
| # of Openings | = 1 | |
| Invert Elev. | = 791.00 | ft |
| Diameter | = 2.5000 | ft |
| Orifice Area | = 4.9087 | sq.ft |
| Orifice Coeff. | = .600 | |
| Weir Length | = 7.85 | ft |
| Weir Coeff. | = 3.300 | |
| K, Submerged | = .000 | |
| K, Reverse | = 1.000 | |
| Kb,Barrel | = .000000 | (per ft of full flow) |
| Barrel Length | = .00 | ft |
| Mannings n | = .0000 | |

| | | |
|---|---|---|
| Structure ID | = o1 | |
| Structure Type | = Orifice-Circular | |
| # of Openings | = 72 | |
| Invert Elev. | = 789.50 | ft |
| Diameter | = .0400 | ft |
| Orifice Coeff. | = .600 | |

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

OUTLET STRUCTURE INPUT DATA

Structure ID = c1
Structure Type = Culvert-Circular
---

| | | | |
|---|---|---|---|
| No. Barrels | = | 1 | |
| Barrel Diameter | = | 1.2500 | ft |
| Upstream Invert | = | 789.00 | ft |
| Dnstream Invert | = | 788.50 | ft |
| Horiz. Length | = | 50.00 | ft |
| Barrel Length | = | 50.00 | ft |
| Barrel Slope | = | .01000 | ft/ft |

OUTLET CONTROL DATA...

| | | | |
|---|---|---|---|
| Mannings n | = | .0130 | |
| Ke | = | .9000 | (forward entrance loss) |
| Kb | = | .023225 | (per ft of full flow) |
| Kr | = | .9000 | (reverse entrance loss) |
| HW Convergence | = | .001 | +/- ft |

INLET CONTROL DATA...

| | | |
|---|---|---|
| Equation form | = | 1 |
| Inlet Control K | = | .0340 |
| Inlet Control M | = | 1.5000 |
| Inlet Control c | = | .05530 |
| Inlet Control Y | = | .5400 |
| T1 ratio (HW/D) | = | 1.258 |
| T2 ratio (HW/D) | = | 1.420 |
| Slope Factor | = | -.500 |

Use unsubmerged inlet control Form 1 equ. below T1 elev.
Use submerged inlet control Form 1 equ. above T2 elev.

In transition zone between unsubmerged and submerged inlet control, interpolate between flows at T1 & T2...
At T1 Elev = 790.57 ft ---> Flow = 4.80 cfs
At T2 Elev = 790.77 ft ---> Flow = 5.49 cfs

Structure ID = TW
Structure Type = TW SETUP, DS Channel
---
FREE OUTFALL CONDITIONS SPECIFIED

CONVERGENCE TOLERANCES...

| | | |
|---|---|---|
| Maximum Iterations | = | 30 |
| Min. TW tolerance | = | .01 ft |
| Max. TW tolerance | = | .01 ft |
| Min. HW tolerance | = | .01 ft |
| Max. HW tolerance | = | .01 ft |

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = e1 (Weir-Rectangular)
---
Upstream ID = (Pond Water Surface)
DNstream ID = TW (Pond Outfall)

| WS Elev,Device Q | | Tail Water | | Notes |
|---|---|---|---|---|
| WS Elev. ft | Q cfs | TW Elev Converge ft | +/-ft | Computation Messages |
| 789.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 790.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 791.00 | .00 | Free Outfall | | WS below an invert; no flow. |
| 791.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 792.50 | .00 | Free Outfall | | WS below an invert; no flow. |
| 793.00 | .00 | Free Outfall | | WS below an invert; no flow. |
| 793.50 | 11.67 | Free Outfall | | H=.50; Htw=.00; Qfree=11.67; |
| 794.00 | 33.00 | Free Outfall | | H=1.00; Htw=.00; Qfree=33.00; |

Type.... Individual Outlet Curves
Name.... SOUTH BASIN2

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = s1 (Stand Pipe)
---
Upstream ID = (Pond Water Surface)
DNstream ID = c1 (Culvert-Circular)

| Pond WS. Elev. ft | Device Q cfs | (into) HW HGL ft | Converge DS HGL ft | Next DS HGL ft | DS HGL Error +/-ft | Q SUM Error +/-cfs | DS Chan. TW ft | TW Error +/-ft |
|---|---|---|---|---|---|---|---|---|
| 789.50 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 790.50 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 791.00 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 791.50 | 7.06 | 791.50 | 791.50 | 791.50 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 792.50 | 8.78 | 792.50 | 792.50 | 792.50 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 793.00 | 9.52 | 793.00 | 793.00 | 793.00 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 793.50 | 10.21 | 793.50 | 793.50 | 793.50 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |
| 794.00 | 10.86 | 794.00 | 794.00 | 794.00 | .000 | .000 | Free Outfall | |
| | | DS HGL+Loss > crest: Flow set to Downstream outlet. | | | | | | |

File.... I:\1370\COLUMBIA.PPK
Title... south basin outlet structure

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = o1 (Orifice-Circular)
---
Upstream ID = (Pond Water Surface)
DNstream ID = c1 (Culvert-Circular)

NUMBER OF OPENINGS = 72
EACH FLOW = SUM OF OPENINGS x FLOW FOR ONE OPENING

| Pond WS. Elev. ft | Device Q cfs | (into) HW HGL ft | Converge DS HGL ft | Next DS HGL ft | DS HGL Error +/-ft | Q SUM Error +/-cfs | DS Chan. TW ft | TW Error +/-ft |
|---|---|---|---|---|---|---|---|---|
| 789.50 | .00 | ... | ... | ... | ... | ... | Free Outfall | |
| | | WS below an invert; no flow. | | | | | | |
| 790.50 | .43 | 790.50 | Free | 789.42 | .000 | .000 | Free Outfall | |
| | | H =.98 | | | | | | |
| 791.00 | .53 | 791.00 | Free | 789.47 | .000 | .000 | Free Outfall | |
| | | H =1.48 | | | | | | |
| 791.50 | .00 | 791.50 | 791.50 | 791.50 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 792.50 | .00 | 792.50 | 792.50 | 792.50 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 793.00 | .00 | 793.00 | 793.00 | 793.00 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 793.50 | .00 | 793.50 | 793.50 | 793.50 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |
| 794.00 | .00 | 794.00 | 794.00 | 794.00 | .000 | .000 | Free Outfall | |
| | | | | Full riser flow. Q=0 this opening. | | | | |

RATING TABLE FOR ONE OUTLET TYPE

Structure ID = c1 (Culvert-Circular)
---
Mannings open channel maximum capacity: 6.95 cfs
UPstream ID's= s1, o1
DNstream ID = TW (Pond Outfall)

| Pond WS. Elev. ft | Device Q cfs | (into) HW HGL ft | Converge DS HGL ft | Next DS HGL ft | DS HGL Error +/-ft | Q SUM Error +/-cfs | DS Chan. TW ft | TW Error +/-ft |
|---|---|---|---|---|---|---|---|---|
| 789.50 | .00 | 789.00 | Free | Free | .000 | .000 | Free Outfall | |
| 790.50 | .43 | 789.42 | Free | Free | .000 | .000 | Free Outfall | |
| | | CRIT.DEPTH CONTROL | | Vh= .089ft | Dcr= .255ft | | CRIT.DEPTH | |
| 791.00 | .53 | 789.47 | Free | Free | .000 | .000 | Free Outfall | |
| | | CRIT.DEPTH CONTROL | | Vh= .100ft | Dcr= .283ft | | CRIT.DEPTH | |
| 791.50 | 7.06 | 791.50 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =2.50 | | | |
| 792.50 | 8.78 | 792.50 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =3.50 | | | |
| 793.00 | 9.52 | 793.00 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =4.00 | | | |
| 793.50 | 10.21 | 793.50 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =4.50 | | | |
| 794.00 | 10.86 | 794.00 | Free | Free | .000 | .000 | Free Outfall | |
| | | INLET CONTROL... | | Submerged: | HW =5.00 | | | |

# Pond Routing Summary

South Basin
25-yr, 24-hr Storm

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

LEVEL POOL ROUTING SUMMARY

HYG Dir = I:\1370\
Inflow HYG file = SBASIN.HYG - south basin 25
Outflow HYG file = NONE STORED - SOUTH BASIN2 OUT 25

Pond Node Data = south basin
Pond Volume Data = south basin
Pond Outlet Data = south basin2

No Infiltration

INITIAL CONDITIONS

| | | |
|---|---|---|
| Starting WS Elev | = | 789.00 ft |
| Starting Volume | = | .000 ac-ft |
| Starting Outflow | = | .00 cfs |
| Starting Infiltr. | = | .00 cfs |
| Starting Total Qout | = | .00 cfs |
| Time Increment | = | .1000 hrs |

INFLOW/OUTFLOW HYDROGRAPH SUMMARY

| | | | | |
|---|---|---|---|---|
| Peak Inflow | = | 69.00 cfs | at | 12.4000 hrs |
| Peak Outflow | = | 7.94 cfs | at | 14.1000 hrs ← Peak discharge from basin |
| Peak Elevation | = | 792.01 ft ← Peak water elevation | | |
| Peak Storage | = | 4.805 ac-ft | | |

MASS BALANCE (ac-ft)

| | | |
|---|---|---|
| + Initial Vol | = | .000 |
| + HYG Vol IN | = | 8.872 |
| - Infiltration | = | .000 |
| - HYG Vol OUT | = | 8.101 |
| - Retained Vol | = | .769 |
| Unrouted Vol | = | -.001 ac-ft (.016% of Inflow Volume) |

WARNING: Inflow hydrograph truncated on left side.
WARNING: Outflow hydrograph truncated on right side.

BT² inc.

Sheet No.
Calc. No.
Rev. No.

Job No. 1370 Job Columbia Plan of Op Update By BLP Date 8/23/00

Client Alliant Subject Basin Calcs Chk'd. MRH Date 8-31-00

# Basin Particle Size Settling Capability

Basin required to settle out ≥ 15 micron (0.015 mm) particle for a 25-yr, 24-hr storm event.

From calculations, peak discharge from basin is 7.94 cfs and peak water elevation is 792.0 ft. The corresponding surface area of the basin at elevation 792.0 is 74,865 sf (see Basin Volume Computations Sectio

The surface area to discharge ratio is therefore

$$\frac{74,865 \text{ sf}}{7.94 \text{ cfs}} = 9,429 \text{ sf/cfs}$$

From the Erosion and Sediment Control Handbook, the required surface area to discharge ratio to settle out a 15 micron particle is 3,125 sf/cfs.

9,429 cfs/sf > 3,125 sf/cfs, therefore the basin is adequately sized to settle out a 15 micron particle

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (1/7)

POND ROUTED TOTAL OUTFLOW HYG...
HYG file =
HYG ID = SOUTH BASIN2 OUT
HYG Tag = 25

| | |
|---|---|
| Peak Discharge = | 7.94 cfs |
| Time to Peak = | 14.1000 hrs |
| HYG Volume = | 8.101 ac-ft |

WARNING: Hydrograph truncated on right side.

Basin dewatering time -
Begin discharge: 12.2
End discharge: 113.8 sa
Total discharge time: 101.6
or 4.2 days, whi
is greater than the
required minimum
of 3 days

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 11.0000 | .00 | .00 | .00 | .00 | .00 |
| 11.5000 | .00 | .00 | .00 | .00 | .00 |
| 12.0000 | .00 | .00 | .10 (Begin discharge) | .24 | .39 |
| 12.5000 | .48 | .92 | 3.82 | 6.00 | 7.14 |
| 13.0000 | 7.31 | 7.44 | 7.55 | 7.64 | 7.72 |
| 13.5000 | 7.78 | 7.83 | 7.87 | 7.90 | 7.92 |
| 14.0000 | 7.93 | 7.94 | 7.94 | 7.94 | 7.93 |
| 14.5000 | 7.92 | 7.91 | 7.90 | 7.89 | 7.87 |
| 15.0000 | 7.84 | 7.82 | 7.80 | 7.77 | 7.75 |
| 15.5000 | 7.73 | 7.71 | 7.68 | 7.66 | 7.63 |
| 16.0000 | 7.60 | 7.57 | 7.54 | 7.51 | 7.48 |
| 16.5000 | 7.45 | 7.42 | 7.40 | 7.37 | 7.34 |
| 17.0000 | 7.31 | 7.28 | 7.26 | 7.23 | 7.20 |
| 17.5000 | 7.18 | 7.15 | 7.13 | 7.10 | 7.08 |
| 18.0000 | 6.96 | 6.77 | 6.60 | 6.44 | 6.28 |
| 18.5000 | 6.14 | 6.00 | 5.88 | 5.76 | 5.65 |
| 19.0000 | 5.55 | 5.45 | 5.36 | 5.27 | 5.19 |
| 19.5000 | 5.12 | 5.01 | 4.89 | 4.77 | 4.66 |
| 20.0000 | 4.55 | 4.46 | 4.36 | 4.28 | 4.20 |
| 20.5000 | 4.12 | 4.05 | 3.99 | 3.92 | 3.87 |
| 21.0000 | 3.81 | 3.76 | 3.71 | 3.67 | 3.63 |
| 21.5000 | 3.59 | 3.55 | 3.51 | 3.48 | 3.45 |
| 22.0000 | 3.42 | 3.40 | 3.37 | 3.35 | 3.33 |
| 22.5000 | 3.31 | 3.29 | 3.24 | 3.16 | 3.09 |
| 23.0000 | 3.02 | 2.95 | 2.89 | 2.84 | 2.78 |
| 23.5000 | 2.74 | 2.69 | 2.65 | 2.61 | 2.57 |
| 24.0000 | 2.53 | 2.47 | 2.37 | 2.29 | 2.21 |
| 24.5000 | 2.13 | 2.06 | 1.99 | 1.93 | 1.87 |
| 25.0000 | 1.82 | 1.77 | 1.72 | 1.67 | 1.60 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (2/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 25.5000 | 1.50 | 1.40 | 1.32 | 1.23 | 1.15 |
| 26.0000 | 1.08 | 1.01 | .95 | .89 | .83 |
| 26.5000 | .78 | .73 | .69 | .64 | .60 |
| 27.0000 | .56 | .53 | .53 | .53 | .53 |
| 27.5000 | .53 | .53 | .53 | .53 | .53 |
| 28.0000 | .53 | .52 | .52 | .52 | .52 |
| 28.5000 | .52 | .52 | .52 | .52 | .52 |
| 29.0000 | .52 | .52 | .52 | .52 | .52 |
| 29.5000 | .52 | .52 | .52 | .52 | .52 |
| 30.0000 | .51 | .51 | .51 | .51 | .51 |
| 30.5000 | .51 | .51 | .51 | .51 | .51 |
| 31.0000 | .51 | .51 | .51 | .51 | .51 |
| 31.5000 | .51 | .51 | .51 | .51 | .50 |
| 32.0000 | .50 | .50 | .50 | .50 | .50 |
| 32.5000 | .50 | .50 | .50 | .50 | .50 |
| 33.0000 | .50 | .50 | .50 | .50 | .50 |
| 33.5000 | .50 | .50 | .50 | .50 | .49 |
| 34.0000 | .49 | .49 | .49 | .49 | .49 |
| 34.5000 | .49 | .49 | .49 | .49 | .49 |
| 35.0000 | .49 | .49 | .49 | .49 | .49 |
| 35.5000 | .49 | .49 | .49 | .49 | .48 |
| 36.0000 | .48 | .48 | .48 | .48 | .48 |
| 36.5000 | .48 | .48 | .48 | .48 | .48 |
| 37.0000 | .48 | .48 | .48 | .48 | .48 |
| 37.5000 | .48 | .48 | .48 | .48 | .48 |
| 38.0000 | .47 | .47 | .47 | .47 | .47 |
| 38.5000 | .47 | .47 | .47 | .47 | .47 |
| 39.0000 | .47 | .47 | .47 | .47 | .47 |
| 39.5000 | .47 | .47 | .47 | .47 | .47 |
| 40.0000 | .47 | .46 | .46 | .46 | .46 |
| 40.5000 | .46 | .46 | .46 | .46 | .46 |
| 41.0000 | .46 | .46 | .46 | .46 | .46 |
| 41.5000 | .46 | .46 | .46 | .46 | .46 |
| 42.0000 | .46 | .46 | .46 | .45 | .45 |
| 42.5000 | .45 | .45 | .45 | .45 | .45 |
| 43.0000 | .45 | .45 | .45 | .45 | .45 |
| 43.5000 | .45 | .45 | .45 | .45 | .45 |
| 44.0000 | .45 | .45 | .45 | .45 | .45 |
| 44.5000 | .44 | .44 | .44 | .44 | .44 |
| 45.0000 | .44 | .44 | .44 | .44 | .44 |
| 45.5000 | .44 | .44 | .44 | .44 | .44 |
| 46.0000 | .44 | .44 | .44 | .44 | .44 |
| 46.5000 | .44 | .44 | .44 | .43 | .43 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (3/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 47.0000 | .43 | .43 | .43 | .43 | .43 |
| 47.5000 | .43 | .43 | .43 | .43 | .43 |
| 48.0000 | .43 | .43 | .43 | .42 | .42 |
| 48.5000 | .42 | .42 | .42 | .42 | .42 |
| 49.0000 | .42 | .42 | .42 | .41 | .41 |
| 49.5000 | .41 | .41 | .41 | .41 | .41 |
| 50.0000 | .41 | .41 | .41 | .41 | .40 |
| 50.5000 | .40 | .40 | .40 | .40 | .40 |
| 51.0000 | .40 | .40 | .40 | .40 | .40 |
| 51.5000 | .39 | .39 | .39 | .39 | .39 |
| 52.0000 | .39 | .39 | .39 | .39 | .39 |
| 52.5000 | .39 | .38 | .38 | .38 | .38 |
| 53.0000 | .38 | .38 | .38 | .38 | .38 |
| 53.5000 | .38 | .38 | .38 | .37 | .37 |
| 54.0000 | .37 | .37 | .37 | .37 | .37 |
| 54.5000 | .37 | .37 | .37 | .37 | .37 |
| 55.0000 | .36 | .36 | .36 | .36 | .36 |
| 55.5000 | .36 | .36 | .36 | .36 | .36 |
| 56.0000 | .36 | .36 | .35 | .35 | .35 |
| 56.5000 | .35 | .35 | .35 | .35 | .35 |
| 57.0000 | .35 | .35 | .35 | .35 | .34 |
| 57.5000 | .34 | .34 | .34 | .34 | .34 |
| 58.0000 | .34 | .34 | .34 | .34 | .34 |
| 58.5000 | .34 | .34 | .33 | .33 | .33 |
| 59.0000 | .33 | .33 | .33 | .33 | .33 |
| 59.5000 | .33 | .33 | .33 | .33 | .33 |
| 60.0000 | .33 | .32 | .32 | .32 | .32 |
| 60.5000 | .32 | .32 | .32 | .32 | .32 |
| 61.0000 | .32 | .32 | .32 | .32 | .31 |
| 61.5000 | .31 | .31 | .31 | .31 | .31 |
| 62.0000 | .31 | .31 | .31 | .31 | .31 |
| 62.5000 | .31 | .31 | .31 | .30 | .30 |
| 63.0000 | .30 | .30 | .30 | .30 | .30 |
| 63.5000 | .30 | .30 | .30 | .30 | .30 |
| 64.0000 | .30 | .30 | .30 | .29 | .29 |
| 64.5000 | .29 | .29 | .29 | .29 | .29 |
| 65.0000 | .29 | .29 | .29 | .29 | .29 |
| 65.5000 | .29 | .29 | .29 | .28 | .28 |
| 66.0000 | .28 | .28 | .28 | .28 | .28 |
| 66.5000 | .28 | .28 | .28 | .28 | .28 |
| 67.0000 | .28 | .28 | .28 | .28 | .27 |
| 67.5000 | .27 | .27 | .27 | .27 | .27 |
| 68.0000 | .27 | .27 | .27 | .27 | .27 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (4/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 68.5000 | .27 | .27 | .27 | .27 | .27 |
| 69.0000 | .26 | .26 | .26 | .26 | .26 |
| 69.5000 | .26 | .26 | .26 | .26 | .26 |
| 70.0000 | .26 | .26 | .26 | .26 | .26 |
| 70.5000 | .26 | .26 | .25 | .25 | .25 |
| 71.0000 | .25 | .25 | .25 | .25 | .25 |
| 71.5000 | .25 | .25 | .25 | .25 | .25 |
| 72.0000 | .25 | .25 | .25 | .25 | .24 |
| 72.5000 | .24 | .24 | .24 | .24 | .24 |
| 73.0000 | .24 | .24 | .24 | .24 | .24 |
| 73.5000 | .24 | .24 | .24 | .24 | .24 |
| 74.0000 | .24 | .24 | .24 | .23 | .23 |
| 74.5000 | .23 | .23 | .23 | .23 | .23 |
| 75.0000 | .23 | .23 | .23 | .23 | .23 |
| 75.5000 | .23 | .23 | .23 | .23 | .23 |
| 76.0000 | .23 | .23 | .22 | .22 | .22 |
| 76.5000 | .22 | .22 | .22 | .22 | .22 |
| 77.0000 | .22 | .22 | .22 | .22 | .22 |
| 77.5000 | .22 | .22 | .22 | .22 | .22 |
| 78.0000 | .22 | .22 | .21 | .21 | .21 |
| 78.5000 | .21 | .21 | .21 | .21 | .21 |
| 79.0000 | .21 | .21 | .21 | .21 | .21 |
| 79.5000 | .21 | .21 | .21 | .21 | .21 |
| 80.0000 | .21 | .21 | .20 | .20 | .20 |
| 80.5000 | .20 | .20 | .20 | .20 | .20 |
| 81.0000 | .20 | .20 | .20 | .20 | .20 |
| 81.5000 | .20 | .20 | .20 | .20 | .20 |
| 82.0000 | .20 | .20 | .20 | .20 | .19 |
| 82.5000 | .19 | .19 | .19 | .19 | .19 |
| 83.0000 | .19 | .19 | .19 | .19 | .19 |
| 83.5000 | .19 | .19 | .19 | .19 | .19 |
| 84.0000 | .19 | .19 | .19 | .19 | .19 |
| 84.5000 | .19 | .19 | .18 | .18 | .18 |
| 85.0000 | .18 | .18 | .18 | .18 | .18 |
| 85.5000 | .18 | .18 | .18 | .18 | .18 |
| 86.0000 | .18 | .18 | .18 | .18 | .18 |
| 86.5000 | .18 | .18 | .18 | .18 | .18 |
| 87.0000 | .18 | .18 | .17 | .17 | .17 |
| 87.5000 | .17 | .17 | .17 | .17 | .17 |
| 88.0000 | .17 | .17 | .17 | .17 | .17 |
| 88.5000 | .17 | .17 | .17 | .17 | .17 |
| 89.0000 | .17 | .17 | .17 | .17 | .17 |
| 89.5000 | .17 | .17 | .17 | .16 | .16 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (5/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 90.0000 | .16 | .16 | .16 | .16 | .16 |
| 90.5000 | .16 | .16 | .16 | .16 | .16 |
| 91.0000 | .16 | .16 | .16 | .16 | .16 |
| 91.5000 | .16 | .16 | .16 | .16 | .16 |
| 92.0000 | .16 | .16 | .16 | .16 | .16 |
| 92.5000 | .15 | .15 | .15 | .15 | .15 |
| 93.0000 | .15 | .15 | .15 | .15 | .15 |
| 93.5000 | .15 | .15 | .15 | .15 | .15 |
| 94.0000 | .15 | .15 | .15 | .15 | .15 |
| 94.5000 | .15 | .15 | .15 | .15 | .15 |
| 95.0000 | .15 | .15 | .15 | .15 | .14 |
| 95.5000 | .14 | .14 | .14 | .14 | .14 |
| 96.0000 | .14 | .14 | .14 | .14 | .14 |
| 96.5000 | .14 | .14 | .14 | .14 | .14 |
| 97.0000 | .14 | .14 | .14 | .14 | .14 |
| 97.5000 | .14 | .14 | .14 | .14 | .14 |
| 98.0000 | .14 | .14 | .14 | .14 | .14 |
| 98.5000 | .14 | .13 | .13 | .13 | .13 |
| 99.0000 | .13 | .13 | .13 | .13 | .13 |
| 99.5000 | .13 | .13 | .13 | .13 | .13 |
| 100.0000 | .13 | .13 | .13 | .13 | .13 |
| 100.5000 | .13 | .13 | .13 | .13 | .13 |
| 101.0000 | .13 | .13 | .13 | .13 | .13 |
| 101.5000 | .13 | .13 | .13 | .13 | .12 |
| 102.0000 | .12 | .12 | .12 | .12 | .12 |
| 102.5000 | .12 | .12 | .12 | .12 | .12 |
| 103.0000 | .12 | .12 | .12 | .12 | .12 |
| 103.5000 | .12 | .12 | .12 | .12 | .12 |
| 104.0000 | .12 | .12 | .12 | .12 | .12 |
| 104.5000 | .12 | .12 | .12 | .12 | .12 |
| 105.0000 | .12 | .12 | .12 | .12 | .12 |
| 105.5000 | .12 | .11 | .11 | .11 | .11 |
| 106.0000 | .11 | .11 | .11 | .11 | .11 |
| 106.5000 | .11 | .11 | .11 | .11 | .11 |
| 107.0000 | .11 | .11 | .11 | .11 | .11 |
| 107.5000 | .11 | .11 | .11 | .11 | .11 |
| 108.0000 | .11 | .11 | .11 | .11 | .11 |
| 108.5000 | .11 | .11 | .11 | .11 | .11 |
| 109.0000 | .11 | .11 | .11 | .11 | .11 |
| 109.5000 | .11 | .10 | .10 | .10 | .10 |
| 110.0000 | .10 | .10 | .10 | .10 | .10 |
| 110.5000 | .10 | .10 | .10 | .10 | .10 |
| 111.0000 | .10 | .10 | .10 | .10 | .10 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (6/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 111.5000 | .10 | .10 | .10 | .10 | .10 |
| 112.0000 | .10 | .10 | .10 | .10 | .10 |
| 112.5000 | .10 | .10 | .10 | .10 | .10 |
| 113.0000 | .10 | .10 | .10 | .10 | .10 |
| 113.5000 | .10 | .10 | .10 | .10 End discharge | .09 |
| 114.0000 | .09 | .09 | .09 | .09 | .09 |
| 114.5000 | .09 | .09 | .09 | .09 | .09 |
| 115.0000 | .09 | .09 | .09 | .09 | .09 |
| 115.5000 | .09 | .09 | .09 | .09 | .09 |
| 116.0000 | .09 | .09 | .09 | .09 | .09 |
| 116.5000 | .09 | .09 | .09 | .09 | .09 |
| 117.0000 | .09 | .09 | .09 | .09 | .09 |
| 117.5000 | .09 | .09 | .09 | .09 | .09 |
| 118.0000 | .09 | .09 | .09 | .09 | .09 |
| 118.5000 | .09 | .09 | .09 | .08 | .08 |
| 119.0000 | .08 | .08 | .08 | .08 | .08 |
| 119.5000 | .08 | .08 | .08 | .08 | .08 |
| 120.0000 | .08 | .08 | .08 | .08 | .08 |
| 120.5000 | .08 | .08 | .08 | .08 | .08 |
| 121.0000 | .08 | .08 | .08 | .08 | .08 |
| 121.5000 | .08 | .08 | .08 | .08 | .08 |
| 122.0000 | .08 | .08 | .08 | .08 | .08 |
| 122.5000 | .08 | .08 | .08 | .08 | .08 |
| 123.0000 | .08 | .08 | .08 | .08 | .08 |
| 123.5000 | .08 | .08 | .08 | .08 | .08 |
| 124.0000 | .08 | .08 | .08 | .07 | .07 |
| 124.5000 | .07 | .07 | .07 | .07 | .07 |
| 125.0000 | .07 | .07 | .07 | .07 | .07 |
| 125.5000 | .07 | .07 | .07 | .07 | .07 |
| 126.0000 | .07 | .07 | .07 | .07 | .07 |
| 126.5000 | .07 | .07 | .07 | .07 | .07 |
| 127.0000 | .07 | .07 | .07 | .07 | .07 |
| 127.5000 | .07 | .07 | .07 | .07 | .07 |
| 128.0000 | .07 | .07 | .07 | .07 | .07 |
| 128.5000 | .07 | .07 | .07 | .07 | .07 |
| 129.0000 | .07 | .07 | .07 | .07 | .07 |
| 129.5000 | .07 | .07 | .07 | .07 | .07 |
| 130.0000 | .07 | .07 | .07 | .07 | .07 |
| 130.5000 | .07 | .06 | .06 | .06 | .06 |
| 131.0000 | .06 | .06 | .06 | .06 | .06 |
| 131.5000 | .06 | .06 | .06 | .06 | .06 |
| 132.0000 | .06 | .06 | .06 | .06 | .06 |
| 132.5000 | .06 | .06 | .06 | .06 | .06 |

Type.... Pond Routed HYG (total out)
Name.... SOUTH BASIN2 Tag: 25

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin Outflow Hydrograph (7/7)

WARNING: Hydrograph truncated on right side.

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

| Time hrs | | | | | |
|---|---|---|---|---|---|
| 133.0000 | .06 | .06 | .06 | .06 | .06 |
| 133.5000 | .06 | .06 | .06 | .06 | .06 |
| 134.0000 | .06 | .06 | .06 | .06 | .06 |
| 134.5000 | .06 | .06 | .06 | .06 | .06 |
| 135.0000 | .06 | .06 | .06 | .06 | .06 |
| 135.5000 | .06 | .06 | .06 | .06 | .06 |
| 136.0000 | .06 | .06 | .06 | .06 | .06 |
| 136.5000 | .06 | .06 | .06 | .06 | .06 |
| 137.0000 | .06 | .06 | .06 | .06 | .06 |
| 137.5000 | .06 | .06 | .06 | .06 | .05 |
| 138.0000 | .05 | .05 | .05 | .05 | .05 |
| 138.5000 | .05 | .05 | .05 | .05 | .05 |
| 139.0000 | .05 | .05 | .05 | .05 | .05 |
| 139.5000 | .05 | .05 | .05 | .05 | .05 |
| 140.0000 | .05 | .05 | .05 | .05 | .05 |
| 140.5000 | .05 | .05 | .05 | .05 | .05 |
| 141.0000 | .05 | .05 | .05 | .05 | .05 |
| 141.5000 | .05 | .05 | .05 | .05 | .05 |
| 142.0000 | .05 | .05 | .05 | .05 | .05 |
| 142.5000 | .05 | .05 | .05 | .05 | .05 |
| 143.0000 | .05 | .05 | .05 | .05 | .05 |
| 143.5000 | .05 | .05 | .05 | .05 | .05 |
| 144.0000 | .05 | .05 | .05 | .05 | .05 |
| 144.5000 | .05 | .05 | .05 | .05 | .05 |
| 145.0000 | .05 | .05 | .05 | .05 | .05 |
| 145.5000 | .05 | .05 | .05 | .05 | .05 |
| 146.0000 | .05 | .05 | .05 | .05 | .05 |
| 146.5000 | .05 | .05 | .04 | .04 | .04 |
| 147.0000 | .04 | .04 | .04 | .04 | .04 |
| 147.5000 | .04 | .04 | .04 | .04 | .04 |
| 148.0000 | .04 | .04 | .04 | .04 | .04 |
| 148.5000 | .04 | .04 | .04 | .04 | .04 |
| 149.0000 | .04 | .04 | .04 | .04 | .04 |
| 149.5000 | .04 | .04 | .04 | .04 | .04 |
| 150.0000 | .04 | .04 | .04 | .04 | .04 |
| 150.5000 | .04 | .04 | .04 | .04 | .04 |
| 151.0000 | .04 | .04 | .04 | .04 | .04 |
| 151.5000 | .04 | .04 | .04 | .04 | .04 |
| 152.0000 | .04 | .04 | .04 | .04 | .04 |
| 152.5000 | .04 | .04 | .04 | .04 | .04 |
| 153.0000 | .04 | .04 | .04 | .04 | .04 |
| 153.5000 | .04 | .04 | .04 | .04 | .04 |
| 154.0000 | .04 | .04 | .04 | .04 | .04 |

File.... I:\1370\COLUMBIA.PPK
Title... routing of hydrograph through south basin

South Basin
100-yr, 24-hr storm

LEVEL POOL ROUTING SUMMARY

HYG Dir = I:\1370\
Inflow HYG file = SBASIN.HYG - south basin 100
Outflow HYG file = NONE STORED - SOUTH BASIN2 OUT 100

Pond Node Data = south basin
Pond Volume Data = south basin
Pond Outlet Data = south basin2

No Infiltration

INITIAL CONDITIONS

| | | |
|---|---|---|
| Starting WS Elev | = 789.00 | ft |
| Starting Volume | = .000 | ac-ft |
| Starting Outflow | = .00 | cfs |
| Starting Infiltr. | = .00 | cfs |
| Starting Total Qout | = .00 | cfs |
| Time Increment | = .1000 | hrs |

INFLOW/OUTFLOW HYDROGRAPH SUMMARY

| | | | | |
|---|---|---|---|---|
| Peak Inflow | = 110.00 cfs | at | 12.4000 hrs | |
| Peak Outflow | = 16.79 cfs | at | 13.7000 hrs | ← Peak discharge from basin |
| Peak Elevation | = 793.29 ft | ← Peak water elevation | | |
| Peak Storage | = 7.080 ac-ft | | | |

MASS BALANCE (ac-ft)

| | | |
|---|---|---|
| + Initial Vol | = | .000 |
| + HYG Vol IN | = | 13.207 |
| - Infiltration | = | .000 |
| - HYG Vol OUT | = | 12.435 |
| - Retained Vol | = | .770 |
| Unrouted Vol | = | -.001 ac-ft (.011% of Inflow Volume) |

WARNING: Inflow hydrograph truncated on left side.
WARNING: Outflow hydrograph truncated on right side.

# References

### Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute $T_t$:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

**Table 3-1.—Roughness coefficients (Manning's n) for sheet flow**

| Surface description | n[1] |
|---|---|
| Smooth surfaces (concrete, asphalt, gravel, or bare soil) | 0.011 |
| Fallow (no residue) | 0.05 |
| Cultivated soils: | |
| Residue cover ≤20% | 0.06 |
| Residue cover >20% | 0.17 |
| Grass: | |
| Short grass prairie | 0.15 |
| Dense grasses[2] | 0.24 |
| Bermudagrass | 0.41 |
| Range (natural) | 0.13 |
| Woods:[3] | |
| Light underbrush | 0.40 |
| Dense underbrush | 0.80 |

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

$T_t$ = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
$P_2$ = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

### Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

### Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

| Cover description | | Curve numbers for hydrologic soil group— | | | |
|---|---|---|---|---|---|
| Cover type | Hydrologic condition | A | B | C | D |
| Pasture, grassland, or range—continuous forage for grazing.[2] | Poor | 68 | 79 | 86 | 89 |
| | Fair | 49 | 69 | 79 | 84 |
| | Good | 39 | 61 | 74 | 80 |
| Meadow—continuous grass, protected from grazing and generally mowed for hay. | — | 30 | 58 | 71 | 78 |
| Brush—brush-weed-grass mixture with brush the major element.[3] | Poor | 48 | 67 | 77 | 83 |
| | Fair | 35 | 56 | 70 | 77 |
| | Good | 30[4] | 48 | 65 | 73 |
| Woods—grass combination (orchard or tree farm).[5] | Poor | 57 | 73 | 82 | 86 |
| | Fair | 43 | 65 | 76 | 82 |
| | Good | 32 | 58 | 72 | 79 |
| Woods.[6] | Poor | 45 | 66 | 77 | 83 |
| | Fair | 36 | 60 | 73 | 79 |
| | Good | 30[4] | 55 | 70 | 77 |
| Farmsteads—buildings, lanes, driveways, and surrounding lots. | — | 59 | 74 | 82 | 86 |

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
*Fair:* 50 to 75% ground cover and not heavily grazed.
*Good:* >75% ground cover and lightly or only occasionally grazed.

[3]*Poor:* <50% ground cover.
*Fair:* 50 to 75% ground cover.
*Good:* >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
*Fair:* Woods are grazed but not burned, and some forest litter covers the soil.
*Good:* Woods are protected from grazing, and litter and brush adequately cover the soil.

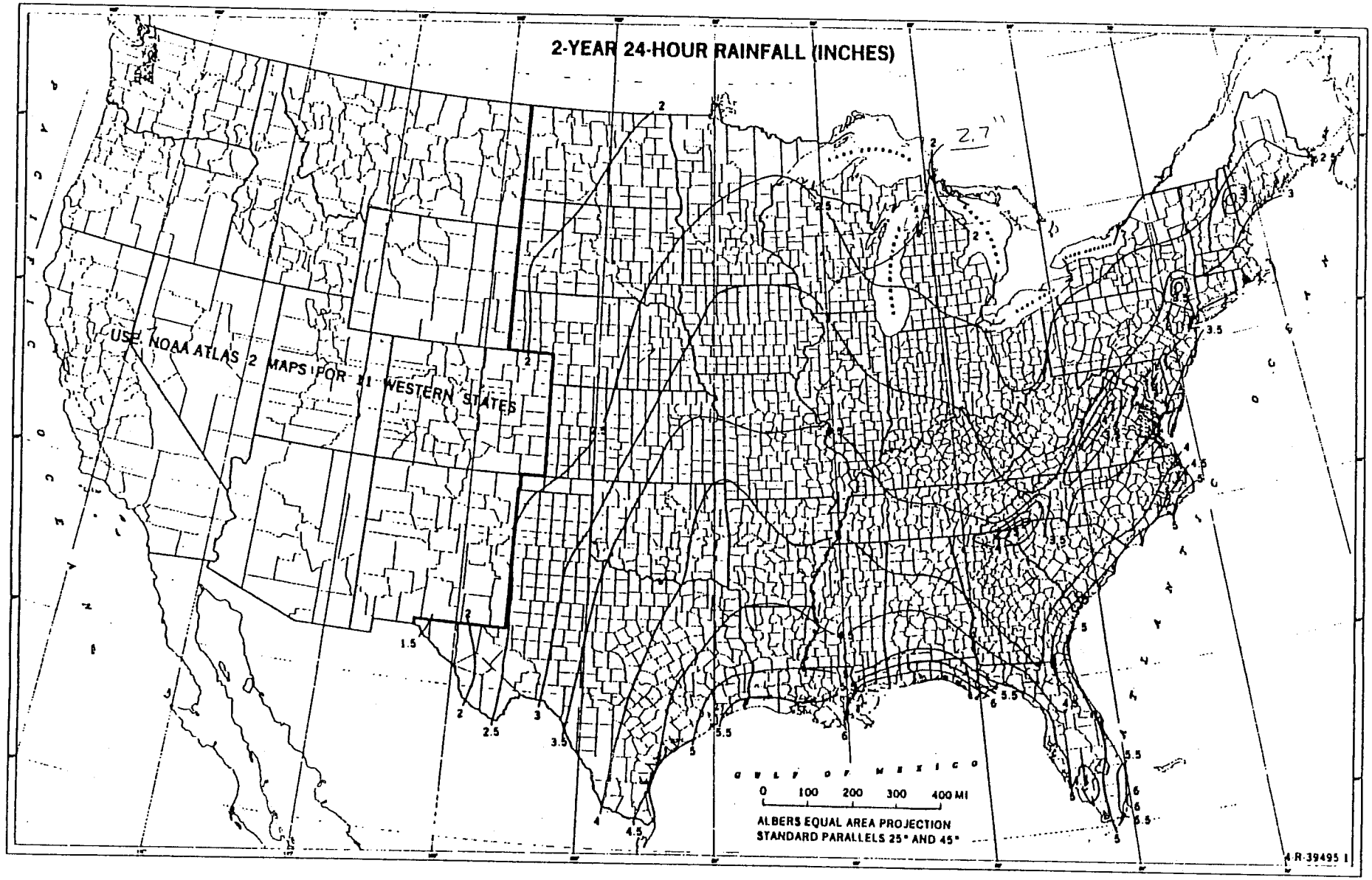



Figure B-3.—Two-year, 24-hour rainfall.

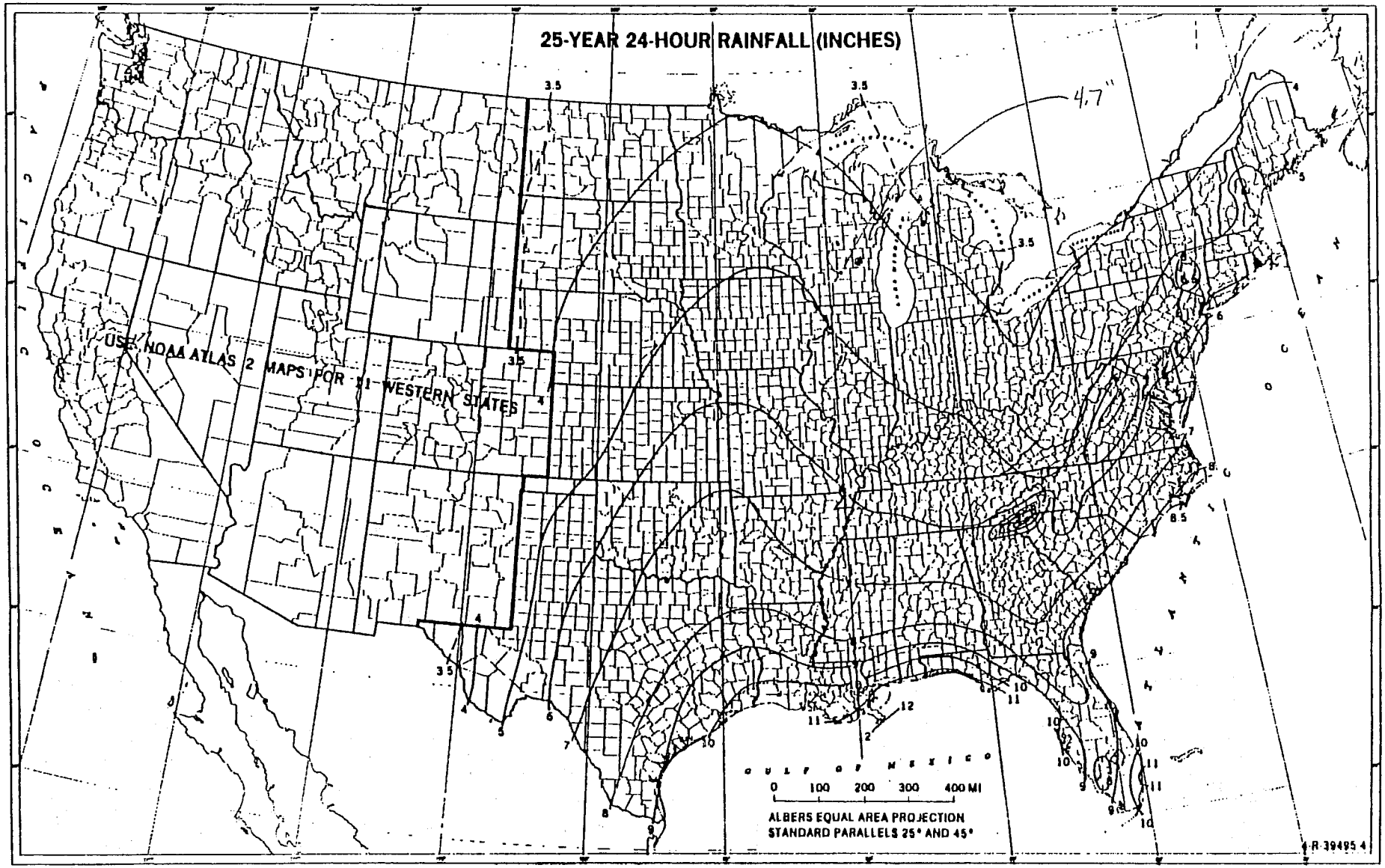



Figure B-6.—Twenty-five-year, 24-hour rainfall.

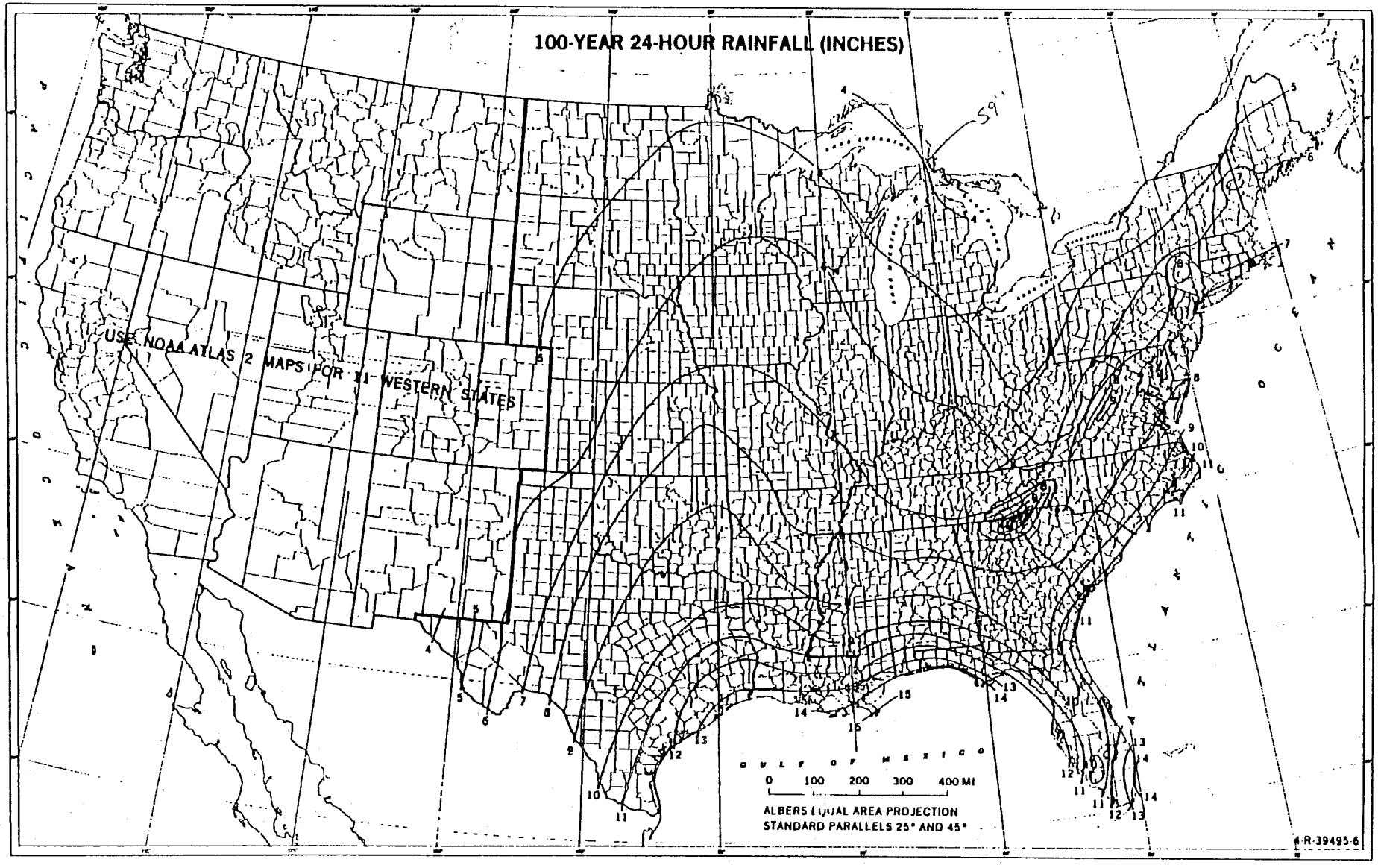



Figure B-8.—One-hundred-year, 24-hour rainfall.

TABLE 8.1 Surface Area Requirements of Sediment Traps and Basins

| Particle size, mm | Settling velocity, ft/sec (m/sec) | Surface area requirements, $ft^2$ per $ft^3$/sec discharge | ($m^2$ per $m^3$/sec discharge) |
|---|---|---|---|
| 0.5 (coarse sand) | 0.19 (0.058) | 6.3 | (20.7) |
| 0.2 (medium sand) | 0.067 (0.020) | 17.9 | (58.7) |
| 0.1 (fine sand) | 0.023 (0.0070) | 52.2 | (171.0) |
| 0.05 (coarse silt) | 0.0062 (0.0019) | 193.6 | (635.0) |
| 0.02 (medium silt) | 0.00096 (0.00029) | 1,250.0 | (4,101.0) |
| 0.01 (fine silt) | 0.00024 (0.000073) | 5,000.0 | (16,404.0) |
| 0.005 (clay) | 0.00006 (0.000018) | 20,000.0 | (65,617.0) |

0.015 <

→ Ave = 3,125 sf/cfs

weight composed of particles in the 0.01- to 0.02-mm range. A surface area 4 times larger would be needed to capture 5 percent more of this soil.

A balance between the cost-effectiveness of a certain basin size and the desire to capture fine particles must be achieved. It is desirable to capture the very small soil particles (clays and fine silts) because they cause turbidity and other water quality problems. However, Table 8.1 shows that a basin would have to be very large to capture particles smaller than 0.02 mm, particularly clay particles 0.005 mm and smaller. Because of the high cost of trapping very small particles, the authors recommend 0.02 as the design particle size for sediment basins except in areas with coarse soils, where a larger design particle may be used. The 0.02-mm particle is classified as a medium silt by the AASHTO soil classification system.

## 8.2d Basin Discharge Rate

The peak discharge, calculated by the rational or another approved method, is used to size the basin riser. During any major storm, a sediment basin should fill with water to the top of its riser and then discharge at the rate of inflow to the basin. A sediment basin is not designed with a large water storage volume as is a reservoir. If the inflow exceeds the design peak flow used to size the riser, the overflow should discharge down an emergency spillway.

## 8.2e Design Runoff Rate

In the equation for surface area of a sediment basin, the discharge rate $Q$ is a variable to be chosen by the designer. The above discussion of basin discharge rate shows that the discharge rate is, to a large extent, equal to the inflow. The riser is sized to handle the peak inflow to the basin. The authors suggest determining the surface area by the *average runoff of a 10-year, 6-hr storm* instead



of the peak flow. A substantial savings in size, and therefore cost, is obtained, and basin efficiency is not significantly decreased.

Consider a basin designed to capture the 0.02-mm particle at the average runoff rate. The average rainfall per hour is 17 percent of the total rainfall in a 6-hr storm (Sec. 4.1f). On a site with soils with a moderately high clay content, under ideal settling conditions this basin would retain about 62 percent of the eroded soil (i.e., 62 percent of the soil, by weight, is composed of 0.02-mm or larger particles).

If the surface area of this basin were instead designed for the peak flow, it would be roughly 3 times larger. According to data from the U.S. Bureau of Reclamation (10), 25 percent of the total rainfall in a 6-hr storm falls in a ½-hr period (Fig. 4.2). Since the rainfall intensity $i$ value is in units of inches (or millimeters) per hour, the peak flow can be calculated by using an $i$ value of 50 percent of the 6-hr total. Since basin surface area is directly proportional to the discharge rate ($A = 1.2Q/V_s$) and the peak discharge rate in a 6-hr storm is 2.9 times the average rate (50% = 2.9 × 17%), the surface area sized for the peak flow would be about 3 times the surface area sized for the average flow. The basin sized for the peak flow would capture, during most of the storm except the peak, particles with approximately one-third the settling velocity of the design particle. Since the 0.02-mm particle settles at 0.00096 ft/sec (0.00029 m/sec), particles with a settling velocity of 0.00032 ft/sec (0.000098 m/sec) would then be captured. These are approximately 0.01-mm particles.

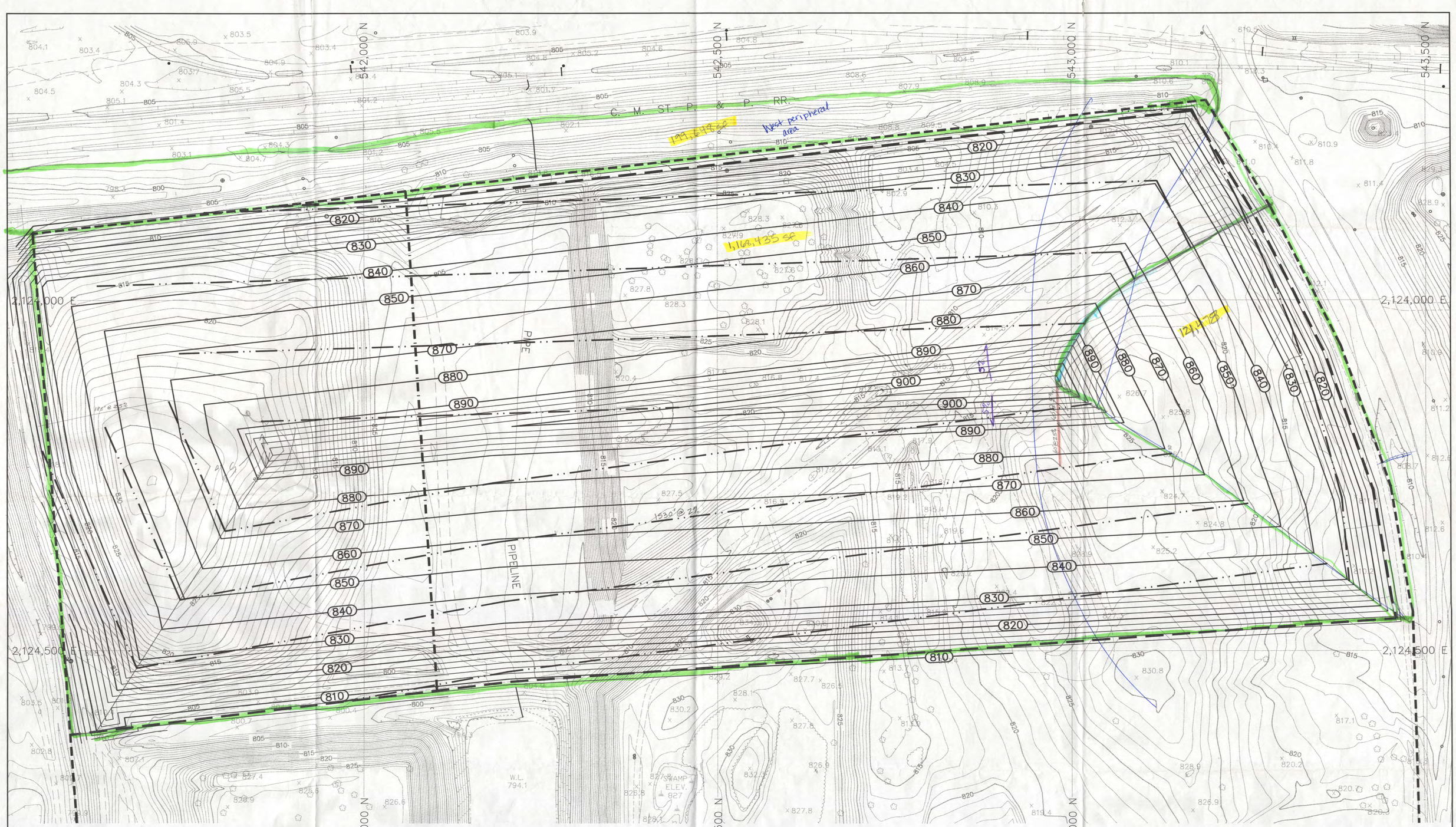
Suppose a basin on a site with clayey soils were sized by using the peak runoff rate. For the purpose of illustration, suppose the soil composition were typical of the San Francisco Bay Area as in the preceding example (62 percent of particles, by weight, greater than 0.02 mm and 5 percent, by weight, from 0.01 to 0.02 mm). A basin with a large surface area based on the peak runoff would capture the 0.01- to 0.02-mm particles as well as particles greater than 0.02 mm, or 67 percent of the eroded material. The basin efficiency would be increased 8 percent (5/62) by tripling the surface area. Thus it is generally much more cost-effective to size a basin by using the average runoff rather than the peak, and basin efficiency will not be significantly lower.

## 8.2f Settling Depth

If a basin is too shallow, water flowing rapidly through the basin may resuspend settled particles and decrease efficiency of capture. A similar problem occurs in grit-settling chambers at sewage treatment plants, where velocity must be controlled to prevent particle resuspension. An equation that describes scour in a grit chamber (2) is:

$$V_{scour} = \frac{1.486}{n} \times \left[ r^{1/6} \times k(S_s - 1) \times \frac{d}{304.8} \right]^{1/2}$$

Source: Goldman, S.J., et al. 1986. Erosion and Sediment Control Handbook. New York McGraw-Hill 1986




LEGEND

| | |
|---|---|
| PROPOSED LIMITS OF FILL | PAVED ROAD |
| APPROVED LIMITS OF FILL | UNPAVED ROAD |
| EXISTING SPOT ELEVATION | VEGETATION |
| EXISTING GRADES (5' INTERVAL) | RAILROAD TRACKS |
| EXISTING GRADES (1' INTERVAL) | FENCE |
| EDGE OF WATER | CULVERT |

Areas obtained from AutoCADD

60 0 60
SCALE: 1" = 60'

N

**PROPOSED FINAL GRADES**

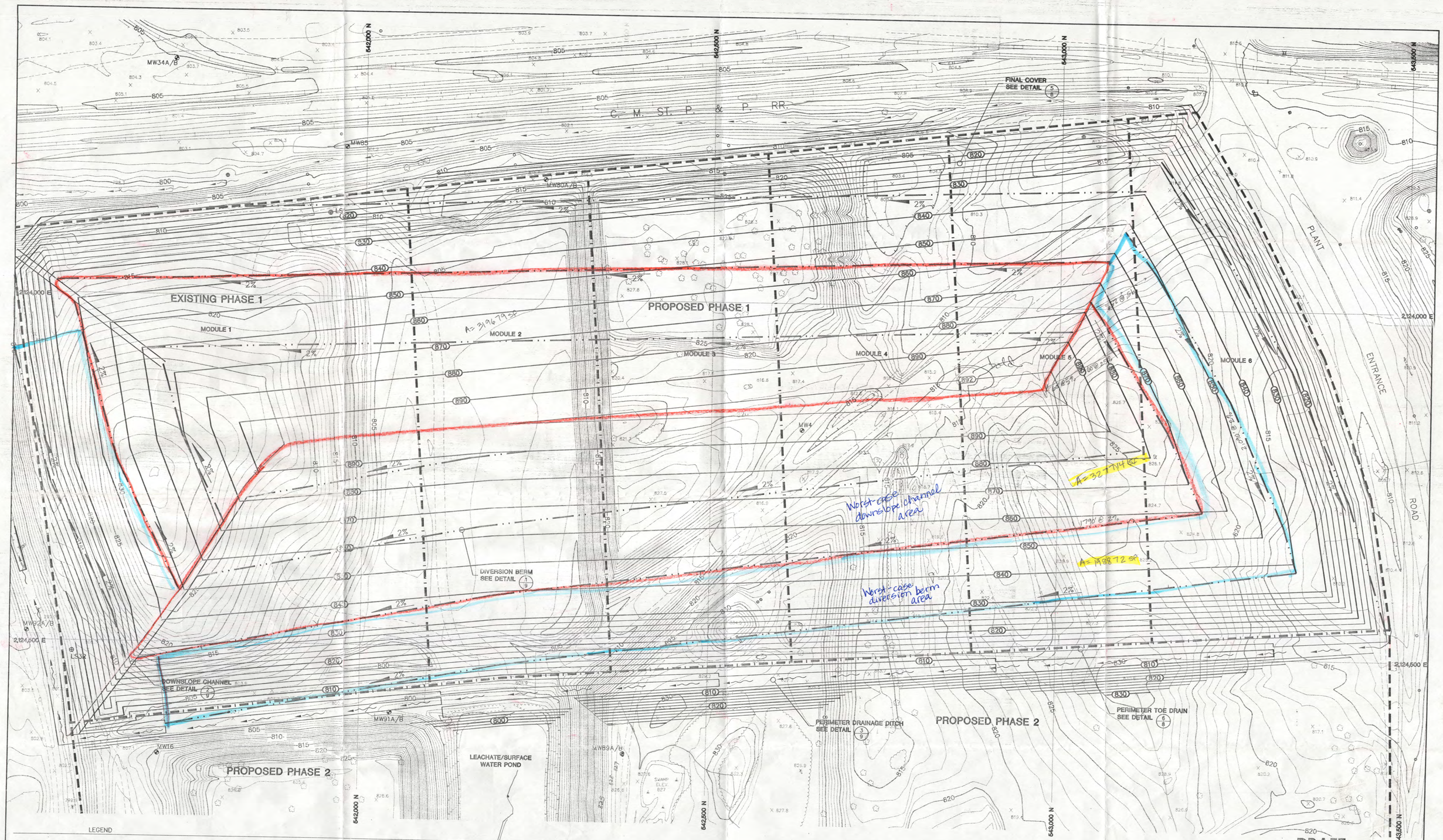
PLAN OF OPERATION UPDATE
ALLIANT – COLUMBIA ASH DISPOSAL FACILITY
TOWN OF PACIFIC
COLUMBIA COUNTY, WISCONSIN

| | |
|---|---|
| PROJECT NO. 1370 | |
| DRAWN BY: RR/KP | |
| CHECKED BY: MRH | |
| DRAWN: 07/28/00 REVISED: 08/16/00 | |
| J:\1370\PO UPDATE\1370FG04.DWG | |

BT² inc.

SHEET 4 OF 8

#1370 ON




LEGEND

| | | |
|---|---|---|
| PHASE/MODULE LIMIT | PAVED ROAD | PROPOSED FINAL GRADES (5' INTERVAL) |
| APPROVED LIMITS OF FILL | UNPAVED ROAD | PROPOSED FINAL GRADES (1' INTERVAL) |
| EXISTING SPOT ELEVATION | VEGETATION | PROPOSED DIVERSION BERM |
| EXISTING GRADES (5' INTERVAL) | RAILROAD TRACKS | PROPOSED DOWNSLOPE CHANNEL |
| EXISTING GRADES (1' INTERVAL) | FENCE | DRAINAGE DITCH |
| EDGE OF WATER | CULVERT | |

Areas determined by planimeter

60 0 60
SCALE: 1" = 60'

N

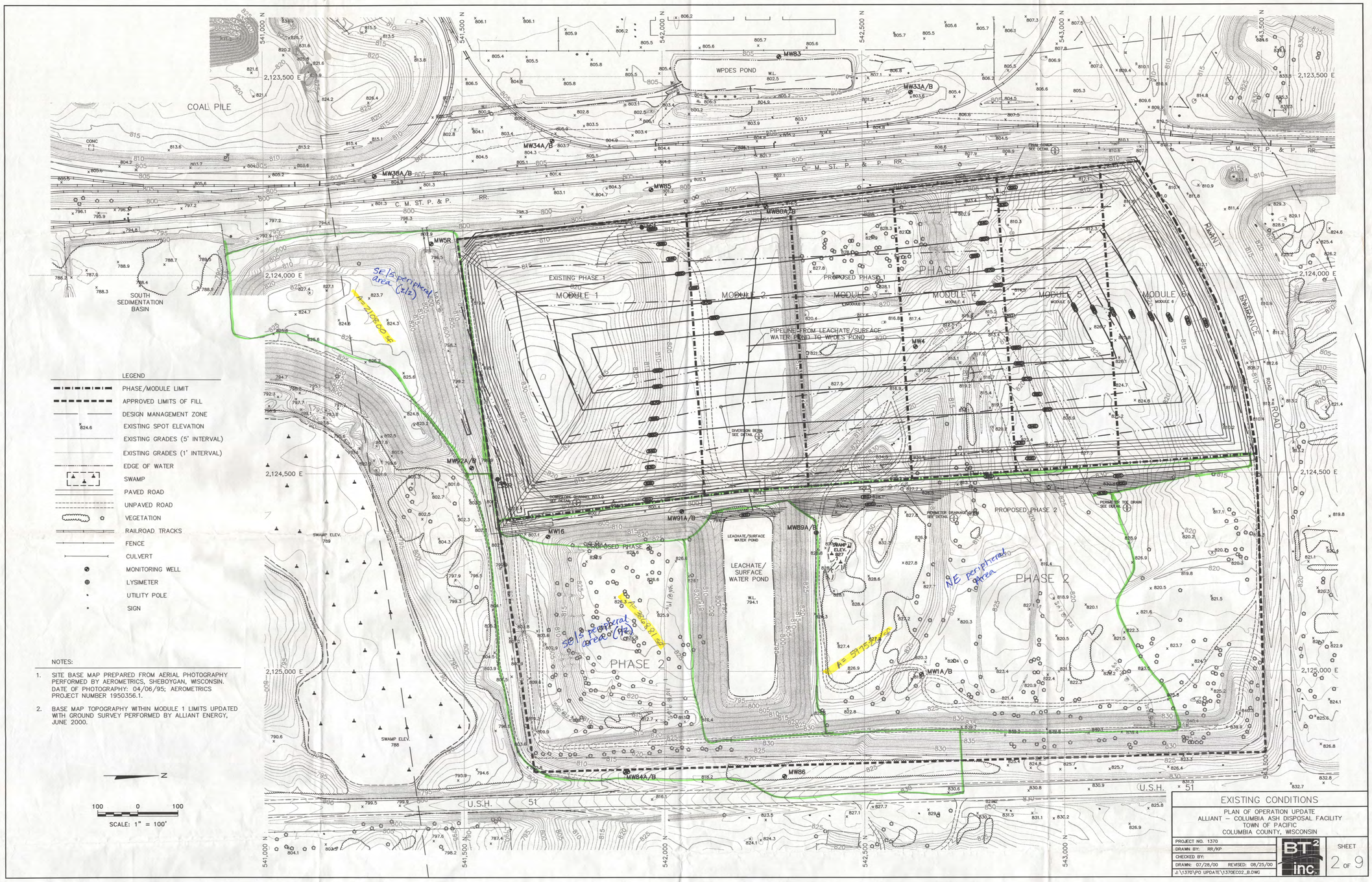
DRAFT

**PROPOSED FINAL GRADES**

PLAN OF OPERATION UPDATE
ALLIANT – COLUMBIA ASH DISPOSAL FACILITY
TOWN OF PACIFIC
COLUMBIA COUNTY, WISCONSIN

| | |
|---|---|
| PROJECT NO. 1370 | BT² inc. |
| DRAWN BY: RR/KP | SHEET 4 OF 9 |
| CHECKED BY: MRH | |
| DRAWN: 07/28/00 REVISED: 08/25/00 | |
| J:\1370\PO UPDATE\1370FG04.DWG | |

#1370 ON




LEGEND

- PHASE/MODULE LIMIT
- APPROVED LIMITS OF FILL
- DESIGN MANAGEMENT ZONE
- EXISTING SPOT ELEVATION (824.6)
- EXISTING GRADES (5' INTERVAL)
- EXISTING GRADES (1' INTERVAL)
- EDGE OF WATER
- SWAMP
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- RAILROAD TRACKS
- FENCE
- CULVERT
- MONITORING WELL
- LYSIMETER
- UTILITY POLE
- SIGN

NOTES:

1. SITE BASE MAP PREPARED FROM AERIAL PHOTOGRAPHY PERFORMED BY AEROMETRICS, SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY: 04/06/95; AEROMETRICS PROJECT NUMBER 1950356.1.
2. BASE MAP TOPOGRAPHY WITHIN MODULE 1 LIMITS UPDATED WITH GROUND SURVEY PERFORMED BY ALLIANT ENERGY, JUNE 2000.

N

100 0 100

SCALE: 1" = 100'

# EXISTING CONDITIONS

PLAN OF OPERATION UPDATE
ALLIANT – COLUMBIA ASH DISPOSAL FACILITY
TOWN OF PACIFIC
COLUMBIA COUNTY, WISCONSIN

| | |
|---|---|
| PROJECT NO. 1370 | |
| DRAWN BY: RR/KP | |
| CHECKED BY: | |
| DRAWN: 07/28/00 REVISED: 08/25/00 | |
| J:\1370\PO UPDATE\1370EC02_8.DWG | |

BT² inc.

SHEET 2 OF 9

#1370 ON

# Appendix A2

# Leachate/Surface Water Pond Capacity Evaluation

| SCS ENGINEERS | | | | |
|---|---|---|---|---|
| | | SHEET NO. | 1 | |
| Job No. | 25220183.00 | CALC. NO. | | |
| Job: | Columbia Energy Center | REV. NO. | | |
| Client | WPL | BY | RJG | DATE 05/25/22 |
| Subject | Module 10/11 - Leachate/Surface Water Pond Evaluation | CHK'D. | MT | DATE 05/25/22 |

**Purpose:**
The purpose of the leachate/surface water pond evaluation is to determine the following based on the as-built leachate/surface water pond top of liner elevation of 796.97 (see Background section below):

- The maximum amount of open area during each filling phase in order to maintain the peak water elevation resulting from the 25-year, 24-hour storm event at the maximum allowable 796.97.
- The amount of open area allowable with pond closure filling in order to maintain the peak water elevation resulting from the 25-year, 24-hour storm event at the maximum allowable 796.97.
- Based on the amount of allowable open area determined from the above, determine the maximum starting water elevations in the leachate/surface water pond to accommodate 1, 2, 5, and 10-year, 24-hour storm events without overtopping.

**Background:**
- During construction of Module 2, the top of the leachate/surface water pond liner was determined to be at elevation 796.97.
- Previous calculations submitted to the WDNR on January 30, 2018, evaluated the leachate/surface water pond capacity based on the as-built pond liner elevation.
- A similar evaluation was performed for Module 3 and 4 construction and then Module 5 and 6 construction that produced a chart of maximum leachate/surface water pond starting elevations vs. rainfall storage capacity.
- Portions of Modules 1, 2, 3, and 4 currently have final or intermediate cover in place and Module 5 and 6 currently have rain cover (see **Figure 1 through 4**).
- Module 10 and 11 will be constructed in 2022.

**Approach:**
- Use the previously developed HydroCAD storm water model to model the below four filling scenarios.
    1. Filling Phase 0 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 1** for filling grades and contributing area
    2. Filling Phase 1 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 2** for filling grades and contributing area
    3. Filling Phase 2 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 3** for filling grades and contributing area.

4. Filling Phase 3 – Assumes portions of Module 2, 3, 4, 5, and 6 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 4** for filling grades and contributing area.
5. Filling Phase 4 – Assumes portions of Module 2, 3, 4, 5, 6, 10, and 11 contributing to the leachate/surface water pond while material is placed from the pond closure and the plant. See **Figure 5** for filling grades and contributing area.

**Assumptions:**

- Ash surfaces and intermediate cover areas were assumed to be impermeable (CN=98).
- The top of pond liner elevation is 796.97 (see Background section).
- Time of Concentration is 20 minutes for open areas.

**Results:**

1. Maximum allowable open area during filling and prior to permeter grade/Module 10 and 11 construction is 7.78 acres.

2. Maximum allowable open area during filling and after perimeter grades/Module 10 and 11 base grades are completed is 8.51 acres.

3. <u>Filling Phase 0:</u>
   - The contributing area of landfill to the leachate/surface water pond is 7.45 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 1** shows a proposed filling sequence, and **Figure 1a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.
4. <u>Filling Phase 1:</u>
   - The contributing area of landfill to the leachate/surface water pond is 7.78 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 2** shows a proposed filling sequence, and **Figure 2a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.
5. <u>Filling Phase 2:</u>
   - The contributing area of landfill to the leachate/surface water pond is 7.69 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.

- The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
- **Figure 3** shows a proposed filling sequence, and **Figure 3a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

6. Filling Phase 3:
   - The contributing area of landfill to the leachate/surface water pond is 7.64 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 4** shows a proposed filling sequence, and **Figure 4a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

7. Filling Phase 4:
   - The contributing area of landfill to the leachate/surface water pond is 8.44 acres for the leachate/surface water pond to accommodate the runoff from a 25-year, 24-hour storm without overtopping.
   - The remainder of landfill would need to be closed/covered with final or intermediate cover and routed away from the pond.
   - **Figure 5** shows a proposed filling sequence, and **Figure 5a** shows the various operating levels of the leachate/surface water pond to accommodate the various storm events with the additional cover in place.

The HydroCAD reports for the maximum open contributing area, each scenario modeled are attached.

**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- CONTACT WATER DRAINAGE
- SURFACE WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA 7.0 ACRES |
|---|---|---|
| 0 | | |
| 1 | | |
| 2 | | |
| 3 | | |
| TOTAL | | 7.0 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.

541,000 N | 541,500 N | 542,000 N | 542,500 N | 543,000 N | 543,500 N

2,123,500 E | 2,124,000 E | 2,124,500 E | 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

EXISTING FINAL COVER

EXISTING OPEN AREA

EXISTING INTERIM COVER

EXISTING RAIN COVER

DRAINAGE AREA = 7.45 ACRES

LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 3.71 ACRES

MURRAY ROAD

BM6

BM19

N

100 0 100

SCALE: 1" = 100'

U:\25220183.000\Drawings\Plan of Operation Update\FIG 5a - closure exhibit - half filling 5a - once stage 0 3 exhibits.dwg
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SCS ENGINEERS
2830 DAIRY DRIVE, MADISON, WI 53718-6751
PHONE: (608) 224-2830

| | |
|---|---|
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |
| PROJECT NO. | 25220183.000 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/20/2022 |

CLIENT: WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WI 53954

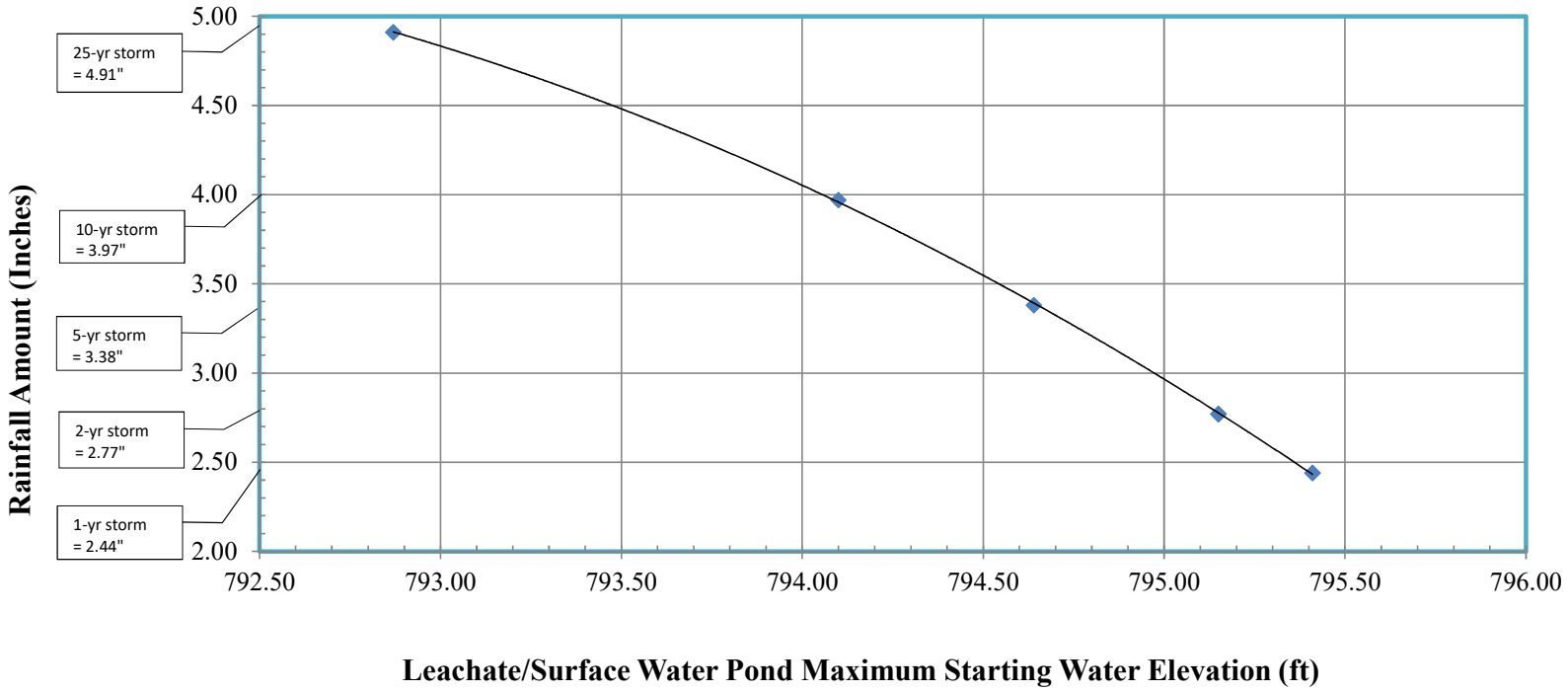
ENGINEER

SITE: PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

FIGURE: STAGE 0 – EXISTING CONDITIONS

1

# Figure 1A
# Columbia Energy Center
# Phase 0 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.46 acres.
   - Leachate/Surface Water Pond Area, 3.71 acres.
5. Maximum open area per HydroCAD model during filling is 7.78 acres.

I:\25220183.00\Data and Calculations\Leachate_Surface Water Pond Evaluation\Issued for Permitting_POO Update\

**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME 121,600 CY | ESTIMATED OPEN AREA 7.3 ACRES |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| TOTAL | 121,600 CY | 7.3 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.

N

100 0 100

SCALE: 1" = 100'

541,000 N 541,500 N 542,000 N 542,500 N 543,000 N 543,500 N

2,123,500 E 2,124,000 E 2,124,500 E 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

EXISTING FINAL COVER

INTERIM COVER

EXISTING INTERIM COVER

STAGE 1 ACTIVE AREA

EXISTING RAIN COVER

DRAINAGE AREA = 7.76 ACRES

NO BOTTOM ASH BEYOND MODULE LIMIT

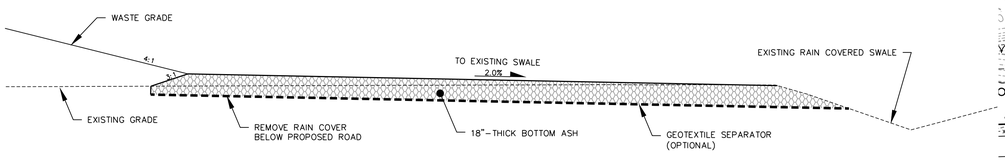
LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 3.71 ACRES

MURRAY ROAD

BM18

BM19




1/2 **40' WIDE HAUL ROAD**

SCALE: 1" = 5'

DRAWN BY: KP
CHECKED BY: PEG/MJT
APPROVED BY: MRH 05/25/2022

PROJECT NO. 25220183.00
DRAWN: 01/15/2022
REVISED: 05/11/2022

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 FORT ROAD
PARDEEVILLE, WI 53954

CLIENT

SGS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA COUNTY, WISCONSIN
TOWN OF PACIFIC, WISCONSIN

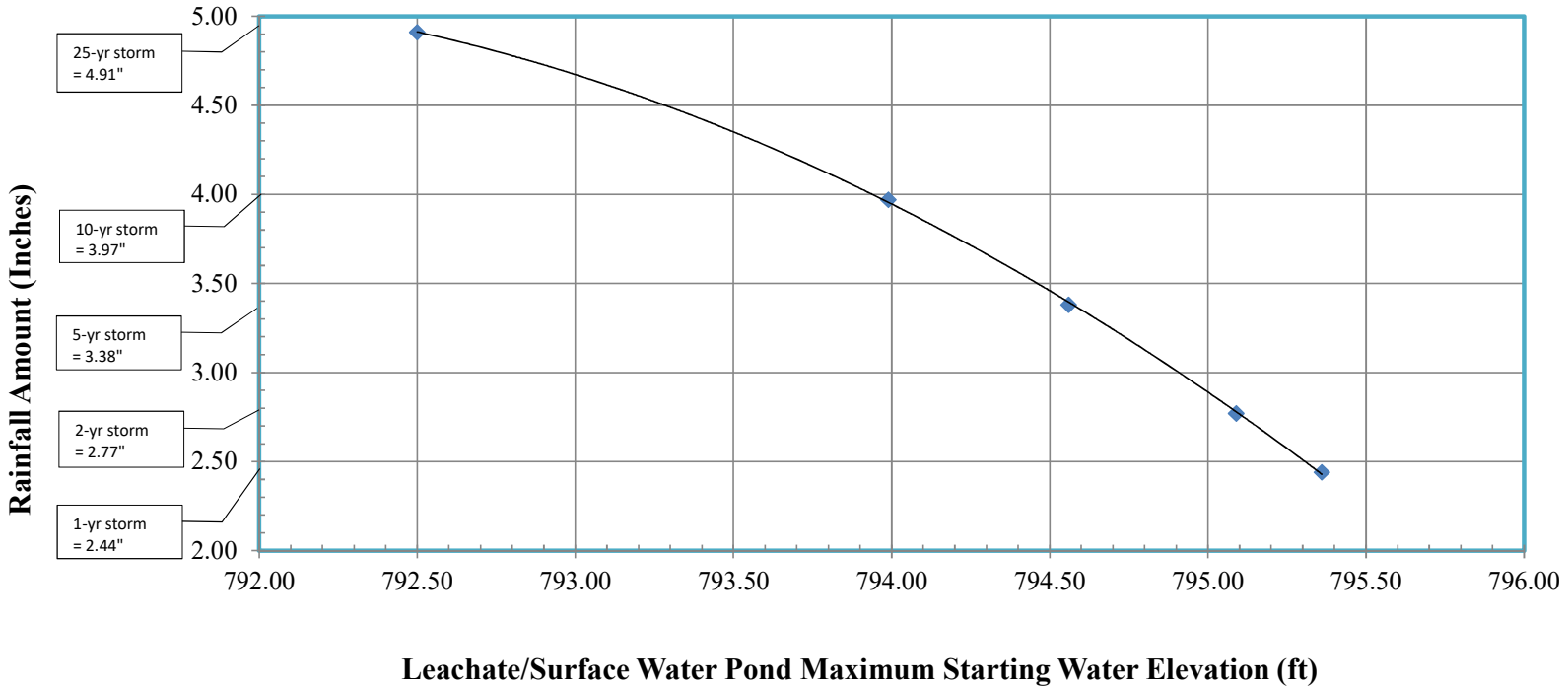
SITE

STAGE 1 – FILLING MODULES 5 AND 6

FIGURE 2

I:\25220183.00\Drawings\Plan of Operation Update\FIG Sht - Intrim and Final - Add Leachate Pond Sht - Intrim Stage 1.dwg
Apr 25, 2022 - 2:52:21pm

# Figure 2A
# Columbia Energy Center
# Phase 1 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.78 acres.
   - Leachate/Surface Water Pond Area, 3.71 acres.
5. Maximum open area per HydroCAD model during filling is 7.78 acres.

I:\25220183.00\Data and Calculations\Leachate_Surface Water Pond Evaluation\Issued for Permitting_POO Update\

**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- 840 — PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (10' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA |
|---|---|---|
| 1 | 121,600 CY | |
| 2 | 151,100 CY | 7.2 ACRES |
| 3 | | |
| 4 | | |
| TOTAL | 272,700 CY | 7.2 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.

N

100 0 100

SCALE: 1" = 100'

541,000 N | 541,500 N | 542,000 N | 542,500 N | 543,000 N | 543,500 N

2,123,500 E | 2,124,000 E | 2,124,500 E | 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

BM6

BM19

REMOVE CULVERT AFTER WEST SLOPE HAS INTERIM COVER

INTERIM COVER

INTERIM COVER BELOW OVERLAY TO BE REMOVED

EXISTING FINAL COVER

EXISTING INTERIM COVER

STAGE 2 ACTIVE AREA

TEMPORARY CONTACT WATER DIVERSION BERM (TYP.)

EXISTING RAIN COVER

DRAINAGE AREA = 7.69 ACRES

LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 2.98 ACRES

MODULE 10/11 LINER UNDER CONSTRUCTION

MURRAY ROAD

| | |
|---|---|
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/09/2022 |
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 FORT ROAD
PARDEEVILLE, WI 53954

CLIENT

SCS ENGINEERS
2830 DAIRY DRIVE, MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

SITE

STAGE 2 – FILLING MODULES 5 AND 6

FIGURE 3

I:\25220183.00\Drawings\Plan of Operation Update\FIG 3a - Annual Activities - with Another Filling Sq - ence Stage 2.dwg
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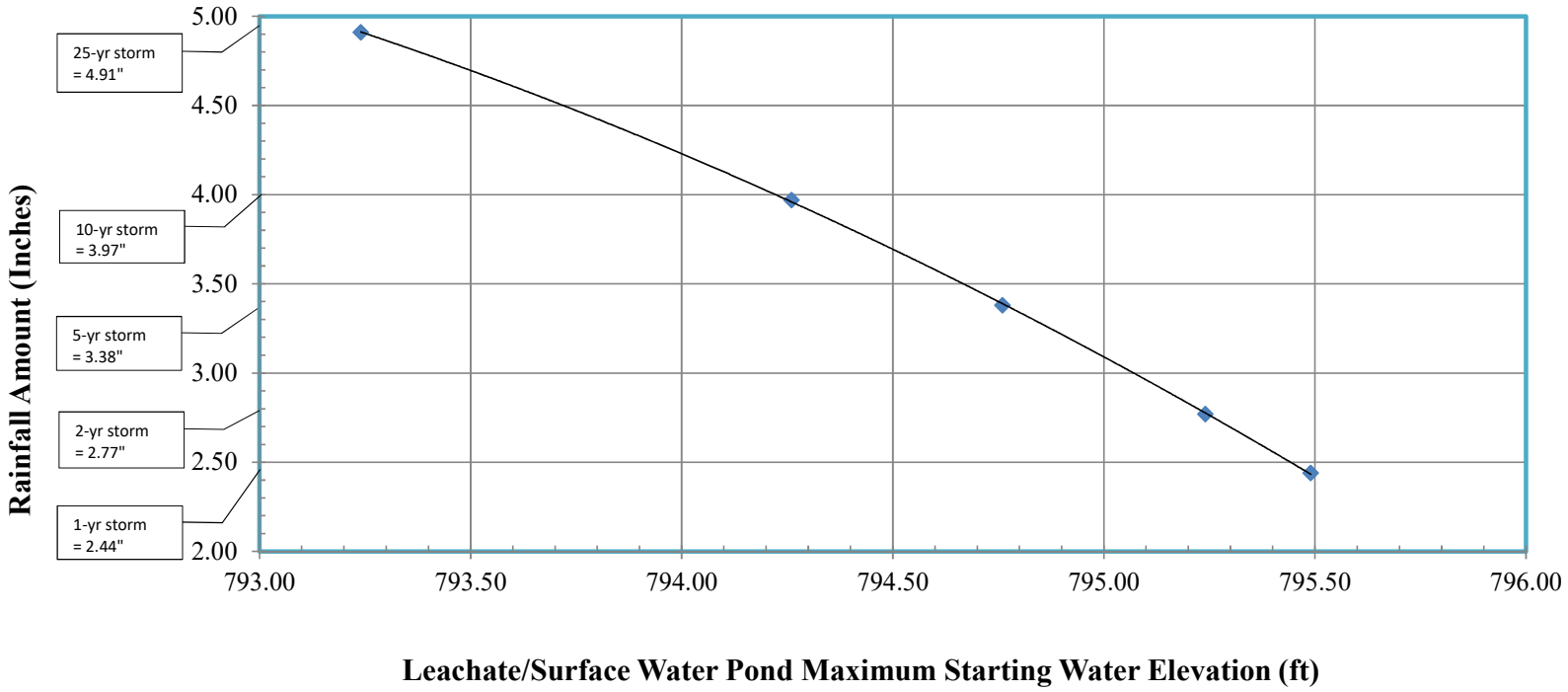
# Figure 3A
# Columbia Energy Center
# Phase 2 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.69 acres.
   - Leachate/Surface Water Pond Area, 2.98 acres.
5. Maximum open area per HydroCAD model during filling is 8.51 acres.

I:\25220183.00\Data and Calculations\Leachate_Surface Water Pond Evaluation\Issued for Permitting_POO Update\

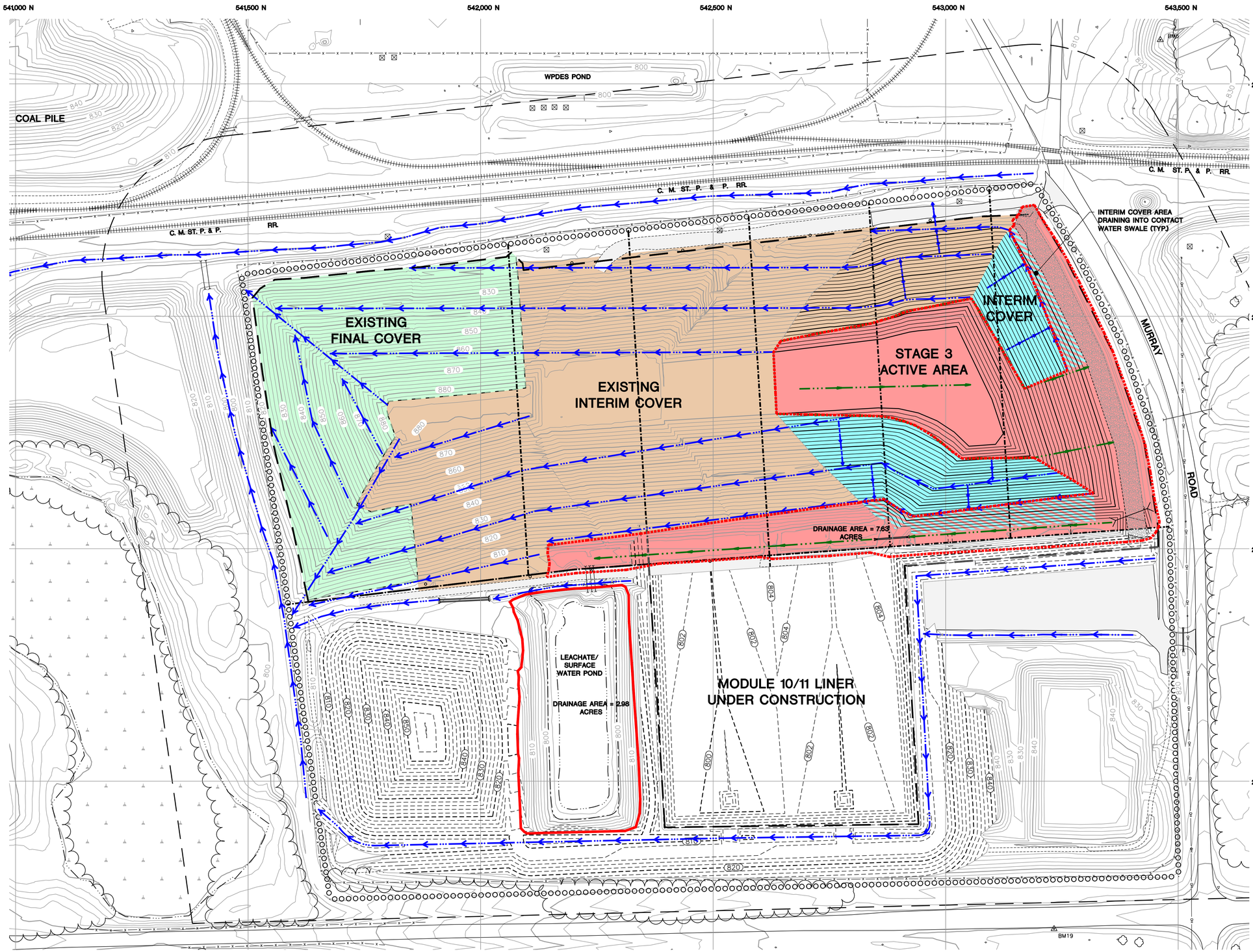
**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (10' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA |
|---|---|---|
| 1 | 121,600 CY | |
| 2 | 151,100 CY | |
| 3 | 107,300 CY | 7.2 ACRES |
| 4 | | |
| TOTAL | 380,000 CY | 7.2 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.




N

100 0 100

SCALE: 1" = 100'

| | |
|---|---|
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/09/2022 |

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 FORT ROAD
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ENGINEER

PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
DRY ASH DISPOSAL FACILITY
COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

SITE

STAGE 3 – FILLING MODULES 5 AND 6

FIGURE

4

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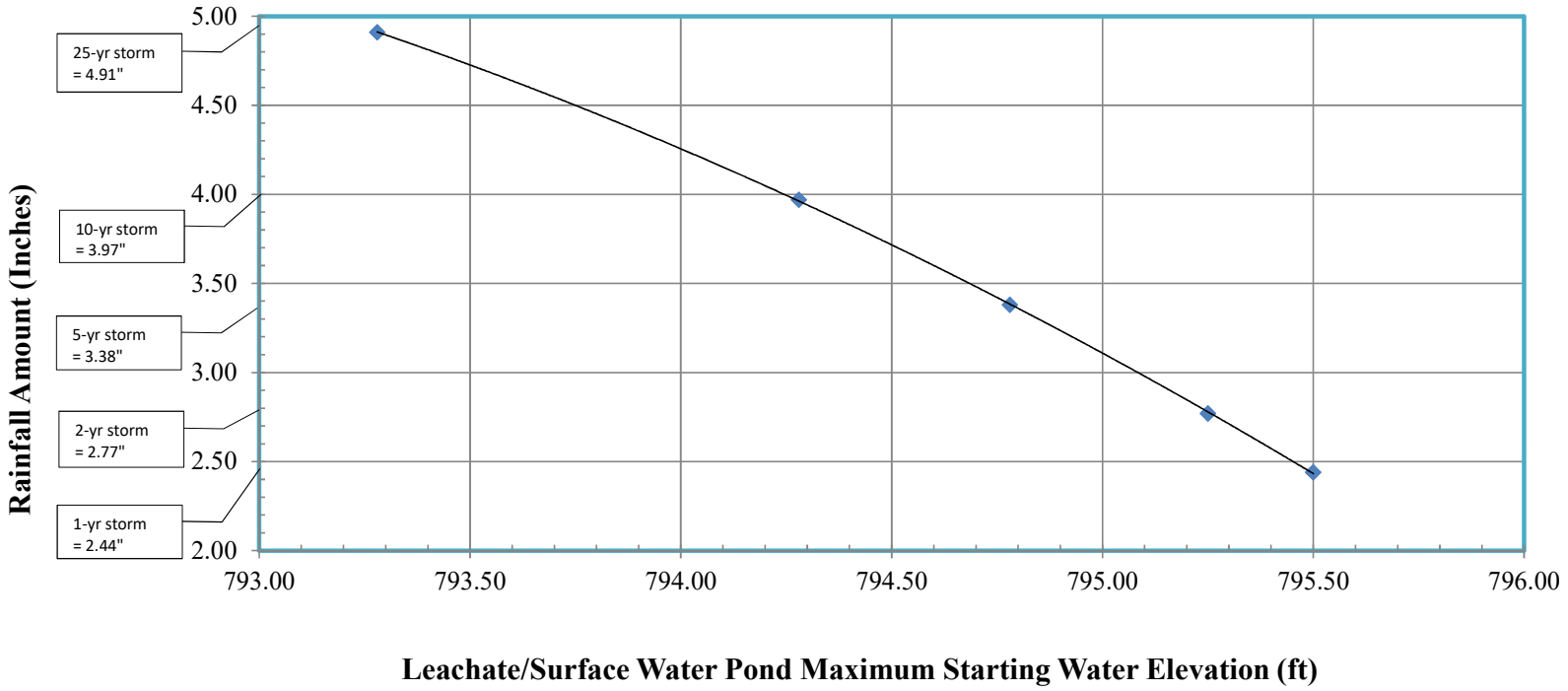
# Figure 4A
# Columbia Energy Center
# Phase 3 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation




Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 7.64 acres.
   - Leachate/Surface Water Pond Area, 2.98 acres.
5. Maximum open area per HydroCAD model during filling is 8.51 acres.

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**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- 840 — PROPOSED WASTE GRADE (10' INTERVAL)
- PROPOSED WASTE GRADE (2' INTERVAL)
- 840 — PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (10' INTERVAL)
- PROPOSED MODULE 10 AND 11 SUBBASE AND PERIMETER WASTE GRADE (2' INTERVAL)
- EXISTING CONTACT WATER DRAINAGE
- PROPOSED CONTACT WATER DRAINAGE
- PROPOSED OPEN LANDFILL DRAINAGE AREA
- PROPOSED LEACHATE/SURFACE WATER DRAINAGE AREA

| FILLING SEQUENCE | ESTIMATED AIRSPACE VOLUME | ESTIMATED OPEN AREA |
|---|---|---|
| 1 | 121,600 CY | |
| 2 | 151,100 CY | |
| 3 | 107,300 CY | |
| 4 | 471,600 cy | 7.3 ACRES |
| TOTAL | 851,600 CY | 7.3 ACRES |

**NOTES:**

1. SEE SHEET 2 FOR BASE MAP LEGEND ITEMS AND NOTES.
2. PROPOSED GRADES ARE CONCEPTUAL. ACTUAL GRADES WILL BE BASED ON PRIMARY AND SECONDARY ASH POND EXCAVATION PRODUCTION RATES, WEATHER, AND PLANT OPERATIONS.
3. THE POND CLOSURE CONTRACTOR WILL CONSTRUCT ADDITIONAL ACCESS ROADS AS NEEDED TO PLACE MATERIAL IN THE ADF.

N

100 0 100

SCALE: 1" = 100'

541,000 N 541,500 N 542,000 N 542,500 N 543,000 N 543,500 N

2,123,500 E 2,124,000 E 2,124,500 E 2,125,000 E

COAL PILE

WPDES POND

C. M. ST. P. & P. RR.

EXISTING FINAL COVER

EXISTING INTERIM COVER

INTERIM COVER

STAGE 4 ACTIVE AREA

DRAINAGE AREA = 8.44 ACRES

LEACHATE/ SURFACE WATER POND

DRAINAGE AREA = 2.98 ACRES

MODULE 10/11 LINER

PUMP CONTACT WATER TO LEACHATE POND

CONTACT WATER CULVERT TO BE REMOVED

TEMPORARY CONTACT WATER STORAGE AREA, USE WELL GRADED MATERAIL FOR 3' THICK FROST PROTECTION LAYER, NO CCR ABOVE FROST PROTECTION LAYER

MURRAY ROAD

BM19

PM6

| | |
|---|---|
| DRAWN BY: | KP |
| CHECKED BY: | PEG/MJT |
| APPROVED BY: | MRH 05/25/2022 |
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/15/2022 |
| REVISED: | 05/11/2022 |

WISCONSIN POWER AND LIGHT COMPANY
COLUMBIA ENERGY CENTER
W8375 FISH HATCHERY ROAD
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CLIENT

SCS ENGINEERS
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PLAN MODIFICATION REQUEST / PLAN OF OPERATION UPDATE
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COLUMBIA ENERGY CENTER
TOWN OF PACIFIC, WISCONSIN

SITE

STAGE 4 – FILLING MODULES 10 AND 11

FIGURE 5

I:\25220183.00\Drawings\Plan of Operation Update\Fill Sq - Annual Landfills - Cell Landfills\ Filling Sq - Annual Stage 4.dwg
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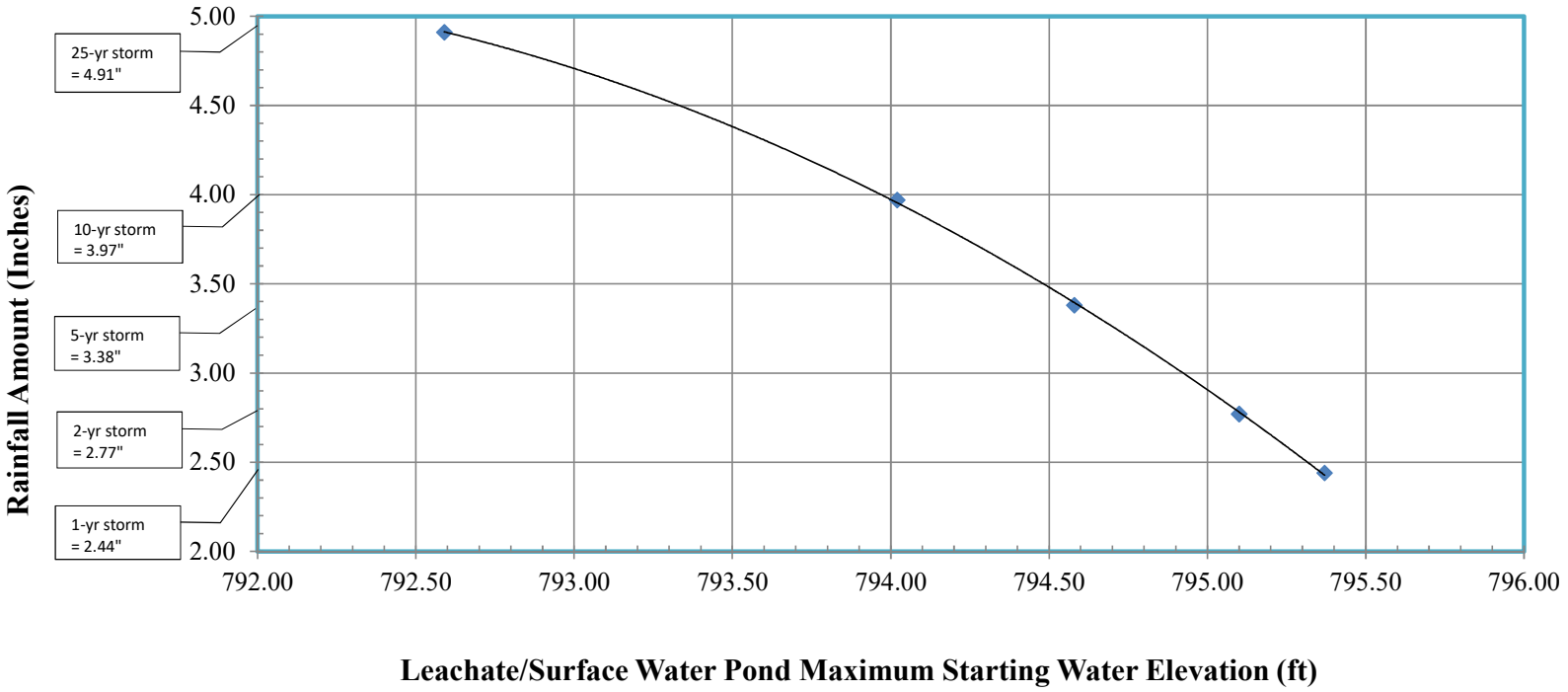
# Figure 5A
# Columbia Energy Center
# Phase 4 Filling- Open Landfill Area
# Leachate/Surface Water Pond Maximum Starting Water Elevation

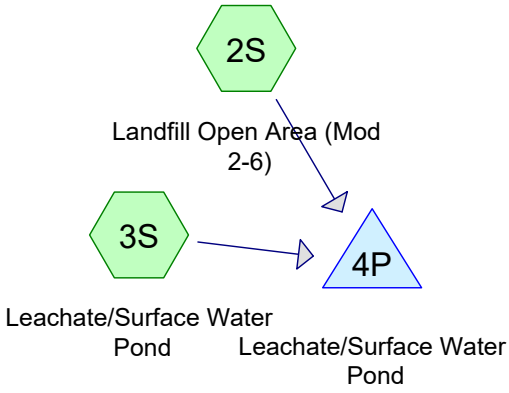


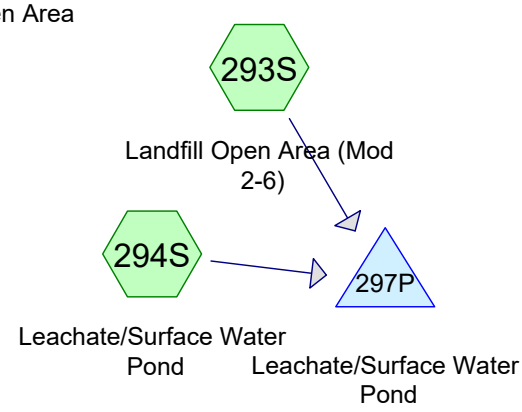

Notes/Assumptions:

1. Maximum starting water elevations based on 2011 Mod 2 as-built survey which determined the top of pond liner elevation = 796.97.
2. Maximum starting water elevation assumes no freeboard.
3. Previously developed HydroCAD model utilized with curve number for intermediate cover areas and ash surfaces assumed at CN = 98.
4. HydroCAD model assumes drainage areas contributing to pond include (Figure 1):
   - Landfill open area = 8.44 acres.
   - Leachate/Surface Water Pond Area, 2.98 acres.
5. Maximum open area per HydroCAD model during filling is 8.51 acres.

I:\25220183.00\Data and Calculations\Leachate_Surface Water Pond Evaluation\Issued for Permitting_POO Update\

Maximum Open Area

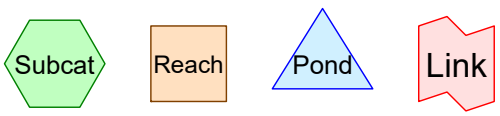



**Phase 0 Filling** **Phase 1 Filling**

**Phase 2 Filling** **Phase 3 Filling**

**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 2S: Landfill Open Area** Runoff Area=7.780 ac 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.75 cfs 3.030 af

**Subcatchment 3S: Leachate/Surface** Runoff Area=3.710 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=26.38 cfs 1.445 af

**Subcatchment 293S: Landfill Open Area** Runoff Area=8.510 ac 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=34.73 cfs 3.314 af

**Subcatchment 294S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Pond 4P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,946 cf Inflow=40.23 cfs 4.475 af
Outflow=0.00 cfs 0.000 af

**Pond 297P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,946 cf Inflow=39.03 cfs 4.475 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 2S: Landfill Open Area (Mod 2-6)

Runoff = 31.75 cfs @ 12.28 hrs, Volume= 3.030 af, Depth= 4.67"
Routed to Pond 4P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 7.075 | 98 | Mod 2 - 6 Open Area |
| * | 0.705 | 98 | Access Road |
| | 7.780 | 98 | Weighted Average |
| | 7.780 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 3S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.38 cfs @ 12.04 hrs, Volume= 1.445 af, Depth= 4.67"
Routed to Pond 4P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.710 | 98 | Leachate Surface Water Pond |
| | 3.710 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 293S: Landfill Open Area (Mod 2-6)

Runoff = 34.73 cfs @ 12.28 hrs, Volume= 3.314 af, Depth= 4.67"
Routed to Pond 297P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 8.510 | 98 | Mod 2 - 11 Open Area |
| | 8.510 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 294S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 297P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 4P: Leachate/Surface Water Pond

Inflow Area = 11.490 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 40.23 cfs @ 12.06 hrs, Volume= 4.475 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,611 sf Storage= 197,946 cf (194,915 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 297P: Leachate/Surface Water Pond

Inflow Area = 11.490 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 39.03 cfs @ 12.27 hrs, Volume= 4.475 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,611 sf Storage= 197,946 cf (194,915 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

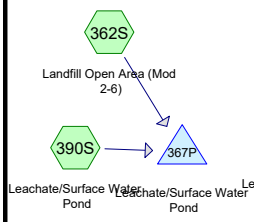
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

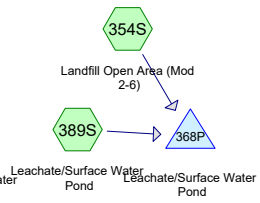
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**1-Year Storm Analysis**

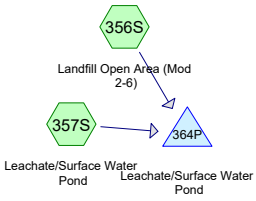
**Phase 0 Filling**



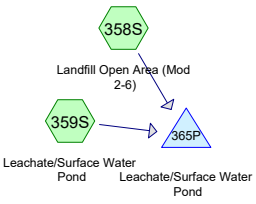

**Phase 1 Filling**



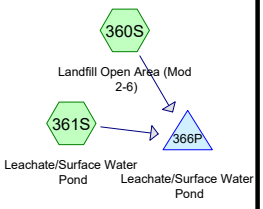

**Phase 2 Filling**

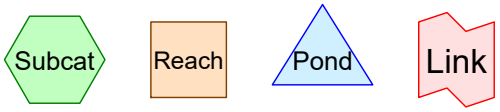



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 354S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=15.52 cfs 1.434 af

**Subcatchment 356S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=15.34 cfs 1.417 af

**Subcatchment 357S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=10.38 cfs 0.549 af

**Subcatchment 358S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=15.23 cfs 1.407 af

**Subcatchment 359S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=10.38 cfs 0.549 af

**Subcatchment 360S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=16.84 cfs 1.556 af

**Subcatchment 361S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=10.38 cfs 0.549 af

**Subcatchment 362S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=2.21"
Tc=20.0 min CN=98 Runoff=14.87 cfs 1.374 af

**Subcatchment 389S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.91 cfs 0.683 af

**Subcatchment 390S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.21"
Tc=0.0 min CN=98 Runoff=12.91 cfs 0.683 af

**Pond 364P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,850 cf Inflow=17.45 cfs 1.966 af
Outflow=0.00 cfs 0.000 af

**Pond 365P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,930 cf Inflow=17.34 cfs 1.956 af
Outflow=0.00 cfs 0.000 af

**Pond 366P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,593 cf Inflow=18.94 cfs 2.105 af
Outflow=0.00 cfs 0.000 af

**Pond 367P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,577 cf Inflow=19.31 cfs 2.056 af
Outflow=0.00 cfs 0.000 af

**Pond 368P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,611 cf Inflow=19.60 cfs 2.117 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 354S: Landfill Open Area (Mod 2-6)

Runoff = 15.52 cfs @ 12.29 hrs, Volume= 1.434 af, Depth= 2.21"
Routed to Pond 368P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 356S: Landfill Open Area (Mod 2-6)

Runoff = 15.34 cfs @ 12.29 hrs, Volume= 1.417 af, Depth= 2.21"
Routed to Pond 364P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 357S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.38 cfs @ 12.04 hrs, Volume= 0.549 af, Depth= 2.21"
Routed to Pond 364P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 358S: Landfill Open Area (Mod 2-6)

Runoff = 15.23 cfs @ 12.29 hrs, Volume= 1.407 af, Depth= 2.21"
Routed to Pond 365P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 359S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.38 cfs @ 12.04 hrs, Volume= 0.549 af, Depth= 2.21"
Routed to Pond 365P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 360S: Landfill Open Area (Mod 2-6)

Runoff = 16.84 cfs @ 12.29 hrs, Volume= 1.556 af, Depth= 2.21"
Routed to Pond 366P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 361S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.38 cfs @ 12.04 hrs, Volume= 0.549 af, Depth= 2.21"
Routed to Pond 366P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 362S: Landfill Open Area (Mod 2-6)

Runoff = 14.87 cfs @ 12.29 hrs, Volume= 1.374 af, Depth= 2.21"
Routed to Pond 367P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 389S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.91 cfs @ 12.04 hrs, Volume= 0.683 af, Depth= 2.21"
Routed to Pond 368P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 390S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 12.91 cfs @ 12.04 hrs, Volume= 0.683 af, Depth= 2.21"
Routed to Pond 367P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 1-yr, 24-hr storm Rainfall=2.44"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 364P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 17.45 cfs @ 12.27 hrs, Volume= 1.966 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.49' Surf.Area= 52,866 sf Storage= 112,201 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,604 sf Storage= 197,850 cf (85,648 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (85,446 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 365P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 17.34 cfs @ 12.27 hrs, Volume= 1.956 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.50' Surf.Area= 52,945 sf Storage= 112,730 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,610 sf Storage= 197,930 cf (85,199 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (84,917 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 366P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 18.94 cfs @ 12.27 hrs, Volume= 2.105 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.37' Surf.Area= 51,921 sf Storage= 105,914 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,593 cf (91,679 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (91,733 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 367P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 19.31 cfs @ 12.05 hrs, Volume= 2.056 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.41' Surf.Area= 52,236 sf Storage= 107,997 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,582 sf Storage= 197,577 cf (89,579 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (89,650 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 368P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 2.21" for 1-yr, 24-hr storm event
Inflow = 19.60 cfs @ 12.06 hrs, Volume= 2.117 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.36' Surf.Area= 51,842 sf Storage= 105,395 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,585 sf Storage= 197,611 cf (92,216 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (92,252 cf above start)

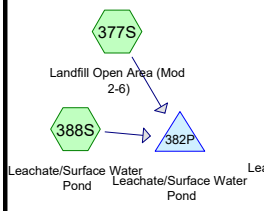
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

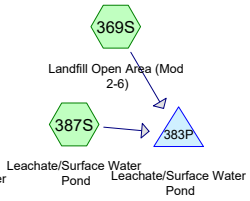
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## 2-Year Storm Analysis

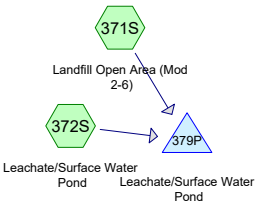
**Phase 0 Filling**



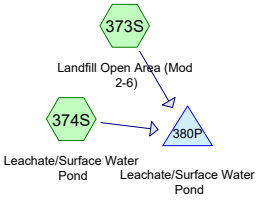

**Phase 1 Filling**



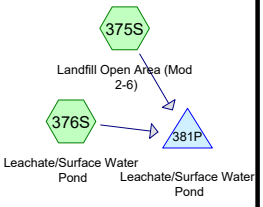

**Phase 2 Filling**

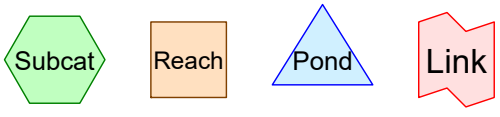



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 369S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=17.70 cfs 1.647 af

**Subcatchment 371S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=17.49 cfs 1.628 af

**Subcatchment 372S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=11.83 cfs 0.631 af

**Subcatchment 373S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=17.37 cfs 1.616 af

**Subcatchment 374S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=11.83 cfs 0.631 af

**Subcatchment 375S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=19.20 cfs 1.787 af

**Subcatchment 376S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=11.83 cfs 0.631 af

**Subcatchment 377S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=2.54"
Tc=20.0 min CN=98 Runoff=16.96 cfs 1.578 af

**Subcatchment 387S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.72 cfs 0.784 af

**Subcatchment 388S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=2.54"
Tc=0.0 min CN=98 Runoff=14.72 cfs 0.784 af

**Pond 379P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,593 cf Inflow=19.90 cfs 2.258 af
Outflow=0.00 cfs 0.000 af

**Pond 380P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,587 cf Inflow=19.77 cfs 2.246 af
Outflow=0.00 cfs 0.000 af

**Pond 381P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,471 cf Inflow=21.61 cfs 2.417 af
Outflow=0.00 cfs 0.000 af

**Pond 382P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,558 cf Inflow=22.04 cfs 2.362 af
Outflow=0.00 cfs 0.000 af

**Pond 383P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,589 cf Inflow=22.37 cfs 2.431 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 369S: Landfill Open Area (Mod 2-6)

Runoff = 17.70 cfs @ 12.29 hrs, Volume= 1.647 af, Depth= 2.54"
Routed to Pond 383P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 371S: Landfill Open Area (Mod 2-6)

Runoff = 17.49 cfs @ 12.29 hrs, Volume= 1.628 af, Depth= 2.54"
Routed to Pond 379P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 372S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 11.83 cfs @ 12.04 hrs, Volume= 0.631 af, Depth= 2.54"
Routed to Pond 379P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 373S: Landfill Open Area (Mod 2-6)

Runoff = 17.37 cfs @ 12.29 hrs, Volume= 1.616 af, Depth= 2.54"
Routed to Pond 380P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 374S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 11.83 cfs @ 12.04 hrs, Volume= 0.631 af, Depth= 2.54"
Routed to Pond 380P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 375S: Landfill Open Area (Mod 2-6)

Runoff = 19.20 cfs @ 12.29 hrs, Volume= 1.787 af, Depth= 2.54"
Routed to Pond 381P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 376S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 11.83 cfs @ 12.04 hrs, Volume= 0.631 af, Depth= 2.54"
Routed to Pond 381P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 377S: Landfill Open Area (Mod 2-6)

Runoff = 16.96 cfs @ 12.29 hrs, Volume= 1.578 af, Depth= 2.54"
Routed to Pond 382P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 387S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.72 cfs @ 12.04 hrs, Volume= 0.784 af, Depth= 2.54"
Routed to Pond 383P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 388S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.72 cfs @ 12.04 hrs, Volume= 0.784 af, Depth= 2.54"
Routed to Pond 382P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 2-yr, 24-hr storm Rainfall=2.77"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 379P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 19.90 cfs @ 12.27 hrs, Volume= 2.258 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.24' Surf.Area= 50,897 sf Storage= 99,231 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,593 cf (98,362 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (98,416 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 380P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 19.77 cfs @ 12.27 hrs, Volume= 2.246 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.25' Surf.Area= 50,975 sf Storage= 99,740 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,587 cf (97,847 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (97,907 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 381P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 21.61 cfs @ 12.27 hrs, Volume= 2.417 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.10' Surf.Area= 49,793 sf Storage= 92,183 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,574 sf Storage= 197,471 cf (105,288 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (105,464 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 382P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 22.04 cfs @ 12.05 hrs, Volume= 2.362 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.15' Surf.Area= 50,187 sf Storage= 94,682 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,581 sf Storage= 197,558 cf (102,876 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (102,965 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 383P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 2.54" for 2-yr, 24-hr storm event
Inflow = 22.37 cfs @ 12.06 hrs, Volume= 2.431 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 795.09' Surf.Area= 49,715 sf Storage= 91,685 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,583 sf Storage= 197,589 cf (105,904 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (105,962 cf above start)

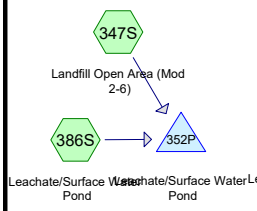
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

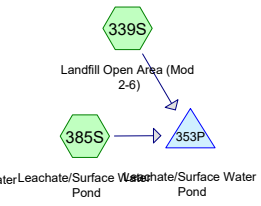
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**5-Year Storm Analysis**

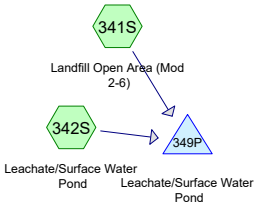
**Phase 0 Filling**



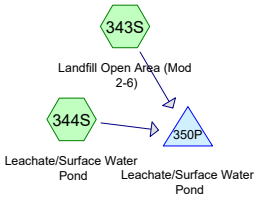

**Phase 1 Filling**



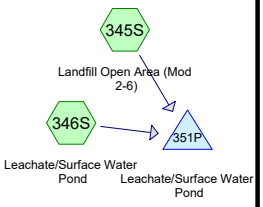

**Phase 2 Filling**

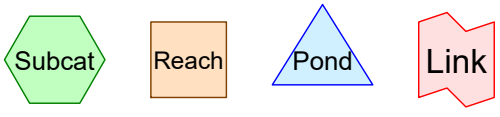



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 339S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=21.73 cfs 2.041 af

**Subcatchment 341S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=21.47 cfs 2.017 af

**Subcatchment 342S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=14.51 cfs 0.781 af

**Subcatchment 343S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=21.31 cfs 2.002 af

**Subcatchment 344S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=14.51 cfs 0.781 af

**Subcatchment 345S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=23.57 cfs 2.214 af

**Subcatchment 346S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=14.51 cfs 0.781 af

**Subcatchment 347S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=3.15"
Tc=20.0 min CN=98 Runoff=20.81 cfs 1.955 af

**Subcatchment 385S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.04 cfs 0.972 af

**Subcatchment 386S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.15"
Tc=0.0 min CN=98 Runoff=18.04 cfs 0.972 af

**Pond 349P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,605 cf Inflow=24.41 cfs 2.798 af
Outflow=0.00 cfs 0.000 af

**Pond 350P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,910 cf Inflow=24.26 cfs 2.784 af
Outflow=0.00 cfs 0.000 af

**Pond 351P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,834 cf Inflow=26.51 cfs 2.995 af
Outflow=0.00 cfs 0.000 af

**Pond 352P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,602 cf Inflow=27.07 cfs 2.927 af
Outflow=0.00 cfs 0.000 af

**Pond 353P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,686 cf Inflow=27.48 cfs 3.013 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 339S: Landfill Open Area (Mod 2-6)

Runoff = 21.73 cfs @ 12.29 hrs, Volume= 2.041 af, Depth= 3.15"
Routed to Pond 353P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 341S: Landfill Open Area (Mod 2-6)

Runoff = 21.47 cfs @ 12.29 hrs, Volume= 2.017 af, Depth= 3.15"
Routed to Pond 349P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 342S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.51 cfs @ 12.04 hrs, Volume= 0.781 af, Depth= 3.15"
Routed to Pond 349P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 343S: Landfill Open Area (Mod 2-6)

Runoff = 21.31 cfs @ 12.29 hrs, Volume= 2.002 af, Depth= 3.15"
Routed to Pond 350P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 344S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.51 cfs @ 12.04 hrs, Volume= 0.781 af, Depth= 3.15"
Routed to Pond 350P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 345S: Landfill Open Area (Mod 2-6)

Runoff = 23.57 cfs @ 12.29 hrs, Volume= 2.214 af, Depth= 3.15"
Routed to Pond 351P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 346S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.51 cfs @ 12.04 hrs, Volume= 0.781 af, Depth= 3.15"
Routed to Pond 351P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 347S: Landfill Open Area (Mod 2-6)

Runoff = 20.81 cfs @ 12.29 hrs, Volume= 1.955 af, Depth= 3.15"
Routed to Pond 352P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 385S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.04 cfs @ 12.04 hrs, Volume= 0.972 af, Depth= 3.15"
Routed to Pond 353P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 386S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 18.04 cfs @ 12.04 hrs, Volume= 0.972 af, Depth= 3.15"
Routed to Pond 352P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 5-yr, 24-hr storm Rainfall=3.38"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 349P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 24.41 cfs @ 12.27 hrs, Volume= 2.798 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.76' Surf.Area= 47,114 sf Storage= 75,708 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,584 sf Storage= 197,605 cf (121,897 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (121,939 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 350P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 24.26 cfs @ 12.27 hrs, Volume= 2.784 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.78' Surf.Area= 47,272 sf Storage= 76,652 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,608 sf Storage= 197,910 cf (121,257 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (120,995 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 351P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 26.51 cfs @ 12.27 hrs, Volume= 2.995 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.58' Surf.Area= 45,696 sf Storage= 67,355 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,602 sf Storage= 197,834 cf (130,479 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (130,292 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 352P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 27.07 cfs @ 12.05 hrs, Volume= 2.927 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.64' Surf.Area= 46,169 sf Storage= 70,111 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,584 sf Storage= 197,602 cf (127,491 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (127,536 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 353P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 3.15" for 5-yr, 24-hr storm event
Inflow = 27.48 cfs @ 12.06 hrs, Volume= 3.013 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

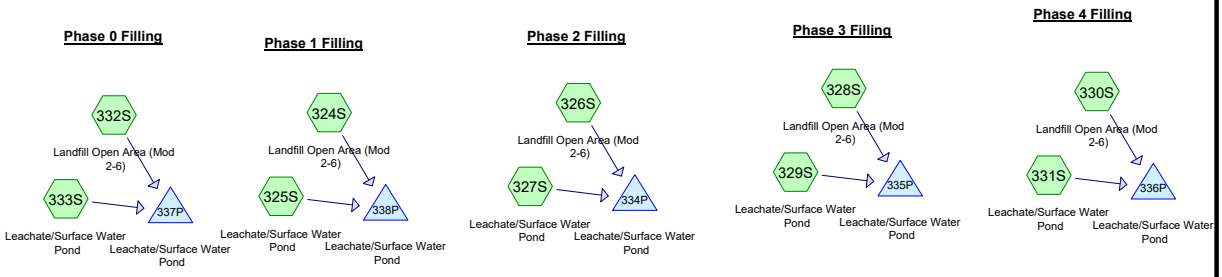
Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.56' Surf.Area= 45,539 sf Storage= 66,443 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,591 sf Storage= 197,686 cf (131,243 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (131,204 cf above start)

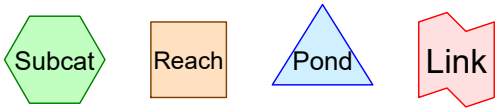
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**10-Year Storm Analysis**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 324S: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=25.60 cfs 2.423 af

**Subcatchment 325S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.25 cfs 1.154 af

**Subcatchment 326S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=25.30 cfs 2.394 af

**Subcatchment 327S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=17.09 cfs 0.928 af

**Subcatchment 328S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=25.12 cfs 2.377 af

**Subcatchment 329S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=17.09 cfs 0.928 af

**Subcatchment 330S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=27.77 cfs 2.628 af

**Subcatchment 331S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=17.09 cfs 0.928 af

**Subcatchment 332S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=3.74"
Tc=20.0 min CN=98 Runoff=24.52 cfs 2.320 af

**Subcatchment 333S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=3.74"
Tc=0.0 min CN=98 Runoff=21.25 cfs 1.154 af

**Pond 334P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,822 cf Inflow=28.77 cfs 3.322 af
Outflow=0.00 cfs 0.000 af

**Pond 335P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,929 cf Inflow=28.58 cfs 3.304 af
Outflow=0.00 cfs 0.000 af

**Pond 336P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,874 cf Inflow=31.24 cfs 3.555 af
Outflow=0.00 cfs 0.000 af

**Pond 337P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,655 cf Inflow=31.91 cfs 3.474 af
Outflow=0.00 cfs 0.000 af

**Pond 338P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,547 cf Inflow=32.39 cfs 3.576 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 324S: Landfill Open Area (Mod 2-6)

Runoff = 25.60 cfs @ 12.29 hrs, Volume= 2.423 af, Depth= 3.74"
Routed to Pond 338P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 325S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.25 cfs @ 12.04 hrs, Volume= 1.154 af, Depth= 3.74"
Routed to Pond 338P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 326S: Landfill Open Area (Mod 2-6)

Runoff = 25.30 cfs @ 12.29 hrs, Volume= 2.394 af, Depth= 3.74"
Routed to Pond 334P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 327S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 17.09 cfs @ 12.04 hrs, Volume= 0.928 af, Depth= 3.74"
Routed to Pond 334P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 328S: Landfill Open Area (Mod 2-6)

Runoff = 25.12 cfs @ 12.29 hrs, Volume= 2.377 af, Depth= 3.74"
Routed to Pond 335P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 329S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 17.09 cfs @ 12.04 hrs, Volume= 0.928 af, Depth= 3.74"
Routed to Pond 335P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 330S: Landfill Open Area (Mod 2-6)

Runoff = 27.77 cfs @ 12.29 hrs, Volume= 2.628 af, Depth= 3.74"
Routed to Pond 336P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 331S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 17.09 cfs @ 12.04 hrs, Volume= 0.928 af, Depth= 3.74"
Routed to Pond 336P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 332S: Landfill Open Area (Mod 2-6)

Runoff = 24.52 cfs @ 12.29 hrs, Volume= 2.320 af, Depth= 3.74"
Routed to Pond 337P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 333S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.25 cfs @ 12.04 hrs, Volume= 1.154 af, Depth= 3.74"
Routed to Pond 337P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 10-yr, 24-hr storm Rainfall=3.97"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 334P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 28.77 cfs @ 12.27 hrs, Volume= 3.322 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.26' Surf.Area= 43,175 sf Storage= 53,136 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,601 sf Storage= 197,822 cf (144,686 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (144,511 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 335P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 28.58 cfs @ 12.27 hrs, Volume= 3.304 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.28' Surf.Area= 43,332 sf Storage= 54,001 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,610 sf Storage= 197,929 cf (143,927 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (143,646 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 336P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 31.24 cfs @ 12.27 hrs, Volume= 3.555 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.02' Surf.Area= 41,284 sf Storage= 43,001 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,605 sf Storage= 197,874 cf (154,873 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (154,646 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 337P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 31.91 cfs @ 12.05 hrs, Volume= 3.474 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 794.10' Surf.Area= 41,914 sf Storage= 46,329 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,588 sf Storage= 197,655 cf (151,326 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (151,318 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 338P: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 3.74" for 10-yr, 24-hr storm event
Inflow = 32.39 cfs @ 12.06 hrs, Volume= 3.576 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.99' Surf.Area= 40,926 sf Storage= 41,767 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,580 sf Storage= 197,547 cf (155,781 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (155,880 cf above start)

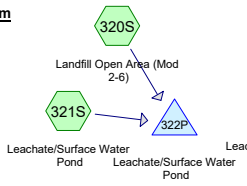
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

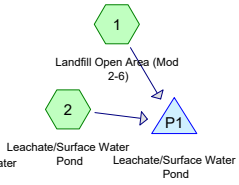
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

**25-Year Storm Analysis**

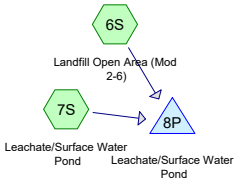
**Phase 0 Filling**



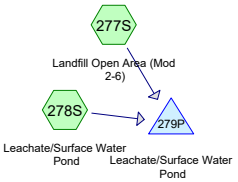

**Phase 1 Filling**



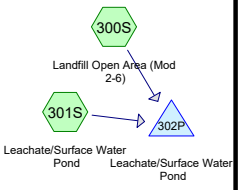

**Phase 2 Filling**

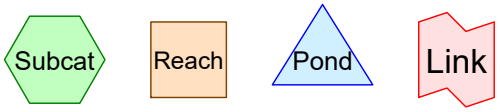



**Phase 3 Filling**




**Phase 4 Filling**




**Routing Diagram for WPL Columbia_Leachate Pond Evaluation_220525**
Prepared by SCS Engineers, Printed 5/25/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-33.00 hrs, dt=0.05 hrs, 661 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment 1: Landfill Open Area** Runoff Area=339,047 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.77 cfs 3.031 af

**Subcatchment 2: Leachate/Surface Water** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=26.35 cfs 1.443 af

**Subcatchment 6S: Landfill Open Area** Runoff Area=335,031 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.39 cfs 2.995 af

**Subcatchment 7S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Subcatchment 277S: Landfill Open Area** Runoff Area=332,594 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=31.16 cfs 2.974 af

**Subcatchment 278S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Subcatchment 300S: Landfill Open Area** Runoff Area=367,758 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=34.46 cfs 3.288 af

**Subcatchment 301S: Leachate/Surface** Runoff Area=2.980 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=21.19 cfs 1.161 af

**Subcatchment 320S: Landfill Open Area** Runoff Area=324,737 sf 100.00% Impervious Runoff Depth=4.67"
Tc=20.0 min CN=98 Runoff=30.43 cfs 2.903 af

**Subcatchment 321S: Leachate/Surface** Runoff Area=3.706 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=26.35 cfs 1.443 af

**Pond 8P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,735 cf Inflow=35.69 cfs 4.156 af
Outflow=0.00 cfs 0.000 af

**Pond 279P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,837 cf Inflow=35.46 cfs 4.134 af
Outflow=0.00 cfs 0.000 af

**Pond 302P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,879 cf Inflow=38.75 cfs 4.448 af
Outflow=0.00 cfs 0.000 af

**Pond 322P: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,831 cf Inflow=39.61 cfs 4.347 af
Outflow=0.00 cfs 0.000 af

**Pond P1: Leachate/Surface Water Pond** Peak Elev=796.97' Storage=197,936 cf Inflow=40.21 cfs 4.474 af
Outflow=0.00 cfs 0.000 af

## Summary for Subcatchment 1: Landfill Open Area (Mod 2-6)

Runoff = 31.77 cfs @ 12.28 hrs, Volume= 3.031 af, Depth= 4.67"
Routed to Pond P1 : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 339,047 | 98 | Mod 2 - 6 Open Area |
| | 339,047 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 2: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.35 cfs @ 12.04 hrs, Volume= 1.443 af, Depth= 4.67"
Routed to Pond P1 : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 6S: Landfill Open Area (Mod 2-6)

Runoff = 31.39 cfs @ 12.28 hrs, Volume= 2.995 af, Depth= 4.67"
Routed to Pond 8P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 335,031 | 98 | Mod 2 - 6 Open Area |
| | 335,031 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 7S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 8P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 277S: Landfill Open Area (Mod 2-6)

Runoff = 31.16 cfs @ 12.28 hrs, Volume= 2.974 af, Depth= 4.67"
Routed to Pond 279P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 332,594 | 98 | Mod 2 - 6 Open Area |
| | 332,594 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 278S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 279P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 300S: Landfill Open Area (Mod 2-6)

Runoff = 34.46 cfs @ 12.28 hrs, Volume= 3.288 af, Depth= 4.67"
Routed to Pond 302P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 367,758 | 98 | Mod 2 - 11 Open Area |
| | 367,758 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 301S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.19 cfs @ 12.04 hrs, Volume= 1.161 af, Depth= 4.67"
Routed to Pond 302P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 2.980 | 98 | Leachate Surface Water Pond |
| | 2.980 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment 320S: Landfill Open Area (Mod 2-6)

Runoff = 30.43 cfs @ 12.28 hrs, Volume= 2.903 af, Depth= 4.67"
Routed to Pond 322P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| * | 324,737 | 98 | Mod 2 - 6 Open Area |
| | 324,737 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 20.0 | | | | | **Direct Entry, Estimated** |

## Summary for Subcatchment 321S: Leachate/Surface Water Pond

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 26.35 cfs @ 12.04 hrs, Volume= 1.443 af, Depth= 4.67"
Routed to Pond 322P : Leachate/Surface Water Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr, 24-hr storm Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 3.706 | 98 | Leachate Surface Water Pond |
| | 3.706 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Pond 8P: Leachate/Surface Water Pond

Inflow Area = 10.671 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 35.69 cfs @ 12.27 hrs, Volume= 4.156 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.24' Surf.Area= 25,898 sf Storage= 16,708 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,594 sf Storage= 197,735 cf (181,027 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (180,939 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 279P: Leachate/Surface Water Pond

Inflow Area = 10.615 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 35.46 cfs @ 12.27 hrs, Volume= 4.134 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 793.28' Surf.Area= 26,699 sf Storage= 17,760 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,603 sf Storage= 197,837 cf (180,077 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (179,887 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 302P: Leachate/Surface Water Pond

Inflow Area = 11.423 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 38.75 cfs @ 12.27 hrs, Volume= 4.448 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.59' Surf.Area= 12,873 sf Storage= 4,108 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,606 sf Storage= 197,879 cf (193,772 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (193,540 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond 322P: Leachate/Surface Water Pond

Inflow Area = 11.161 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 39.61 cfs @ 12.05 hrs, Volume= 4.347 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.87' Surf.Area= 18,484 sf Storage= 8,498 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,602 sf Storage= 197,831 cf (189,333 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (189,150 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

## Summary for Pond P1: Leachate/Surface Water Pond

Inflow Area = 11.489 ac,100.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr storm event
Inflow = 40.21 cfs @ 12.06 hrs, Volume= 4.474 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-33.00 hrs, dt= 0.05 hrs
Starting Elev= 792.50' Surf.Area= 11,070 sf Storage= 3,030 cf
Peak Elev= 796.97' @ 25.15 hrs Surf.Area= 61,610 sf Storage= 197,936 cf (194,906 cf above start)
Flood Elev= 796.97' Surf.Area= 61,588 sf Storage= 197,647 cf (194,617 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 792.00' | 405,390 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 792.00 | 1,051 | 0 | 0 |
| 794.00 | 41,126 | 42,177 | 42,177 |
| 796.00 | 56,885 | 98,011 | 140,188 |
| 798.00 | 66,581 | 123,466 | 263,654 |
| 800.00 | 75,155 | 141,736 | 405,390 |

# Appendix A3

# 2022 Module 10 and Module 11 Design and South Sediment Basin Check

**Storm Water Management Calculations**

**Purpose:**
The purpose of the storm water runoff calculations is to demonstrate that the existing storm water sedimentation basin and proposed storm water management features included in the Modules 10 and 11 Plan Modification Request can accommodate and safely convey the runoff from a 25-year, 24-hour storm event during post closure conditions.

Items addressed in these calculations:

- Sedimentation Basin
- Swales
- Culverts
- Diversion Berms
- Downslope Flumes & Energy Dissipaters
- Rock Chutes
- Discharge Aprons

The proposed storm water management conditions are shown on **Figure 1**.

The calculations support the capacity check of the following existing storm water management feature:

| Feature | Purpose | Design Method |
|---|---|---|
| Sedimentation Basin | To safely handle 25-year, 24-hour storm event without overtopping the 100-year, 24-hour emergency spillway. | HydroCAD runoff modeling |
| Swales | Convey storm water runoff from adjacent areas to Culvert C2 and offsite during post construction conditions | HydroCAD runoff modeling and Swale Calculation |
| Culverts | Convey storm water from the final cover perimeter swales during post construction conditions | HydroCAD runoff modeling and HY-8 Culvert Model |
| Diversion Berms | Reduce storm water runoff from long final cover slopes and to divert water to perimeter swales during post construction conditions | HydroCAD runoff modeling and Diversion Berm Calculations |
| Downslope Flumes & Energy Dissipators | Convey storm water from diversion berms down slope to discharge locations during post construction conditions | HydroCAD runoff modeling and Downslope Flume Calculations |
| Rock Chutes | Erosion protection and convey storm water from energy dissipators (Flume 1 and Flume 2) to existing swale during post construction conditions | HydroCAD runoff modeling and Rock Chute Calculation |
| Discharge Aprons | Erosion protection from culvert discharge at culverts | HydroCAD runoff modeling and Riprap Apron Calculation |

**Approach:**
Hydrograph Generation
HydroCAD was used to model the storm water management system and develop the hydrographs

using TR-20 methodologies. The model is designed to simulate the surface runoff response of a watershed to a precipitation event. Input parameters for the model include precipitation depth for the design storm events from NOAA ATLAS 14, contributing drainage areas, runoff curve numbers, and time of concentration.

Swale Sizing
The proposed swales were sized for the 25-year, 24-hour storm event. A spreadsheet based on Manning's equation was used to determine the depth of flow and velocity in the swales based on the swale geometry and peak flow in the swales (as determined by the Hydrograph Generation models).

Culvert Sizing
Culverts were sized for the 25-year, 24-hour storm event using the HY-8 computer model developed by the US Department of Transportation, Federal Highway Administration.

Diversion Berms
Diversion berms were sized for the 25-year, 24-hour storm event using the Manning's Equation to determine the depth of flow and velocity in the swale based on the swale geometry and peak flow for the storm event (as determined by the Hydrograph Generation Calculations).

Downslope Flumes and Energy Dissipaters Sizing
Flumes and energy dissipaters were sized for the 25-year, 24-hour storm event. Manning's equation and the orifice equation were used to size the flumes. Energy dissipaters were sized using tables from the reference book "Hydraulic Design of Energy Dissipaters for Culverts and Channels" US Department of Transportation, Federal Highway Administration, July 2006.

Rock Cute Sizing
Rock chutes were sized for the 25-year, 24-hour storm event. Rock Chutes were sized based on the flow to each culvert location. The Iowa NRCS Rock Chute Design spreadsheet was used to size the chute and riprap.

Discharge Apron Sizing
Riprap aprons were sized for the 25-year, 24-hour storm event using equations in Section 5.2 – Riprap Blanket of WisDOT FDM 13-35-5. The riprap aprons were sized based on the flow to the culvert location. The riprap sizing was used to size the riprap discharge apron.

Basin Sizing
Route the proposed construction and existing drainage runoff through the sedimentation basin to confirm the basin can handle the 25-year, 24-hour storm event. HydroCAD was used to model the runoff flow through the basin outfall (as determined by the Hydrograph Generation model).

**Key Assumptions:**

- Drainage areas and time of concentration flow paths are as shown on **Figure 1** for Post Construction Conditions.
- An MSE4 rainfall distribution was used based on NRCS Wisconsin rainfall distribution regions. The precipitation depth for the 25-year, 24-hour storm was assumed to be 4.91 inches, based on NOAA ATLAS 14 Point Precipitation Frequency Estimates (NOAA's National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server).

- Runoff curve numbers were based on tables presented in Urban Hydrology for Small Watersheds, and were assumed as follows and as listed in the modeling.

| Cover Type | CN |
|---|---|
| Final Cover | 69 – Pasture/grassland/range in good condition, hydrologic soil group (HSG) C/B (assumed mid value between each soil group) |
| Pasture, grassland or range | 39 – Pasture/grassland/range, Good, HSG A |
| Rain Cover | 98 – Rain Cover (plastic smooth material) |
| Pavement | 98 – impervious HSG A |
| Gravel | 96 – Gravel, HSG A |

- Type A soil group for non-disturbed areas outside the landfill as soils are loamy sand.
- Other assumptions are included with the calculations attached to this appendix.

**Results:**

Hydrograph Generation

The hydrograph modeling results for the 25-year and 100-year, 24-hour storm events are included in the Post Construction Conditions Hydrograph Generation section.

Basin Sizing

The existing sedimentation basin has the capacity to safely contain the 25-year, 24-hour storm event and safely pass the 100-year, 24-hour storm event through the emergency spillway. Refer to the Basin Sizing section.

Swale Sizing

The proposed swales will be constructed as shown on the Drawings. The swales have the capacity to safely convey the both the 25-year, 24-hour storm events and maintain a minimum 0.5 foot of freeboard. Refer to the Swale Sizing section.
Appropriate erosion control product was selected based on the velocities and shear stress in the swales. Refer to the Swale Sizing section below for the evaluation.

Culvert Sizing

Culverts will be as shown in the Drawings. The culverts have the capacity to safely convey the 25-year, 24-hour storm event. Refer to the Culvert Sizing Section for the detailed calculations.

Diversion Berm Sizing

The proposed final berms will be constructed as shown on the Drawings. The diversion berms will contain the runoff from the 25-year, 24-hour storm event. Refer to the Diversion Berm Design section.

Downslope Flume and Energy Dissipater Sizing

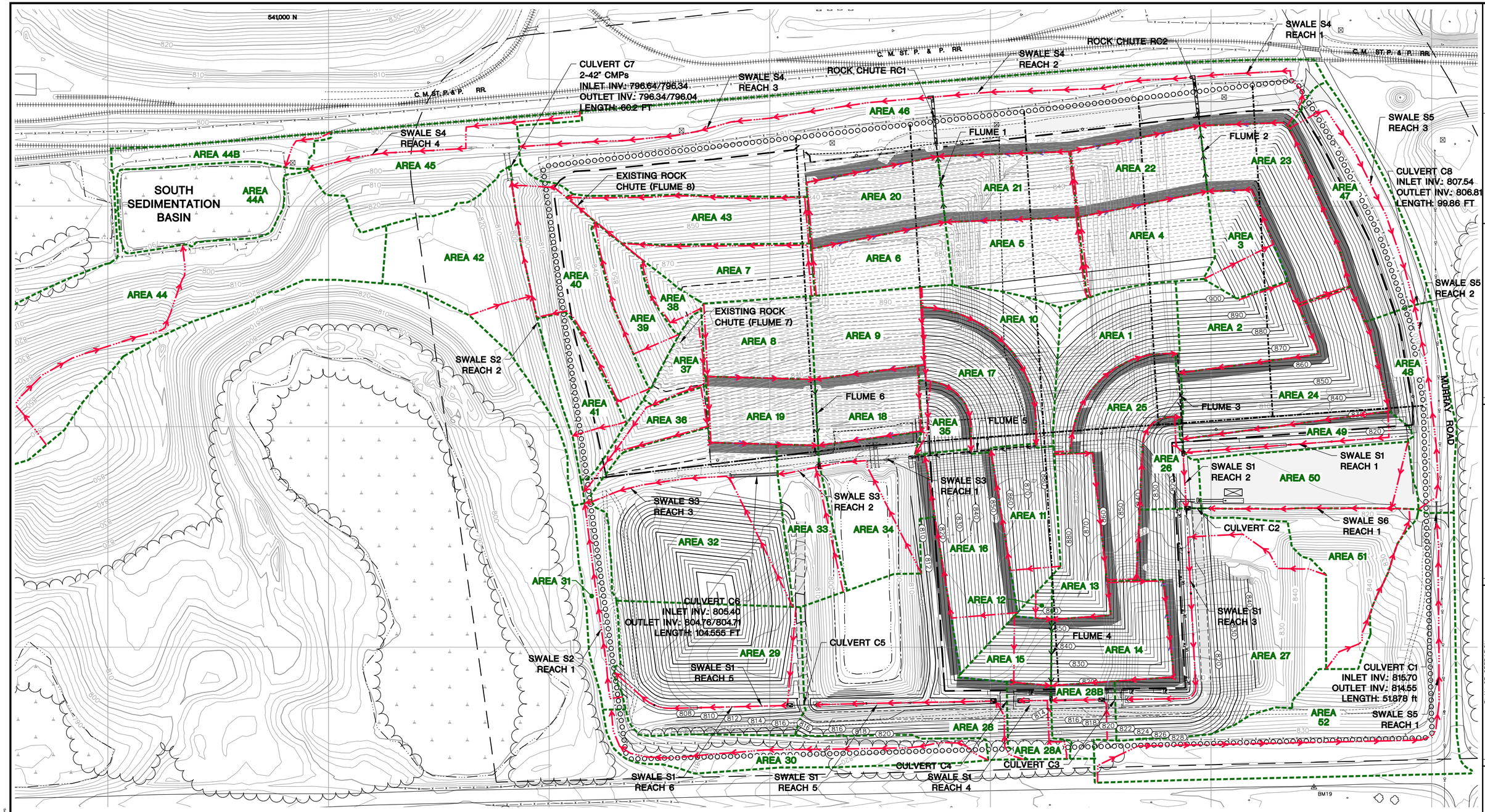
The downslope flumes and energy dissipaters will be constructed as shown on the Drawings. The downslope flumes are designed to contain the runoff from the 25-year, 24-hour storm event. Energy dissipaters at the bottom of the downslope flumes have been designed to handle the peak velocities. Refer to the Downslope Flume and Energy Dissipater Sizing section below for detailed calculations.

Rock Chute Sizing

The proposed rock chutes will be constructed as shown in the Drawings. The rock chutes will accommodate the runoff from the 25-year, 24-hour storm event. Refer to the Rock Chute Sizing section.

Discharge Apron Sizing

The proposed riprap aprons will be constructed as shown in the Drawings. The aprons will accommodate the runoff from the 25-year, 24-hour storm event. Refer to Discharge Apron Sizing for design calculations.




**LEGEND**

- DRY ASH DISPOSAL FACILITY LIMITS
- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- FINAL COVER LIMITS
- APPROXIMATE INTERMEDIATE COVER LIMITS/AREA
- PAVED ROAD
- UNPAVED ROAD
- VEGETATION
- FENCE
- 810 EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- 840 PROPOSED PHASE 1 FINAL GRADE (10' INTERVAL)
- PROPOSED PHASE 1 FINAL GRADE (2' INTERVAL)
- 840 PROPOSED GRADE (10' INTERVAL)
- PROPOSED GRADE (2' INTERVAL)
- PROPOSED PERIMETER ROAD
- PROPOSED SWALE
- PROPOSED CULVERT
- PROPOSED LEACHATE COLLECTION SYSTEM CLEANOUT
- PROPOSED LEACHATE VAULT
- FM PROPOSED LEACHATE FORCEMAIN
- UE PROPOSED UNDERGROUND ELECTRIC
- PROPOSED DIVERSION BERM
- PROPOSED DOWNSLOPE FLUME
- PROPOSED ENERGY DISSIPATOR
- PROPOSED RIPRAP
- DRAINAGE AREA DIVIDES
- FLOW PATH

**NOTES:**

1. SEE SHEET 2 OF PLAN OF OPERATION UPDATE (2022) PLAN SET FOR BASE MAP LEGEND ITEMS AND NOTES.
2. SWALE S4 REACHES ARE BETWEEN AREA BOUNDARY AND FLUMES IN AREA 45 AND 46.
3. FINAL SLOPES IN AREAS 27, 29, 32, 33, 34, AND 51 ARE ASSUMED DUE TO THESE AREAS BEING USED FOR STOCKPILES DURING CONSTRUCTION DURING THE LIFE OF THE DRY ASH DISPOSAL FACILITY.

N

100 0 100

SCALE: 1" = 100'

DRAWN BY: KP
CHECKED BY: RJG
APPROVED BY: MRH 05/25/2022

PROJECT NO. 25220183.00
DRAWN: 01/25/2022
REVISED: 05/02/2022

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

Wisconsin Power and Light Company

CLIENT

SCS ENGINEERS
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ENGINEER

PLAN OF OPERATION
2022 UPDATE
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

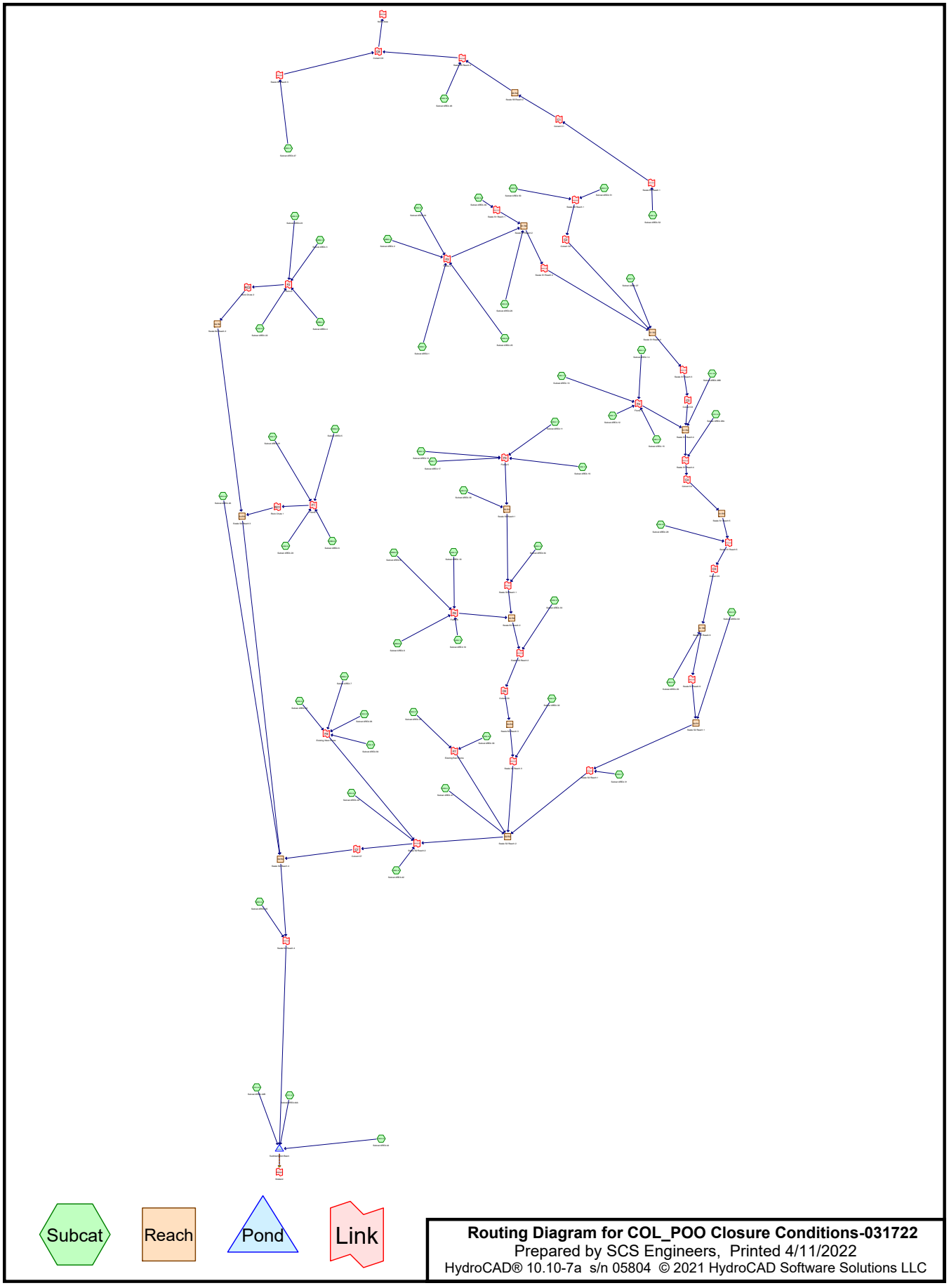
SITE

STORM WATER MODELING

FIGURE
1

Post Construction Conditions Hydrograph Generation

- 25-year, 24-hour Storm Event
- 100-year, 24-hour Storm Event




**Routing Diagram for COL_POO Closure Conditions-031722**
Prepared by SCS Engineers, Printed 4/11/2022
HydroCAD® 10.10-7a s/n 05804 © 2021 HydroCAD Software Solutions LLC

Time span=0.00-40.00 hrs, dt=0.01 hrs, 4001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment AREA 1: Subcat AREA 1** Runoff Area=1.288 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=408' Tc=2.6 min CN=69 Runoff=4.58 cfs 0.203 af

**Subcatchment AREA 10: Subcat AREA 10** Runoff Area=0.914 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=500' Tc=3.2 min CN=69 Runoff=3.17 cfs 0.144 af

**Subcatchment AREA 11: Subcat AREA 11** Runoff Area=0.949 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=391' Tc=4.6 min CN=69 Runoff=3.10 cfs 0.150 af

**Subcatchment AREA 12: Subcat AREA 12** Runoff Area=0.098 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=92' Tc=2.5 min CN=69 Runoff=0.35 cfs 0.015 af

**Subcatchment AREA 13: Subcat AREA 13** Runoff Area=0.890 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=590' Tc=4.6 min CN=69 Runoff=2.91 cfs 0.140 af

**Subcatchment AREA 14: Subcat AREA 14** Runoff Area=1.145 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=625' Tc=5.1 min CN=69 Runoff=3.66 cfs 0.181 af

**Subcatchment AREA 15: Subcat AREA 15** Runoff Area=0.512 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=235' Tc=4.2 min CN=69 Runoff=1.71 cfs 0.081 af

**Subcatchment AREA 16: Subcat AREA 16** Runoff Area=1.510 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=522' Tc=4.9 min CN=69 Runoff=4.89 cfs 0.238 af

**Subcatchment AREA 17: Subcat AREA 17** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=386' Tc=4.7 min CN=69 Runoff=4.00 cfs 0.194 af

**Subcatchment AREA 18: Subcat AREA 18** Runoff Area=0.813 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=383' Tc=4.6 min CN=69 Runoff=2.66 cfs 0.128 af

**Subcatchment AREA 19: Subcat AREA 19** Runoff Area=0.847 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=394' Tc=4.6 min CN=69 Runoff=2.77 cfs 0.134 af

**Subcatchment AREA 2: Subcat AREA 2** Runoff Area=1.167 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=613' Tc=5.1 min CN=69 Runoff=3.73 cfs 0.184 af

**Subcatchment AREA 20: Subcat AREA 20** Runoff Area=1.054 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=453' Tc=4.7 min CN=69 Runoff=3.43 cfs 0.166 af

**Subcatchment AREA 21: Subcat AREA 21** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=448' Tc=4.7 min CN=69 Runoff=3.35 cfs 0.162 af

**Subcatchment AREA 22: Subcat AREA 22** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=448' Tc=4.7 min CN=69 Runoff=3.35 cfs 0.162 af

**Subcatchment AREA 23: Subcat AREA 23** Runoff Area=1.548 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=715' Tc=5.4 min CN=69 Runoff=4.89 cfs 0.244 af

**Subcatchment AREA 24: Subcat AREA 24** Runoff Area=1.952 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=889' Tc=5.8 min CN=69 Runoff=6.05 cfs 0.308 af

**Subcatchment AREA 25: Subcat AREA 25** Runoff Area=1.515 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=495' Tc=3.9 min CN=69 Runoff=5.13 cfs 0.239 af

**Subcatchment AREA 26: Subcat AREA 26** Runoff Area=0.518 ac 0.00% Impervious Runoff Depth=1.74"
Flow Length=216' Tc=4.1 min CN=67 Runoff=1.59 cfs 0.075 af

**Subcatchment AREA 27: Subcat AREA 27** Runoff Area=4.140 ac 0.00% Impervious Runoff Depth=0.55"
Flow Length=864' Tc=12.0 min CN=48 Runoff=1.68 cfs 0.191 af

**Subcatchment AREA 28: Subcat AREA 28** Runoff Area=142,960 sf 0.00% Impervious Runoff Depth=0.66"
Flow Length=573' Tc=9.1 min CN=50 Runoff=2.08 cfs 0.179 af

**Subcatchment AREA 28A: Subcat AREA 28A** Runoff Area=0.423 ac 0.00% Impervious Runoff Depth=0.60"
Flow Length=234' Tc=9.1 min CN=49 Runoff=0.23 cfs 0.021 af

**Subcatchment AREA 28B: Subcat AREA 28B** Runoff Area=0.476 ac 0.00% Impervious Runoff Depth=0.71"
Flow Length=211' Tc=4.5 min CN=51 Runoff=0.47 cfs 0.028 af

**Subcatchment AREA 29: Subcat AREA 29** Runoff Area=2.792 ac 0.00% Impervious Runoff Depth=0.22"
Flow Length=463' Tc=14.8 min CN=40 Runoff=0.16 cfs 0.050 af

**Subcatchment AREA 3: Subcat AREA 3** Runoff Area=0.717 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=409' Tc=6.3 min CN=69 Runoff=2.17 cfs 0.113 af

**Subcatchment AREA 30: Subcat AREA 30** Runoff Area=1.415 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=941' Slope=0.0260 '/' Tc=22.0 min CN=39 Runoff=0.06 cfs 0.021 af

**Subcatchment AREA 31: Subcat AREA 31** Runoff Area=0.698 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=481' Tc=4.4 min CN=39 Runoff=0.03 cfs 0.011 af

**Subcatchment AREA 32: Subcat AREA 32** Runoff Area=3.353 ac 0.00% Impervious Runoff Depth=0.46"
Flow Length=663' Tc=17.3 min CN=46 Runoff=0.81 cfs 0.128 af

**Subcatchment AREA 33: Subcat AREA 33** Runoff Area=38,914 sf 0.00% Impervious Runoff Depth=0.60"
Flow Length=377' Tc=16.0 min CN=49 Runoff=0.37 cfs 0.045 af

**Subcatchment AREA 34: Subcat AREA 34** Runoff Area=68,484 sf 0.00% Impervious Runoff Depth=0.37"
Flow Length=488' Tc=16.2 min CN=44 Runoff=0.25 cfs 0.049 af

**Subcatchment AREA 35: Subcat AREA 35** Runoff Area=0.375 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=174' Slope=0.2500 '/' Tc=4.2 min CN=69 Runoff=1.25 cfs 0.059 af

**Subcatchment AREA 36: Subcat AREA 36** Runoff Area=0.487 ac 0.00% Impervious Runoff Depth=1.82"
Flow Length=425' Tc=4.4 min CN=68 Runoff=1.54 cfs 0.074 af

**Subcatchment AREA 37: Subcat AREA 37** Runoff Area=0.344 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=510' Tc=4.6 min CN=69 Runoff=1.12 cfs 0.054 af

**Subcatchment AREA 38: Subcat AREA 38** Runoff Area=0.223 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=590' Tc=4.1 min CN=69 Runoff=0.75 cfs 0.035 af

**Subcatchment AREA 39: Subcat AREA 39** Runoff Area=0.656 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=642' Tc=5.3 min CN=69 Runoff=2.08 cfs 0.103 af

**Subcatchment AREA 4: Subcat AREA 4** Runoff Area=1.247 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=478' Tc=6.6 min CN=69 Runoff=3.74 cfs 0.197 af

**Subcatchment AREA 40: Subcat AREA 40** Runoff Area=1.618 ac 0.00% Impervious Runoff Depth=1.18"
Flow Length=699' Tc=5.2 min CN=59 Runoff=3.05 cfs 0.160 af

**Subcatchment AREA 41: Subcat AREA 41** Runoff Area=0.826 ac 0.00% Impervious Runoff Depth=1.12"
Flow Length=722' Tc=5.9 min CN=58 Runoff=1.40 cfs 0.077 af

**Subcatchment AREA 42: Subcat AREA 42** Runoff Area=2.177 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=415' Tc=9.1 min CN=39 Runoff=0.09 cfs 0.033 af

**Subcatchment AREA 43: Subcat AREA 43** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=778' Tc=5.9 min CN=69 Runoff=3.79 cfs 0.194 af

**Subcatchment AREA 44: Subcat AREA 44** Runoff Area=5.227 ac 0.00% Impervious Runoff Depth=0.18"
Flow Length=701' Tc=7.9 min CN=39 Runoff=0.22 cfs 0.079 af

**Subcatchment AREA 44A: Subcat AREA** Runoff Area=1.508 ac 100.00% Impervious Runoff Depth=4.67"
Tc=0.0 min CN=98 Runoff=10.70 cfs 0.587 af

**Subcatchment AREA 44B: Subcat AREA 44B** Runoff Area=0.594 ac 0.00% Impervious Runoff Depth=0.66"
Flow Length=147' Slope=0.0544 '/' Tc=7.6 min CN=50 Runoff=0.41 cfs 0.032 af

**Subcatchment AREA 45: Subcat AREA 45** Runoff Area=2.001 ac 0.00% Impervious Runoff Depth=0.33"
Flow Length=681' Tc=21.9 min CN=43 Runoff=0.24 cfs 0.055 af

**Subcatchment AREA 46: Subcat AREA 46** Runoff Area=7.367 ac 0.36% Impervious Runoff Depth=1.18"
Flow Length=1,904' Tc=9.2 min CN=59 Runoff=11.31 cfs 0.727 af

**Subcatchment AREA 47: Subcat AREA 47** Runoff Area=79,132 sf 8.81% Impervious Runoff Depth=1.52"
Flow Length=582' Tc=9.1 min CN=64 Runoff=3.79 cfs 0.230 af

**Subcatchment AREA 48: Subcat AREA 48** Runoff Area=57,540 sf 11.76% Impervious Runoff Depth=1.32"
Flow Length=489' Tc=5.4 min CN=61 Runoff=2.79 cfs 0.145 af

**Subcatchment AREA 49: Subcat AREA 49** Runoff Area=0.691 ac 0.00% Impervious Runoff Depth=1.18"
Flow Length=522' Tc=4.3 min CN=59 Runoff=1.37 cfs 0.068 af

**Subcatchment AREA 5: Subcat AREA 5** Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=482' Tc=6.6 min CN=69 Runoff=3.58 cfs 0.188 af

**Subcatchment AREA 50: Subcat AREA 50** Runoff Area=1.482 ac 0.00% Impervious Runoff Depth=4.00"
Flow Length=570' Tc=3.4 min CN=92 Runoff=9.68 cfs 0.494 af

**Subcatchment AREA 51: Subcat AREA 51** Runoff Area=1.417 ac 0.00% Impervious Runoff Depth=0.22"
Flow Length=884' Tc=12.2 min CN=40 Runoff=0.08 cfs 0.025 af

**Subcatchment AREA 52: Subcat AREA 52** Runoff Area=197,330 sf 13.14% Impervious Runoff Depth=0.51"
Flow Length=1,294' Tc=6.3 min CN=47 Runoff=2.06 cfs 0.191 af

**Subcatchment AREA 6: Subcat AREA 6** Runoff Area=0.892 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=415' Tc=4.6 min CN=69 Runoff=2.92 cfs 0.141 af

**Subcatchment AREA 7: Subcat AREA 7** Runoff Area=1.017 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=833' Tc=5.8 min CN=69 Runoff=3.15 cfs 0.160 af

**Subcatchment AREA 8: Subcat AREA 8** Runoff Area=1.009 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=409' Tc=4.7 min CN=69 Runoff=3.29 cfs 0.159 af

**Subcatchment AREA 9: Subcat AREA 9** Runoff Area=1.047 ac 0.00% Impervious Runoff Depth=1.89"
Flow Length=426' Tc=4.8 min CN=69 Runoff=3.40 cfs 0.165 af

**Reach S1 R2: Swale S1 Reach 2** Avg. Flow Depth=0.76' Max Vel=2.58 fps Inflow=22.03 cfs 1.077 af
n=0.030 L=127.0' S=0.0055 '/' Capacity=140.64 cfs Outflow=21.68 cfs 1.077 af

**Reach S1 R3: Swale S1 Reach 3** Avg. Flow Depth=0.88' Max Vel=2.69 fps Inflow=31.44 cfs 1.788 af
n=0.030 L=578.0' S=0.0051 '/' Capacity=135.10 cfs Outflow=27.38 cfs 1.788 af

**Reach S1 R4: Swale S1 Reach 4** Avg. Flow Depth=0.94' Max Vel=3.19 fps Inflow=35.79 cfs 2.233 af
n=0.030 L=195.8' S=0.0066 '/' Capacity=154.36 cfs Outflow=35.20 cfs 2.233 af

**Reach S1 R5: Swale S1 Reach 5** Avg. Flow Depth=0.97' Max Vel=2.89 fps Inflow=35.39 cfs 2.255 af
n=0.030 L=411.6' S=0.0053 '/' Capacity=137.86 cfs Outflow=33.17 cfs 2.255 af

**Reach S1 R6: Swale S1 Reach 6** Avg. Flow Depth=0.97' Max Vel=2.87 fps Inflow=35.21 cfs 2.484 af
n=0.030 L=430.9' S=0.0052 '/' Capacity=136.28 cfs Outflow=33.18 cfs 2.484 af

**Reach S2 R1: Swale S2 Reach 1** Avg. Flow Depth=1.18' Max Vel=1.99 fps Inflow=33.19 cfs 2.506 af
n=0.030 L=472.0' S=0.0020 '/' Capacity=84.99 cfs Outflow=29.93 cfs 2.506 af

**Reach S2 R2: Swale S2 Reach 2** Avg. Flow Depth=0.98' Max Vel=3.41 fps Inflow=48.80 cfs 4.314 af
n=0.030 L=751.0' S=0.0069 '/' Capacity=182.04 cfs Outflow=46.24 cfs 4.314 af

**Reach S3 R1: Swale S3 Reach 1** Avg. Flow Depth=0.63' Max Vel=2.73 fps Inflow=16.31 cfs 0.785 af
n=0.030 L=215.0' S=0.0070 '/' Capacity=125.24 cfs Outflow=15.87 cfs 0.785 af

**Reach S3 R2: Swale S3 Reach 2** Avg. Flow Depth=1.75' Max Vel=3.61 fps Inflow=27.94 cfs 1.419 af
n=0.030 L=97.0' S=0.0070 '/' Capacity=71.57 cfs Outflow=27.78 cfs 1.419 af

**Reach S3 R3: Swale S3 Reach 3** Avg. Flow Depth=0.73' Max Vel=3.34 fps Inflow=27.86 cfs 1.464 af
n=0.030 L=353.0' S=0.0097 '/' Capacity=186.19 cfs Outflow=26.59 cfs 1.464 af

**Reach S4 R2: Swale S4 Reach 2** Avg. Flow Depth=0.46' Max Vel=2.23 fps Inflow=14.04 cfs 0.716 af
n=0.030 L=601.0' S=0.0069 '/' Capacity=174.20 cfs Outflow=11.87 cfs 0.716 af

**Reach S4 R3: Swale S4 Reach 3** Avg. Flow Depth=0.63' Max Vel=2.42 fps Inflow=23.93 cfs 1.374 af
n=0.030 L=946.0' S=0.0056 '/' Capacity=156.53 cfs Outflow=18.66 cfs 1.374 af

**Reach S4 R4: Swale S4 Reach 4** Avg. Flow Depth=1.27' Max Vel=4.35 fps Inflow=81.28 cfs 7.099 af
n=0.030 L=483.0' S=0.0082 '/' Capacity=427.66 cfs Outflow=80.05 cfs 7.099 af

**Reach S5 R2: Swale S5 Reach 2** Inflow=2.06 cfs 0.191 af
Outflow=2.06 cfs 0.191 af

**Pond Sed Pond: Sedimentation Basin** Peak Elev=791.59' Storage=137,326 cf Inflow=82.78 cfs 7.853 af
fs 5.880 af Primary=9.42 cfs 1.973 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=14.75 cfs 7.854 af

**Link C1: Culvert C1** Inflow=2.06 cfs 0.191 af
Primary=2.06 cfs 0.191 af

**Link C2: Culvert C2** Inflow=9.68 cfs 0.520 af
Primary=9.68 cfs 0.520 af

**Link C3: Culvert C3** Inflow=27.38 cfs 1.788 af
Primary=27.38 cfs 1.788 af

**Link C4: Culvert C4** Inflow=35.39 cfs 2.255 af
Primary=35.39 cfs 2.255 af

**Link C5: Culvert C5** Inflow=35.21 cfs 2.434 af
Primary=35.21 cfs 2.434 af

**Link C6: Culvert C6** Inflow=27.86 cfs 1.464 af
Primary=27.86 cfs 1.464 af

**Link C7: Culvert C7** Inflow=52.15 cfs 4.999 af
Primary=52.15 cfs 4.999 af

**Link C8: Culvert C8** Inflow=8.32 cfs 0.566 af
Primary=8.32 cfs 0.566 af

**Link F1: Flume 1** Inflow=13.17 cfs 0.658 af
Primary=13.17 cfs 0.658 af

**Link F2: Flume 2** Inflow=14.04 cfs 0.716 af
Primary=14.04 cfs 0.716 af

**Link F3: Flume 3** Inflow=19.08 cfs 0.934 af
Primary=19.08 cfs 0.934 af

**Link F4: Flume 4** Inflow=8.58 cfs 0.417 af
Primary=8.58 cfs 0.417 af

**Link F5: Flume 5** Inflow=15.06 cfs 0.725 af
Primary=15.06 cfs 0.725 af

**Link F6: Flume 6** Inflow=12.11 cfs 0.586 af
Primary=12.11 cfs 0.586 af

**Link F7: Existing East Flume** Inflow=2.66 cfs 0.128 af
Primary=2.66 cfs 0.128 af

**Link F8: Existing West Flume** Inflow=9.73 cfs 0.492 af
Primary=9.73 cfs 0.492 af

**Link North Area: North Area** Inflow=8.32 cfs 0.566 af
Primary=8.32 cfs 0.566 af

**Link RC1: Rock Chute 1** Inflow=13.17 cfs 0.658 af
Primary=13.17 cfs 0.658 af

**Link RC2: Rock Chute 2** Inflow=14.04 cfs 0.716 af
Primary=14.04 cfs 0.716 af

**Link Swale 1 R6: Swale S1 Reach 6** Inflow=33.18 cfs 2.484 af
Primary=33.18 cfs 2.484 af

**Link Swale S1 R1: Swale S1 Reach 1** Inflow=1.37 cfs 0.068 af
Primary=1.37 cfs 0.068 af

**Link Swale S1 R2: Swale S1 Reach 2** Inflow=21.68 cfs 1.077 af
Primary=21.68 cfs 1.077 af

**Link Swale S1 R3: Swale S1 Reach 3** Inflow=27.38 cfs 1.788 af
Primary=27.38 cfs 1.788 af

**Link Swale S1 R4: Swale S1 Reach 4** Inflow=35.39 cfs 2.255 af
Primary=35.39 cfs 2.255 af

**Link Swale S1 R5: Swale S1 Reach 5** Inflow=35.21 cfs 2.434 af
Primary=35.21 cfs 2.434 af

**Link Swale S2 R1: Swale S2 Reach 1** Inflow=29.95 cfs 2.516 af
Primary=29.95 cfs 2.516 af

**Link Swale S2 R2: Swale S2 Reach 2** Inflow=52.15 cfs 4.999 af
Primary=52.15 cfs 4.999 af

**Link Swale S3 R1: Swale S3 Reach 1** Inflow=15.88 cfs 0.833 af
Primary=15.88 cfs 0.833 af

**Link Swale S3 R2: Swale S3 Reach 2** Inflow=27.86 cfs 1.464 af
Primary=27.86 cfs 1.464 af

**Link Swale S3 R3: Swale S3 Reach 3** Inflow=26.70 cfs 1.592 af
Primary=26.70 cfs 1.592 af

**Link Swale S4 R4: Swale S4 Reach 4** Inflow=80.09 cfs 7.154 af
Primary=80.09 cfs 7.154 af

**Link Swale S5 R1: Swale S5 Reach 1** Inflow=2.06 cfs 0.191 af
Primary=2.06 cfs 0.191 af

**Link Swale S5 R2: Swale S5 Reach 2** Inflow=4.68 cfs 0.336 af
Primary=4.68 cfs 0.336 af

**Link Swale S5 R3: Swale S5 Reach 3** Inflow=3.79 cfs 0.230 af
Primary=3.79 cfs 0.230 af

**Link Swale S6 R1: Swale S6 Reach 1** Inflow=9.68 cfs 0.520 af
Primary=9.68 cfs 0.520 af

**Link Wetland: Wetland** Inflow=9.42 cfs 1.973 af
Primary=9.42 cfs 1.973 af

**Total Runoff Area = 82.060 ac Runoff Volume = 8.419 af Average Runoff Depth = 1.23"**
**97.02% Pervious = 79.615 ac 2.98% Impervious = 2.446 ac**

## Summary for Subcatchment AREA 1: Subcat AREA 1

Runoff = 4.58 cfs @ 12.11 hrs, Volume= 0.203 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.288 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.288 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.7 | 37 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.9 | 371 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.6 | 408 | Total | | | |

## Summary for Subcatchment AREA 10: Subcat AREA 10

Runoff = 3.17 cfs @ 12.11 hrs, Volume= 0.144 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.914 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.1 | 46 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 454 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.2 | 500 | Total | | | |

## Summary for Subcatchment AREA 11: Subcat AREA 11

Runoff = 3.10 cfs @ 12.12 hrs, Volume= 0.150 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.949 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.949 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 277 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 391 | Total | | | |

## Summary for Subcatchment AREA 12: Subcat AREA 12

Runoff = 0.35 cfs @ 12.11 hrs, Volume= 0.015 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.098 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.098 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 36 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.5 | 92 | Total | | | |

## Summary for Subcatchment AREA 13: Subcat AREA 13

Runoff = 2.91 cfs @ 12.12 hrs, Volume= 0.140 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.890 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.890 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.4 | 87 | 0.2500 | 0.42 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.2 | 503 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 590 | Total | | | |

## Summary for Subcatchment AREA 14: Subcat AREA 14

Runoff = 3.66 cfs @ 12.13 hrs, Volume= 0.181 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.145 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.145 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 27 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 498 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 625 | Total | | | |

## Summary for Subcatchment AREA 15: Subcat AREA 15

Runoff = 1.71 cfs @ 12.12 hrs, Volume= 0.081 af, Depth= 1.89"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.512 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.512 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 85 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.2 | 235 | Total | | | |

## Summary for Subcatchment AREA 16: Subcat AREA 16

Runoff = 4.89 cfs @ 12.13 hrs, Volume= 0.238 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.510 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.510 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 372 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.9 | 522 | Total | | | |

## Summary for Subcatchment AREA 17: Subcat AREA 17

Runoff = 4.00 cfs @ 12.12 hrs, Volume= 0.194 af, Depth= 1.89"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 63 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 223 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 386 | Total | | | |

## Summary for Subcatchment AREA 18: Subcat AREA 18

Runoff = 2.66 cfs @ 12.12 hrs, Volume= 0.128 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.813 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.813 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 48 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 235 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 383 | Total | | | |

## Summary for Subcatchment AREA 19: Subcat AREA 19

Runoff = 2.77 cfs @ 12.12 hrs, Volume= 0.134 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.847 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.847 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 244 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 394 | Total | | | |

## Summary for Subcatchment AREA 2: Subcat AREA 2

Runoff = 3.73 cfs @ 12.13 hrs, Volume= 0.184 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.167 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.167 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 495 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 613 | Total | | | |

## Summary for Subcatchment AREA 20: Subcat AREA 20

Runoff = 3.43 cfs @ 12.12 hrs, Volume= 0.166 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.054 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.054 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 303 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 453 | Total | | | |

## Summary for Subcatchment AREA 21: Subcat AREA 21

Runoff = 3.35 cfs @ 12.12 hrs, Volume= 0.162 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 22: Subcat AREA 22

Runoff = 3.35 cfs @ 12.12 hrs, Volume= 0.162 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 23: Subcat AREA 23

Runoff = 4.89 cfs @ 12.13 hrs, Volume= 0.244 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.548 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.548 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 591 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 715 | Total | | | |

## Summary for Subcatchment AREA 24: Subcat AREA 24

Runoff = 6.05 cfs @ 12.13 hrs, Volume= 0.308 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.952 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.952 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 765 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.8 | 889 | Total | | | |

## Summary for Subcatchment AREA 25: Subcat AREA 25

Runoff = 5.13 cfs @ 12.12 hrs, Volume= 0.239 af, Depth= 1.89"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.515 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.515 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.8 | 67 | 0.2500 | 0.40 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 428 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.9 | 495 | Total | | | |

## Summary for Subcatchment AREA 26: Subcat AREA 26

Runoff = 1.59 cfs @ 12.12 hrs, Volume= 0.075 af, Depth= 1.74"
Routed to Reach S1 R2 : Swale S1 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.396 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.072 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.049 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 0.518 | 67 | Weighted Average |
| | 0.518 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 93 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 123 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.1 | 216 | Total | | | |

## Summary for Subcatchment AREA 27: Subcat AREA 27

Runoff = 1.68 cfs @ 12.25 hrs, Volume= 0.191 af, Depth= 0.55"
Routed to Reach S1 R3 : Swale S1 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.651 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 2.758 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.010 | 96 | Gravel surface, HSG A |
| | 0.295 | 96 | Gravel surface, HSG A |
| | 0.426 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 4.140 | 48 | Weighted Average |
| | 4.140 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.3 | 217 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 513 | 0.0051 | 4.23 | 135.28 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 12.0 | 864 | Total | | | |

## Summary for Subcatchment AREA 28: Subcat AREA 28

Runoff = 2.08 cfs @ 12.19 hrs, Volume= 0.179 af, Depth= 0.66"
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 30,267 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 100,859 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 11,834 | 96 | Gravel surface |
| | 142,960 | 50 | Weighted Average |
| | 142,960 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 5.9 | 78 | 0.0526 | 0.22 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 22 | 0.2500 | 0.32 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 23 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.6 | 410 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 573 | Total | | | |

## Summary for Subcatchment AREA 28A: Subcat AREA 28A

Runoff = 0.23 cfs @ 12.20 hrs, Volume= 0.021 af, Depth= 0.60"
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.035 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.257 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.075 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.010 | 96 | Gravel surface, HSG A |
| 0.046 | 96 | Gravel surface, HSG A |
| 0.423 | 49 | Weighted Average |
| 0.423 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 82 | 0.0334 | 0.19 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 34 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 13 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 67 | 0.0069 | 4.92 | 157.36 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 234 | Total | | | |

## Summary for Subcatchment AREA 28B: Subcat AREA 28B

Runoff = 0.47 cfs @ 12.13 hrs, Volume= 0.028 af, Depth= 0.71"
Routed to Reach S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.050 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.110 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.240 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.009 | 96 | Gravel surface, HSG A |
| 0.067 | 96 | Gravel surface, HSG A |
| 0.476 | 51 | Weighted Average |
| 0.476 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 58 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.6 | 20 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 115 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.5 | 211 | Total | | | |

## Summary for Subcatchment AREA 29: Subcat AREA 29

Runoff = 0.16 cfs @ 12.58 hrs, Volume= 0.050 af, Depth= 0.22"
Routed to Reach S1 R6 : Swale S1 Reach 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.056 | 96 | Gravel surface, HSG A |
| | 2.735 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Gravel surface |
| | 2.792 | 40 | Weighted Average |
| | 2.792 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 11.8 | 100 | 0.0150 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 100 | 0.0150 | 0.86 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 247 | 0.0052 | 4.27 | 136.60 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 5** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 14.8 | 463 | Total | | | |

## Summary for Subcatchment AREA 3: Subcat AREA 3

Runoff = 2.17 cfs @ 12.14 hrs, Volume= 0.113 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.717 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.717 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.9 | 44 | 0.1000 | 0.26 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 233 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 409 | Total | | | |

## Summary for Subcatchment AREA 30: Subcat AREA 30

Runoff = 0.06 cfs @ 13.18 hrs, Volume= 0.021 af, Depth= 0.18"
Routed to Reach S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.415 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.415 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 9.5 | 100 | 0.0260 | 0.18 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 194 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 9.6 | 647 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 22.0 | 941 | Total | | | |

## Summary for Subcatchment AREA 31: Subcat AREA 31

Runoff = 0.03 cfs @ 12.44 hrs, Volume= 0.011 af, Depth= 0.18"
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.698 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.698 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.8 | 447 | 0.0020 | 2.65 | 84.72 | **Trap/Vee/Rect Channel Flow, Swale 2 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.4 | 481 | Total | | | |

## Summary for Subcatchment AREA 32: Subcat AREA 32

Runoff = 0.81 cfs @ 12.38 hrs, Volume= 0.128 af, Depth= 0.46"
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.567 | 69 | Pasture/grassland/range, Fair, HSG B |
| 2.413 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.099 | 96 | Gravel surface, HSG A |
| 0.274 | 39 | Pasture/grassland/range, Good, HSG A |
| 3.353 | 46 | Weighted Average |
| 3.353 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.2 | 211 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 23 | 0.1740 | 2.92 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 329 | 0.0097 | 5.83 | 186.57 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 17.3 | 663 | Total | | | |

## Summary for Subcatchment AREA 33: Subcat AREA 33

Runoff = 0.37 cfs @ 12.32 hrs, Volume= 0.045 af, Depth= 0.60"
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 4,079 | 96 | Gravel surface, HSG A |
| | 1,422 | 96 | Gravel surface, HSG A |
| | 30,707 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 2,706 | 69 | Pasture/grassland/range, Fair, HSG A |
| | 38,914 | 49 | Weighted Average |
| | 38,914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.6 | 178 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.0 | 12 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 87 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 2** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.0 | 377 | Total | | | |

## Summary for Subcatchment AREA 34: Subcat AREA 34

Runoff = 0.25 cfs @ 12.43 hrs, Volume= 0.049 af, Depth= 0.37"
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 5,695 | 69 | Pasture/grassland/range, Fair, HSG B |
| 3,470 | 96 | Gravel surface, HSG A |
| 59,319 | 39 | Pasture/grassland/range, Good, HSG A |
| 68,484 | 44 | Weighted Average |
| 68,484 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 170 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 15 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 203 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 1** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.2 | 488 | Total | | | |

## Summary for Subcatchment AREA 35: Subcat AREA 35

Runoff = 1.25 cfs @ 12.12 hrs, Volume= 0.059 af, Depth= 1.89"
Routed to Reach S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.375 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.375 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 74 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 4.2 | 174 | Total | | | |

## Summary for Subcatchment AREA 36: Subcat AREA 36

Runoff = 1.54 cfs @ 12.12 hrs, Volume= 0.074 af, Depth= 1.82"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.470 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.016 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 0.487 | 68 | Weighted Average |
| | 0.487 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 90 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.7 | 201 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 134 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.4 | 425 | Total | | | |

## Summary for Subcatchment AREA 37: Subcat AREA 37

Runoff = 1.12 cfs @ 12.12 hrs, Volume= 0.054 af, Depth= 1.89"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.344 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.344 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 30 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 126 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 254 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.6 | 510 | Total | | | |

## Summary for Subcatchment AREA 38: Subcat AREA 38

Runoff = 0.75 cfs @ 12.12 hrs, Volume= 0.035 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.223 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.223 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 156 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.5 | 357 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.1 | 590 | Total | | | |

## Summary for Subcatchment AREA 39: Subcat AREA 39

Runoff = 2.08 cfs @ 12.13 hrs, Volume= 0.103 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.656 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.656 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 314 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 217 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.3 | 642 | Total | | | |

## Summary for Subcatchment AREA 4: Subcat AREA 4

Runoff = 3.74 cfs @ 12.14 hrs, Volume= 0.197 af, Depth= 1.89"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.247 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.247 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 57 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 83 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 295 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 478 | Total | | | |

## Summary for Subcatchment AREA 40: Subcat AREA 40

Runoff = 3.05 cfs @ 12.13 hrs, Volume= 0.160 af, Depth= 1.18"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 1.079 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.539 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 1.618 | 59 | Weighted Average |
| | 1.618 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.8 | 237 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 70 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 315 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.2 | 699 | Total | | | |

## Summary for Subcatchment AREA 41: Subcat AREA 41

Runoff = 1.40 cfs @ 12.14 hrs, Volume= 0.077 af, Depth= 1.12"
Routed to Reach S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.520 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.306 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.826 | 58 | Weighted Average |
| 0.826 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 26 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 596 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.9 | 722 | Total | | | |

## Summary for Subcatchment AREA 42: Subcat AREA 42

Runoff = 0.09 cfs @ 12.55 hrs, Volume= 0.033 af, Depth= 0.18"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 2.177 | 39 | Pasture/grassland/range, Good, HSG A |
| 2.177 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 6.4 | 66 | 0.0303 | 0.17 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 49 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 266 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 415 | Total | | | |

## Summary for Subcatchment AREA 43: Subcat AREA 43

Runoff = 3.79 cfs @ 12.14 hrs, Volume= 0.194 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 6 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 541 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 131 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.9 | 778 | Total | | | |

## Summary for Subcatchment AREA 44: Subcat AREA 44

Runoff = 0.22 cfs @ 12.54 hrs, Volume= 0.079 af, Depth= 0.18"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 5.227 | 39 | Pasture/grassland/range, Good, HSG A |
| 5.227 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 4.5 | 75 | 0.0933 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.3 | 25 | 0.2500 | 0.33 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 10 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 381 | 0.0265 | 7.85 | 109.92 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=14.00' n= 0.030 Earth, grassed & winding |
| 0.8 | 162 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.5 | 48 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.9 | 701 | Total | | | |

## Summary for Subcatchment AREA 44A: Subcat AREA 44A

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.70 cfs @ 12.09 hrs, Volume= 0.587 af, Depth= 4.67"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.508 | 98 | Water Surface, HSG A |
| 1.508 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment AREA 44B: Subcat AREA 44B

Runoff = 0.41 cfs @ 12.17 hrs, Volume= 0.032 af, Depth= 0.66"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.479 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.115 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| | 0.594 | 50 | Weighted Average |
| | 0.594 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.1 | 100 | 0.0544 | 0.24 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 47 | 0.0544 | 1.63 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.6 | 147 | Total | | | |

## Summary for Subcatchment AREA 45: Subcat AREA 45

Runoff = 0.24 cfs @ 12.57 hrs, Volume= 0.055 af, Depth= 0.33"
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 0.000 | 0 | , HSG A |
| | 1.870 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.000 | 96 | Gravel surface, HSG A |
| | 0.130 | 96 | Gravel surface, HSG A |
| | 2.001 | 43 | Weighted Average |
| | 2.001 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 15.7 | 100 | 0.0074 | 0.11 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.7 | 169 | 0.0074 | 0.60 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 49 | 0.0800 | 1.98 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 363 | 0.0082 | 5.42 | 162.67 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 21.9 | 681 | Total | | | |

## Summary for Subcatchment AREA 46: Subcat AREA 46

Runoff = 11.31 cfs @ 12.18 hrs, Volume= 0.727 af, Depth= 1.18"
Routed to Reach S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 3.081 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.590 | 96 | Gravel surface, HSG B |
| | 3.264 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.017 | 98 | Paved parking, HSG A |
| | 0.009 | 98 | Paved parking, HSG A |
| | 0.378 | 96 | Gravel surface, HSG A |
| | 0.001 | 96 | Gravel surface, HSG A |
| | 0.026 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 7.367 | 59 | Weighted Average |
| | 7.340 | | 99.64% Pervious Area |
| | 0.027 | | 0.36% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.2 | 51 | 0.2500 | 0.38 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 16 | 0.2500 | 2.44 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.9 | 31 | 0.0050 | 0.58 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0650 | 1.78 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 5.6 | 1,759 | 0.0073 | 5.26 | 178.68 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 1** Bot.W=10.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.2 | 1,904 | Total | | | |

## Summary for Subcatchment AREA 47: Subcat AREA 47

Runoff = 3.79 cfs @ 12.17 hrs, Volume= 0.230 af, Depth= 1.52"
Routed to Link Swale S5 R3 : Swale S5 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 49,617 | 69 | Pasture/grassland/range, Fair, HSG B |
| 6,971 | 98 | Paved parking, HSG A |
| 1,619 | 96 | Gravel surface, HSG A |
| 20,925 | 39 | Pasture/grassland/range, Good, HSG A |
| 79,132 | 64 | Weighted Average |
| 72,161 | | 91.19% Pervious Area |
| 6,971 | | 8.81% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.1111 | 1.63 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.7 | 12 | 0.2500 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 28 | 0.0393 | 0.16 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 488 | 0.0024 | 2.40 | 52.81 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 3** Bot.W=0.00' D=2.00' Z= 5.0 & 6.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 582 | Total | | | |

## Summary for Subcatchment AREA 48: Subcat AREA 48

Runoff = 2.79 cfs @ 12.13 hrs, Volume= 0.145 af, Depth= 1.32"
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 24,597 | 69 | Pasture/grassland/range, Fair, HSG B |
| 24,117 | 39 | Pasture/grassland/range, Good, HSG A |
| 2,057 | 96 | Gravel surface, HSG A |
| 6,769 | 98 | Paved parking, HSG A |
| 57,540 | 61 | Weighted Average |
| 50,771 | | 88.24% Pervious Area |
| 6,769 | | 11.76% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 19 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.7 | 29 | 0.1667 | 0.29 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.1 | 441 | 0.0024 | 2.38 | 40.39 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 2** Bot.W=0.00' D=2.00' Z= 2.5 & 6.0 '/' Top.W=17.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 489 | Total | | | |

## Summary for Subcatchment AREA 49: Subcat AREA 49

Runoff = 1.37 cfs @ 12.12 hrs, Volume= 0.068 af, Depth= 1.18"
Routed to Link Swale S1 R1 : Swale S1 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.439 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.246 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.006 | 96 | Gravel surface, HSG A |
| 0.691 | 59 | Weighted Average |
| 0.691 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 59 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.8 | 463 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |

4.3 522 Total

## Summary for Subcatchment AREA 5: Subcat AREA 5

Runoff = 3.58 cfs @ 12.14 hrs, Volume= 0.188 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.195 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.195 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 59 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 41 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 85 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 297 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 482 | Total | | | |

## Summary for Subcatchment AREA 50: Subcat AREA 50

Runoff = 9.68 cfs @ 12.11 hrs, Volume= 0.494 af, Depth= 4.00"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.100 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.001 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.382 | 96 | Gravel surface, HSG A |
| 1.482 | 92 | Weighted Average |
| 1.482 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 100 | 0.0119 | 1.04 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0119 | 1.76 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.0 | 10 | 0.5000 | 4.95 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.4 | 413 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 3.4 | 570 | Total | | | |

## Summary for Subcatchment AREA 51: Subcat AREA 51

Runoff = 0.08 cfs @ 12.54 hrs, Volume= 0.025 af, Depth= 0.22"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.396 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.020 | 96 | Gravel surface, HSG A |
| 1.417 | 40 | Weighted Average |
| 1.417 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.2 | 302 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 53 | 0.0313 | 2.85 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 1.4 | 429 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 12.2 | 884 | Total | | | |

## Summary for Subcatchment AREA 52: Subcat AREA 52

Runoff = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Depth= 0.51"
Routed to Link Swale S5 R1 : Swale S5 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (sf) | CN | Description |
|---|---|---|
| 169,213 | 39 | Pasture/grassland/range, Good, HSG A |
| 25,933 | 98 | Paved parking, HSG A |
| 2,184 | 96 | Gravel surface, HSG A |
| 197,330 | 47 | Weighted Average |
| 171,397 | | 86.86% Pervious Area |
| 25,933 | | 13.14% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 18 | 0.0050 | 0.52 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.4 | 21 | 0.1333 | 0.25 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.3 | 1,255 | 0.0096 | 4.82 | 125.20 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 1** Bot.W=0.00' D=2.00' Z= 6.0 & 7.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 1,294 | Total | | | |

## Summary for Subcatchment AREA 6: Subcat AREA 6

Runoff = 2.92 cfs @ 12.12 hrs, Volume= 0.141 af, Depth= 1.89"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 0.892 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.892 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 7 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 308 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 415 | Total | | | |

## Summary for Subcatchment AREA 7: Subcat AREA 7

Runoff = 3.15 cfs @ 12.13 hrs, Volume= 0.160 af, Depth= 1.89"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.017 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.017 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 419 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.4 | 296 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow,** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.8 | 833 | Total | | | |

## Summary for Subcatchment AREA 8: Subcat AREA 8

Runoff = 3.29 cfs @ 12.12 hrs, Volume= 0.159 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.009 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.009 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 66 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 243 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 409 | Total | | | |

## Summary for Subcatchment AREA 9: Subcat AREA 9

Runoff = 3.40 cfs @ 12.13 hrs, Volume= 0.165 af, Depth= 1.89"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 25-yr, 24-hr Rainfall=4.91"

| Area (ac) | CN | Description |
|---|---|---|
| 1.047 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.047 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 250 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.8 | 426 | Total | | | |

## Summary for Reach S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 1.81" for 25-yr, 24-hr event
Inflow = 22.03 cfs @ 12.12 hrs, Volume= 1.077 af
Outflow = 21.68 cfs @ 12.13 hrs, Volume= 1.077 af, Atten= 2%, Lag= 0.5 min
Routed to Link Swale S1 R2 : Swale S1 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.58 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 0.69 fps, Avg. Travel Time= 3.1 min

Peak Storage= 1,066 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.76' , Surface Width= 14.08'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 140.64 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 127.0' Slope= 0.0055 '/'
Inlet Invert= 814.81', Outlet Invert= 814.11'

‡

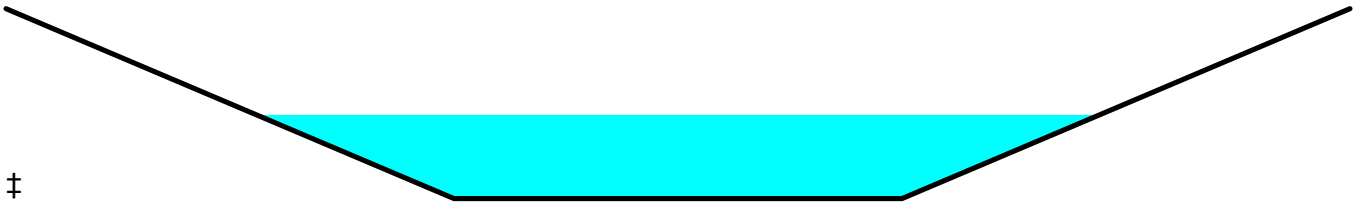
## Summary for Reach S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 1.51" for 25-yr, 24-hr event
Inflow = 31.44 cfs @ 12.12 hrs, Volume= 1.788 af
Outflow = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af, Atten= 13%, Lag= 1.6 min
Routed to Link Swale S1 R3 : Swale S1 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.69 fps, Min. Travel Time= 3.6 min
Avg. Velocity = 0.61 fps, Avg. Travel Time= 15.9 min

Peak Storage= 5,875 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.88' , Surface Width= 15.05'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 135.10 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 578.0' Slope= 0.0051 '/'
Inlet Invert= 814.11', Outlet Invert= 811.17'



‡

## Summary for Reach S1 R4: Swale S1 Reach 4

Inflow Area = 17.292 ac, 0.00% Impervious, Inflow Depth = 1.55" for 25-yr, 24-hr event
Inflow = 35.79 cfs @ 12.14 hrs, Volume= 2.233 af
Outflow = 35.20 cfs @ 12.15 hrs, Volume= 2.233 af, Atten= 2%, Lag= 0.7 min
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.19 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 0.70 fps, Avg. Travel Time= 4.6 min

Peak Storage= 2,163 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.94' , Surface Width= 15.52'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 154.36 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 195.8' Slope= 0.0066 '/'
Inlet Invert= 811.17', Outlet Invert= 809.87'

‡

## Summary for Reach S1 R5: Swale S1 Reach 5

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af
Outflow = 33.17 cfs @ 12.18 hrs, Volume= 2.255 af, Atten= 6%, Lag= 1.6 min
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.89 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 0.64 fps, Avg. Travel Time= 10.7 min

Peak Storage= 4,722 cf @ 12.18 hrs
Average Depth at Peak Storage= 0.97' , Surface Width= 15.73'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 137.86 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 411.6' Slope= 0.0053 '/'
Inlet Invert= 809.77', Outlet Invert= 807.59'

‡

## Summary for Reach S1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 1.25" for 25-yr, 24-hr event
Inflow = 35.21 cfs @ 12.18 hrs, Volume= 2.484 af
Outflow = 33.18 cfs @ 12.21 hrs, Volume= 2.484 af, Atten= 6%, Lag= 1.8 min
Routed to Link Swale 1 R6 : Swale S1 Reach 6

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.87 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 0.65 fps, Avg. Travel Time= 11.0 min

Peak Storage= 4,986 cf @ 12.21 hrs
Average Depth at Peak Storage= 0.97' , Surface Width= 15.78'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 136.28 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 430.9' Slope= 0.0052 '/'
Inlet Invert= 807.15', Outlet Invert= 804.92'

‡

## Summary for Reach S2 R1: Swale S2 Reach 1

Inflow Area = 25.203 ac, 0.00% Impervious, Inflow Depth = 1.19" for 25-yr, 24-hr event
Inflow = 33.19 cfs @ 12.21 hrs, Volume= 2.506 af
Outflow = 29.93 cfs @ 12.26 hrs, Volume= 2.506 af, Atten= 10%, Lag= 3.0 min
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.99 fps, Min. Travel Time= 4.0 min
Avg. Velocity = 0.45 fps, Avg. Travel Time= 17.6 min

Peak Storage= 7,099 cf @ 12.26 hrs
Average Depth at Peak Storage= 1.18' , Surface Width= 17.45'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 84.99 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 472.0' Slope= 0.0020 '/'
Inlet Invert= 802.25', Outlet Invert= 801.30'

‡

## Summary for Reach S2 R2: Swale S2 Reach 2

Inflow Area = 42.068 ac, 0.00% Impervious, Inflow Depth = 1.23" for 25-yr, 24-hr event
Inflow = 48.80 cfs @ 12.18 hrs, Volume= 4.314 af
Outflow = 46.24 cfs @ 12.25 hrs, Volume= 4.314 af, Atten= 5%, Lag= 4.2 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.41 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 0.75 fps, Avg. Travel Time= 16.7 min

Peak Storage= 10,190 cf @ 12.25 hrs
Average Depth at Peak Storage= 0.98' , Surface Width= 17.81'
Bank-Full Depth= 2.00' Flow Area= 36.0 sf, Capacity= 182.04 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 26.00'
Length= 751.0' Slope= 0.0069 '/'
Inlet Invert= 801.30', Outlet Invert= 796.10'

‡

## Summary for Reach S3 R1: Swale S3 Reach 1

Inflow Area = 4.976 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 16.31 cfs @ 12.12 hrs, Volume= 0.785 af
Outflow = 15.87 cfs @ 12.13 hrs, Volume= 0.785 af, Atten= 3%, Lag= 0.7 min
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.73 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 0.67 fps, Avg. Travel Time= 5.4 min

Peak Storage= 1,248 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 10.51'
Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 125.24 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 215.0' Slope= 0.0070 '/'
Inlet Invert= 807.58', Outlet Invert= 806.08'

‡

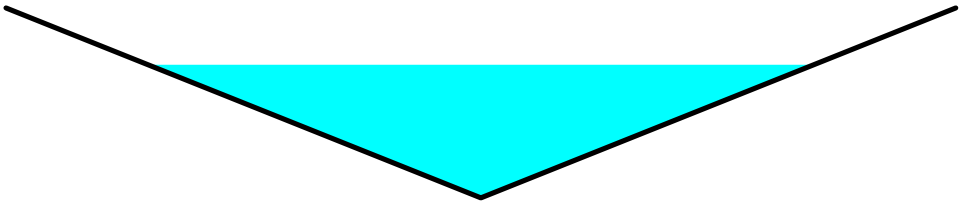
## Summary for Reach S3 R2: Swale S3 Reach 2

Inflow Area = 10.265 ac, 0.00% Impervious, Inflow Depth = 1.66" for 25-yr, 24-hr event
Inflow = 27.94 cfs @ 12.13 hrs, Volume= 1.419 af
Outflow = 27.78 cfs @ 12.13 hrs, Volume= 1.419 af, Atten= 1%, Lag= 0.3 min
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.61 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.31 fps, Avg. Travel Time= 1.2 min

Peak Storage= 745 cf @ 12.13 hrs
Average Depth at Peak Storage= 1.75' , Surface Width= 8.77'
Bank-Full Depth= 2.50' Flow Area= 15.6 sf, Capacity= 71.57 cfs

0.00' x 2.50' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.5 '/' Top Width= 12.50'
Length= 97.0' Slope= 0.0070 '/'
Inlet Invert= 806.08', Outlet Invert= 805.40'



## Summary for Reach S3 R3: Swale S3 Reach 3

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-yr, 24-hr event
Inflow = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af
Outflow = 26.59 cfs @ 12.15 hrs, Volume= 1.464 af, Atten= 5%, Lag= 1.0 min
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.34 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.88 fps, Avg. Travel Time= 6.7 min

Peak Storage= 2,810 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.73' , Surface Width= 13.83'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 186.19 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 353.0' Slope= 0.0097 '/'
Inlet Invert= 804.71', Outlet Invert= 801.30'

‡

## Summary for Reach S4 R2: Swale S4 Reach 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af
Outflow = 11.87 cfs @ 12.17 hrs, Volume= 0.716 af, Atten= 15%, Lag= 2.1 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.23 fps, Min. Travel Time= 4.5 min
Avg. Velocity = 0.55 fps, Avg. Travel Time= 18.3 min

Peak Storage= 3,193 cf @ 12.17 hrs
Average Depth at Peak Storage= 0.46' , Surface Width= 13.21'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 174.20 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 3.0 '/' Top Width= 24.00'
Length= 601.0' Slope= 0.0069 '/'
Inlet Invert= 806.43', Outlet Invert= 802.26'

‡

## Summary for Reach S4 R3: Swale S4 Reach 3

[62] Hint: Exceeded Reach S4 R2 OUTLET depth by 0.23' @ 12.28 hrs

Inflow Area = 8.711 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 23.93 cfs @ 12.14 hrs, Volume= 1.374 af
Outflow = 18.66 cfs @ 12.20 hrs, Volume= 1.374 af, Atten= 22%, Lag= 3.4 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.42 fps, Min. Travel Time= 6.5 min
Avg. Velocity = 0.57 fps, Avg. Travel Time= 27.9 min

Peak Storage= 7,289 cf @ 12.20 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 14.42'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 156.53 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 24.00'
Length= 946.0' Slope= 0.0056 '/'
Inlet Invert= 802.26', Outlet Invert= 796.96'

‡

## Summary for Reach S4 R4: Swale S4 Reach 4

[62] Hint: Exceeded Reach S4 R3 OUTLET depth by 0.67' @ 12.27 hrs

Inflow Area = 65.063 ac, 0.04% Impervious, Inflow Depth = 1.31" for 25-yr, 24-hr event
Inflow = 81.28 cfs @ 12.20 hrs, Volume= 7.099 af
Outflow = 80.05 cfs @ 12.23 hrs, Volume= 7.099 af, Atten= 2%, Lag= 1.7 min
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.35 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 0.97 fps, Avg. Travel Time= 8.3 min

Peak Storage= 8,890 cf @ 12.23 hrs
Average Depth at Peak Storage= 1.27' , Surface Width= 18.91'
Bank-Full Depth= 3.00' Flow Area= 61.5 sf, Capacity= 427.66 cfs

10.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 31.00'
Length= 483.0' Slope= 0.0082 '/'
Inlet Invert= 796.96', Outlet Invert= 793.00'

‡

## Summary for Reach S5 R2: Swale S5 Reach 2

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 0.51" for 25-yr, 24-hr event
Inflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af
Outflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Pond Sed Pond: Sedimentation Basin

[87] Warning: Oscillations may require smaller dt or Finer Routing (severity=42)

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 1.27" for 25-yr, 24-hr event
Inflow = 82.78 cfs @ 12.23 hrs, Volume= 7.853 af
Outflow = 14.75 cfs @ 13.29 hrs, Volume= 7.854 af, Atten= 82%, Lag= 64.1 min
Discarded = 5.33 cfs @ 13.29 hrs, Volume= 5.880 af
Primary = 9.42 cfs @ 13.29 hrs, Volume= 1.973 af
Routed to Link Wetland : Wetland
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link Wetland : Wetland
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link Wetland : Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Peak Elev= 791.59' @ 13.29 hrs Surf.Area= 63,986 sf Storage= 137,326 cf
Flood Elev= 794.00' Surf.Area= 75,797 sf Storage= 304,443 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 184.8 min ( 1,043.0 - 858.2 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 789.00' | 304,443 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 789.00 | 27,325 | 0 | 0 |
| 790.00 | 55,972 | 41,649 | 41,649 |
| 791.00 | 61,532 | 58,752 | 100,401 |
| 792.00 | 65,703 | 63,618 | 164,018 |
| 793.00 | 69,675 | 67,689 | 231,707 |
| 794.00 | 75,797 | 72,736 | 304,443 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 787.70' | **15.0" Round Culvert**<br>L= 40.0' RCP, mitered to conform to fill, Ke= 0.700<br>Inlet / Outlet Invert= 787.70' / 787.50' S= 0.0050 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 1.23 sf |
| #2 | Device 1 | 791.00' | **30.0" Horiz. Orifice/Grate** C= 0.600<br>Limited to weir flow at low heads |
| #3 | Device 1 | 790.50' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #4 | Device 1 | 790.00' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #5 | Device 1 | 789.00' | **0.5" Vert. Orifice/Grate X 14.00 columns**<br>X 6 rows with 6.0" cc spacing C= 0.600<br>Limited to weir flow at low heads |
| #6 | Secondary | 792.50' | **20.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #7 | Tertiary | 793.00' | **158.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #8 | Discarded | 789.00' | **3.600 in/hr Exfiltration over Surface area** |

**Discarded OutFlow** Max=5.33 cfs @ 13.29 hrs HW=791.59' (Free Discharge)
└**8=Exfiltration** (Exfiltration Controls 5.33 cfs)

**Primary OutFlow** Max=9.42 cfs @ 13.29 hrs HW=791.59' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 9.42 cfs @ 7.67 fps)
  ├**2=Orifice/Grate** (Passes < 11.59 cfs potential flow)
  ├**3=Orifice/Grate** (Passes < 0.07 cfs potential flow)
  ├**4=Orifice/Grate** (Passes < 0.08 cfs potential flow)
  └**5=Orifice/Grate** (Passes < 0.58 cfs potential flow)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=789.00' TW=0.00' (Dynamic Tailwater)
└**6=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

**Tertiary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=789.00' TW=0.00' (Dynamic Tailwater)
└**7=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

## Summary for Link C1: Culvert C1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 0.51" for 25-yr, 24-hr event
Inflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af
Primary = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S5 R2 : Swale S5 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C2: Culvert C2

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 2.15" for 25-yr, 24-hr event
Inflow = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af
Primary = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C3: Culvert C3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 1.51" for 25-yr, 24-hr event
Inflow = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af
Primary = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C4: Culvert C4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af
Primary = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R5 : Swale S1 Reach 5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C5: Culvert C5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af
Primary = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R6 : Swale S1 Reach 6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C6: Culvert C6

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-yr, 24-hr event
Inflow = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af
Primary = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R3 : Swale S3 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C7: Culvert C7

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 1.22" for 25-yr, 24-hr event
Inflow = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af
Primary = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C8: Culvert C8

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 0.89" for 25-yr, 24-hr event
Inflow = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af
Primary = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af, Atten= 0%, Lag= 0.0 min
Routed to Link North Area : North Area

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F1: Flume 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af
Primary = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC1 : Rock Chute 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F2: Flume 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af
Primary = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC2 : Rock Chute 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F3: Flume 3

Inflow Area = 5.923 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 19.08 cfs @ 12.12 hrs, Volume= 0.934 af
Primary = 19.08 cfs @ 12.12 hrs, Volume= 0.934 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F4: Flume 4

Inflow Area = 2.645 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 8.58 cfs @ 12.12 hrs, Volume= 0.417 af
Primary = 8.58 cfs @ 12.12 hrs, Volume= 0.417 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F5: Flume 5

Inflow Area = 4.601 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 15.06 cfs @ 12.12 hrs, Volume= 0.725 af
Primary = 15.06 cfs @ 12.12 hrs, Volume= 0.725 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R1 : Swale S3 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F6: Flume 6

Inflow Area = 3.717 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 12.11 cfs @ 12.12 hrs, Volume= 0.586 af
Primary = 12.11 cfs @ 12.12 hrs, Volume= 0.586 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F7: Existing East Flume

Inflow Area = 0.830 ac, 0.00% Impervious, Inflow Depth = 1.85" for 25-yr, 24-hr event
Inflow = 2.66 cfs @ 12.12 hrs, Volume= 0.128 af
Primary = 2.66 cfs @ 12.12 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F8: Existing West Flume

Inflow Area = 3.122 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 9.73 cfs @ 12.13 hrs, Volume= 0.492 af
Primary = 9.73 cfs @ 12.13 hrs, Volume= 0.492 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link North Area: North Area

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 0.89" for 25-yr, 24-hr event
Inflow = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af
Primary = 8.32 cfs @ 12.15 hrs, Volume= 0.566 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC1: Rock Chute 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af
Primary = 13.17 cfs @ 12.13 hrs, Volume= 0.658 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC2: Rock Chute 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 1.89" for 25-yr, 24-hr event
Inflow = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af
Primary = 14.04 cfs @ 12.13 hrs, Volume= 0.716 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R2 : Swale S4 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale 1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 1.25" for 25-yr, 24-hr event
Inflow = 33.18 cfs @ 12.21 hrs, Volume= 2.484 af
Primary = 33.18 cfs @ 12.21 hrs, Volume= 2.484 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R1 : Swale S2 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R1: Swale S1 Reach 1

Inflow Area = 0.691 ac, 0.00% Impervious, Inflow Depth = 1.18" for 25-yr, 24-hr event
Inflow = 1.37 cfs @ 12.12 hrs, Volume= 0.068 af
Primary = 1.37 cfs @ 12.12 hrs, Volume= 0.068 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 1.81" for 25-yr, 24-hr event
Inflow = 21.68 cfs @ 12.13 hrs, Volume= 1.077 af
Primary = 21.68 cfs @ 12.13 hrs, Volume= 1.077 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 1.51" for 25-yr, 24-hr event
Inflow = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af
Primary = 27.38 cfs @ 12.15 hrs, Volume= 1.788 af, Atten= 0%, Lag= 0.0 min
Routed to Link C3 : Culvert C3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R4: Swale S1 Reach 4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af
Primary = 35.39 cfs @ 12.15 hrs, Volume= 2.255 af, Atten= 0%, Lag= 0.0 min
Routed to Link C4 : Culvert C4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R5: Swale S1 Reach 5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af
Primary = 35.21 cfs @ 12.18 hrs, Volume= 2.434 af, Atten= 0%, Lag= 0.0 min
Routed to Link C5 : Culvert C5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R1: Swale S2 Reach 1

Inflow Area = 25.901 ac, 0.00% Impervious, Inflow Depth = 1.17" for 25-yr, 24-hr event
Inflow = 29.95 cfs @ 12.26 hrs, Volume= 2.516 af
Primary = 29.95 cfs @ 12.26 hrs, Volume= 2.516 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R2: Swale S2 Reach 2

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 1.22" for 25-yr, 24-hr event
Inflow = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af
Primary = 52.15 cfs @ 12.23 hrs, Volume= 4.999 af, Atten= 0%, Lag= 0.0 min
Routed to Link C7 : Culvert C7

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R1: Swale S3 Reach 1

Inflow Area = 6.548 ac, 0.00% Impervious, Inflow Depth = 1.53" for 25-yr, 24-hr event
Inflow = 15.88 cfs @ 12.13 hrs, Volume= 0.833 af
Primary = 15.88 cfs @ 12.13 hrs, Volume= 0.833 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R2: Swale S3 Reach 2

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-yr, 24-hr event
Inflow = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af
Primary = 27.86 cfs @ 12.13 hrs, Volume= 1.464 af, Atten= 0%, Lag= 0.0 min
Routed to Link C6 : Culvert C6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R3: Swale S3 Reach 3

Inflow Area = 14.511 ac, 0.00% Impervious, Inflow Depth = 1.32" for 25-yr, 24-hr event
Inflow = 26.70 cfs @ 12.15 hrs, Volume= 1.592 af
Primary = 26.70 cfs @ 12.15 hrs, Volume= 1.592 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S4 R4: Swale S4 Reach 4

Inflow Area = 67.064 ac, 0.04% Impervious, Inflow Depth = 1.28" for 25-yr, 24-hr event
Inflow = 80.09 cfs @ 12.23 hrs, Volume= 7.154 af
Primary = 80.09 cfs @ 12.23 hrs, Volume= 7.154 af, Atten= 0%, Lag= 0.0 min
Routed to Pond Sed Pond : Sedimentation Basin

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R1: Swale S5 Reach 1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 0.51" for 25-yr, 24-hr event
Inflow = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af
Primary = 2.06 cfs @ 12.16 hrs, Volume= 0.191 af, Atten= 0%, Lag= 0.0 min
Routed to Link C1 : Culvert C1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R2: Swale S5 Reach 2

Inflow Area = 5.851 ac, 12.83% Impervious, Inflow Depth = 0.69" for 25-yr, 24-hr event
Inflow = 4.68 cfs @ 12.15 hrs, Volume= 0.336 af
Primary = 4.68 cfs @ 12.15 hrs, Volume= 0.336 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R3: Swale S5 Reach 3

Inflow Area = 1.817 ac, 8.81% Impervious, Inflow Depth = 1.52" for 25-yr, 24-hr event
Inflow = 3.79 cfs @ 12.17 hrs, Volume= 0.230 af
Primary = 3.79 cfs @ 12.17 hrs, Volume= 0.230 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S6 R1: Swale S6 Reach 1

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 2.15" for 25-yr, 24-hr event
Inflow = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af
Primary = 9.68 cfs @ 12.11 hrs, Volume= 0.520 af, Atten= 0%, Lag= 0.0 min
Routed to Link C2 : Culvert C2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Wetland: Wetland

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 0.32" for 25-yr, 24-hr event
Inflow = 9.42 cfs @ 13.29 hrs, Volume= 1.973 af
Primary = 9.42 cfs @ 13.29 hrs, Volume= 1.973 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

Time span=0.00-40.00 hrs, dt=0.01 hrs, 4001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment AREA 1: Subcat AREA 1** Runoff Area=1.288 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=408' Tc=2.6 min CN=69 Runoff=7.63 cfs 0.342 af

**Subcatchment AREA 10: Subcat AREA 10** Runoff Area=0.914 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=500' Tc=3.2 min CN=69 Runoff=5.29 cfs 0.242 af

**Subcatchment AREA 11: Subcat AREA 11** Runoff Area=0.949 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=391' Tc=4.6 min CN=69 Runoff=5.21 cfs 0.251 af

**Subcatchment AREA 12: Subcat AREA 12** Runoff Area=0.098 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=92' Tc=2.5 min CN=69 Runoff=0.58 cfs 0.026 af

**Subcatchment AREA 13: Subcat AREA 13** Runoff Area=0.890 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=590' Tc=4.6 min CN=69 Runoff=4.89 cfs 0.236 af

**Subcatchment AREA 14: Subcat AREA 14** Runoff Area=1.145 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=625' Tc=5.1 min CN=69 Runoff=6.17 cfs 0.303 af

**Subcatchment AREA 15: Subcat AREA 15** Runoff Area=0.512 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=235' Tc=4.2 min CN=69 Runoff=2.86 cfs 0.136 af

**Subcatchment AREA 16: Subcat AREA 16** Runoff Area=1.510 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=522' Tc=4.9 min CN=69 Runoff=8.20 cfs 0.400 af

**Subcatchment AREA 17: Subcat AREA 17** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=386' Tc=4.7 min CN=69 Runoff=6.72 cfs 0.326 af

**Subcatchment AREA 18: Subcat AREA 18** Runoff Area=0.813 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=383' Tc=4.6 min CN=69 Runoff=4.47 cfs 0.215 af

**Subcatchment AREA 19: Subcat AREA 19** Runoff Area=0.847 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=394' Tc=4.6 min CN=69 Runoff=4.66 cfs 0.225 af

**Subcatchment AREA 2: Subcat AREA 2** Runoff Area=1.167 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=613' Tc=5.1 min CN=69 Runoff=6.28 cfs 0.309 af

**Subcatchment AREA 20: Subcat AREA 20** Runoff Area=1.054 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=453' Tc=4.7 min CN=69 Runoff=5.77 cfs 0.279 af

**Subcatchment AREA 21: Subcat AREA 21** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=448' Tc=4.7 min CN=69 Runoff=5.64 cfs 0.273 af

**Subcatchment AREA 22: Subcat AREA 22** Runoff Area=1.030 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=448' Tc=4.7 min CN=69 Runoff=5.64 cfs 0.273 af

**Subcatchment AREA 23: Subcat AREA 23** Runoff Area=1.548 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=715' Tc=5.4 min CN=69 Runoff=8.23 cfs 0.410 af

**Subcatchment AREA 24: Subcat AREA 24** Runoff Area=1.952 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=889' Tc=5.8 min CN=69 Runoff=10.20 cfs 0.517 af

**Subcatchment AREA 25: Subcat AREA 25** Runoff Area=1.515 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=495' Tc=3.9 min CN=69 Runoff=8.59 cfs 0.402 af

**Subcatchment AREA 26: Subcat AREA 26** Runoff Area=0.518 ac 0.00% Impervious Runoff Depth=2.98"
Flow Length=216' Tc=4.1 min CN=67 Runoff=2.74 cfs 0.129 af

**Subcatchment AREA 27: Subcat AREA 27** Runoff Area=4.140 ac 0.00% Impervious Runoff Depth=1.28"
Flow Length=864' Tc=12.0 min CN=48 Runoff=5.63 cfs 0.442 af

**Subcatchment AREA 28: Subcat AREA 28** Runoff Area=142,960 sf 0.00% Impervious Runoff Depth=1.44"
Flow Length=573' Tc=9.1 min CN=50 Runoff=5.98 cfs 0.395 af

**Subcatchment AREA 28A: Subcat AREA 28A** Runoff Area=0.423 ac 0.00% Impervious Runoff Depth=1.36"
Flow Length=234' Tc=9.1 min CN=49 Runoff=0.71 cfs 0.048 af

**Subcatchment AREA 28B: Subcat AREA 28B** Runoff Area=0.476 ac 0.00% Impervious Runoff Depth=1.53"
Flow Length=211' Tc=4.5 min CN=51 Runoff=1.20 cfs 0.061 af

**Subcatchment AREA 29: Subcat AREA 29** Runoff Area=2.792 ac 0.00% Impervious Runoff Depth=0.69"
Flow Length=463' Tc=14.8 min CN=40 Runoff=1.21 cfs 0.161 af

**Subcatchment AREA 3: Subcat AREA 3** Runoff Area=0.717 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=409' Tc=6.3 min CN=69 Runoff=3.66 cfs 0.190 af

**Subcatchment AREA 30: Subcat AREA 30** Runoff Area=1.415 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=941' Slope=0.0260 '/' Tc=22.0 min CN=39 Runoff=0.43 cfs 0.074 af

**Subcatchment AREA 31: Subcat AREA 31** Runoff Area=0.698 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=481' Tc=4.4 min CN=39 Runoff=0.42 cfs 0.036 af

**Subcatchment AREA 32: Subcat AREA 32** Runoff Area=3.353 ac 0.00% Impervious Runoff Depth=1.13"
Flow Length=663' Tc=17.3 min CN=46 Runoff=3.11 cfs 0.315 af

**Subcatchment AREA 33: Subcat AREA 33** Runoff Area=38,914 sf 0.00% Impervious Runoff Depth=1.36"
Flow Length=377' Tc=16.0 min CN=49 Runoff=1.14 cfs 0.101 af

**Subcatchment AREA 34: Subcat AREA 34** Runoff Area=68,484 sf 0.00% Impervious Runoff Depth=0.98"
Flow Length=488' Tc=16.2 min CN=44 Runoff=1.20 cfs 0.128 af

**Subcatchment AREA 35: Subcat AREA 35** Runoff Area=0.375 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=174' Slope=0.2500 '/' Tc=4.2 min CN=69 Runoff=2.10 cfs 0.099 af

**Subcatchment AREA 36: Subcat AREA 36** Runoff Area=0.487 ac 0.00% Impervious Runoff Depth=3.08"
Flow Length=425' Tc=4.4 min CN=68 Runoff=2.62 cfs 0.125 af

**Subcatchment AREA 37: Subcat AREA 37** Runoff Area=0.344 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=510' Tc=4.6 min CN=69 Runoff=1.89 cfs 0.091 af

**Subcatchment AREA 38: Subcat AREA 38** Runoff Area=0.223 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=590' Tc=4.1 min CN=69 Runoff=1.25 cfs 0.059 af

**Subcatchment AREA 39: Subcat AREA 39** Runoff Area=0.656 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=642' Tc=5.3 min CN=69 Runoff=3.50 cfs 0.174 af

**Subcatchment AREA 4: Subcat AREA 4** Runoff Area=1.247 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=478' Tc=6.6 min CN=69 Runoff=6.31 cfs 0.331 af

**Subcatchment AREA 40: Subcat AREA 40** Runoff Area=1.618 ac 0.00% Impervious Runoff Depth=2.23"
Flow Length=699' Tc=5.2 min CN=59 Runoff=6.03 cfs 0.300 af

**Subcatchment AREA 41: Subcat AREA 41** Runoff Area=0.826 ac 0.00% Impervious Runoff Depth=2.13"
Flow Length=722' Tc=5.9 min CN=58 Runoff=2.84 cfs 0.147 af

**Subcatchment AREA 42: Subcat AREA 42** Runoff Area=2.177 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=415' Tc=9.1 min CN=39 Runoff=0.93 cfs 0.114 af

**Subcatchment AREA 43: Subcat AREA 43** Runoff Area=1.228 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=778' Tc=5.9 min CN=69 Runoff=6.39 cfs 0.325 af

**Subcatchment AREA 44: Subcat AREA 44** Runoff Area=5.227 ac 0.00% Impervious Runoff Depth=0.63"
Flow Length=701' Tc=7.9 min CN=39 Runoff=2.38 cfs 0.273 af

**Subcatchment AREA 44A: Subcat AREA** Runoff Area=1.508 ac 100.00% Impervious Runoff Depth=6.35"
Tc=0.0 min CN=98 Runoff=14.38 cfs 0.798 af

**Subcatchment AREA 44B: Subcat AREA 44B** Runoff Area=0.594 ac 0.00% Impervious Runoff Depth=1.44"
Flow Length=147' Slope=0.0544 '/' Tc=7.6 min CN=50 Runoff=1.17 cfs 0.071 af

**Subcatchment AREA 45: Subcat AREA 45** Runoff Area=2.001 ac 0.00% Impervious Runoff Depth=0.90"
Flow Length=681' Tc=21.9 min CN=43 Runoff=1.16 cfs 0.150 af

**Subcatchment AREA 46: Subcat AREA 46** Runoff Area=7.367 ac 0.36% Impervious Runoff Depth=2.23"
Flow Length=1,904' Tc=9.2 min CN=59 Runoff=22.74 cfs 1.366 af

**Subcatchment AREA 47: Subcat AREA 47** Runoff Area=79,132 sf 8.81% Impervious Runoff Depth=2.69"
Flow Length=582' Tc=9.1 min CN=64 Runoff=6.90 cfs 0.408 af

**Subcatchment AREA 48: Subcat AREA 48** Runoff Area=57,540 sf 11.76% Impervious Runoff Depth=2.41"
Flow Length=489' Tc=5.4 min CN=61 Runoff=5.30 cfs 0.265 af

**Subcatchment AREA 49: Subcat AREA 49** Runoff Area=0.691 ac 0.00% Impervious Runoff Depth=2.23"
Flow Length=522' Tc=4.3 min CN=59 Runoff=2.68 cfs 0.128 af

**Subcatchment AREA 5: Subcat AREA 5** Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=482' Tc=6.6 min CN=69 Runoff=6.05 cfs 0.317 af

**Subcatchment AREA 50: Subcat AREA 50** Runoff Area=1.482 ac 0.00% Impervious Runoff Depth=5.65"
Flow Length=570' Tc=3.4 min CN=92 Runoff=13.35 cfs 0.698 af

**Subcatchment AREA 51: Subcat AREA 51** Runoff Area=1.417 ac 0.00% Impervious Runoff Depth=0.69"
Flow Length=884' Tc=12.2 min CN=40 Runoff=0.67 cfs 0.082 af

**Subcatchment AREA 52: Subcat AREA 52** Runoff Area=197,330 sf 13.14% Impervious Runoff Depth=1.20"
Flow Length=1,294' Tc=6.3 min CN=47 Runoff=7.48 cfs 0.454 af

**Subcatchment AREA 6: Subcat AREA 6** Runoff Area=0.892 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=415' Tc=4.6 min CN=69 Runoff=4.90 cfs 0.236 af

**Subcatchment AREA 7: Subcat AREA 7** Runoff Area=1.017 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=833' Tc=5.8 min CN=69 Runoff=5.31 cfs 0.269 af

**Subcatchment AREA 8: Subcat AREA 8** Runoff Area=1.009 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=409' Tc=4.7 min CN=69 Runoff=5.52 cfs 0.268 af

**Subcatchment AREA 9: Subcat AREA 9** Runoff Area=1.047 ac 0.00% Impervious Runoff Depth=3.18"
Flow Length=426' Tc=4.8 min CN=69 Runoff=5.71 cfs 0.278 af

**Reach S1 R2: Swale S1 Reach 2** Avg. Flow Depth=1.01' Max Vel=3.03 fps Inflow=37.51 cfs 1.827 af
n=0.030 L=127.0' S=0.0055 '/' Capacity=140.64 cfs Outflow=37.05 cfs 1.827 af

**Reach S1 R3: Swale S1 Reach 3** Avg. Flow Depth=1.18' Max Vel=3.17 fps Inflow=53.22 cfs 3.049 af
n=0.030 L=578.0' S=0.0051 '/' Capacity=135.10 cfs Outflow=47.76 cfs 3.049 af

**Reach S1 R4: Swale S1 Reach 4** Avg. Flow Depth=1.26' Max Vel=3.74 fps Inflow=62.37 cfs 3.811 af
n=0.030 L=195.8' S=0.0066 '/' Capacity=154.36 cfs Outflow=61.58 cfs 3.811 af

**Reach S1 R5: Swale S1 Reach 5** Avg. Flow Depth=1.31' Max Vel=3.42 fps Inflow=62.23 cfs 3.859 af
n=0.030 L=411.6' S=0.0053 '/' Capacity=137.86 cfs Outflow=59.21 cfs 3.859 af

**Reach S1 R6: Swale S1 Reach 6** Avg. Flow Depth=1.36' Max Vel=3.44 fps Inflow=65.66 cfs 4.415 af
n=0.030 L=430.9' S=0.0052 '/' Capacity=136.28 cfs Outflow=62.73 cfs 4.415 af

**Reach S2 R1: Swale S2 Reach 1** Avg. Flow Depth=1.65' Max Vel=2.39 fps Inflow=62.82 cfs 4.489 af
n=0.030 L=472.0' S=0.0020 '/' Capacity=84.99 cfs Outflow=57.87 cfs 4.489 af

**Reach S2 R2: Swale S2 Reach 2** Avg. Flow Depth=1.40' Max Vel=4.16 fps Inflow=95.28 cfs 7.736 af
n=0.030 L=751.0' S=0.0069 '/' Capacity=182.04 cfs Outflow=90.88 cfs 7.736 af

**Reach S3 R1: Swale S3 Reach 1** Avg. Flow Depth=0.85' Max Vel=3.26 fps Inflow=27.41 cfs 1.319 af
n=0.030 L=215.0' S=0.0070 '/' Capacity=125.24 cfs Outflow=26.88 cfs 1.319 af

**Reach S3 R2: Swale S3 Reach 2** Avg. Flow Depth=2.14' Max Vel=4.13 fps Inflow=47.52 cfs 2.432 af
n=0.030 L=97.0' S=0.0070 '/' Capacity=71.57 cfs Outflow=47.32 cfs 2.432 af

**Reach S3 R3: Swale S3 Reach 3** Avg. Flow Depth=0.98' Max Vel=3.94 fps Inflow=47.83 cfs 2.533 af
n=0.030 L=353.0' S=0.0097 '/' Capacity=186.19 cfs Outflow=46.22 cfs 2.533 af

**Reach S4 R2: Swale S4 Reach 2** Avg. Flow Depth=0.63' Max Vel=2.70 fps Inflow=23.68 cfs 1.204 af
n=0.030 L=601.0' S=0.0069 '/' Capacity=174.20 cfs Outflow=20.91 cfs 1.204 af

**Reach S4 R3: Swale S4 Reach 3** Avg. Flow Depth=0.89' Max Vel=2.94 fps Inflow=41.60 cfs 2.309 af
n=0.030 L=946.0' S=0.0056 '/' Capacity=156.53 cfs Outflow=34.31 cfs 2.309 af

**Reach S4 R4: Swale S4 Reach 4** Avg. Flow Depth=1.82' Max Vel=5.29 fps Inflow=159.67 cfs 12.653 af
n=0.030 L=483.0' S=0.0082 '/' Capacity=427.66 cfs Outflow=157.44 cfs 12.653 af

**Reach S5 R2: Swale S5 Reach 2** Inflow=7.48 cfs 0.454 af
Outflow=7.48 cfs 0.454 af

**Pond Sed Pond: Sedimentation Basin** Peak Elev=793.06' Storage=236,005 cf Inflow=164.77 cfs 13.946 af
.167 af Primary=11.35 cfs 4.914 af Secondary=22.50 cfs 1.762 af Tertiary=6.00 cfs 0.104 af Outflow=45.68 cfs 13.947 af

**Link C1: Culvert C1** Inflow=7.48 cfs 0.454 af
Primary=7.48 cfs 0.454 af

**Link C2: Culvert C2** Inflow=13.45 cfs 0.780 af
Primary=13.45 cfs 0.780 af

**Link C3: Culvert C3** Inflow=47.76 cfs 3.049 af
Primary=47.76 cfs 3.049 af

**Link C4: Culvert C4** Inflow=62.23 cfs 3.859 af
Primary=62.23 cfs 3.859 af

**Link C5: Culvert C5** Inflow=65.15 cfs 4.254 af
Primary=65.15 cfs 4.254 af

**Link C6: Culvert C6** Inflow=47.83 cfs 2.533 af
Primary=47.83 cfs 2.533 af

**Link C7: Culvert C7** Inflow=103.37 cfs 8.978 af
Primary=103.37 cfs 8.978 af

**Link C8: Culvert C8** Inflow=19.20 cfs 1.127 af
Primary=19.20 cfs 1.127 af

**Link F1: Flume 1** Inflow=22.19 cfs 1.105 af
Primary=22.19 cfs 1.105 af

**Link F2: Flume 2** Inflow=23.68 cfs 1.204 af
Primary=23.68 cfs 1.204 af

**Link F3: Flume 3** Inflow=32.10 cfs 1.570 af
Primary=32.10 cfs 1.570 af

**Link F4: Flume 4** Inflow=14.43 cfs 0.701 af
Primary=14.43 cfs 0.701 af

**Link F5: Flume 5** Inflow=25.31 cfs 1.219 af
Primary=25.31 cfs 1.219 af

**Link F6: Flume 6** Inflow=20.36 cfs 0.985 af
Primary=20.36 cfs 0.985 af

**Link F7: Existing East Flume** Inflow=4.50 cfs 0.216 af
Primary=4.50 cfs 0.216 af

**Link F8: Existing West Flume** Inflow=16.40 cfs 0.828 af
Primary=16.40 cfs 0.828 af

**Link North Area: North Area** Inflow=19.20 cfs 1.127 af
Primary=19.20 cfs 1.127 af

**Link RC1: Rock Chute 1** Inflow=22.19 cfs 1.105 af
Primary=22.19 cfs 1.105 af

**Link RC2: Rock Chute 2** Inflow=23.68 cfs 1.204 af
Primary=23.68 cfs 1.204 af

**Link Swale 1 R6: Swale S1 Reach 6** Inflow=62.73 cfs 4.415 af
Primary=62.73 cfs 4.415 af

**Link Swale S1 R1: Swale S1 Reach 1** Inflow=2.68 cfs 0.128 af
Primary=2.68 cfs 0.128 af

**Link Swale S1 R2: Swale S1 Reach 2** Inflow=37.05 cfs 1.827 af
Primary=37.05 cfs 1.827 af

**Link Swale S1 R3: Swale S1 Reach 3** Inflow=47.76 cfs 3.049 af
Primary=47.76 cfs 3.049 af

**Link Swale S1 R4: Swale S1 Reach 4** Inflow=62.23 cfs 3.859 af
Primary=62.23 cfs 3.859 af

**Link Swale S1 R5: Swale S1 Reach 5** Inflow=65.15 cfs 4.254 af
Primary=65.15 cfs 4.254 af

**Link Swale S2 R1: Swale S2 Reach 1** Inflow=58.13 cfs 4.525 af
Primary=58.13 cfs 4.525 af

**Link Swale S2 R2: Swale S2 Reach 2** Inflow=103.37 cfs 8.978 af
Primary=103.37 cfs 8.978 af

**Link Swale S3 R1: Swale S3 Reach 1** Inflow=27.22 cfs 1.447 af
Primary=27.22 cfs 1.447 af

**Link Swale S3 R2: Swale S3 Reach 2** Inflow=47.83 cfs 2.533 af
Primary=47.83 cfs 2.533 af

**Link Swale S3 R3: Swale S3 Reach 3** Inflow=47.45 cfs 2.848 af
Primary=47.45 cfs 2.848 af

**Link Swale S4 R4: Swale S4 Reach 4** Inflow=157.92 cfs 12.803 af
Primary=157.92 cfs 12.803 af

**Link Swale S5 R1: Swale S5 Reach 1** Inflow=7.48 cfs 0.454 af
Primary=7.48 cfs 0.454 af

**Link Swale S5 R2: Swale S5 Reach 2** Inflow=12.65 cfs 0.720 af
Primary=12.65 cfs 0.720 af

**Link Swale S5 R3: Swale S5 Reach 3** Inflow=6.90 cfs 0.408 af
Primary=6.90 cfs 0.408 af

**Link Swale S6 R1: Swale S6 Reach 1** Inflow=13.45 cfs 0.780 af
Primary=13.45 cfs 0.780 af

**Link Wetland: Wetland** Inflow=39.85 cfs 6.780 af
Primary=39.85 cfs 6.780 af

**Total Runoff Area = 82.060 ac Runoff Volume = 15.074 af Average Runoff Depth = 2.20"**
**97.02% Pervious = 79.615 ac 2.98% Impervious = 2.446 ac**

## Summary for Subcatchment AREA 1: Subcat AREA 1

Runoff = 7.63 cfs @ 12.11 hrs, Volume= 0.342 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.288 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.288 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.7 | 37 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.9 | 371 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.6 | 408 | Total | | | |

## Summary for Subcatchment AREA 10: Subcat AREA 10

Runoff = 5.29 cfs @ 12.11 hrs, Volume= 0.242 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.914 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.1 | 46 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 454 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.2 | 500 | Total | | | |

## Summary for Subcatchment AREA 11: Subcat AREA 11

Runoff = 5.21 cfs @ 12.12 hrs, Volume= 0.251 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.949 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.949 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 277 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 391 | Total | | | |

## Summary for Subcatchment AREA 12: Subcat AREA 12

Runoff = 0.58 cfs @ 12.11 hrs, Volume= 0.026 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.098 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.098 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 36 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 2.5 | 92 | Total | | | |

## Summary for Subcatchment AREA 13: Subcat AREA 13

Runoff = 4.89 cfs @ 12.12 hrs, Volume= 0.236 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.890 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.890 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.4 | 87 | 0.2500 | 0.42 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.2 | 503 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 590 | Total | | | |

## Summary for Subcatchment AREA 14: Subcat AREA 14

Runoff = 6.17 cfs @ 12.13 hrs, Volume= 0.303 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.145 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.145 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 27 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 498 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 625 | Total | | | |

## Summary for Subcatchment AREA 15: Subcat AREA 15

Runoff = 2.86 cfs @ 12.12 hrs, Volume= 0.136 af, Depth= 3.18"
Routed to Link F4 : Flume 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.512 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.512 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 85 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.2 | 235 | Total | | | |

## Summary for Subcatchment AREA 16: Subcat AREA 16

Runoff = 8.20 cfs @ 12.12 hrs, Volume= 0.400 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.510 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.510 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 372 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.9 | 522 | Total | | | |

## Summary for Subcatchment AREA 17: Subcat AREA 17

Runoff = 6.72 cfs @ 12.12 hrs, Volume= 0.326 af, Depth= 3.18"
Routed to Link F5 : Flume 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 63 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 223 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 386 | Total | | | |

## Summary for Subcatchment AREA 18: Subcat AREA 18

Runoff = 4.47 cfs @ 12.12 hrs, Volume= 0.215 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.813 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.813 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 48 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 235 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 383 | Total | | | |

## Summary for Subcatchment AREA 19: Subcat AREA 19

Runoff = 4.66 cfs @ 12.12 hrs, Volume= 0.225 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.847 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.847 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 244 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 394 | Total | | | |

## Summary for Subcatchment AREA 2: Subcat AREA 2

Runoff = 6.28 cfs @ 12.13 hrs, Volume= 0.309 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.167 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.167 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.2 | 495 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.1 | 613 | Total | | | |

## Summary for Subcatchment AREA 20: Subcat AREA 20

Runoff = 5.77 cfs @ 12.12 hrs, Volume= 0.279 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.054 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.054 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 303 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 453 | Total | | | |

## Summary for Subcatchment AREA 21: Subcat AREA 21

Runoff = 5.64 cfs @ 12.12 hrs, Volume= 0.273 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 22: Subcat AREA 22

Runoff = 5.64 cfs @ 12.12 hrs, Volume= 0.273 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.030 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.030 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 50 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 298 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 448 | Total | | | |

## Summary for Subcatchment AREA 23: Subcat AREA 23

Runoff = 8.23 cfs @ 12.13 hrs, Volume= 0.410 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.548 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.548 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 591 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 715 | Total | | | |

## Summary for Subcatchment AREA 24: Subcat AREA 24

Runoff = 10.20 cfs @ 12.13 hrs, Volume= 0.517 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.952 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.952 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 765 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 5.8 | 889 | Total | | | |

## Summary for Subcatchment AREA 25: Subcat AREA 25

Runoff = 8.59 cfs @ 12.12 hrs, Volume= 0.402 af, Depth= 3.18"
Routed to Link F3 : Flume 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.515 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.515 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.8 | 67 | 0.2500 | 0.40 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 428 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 3.9 | 495 | Total | | | |

## Summary for Subcatchment AREA 26: Subcat AREA 26

Runoff = 2.74 cfs @ 12.12 hrs, Volume= 0.129 af, Depth= 2.98"
Routed to Reach S1 R2 : Swale S1 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.396 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.072 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.049 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 0.518 | 67 | Weighted Average |
| | 0.518 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 93 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 123 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.1 | 216 | Total | | | |

## Summary for Subcatchment AREA 27: Subcat AREA 27

Runoff = 5.63 cfs @ 12.22 hrs, Volume= 0.442 af, Depth= 1.28"
Routed to Reach S1 R3 : Swale S1 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.651 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 2.758 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.010 | 96 | Gravel surface, HSG A |
| | 0.295 | 96 | Gravel surface, HSG A |
| | 0.426 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 4.140 | 48 | Weighted Average |
| | 4.140 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.3 | 217 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 14 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 513 | 0.0051 | 4.23 | 135.28 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 12.0 | 864 | Total | | | |

## Summary for Subcatchment AREA 28: Subcat AREA 28

Runoff = 5.98 cfs @ 12.18 hrs, Volume= 0.395 af, Depth= 1.44"
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 30,267 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 100,859 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 11,834 | 96 | Gravel surface |
| | 142,960 | 50 | Weighted Average |
| | 142,960 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 5.9 | 78 | 0.0526 | 0.22 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.1 | 22 | 0.2500 | 0.32 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 24 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 23 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.6 | 410 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale 1 Reach** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 573 | Total | | | |

## Summary for Subcatchment AREA 28A: Subcat AREA 28A

Runoff = 0.71 cfs @ 12.18 hrs, Volume= 0.048 af, Depth= 1.36"
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.035 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.257 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.075 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.010 | 96 | Gravel surface, HSG A |
| 0.046 | 96 | Gravel surface, HSG A |
| 0.423 | 49 | Weighted Average |
| 0.423 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 82 | 0.0334 | 0.19 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 34 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 20 | 0.0050 | 1.14 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.1 | 13 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.2 | 67 | 0.0069 | 4.92 | 157.36 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 234 | Total | | | |

## Summary for Subcatchment AREA 28B: Subcat AREA 28B

Runoff = 1.20 cfs @ 12.13 hrs, Volume= 0.061 af, Depth= 1.53"
Routed to Reach S1 R4 : Swale S1 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.050 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.110 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.240 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.009 | 96 | Gravel surface, HSG A |
| 0.067 | 96 | Gravel surface, HSG A |
| 0.476 | 51 | Weighted Average |
| 0.476 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 58 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.6 | 20 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.0 | 18 | 0.2500 | 0.31 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 115 | 0.0055 | 4.39 | 140.49 | **Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.5 | 211 | Total | | | |

## Summary for Subcatchment AREA 29: Subcat AREA 29

Runoff = 1.21 cfs @ 12.31 hrs, Volume= 0.161 af, Depth= 0.69"
Routed to Reach S1 R6 : Swale S1 Reach 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.056 | 96 | Gravel surface, HSG A |
| | 2.735 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Gravel surface |
| | 2.792 | 40 | Weighted Average |
| | 2.792 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 11.8 | 100 | 0.0150 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 100 | 0.0150 | 0.86 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 16 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 247 | 0.0052 | 4.27 | 136.60 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 5** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 14.8 | 463 | Total | | | |

## Summary for Subcatchment AREA 3: Subcat AREA 3

Runoff = 3.66 cfs @ 12.14 hrs, Volume= 0.190 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.717 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.717 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.9 | 44 | 0.1000 | 0.26 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.4 | 56 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 233 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 409 | Total | | | |

## Summary for Subcatchment AREA 30: Subcat AREA 30

Runoff = 0.43 cfs @ 12.46 hrs, Volume= 0.074 af, Depth= 0.63"
Routed to Reach S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.415 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.415 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 9.5 | 100 | 0.0260 | 0.18 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 194 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 9.6 | 647 | 0.0260 | 1.13 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 22.0 | 941 | Total | | | |

## Summary for Subcatchment AREA 31: Subcat AREA 31

Runoff = 0.42 cfs @ 12.14 hrs, Volume= 0.036 af, Depth= 0.63"
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.698 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.698 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.8 | 447 | 0.0020 | 2.65 | 84.72 | **Trap/Vee/Rect Channel Flow, Swale 2 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 4.4 | 481 | Total | | | |

## Summary for Subcatchment AREA 32: Subcat AREA 32

Runoff = 3.11 cfs @ 12.31 hrs, Volume= 0.315 af, Depth= 1.13"
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.567 | 69 | Pasture/grassland/range, Fair, HSG B |
| 2.413 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.099 | 96 | Gravel surface, HSG A |
| 0.274 | 39 | Pasture/grassland/range, Good, HSG A |
| 3.353 | 46 | Weighted Average |
| 3.353 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.2 | 211 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 23 | 0.1740 | 2.92 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 329 | 0.0097 | 5.83 | 186.57 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 3** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 17.3 | 663 | Total | | | |

## Summary for Subcatchment AREA 33: Subcat AREA 33

Runoff = 1.14 cfs @ 12.28 hrs, Volume= 0.101 af, Depth= 1.36"
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (sf) | CN | Description |
|---|---|---|---|
| | 4,079 | 96 | Gravel surface, HSG A |
| | 1,422 | 96 | Gravel surface, HSG A |
| | 30,707 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 2,706 | 69 | Pasture/grassland/range, Fair, HSG A |
| | 38,914 | 49 | Weighted Average |
| | 38,914 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.6 | 178 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.0 | 12 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 87 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 2** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.0 | 377 | Total | | | |

## Summary for Subcatchment AREA 34: Subcat AREA 34

Runoff = 1.20 cfs @ 12.30 hrs, Volume= 0.128 af, Depth= 0.98"
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 5,695 | 69 | Pasture/grassland/range, Fair, HSG B |
| 3,470 | 96 | Gravel surface, HSG A |
| 59,319 | 39 | Pasture/grassland/range, Good, HSG A |
| 68,484 | 44 | Weighted Average |
| 68,484 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 12.1 | 100 | 0.0140 | 0.14 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 170 | 0.0140 | 0.83 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.1 | 15 | 0.4000 | 4.43 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 203 | 0.0070 | 5.23 | 125.44 | **Trap/Vee/Rect Channel Flow, Swale 3 Reach 1** Bot.W=8.00' D=2.00' Z= 2.0 '/' Top.W=16.00' n= 0.030 Earth, grassed & winding |
| 16.2 | 488 | Total | | | |

## Summary for Subcatchment AREA 35: Subcat AREA 35

Runoff = 2.10 cfs @ 12.12 hrs, Volume= 0.099 af, Depth= 3.18"
Routed to Reach S3 R1 : Swale S3 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.375 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.375 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 74 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 4.2 | 174 | Total | | | |

## Summary for Subcatchment AREA 36: Subcat AREA 36

Runoff = 2.62 cfs @ 12.12 hrs, Volume= 0.125 af, Depth= 3.08"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.470 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.016 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 0.487 | 68 | Weighted Average |
| | 0.487 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 90 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.7 | 201 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 134 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.4 | 425 | Total | | | |

## Summary for Subcatchment AREA 37: Subcat AREA 37

Runoff = 1.89 cfs @ 12.12 hrs, Volume= 0.091 af, Depth= 3.18"
Routed to Link F7 : Existing East Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.344 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.344 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 30 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 126 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 254 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.6 | 510 | Total | | | |

## Summary for Subcatchment AREA 38: Subcat AREA 38

Runoff = 1.25 cfs @ 12.12 hrs, Volume= 0.059 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.223 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.223 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 156 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.5 | 357 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 4.1 | 590 | Total | | | |

## Summary for Subcatchment AREA 39: Subcat AREA 39

Runoff = 3.50 cfs @ 12.13 hrs, Volume= 0.174 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.656 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.656 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 314 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 217 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.3 | 642 | Total | | | |

## Summary for Subcatchment AREA 4: Subcat AREA 4

Runoff = 6.31 cfs @ 12.14 hrs, Volume= 0.331 af, Depth= 3.18"
Routed to Link F2 : Flume 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.247 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.247 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.5 | 57 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 83 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 295 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 478 | Total | | | |

## Summary for Subcatchment AREA 40: Subcat AREA 40

Runoff = 6.03 cfs @ 12.13 hrs, Volume= 0.300 af, Depth= 2.23"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 1.079 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.539 | 39 | Pasture/grassland/range, Good, HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Good |
| | 1.618 | 59 | Weighted Average |
| | 1.618 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.1 | 77 | 0.2500 | 0.41 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.8 | 237 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.3 | 70 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.0 | 315 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.2 | 699 | Total | | | |

## Summary for Subcatchment AREA 41: Subcat AREA 41

Runoff = 2.84 cfs @ 12.14 hrs, Volume= 0.147 af, Depth= 2.13"
Routed to Reach S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.520 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.306 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.826 | 58 | Weighted Average |
| 0.826 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 26 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 2.0 | 596 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 5.9 | 722 | Total | | | |

## Summary for Subcatchment AREA 42: Subcat AREA 42

Runoff = 0.93 cfs @ 12.22 hrs, Volume= 0.114 af, Depth= 0.63"
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 2.177 | 39 | Pasture/grassland/range, Good, HSG A |
| 2.177 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 6.4 | 66 | 0.0303 | 0.17 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.6 | 34 | 0.2500 | 0.35 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.2 | 49 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.9 | 266 | 0.0069 | 5.05 | 181.72 | **Trap/Vee/Rect Channel Flow, Swale S2 Reach 2** Bot.W=10.00' D=2.00' Z= 4.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 415 | Total | | | |

## Summary for Subcatchment AREA 43: Subcat AREA 43

Runoff = 6.39 cfs @ 12.13 hrs, Volume= 0.325 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.228 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.228 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 6 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.9 | 541 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.2 | 131 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow, Riprap Flume** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.9 | 778 | Total | | | |

## Summary for Subcatchment AREA 44: Subcat AREA 44

Runoff = 2.38 cfs @ 12.19 hrs, Volume= 0.273 af, Depth= 0.63"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 5.227 | 39 | Pasture/grassland/range, Good, HSG A |
| 5.227 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 4.5 | 75 | 0.0933 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.3 | 25 | 0.2500 | 0.33 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 10 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 381 | 0.0265 | 7.85 | 109.92 | **Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=14.00' n= 0.030 Earth, grassed & winding |
| 0.8 | 162 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.5 | 48 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.9 | 701 | Total | | | |

## Summary for Subcatchment AREA 44A: Subcat AREA 44A

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.38 cfs @ 12.09 hrs, Volume= 0.798 af, Depth= 6.35"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.508 | 98 | Water Surface, HSG A |
| 1.508 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.0 | | | | | **Direct Entry,** |

## Summary for Subcatchment AREA 44B: Subcat AREA 44B

Runoff = 1.17 cfs @ 12.16 hrs, Volume= 0.071 af, Depth= 1.44"
Routed to Pond Sed Pond : Sedimentation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 0.479 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.115 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| | 0.594 | 50 | Weighted Average |
| | 0.594 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.1 | 100 | 0.0544 | 0.24 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.5 | 47 | 0.0544 | 1.63 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 7.6 | 147 | Total | | | |

## Summary for Subcatchment AREA 45: Subcat AREA 45

Runoff = 1.16 cfs @ 12.41 hrs, Volume= 0.150 af, Depth= 0.90"
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| * | 0.000 | 0 | , HSG A |
| | 1.870 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.000 | 96 | Gravel surface, HSG A |
| | 0.130 | 96 | Gravel surface, HSG A |
| | 2.001 | 43 | Weighted Average |
| | 2.001 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 15.7 | 100 | 0.0074 | 0.11 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.7 | 169 | 0.0074 | 0.60 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.4 | 49 | 0.0800 | 1.98 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.1 | 363 | 0.0082 | 5.42 | 162.67 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 2** Bot.W=8.00' D=2.00' Z= 4.0 & 3.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 21.9 | 681 | Total | | | |

## Summary for Subcatchment AREA 46: Subcat AREA 46

Runoff = 22.74 cfs @ 12.17 hrs, Volume= 1.366 af, Depth= 2.23"
Routed to Reach S4 R4 : Swale S4 Reach 4

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| | Area (ac) | CN | Description |
|---|---|---|---|
| | 3.081 | 69 | Pasture/grassland/range, Fair, HSG B |
| | 0.590 | 96 | Gravel surface, HSG B |
| | 3.264 | 39 | Pasture/grassland/range, Good, HSG A |
| | 0.017 | 98 | Paved parking, HSG A |
| | 0.009 | 98 | Paved parking, HSG A |
| | 0.378 | 96 | Gravel surface, HSG A |
| | 0.001 | 96 | Gravel surface, HSG A |
| | 0.026 | 96 | Gravel surface, HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | , HSG A |
| * | 0.000 | 0 | Pasture/grassland/range, Fair |
| | 7.367 | 59 | Weighted Average |
| | 7.340 | | 99.64% Pervious Area |
| | 0.027 | | 0.36% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.2 | 51 | 0.2500 | 0.38 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 16 | 0.2500 | 2.44 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.9 | 31 | 0.0050 | 0.58 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0650 | 1.78 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 5.6 | 1,759 | 0.0073 | 5.26 | 178.68 | **Trap/Vee/Rect Channel Flow, Swale S4 Reach 1** Bot.W=10.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |
| 9.2 | 1,904 | Total | | | |

## Summary for Subcatchment AREA 47: Subcat AREA 47

Runoff = 6.90 cfs @ 12.17 hrs, Volume= 0.408 af, Depth= 2.69"
Routed to Link Swale S5 R3 : Swale S5 Reach 3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 49,617 | 69 | Pasture/grassland/range, Fair, HSG B |
| 6,971 | 98 | Paved parking, HSG A |
| 1,619 | 96 | Gravel surface, HSG A |
| 20,925 | 39 | Pasture/grassland/range, Good, HSG A |
| 79,132 | 64 | Weighted Average |
| 72,161 | | 91.19% Pervious Area |
| 6,971 | | 8.81% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.0 | 43 | 0.2500 | 0.37 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 11 | 0.1111 | 1.63 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.7 | 12 | 0.2500 | 0.28 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 2.9 | 28 | 0.0393 | 0.16 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.4 | 488 | 0.0024 | 2.40 | 52.81 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 3** Bot.W=0.00' D=2.00' Z= 5.0 & 6.0 '/' Top.W=22.00' n= 0.030 Earth, grassed & winding |
| 9.1 | 582 | Total | | | |

## Summary for Subcatchment AREA 48: Subcat AREA 48

Runoff = 5.30 cfs @ 12.13 hrs, Volume= 0.265 af, Depth= 2.41"
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 24,597 | 69 | Pasture/grassland/range, Fair, HSG B |
| 24,117 | 39 | Pasture/grassland/range, Good, HSG A |
| 2,057 | 96 | Gravel surface, HSG A |
| 6,769 | 98 | Paved parking, HSG A |
| 57,540 | 61 | Weighted Average |
| 50,771 | | 88.24% Pervious Area |
| 6,769 | | 11.76% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 19 | 0.0050 | 0.53 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.7 | 29 | 0.1667 | 0.29 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.1 | 441 | 0.0024 | 2.38 | 40.39 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 2** Bot.W=0.00' D=2.00' Z= 2.5 & 6.0 '/' Top.W=17.00' n= 0.030 Earth, grassed & winding |
| 5.4 | 489 | Total | | | |

## Summary for Subcatchment AREA 49: Subcat AREA 49

Runoff = 2.68 cfs @ 12.12 hrs, Volume= 0.128 af, Depth= 2.23"
Routed to Link Swale S1 R1 : Swale S1 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.439 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.246 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.006 | 96 | Gravel surface, HSG A |
| 0.691 | 59 | Weighted Average |
| 0.691 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 59 | 0.2500 | 0.39 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.8 | 463 | 0.0053 | 4.31 | 137.91 | **Trap/Vee/Rect Channel Flow, Swale S1 Reach 1** Bot.W=8.00' D=2.00' Z= 4.0 '/' Top.W=24.00' n= 0.030 Earth, grassed & winding |

4.3 522 Total

## Summary for Subcatchment AREA 5: Subcat AREA 5

Runoff = 6.05 cfs @ 12.14 hrs, Volume= 0.317 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.195 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.195 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.6 | 59 | 0.1000 | 0.27 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 1.9 | 41 | 0.2500 | 0.36 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 85 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.7 | 297 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 6.6 | 482 | Total | | | |

## Summary for Subcatchment AREA 50: Subcat AREA 50

Runoff = 13.35 cfs @ 12.11 hrs, Volume= 0.698 af, Depth= 5.65"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.100 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.001 | 39 | Pasture/grassland/range, Good, HSG A |
| 1.382 | 96 | Gravel surface, HSG A |
| 1.482 | 92 | Weighted Average |
| 1.482 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.6 | 100 | 0.0119 | 1.04 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 0.4 | 47 | 0.0119 | 1.76 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 0.0 | 10 | 0.5000 | 4.95 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.4 | 413 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 3.4 | 570 | Total | | | |

## Summary for Subcatchment AREA 51: Subcat AREA 51

Runoff = 0.67 cfs @ 12.27 hrs, Volume= 0.082 af, Depth= 0.69"
Routed to Link Swale S6 R1 : Swale S6 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.396 | 39 | Pasture/grassland/range, Good, HSG A |
| 0.020 | 96 | Gravel surface, HSG A |
| 1.417 | 40 | Weighted Average |
| 1.417 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.3 | 100 | 0.0500 | 0.23 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 3.2 | 302 | 0.0500 | 1.57 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.3 | 53 | 0.0313 | 2.85 | | **Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps |
| 1.4 | 429 | 0.0066 | 5.00 | 130.01 | **Trap/Vee/Rect Channel Flow, Swale S6 Reach 1** Bot.W=8.00' D=2.00' Z= 2.5 '/' Top.W=18.00' n= 0.030 Earth, grassed & winding |
| 12.2 | 884 | Total | | | |

## Summary for Subcatchment AREA 52: Subcat AREA 52

Runoff = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Depth= 1.20"
Routed to Link Swale S5 R1 : Swale S5 Reach 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (sf) | CN | Description |
|---|---|---|
| 169,213 | 39 | Pasture/grassland/range, Good, HSG A |
| 25,933 | 98 | Paved parking, HSG A |
| 2,184 | 96 | Gravel surface, HSG A |
| 197,330 | 47 | Weighted Average |
| 171,397 | | 86.86% Pervious Area |
| 25,933 | | 13.14% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 0.6 | 18 | 0.0050 | 0.52 | | **Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.77" |
| 1.4 | 21 | 0.1333 | 0.25 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 4.3 | 1,255 | 0.0096 | 4.82 | 125.20 | **Trap/Vee/Rect Channel Flow, Swale S5 Reach 1** Bot.W=0.00' D=2.00' Z= 6.0 & 7.0 '/' Top.W=26.00' n= 0.030 Earth, grassed & winding |
| 6.3 | 1,294 | Total | | | |

## Summary for Subcatchment AREA 6: Subcat AREA 6

Runoff = 4.90 cfs @ 12.12 hrs, Volume= 0.236 af, Depth= 3.18"
Routed to Link F1 : Flume 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 0.892 | 69 | Pasture/grassland/range, Fair, HSG B |
| 0.892 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.0 | 7 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 308 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.6 | 415 | Total | | | |

## Summary for Subcatchment AREA 7: Subcat AREA 7

Runoff = 5.31 cfs @ 12.13 hrs, Volume= 0.269 af, Depth= 3.18"
Routed to Link F8 : Existing West Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.017 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.017 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.1 | 18 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 1.5 | 419 | 0.0200 | 4.80 | 23.38 | **Trap/Vee/Rect Channel Flow, Existing Diversion Berm** Bot.W=0.00' D=1.18' Z= 4.0 & 3.0 '/' Top.W=8.26' n= 0.030 Earth, grassed & winding |
| 0.4 | 296 | 0.2500 | 12.26 | 441.43 | **Trap/Vee/Rect Channel Flow,** Bot.W=12.00' D=2.00' Z= 3.0 '/' Top.W=24.00' n= 0.078 Riprap, 12-inch |
| 5.8 | 833 | Total | | | |

## Summary for Subcatchment AREA 8: Subcat AREA 8

Runoff = 5.52 cfs @ 12.12 hrs, Volume= 0.268 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.009 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.009 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.3 | 66 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 243 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.7 | 409 | Total | | | |

## Summary for Subcatchment AREA 9: Subcat AREA 9

Runoff = 5.71 cfs @ 12.12 hrs, Volume= 0.278 af, Depth= 3.18"
Routed to Link F6 : Flume 6

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
MSE 24-hr 4 100-yr, 24-hr Rainfall=6.59"

| Area (ac) | CN | Description |
|---|---|---|
| 1.047 | 69 | Pasture/grassland/range, Fair, HSG B |
| 1.047 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 3.8 | 100 | 0.2500 | 0.43 | | **Sheet Flow,** Grass: Short n= 0.150 P2= 2.77" |
| 0.4 | 76 | 0.2500 | 3.50 | | **Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps |
| 0.6 | 250 | 0.0200 | 6.74 | 80.87 | **Trap/Vee/Rect Channel Flow, Diversion Berm** Bot.W=0.00' D=2.00' Z= 4.0 & 2.0 '/' Top.W=12.00' n= 0.030 Earth, grassed & winding |
| 4.8 | 426 | Total | | | |

## Summary for Reach S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 3.07" for 100-yr, 24-hr event
Inflow = 37.51 cfs @ 12.12 hrs, Volume= 1.827 af
Outflow = 37.05 cfs @ 12.12 hrs, Volume= 1.827 af, Atten= 1%, Lag= 0.4 min
Routed to Link Swale S1 R2 : Swale S1 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.03 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 0.80 fps, Avg. Travel Time= 2.7 min

Peak Storage= 1,553 cf @ 12.12 hrs
Average Depth at Peak Storage= 1.01' , Surface Width= 16.12'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 140.64 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 127.0' Slope= 0.0055 '/'
Inlet Invert= 814.81', Outlet Invert= 814.11'

‡

## Summary for Reach S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 2.58" for 100-yr, 24-hr event
Inflow = 53.22 cfs @ 12.12 hrs, Volume= 3.049 af
Outflow = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af, Atten= 10%, Lag= 1.5 min
Routed to Link Swale S1 R3 : Swale S1 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.17 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 0.70 fps, Avg. Travel Time= 13.8 min

Peak Storage= 8,716 cf @ 12.15 hrs
Average Depth at Peak Storage= 1.18' , Surface Width= 17.47'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 135.10 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 578.0' Slope= 0.0051 '/'
Inlet Invert= 814.11', Outlet Invert= 811.17'

‡

## Summary for Reach S1 R4: Swale S1 Reach 4

Inflow Area = 17.292 ac, 0.00% Impervious, Inflow Depth = 2.64" for 100-yr, 24-hr event
Inflow = 62.37 cfs @ 12.14 hrs, Volume= 3.811 af
Outflow = 61.58 cfs @ 12.15 hrs, Volume= 3.811 af, Atten= 1%, Lag= 0.6 min
Routed to Link Swale S1 R4 : Swale S1 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.74 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 0.81 fps, Avg. Travel Time= 4.0 min

Peak Storage= 3,220 cf @ 12.15 hrs
Average Depth at Peak Storage= 1.26' , Surface Width= 18.09'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 154.36 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 195.8' Slope= 0.0066 '/'
Inlet Invert= 811.17', Outlet Invert= 809.87'

‡

## Summary for Reach S1 R5: Swale S1 Reach 5

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 2.61" for 100-yr, 24-hr event
Inflow = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af
Outflow = 59.21 cfs @ 12.17 hrs, Volume= 3.859 af, Atten= 5%, Lag= 1.3 min
Routed to Link Swale S1 R5 : Swale S1 Reach 5

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.42 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 0.74 fps, Avg. Travel Time= 9.2 min

Peak Storage= 7,135 cf @ 12.17 hrs
Average Depth at Peak Storage= 1.31' , Surface Width= 18.48'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 137.86 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 411.6' Slope= 0.0053 '/'
Inlet Invert= 809.77', Outlet Invert= 807.59'

‡

## Summary for Reach S1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 2.23" for 100-yr, 24-hr event
Inflow = 65.66 cfs @ 12.17 hrs, Volume= 4.415 af
Outflow = 62.73 cfs @ 12.20 hrs, Volume= 4.415 af, Atten= 4%, Lag= 1.5 min
Routed to Link Swale 1 R6 : Swale S1 Reach 6

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.44 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 0.76 fps, Avg. Travel Time= 9.4 min

Peak Storage= 7,852 cf @ 12.20 hrs
Average Depth at Peak Storage= 1.36' , Surface Width= 18.86'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 136.28 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 430.9' Slope= 0.0052 '/'
Inlet Invert= 807.15', Outlet Invert= 804.92'

‡

## Summary for Reach S2 R1: Swale S2 Reach 1

Inflow Area = 25.203 ac, 0.00% Impervious, Inflow Depth = 2.14" for 100-yr, 24-hr event
Inflow = 62.82 cfs @ 12.20 hrs, Volume= 4.489 af
Outflow = 57.87 cfs @ 12.24 hrs, Volume= 4.489 af, Atten= 8%, Lag= 2.5 min
Routed to Link Swale S2 R1 : Swale S2 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.39 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 0.52 fps, Avg. Travel Time= 15.1 min

Peak Storage= 11,415 cf @ 12.24 hrs
Average Depth at Peak Storage= 1.65' , Surface Width= 21.24'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 84.99 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 472.0' Slope= 0.0020 '/'
Inlet Invert= 802.25', Outlet Invert= 801.30'

‡

## Summary for Reach S2 R2: Swale S2 Reach 2

Inflow Area = 42.068 ac, 0.00% Impervious, Inflow Depth = 2.21" for 100-yr, 24-hr event
Inflow = 95.28 cfs @ 12.17 hrs, Volume= 7.736 af
Outflow = 90.88 cfs @ 12.23 hrs, Volume= 7.736 af, Atten= 5%, Lag= 3.1 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.16 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 0.88 fps, Avg. Travel Time= 14.3 min

Peak Storage= 16,407 cf @ 12.23 hrs
Average Depth at Peak Storage= 1.40' , Surface Width= 21.20'
Bank-Full Depth= 2.00' Flow Area= 36.0 sf, Capacity= 182.04 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 26.00'
Length= 751.0' Slope= 0.0069 '/'
Inlet Invert= 801.30', Outlet Invert= 796.10'

‡

## Summary for Reach S3 R1: Swale S3 Reach 1

Inflow Area = 4.976 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 27.41 cfs @ 12.12 hrs, Volume= 1.319 af
Outflow = 26.88 cfs @ 12.13 hrs, Volume= 1.319 af, Atten= 2%, Lag= 0.6 min
Routed to Link Swale S3 R1 : Swale S3 Reach 1

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.26 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 0.77 fps, Avg. Travel Time= 4.7 min

Peak Storage= 1,774 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.85' , Surface Width= 11.40'
Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 125.24 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 215.0' Slope= 0.0070 '/'
Inlet Invert= 807.58', Outlet Invert= 806.08'

‡

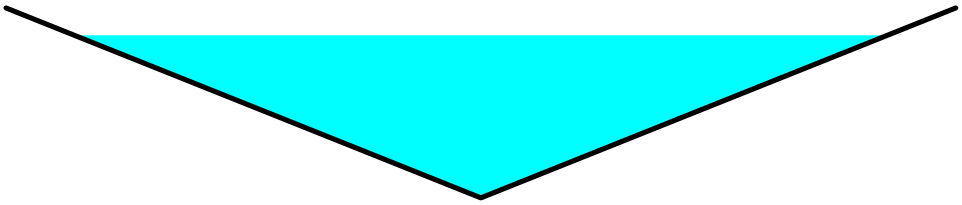
## Summary for Reach S3 R2: Swale S3 Reach 2

Inflow Area = 10.265 ac, 0.00% Impervious, Inflow Depth = 2.84" for 100-yr, 24-hr event
Inflow = 47.52 cfs @ 12.13 hrs, Volume= 2.432 af
Outflow = 47.32 cfs @ 12.13 hrs, Volume= 2.432 af, Atten= 0%, Lag= 0.3 min
Routed to Link Swale S3 R2 : Swale S3 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.13 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.45 fps, Avg. Travel Time= 1.1 min

Peak Storage= 1,111 cf @ 12.13 hrs
Average Depth at Peak Storage= 2.14' , Surface Width= 10.70'
Bank-Full Depth= 2.50' Flow Area= 15.6 sf, Capacity= 71.57 cfs

0.00' x 2.50' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.5 '/' Top Width= 12.50'
Length= 97.0' Slope= 0.0070 '/'
Inlet Invert= 806.08', Outlet Invert= 805.40'



## Summary for Reach S3 R3: Swale S3 Reach 3

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 2.72" for 100-yr, 24-hr event
Inflow = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af
Outflow = 46.22 cfs @ 12.15 hrs, Volume= 2.533 af, Atten= 3%, Lag= 0.9 min
Routed to Link Swale S3 R3 : Swale S3 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.94 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.02 fps, Avg. Travel Time= 5.8 min

Peak Storage= 4,140 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.98' , Surface Width= 15.86'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 186.19 cfs

8.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 353.0' Slope= 0.0097 '/'
Inlet Invert= 804.71', Outlet Invert= 801.30'

‡

## Summary for Reach S4 R2: Swale S4 Reach 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af
Outflow = 20.91 cfs @ 12.16 hrs, Volume= 1.204 af, Atten= 12%, Lag= 1.8 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.70 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 0.63 fps, Avg. Travel Time= 16.0 min

Peak Storage= 4,652 cf @ 12.16 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 14.44'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 174.20 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 3.0 '/' Top Width= 24.00'
Length= 601.0' Slope= 0.0069 '/'
Inlet Invert= 806.43', Outlet Invert= 802.26'

‡

## Summary for Reach S4 R3: Swale S4 Reach 3

[62] Hint: Exceeded Reach S4 R2 OUTLET depth by 0.32' @ 12.25 hrs

Inflow Area = 8.711 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 41.60 cfs @ 12.14 hrs, Volume= 2.309 af
Outflow = 34.31 cfs @ 12.18 hrs, Volume= 2.309 af, Atten= 18%, Lag= 2.7 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.94 fps, Min. Travel Time= 5.4 min
Avg. Velocity = 0.64 fps, Avg. Travel Time= 24.5 min

Peak Storage= 11,027 cf @ 12.18 hrs
Average Depth at Peak Storage= 0.89' , Surface Width= 16.22'
Bank-Full Depth= 2.00' Flow Area= 34.0 sf, Capacity= 156.53 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 24.00'
Length= 946.0' Slope= 0.0056 '/'
Inlet Invert= 802.26', Outlet Invert= 796.96'

‡

## Summary for Reach S4 R4: Swale S4 Reach 4

[62] Hint: Exceeded Reach S4 R3 OUTLET depth by 0.96' @ 12.25 hrs

Inflow Area = 65.063 ac, 0.04% Impervious, Inflow Depth = 2.33" for 100-yr, 24-hr event
Inflow = 159.67 cfs @ 12.19 hrs, Volume= 12.653 af
Outflow = 157.44 cfs @ 12.21 hrs, Volume= 12.653 af, Atten= 1%, Lag= 1.3 min
Routed to Link Swale S4 R4 : Swale S4 Reach 4

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.29 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.12 fps, Avg. Travel Time= 7.2 min

Peak Storage= 14,379 cf @ 12.21 hrs
Average Depth at Peak Storage= 1.82' , Surface Width= 22.73'
Bank-Full Depth= 3.00' Flow Area= 61.5 sf, Capacity= 427.66 cfs

10.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 3.0 4.0 '/' Top Width= 31.00'
Length= 483.0' Slope= 0.0082 '/'
Inlet Invert= 796.96', Outlet Invert= 793.00'

‡

## Summary for Reach S5 R2: Swale S5 Reach 2

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 1.20" for 100-yr, 24-hr event
Inflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af
Outflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S5 R2 : Swale S5 Reach 2

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Pond Sed Pond: Sedimentation Basin

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 2.25" for 100-yr, 24-hr event
Inflow = 164.77 cfs @ 12.20 hrs, Volume= 13.946 af
Outflow = 45.68 cfs @ 12.70 hrs, Volume= 13.947 af, Atten= 72%, Lag= 30.2 min
Discarded = 5.84 cfs @ 12.70 hrs, Volume= 7.167 af
Primary = 11.35 cfs @ 12.70 hrs, Volume= 4.914 af
Routed to Link Wetland : Wetland
Secondary = 22.50 cfs @ 12.70 hrs, Volume= 1.762 af
Routed to Link Wetland : Wetland
Tertiary = 6.00 cfs @ 12.70 hrs, Volume= 0.104 af
Routed to Link Wetland : Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Peak Elev= 793.06' @ 12.70 hrs Surf.Area= 70,052 sf Storage= 236,005 cf
Flood Elev= 794.00' Surf.Area= 75,797 sf Storage= 304,443 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 169.7 min ( 1,014.6 - 845.0 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 789.00' | 304,443 cf | **Custom Stage Data (Prismatic)**Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 789.00 | 27,325 | 0 | 0 |
| 790.00 | 55,972 | 41,649 | 41,649 |
| 791.00 | 61,532 | 58,752 | 100,401 |
| 792.00 | 65,703 | 63,618 | 164,018 |
| 793.00 | 69,675 | 67,689 | 231,707 |
| 794.00 | 75,797 | 72,736 | 304,443 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 787.70' | **15.0" Round Culvert**<br>L= 40.0' RCP, mitered to conform to fill, Ke= 0.700<br>Inlet / Outlet Invert= 787.70' / 787.50' S= 0.0050 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 1.23 sf |
| #2 | Device 1 | 791.00' | **30.0" Horiz. Orifice/Grate** C= 0.600<br>Limited to weir flow at low heads |
| #3 | Device 1 | 790.50' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #4 | Device 1 | 790.00' | **0.8" Vert. Orifice/Grate X 4.00** C= 0.600<br>Limited to weir flow at low heads |
| #5 | Device 1 | 789.00' | **0.5" Vert. Orifice/Grate X 14.00 columns**<br>X 6 rows with 6.0" cc spacing C= 0.600<br>Limited to weir flow at low heads |
| #6 | Secondary | 792.50' | **20.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #7 | Tertiary | 793.00' | **158.0' long x 10.0' breadth Broad-Crested Rectangular Weir**<br>Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60<br>Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64 |
| #8 | Discarded | 789.00' | **3.600 in/hr Exfiltration over Surface area** |

**Discarded OutFlow** Max=5.84 cfs @ 12.70 hrs HW=793.06' (Free Discharge)
└**8=Exfiltration** (Exfiltration Controls 5.84 cfs)

**Primary OutFlow** Max=11.35 cfs @ 12.70 hrs HW=793.06' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 11.35 cfs @ 9.25 fps)
  ├**2=Orifice/Grate** (Passes < 33.94 cfs potential flow)
  ├**3=Orifice/Grate** (Passes < 0.11 cfs potential flow)
  ├**4=Orifice/Grate** (Passes < 0.12 cfs potential flow)
  └**5=Orifice/Grate** (Passes < 0.91 cfs potential flow)

**Secondary OutFlow** Max=22.49 cfs @ 12.70 hrs HW=793.06' TW=0.00' (Dynamic Tailwater)
└**6=Broad-Crested Rectangular Weir** (Weir Controls 22.49 cfs @ 2.00 fps)

**Tertiary OutFlow** Max=5.99 cfs @ 12.70 hrs HW=793.06' TW=0.00' (Dynamic Tailwater)
└**7=Broad-Crested Rectangular Weir** (Weir Controls 5.99 cfs @ 0.62 fps)

## Summary for Link C1: Culvert C1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 1.20" for 100-yr, 24-hr event
Inflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af
Primary = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S5 R2 : Swale S5 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C2: Culvert C2

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 3.23" for 100-yr, 24-hr event
Inflow = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af
Primary = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C3: Culvert C3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 2.58" for 100-yr, 24-hr event
Inflow = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af
Primary = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C4: Culvert C4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 2.61" for 100-yr, 24-hr event
Inflow = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af
Primary = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R5 : Swale S1 Reach 5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C5: Culvert C5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 2.43" for 100-yr, 24-hr event
Inflow = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af
Primary = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R6 : Swale S1 Reach 6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C6: Culvert C6

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 2.72" for 100-yr, 24-hr event
Inflow = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af
Primary = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R3 : Swale S3 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C7: Culvert C7

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 2.20" for 100-yr, 24-hr event
Inflow = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af
Primary = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R4 : Swale S4 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link C8: Culvert C8

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 1.76" for 100-yr, 24-hr event
Inflow = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af
Primary = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af, Atten= 0%, Lag= 0.0 min
Routed to Link North Area : North Area

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F1: Flume 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af
Primary = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC1 : Rock Chute 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F2: Flume 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af
Primary = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af, Atten= 0%, Lag= 0.0 min
Routed to Link RC2 : Rock Chute 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F3: Flume 3

Inflow Area = 5.923 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 32.10 cfs @ 12.12 hrs, Volume= 1.570 af
Primary = 32.10 cfs @ 12.12 hrs, Volume= 1.570 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F4: Flume 4

Inflow Area = 2.645 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 14.43 cfs @ 12.12 hrs, Volume= 0.701 af
Primary = 14.43 cfs @ 12.12 hrs, Volume= 0.701 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R4 : Swale S1 Reach 4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F5: Flume 5

Inflow Area = 4.601 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 25.31 cfs @ 12.12 hrs, Volume= 1.219 af
Primary = 25.31 cfs @ 12.12 hrs, Volume= 1.219 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R1 : Swale S3 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F6: Flume 6

Inflow Area = 3.717 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 20.36 cfs @ 12.12 hrs, Volume= 0.985 af
Primary = 20.36 cfs @ 12.12 hrs, Volume= 0.985 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F7: Existing East Flume

Inflow Area = 0.830 ac, 0.00% Impervious, Inflow Depth = 3.12" for 100-yr, 24-hr event
Inflow = 4.50 cfs @ 12.12 hrs, Volume= 0.216 af
Primary = 4.50 cfs @ 12.12 hrs, Volume= 0.216 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link F8: Existing West Flume

Inflow Area = 3.122 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 16.40 cfs @ 12.13 hrs, Volume= 0.828 af
Primary = 16.40 cfs @ 12.13 hrs, Volume= 0.828 af, Atten= 0%, Lag= 0.0 min
Routed to Link Swale S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link North Area: North Area

Inflow Area = 7.668 ac, 11.88% Impervious, Inflow Depth = 1.76" for 100-yr, 24-hr event
Inflow = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af
Primary = 19.20 cfs @ 12.15 hrs, Volume= 1.127 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC1: Rock Chute 1

Inflow Area = 4.170 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af
Primary = 22.19 cfs @ 12.13 hrs, Volume= 1.105 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R3 : Swale S4 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link RC2: Rock Chute 2

Inflow Area = 4.541 ac, 0.00% Impervious, Inflow Depth = 3.18" for 100-yr, 24-hr event
Inflow = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af
Primary = 23.68 cfs @ 12.13 hrs, Volume= 1.204 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S4 R2 : Swale S4 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale 1 R6: Swale S1 Reach 6

Inflow Area = 23.788 ac, 0.00% Impervious, Inflow Depth = 2.23" for 100-yr, 24-hr event
Inflow = 62.73 cfs @ 12.20 hrs, Volume= 4.415 af
Primary = 62.73 cfs @ 12.20 hrs, Volume= 4.415 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R1 : Swale S2 Reach 1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R1: Swale S1 Reach 1

Inflow Area = 0.691 ac, 0.00% Impervious, Inflow Depth = 2.23" for 100-yr, 24-hr event
Inflow = 2.68 cfs @ 12.12 hrs, Volume= 0.128 af
Primary = 2.68 cfs @ 12.12 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R2 : Swale S1 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R2: Swale S1 Reach 2

Inflow Area = 7.131 ac, 0.00% Impervious, Inflow Depth = 3.07" for 100-yr, 24-hr event
Inflow = 37.05 cfs @ 12.12 hrs, Volume= 1.827 af
Primary = 37.05 cfs @ 12.12 hrs, Volume= 1.827 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S1 R3 : Swale S1 Reach 3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R3: Swale S1 Reach 3

Inflow Area = 14.170 ac, 0.00% Impervious, Inflow Depth = 2.58" for 100-yr, 24-hr event
Inflow = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af
Primary = 47.76 cfs @ 12.15 hrs, Volume= 3.049 af, Atten= 0%, Lag= 0.0 min
Routed to Link C3 : Culvert C3

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R4: Swale S1 Reach 4

Inflow Area = 17.714 ac, 0.00% Impervious, Inflow Depth = 2.61" for 100-yr, 24-hr event
Inflow = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af
Primary = 62.23 cfs @ 12.15 hrs, Volume= 3.859 af, Atten= 0%, Lag= 0.0 min
Routed to Link C4 : Culvert C4

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S1 R5: Swale S1 Reach 5

Inflow Area = 20.996 ac, 0.00% Impervious, Inflow Depth = 2.43" for 100-yr, 24-hr event
Inflow = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af
Primary = 65.15 cfs @ 12.17 hrs, Volume= 4.254 af, Atten= 0%, Lag= 0.0 min
Routed to Link C5 : Culvert C5

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R1: Swale S2 Reach 1

Inflow Area = 25.901 ac, 0.00% Impervious, Inflow Depth = 2.10" for 100-yr, 24-hr event
Inflow = 58.13 cfs @ 12.24 hrs, Volume= 4.525 af
Primary = 58.13 cfs @ 12.24 hrs, Volume= 4.525 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S2 R2: Swale S2 Reach 2

Inflow Area = 48.985 ac, 0.00% Impervious, Inflow Depth = 2.20" for 100-yr, 24-hr event
Inflow = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af
Primary = 103.37 cfs @ 12.20 hrs, Volume= 8.978 af, Atten= 0%, Lag= 0.0 min
Routed to Link C7 : Culvert C7

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R1: Swale S3 Reach 1

Inflow Area = 6.548 ac, 0.00% Impervious, Inflow Depth = 2.65" for 100-yr, 24-hr event
Inflow = 27.22 cfs @ 12.13 hrs, Volume= 1.447 af
Primary = 27.22 cfs @ 12.13 hrs, Volume= 1.447 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S3 R2 : Swale S3 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R2: Swale S3 Reach 2

Inflow Area = 11.158 ac, 0.00% Impervious, Inflow Depth = 2.72" for 100-yr, 24-hr event
Inflow = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af
Primary = 47.83 cfs @ 12.13 hrs, Volume= 2.533 af, Atten= 0%, Lag= 0.0 min
Routed to Link C6 : Culvert C6

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S3 R3: Swale S3 Reach 3

Inflow Area = 14.511 ac, 0.00% Impervious, Inflow Depth = 2.36" for 100-yr, 24-hr event
Inflow = 47.45 cfs @ 12.15 hrs, Volume= 2.848 af
Primary = 47.45 cfs @ 12.15 hrs, Volume= 2.848 af, Atten= 0%, Lag= 0.0 min
Routed to Reach S2 R2 : Swale S2 Reach 2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S4 R4: Swale S4 Reach 4

Inflow Area = 67.064 ac, 0.04% Impervious, Inflow Depth = 2.29" for 100-yr, 24-hr event
Inflow = 157.92 cfs @ 12.21 hrs, Volume= 12.803 af
Primary = 157.92 cfs @ 12.21 hrs, Volume= 12.803 af, Atten= 0%, Lag= 0.0 min
Routed to Pond Sed Pond : Sedimentation Basin

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R1: Swale S5 Reach 1

Inflow Area = 4.530 ac, 13.14% Impervious, Inflow Depth = 1.20" for 100-yr, 24-hr event
Inflow = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af
Primary = 7.48 cfs @ 12.15 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min
Routed to Link C1 : Culvert C1

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R2: Swale S5 Reach 2

Inflow Area = 5.851 ac, 12.83% Impervious, Inflow Depth = 1.48" for 100-yr, 24-hr event
Inflow = 12.65 cfs @ 12.14 hrs, Volume= 0.720 af
Primary = 12.65 cfs @ 12.14 hrs, Volume= 0.720 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S5 R3: Swale S5 Reach 3

Inflow Area = 1.817 ac, 8.81% Impervious, Inflow Depth = 2.69" for 100-yr, 24-hr event
Inflow = 6.90 cfs @ 12.17 hrs, Volume= 0.408 af
Primary = 6.90 cfs @ 12.17 hrs, Volume= 0.408 af, Atten= 0%, Lag= 0.0 min
Routed to Link C8 : Culvert C8

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Swale S6 R1: Swale S6 Reach 1

Inflow Area = 2.899 ac, 0.00% Impervious, Inflow Depth = 3.23" for 100-yr, 24-hr event
Inflow = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af
Primary = 13.45 cfs @ 12.11 hrs, Volume= 0.780 af, Atten= 0%, Lag= 0.0 min
Routed to Link C2 : Culvert C2

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

## Summary for Link Wetland: Wetland

Inflow Area = 74.393 ac, 2.06% Impervious, Inflow Depth = 1.09" for 100-yr, 24-hr event
Inflow = 39.85 cfs @ 12.70 hrs, Volume= 6.780 af
Primary = 39.85 cfs @ 12.70 hrs, Volume= 6.780 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs

Swale Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No: | 1 of 2 |
| | | Calc. No. | |
| | | Rev. No. | 0 |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Swale Sizing | Chk'd: MJT | Date: 4/5/22 |

**Purpose:**

To size the proposed swale along Module 10 and 11 to accommodate the 25-year, 24-hour storm event and determine required rolled erosion control product. To confirm capacity of existing swale during closure condition.

**References:**

1. WisDOT Facilities Development Manual Chapter 13, Section 30-15 - Grass Lined Channels.
2. Design of Roadside Channels with Flexible Linings, HEC-15, USDOT FHWA.
3. HydroCAD Report_POO Landfill Closure
4. Table 7E-5.01: Typical Rolled Erosion Control Product Properties and Uses, Iowa SUDAS Design and Specifications Manual.

**Approach:**

Use the HydroCAD Model results to obtain the peak flow during a 25-year, 24-hour storm event.

Use Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2 (from Reference #1) to size the swale for each design swale cross section. The WisDOT spreadsheet incorporates the design guidelines and equations described in "Design of Roadside Channels with Flexible Linings", HEC-15, USDOT FHWA (Reference #2).

Confirm the swale is stable and has enough capacity for the design flow rate.

Use Table 7E-5.01 (see Reference #4) to select appropriate erosion control mat based on shear stress and application.

**Assumptions:**

1. Swales geometry shown on the drawing set.

2. Assume the following parameters per Section 15.2 - Grass Lining Properties from Reference #1:
   Vegetation Retardance Class = C for Swales
   Vegetation Condition = Good
   Vegetation Growth Form = Turf
3. Assume cohesive soil type with ASTM Soil Class SC and a Plasticity Index (PI) of 16.

**Calculations:**

From the HydroCAD Report, the 25-year, 24-hour peak discharge rates in the swales are

| Swales: | 25-year | | 25-year | | 25-year |
|---|---|---|---|---|---|
| **Swale S1 Reach 1=** | 1.37 cfs | **Swale S2 Reach 2=** | 52.2 cfs | **Swale S4 Reach 4=** | 80.1 cfs |
| **Swale S1 Reach 2=** | 21.7 cfs | **Swale S3 Reach 1=** | 15.9 cfs | **Swale S5 Reach 1=** | 2.1 cfs |
| **Swale S1 Reach 3=** | 27.4 cfs | **Swale S3 Reach 2=** | 27.9 cfs | **Swale S5 Reach 2=** | 4.7 cfs |
| **Swale S1 Reach 4=** | 35.4 cfs | **Swale S3 Reach 3=** | 26.7 cfs | **Swale S5 Reach 3=** | 3.8 cfs |
| **Swale S1 Reach 5=** | 35.2 cfs | **Swale S4 Reach 1*=** | cfs | **Swale S6 Reach 1=** | 9.7 cfs |
| **Swale S1 Reach 6=** | 33.2 cfs | **Swale S4 Reach 2*=** | cfs | | |
| **Swale S2 Reach 1=** | 30.0 cfs | **Swale S4 Reach 3*=** | cfs | | |

Use max. flow from Swale S1 reaches to confirm swale works since slope is constant.

*Use full Swale S4 Reach 4 for swale flow in Swale S4 reaches.

Use the WisDOT Grass Swale Design Spreadsheet (Page 2) to determine the flow depth, velocity and shear stress in the swales.

**Results:**

The swales are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

The swales are stable at the design flow rates.

Use Class I, Type B erosion mat.

| ***Channel/Ditch Geometry*** | **Swale S1** | **Swale S1 Reach 1** | **Swale S1 Reach 2** | **Swale S1 Reach 3** | **Swale S1 Reach 4** | **Swale S1 Reach 5** | **Swale S1 Reach 6** | **Swale S2 Reach 1** | **Swale S2 Reach 2** | **Swale S3 Reach 1** | **Swale S3 Reach 2** | **Swale S3 Reach 3** | **Swale S4 Reach 1** | **Swale S4 Reach 2** | **Swale S4 Reach 3** | **Swale S4 Reach 4** | **Swale S5 Reach 1** | **Swale S5 Reach 2** | **Swale S5 Reach 3** | **Swale S6 Reach 1** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Channel Slope, $S_1$ (ft/ft) | **0.0055** | **0.0053** | **0.0055** | **0.0051** | **0.0069** | **0.0053** | **0.0084** | **0.0020** | **0.0069** | **0.0070** | **0.0070** | **0.0097** | **0.0155** | **0.0069** | **0.0056** | **0.0082** | **0.0096** | **0.0024** | **0.0024** | **0.0066** |
| Channel Bottom Width, B (ft) | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **10** | **8** | **8** | **0** | **10** | **10** | **10** | **10** | **0** | **0** | **0** | **8** |
| Channel Side Slope, $z_1$ | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **2** | **2** | **4** | **4** | **4** | **4** | **4** | **6** | **6** | **6** | **2.5** |
| Channel Side Slope, $z_2$ | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **4** | **2** | **2** | **4** | **3** | **3** | **3** | **3** | **7** | **2.5** | **2.5** | **2.5** |
| Flow Depth, d (ft) Solve iteratively | **1.59** | **0.37** | **1.30** | **1.47** | **1.46** | **1.61** | **1.32** | **2.18** | **1.61** | **1.07** | **1.39** | **1.81** | **1.42** | **1.97** | **2.13** | **1.85** | **0.67** | **1.51** | **1.41** | **0.85** |
| Safety Factor, SF | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** |
| ***Vegetation/Soil Parameters*** | | | | | | | | | | | | | | | | | | | | |
| Vegetation Retardance Class | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** |
| Vegetation Condition | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** | **good** |
| Vegetation Growth Form | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** | **turf** |
| Soil Type | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** | **cohesive** |
| $D_{75}$ (in) (Set at 0.00 for cohesive soils) | | | | | | | | | | | | | | | | | | | | |
| ASTM Soil Class | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** | **SC** |
| Plasticity Index, PI | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** | **16** |
| ***Results Summary*** | | | | | | | | | | | | | | | | | | | | |
| Design Q ($ft^3/s$) | **35.4** | **1.4** | **21.7** | **27.4** | **35.4** | **35.2** | **33.2** | **30.0** | **52.2** | **15.9** | **27.9** | **26.7** | **80.1** | **80.1** | **80.1** | **80.1** | **2.1** | **4.7** | **3.8** | **9.7** |
| 1. Swales geometry shown on the drawing set | 35.4 | 1.4 | 22.1 | 27.4 | 35.4 | 35.2 | 33.5 | 29.8 | 52.5 | 16.0 | 28.0 | 27.1 | 79.6 | 80.5 | 79.5 | 81.6 | 2.1 | 4.7 | 3.8 | 9.6 |
| Difference Between Design & Calc. Flow (%) | 0.2% | 0.2% | 1.9% | 0.0% | 0.1% | 0.0% | 1.0% | -0.4% | 0.6% | 0.5% | 0.6% | 1.6% | -0.6% | 0.5% | -0.7% | 1.8% | 0.0% | -0.3% | 0.2% | -0.5% |
| **Stable (Yes or No)** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** |
| ***Channel Parameters*** | | | | | | | | | | | | | | | | | | | | |
| Vegetation Height, h (ft) | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| Grass Roughness Coefficient, $C_n$ | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 |
| Cover Factor, $C_f$ | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| Noncohesive Soil | | | | | | | | | | | | | | | | | | | | |
| Soil Grain Roughness, $\eta_1$ | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 |
| Permissible Soil Shear Stress, $\tau_o$ ($lb/ft^2$) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Cohesive Soil | | | | | | | | | | | | | | | | | | | | |
| Porosity, e | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Soil Coefficient 1, $c_1$ | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 | 1.0700 |
| Soil Coefficient 2, $c_2$ | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 | 14.30 |
| Soil Coefficient 3, $c_3$ | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 | 47.700 |
| Soil Coefficient 4, $c_4$ | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 |
| Soil Coefficient 5, $c_5$ | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 | -0.61 |
| Soil Coefficient 6, $c_6$ | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 |
| Permissible Soil Shear Stress, $\tau_o$ ($lb/ft^2$) | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 |
| Total Permissible Shear Stress, $\tau_p$ ($lb/ft^2$) | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 |
| Cross Sectional Area, A ($ft^2$) | 22.832 | 3.453 | 17.160 | 20.404 | 20.206 | 23.248 | 17.530 | 36.450 | 26.468 | 10.850 | 14.984 | 13.104 | 21.257 | 33.283 | 37.179 | 30.479 | 2.874 | 9.690 | 8.449 | 8.606 |
| Wetted Perimeter, P (ft) | 21.11 | 11.01 | 18.72 | 20.12 | 20.04 | 21.28 | 18.88 | 25.98 | 23.28 | 12.79 | 14.22 | 14.93 | 20.35 | 24.35 | 25.52 | 23.48 | 8.75 | 13.25 | 12.37 | 12.58 |
| Hydraulic Radius, R (ft) | 1.082 | 0.314 | 0.917 | 1.014 | 1.008 | 1.093 | 0.928 | 1.403 | 1.137 | 0.849 | 1.054 | 0.878 | 1.045 | 1.367 | 1.457 | 1.298 | 0.329 | 0.731 | 0.683 | 0.684 |
| Top Width, T (ft) | 20.72 | 10.92 | 18.40 | 19.76 | 19.68 | 20.88 | 18.56 | 25.44 | 22.88 | 12.28 | 13.56 | 14.48 | 19.94 | 23.79 | 24.91 | 22.95 | 8.65 | 12.84 | 11.99 | 12.25 |
| Hydraulic Depth, D (ft) | 1.102 | 0.316 | 0.933 | 1.033 | 1.027 | 1.113 | 0.944 | 1.433 | 1.157 | 0.884 | 1.105 | 0.905 | 1.066 | 1.399 | 1.493 | 1.328 | 0.333 | 0.755 | 0.705 | 0.703 |
| Froude Number (Q design) | 0.261 | 0.125 | 0.235 | 0.233 | 0.305 | 0.253 | 0.347 | 0.121 | 0.325 | 0.276 | 0.314 | 0.383 | 0.639 | 0.360 | 0.309 | 0.409 | 0.219 | 0.098 | 0.094 | 0.235 |
| Channel Shear Stress, $\tau_o$ ($lb/ft^2$) | 0.37 | 0.10 | 0.31 | 0.32 | 0.43 | 0.36 | 0.49 | 0.18 | 0.49 | 0.37 | 0.46 | 0.53 | 1.01 | 0.59 | 0.51 | 0.66 | 0.20 | 0.11 | 0.10 | 0.28 |
| Actual Sheer Stress, $\tau_d$ ($lb/ft^2$) | 0.55 | 0.12 | 0.45 | 0.47 | 0.63 | 0.53 | 0.69 | 0.27 | 0.69 | 0.47 | 0.61 | 1.10 | 1.37 | 0.85 | 0.74 | 0.95 | 0.40 | 0.23 | 0.21 | 0.35 |
| Mannings n | 0.075 | 0.126 | 0.081 | 0.080 | 0.071 | 0.076 | 0.068 | 0.102 | 0.068 | 0.076 | 0.069 | 0.065 | 0.051 | 0.063 | 0.067 | 0.060 | 0.097 | 0.123 | 0.126 | 0.084 |
| Average Velocity, V (ft/s) | 1.55 | 0.40 | 1.26 | 1.34 | 1.75 | 1.51 | 1.89 | 0.82 | 1.97 | 1.46 | 1.86 | 2.04 | 3.77 | 2.41 | 2.15 | 2.63 | 0.72 | 0.48 | 0.45 | 1.12 |
| Calculated Flow, Q ($ft^3/s$) | 35.4 | 1.4 | 22.1 | 27.4 | 35.4 | 35.2 | 33.5 | 29.8 | 52.5 | 16.0 | 28.0 | 27.1 | 79.6 | 80.5 | 79.5 | 81.6 | 2.1 | 4.7 | 3.8 | 9.6 |
| Difference Between Design & Calc. Flow (%) | 0.2% | 0.2% | 1.9% | 0.0% | 0.1% | 0.0% | 1.0% | -0.4% | 0.6% | 0.5% | 0.6% | 1.6% | -0.6% | 0.5% | -0.7% | 1.8% | 0.0% | -0.3% | 0.2% | -0.5% |
| Effective Shear on Soil Surface, $\tau_e$ ($lb/ft^2$) | 0.002 | 0.000 | 0.002 | 0.002 | 0.003 | 0.002 | 0.004 | 0.001 | 0.004 | 0.002 | 0.003 | 0.007 | 0.014 | 0.005 | 0.004 | 0.007 | 0.001 | 0.000 | 0.000 | 0.001 |
| Total Permissible Shear on Veg., $\tau_{p,veg}$ ($lb/ft^2$) | 17.60 | 49.69 | 20.53 | 20.03 | 15.78 | 18.08 | 14.47 | 32.56 | 14.47 | 18.08 | 14.90 | 13.22 | 8.14 | 12.42 | 14.05 | 11.27 | 29.45 | 47.35 | 49.69 | 22.08 |
| Stable (Y or N) | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |

Source: Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2

## Non-Channel Erosion Mat
(1052)

Wisconsin Department of Natural Resources
Conservation Practice Standard

To differentiate applications Erosion mats are organized into three Classes of mats, which are further broken down into various Types.

A. **Class I**: A short-term duration (minimum of 6 months), light duty, organic mat with photodegradable plastic or biodegradable netting.

   1. **Type A** – Use on erodible slopes 2.5:1 or flatter.

   2. **Type B** – Double netted product for use on erodible slopes 2:1 or flatter.

B. **Class I, Urban**: A short-term duration (minimum of 6 months), light duty, organic erosion control mat for areas where mowing may be accomplished within two weeks after installation.

   1. **Urban, Type A** – Use on erodible soils with slopes 4:1 or flatter.

   2. **Urban, Type B** – A double netted product for use on slopes 2.5:1 or flatter.

C. **Class II**: A long-term duration (three years or greater), organic erosion control revegetative mat.

   1. **Type A** – Jute fiber only for use on slopes 2:1 or flatter for sod reinforcement.

   2. **Type B** – For use on slopes 2:1 or greater made with plastic or biodegradable net.

   3. **Type C** – A woven mat of 100% organic fibers for use on slopes 2:1 or flatter and in environmentally and biologically sensitive areas where plastic netting is inappropriate.

D. **Class III**: A permanent 100% synthetic ECRM or TRM. Either a soil stabilizer Type A or Class I, Type A or B erosion mat must be placed over the soil filled TRM.

   1. **Type A** – An ECRM for use on slopes 2:1 or flatter.

   2. **Type B or C** – A TRM for use on slopes 2:1 or flatter.

   3. **Type D** – A TRM for use on slopes 1:1 or flatter.

## Channel Erosion Mat
(1053)

Wisconsin Department of Natural Resources
Conservation Practice Standard

To differentiate applications WisDOT organizes erosion mats into three classes of mats, which are further broken down into various Types.

A. **Class I**: A short-term duration (minimum of 6 months), light duty, organic ECRM with plastic or biodegradable netting.

   1. **Type A** – Only suitable for slope applications, not channel applications.

   2. **Type B** – Double netted product for use in channels where the calculated (design) shear stress is 1.5 lbs/ft$^2$ or less.

B. **Class II**: A long-term duration (three years or greater), organic ECRM.

   1. **Type A** – Jute fiber only for use in channels to reinforce sod.

   2. **Type B** – For use in channels where the calculated (design) shear stress is 2.0 lbs/ft$^2$ or less. Made with plastic or biodegradable mat.

   3. **Type C** – A woven mat of 100% organic material for use in channels where the calculated (design) shear stress is 2.0 lbs/ft$^2$ or less. Applicable for use in environmentally sensitive areas where plastic netting is inappropriate.

C. **Class III**: A permanent 100% synthetic ECRM or TRM. Class I, Type B erosion mat or Class II, Type B or C erosion mat must be placed over a soil filled TRM.

   1. **Type A** – An ECRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft$^2$ or less.

   2. **Type B** – A TRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft$^2$ or less.

   3. **Type C** – A TRM for use in channels where the calculated (design) shear stress of 3.5 lbs/ft$^2$ or less.

   4. **Type D** – A TRM for use in channels where the calculated (design) shear stress of 5.0 lbs/ft$^2$ or less.

# Culvert Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| Sheet No: 1/7 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: COL - POO | By: RJG | Date: 4/7/22 |
| Client: WPL | Subject: Culvert Sizing | Chk'd: MJT | Date: |

**Purpose:**

To size the post closure culverts to accommodate the 25-year, 24-hour storm event.

**References:**

1. HY-8 7.40 Computer Model
2. HydroCAD Report_Post Construction and HydroCAD Report_Post Construction Temporary Culvert
3. Figure 1 - Storm Water Post Construction

**Approach:**

1. Create culvert crossing in HY-8 and input data from Reference #2 and #3.
2. Adjust diameter size and number of culverts in model until design flow does not over top berm/road crossing.

**Assumptions:**

1. Assume the tailwater channel data is a based on discharge swale or rock chute geometry (Reference #2).
2. Culverts are circular, PE Pipe with smooth interior, and with square edge with headwall.
3. Culvert elevatons,lengths, and slopes based on Figure 1 (Reference #3).
4. Roadwa data for crossing based on Figure 1 (Reference #3).
5. Discharge flows from HydroCAD report (Refence #2).

**Calculations:**

See attached HY-8 Model output reports.

**Results:**

The culverts are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

| Culvert | Dia. (ft) | # of Barrels | Upstream Invert (ft) | Downstream Invert (ft) | Slope (%) | Length (ft) |
|---|---|---|---|---|---|---|
| C1 | 2 | 1 | 815.70 | 814.55 | 2.22 | 52 |
| C2 | 1.5 | 2 | 814.40 | 814.20 | 0.49 | 41 |
| C3 | 2.5 | 2 | 811.17 | 811.16 | 0.02 | 50 |
| C4 | 2.5 | 2 | 809.87 | 809.74 | 0.26 | 50 |
| C5 | 2.5 | 2 | 807.57 | 807.15 | 0.84 | 50 |
| C6 | 2 | 2 | 805.40 | 804.76 | 0.61 | 105 |
| C7 | 3.5 | 2 | 796.64 | 796.34 | 0.50 | 60 |
| C8 | 2 | 1 | 807.54 | 806.81 | 0.73 | 100 |

# HY-8 Culvert Analysis Report _ Culvert C1

## Site Data - Culvert C1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 815.70 ft

Outlet Station: 51.88 ft

Outlet Elevation: 814.55 ft

Number of Barrels: 1

## Culvert Data Summary - Culvert C1

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Crossing Discharge Data

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

Minimum Flow: 2.06 cfs

Design Flow: 2.06 cfs

Maximum Flow: 7.48 cfs

## Tailwater Channel Data - Culvert C1

Tailwater Channel Option: Triangular Channel

Side Slope (H:V): 6.00 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0300

Channel Invert Elevation: 815.32 ft

## Table 1 - Culvert Summary Table: Culvert C1

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.06 | 2.06 | 816.37 | 0.670 | 0.0* | 1-JS1t | 0.321 | 0.498 | 1.127 | 0.357 | 1.129 | 2.695 |
| 2.60 | 2.60 | 816.46 | 0.758 | 0.031 | 1-JS1t | 0.361 | 0.562 | 1.160 | 0.390 | 1.378 | 2.857 |
| 3.14 | 3.14 | 816.54 | 0.838 | 0.070 | 1-JS1t | 0.396 | 0.619 | 1.188 | 0.418 | 1.616 | 2.995 |
| 3.69 | 3.69 | 816.61 | 0.912 | 0.108 | 1-JS1t | 0.428 | 0.672 | 1.214 | 0.444 | 1.847 | 3.117 |
| 4.23 | 4.23 | 816.68 | 0.982 | 0.145 | 1-JS1t | 0.459 | 0.722 | 1.237 | 0.467 | 2.072 | 3.226 |
| 4.77 | 4.77 | 816.76 | 1.058 | 0.182 | 1-S2n | 0.487 | 0.768 | 0.503 | 0.489 | 7.698 | 3.324 |
| 5.31 | 5.31 | 816.83 | 1.134 | 0.220 | 1-S2n | 0.515 | 0.813 | 0.533 | 0.509 | 7.895 | 3.415 |
| 5.85 | 5.85 | 816.91 | 1.206 | 0.258 | 1-S2n | 0.541 | 0.855 | 0.562 | 0.528 | 8.081 | 3.499 |
| 6.40 | 6.40 | 816.98 | 1.275 | 0.298 | 1-S2n | 0.566 | 0.895 | 0.590 | 0.546 | 8.262 | 3.577 |
| 6.94 | 6.94 | 817.04 | 1.342 | 0.338 | 1-S2n | 0.590 | 0.934 | 0.617 | 0.563 | 8.416 | 3.651 |
| 7.48 | 7.48 | 817.11 | 1.406 | 0.379 | 1-S2n | 0.614 | 0.972 | 0.643 | 0.579 | 8.566 | 3.720 |

* Full Flow Headwater elevation is below inlet invert.

**********

Straight Culvert

Inlet Elevation (invert): 815.70 ft, Outlet Elevation (invert): 814.55 ft

Culvert Length: 51.89 ft, Culvert Slope: 0.0222

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C1**

| Headwater Elevation (ft) | Total Discharge (cfs) | Culvert C1 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 816.37 | 2.06 | 2.06 | 0.00 | 1 |
| 816.46 | 2.60 | 2.60 | 0.00 | 1 |
| 816.54 | 3.14 | 3.14 | 0.00 | 1 |
| 816.61 | 3.69 | 3.69 | 0.00 | 1 |
| 816.68 | 4.23 | 4.23 | 0.00 | 1 |
| 816.76 | 4.77 | 4.77 | 0.00 | 1 |
| 816.83 | 5.31 | 5.31 | 0.00 | 1 |
| 816.91 | 5.85 | 5.85 | 0.00 | 1 |
| 816.98 | 6.40 | 6.40 | 0.00 | 1 |
| 817.04 | 6.94 | 6.94 | 0.00 | 1 |
| 817.11 | 7.48 | 7.48 | 0.00 | 1 |
| 819.06 | 22.61 | 22.61 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C2

## Site Data - C2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 814.40 ft

Outlet Station: 41.00 ft

Outlet Elevation: 814.20 ft

Number of Barrels: 2

## Culvert Data Summary - C2

Barrel Shape: Circular

Barrel Diameter: 1.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C2

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 814.10 ft

## Crossing Discharge Data

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

Minimum Flow: 9.68 cfs

Design Flow: 9.68 cfs

Maximum Flow: 13.45 cfs

## Table 1 - Culvert Summary Table: C2

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.68 | 9.68 | 815.67 | 1.271 | 0.199 | 1-S2n | 0.767 | 0.842 | 0.767 | 0.499 | 4.728 | 1.939 |
| 10.06 | 10.06 | 815.70 | 1.302 | 0.926 | 1-S2n | 0.786 | 0.858 | 0.786 | 0.510 | 4.769 | 1.963 |
| 10.43 | 10.43 | 815.73 | 1.333 | 0.966 | 1-S2n | 0.805 | 0.877 | 0.805 | 0.521 | 4.807 | 1.987 |
| 10.81 | 10.81 | 815.76 | 1.364 | 1.003 | 1-S2n | 0.824 | 0.893 | 0.824 | 0.531 | 4.842 | 2.010 |
| 11.19 | 11.19 | 815.79 | 1.395 | 1.041 | 1-S2n | 0.843 | 0.909 | 0.843 | 0.542 | 4.871 | 2.032 |
| 11.57 | 11.57 | 815.83 | 1.426 | 1.079 | 1-S2n | 0.863 | 0.924 | 0.863 | 0.552 | 4.899 | 2.053 |
| 11.94 | 11.94 | 815.86 | 1.457 | 1.117 | 1-S2n | 0.882 | 0.939 | 0.882 | 0.562 | 4.943 | 2.074 |
| 12.32 | 12.32 | 815.89 | 1.489 | 1.156 | 1-S2n | 0.902 | 0.954 | 0.902 | 0.572 | 4.973 | 2.095 |
| 12.70 | 12.70 | 815.92 | 1.521 | 1.196 | 5-S2n | 0.921 | 0.968 | 0.921 | 0.581 | 5.001 | 2.115 |
| 13.07 | 13.07 | 815.95 | 1.553 | 1.240 | 5-S2n | 0.941 | 0.987 | 0.941 | 0.591 | 5.028 | 2.134 |
| 13.45 | 13.45 | 815.99 | 1.586 | 1.281 | 5-S2n | 0.962 | 1.001 | 0.962 | 0.600 | 5.048 | 2.153 |

**********

Straight Culvert

Inlet Elevation (invert): 814.40 ft, Outlet Elevation (invert): 814.20 ft

Culvert Length: 41.00 ft, Culvert Slope: 0.0049

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C2**

| Headwater Elevation (ft) | Total Discharge (cfs) | C2 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 815.67 | 9.68 | 9.68 | 0.00 | 1 |
| 815.70 | 10.06 | 10.06 | 0.00 | 1 |
| 815.73 | 10.43 | 10.43 | 0.00 | 1 |
| 815.76 | 10.81 | 10.81 | 0.00 | 1 |
| 815.79 | 11.19 | 11.19 | 0.00 | 1 |
| 815.83 | 11.57 | 11.57 | 0.00 | 1 |
| 815.86 | 11.94 | 11.94 | 0.00 | 1 |
| 815.89 | 12.32 | 12.32 | 0.00 | 1 |
| 815.92 | 12.70 | 12.70 | 0.00 | 1 |
| 815.95 | 13.07 | 13.07 | 0.00 | 1 |
| 815.99 | 13.45 | 13.45 | 0.00 | 1 |
| 816.90 | 21.79 | 21.79 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C3

## Site Data - C3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 811.17 ft

Outlet Station: 50.00 ft

Outlet Elevation: 811.16 ft

Number of Barrels: 2

## Culvert Data Summary - C3

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C3

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 811.17 ft

## Crossing Discharge Data

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

Minimum Flow: 27.38 cfs

Design Flow: 27.38 cfs

Maximum Flow: 47.76 cfs

## Table 1 - Culvert Summary Table: C3

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.38 | 27.38 | 813.15 | 1.836 | 1.981 | 7-H2c | -1.000 | 1.245 | 1.245 | 0.886 | 5.607 | 2.677 |
| 29.42 | 29.42 | 813.23 | 1.918 | 2.064 | 7-H2c | -1.000 | 1.292 | 1.292 | 0.921 | 5.745 | 2.735 |
| 31.46 | 31.46 | 813.32 | 1.998 | 2.147 | 7-H2c | -1.000 | 1.339 | 1.339 | 0.954 | 5.878 | 2.789 |
| 33.49 | 33.49 | 813.40 | 2.077 | 2.228 | 7-H2c | -1.000 | 1.383 | 1.383 | 0.987 | 6.009 | 2.841 |
| 35.53 | 35.53 | 813.48 | 2.155 | 2.308 | 7-H2c | -1.000 | 1.427 | 1.427 | 1.018 | 6.137 | 2.891 |
| 37.57 | 37.46 | 813.55 | 2.229 | 2.384 | 7-H2c | -1.000 | 1.467 | 1.467 | 1.049 | 6.257 | 2.938 |
| 39.61 | 38.68 | 813.60 | 2.276 | 2.431 | 7-H2c | -1.000 | 1.492 | 1.492 | 1.078 | 6.332 | 2.983 |
| 41.65 | 39.64 | 813.64 | 2.312 | 2.468 | 7-H2c | -1.000 | 1.511 | 1.511 | 1.107 | 6.391 | 3.027 |
| 43.68 | 40.50 | 813.67 | 2.345 | 2.502 | 7-H2c | -1.000 | 1.528 | 1.528 | 1.135 | 6.443 | 3.068 |
| 45.72 | 41.26 | 813.70 | 2.374 | 2.531 | 7-H2c | -1.000 | 1.543 | 1.543 | 1.163 | 6.490 | 3.109 |
| 47.76 | 42.00 | 813.73 | 2.403 | 2.559 | 7-H2c | -1.000 | 1.557 | 1.557 | 1.189 | 6.534 | 3.148 |

**********

Straight Culvert

Inlet Elevation (invert): 811.17 ft, Outlet Elevation (invert): 811.16 ft

Culvert Length: 50.00 ft, Culvert Slope: 0.0002

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**Table 2 - Summary of Culvert Flows at Crossing: Culvert C3**

| Headwater Elevation (ft) | Total Discharge (cfs) | C3 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 813.15 | 27.38 | 27.38 | 0.00 | 1 |
| 813.23 | 29.42 | 29.42 | 0.00 | 1 |
| 813.32 | 31.46 | 31.46 | 0.00 | 1 |
| 813.40 | 33.49 | 33.49 | 0.00 | 1 |
| 813.48 | 35.53 | 35.53 | 0.00 | 1 |
| 813.55 | 37.57 | 37.46 | 0.02 | 10 |
| 813.60 | 39.61 | 38.68 | 0.85 | 6 |
| 813.64 | 41.65 | 39.64 | 1.94 | 5 |
| 813.67 | 43.68 | 40.50 | 3.15 | 5 |
| 813.70 | 45.72 | 41.26 | 4.38 | 4 |
| 813.73 | 47.76 | 42.00 | 5.71 | 4 |
| 813.55 | 37.37 | 37.37 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C4

## Site Data - C4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 809.87 ft

Outlet Station: 50.00 ft

Outlet Elevation: 809.74 ft

Number of Barrels: 2

## Culvert Data Summary - C4

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C4

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0070

Channel Manning's n: 0.0300

Channel Invert Elevation: 809.87 ft

## Crossing Discharge Data

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

Minimum Flow: 35.39 cfs

Design Flow: 35.39 cfs

Maximum Flow: 62.23 cfs

## Table 1 - Culvert Summary Table: C4

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 35.39 | 35.39 | 812.13 | 2.147 | 2.263 | 2-M2c | 1.660 | 1.424 | 1.424 | 0.929 | 6.128 | 3.252 |
| 38.07 | 38.07 | 812.24 | 2.249 | 2.365 | 2-M2c | 1.752 | 1.479 | 1.479 | 0.966 | 6.295 | 3.322 |
| 40.76 | 40.41 | 812.32 | 2.338 | 2.454 | 2-M2c | 1.837 | 1.526 | 1.526 | 1.002 | 6.438 | 3.389 |
| 43.44 | 41.81 | 812.38 | 2.392 | 2.507 | 7-M2c | 1.891 | 1.553 | 1.553 | 1.036 | 6.523 | 3.453 |
| 46.13 | 42.96 | 812.42 | 2.437 | 2.550 | 7-M2c | 1.938 | 1.575 | 1.575 | 1.069 | 6.593 | 3.513 |
| 48.81 | 44.01 | 812.46 | 2.478 | 2.589 | 7-M2c | 1.983 | 1.595 | 1.595 | 1.102 | 6.656 | 3.571 |
| 51.49 | 44.95 | 812.49 | 2.515 | 2.624 | 7-M2c | 2.027 | 1.613 | 1.613 | 1.133 | 6.713 | 3.627 |
| 54.18 | 45.85 | 812.53 | 2.550 | 2.658 | 7-M2c | 2.073 | 1.629 | 1.629 | 1.163 | 6.767 | 3.680 |
| 56.86 | 46.71 | 812.56 | 2.585 | 2.691 | 7-M2c | 2.121 | 1.645 | 1.645 | 1.193 | 6.819 | 3.731 |
| 59.55 | 47.53 | 812.59 | 2.617 | 2.721 | 7-M2c | 2.174 | 1.660 | 1.660 | 1.222 | 6.868 | 3.781 |
| 62.23 | 48.31 | 812.62 | 2.649 | 2.751 | 7-M2c | 2.500 | 1.674 | 1.674 | 1.250 | 6.915 | 3.828 |

**********

Straight Culvert

Inlet Elevation (invert): 809.87 ft, Outlet Elevation (invert): 809.74 ft

Culvert Length: 50.00 ft, Culvert Slope: 0.0026

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C4**

| Headwater Elevation (ft) | Total Discharge (cfs) | C4 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 812.13 | 35.39 | 35.39 | 0.00 | 1 |
| 812.24 | 38.07 | 38.07 | 0.00 | 1 |
| 812.32 | 40.76 | 40.41 | 0.26 | 9 |
| 812.38 | 43.44 | 41.81 | 1.56 | 6 |
| 812.42 | 46.13 | 42.96 | 3.08 | 5 |
| 812.46 | 48.81 | 44.01 | 4.75 | 5 |
| 812.49 | 51.49 | 44.95 | 6.46 | 4 |
| 812.53 | 54.18 | 45.85 | 8.25 | 4 |
| 812.56 | 56.86 | 46.71 | 10.10 | 4 |
| 812.59 | 59.55 | 47.53 | 11.98 | 4 |
| 812.62 | 62.23 | 48.31 | 13.89 | 4 |
| 812.30 | 39.78 | 39.78 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C5

## Site Data - C5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 807.57 ft

Outlet Station: 50.00 ft

Outlet Elevation: 807.15 ft

Number of Barrels: 2

## Culvert Data Summary - C5

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C5

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 807.59 ft

## Crossing Discharge Data

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

Minimum Flow: 35.21 cfs

Design Flow: 35.21 cfs

Maximum Flow: 65.15 cfs

## Table 1 - Culvert Summary Table: C5

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 35.21 | 35.21 | 809.70 | 2.133 | 1.411 | 1-S2n | 1.148 | 1.420 | 1.190 | 1.013 | 7.642 | 2.883 |
| 38.20 | 38.20 | 809.82 | 2.247 | 1.523 | 1-S2n | 1.203 | 1.482 | 1.248 | 1.058 | 7.801 | 2.952 |
| 41.20 | 41.20 | 809.93 | 2.362 | 1.638 | 1-S2n | 1.257 | 1.541 | 1.305 | 1.101 | 7.950 | 3.017 |
| 44.19 | 44.19 | 810.05 | 2.478 | 1.773 | 1-S2n | 1.311 | 1.598 | 1.360 | 1.142 | 8.093 | 3.079 |
| 47.19 | 47.19 | 810.17 | 2.596 | 1.912 | 5-S2n | 1.364 | 1.654 | 1.415 | 1.182 | 8.230 | 3.137 |
| 50.18 | 50.18 | 810.29 | 2.719 | 2.054 | 5-S2n | 1.417 | 1.707 | 1.470 | 1.220 | 8.362 | 3.193 |
| 53.17 | 53.17 | 810.42 | 2.846 | 2.199 | 5-S2n | 1.470 | 1.758 | 1.523 | 1.257 | 8.490 | 3.246 |
| 56.17 | 55.74 | 810.53 | 2.959 | 2.326 | 5-S2n | 1.516 | 1.800 | 1.569 | 1.294 | 8.595 | 3.296 |
| 59.16 | 57.10 | 810.59 | 3.021 | 2.395 | 5-S2n | 1.541 | 1.822 | 1.593 | 1.329 | 8.650 | 3.345 |
| 62.16 | 58.20 | 810.64 | 3.072 | 2.451 | 5-S2n | 1.561 | 1.839 | 1.613 | 1.363 | 8.693 | 3.391 |
| 65.15 | 59.19 | 810.69 | 3.118 | 2.501 | 5-S2n | 1.578 | 1.854 | 1.630 | 1.396 | 8.732 | 3.436 |

**********

Straight Culvert

Inlet Elevation (invert): 807.57 ft, Outlet Elevation (invert): 807.15 ft

Culvert Length: 50.00 ft, Culvert Slope: 0.0084

**********

## Table 24 - Summary of Culvert Flows at Crossing: Culvert C5

| Headwater Elevation (ft) | Total Discharge (cfs) | C5 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 809.70 | 35.21 | 35.21 | 0.00 | 1 |
| 809.82 | 38.20 | 38.20 | 0.00 | 1 |
| 809.93 | 41.20 | 41.20 | 0.00 | 1 |
| 810.05 | 44.19 | 44.19 | 0.00 | 1 |
| 810.17 | 47.19 | 47.19 | 0.00 | 1 |
| 810.29 | 50.18 | 50.18 | 0.00 | 1 |
| 810.42 | 53.17 | 53.17 | 0.00 | 1 |
| 810.53 | 56.17 | 55.74 | 0.36 | 10 |
| 810.59 | 59.16 | 57.10 | 1.98 | 6 |
| 810.64 | 62.16 | 58.20 | 3.88 | 5 |
| 810.69 | 65.15 | 59.19 | 5.92 | 5 |
| 810.50 | 55.08 | 55.08 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C6

## Site Data - C6

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 805.40 ft

Outlet Station: 104.56 ft

Outlet Elevation: 804.76 ft

Number of Barrels: 2

## Culvert Data Summary - C6

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Mitered to Conform to Slope

Inlet Depression: None

## Crossing Discharge Data

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

Minimum Flow: 27.86 cfs

Design Flow: 27.86 cfs

Maximum Flow: 47.83 cfs

## Tailwater Channel Data - Culvert C6

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0070

Channel Manning's n: 0.0300

Channel Invert Elevation: 804.56 ft

## Table 1 - Culvert Summary Table: C6

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.86 | 27.86 | 807.61 | 2.214 | 1.559 | 5-S2n | 1.263 | 1.344 | 1.263 | 0.769 | 6.666 | 3.141 |
| 29.86 | 29.86 | 807.76 | 2.362 | 1.734 | 5-S2n | 1.325 | 1.392 | 1.325 | 0.800 | 6.758 | 3.216 |
| 31.85 | 31.85 | 807.92 | 2.520 | 1.916 | 5-S2n | 1.390 | 1.439 | 1.391 | 0.831 | 6.829 | 3.287 |
| 33.85 | 33.85 | 808.09 | 2.689 | 2.105 | 5-S2n | 1.458 | 1.483 | 1.458 | 0.861 | 6.901 | 3.355 |
| 35.85 | 35.85 | 808.27 | 2.869 | 2.806 | 7-M2c | 1.531 | 1.525 | 1.525 | 0.890 | 6.973 | 3.420 |
| 37.84 | 37.84 | 808.46 | 3.061 | 2.896 | 7-M2c | 1.613 | 1.565 | 1.565 | 0.918 | 7.174 | 3.483 |
| 39.84 | 39.00 | 808.58 | 3.176 | 2.950 | 7-M2c | 1.669 | 1.587 | 1.587 | 0.946 | 7.293 | 3.543 |
| 41.84 | 39.67 | 808.64 | 3.245 | 2.982 | 7-M2c | 1.705 | 1.600 | 1.600 | 0.973 | 7.363 | 3.601 |
| 43.84 | 40.22 | 808.70 | 3.302 | 3.010 | 7-M2c | 1.740 | 1.610 | 1.610 | 0.999 | 7.421 | 3.656 |
| 45.83 | 40.73 | 808.76 | 3.356 | 3.038 | 7-M2c | 1.780 | 1.619 | 1.619 | 1.025 | 7.474 | 3.710 |
| 47.83 | 41.19 | 808.80 | 3.404 | 3.064 | 7-M2c | 2.000 | 1.627 | 1.627 | 1.051 | 7.523 | 3.762 |

**********

Straight Culvert

Inlet Elevation (invert): 805.40 ft, Outlet Elevation (invert): 804.76 ft

Culvert Length: 104.56 ft, Culvert Slope: 0.0061

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C6**

| Headwater Elevation (ft) | Total Discharge (cfs) | C6 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 807.61 | 27.86 | 27.86 | 0.00 | 1 |
| 807.76 | 29.86 | 29.86 | 0.00 | 1 |
| 807.92 | 31.85 | 31.85 | 0.00 | 1 |
| 808.09 | 33.85 | 33.85 | 0.00 | 1 |
| 808.27 | 35.85 | 35.85 | 0.00 | 1 |
| 808.46 | 37.84 | 37.84 | 0.00 | 1 |
| 808.58 | 39.84 | 39.00 | 0.80 | 8 |
| 808.64 | 41.84 | 39.67 | 2.13 | 6 |
| 808.70 | 43.84 | 40.22 | 3.56 | 5 |
| 808.76 | 45.83 | 40.73 | 5.07 | 5 |
| 808.80 | 47.83 | 41.19 | 6.62 | 5 |
| 808.50 | 38.24 | 38.24 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C7

## Site Data - C7

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 796.64 ft

Outlet Station: 60.20 ft

Outlet Elevation: 796.34 ft

Number of Barrels: 2

## Culvert Data Summary - C7

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

## Tailwater Channel Data - Culvert C7

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0300

Channel Invert Elevation: 795.60 ft

## Crossing Discharge Data

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

Minimum Flow: 52.15 cfs

Design Flow: 52.15 cfs

Maximum Flow: 103.37 cfs

## Table 1 - Culvert Summary Table: C7

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52.15 | 52.15 | 799.12 | 2.228 | 2.484 | 2-M2c | 2.109 | 1.572 | 1.572 | 0.943 | 6.224 | 4.017 |
| 57.27 | 57.27 | 799.26 | 2.356 | 2.622 | 2-M2c | 2.247 | 1.651 | 1.651 | 0.992 | 6.414 | 4.133 |
| 62.39 | 62.39 | 799.40 | 2.481 | 2.756 | 2-M2c | 2.389 | 1.727 | 1.727 | 1.039 | 6.596 | 4.241 |
| 67.52 | 67.52 | 799.53 | 2.604 | 2.889 | 2-M2c | 2.539 | 1.800 | 1.800 | 1.084 | 6.773 | 4.342 |
| 72.64 | 72.64 | 799.66 | 2.725 | 3.019 | 2-M2c | 2.703 | 1.870 | 1.870 | 1.128 | 6.945 | 4.438 |
| 77.76 | 77.76 | 799.79 | 2.846 | 3.148 | 2-M2c | 2.898 | 1.938 | 1.938 | 1.170 | 7.112 | 4.528 |
| 82.88 | 82.88 | 799.92 | 2.966 | 3.277 | 2-M2c | 3.500 | 2.004 | 2.004 | 1.210 | 7.277 | 4.614 |
| 88.00 | 88.00 | 800.04 | 3.086 | 3.405 | 2-M2c | 3.500 | 2.067 | 2.067 | 1.250 | 7.439 | 4.696 |
| 93.13 | 93.13 | 800.17 | 3.207 | 3.534 | 7-M2c | 3.500 | 2.129 | 2.129 | 1.288 | 7.599 | 4.774 |
| 98.25 | 98.25 | 800.30 | 3.330 | 3.663 | 7-M2c | 3.500 | 2.189 | 2.189 | 1.324 | 7.758 | 4.849 |
| 103.37 | 103.37 | 800.43 | 3.454 | 3.794 | 7-M2c | 3.500 | 2.248 | 2.248 | 1.360 | 7.916 | 4.921 |

**********

Straight Culvert

Inlet Elevation (invert): 796.64 ft, Outlet Elevation (invert): 796.34 ft

Culvert Length: 60.20 ft, Culvert Slope: 0.0050

**********

## Table 15 - Summary of Culvert Flows at Crossing: Culvert C7

| Headwater Elevation (ft) | Total Discharge (cfs) | C7 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 799.12 | 52.15 | 52.15 | 0.00 | 1 |
| 799.26 | 57.27 | 57.27 | 0.00 | 1 |
| 799.40 | 62.39 | 62.39 | 0.00 | 1 |
| 799.53 | 67.52 | 67.52 | 0.00 | 1 |
| 799.66 | 72.64 | 72.64 | 0.00 | 1 |
| 799.79 | 77.76 | 77.76 | 0.00 | 1 |
| 799.92 | 82.88 | 82.88 | 0.00 | 1 |
| 800.04 | 88.00 | 88.00 | 0.00 | 1 |
| 800.17 | 93.13 | 93.13 | 0.00 | 1 |
| 800.30 | 98.25 | 98.25 | 0.00 | 1 |
| 800.43 | 103.37 | 103.37 | 0.00 | 1 |
| 802.50 | 162.85 | 162.85 | 0.00 | Overtopping |

# HY-8 Culvert Analysis Report _ Culvert C8

## Site Data - C8

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 807.54 ft

Outlet Station: 99.86 ft

Outlet Elevation: 806.81 ft

Number of Barrels: 1

## Culvert Data Summary - C8

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

## Tailwater Channel Data - Culvert C8

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 12.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0560

Channel Manning's n: 0.0450

Channel Invert Elevation: 807.44 ft

## Crossing Discharge Data

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

Minimum Flow: 8.32 cfs

Design Flow: 8.32 cfs

Maximum Flow: 19.2 cfs

## Table 1 - Culvert Summary Table: C8

| Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) | Tailwater Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.32 | 8.32 | 809.29 | 1.614 | 1.747 | 2-M2c | 1.344 | 1.028 | 1.028 | 0.230 | 5.117 | 2.797 |
| 9.41 | 9.41 | 809.43 | 1.751 | 1.891 | 2-M2c | 1.478 | 1.096 | 1.096 | 0.248 | 5.339 | 2.926 |
| 10.50 | 10.50 | 809.58 | 1.890 | 2.038 | 7-M2c | 1.639 | 1.160 | 1.160 | 0.264 | 5.553 | 3.045 |
| 11.58 | 11.58 | 809.74 | 2.033 | 2.199 | 7-M2c | 2.000 | 1.222 | 1.222 | 0.280 | 5.762 | 3.156 |
| 12.67 | 12.67 | 809.92 | 2.182 | 2.381 | 7-M2c | 2.000 | 1.280 | 1.280 | 0.295 | 5.968 | 3.260 |
| 13.76 | 13.76 | 810.22 | 2.338 | 2.679 | 7-M2c | 2.000 | 1.336 | 1.336 | 0.310 | 6.173 | 3.357 |
| 14.85 | 14.85 | 810.57 | 2.504 | 3.026 | 7-M2c | 2.000 | 1.389 | 1.389 | 0.324 | 6.378 | 3.451 |
| 15.94 | 15.94 | 810.93 | 2.679 | 3.391 | 7-M2c | 2.000 | 1.439 | 1.439 | 0.337 | 6.585 | 3.538 |
| 17.02 | 17.02 | 811.32 | 2.866 | 3.776 | 7-M2c | 2.000 | 1.487 | 1.487 | 0.351 | 6.796 | 3.622 |
| 18.11 | 18.11 | 811.72 | 3.066 | 4.183 | 7-M2c | 2.000 | 1.533 | 1.533 | 0.364 | 7.011 | 3.703 |
| 19.20 | 19.20 | 812.15 | 3.279 | 4.611 | 7-M2c | 2.000 | 1.576 | 1.576 | 0.376 | 7.231 | 3.780 |

**********

Straight Culvert

Inlet Elevation (invert): 807.54 ft, Outlet Elevation (invert): 806.81 ft

Culvert Length: 99.86 ft, Culvert Slope: 0.0073

**********

**Table 2 - Summary of Culvert Flows at Crossing: Culvert C8**

| Headwater Elevation (ft) | Total Discharge (cfs) | C8 Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 809.29 | 8.32 | 8.32 | 0.00 | 1 |
| 809.43 | 9.41 | 9.41 | 0.00 | 1 |
| 809.58 | 10.50 | 10.50 | 0.00 | 1 |
| 809.74 | 11.58 | 11.58 | 0.00 | 1 |
| 809.92 | 12.67 | 12.67 | 0.00 | 1 |
| 810.22 | 13.76 | 13.76 | 0.00 | 1 |
| 810.57 | 14.85 | 14.85 | 0.00 | 1 |
| 810.93 | 15.94 | 15.94 | 0.00 | 1 |
| 811.32 | 17.02 | 17.02 | 0.00 | 1 |
| 811.72 | 18.11 | 18.11 | 0.00 | 1 |
| 812.15 | 19.20 | 19.20 | 0.00 | 1 |
| 812.40 | 19.87 | 19.87 | 0.00 | Overtopping |

Diversion Berm Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| Sheet No. | 1 of 5 | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: Columbia POO Update | By: RJG | Date: 2/15/22 |
| Client: WPL | Subject: Diversion Berm Spacing Calculation | Chk'd: MJT | Date: 4/1/22 |

**Purpose:**

Determine the spacing between diversion berms on the landfill final cover, with the goal of maintaining ≤ 3 ton/acre of soil loss along the final cover.

**References**

1. "Predicting Rainfall Erosion Losses," USDA Agriculture Handbook Number 537, 1978. (Figure 1 on Sheet 2 and Tables 10 and 13 on Sheet 4).
2. Erosion and Sediment Control Handbook," Goldman, Jackson, & Bursztynsky, 1986. (Table 5.5 on Sheet 5).
3. Rainfed retention probabilities computed for different cropping tillage systems. Agricultural Water Management, A.W. Mills & G.W. Thomas, 1985. Table 5.10 on Sheet 3)
4. Colombia Energy Center POO Update Drawings

**Approach:**

Use the Universal Soil Loss Equation (USLE) to determine diversion berm spacing. Longest flow length is 401 feet.

USLE Equation: $A = R * K * LS * C * P$

where: A = Average annual soil loss, tons/acre
R = Rainfall and runoff erosivity index
K = Soil erodibility factor, tons/acre
LS = Slope length and steepness factor
C = Cover management factor
P = Practice factor

or $LS = \frac{A}{R \times K \times C \times P}$

**Assumptions:**

| | | |
|---|---|---|
| A = | 3 | tons/acre |
| R = | 145 | see Figure 1 on Sheet 2 (Reference #1) |
| K = | 0.38 | see Table 5.10 on Sheet 3 for Loamy Very Fine Sand (Reference #3) |
| C = | 0.0064 | see Table 10 on Sheet 4, assuming 90% cover (Reference #1) |
| P = | 1.0 | assume no support practice used |

**Calculation:**

$$LS = \frac{A}{R \times K \times C \times P} = \frac{3}{145 \times 0.38 \times 0.0064 \times 1.0} = 8.51$$

From the LS Values Table (Sheet 5), based on the 4:1 final cover slope, the slope distance is between 200 and 250 feet.
Use linear interpolation between the LS values for 200 and 250 feet to determine the slope length value for the 4:1 slope.

| | | | | |
|---|---|---|---|---|
| Slope Length @ | 200 | ft | LS= | 8.33 |
| Slope Length @ | 250 | ft | LS= | 9.31 |

Slope length for the calculate LS factor = 209 ft

**Results:**

The maximum distance between diversion berms along the final cover to maintain less than 3 tons/acre soil loss is 209 ft.

SCS ENGINEERS

| | |
|---|---|
| Sheet No. | 2 of 5 |
| Calc. No. | |
| Rev. No. | |

| | | | |
|---|---|---|---|
| Job No. 25220183.00 | Job: Columbia POO Update | By: RJG | Date: 2/15/22 |
| Client: WPL | Subject: Diversion Berm Spacing Calculation | Chk'd: MJT | Date: 4/1/22 |

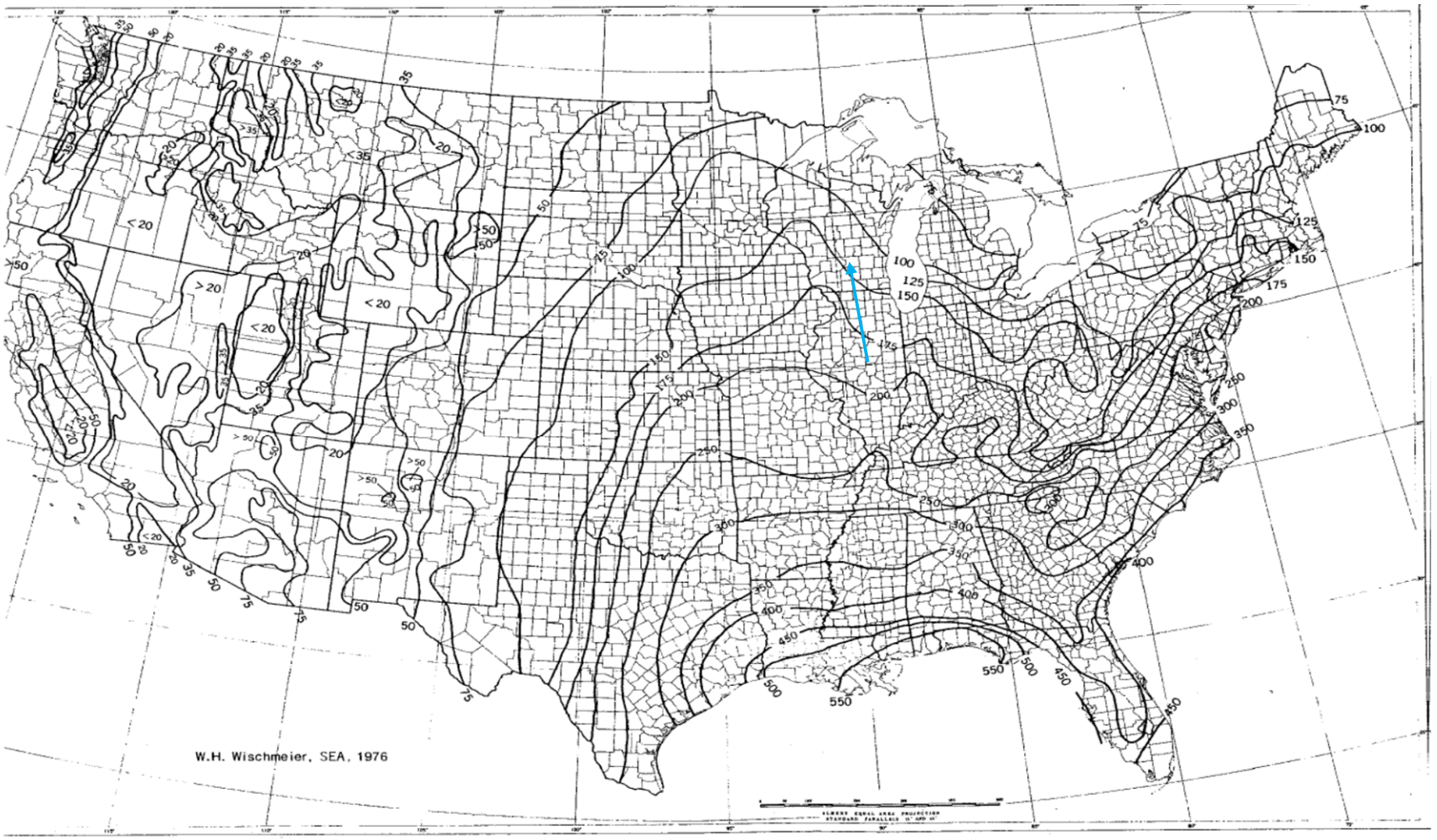



FIGURE 1.—Average annual values of the rainfall erosion index.

Source: "Predicting Rainfall Erosion Losses," USDA Agriculture Handbook Number 537, 1978.

**Table 5.10**. Soil Erodibility Factor $K_{fact}$ (after Stewart et al. 1975)[a]

| | $P_{om}$(%) | | |
|---|---|---|---|
| Textural Class | <0.5 | 2 | 4 |
| Sand | 0.05 | 0.03 | 0.02 |
| Fine sand | 0.16 | 0.14 | 0.10 |
| Very finesand | 0.42 | 0.36 | 0.28 |
| Loamy sand | 0.12 | 0.10 | 0.08 |
| Loamy finesand | 0.24 | 0.20 | 0.16 |
| Loamy veryfine sand | 0.44 | 0.38 | 0.30 |
| Sandy loam | 0.27 | 0.24 | 0.19 |
| Fine sandyloam | 0.35 | 0.30 | 0.24 |
| Very fine sandy loam | 0.47 | 0.41 | 0.33 |
| Loam | 0.38 | 0.34 | 0.29 |
| Silt loam | 0.48 | 0.42 | 0.33 |
| Silt | 0.60 | 0.52 | 0.42 |
| Sandy clayloam | 0.27 | 0.25 | 0.21 |
| Clay loam | 0.28 | 0.25 | 0.21 |
| Silty clayloam | 0.37 | 0.32 | 0.26 |
| Sandy clay | 0.14 | 0.13 | 0.12 |
| Silty clay | 0.25 | 0.23 | 0.19 |
| Clay | | 0.13-0.2 | |

(a) The values shown are estimated averages of broad ranges of specific soil values. When a texture is near the border line of two texture classes, use the average of the two $K_{fact}$ values.

In addition, the values shown are commensurate with the English units used in the cited reference (and as used in the source-term module input files). To obtain analagous values in the metric units used in this report, the above values should be multiplied by 1.292.

TABLE 10.—*Factor* **C** *for permanent pasture, range, and idle land*[1]

| Vegetative canopy | | | Cover that contacts the soil surface | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type and height[2] | Percent cover[3] | | Percent ground cover | | | | | |
| | | Type[4] | 0 | 20 | 40 | 60 | 80 | 95+ |
| No appreciable canopy | | G | 0.45 | 0.20 | 0.10 | 0.042 | 0.013 | 0.003 |
| | | W | .45 | .24 | .15 | .091 | .043 | .011 |
| Tall weeds or short brush with average drop fall height of 20 in | 25 | G | .36 | .17 | .09 | .038 | .013 | .003 |
| | | W | .36 | .20 | .13 | .083 | .041 | .011 |
| | 50 | G | .26 | .13 | .07 | .035 | .012 | .003 |
| | | W | .26 | .16 | .11 | .076 | .039 | .011 |
| | 75 | G | .17 | .10 | .06 | .032 | .011 | .003 |
| | | W | .17 | .12 | .09 | .068 | .038 | .011 |
| Appreciable brush or bushes, with average drop fall height of 6½ ft | 25 | G | .40 | .18 | .09 | .040 | .013 | .003 |
| | | W | .40 | .22 | .14 | .087 | .042 | .011 |
| | 50 | G | .34 | .16 | .08 | .038 | .012 | .003 |
| | | W | .34 | .19 | .13 | .082 | .041 | .011 |
| | 75 | G | .28 | .14 | .08 | .036 | .012 | .003 |
| | | W | .28 | .17 | .12 | .078 | .040 | .011 |
| Trees, but no appreciable low brush. Average drop fall height of 13 ft | 25 | G | .42 | .19 | .10 | .041 | .013 | .003 |
| | | W | .42 | .23 | .14 | .089 | .042 | .011 |
| | 50 | G | .39 | .18 | .09 | .040 | .013 | .003 |
| | | W | .39 | .21 | .14 | .087 | .042 | .011 |
| | 75 | G | .36 | .17 | .09 | .039 | .012 | .003 |
| | | W | .36 | .20 | .13 | .084 | .041 | .011 |

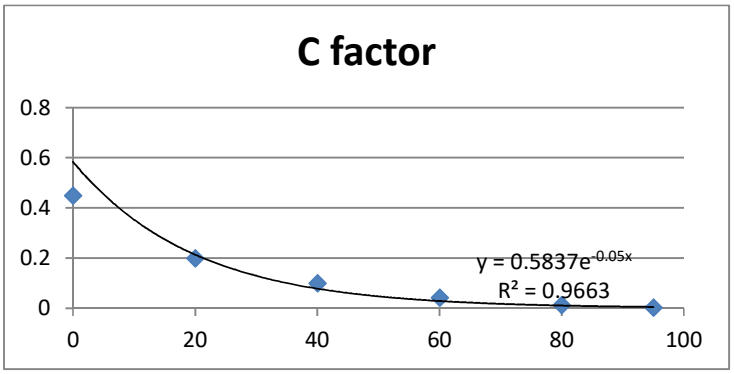
[1] The listed **C** values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in deep.
W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

Source: "Predicting Rainfall Erosion Losses," USDA Agriculture Handbook Number 537, 1978.




= 90 % cover
0.0065

**TABLE 5.5 LS Values* (10)**

| Slope ratio | Slope gradient s, % | LS values for following slope lengths l, ft (m) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 (3.0) | 20 (6.1) | 30 (9.1) | 40 (12.2) | 50 (15.2) | 60 (18.3) | 70 (21.3) | 80 (24.4) | 90 (27.4) | 100 (30.5) |
| | 0.5 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 |
| 100:1 | 1 | 0.08 | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 |
| | 2 | 0.10 | 0.12 | 0.14 | 0.15 | 0.16 | 0.17 | 0.18 | 0.19 | 0.19 | 0.20 |
| | 3 | 0.14 | 0.18 | 0.20 | 0.22 | 0.23 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 |
| | 4 | 0.16 | 0.21 | 0.25 | 0.28 | 0.30 | 0.33 | 0.35 | 0.37 | 0.38 | 0.40 |
| 20:1 | 5 | 0.17 | 0.24 | 0.29 | 0.34 | 0.38 | 0.41 | 0.45 | 0.48 | 0.51 | 0.53 |
| | 6 | 0.21 | 0.30 | 0.37 | 0.43 | 0.48 | 0.52 | 0.56 | 0.60 | 0.64 | 0.67 |
| | 7 | 0.26 | 0.37 | 0.45 | 0.52 | 0.58 | 0.64 | 0.69 | 0.74 | 0.78 | 0.82 |
| 12½:1 | 8 | 0.31 | 0.44 | 0.54 | 0.63 | 0.70 | 0.77 | 0.83 | 0.89 | 0.94 | 0.99 |
| | 9 | 0.37 | 0.52 | 0.64 | 0.74 | 0.83 | 0.91 | 0.98 | 1.05 | 1.11 | 1.17 |
| 10:1 | 10 | 0.43 | 0.61 | 0.75 | 0.87 | 0.97 | 1.06 | 1.15 | 1.22 | 1.30 | 1.37 |
| | 11 | 0.50 | 0.71 | 0.86 | 1.00 | 1.12 | 1.22 | 1.32 | 1.41 | 1.50 | 1.58 |
| 8:1 | 12.5 | 0.61 | 0.86 | 1.05 | 1.22 | 1.36 | 1.49 | 1.61 | 1.72 | 1.82 | 1.92 |
| | 15 | 0.81 | 1.14 | 1.40 | 1.62 | 1.81 | 1.98 | 2.14 | 2.29 | 2.43 | 2.56 |
| 6:1 | 16.7 | 0.96 | 1.36 | 1.67 | 1.92 | 2.15 | 2.36 | 2.54 | 2.72 | 2.88 | 3.04 |
| 5:1 | 20 | 1.29 | 1.82 | 2.23 | 2.58 | 2.88 | 3.16 | 3.41 | 3.65 | 3.87 | 4.08 |
| 4½:1 | 22 | 1.51 | 2.13 | 2.61 | 3.02 | 3.37 | 3.69 | 3.99 | 4.27 | 4.53 | 4.77 |
| 4:1 | 25 | 1.86 | 2.63 | 3.23 | 3.73 | 4.16 | 4.56 | 4.93 | 5.27 | 5.59 | 5.89 |
| | 30 | 2.51 | 3.56 | 4.36 | 5.03 | 5.62 | 6.16 | 6.65 | 7.11 | 7.54 | 7.95 |
| 3:1 | 33.3 | 2.98 | 4.22 | 5.17 | 5.96 | 6.67 | 7.30 | 7.89 | 8.43 | 8.95 | 9.43 |
| | 35 | 3.23 | 4.57 | 5.60 | 6.46 | 7.23 | 7.92 | 8.55 | 9.14 | 9.70 | 10.22 |
| 2⅔:1 | 40 | 4.00 | 5.66 | 6.93 | 8.00 | 8.95 | 9.80 | 10.59 | 11.32 | 12.00 | 12.65 |
| | 45 | 4.81 | 6.80 | 8.33 | 9.61 | 10.75 | 11.77 | 12.72 | 13.60 | 14.42 | 15.20 |
| 2:1 | 50 | 5.64 | 7.97 | 9.76 | 11.27 | 12.60 | 13.81 | 14.91 | 15.94 | 16.91 | 17.82 |
| | 55 | 6.48 | 9.16 | 11.22 | 12.96 | 14.48 | 15.87 | 17.14 | 18.32 | 19.43 | 20.48 |
| 1¾:1 | 57 | 6.82 | 9.64 | 11.80 | 13.63 | 15.24 | 16.69 | 18.03 | 19.28 | 20.45 | 21.55 |
| | 60 | 7.32 | 10.35 | 12.68 | 14.64 | 16.37 | 17.93 | 19.37 | 20.71 | 21.96 | 23.15 |
| 1½:1 | 66.7 | 8.44 | 11.93 | 14.61 | 16.88 | 18.87 | 20.67 | 22.32 | 23.87 | 25.31 | 26.68 |
| | 70 | 8.98 | 12.70 | 15.55 | 17.96 | 20.08 | 21.99 | 23.75 | 25.39 | 26.93 | 28.39 |
| | 75 | 9.78 | 13.83 | 16.94 | 19.56 | 21.87 | 23.95 | 25.87 | 27.66 | 29.34 | 30.92 |
| 1¼:1 | 80 | 10.55 | 14.93 | 18.28 | 21.11 | 23.60 | 25.85 | 27.93 | 29.85 | 31.66 | 33.38 |
| | 85 | 11.30 | 15.98 | 19.58 | 22.61 | 25.27 | 27.69 | 29.90 | 31.97 | 33.91 | 35.74 |
| | 90 | 12.02 | 17.00 | 20.82 | 24.04 | 26.88 | 29.44 | 31.80 | 34.00 | 36.06 | 38.01 |
| | 95 | 12.71 | 17.97 | 22.01 | 25.41 | 28.41 | 31.12 | 33.62 | 35.94 | 38.12 | 40.18 |
| 1:1 | 100 | 13.36 | 18.89 | 23.14 | 26.72 | 29.87 | 32.72 | 35.34 | 37.78 | 40.08 | 42.24 |

| Slope ratio | Slope gradient s, % | LS values for following slope lengths l, ft (m) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 150 (46) | 200 (61) | 250 (76) | 300 (91) | 350 (107) | 400 (122) | 450 (137) | 500 (152) | 600 (183) | 700 (213) | 800 (244) | 900 (274) | 1000 (305) | | | | | | | | | | |
| | 0.5 | 0.10 | 0.11 | 0.11 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | | | | | | | | | | |
| 100:1 | 1 | 0.14 | 0.14 | 0.15 | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.18 | 0.18 | 0.19 | 0.19 | 0.20 | | | | | | | | | | |
| | 2 | 0.23 | 0.25 | 0.26 | 0.28 | 0.29 | 0.30 | 0.32 | 0.33 | 0.34 | 0.36 | 0.37 | 0.39 | 0.40 | | | | | | | | | | |
| | 3 | 0.32 | 0.35 | 0.38 | 0.40 | 0.42 | 0.43 | 0.45 | 0.46 | 0.49 | 0.51 | 0.54 | 0.55 | 0.57 | | | | | | | | | | |
| | 4 | 0.47 | 0.53 | 0.58 | 0.62 | 0.66 | 0.70 | 0.73 | 0.76 | 0.82 | 0.87 | 0.92 | 0.96 | 1.00 | | | | | | | | | | |
| 20:1 | 5 | 0.66 | 0.76 | 0.85 | 0.93 | 1.00 | 1.07 | 1.13 | 1.20 | 1.31 | 1.42 | 1.51 | 1.60 | 1.69 | | | | | | | | | | |
| | 6 | 0.82 | 0.95 | 1.06 | 1.16 | 1.26 | 1.34 | 1.43 | 1.50 | 1.65 | 1.78 | 1.90 | 2.02 | 2.13 | | | | | | | | | | |
| | 7 | 1.01 | 1.17 | 1.30 | 1.43 | 1.54 | 1.65 | 1.75 | 1.84 | 2.02 | 2.18 | 2.33 | 2.47 | 2.61 | | | | | | | | | | |
| 12½:1 | 8 | 1.21 | 1.40 | 1.57 | 1.72 | 1.85 | 1.98 | 2.10 | 2.22 | 2.43 | 2.62 | 2.80 | 2.97 | 3.13 | | | | | | | | | | |
| | 9 | 1.44 | 1.66 | 1.85 | 2.03 | 2.19 | 2.35 | 2.49 | 2.62 | 2.87 | 3.10 | 3.32 | 3.52 | 3.71 | | | | | | | | | | |
| 10:1 | 10 | 1.68 | 1.94 | 2.16 | 2.37 | 2.56 | 2.74 | 2.90 | 3.06 | 3.35 | 3.62 | 3.87 | 4.11 | 4.33 | | | | | | | | | | |
| | 11 | 1.93 | 2.23 | 2.50 | 2.74 | 2.95 | 3.16 | 3.35 | 3.53 | 3.87 | 4.18 | 4.47 | 4.74 | 4.99 | | | | | | | | | | |
| 8:1 | 12.5 | 2.36 | 2.72 | 3.04 | 3.33 | 3.59 | 3.84 | 4.08 | 4.30 | 4.71 | 5.08 | 5.43 | 5.76 | 6.08 | | | | | | | | | | |
| | 15 | 3.13 | 3.62 | 4.05 | 4.43 | 4.79 | 5.12 | 5.43 | 5.72 | 6.27 | 6.77 | 7.24 | 7.68 | 8.09 | | | | | | | | | | |
| 6:1 | 16.7 | 3.72 | 4.30 | 4.81 | 5.27 | 5.69 | 6.08 | 6.45 | 6.80 | 7.45 | 8.04 | 8.60 | 9.12 | 9.62 | | | | | | | | | | |
| 5:1 | 20 | 5.00 | 5.77 | 6.45 | 7.06 | 7.63 | 8.16 | 8.65 | 9.12 | 9.99 | 10.79 | 11.54 | 12.24 | 12.90 | | | | | | | | | | |
| 4½:1 | 22 | 5.84 | 6.75 | 7.54 | 8.26 | 8.92 | 9.54 | 10.12 | 10.67 | 11.68 | 12.62 | 13.49 | 14.31 | 15.08 | | | | | | | | | | |
| 4:1 | 25 | 7.21 | 8.33 | 9.31 | 10.20 | 11.02 | 11.78 | 12.49 | 13.17 | 14.43 | 15.58 | 16.66 | 17.67 | 18.63 | | | | | | | | | | |
| | 30 | 9.74 | 11.25 | 12.57 | 13.77 | 14.88 | 15.91 | 16.87 | 17.78 | 19.48 | 21.04 | 22.49 | 23.86 | 25.15 | | | | | | | | | | |
| 3:1 | 33.3 | 11.55 | 13.34 | 14.91 | 16.33 | 17.64 | 18.86 | 20.00 | 21.09 | 23.10 | 24.95 | 26.67 | 28.29 | 29.82 | | | | | | | | | | |
| | 35 | 12.52 | 14.46 | 16.16 | 17.70 | 19.12 | 20.44 | 21.68 | 22.86 | 25.04 | 27.04 | 28.91 | 30.67 | 32.32 | | | | | | | | | | |
| 2⅔:1 | 40 | 15.50 | 17.89 | 20.01 | 21.91 | 23.67 | 25.30 | 26.84 | 28.29 | 30.99 | 33.48 | 35.79 | 37.96 | 40.01 | | | | | | | | | | |
| | 45 | 18.62 | 21.50 | 24.03 | 26.33 | 28.44 | 30.40 | 32.24 | 33.99 | 37.23 | 40.22 | 42.99 | 45.60 | 48.07 | | | | | | | | | | |
| 2:1 | 50 | 21.83 | 25.21 | 28.18 | 30.87 | 33.34 | 35.65 | 37.81 | 39.85 | 43.66 | 47.16 | 50.41 | 53.47 | 56.36 | | | | | | | | | | |
| | 55 | 25.09 | 28.97 | 32.39 | 35.48 | 38.32 | 40.97 | 43.45 | 45.80 | 50.18 | 54.20 | 57.94 | 61.45 | 64.78 | | | | | | | | | | |
| 1¾:1 | 57 | 26.40 | 30.48 | 34.08 | 37.33 | 40.32 | 43.10 | 45.72 | 48.19 | 52.79 | 57.02 | 60.96 | 64.66 | 68.15 | | | | | | | | | | |
| | 60 | 28.35 | 32.74 | 36.60 | 40.10 | 43.31 | 46.30 | 49.11 | 51.77 | 56.71 | 61.25 | 65.48 | 69.45 | 73.21 | | | | | | | | | | |
| 1½:1 | 66.7 | 32.68 | 37.74 | 42.19 | 46.22 | 49.92 | 53.37 | 56.60 | 59.66 | 65.36 | 70.60 | 75.47 | 80.05 | 84.38 | | | | | | | | | | |
| | 70 | 34.77 | 40.15 | 44.89 | 49.17 | 53.11 | 56.78 | 60.23 | 63.48 | 69.54 | 75.12 | 80.30 | 85.17 | 89.78 | | | | | | | | | | |
| | 75 | 37.87 | 43.73 | 48.89 | 53.56 | 57.85 | 61.85 | 65.60 | 69.15 | 75.75 | 81.82 | 87.46 | 92.77 | 97.79 | | | | | | | | | | |
| 1¼:1 | 80 | 40.88 | 47.20 | 52.77 | 57.81 | 62.44 | 66.75 | 70.80 | 74.63 | 81.76 | 88.31 | 94.41 | 100.13 | 105.55 | | | | | | | | | | |
| | 85 | 43.78 | 50.55 | 56.51 | 61.91 | 66.87 | 71.48 | 75.82 | 79.92 | 87.55 | 94.57 | 101.09 | 107.23 | 113.03 | | | | | | | | | | |
| | 90 | 46.55 | 53.76 | 60.10 | 65.84 | 71.11 | 76.02 | 80.63 | 84.99 | 93.11 | 100.57 | 107.51 | 114.03 | 120.20 | | | | | | | | | | |
| | 95 | 49.21 | 56.82 | 63.53 | 69.59 | 75.17 | 80.36 | 85.23 | 89.84 | 98.42 | 106.30 | 113.64 | 120.54 | 127.06 | | | | | | | | | | |
| 1:1 | 100 | 51.74 | 59.74 | 66.79 | 73.17 | 79.03 | 84.49 | 89.61 | 94.46 | 103.48 | 111.77 | 119.48 | 126.73 | 133.59 | | | | | | | | | | |

*Calculated from

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065\right)\left(\frac{l}{72.5}\right)^m$$

LS = topographic factor
$l$ = slope length, ft (m × 0.3048)
$s$ = slope steepness,
$m$ = exponent dependent upon slope steep
(0.2 for slopes < 1%, 0.3 for slopes 1 t
0.4 for slopes 3.5 to 4.5%, and
0.5 for slopes > 5%)

FROM "EROSION & SEDIMENT CONTROL HANDBOOK", Goldman, Jackson, + Bursztynsky, 1986

5.20

5.21

Source: Erosion and Sediment Control Handbook," Goldman, Jackson, & Bursztynsky, 1986.

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No: 1/2 | |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Project: Columbia Energy Center POO Update | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Diversion Berm Sizing | Chk'd: MJT | Date: 4/1/22 |

**Purpose:**

To size the post closure diversion berms on the final cover to accommodate the 25-year, 24-hour storm event.

**References:**

1. WisDOT Facilities Development Manual Chapter 13, Section 30-15 - Grass Lined Channels.
2. Design of Roadside Channels with Flexible Linings, HEC-15, USDOT FHWA.
3. HydroCAD Report_Post Construction

**Approach:**

Use the Post Closure HydroCAD Model results to obtain the peak flow during a 25-year, 24-hour storm event along the diversion berms.

Use Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2 (from Reference #1) to size the swale for each design swale cross section. The WisDOT spreadsheet incorporates the design guidelines and equations described in "Design of Roadside Channels with Flexible Linings", HEC-15, USDOT FHWA (Reference #2).

Confirm the swale is stable and has enough capacity for the design flow rate.

**Assumptions:**

1. Assume the channel geometry is a v-notch swale with one sideslope at 4:1 and one sideslope at 2:1 and a depth of 2.0 ft.
2. Assume 2.0% slope along the flowpath of the diversion swale.
3. Assume the following parameters per Section 15.2 - Grass Lining Properties from Reference #1:
   Vegetation Retardance Class = C for Swales
   Vegetation Condition = Good
   Vegetation Growth Form = Turf
4. Assume cohesive soil type with ASTM Soil Class SC and a Plasticity Index (PI) of 16.

**Calculations:**

From the HydroCAD Report, the peak flow rate along the diversion berms are as follows:

| Areas | | Areas | | Areas | | Areas | |
|---|---|---|---|---|---|---|---|
| 1 | 4.58 cfs | 8 | 3.29 cfs | 14 | 3.66 cfs | 20 | 3.43 cfs |
| 2 | 3.73 cfs | 9 | 3.40 cfs | 15 | 1.71 cfs | 21 | 3.35 cfs |
| 3 | 2.17 cfs | 10 | 3.17 cfs | 16 | 4.89 cfs | 22 | 3.35 cfs |
| 4 | 3.74 cfs | 11 | 3.10 cfs | 17 | 4.00 cfs | 23 | 4.89 cfs |
| 5 | 3.58 cfs | 12 | 0.35 cfs | 18 | 2.66 cfs | 24 | 6.05 cfs |
| 6 | 2.92 cfs | 13 | 2.91 cfs | 19 | 2.77 cfs | 25 | 5.13 cfs |

Use highest flow to confirm diversion berm functions.

Use the Grass Swale Design Spreadsheet (Page 2) to determine the flow depth, velocity and shear stress in the swales.

**Results:**

The diversion berms are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

The diversion berms are stable at the design flow rates. The design flow depth of 2.0 feet maintains at least 0.5 ft of freeboard during the 25-year, 24-hour storm event.

| ***Channel/Ditch Geometry*** | *Area 24* |
|---|---|
| Channel Slope, $S_o$ (ft/ft) | **0.02** |
| Channel Bottom Width, B (ft) | **0** |
| Channel Side Slope, $z_1$ | **4** |
| Channel Side Slope, $z_2$ | **2** |
| Flow Depth, d (ft) Solve iteratively | **1.00** |
| Safety Factor, SF | **1.0** |
| ***Vegetation/Soil Parameters*** | |
| Vegetation Retardance Class | **C** |
| Vegetation Condition | **good** |
| Vegetation Growth Form | **turf** |
| Soil Type | **cohesive** |
| $D_{75}$ (in) (Set at 0.00 for cohesive soils) | |
| ASTM Soil Class | **SC** |
| Plasticity Index, PI | **16** |
| ***Results Summary*** | |
| Design Q ($ft^3/s$) | **6.1** |
| Calculated Q ($ft^3/s$) | 6.1 |
| Difference Between Design & Calc. Flow (%) | 0.5% |
| **Stable (Yes or No)** | **YES** |
| ***Channel Parameters*** | |
| Vegetation Height, h (ft) | 0.67 |
| Grass Roughness Coefficient, $C_n$ | 0.238 |
| Cover Factor, $C_f$ | 0.90 |
| Noncohesive Soil | |
| Soil Grain Roughness, $n_s$ | 0.016 |
| Permissible Soil Shear Stress, $\tau_p$ ($lb/ft^2$) | N/A |
| Cohesive Soil | |
| Porosity, e | 0.35 |
| Soil Coefficient 1, $c_1$ | 1.0700 |
| Soil Coefficient 2, $c_2$ | 14.30 |
| Soil Coefficient 3, $c_3$ | 47.700 |
| Soil Coefficient 4, $c_4$ | 1.42 |
| Soil Coefficient 5, $c_5$ | -0.61 |
| Soil Coefficient 6, $c_6$ | 0.00010 |
| Permissible Soil Shear Stress, $\tau_p$ ($lb/ft^2$) | 0.080 |
| Total Permissible Shear Stress, $\tau_p$ ($lb/ft^2$) | 0.080 |
| Cross Sectional Area, A ($ft^2$) | 3.000 |
| Wetted Perimeter, P (ft) | 6.36 |
| Hydraulic Radius, R (ft) | 0.472 |
| Top Width, T (ft) | 6.00 |
| Hydraulic Depth, D (ft) | 0.500 |
| Froude Number (Q design) | 0.505 |
| Channel Shear Stress, $\tau_o$ ($lb/ft^2$) | 0.59 |
| Actual Sheer Stress, $\tau_d$ ($lb/ft^2$) | 1.25 |
| Mannings n | 0.063 |
| Average Velocity, V (ft/s) | 2.02 |
| Calculated Flow, Q ($ft^3/s$) | 6.1 |
| Difference Between Design & Calc. Flow (%) | 0.5% |
| Effective Shear on Soil Surface, $\tau_e$ ($lb/ft^2$) | 0.008 |
| Total Permissible Shear on Veg., $\tau_{p\,veg}$ ($lb/ft^2$) | 12.42 |
| Stable (Y or N) | YES |

Source: Grass Lined Channel Design WisDOT Spreadsheet, FDM 13-30 Attachment 15.2

Downslope Flume & Energy Dissipater Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No: 1/3 | |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Downslope Pipe and Inlet Sizing | Chk'd: MJT | Date: 04/04/22 |

**Purpose:**

To size the downslope pipe and inlet to accommodate the 25-year, 24-hour storm event.

**References:**

1. HydroCAD Report_POO Landfill Closure

**Approach:**

Use the orifice equation to size the downslope pipe inlet. Size the inlet for the largest diversion berm flow rate and apply that inlet size to all downslope pipe inlets. Confirm the head (h) acting on the orifice will not overtop the diversion berm depth of 2.0 ft.

Use Manning's equation to size the downslope pipe based on the largest diversion berm flow rate.
Confirm the pipe has capacity for the design flow under open channel flow conditions.

**Assumptions:**

1. Orifice coefficient = 0.63
2. Assume the orifice head (h) acts on the centerline of the inlet pipe.
3. Manning's n = 0.012 (For smooth walled HDPE pipe: http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)
4. Size flumes under the vegetated cover condition.

**Calculations:**

Size the downslope pipe inlet:

From the HydroCAD report (Reference #1), the maximum 25-year, 24-hour flow along a diversion berm is 6.1 cfs
in HydroCAD model). Flume 3 Area 24

Orifice Equation: $Q = C * A * (2 * g * h)^{0.5}$

where: Q = flow rate (cfs) = 6.1 (From above)
C = orifice coefficient = 0.63 (See assumption #1)
A = orifice area (sf) = 1.77 (area of 18" diameter pipe) Actual Pipe Diameter = 18 inches
g = gravity ($ft/sec^2$)= 32.2
h = orifice head acting on centerline (ft)
$h = (Q/(C * A))^2/(2 * g)$ = 0.5 ft
Given Assumption #2, depth of flow along diversion berm = h + D/2/12 = 1.21 ft

**Results:**

Based on the inlet sizing calculation, an 18" diameter inlet will convey the stormwater runoff from the largest flow rate to a flume.

Based on the Manning's calculation for flow within the pipe, the 12" diameter downslope pipe will accommodate the design flow under open channel flow conditions. Although the flow for the downslope pipes can be handled by 12" dia. pipes, for ease of construction, all downslope pipes will be 18" dia.

**Calculations (Continued):**

The diversion swale depth of 2 ft is sufficient to prevent overtopping at the downslope pipe inlet locations. The depth of the diversion berm increases at the entrance of the down slope pipes due to mounding of the soil over the pipe.

Size the downslope flume pipe:

Use Manning's equation to size the downslope pipe.

Manning's Equation: $Q = (1.49/n) \times A \times R^{(2/3)} \times S^{(1/2)}$

where: Q = Flow Rate, cfs
n = Manning's Roughness Coefficient
A = Flow Area, sf
R = Hydraulic Radius, ft (= A/P)
S = Channel Slope, ft/ft

From the HydroCAD Report (Reference 1) , the peak discharge to each downslope flume resulting from a 25-year, 24-hour storm is as follows:

| **Flume 1** 3.58 cfs | | **Flume 2** 4.89 cfs | | **Flume 3** 6.05 cfs | | **Flume 4** 3.66 cfs | | **Flume 5** 4.89 cfs | |
|---|---|---|---|---|---|---|---|---|---|
| Area 5 | 3.58 | Area 3 | 2.17 | Area 1 | 4.58 | Area 12 | 0.35 | Area 10 | 3.17 |
| Area 6 | 2.92 | Area 4 | 3.74 | Area 2 | 3.73 | Area 13 | 2.91 | Area 11 | 3.10 |
| Area 20 | 3.43 | Area 22 | 3.35 | Area 24 | 6.05 | Area 14 | 3.66 | Area 16 | 4.89 |
| Area 21 | 3.35 | Area 23 | 4.89 | Area 25 | 5.13 | Area 15 | 1.71 | Area 17 | 4.00 |
| Total = | 13.28 | | 14.15 | | 19.49 | | 8.63 | | 15.16 |

| **Flume 6** 3.40 cfs | |
|---|---|
| Area 8 | 3.29 |
| Area 9 | 3.40 |
| Area 18 | 2.66 |
| Area 19 | 2.77 |
| Total = | 12.12 |

For flow rates < 20 cfs, assume a 12" diameter downslope flume:

Use 19.49 cfs to Flume 3 to check sizing (max flow to a flume that is < 20 cfs)

Design Criteria

Pipe Diameter (in) = D = 12

Pipe Slope (ft/ft) = S = 0.25

Manning's Roughness Coefficient = n = 0.012

See Downslope Flume 3 pipe flow calculator on Sheet 3

**Calculations (Continued):**

## Manning Formula Uniform Pipe Flow at Given Slope and Depth

**Inputs:**

| | | |
|---|---|---|
| Pipe Diameter, $d_o$ | 12.00 | in |
| Manning Roughness, n | 0.0120 | |
| Pressure slope (possibly equal to pipe slope), $S_o$ | 0.2500 | slope |
| Percent of (or ratio to) full depth (100% or 1 if flowing full) | 0.8290 | fraction |

**Results:**

| | | |
|---|---|---|
| Flow, Q | 19.4905 | ft^3/s |
| Velocity, v | 27.9991 | ft/s |
| Velocity head, hv | 12.1838 | ft |
| Flow Area, A | 0.6961 | ft^2 |
| Wetted Perimeter, P | 2.2890 | ft |
| Hydraulic Radius | 0.3041 | ft |
| Top Width, T | 0.7530 | ft |
| Froude Number, F | 5.21 | |
| Shear Stress (tractive force), τ | 12.9373 | psf |

**Calculations (Continued):**

## Manning Formula Uniform Pipe Flow at Given Slope and Depth

**Inputs:**

| | | |
|---|---|---|
| Pipe Diameter, $d_o$ | 18.00 | in |
| Manning Roughness, n | 0.0120 | |
| Pressure slope (possibly equal to pipe slope), $S_o$ | 0.2500 | slope |
| Percent of (or ratio to) full depth (100% or 1 if flowing full) | 0.4037 | fraction |

**Results:**

| | | |
|---|---|---|
| Flow, Q | 19.4983 | ft^3/s |
| Velocity, v | 29.1783 | ft/s |
| Velocity head, hv | 13.2317 | ft |
| Flow Area, A | 0.6682 | ft^2 |
| Wetted Perimeter, P | 2.0655 | ft |
| Hydraulic Radius | 0.3235 | ft |
| Top Width, T | 1.4719 | ft |
| Froude Number, F | 7.75 | |
| Shear Stress (tractive force), τ | 9.4502 | psf |

SCS ENGINEERS

| | | | |
|---|---|---|---|
| Sheet No. 1 of 7 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/23/22 |
| Client: WPL | Subject: Energy Dissipator Sizing | Chk'd: MJT | Date: 4/1/22 |

**Purpose:**

To size an energy dissipator structure and riprap apron at the outlet of the downslope flume pipes.

**References:**

1. "Hydraulic Design of Energy Dissipators for Culverts and Channels," HEC-14, Third Edition, July 2006, USDOT FHWA.
2. Downslope Pipe and Inlet Sizing calculation (for pipe size, flow rate, and pipe velocity).
3. HydroCAD Model_POO Landfill Closure
4. Facilities Development Manual Chapter 13, Section 13-30 - Rock Riprap Lined Chutes.

**Approach:**

Use the downslope pipe outlet velocity to size an energy dissipator structure (USBR Type VI Impact Basin) following the design approach outlined in Section 9.4 of Reference #1.

Use Rock Chute Data Spreadsheet, FDM 13-30-30 Attachment 30.1 (from Reference #5) to design the rock chute.

For construction purposes use the maximum flow to size all dissipators and riprap apron.

**Assumptions:**

1. Riprap specific gravity = 2.65
2. From the HydroCAD Report, the 25-year, 24-hour peak discharge to each downslope flume is as follows:

| **Flume 1** 3.58 cfs | | **Flume 2** 4.89 cfs | | **Flume 3** 6.05 cfs | | **Flume 4** 3.66 cfs | | **Flume 5** 4.89 cfs | |
|---|---|---|---|---|---|---|---|---|---|
| Area 5 | 3.58 | Area 3 | 2.17 | Area 1 | 4.58 | Area 12 | 0.35 | Area 10 | 3.17 |
| Area 6 | 2.92 | Area 4 | 3.74 | Area 2 | 3.73 | Area 13 | 2.91 | Area 11 | 3.10 |
| Area 20 | 3.43 | Area 22 | 3.35 | Area 24 | 6.05 | Area 14 | 3.66 | Area 16 | 4.89 |
| Area 21 | 3.35 | Area 23 | 4.89 | Area 25 | 5.13 | Area 15 | 1.71 | Area 17 | 4.00 |
| Total = | 13.28 | | 14.15 | | 19.49 | | 8.63 | | 15.16 |

| **Flume 6** 3.40 cfs | |
|---|---|
| Area 8 | 3.29 |
| Area 9 | 3.40 |
| Area 18 | 2.66 |
| Area 19 | 2.77 |
| Total = | 12.12 |

Using Figure 9.14 (See Sheet 4), enter the Froude Number and the Energy from Step 2 to determine the from the downslope flume pipe and inlet sizing calculation.

**Results:**

The energy dissipator structures for the 18" dia. downslope flume pipes will consist of dissipator structures with widths ($W_B$) of 6 feet, with the remaining dimensions from Table 9.2 on Sheets 5 and 6.

Riprap at the Flume 3, 4, 5 and 6 energy dissipator outlets will consist of WisDOT Light Riprap (D50= 5.5 inches) (See Page 3). The riprap apron footprint will be based on the energy dissipator width and the outlet swale geometry.

Riprap at Flume 1 and 2 energy dissipator outlets will consist of WisDOT Light Riprap (D50= 5.8 and 3.6 inches). The riprap apron footprint will be 6 feet wide (based on rock chute calcs for RC1 and RC2) and extend down to the existing swale (Swale S4).

**Calculations:**

For 18" dia. downslope flume pipes

From Reference #2:

Flow rate (Q) = 19.5 cfs

Pipe velocity (V) = 8.9 ft/s

Flow area (A) = Q/V = 2.19 sf

Design procedure from pg. 9-40 of Reference #1:

Step 1: Compute the Equivalent Depth of Flow Entering Dissipator:

$Y_e = (A/2)^{1/2}$ where: Ye = Equivalent depth

A = Area (from above)

$Y_e$ = 1.05 ft

Step 2: Compute the Froude Number and the energy at the end of the pipe:

$Fr = V/[(g*Y_e)^{1/2}]$ where: Fr = Froude Number

V = Velocity (from above)

g = Gravity constant (32.2 ft/sec$^2$)

Fr = 1.5 $Y_e$ = Equivalent depth (from Step 1 above)

$H_o = Y_e + V^2/2g$ where: $H_o$ = Energy at the end of the pipe

$Y_e$ = Equivalent depth (from above)

V = Velocity (from above)

Ho = 2.3 ft g = Gravity constant (32.2 ft/sec$^2$)

Step 3: Determine $H_o/W_B$ and calculate the required width of the energy dissipator:

Using Figure 9.14 (See Sheet 4), enter the Froude Number and the Energy from Step 2 to determine the width of the energy dissipator.

From Figure 9.14, $H_o/W_B$ = 0.40

$W_B = H_o/(H_o/W_B)$ $W_B$ = 5.7 ft.

Use $W_B$ = 6.0 ft.

Step 4: Obtain the remaining energy dissipator dimensions from Table 9.2 from Reference #1 (see Sheets 5 and 6)

Step 5: Size the riprap at the structure outlet

From Reference #5, use Rock Chute Design spreadsheet (see Sheet 3)

# Rock Chute Design Data

(Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Revised for WisDOT 9/2010

**Project:** COL - POO Landfill Closure
**Designer:** RJG
**Date:** February 23, 2022

**County:** Columbia
**Checked by:** MJT
**Date:** 04/05/22

## Input Geometry:

| Upstream Channel | | Chute | | | Downstream Channel | |
|---|---|---|---|---|---|---|
| Bottom Width = | 6.0 ft. | Bottom Width = | 6.0 ft. | | Bottom Width = | 6.0 ft. |
| Side slopes = | 1.0 (m:1) | Factor of safety = | 1.20 (SF) | 1.2 Min | Side slopes = | 2.0 (m:1) |
| Mannings n value = | 0.012 | Side slopes = | 2.0 (z:1) | 2.0:1 max. | Mannings n value = | 0.030 |
| Bed slope = | 0.0001 ft./ft. | Bed slope = | 0.2500 ft./ft | 3.0:1 max. | Bed slope = | 0.0050 ft./ft. |
| Note: Use procedures 13-30-15 or 13-30-25 for upstream and downstream Mannings n | | Freeboard = | 1.0 ft. | | | |
| | | Outlet apron depth, d = | 1.0 ft. | | Base flow = | 0.0 cfs |

## Flow and Elevation Data:

Apron elev. --- Inlet = 818.0 ft. ------ Outlet 816.0 ft. --- ($H_{drop}$ = 1 ft.)

Degree of angularity = 1

$Q_{high}$ = Runoff from design storm
$Q_5$ = Runoff from a 5-year,24-hour storm

1 --> 50% angular, 50% rounded
2 --> 100 % rounded

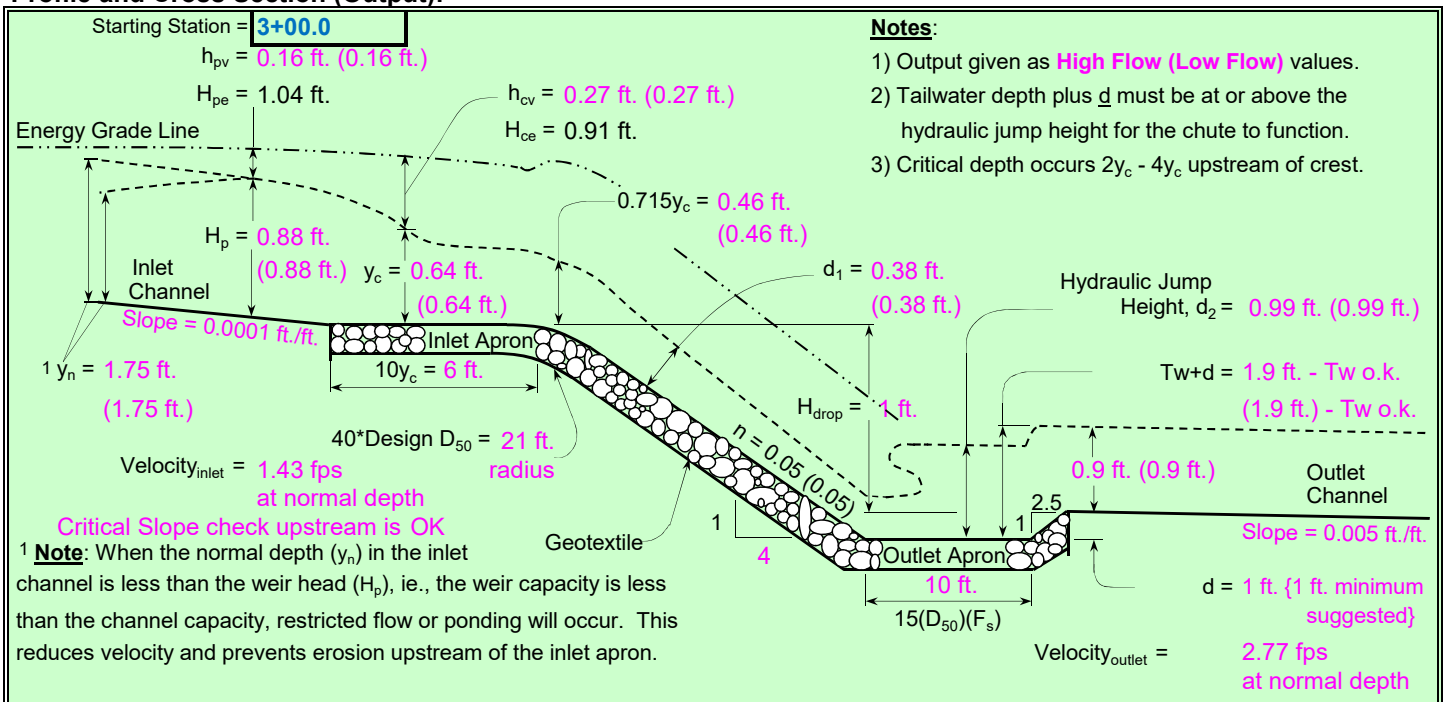
$Q_{high}$ = 19.5 cfs — High flow storm through chute → Tw (ft.) = **Program**

$Q_{low}$ = 19.5 cfs — Low flow storm through chute → Tw (ft.) = **Program**

**Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.

**Input tailwater (Tw)**: 0.25 1.20

## Profile and Cross Section (Output):

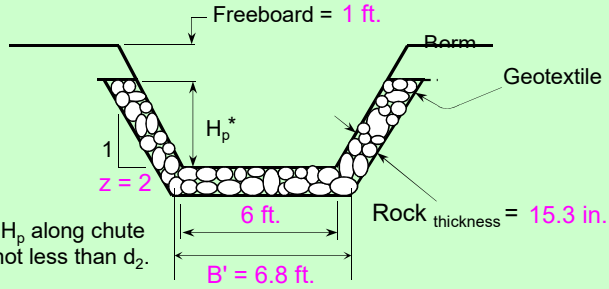



**Notes**:
1) Output given as **High Flow (Low Flow)** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.

[1] **Note**: When the normal depth ($y_n$) in the inlet channel is less than the weir head ($H_p$), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

## Profile Along Centerline of Chute

### Typical Cross Section




* Use $H_p$ along chute but not less than $d_2$.

| | | |
|---|---|---|
| | 2.9 cfs/ft. | Equivalent unit discharge |
| SF = | 1.20 | Factor of safety (multiplier) |
| $d_1$ = | 0.38 ft. | Normal depth in chute |
| n-value = | 0.05 | Manning's roughness coefficient |
| $D_{50}$(SF) = | 7.6 in. | Minimum Design $D_{50}$* |
| $2(D_{50})(SF)$ = | 15.3 in. | Rock chute thickness |
| Tw + d = | 1.9 ft. | Tailwater above outlet apron |
| $d_2$ = | 0.99 ft. | Hydraulic jump height |
| *** The outlet | will | function adequately |

### High Flow Storm Information

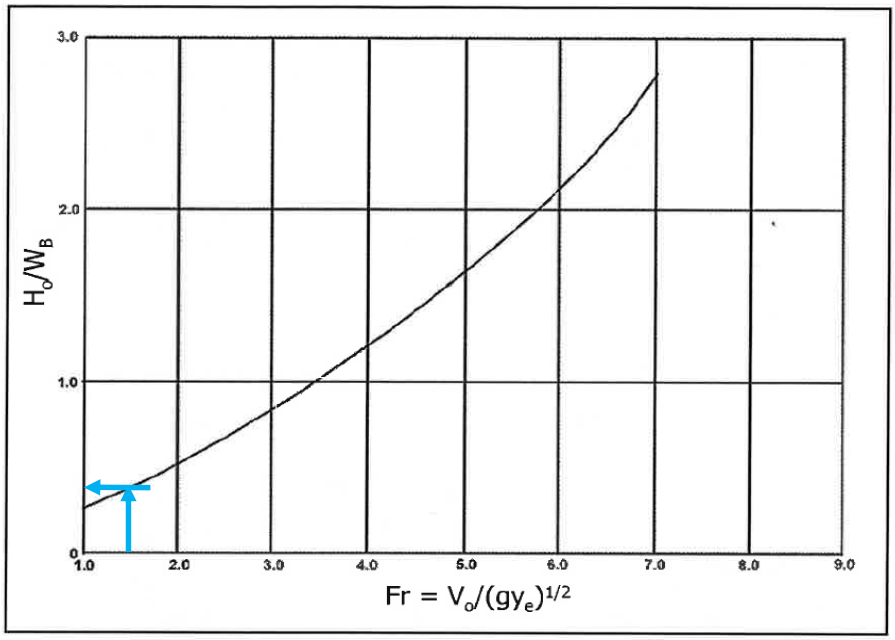



**Figure 9.14. Design Curve for USBR Type VI Impact Basin**

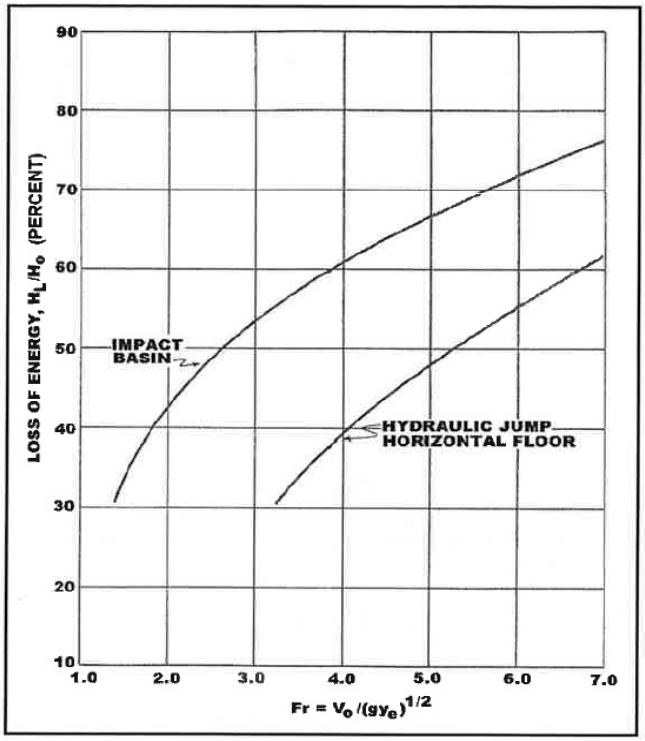



**Figure 9.15. Energy Loss of USBR Type VI Impact Basin versus Hydraulic Jump**

**Table 9.2 (CU). USBR Type VI Impact Basin Dimensions (ft) (AASHTO, 2005)**

| $W_B$ | $h_1$ | $h_2$ | $h_3$ | $h_4$ | L | $L_1$ | $L_2$ |
|---|---|---|---|---|---|---|---|
| 4. | 3.08 | 1.50 | 0.67 | 1.67 | 5.42 | 2.33 | 3.08 |
| 5. | 3.83 | 1.92 | 0.83 | 2.08 | 6.67 | 2.92 | 3.83 |
| 6. | 4.58 | 2.25 | 1.00 | 2.50 | 8.00 | 3.42 | 4.58 |
| 7. | 5.42 | 2.58 | 1.17 | 2.92 | 9.42 | 4.00 | 5.42 |
| 8. | 6.17 | 3.00 | 1.33 | 3.33 | 10.67 | 4.58 | 6.17 |
| 9. | 6.92 | 3.42 | 1.50 | 3.75 | 12.00 | 5.17 | 6.92 |
| 10. | 7.58 | 3.75 | 1.67 | 4.17 | 13.42 | 5.75 | 7.67 |
| 11. | 8.42 | 4.17 | 1.83 | 4.58 | 14.58 | 6.33 | 8.42 |
| 12. | 9.17 | 4.50 | 2.00 | 5.00 | 16.00 | 6.83 | 9.17 |
| 13. | 10.17 | 4.92 | 2.17 | 5.42 | 17.33 | 7.42 | 10.00 |
| 14. | 10.75 | 5.25 | 2.33 | 5.83 | 18.67 | 8.00 | 10.75 |
| 15. | 11.50 | 5.58 | 2.50 | 6.25 | 20.00 | 8.50 | 11.50 |
| 16. | 12.25 | 6.00 | 2.67 | 6.67 | 21.33 | 9.08 | 12.25 |
| 17. | 13.00 | 6.33 | 2.83 | 7.08 | 21.50 | 9.67 | 13.00 |
| 18. | 13.75 | 6.67 | 3.00 | 7.50 | 23.92 | 10.25 | 13.75 |
| 19. | 14.58 | 7.08 | 3.17 | 7.92 | 25.33 | 10.83 | 14.58 |
| 20. | 15.33 | 7.50 | 3.33 | 8.33 | 26.58 | 11.42 | 15.33 |

| $W_B$ | $W_1$ | $W_2$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ |
|---|---|---|---|---|---|---|---|
| 4. | 0.33 | 1.08 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 5. | 0.42 | 1.42 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 6. | 0.50 | 1.67 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 7. | 0.50 | 1.92 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 |
| 8. | 0.58 | 2.17 | 0.50 | 0.58 | 0.58 | 0.50 | 0.25 |
| 9. | 0.67 | 2.50 | 0.58 | 0.58 | 0.67 | 0.58 | 0.25 |
| 10. | 0.75 | 2.75 | 0.67 | 0.67 | 0.75 | 0.67 | 0.25 |
| 11. | 0.83 | 3.00 | 0.67 | 0.75 | 0.75 | 0.67 | 0.33 |
| 12. | 0.92 | 3.00 | 0.67 | 0.83 | 0.83 | 0.75 | 0.33 |
| 13. | 1.00 | 3.00 | 0.67 | 0.92 | 0.83 | 0.83 | 0.33 |
| 14. | 1.08 | 3.00 | 0.67 | 1.00 | 0.92 | 0.92 | 0.42 |
| 15. | 1.17 | 3.00 | 0.67 | 1.00 | 1.00 | 1.00 | 0.42 |
| 16. | 1.25 | 3.00 | 0.75 | 1.00 | 1.00 | 1.00 | 0.50 |
| 17. | 1.33 | 3.00 | 0.75 | 1.08 | 1.00 | 1.00 | 0.50 |
| 18. | 1.33 | 3.00 | 0.75 | 1.08 | 1.08 | 1.08 | 0.58 |
| 19. | 1.42 | 3.00 | 0.83 | 1.17 | 1.08 | 1.08 | 0.58 |
| 20. | 1.50 | 3.00 | 0.83 | 1.17 | 1.17 | 1.17 | 0.67 |

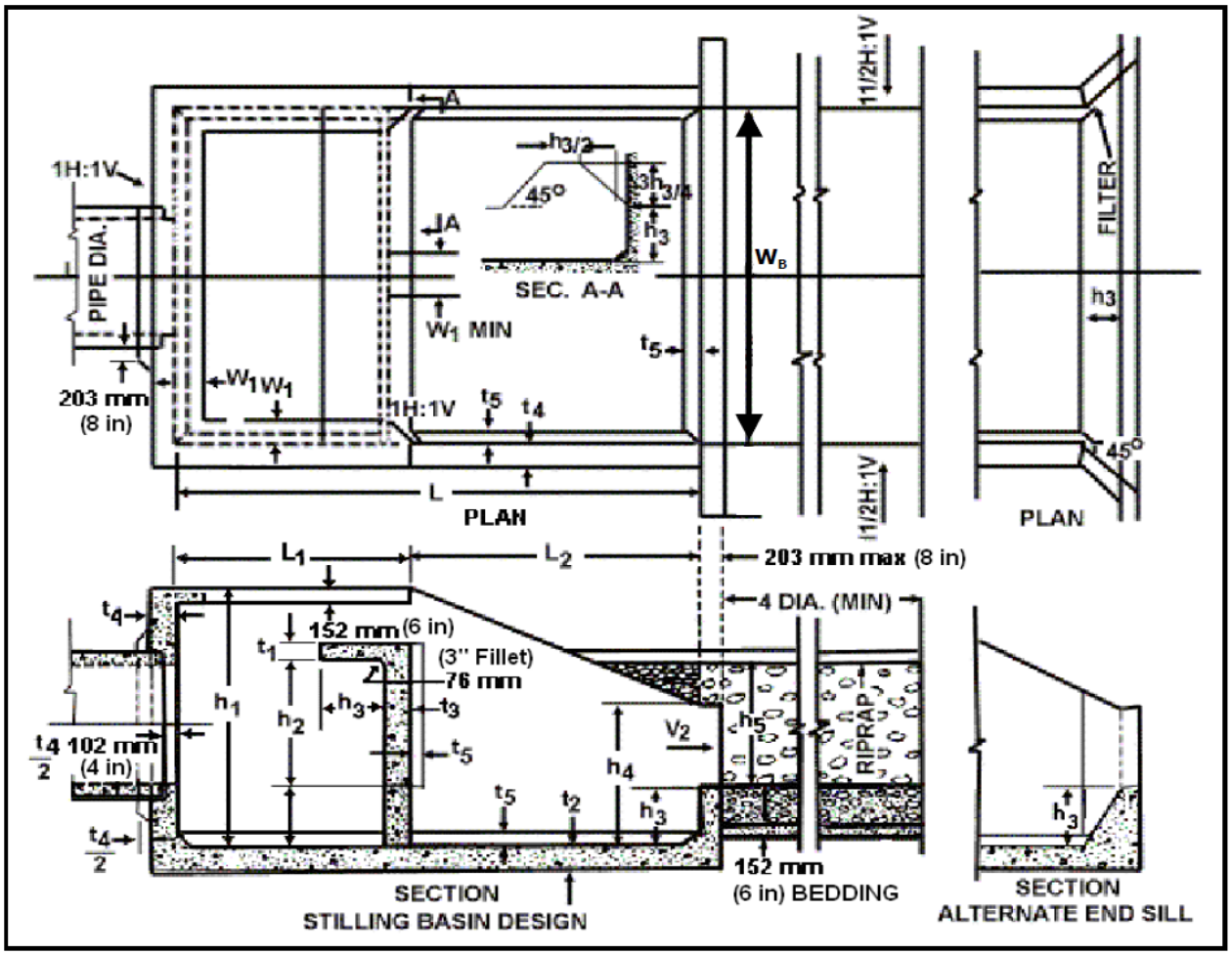



**Figure 9.13. USBR Type VI Impact Basin**

**Calculations (Continued):**

## Downslope Flume 3 - Velocity Calculator (Q = 19.49 cfs)

## Manning Formula Uniform Pipe Flow at Given Slope and Depth

**Inputs:**

| | | |
|---|---|---|
| Pipe Diameter, $d_o$ | 18 | in |
| Manning Roughness, n | 0.0120 | |
| Pressure slope | 0.2500 | slope |
| Percent of (or ratio to) full depth (100% or 1 if flowing full) | 0.4037 | fraction |

**Results:**

| | | |
|---|---|---|
| Flow, Q | 19.4983 | ft^3/s |
| Velocity, v | 8.8936 | m/s |
| Velocity head, hv | 4.0330 | m |
| Flow Area, A | 0.0621 | m^2 |
| Wetted Perimeter, P | 0.6296 | m |
| Hydraulic Radius | 0.0986 | m |
| Top Width, T | 0.4486 | m |
| Froude Number, F | 7.75 | |
| Shear Stress (tractive force), τ | 452.4774 | N/m^2 |

Version 2.0 (20 June 2017)

HawsEDC Calculators

Rock Chute

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| | | | |
|---|---|---|---|
| Sheet No: 1 of 4 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 25220183.00 | Job: COL - POO | By: RJG | Date: 4/11/22 |
| Client: WPL | Subject: Rock Chute Sizing & Riprap Size | Chk'd: MJT | Date: 4/13/22 |

**Purpose:**

To size the rock chutes to accommodate the 25-year, 24-hour storm event.

**References:**

1. Rock Chute Design Data spreadsheet Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998.
2. HydroCAD Report_Post Construction
3. Figure 1 - Storm Water Post Construction
4. Stable 25.1 Typical Particle Sizes of Native Sands at 75 Percent Passing (D75) from WisDOT Facilities. Development Manual (FDM).

**Approach:**

1. Enter Inlet Channel data based on culvert apron or swale geometry Reference #2 and #3.
2. Enter Chute data based on slope from Reference #3, start the width, Bw equal to inlet channel Bw.
3. Enter Outlet Channel data based on Reference #3, start the width, Bw equal to inlet channel Bw.
4. Enter drainage area, apron elevations, flow (Q), and rainfall.
5. Adjust Bw for Chute and Outlet Channel until spreadsheet shows the rock chute "will" function adequately.
6. Determine rip rap classification based on D50 weight per Reference #4.

**Assumptions:**

1. Assume side slopes of chute and outlet channel are 2:1.
2. Assume Factor of Safey is 1.2.
3. n-value is based on proposed conditions at the channel.
4. Assume Outlet apron depth, d is 1.0 ft.
5. Freeboard is 1.0 ft.
6. Use 25-year, 24-hour storm event flow (Reference #2) for $Q_{high}$ and $Q_{low}$.
7. Classification of riprap is based on weight (Reference #4).

**Calculations:**

See attached spreadsheet calcs for each rock chute.

**Results:**

The rock chutes are adequately designed to accommodate the flows from the 25-year, 24-hour storm event.

| Rock Chute | Width (ft) | Thickness (in) | Apron Width (ft) | Apron Length (ft) | $D_{50}$ (in) | WisDOT Rip Rap Classification |
|---|---|---|---|---|---|---|
| RC1 | 6 | 12 | 6 | 7 | 5.8 | Light Riprap Type R |
| RC2 | 6 | 8 | 6 | 5 | 3.6 | Light Riprap Type R |

# Rock Chute Design Data

(Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Revised for WisDOT 9/2010

**Project:** COL - POO Landfill Closure RC1 **County:** Columbia
**Designer:** RJG **Checked by:** MJT
**Date:** April 11, 2022 **Date:** 04/13/22

## Input Geometry:

| Upstream Channel | | Chute | | | Downstream Channel | |
|---|---|---|---|---|---|---|
| Bottom Width = | 6.0 ft. | Bottom Width = | 6.0 ft. | | Bottom Width = | 6.0 ft. |
| Side slopes = | 1.0 (m:1) | Factor of safety = | 1.20 (SF) | 1.2 Min | Side slopes = | 2.0 (m:1) |
| Mannings n value = | 0.012 | Side slopes = | 2.0 (z:1) | 2.0:1 max. | Mannings n value = | 0.030 |
| Bed slope = | 0.0001 ft./ft. | Bed slope = | 0.1967 ft./ft | 3.0:1 max. | Bed slope = | 0.0050 ft./ft. |
| Note: Use procedures 13-30-15 or 13-30-25 for upstream and downstream Mannings n | | Freeboard = | 1.0 ft. | | | |
| | | Outlet apron depth, d = | 1.0 ft. | | Base flow = | 0.0 cfs |

## Flow and Elevation Data:

Apron elev. --- Inlet = 822.8 ft. ---- Outlet 802.4 ft. --- ($H_{drop}$ = 19.4 ft.)

Degree of angularity = 1

$Q_{high}$ = Runoff from design storm
$Q_5$ = Runoff from a 5-year,24-hour storm

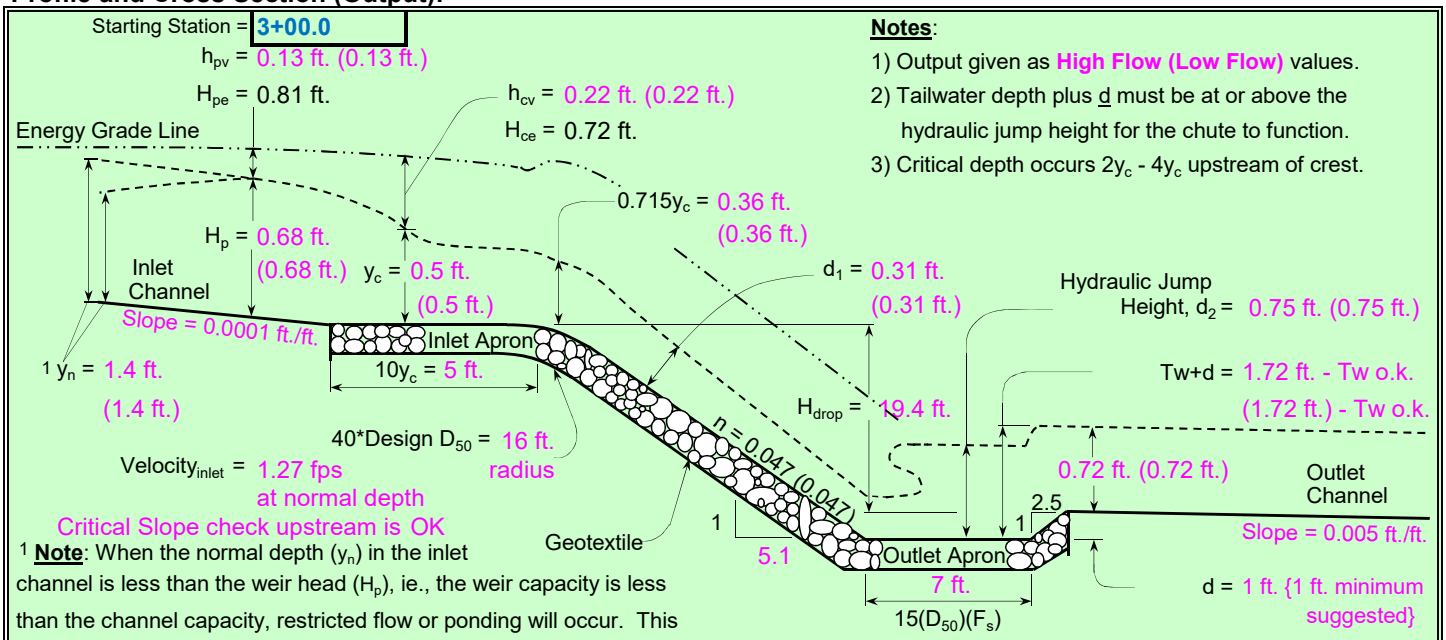
1 --> 50% angular, 50% rounded
2 --> 100 % rounded

$Q_{high}$ = 13.2 cfs High flow storm through chute → Tw (ft.) = Program
$Q_{low}$ = 13.2 cfs Low flow storm through chute → Tw (ft.) = Program

**Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.

**Input tailwater (Tw)**: 0.20 1.20

## Profile and Cross Section (Output):

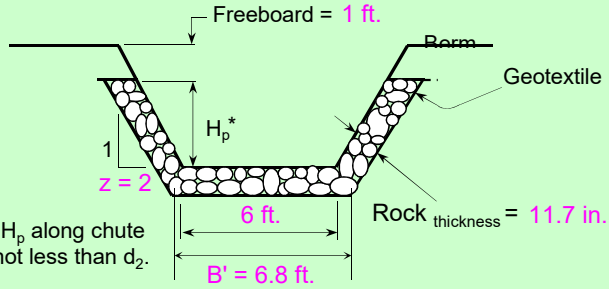



**Notes**:
1) Output given as **High Flow (Low Flow)** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.

[1] **Note**: When the normal depth ($y_n$) in the inlet channel is less than the weir head ($H_p$), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

## Profile Along Centerline of Chute

### Typical Cross Section




* Use $H_p$ along chute but not less than $d_2$.

| | | |
|---|---|---|
| | 2.01 cfs/ft. | Equivalent unit discharge |
| SF = | 1.20 | Factor of safety (multiplier) |
| $d_1$ = | 0.31 ft. | Normal depth in chute |
| n-value = | 0.047 | Manning's roughness coefficient |
| $D_{50}$(SF) = | 5.8 in. | Minimum Design $D_{50}$* |
| 2($D_{50}$)(SF) = | 11.7 in. | Rock chute thickness |
| Tw + d = | 1.72 ft. | Tailwater above outlet apron |
| $d_2$ = | 0.75 ft. | Hydraulic jump height |
| *** The outlet | will | function adequately |

### High Flow Storm Information

# Rock Chute Design Data

(Version WI-April-2005, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Revised for WisDOT 9/2010

**Project:** COL - POO Landfill Closure RC2 **County:** Columbia
**Designer:** RJG **Checked by:** MJT
**Date:** April 11, 2022 **Date:** 04/13/22

## Input Geometry:

| Upstream Channel | | Chute | | | Downstream Channel | |
|---|---|---|---|---|---|---|
| Bottom Width = | 6.0 ft. | Bottom Width = | 6.0 ft. | | Bottom Width = | 6.0 ft. |
| Side slopes = | 1.0 (m:1) | Factor of safety = | 1.20 (SF) | 1.2 Min | Side slopes = | 2.0 (m:1) |
| Mannings n value = | 0.012 | Side slopes = | 2.0 (z:1) | 2.0:1 max. | Mannings n value = | 0.030 |
| Bed slope = | 0.0001 ft./ft. | Bed slope = | 0.0690 ft./ft | 3.0:1 max. | Bed slope = | 0.0050 ft./ft. |
| Note: Use procedures 13-30-15 or 13-30-25 for upstream and downstream Mannings n | | Freeboard = | 1.0 ft. | | | |
| | | Outlet apron depth, d = | 1.0 ft. | | Base flow = | 0.0 cfs |

## Flow and Elevation Data:

Apron elev. --- Inlet = 815.8 ft. ------ Outlet 808.4 ft. --- ($H_{drop}$ = 6.4 ft.)

Degree of angularity = 1

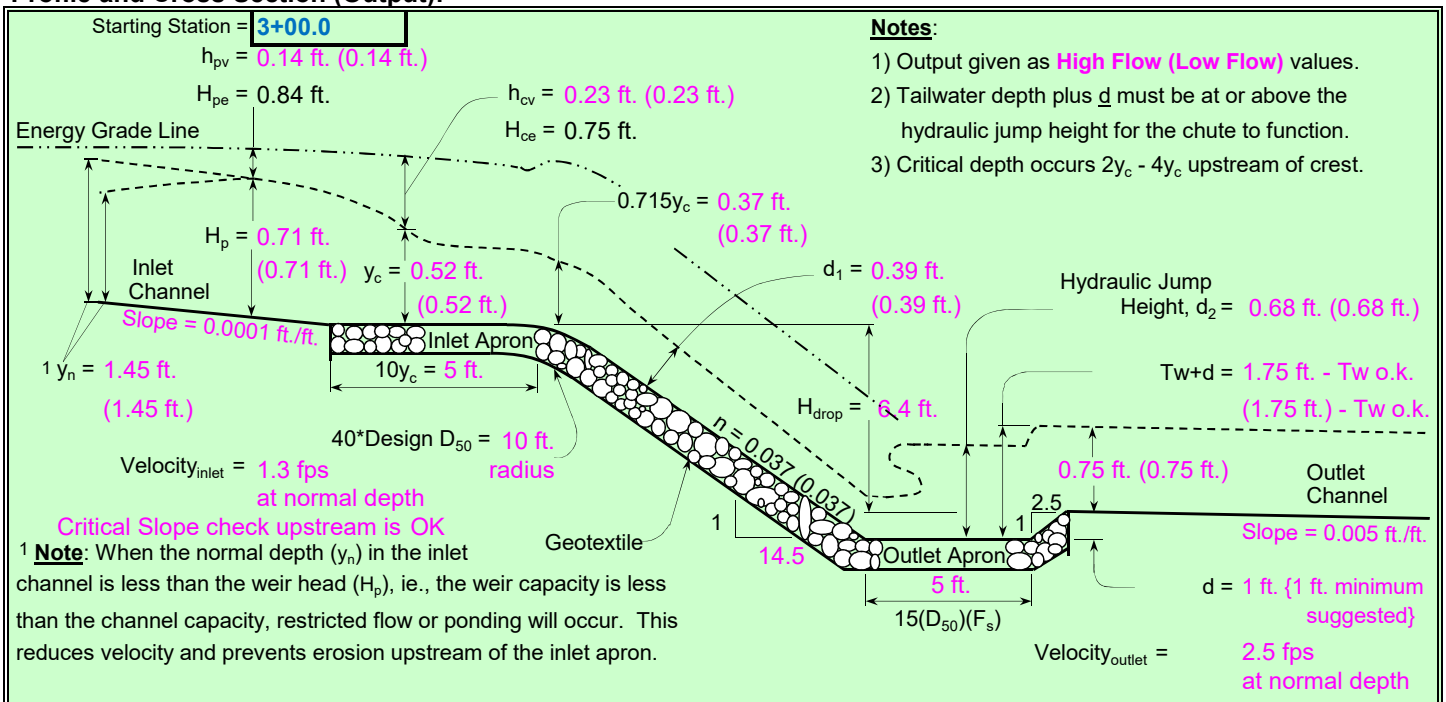
$Q_{high}$ = Runoff from design storm
$Q_5$ = Runoff from a 5-year,24-hour storm
1 --> 50% angular, 50% rounded
2 --> 100 % rounded

$Q_{high}$ = 14.0 cfs High flow storm through chute → Tw (ft.) = Program
$Q_{low}$ = 14.0 cfs Low flow storm through chute → Tw (ft.) = Program

**Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.

**Input tailwater (Tw)**: 0.07 1.20

## Profile and Cross Section (Output):

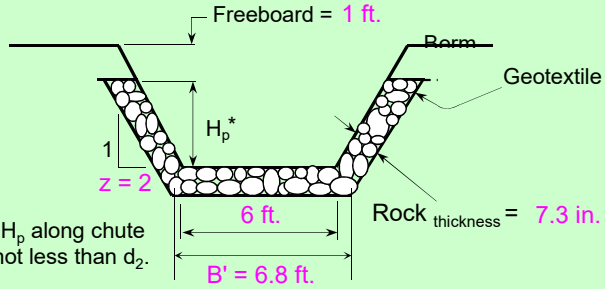



**Notes**:
1) Output given as **High Flow (Low Flow)** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.

[1] **Note**: When the normal depth ($y_n$) in the inlet channel is less than the weir head ($H_p$), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

## Profile Along Centerline of Chute

### Typical Cross Section




* Use $H_p$ along chute but not less than $d_2$.

| | | |
|---|---|---|
| | 2.14 cfs/ft. | Equivalent unit discharge |
| SF = | 1.20 | Factor of safety (multiplier) |
| $d_1$ = | 0.39 ft. | Normal depth in chute |
| n-value = | 0.037 | Manning's roughness coefficient |
| $D_{50}$(SF) = | 3.6 in. | Minimum Design $D_{50}$* |
| 2($D_{50}$)(SF) = | 7.3 in. | Rock chute thickness |
| Tw + d = | 1.75 ft. | Tailwater above outlet apron |
| $d_2$ = | 0.68 ft. | Hydraulic jump height |
| *** The outlet | will | function adequately |

### High Flow Storm Information

# Discharge Apron Sizing

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 2 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Energy Center POO Landfill Closure | By: RJG | Date: 2/21/22 |
| Client: WPL | Subject: Riprap Sizing at Culvert Outlet | Chk'd: MJT | Date: 4/5/22 |

**Purpose:**

To size the riprap apron dimensions at culvert C2, C3, C4, and C5 based on a 25-year, 24 hour storm event:

**References:**

1. "Energy Dissipators," Wisconsin Department of Transportation (WisDOT), Facilities Development Manual (FDM) 13-35-5.
2. Post Construction Condition HydroCAD Model.
3. "Rock Riprap Lined Channels," WisDOT FDM 13-30-25.
4. Culvert Sizing Calculation.
5. WisDOT FDM Chapter 13, Section 30 - Rock Riprap Lined Chutes

**Approach:**

Use the equations in Section 5.2 - Riprap Blanket of WisDOT FDM 13-35-5 (Energy Dissipators) to determine the average size of stone ($d_{50}$) and riprap apron length. Round up the calculated $d_{50}$ to the nearest WisDOT standard riprap size.

Use WisDOT FDM 13-35 Attachment 5.2 to determine the width of the riprap apron for discharges to a flat area. For discharges to channels, extend riprap across the channel bottom and up the sides.

**Assumptions:**

Assume riprap apron thickness (T) is 2 * $d_{50}$ to protect against washout and undercutting of the riprap.

Assume tailwater depth, TW = 0.40 * $D_o$

Assume max TW conditions for the riprap apron width.

Assume that when there are multiple culverts, the total discharge to the culverts is distributed evenly through each barrel.

**Calculation:**

From WisDOT Section 5.2 - Riprap Blanket:

$$d_{50}/D_o = 0.020\ (D_o/TW)\ (Q/D_o^{5/2})^{4/3}$$

$$L_{sp}/D_o = 1.7\ (Q/D_o^{5/2}) + 8$$

Or:

$$d_{50} = 0.02 \times (D_o/TW) \times (Q/D_o^{5/2})^{4/3} \times D_o$$

$$L_{sp} = (1.7\ (Q/D_o^{5/2}) + 8) \times D_o$$

where: $D_o$ = Diameter or width of culvert (ft)

Q = Flow rate (cfs) (discharge rate through culvert, from Worst Case Condition HydroCAD Model (Reference #2))

TW = Tail water depth (ft)

$d_{50}$ = Average size of stone (ft)

$L_{sp}$ = Length of stone protection (Apron Length) (ft)

| Location | Total Flow (Q, cfs) | Number of Pipes | $D_o$ (ft) | Q (cfs) | TW (ft) | $d_{50\ calculated}$ | $d_{50\ Design}$ | $L_{sp}$ |
|---|---|---|---|---|---|---|---|---|
| Culvert C2 | 9.68 | 2 | 1.5 | 4.8 | 0.60 | 0.16 | 0.83 | 16 |
| Culvert C3 | 27.38 | 2 | 2.5 | 13.7 | 1.00 | 0.19 | 0.83 | 26 |
| Culvert C4 | 35.39 | 2 | 2.5 | 17.7 | 1.00 | 0.27 | 0.83 | 28 |
| Culvert C5 | 35.21 | 2 | 2.5 | 17.6 | 1.00 | 0.27 | 0.83 | 28 |

**Results:**

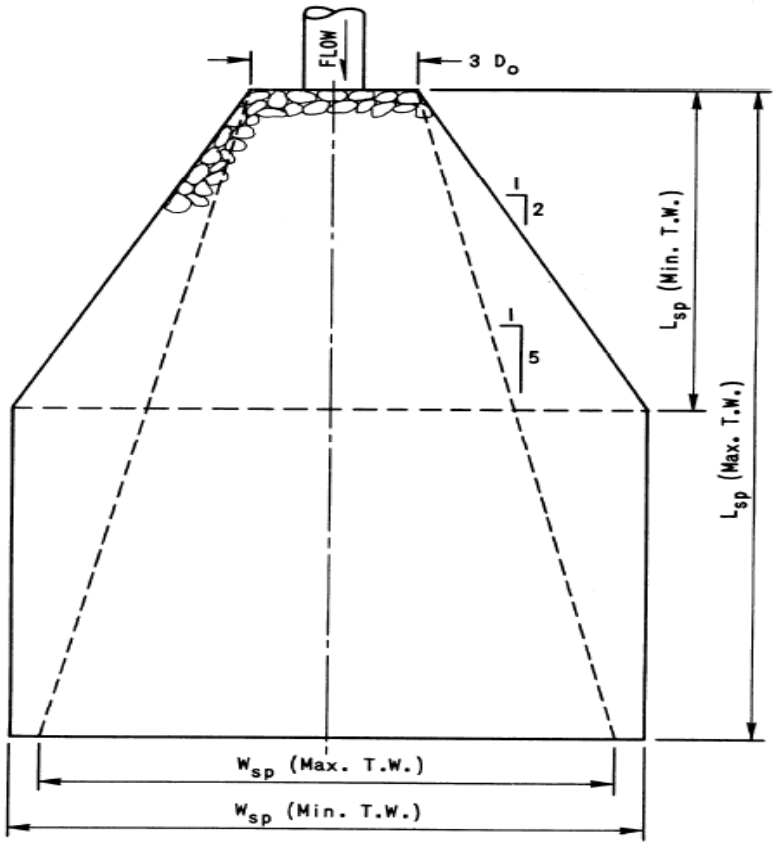
Below is a summary of the $d_{50}$ , thickness (T), and configuration of the riprap apron. Also refer to WisDOT FDM Attachment 5.2 (Sheet 2) for details on apron layout. Use WisDOT Light Riprap at culvert discharge.

| Location | $d_{50}$ (in)* | T (in) | $L_{sp}$ (ft) | $W_{sp}$ (ft) |
|---|---|---|---|---|
| Culvert C2 | 10.0 | 20 | 16 | See Note 1 |
| Culvert C3 | 10.0 | 20 | 26 | See Note 1 |
| Culvert C4 | 10.0 | 20 | 28 | See Note 1 |
| Culvert C5 | 10.0 | 20 | 28 | See Note 1 |

1. For discharges to channels, place riprap along channel bottom and up side of channel.

*Per Table 25.1 on Sheet 2 for standard WisDOT riprap sizes use Light Riprap.

*FDM 13-35 Attachment 5.2 Recommended Configuration of Riprap Blanket Subject to Maximum and Minimum Tail Waters*




RECOMMENDED CONFIGURATION OF RIPRAP BLANKET SUBJECT TO MAXIMUM AND MINIMUM TAILWATERS

Source: Miscellaneous paper H-72-5, "Practical Guidance for Estimating and Controlling Erosion at Culvert Outlets", U.S. Army Engineer Waterways Experiment Station, May, 1972.

***Table 25.1 Typical Particle Sizes of Native Sands at 75 Percent Passing ($D_{75}$)***

| Riprap Type | D50 (inches) | D50 (feet) | Riprap Thickness (in) | Geotextile Type |
|---|---|---|---|---|
| Select Crushed Material | 2.2 | 0.18 | 5 | Type R |
| Light Riprap | 10 | 0.83 | 12 | Type R |
| Medium Riprap | 12.5 | 1.04 | 18 | Type HR |
| Heavy Riprap | 16 | 1.33 | 24 | Type HR |
| Extra-Heavy Riprap | 20 | 1.67 | 30 | Type HR |

Source: Table 25.1 from WisDOT FDM.

# Appendix C3

# Written Closure Plan

# Closure Plan

## Columbia Dry Ash Disposal Facility
Phase 1 Module 1
Phase 1 Module 2
Phase 1 Module 3
Phase 1 Module 4
Phase 1 Module 5
Phase 1 Module 6
Phase 2 Module 10
Phase 2 Module 11

Prepared for:

Wisconsin Power and Light Company
Columbia Energy Center
W8375 Murray Road
Pardeeville, Wisconsin 53954

SCS ENGINEERS

25222260.00 | February 1, 2023

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Madison, WI 53718-6751
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A2 Alternative Final Cover Stability Calculations
Appendix B Schedule

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# PE CERTIFICATION

I, Phillip Gearing, hereby certify that I am a licensed professional engineer in the State of Wisconsin in accordance with the requirements of ch. A–E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A–E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code.

Specifically,

- This Closure Plan was prepared by me or under my direct supervision and meets the requirements of 40 CFR 257.102(b) and NR 514.07(10)(c)

| | |
|---|---|
| (signature) | February 1, 2023 (date) |
| Phillip E. Gearing (printed or typed name) | |

License number ____E-45115_____

My license renewal date is ___July 31, 2024_____.

Pages or sheets covered by this seal:

ALL

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# 1.0 INTRODUCTION AND PROJECT SUMMARY

On behalf of Wisconsin Power and Light Company (WPL), SCS Engineers (SCS) has prepared this Closure Plan for the Columbia (COL) Dry Ash Disposal Facility Phase 1, Modules 1 through 6 and Phase 2, Modules 10 and 11 as required by 40 Code of Federal Regulations (CFR) 257.102(b) and Wisconsin Administrative Code NR 514.07(10)(c), as stated below.

40 CFR 257.102(b) *"Written closure plan – (1) Content of the plan. The owner or operator of a CCR unit must prepare a written closure plan that describes the steps necessary to close the CCR unit at any point during the active life of the CCR unit consistent with recognized and generally accepted good engineering practices. The written closure plan must include, at a minimum, the information specified in paragraphs (b)(1)(i) through (vi) of this section."*

NR 517.07(10)(c) *"A written closure plan in accordance with the requirements under s. NR 514.06 (10) and all of the following: (1) A narrative description of how the CCR landfill will be closed, including a description of the steps necessary to close the CCR unit at any point during the active life of the CCR unit, consistent with recognized and generally accepted good engineering practices."*

The COL facility includes an active coal combustion residual (CCR) landfill, which currently consists of the following modules, located in Phase 1 and Phase 2 of the facility.

- **Phase 1, Module 1** – This module has received final cover over outer sideslope areas that will no longer receive additional CCR; intermediate cover has been placed over remaining areas. The final cover placed complies with the CCR Rule.

- **Phase 1, Module 2** – This module has received intermediate cover over a majority of the in-place CCR.

- **Phase 1, Module 3** – This module has received intermediate cover over a majority of the in-place CCR.

- **Phase 1, Module 4** – This module is currently being filled and also has received intermediate cover over areas of the in-place CCR.

- **Phase 1, Module 5** – This module is currently being filled and has received intermediate cover over areas of the in-place CCR.

- **Phase 1, Module 6** – This module is currently being filled and has received intermediate cover over areas of the in-place CCR.

- **Phase 2, Module 10** – Construction of the Module 10 liner began in 2022. The new module will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for WDNR review early in 2023. Filling is anticipated to begin in 2023.

- **Phase 2, Module 11** – Construction of the Module 11 liner began in 2022. The new module will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for WDNR review early in 2023. Filling is anticipated to begin in 2023.

Phase 1, Modules 1-3 were previously described as separate existing CCR landfills although they are contiguous and are managed as a single landfill by the facility and by the WDNR. WPL has clarified in the operating record for the Columbia facility that Modules 1-3 are one existing CCR landfill as defined in 40 CFR 257.53 of the federal CCR Rule. Phase 1, Modules 4-6 are considered to be a new CCR landfill that initiated construction after October 19, 2015, and is therefore managed as a separate CCR unit under the CCR Rule even though they are contiguous to the existing CCR landfill (Modules 1-3). In addition, the new CCR landfill will include Phase 2, Modules 10 and 11, once the liner construction documentation is approved by the WDNR in 2023. Construction of additional modules is not currently planned prior to retirement of the Columbia Energy Center, which is currently scheduled to occur no later than June 1, 2026.

**Figure 1** shows the site location. **Figure 2** shows the closure areas. A detail of the final cover system is shown on **Figure 3**.

# 2.0 PROPOSED CLOSURE PLAN NARRATIVE

40 CFR 257.102(b)(1)(i) *"A narrative description of how the CCR unit will be closed in accordance with this section."*

NR 517.07(10)(c)(1) *"A narrative description of how the CCR landfill will be closed, including a description of the steps necessary to close the CCR unit at any point during the active life of the CCR unit, consistent with recognized and generally accepted good engineering practices."*

When CCR placement is completed in the CCR unit, or if early closure is required, the unit will be closed by covering the CCR with the final cover system described in **Section 3.0**. Prior to final cover system construction, the CCR surfaces will be graded and compacted to establish a firm subgrade for final cover construction. In addition, all required notifications will be submitted to the Wisconsin Department of Natural Resources (WDNR, or "Department"), and WPL will obtain all additional necessary permits (for example, general permit coverage for construction storm water management). WPL may also engage in procurement activities to secure services for installing the final cover system.

The timing for completion of CCR placement in the units that are addressed with this closure plan will depend on CCR generation and disposal rates. Future CCR unit development will also impact the timing of closure. Each of the existing CCR units is designed to receive additional CCR once adjacent units are constructed and overlay airspace is available for filling. Based on the current CCR units alone, if early closure of all units is required, final cover will be placed in the active landfill areas shown on **Figure 2**. A closure schedule is discussed in **Section 6.0** and presented in **Appendix B**.

The initiation of closure activities will commence no later than 30 days after the known final receipt of CCR as required by 40 CFR 257.102(e)(1) and NR 506.083(2)(a), or in accordance with 40 CFR 257.102(e)(2) and NR 506.083(2)(b).

# 3.0 FINAL COVER SYSTEM AND PERFORMANCE

40 CFR 257.102(b)(1)(iii) *"If closure of the CCR unit will be accomplished by leaving CCR in place, a description of the final cover system, designed in accordance with paragraph (d) of this section, and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover system will achieve the performance standards specified in paragraph (d) of this section."*

40 CFR 257.102(d) *"Closure performance standard when leaving CCR in place."*

40 CFR 257.102(d)(1) *"The owner or operator of a CCR unit must ensure that, at a minimum, the CCR unit is closed in a manner that will:"*

> 40 CFR 257.102(d)(1)(i) "*Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;"*

NR 514.07(10)(c)(3) *"A demonstration, including a narrative discussion, of how final closure will meet the performance standards under s. NR 506.083(6)."*

NR 506.083(6) *"Closure performance standards when leaving CCR in place. An owner or operator of a CCR landfill shall ensure that, at a minimum the CCR landfill is closed in a manner that will achieve all of the following performance standards:"*

> NR 506.083(6)(a) *"Control, minimization or elimination, to the maximum extent feasible, of post-closure infiltration of liquids into the waste and of releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere."*

The final cover system design will minimize or eliminate infiltration, as further described below.

> 40 CFR 257.102(d)(1)(ii) *"Preclude the probability of future impoundment of water, sediment, or slurry;"*
>
> NR 506.083(6)(b) *"Prevention of the impoundment of water, sediment or slurry."*

The final cover system will meet these criteria, as further described below.

> 40 CFR 257.102(d)(1)(iii) "*Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;"*
>
> NR 506.083(6)(c) *"Slope stability to prevent the sloughing or movement of the final cover system during the closure and long-term care period.*

The final cover system is designed to provide slope stability and to prevent sloughing or movement during the closure and post-closure care period. Stability of the final cover system was assessed as part of the WDNR landfill permitting process and is further addressed below.

> 40 CFR 257.102(d)(1)(iv) "*Minimize the need for further maintenance of the CCR unit; and"*
>
> NR 506.083(6)(d) *"Minimization of the need for long-term maintenance of the CCR landfill."*

Maintenance of the final cover will be minimized by the establishment of vegetative cover and the erosion control systems, which are further described below.

> 40 CFR 257.102(d)(1)(v) *"Be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices."*
>
> NR 506.083(6)(e) *"Complete closure in the shortest amount of time consistent with recognized and generally accepted good engineering practices."*

All closure activities for the CCR units will be completed within 6 months, as stated in **Section 7.0** below.

40 CFR 257.102(d)(2) *"Drainage and stabilization of CCR surface impoundments."*

This does not apply to the COL CCR landfill units.

40 CFR 257.102(d)(3) *"Final cover system"*

NR 517.07(10)(c)(2) *"A description of the final cover system, designed in accordance with s. NR 504.07, and the methods and procedures to be used to install the final cover."*

NR 504.12(4)(b) *"The owner or operator of a new or existing CCR landfill or a lateral expansion of a CCR landfill may propose an alternative final cover system design within a written closure plan in accordance with s. NR 504.10 and all of the following:"*

The alternative final cover design has been developed to meet the requirements of NR 504.12(4)(b) and is discussed in detail below.

The existing final cover system (see **Figure 3** for details) in place on part of Module 1 will be extended to cover the remaining portion of Module 1. The Module 1 final cover system is as follows from the bottom up:

- 3-inch grading layer
- Geosynthetic clay liner (GCL)
- 40-millimeters (mil) linear low-density polyethylene (LLDPE) geomembrane
- 12 inches of drainage material
- 12 inches of rooting zone
- 6 inches of topsoil

This final cover meets and exceeds the minimum requirements of 40 CFR 257.102(d)(3)(i)(A) through (D) and NR 504.12(4)(b)(1) through (4) as follows:

- Per 257.102(d)(3)(i)(A) and NR 504.12(4)(b)(1), the permeability of the final cover system is less than or equal to the permeability of the bottom liner system and is less than $1x10^{-5}$ centimeters per second (cm/sec) required by the rule. The COL cover system contains a GCL with a permeability of $5x10^{-9}$ cm/sec. The geomembrane above the GCL makes the cover system even less permeable.

The bottom liner system for the existing CCR landfill in Module 1 is as follows:

- Phase 1, Module 1 South:
  - GCL
  - 40-mil high density polyethylene (HDPE) geomembrane
  - The layers of the liner system are less than the cover system layers; therefore, infiltration will be more than the cover system.

- Phase 1, Module 1 North:
  - 3 feet of compacted ash
  - The liner here does not include a geomembrane, and therefore the infiltration through the cover system will be less than this base liner.

An alternate final cover system will be installed in future remaining areas of final cover north of Module 1 (Phase 1, Modules 2, 3, 4, 5, and 6 and Phase 2, Modules 10 and 11). The alternate cover consists of the following components, from bottom to top:

- 3-inch-thick grading layer
- GCL
- 40-mil polyethylene geomembrane
- Geocomposite drainage layer
- 24-inch-thick rooting zone layer
- 6-inch-thick topsoil layer

This alternative final cover meets and exceeds the minimum requirements of 40 CFR 257.102(d)(3)(i)(A) through (D) and NR 504.12(4)(b)(1) through (4) as follows:

- Per 257.102(d)(3)(ii)(A), 257.102(d)(3)(i)(A), and NR 504.12(4)(b)(1), the permeability of the final cover system is less than or equal to the permeability of the bottom liner system and is less than $1x10^{-5}$ centimeters per second (cm/sec) required by the rule. The COL cover system contains a GCL with a permeability of $5x10^{-9}$ cm/sec. The geomembrane above the GCL makes the cover system even less permeable.

The bottom liner system for the existing CCR landfill is as follows:

- Phase 1, Modules 2 and 3:
  - 2 feet of compacted clay
  - GCL
  - 60-mil HDPE geomembrane

The bottom liner system for the new CCR landfill is as follows:

- Phase 1, Modules 4, 5, and 6 and Phase 2, Modules 10 and 11:
  - 2 feet of compacted clay
  - GCL
  - 60-mil HDPE geomembrane

Based on a comparison of the design slopes and drainage system components in the liner system and final cover system (described in greater detail below), the final cover system is at least

equivalent in permeability when compared to the liner system in Phase 1, Modules 1, 2, 3, 4, 5, and 6 and Phase 2, Modules 10 and 11.

- Per 257.102(d)(3)(i)(B), the existing final cover system includes 2.5 feet of soil, which is greater than the 18 inches of earthen material required to minimize infiltration.

- Per 257.102(d)(3)(ii)(A) and 257.102(d)(3)(i)(B), the alternative final cover system includes 2.5 feet of soil, which is greater than the 18 inches of earthen material required to minimize infiltration.

- Per NR 504.12(4)(b)(2), the proposed final cover contains a GCL infiltration layer. Water infiltrating the final cover will be contained in the drainage layers (sand, geocomposite, and high capacity geocomposite), which will limit infiltration further through the final cover system. Based on our understanding of the regulations, it is unclear if the WDNR will require a soil barrier layer to be added below the final cover GCL. Further discussions with the WDNR will be needed to determine if the current final cover design is acceptable or if updates to the design are required.

- Per 257.102(d)(3)(i)(C) and NR 504.12(4)(b)(3), erosion of the existing final cover system is minimized with a vegetative support layer consisting of 12 inches of uncompacted rooting zone material and 6 inches of topsoil. This provides more than the required 6-inch thickness for plant growth.

- Per 257.102(d)(3)(ii)(B), 257.102(d)(3)(i)(C), and NR 504.12(4)(b)(3), erosion of the alternative final cover system is minimized with a vegetative support layer consisting of 24 inches of uncompacted rooting zone material and 6 inches of topsoil. This provides more than the required 6-inch thickness for plant growth.

Also, the existing final cover system and alternative final cover system limits infiltration while promoting surface water run-off in a controlled manner to minimize erosion and promote stability. The surface layer of 18 inches (existing) or 30 inches (alternative) of soil supports vegetation that assists with erosion control. Water that infiltrates will be collected by the 12-inch drainage layer (existing) or geocomposite drainage layer (alternate) and will be routed to the perimeter drainage system.

In addition, the surface has intermediate drainage swales to reduce the flow lengths down the final cover slope, also aiding in erosion control. Where needed, the intermediate drainage swales are connected to downslope channels to control storm water runoff and prevent erosion of the final cover.

- Per 257.102(d)(3)(i)(D) and NR 504.12(4)(b)(4), the design of the existing final cover system minimizes disruptions to the final cover system. Stability of the final cover system was assessed as part of the WDNR landfill permitting process. The stability calculations are included in **Appendix A1**.

- Per 257.102(d)(3)(ii)(C) and NR 504.12(4)(b)(4), the design of the alternative final cover system minimizes disruptions to the final cover system. Stability of the final cover system was assessed as part of the WDNR landfill permitting process. The stability calculations are included in **Appendix A2**.

The design of the final cover system accommodates settling and subsidence of the CCR fill below the cover. The CCR at COL is placed dry and is compacted in place. CCR continues to consolidate and gain strength as filling progresses prior to final cover placement. The final cover system is designed with a maximum slope of 25 percent (4 horizontal to 1 vertical). Because the final cover has a relatively large positive slope and the CCR has been gaining strength over time, the final cover is expected to easily accommodate the remaining relatively minor settlement potential of the CCR fill when fill placement ends and the landfill is closed.

All final cover materials will be tested to confirm they meet specifications, and construction will be overseen and documented by a licensed engineer. Rooting zone and topsoil layers will be checked for thickness. All areas will be restored after final cover is placed. Vegetation will be monitored and maintained.

# 4.0 MAXIMUM INVENTORY OF CCR

40 CFR 257.102(b)(1)(iv) *"An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR unit."*

NR 514.07(10)(c)(4) *"An estimate of the maximum volume in cubic yards of CCR that will be disposed on–site over the active life of the CCR landfill."*

The following table reflects the estimated maximum volume of CCR disposed on site at the COL facility.

| Area | Maximum Capacity (cy) |
|---|---|
| Phase 1, Modules 1-6, Phase 2, Modules 10-11 | 2,583,692 |

The estimated maximum inventory of CCR ever on site over the active life of the CCR landfill units is based on the design capacity of the landfill. The maximum design capacity was submitted in the WDNR approved 2022 Plan of Operation Update.

# 5.0 LARGEST AREA OF CCR UNIT REQUIRING FINAL COVER

40 CFR 257.102(b)(1)(v) *"An estimate of the largest area of the CCR unit ever requiring a final cover as required by paragraph (d) of this section at any time during the CCR unit's active life."*

NR 514.07(10)(c)(5) *"An estimate of the largest area of the CCR landfill that will require a final cover at any time during the CCR landfill's active life."*

The largest area of each CCR unit requiring final cover is the open area shown on **Figure 2**, with areas as follows:

| Areas Requiring Final Cover (acres) | |
|---|---|
| Phase 1, Modules 1- 3 | 12.9 |
| Phase 1, Modules 4-6 | 12.0 |
| Phase 2, Modules 10-11 | 7.3 |
| **Total** | **32.2** |

# 6.0 SCHEDULE OF SEQUENTIAL CLOSURE ACTIVITIES

40 CFR 257.102(b)(1)(vi) *"A schedule for completing all activities necessary to satisfy the closure criteria in this section, including an estimate of the year in which all closure activities for the CCR unit will be completed."*

NR 514.07(10)(c)(6) *"A schedule for completion of all closure activities, including an estimate of the year in which all closure activities for the CCR landfill will be completed."*

CCR placement is anticipated to permanently end at this facility following retirement of the Columbia Generating Station by June 2026, as announced by WPL. Some CCR disposal activity may be necessary following retirement of Columbia as part of decommissioning efforts (for example, cleaning of ducts and other equipment that may contain CCR following retirement). Closure activities are expected to be complete by the end of 2027.The potential schedule for closure of the existing CCR modules is provided in **Appendix B**.

# 7.0 COMPLETION OF CLOSURE ACTIVITIES

40 CFR 257.102(f)(1) *"Except as provided for in paragraph (f)(2) of this section, the owner or operator must complete closure of the CCR unit:*

*(i) For existing and new CCR landfills and any lateral expansion of a CCR landfill, within six months of commencing closure activities."*

NR 506.083(3)(a) *"The owner or operator shall complete closure of the CCR landfill within 6 months of commencing closure activities."*

As shown on the enclosed schedule, closure of each CCR unit will be completed within 6 months of commencing closure activities.

40 CFR 257.102(f)(3) *"Upon completion, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer verifying that closure has been completed in accordance with the closure plan specified in paragraph (b) of this section and the requirements of this section."*

NR 506.083(1)(b) *"Within 30 days following completion of closure of a CCR landfill under sub. (3), the owner or operator shall prepare and submit a notification of closure to the department and place a copy in the facility's operating record. The notification shall include the certification required under s. NR 516.04(3)(d)."*

A qualified licensed engineer will oversee the final cover construction. The engineer will verify final cover materials and methods and oversee material testing. At the end of construction, the engineer

will provide a report summarizing and documenting construction and will certify compliance with the requirements.

# 8.0 CERTIFICATION

40 CFR 257.102(b)(4) *"The owner or operator of the CCR unit must obtain a written certification from a qualified professional engineer that the initial and any amendment of the written closure plan meets the requirement of this section."*

NR 500.05 *"Unless otherwise specified, all submittals for review and approval of any initial site report, feasibility report, plan of operation site investigation report, remedial action options report, construction documentation report, or closure plan, or any modifications to those plans, shall include all of the following:*

*(4) CERTIFICATION. (a) The reports and plan sheets shall be under the seal of a licensed professional engineer."*

Phillip Gearing, PE, a licensed professional engineer in the State of Wisconsin has overseen the preparation of this Closure Plan. A certification statement is provided on **page iii** of this plan.

40 CFR 257.102(d)(2)(iii) *"The owner or operator of the CCR unit must obtain a written certification from a qualified professional engineer that the design of the final cover system meets the requirement of this section."*

Phillip Gearing, PE, a licensed professional engineer in the State of Wisconsin has overseen the design of the final cover system and certifies that the design meets the requirements of 40 CFR 257.102(d). The certification statement is provided on **page iii** of this plan.

# 9.0 RECORDKEEPING AND REPORTING

40 CFR 257.102(b)(vi)(2)(iii) *"The owner or operator has completed the written closure plan when the plan including the certification required by paragraph (b)(4) of this section, has been placed in the facility's operating record as required by Section 257.105(i)(4)."*

NR 506.17(2)(e) *"The written operating record shall contain the plan of operation, plan modifications, construction documentation, department approvals, annual reports, inspection records, monitoring and corrective action records, notifications to the department, and records of public comments received during any public comment period."*

The Closure Plan will be placed in the facility's operating record and on Alliant Energy's CCR Rule Compliance Data and Information website.

Amendments to the written Closure Plan will be done when a new module is constructed, when there is a change in the operation of the CCR unit that affects the plan, or when unanticipated events warrant revision to the written Closure Plan as required by 40 CFR 257.102(b)(3) and NR 514.07(10)(c)(7).

WPL will provide notification as follows:

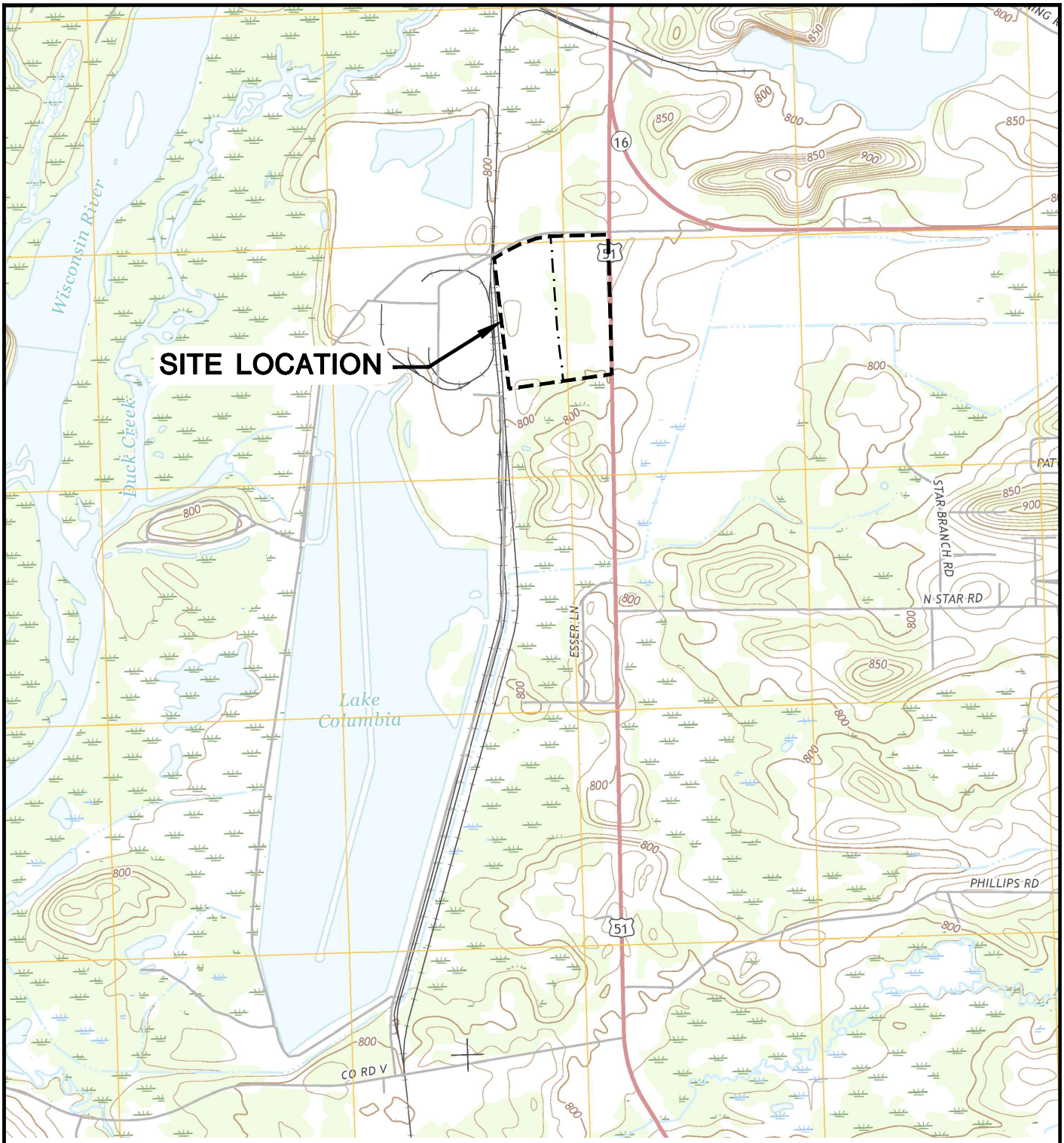
- Intent to initiate closure
- Closure completion

- Availability of the written Closure Plan and any amendments

All notifications will be placed in the facility's operating record and on the website per 40 CFR 257.105(i), 257.106(i), 257.107(i), and NR 506.17(2).

# Figures

1 Site Location Map
2 Closure Plan
3 Final Cover System




N

POYNETTE QUADRANGLE
WISCONSIN–COLUMBIA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
2016
SCALE: 1" = 2,000'

| | | | |
|---|---|---|---|
| CLIENT | WISCONSIN POWER AND LIGHT<br>COLUMBIA ENERGY CENTER<br>W8375 MURRAY ROAD<br>PARDEEVILLE, WISCONSIN 53954 | SITE | CLOSURE PLAN<br>COLUMBIA DRY ASH DISPOSAL FACILITY<br>TOWN OF PACIFIC, WISCONSIN |

SITE LOCATION MAP

| | | | |
|---|---|---|---|
| PROJECT NO. | 25222260.00 | DRAWN BY: | AHB |
| DRAWN: | 08/09/2016 | CHECKED BY: | RJG |
| REVISED: | 12/28/2022 | APPROVED BY: | PEG 01/31/23 |

ENGINEER

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

FIGURE
1

I:\25222260.00\Drawings\Closure Plan\1_Site Location.dwg, 1/31/2023 3:04:36 PM

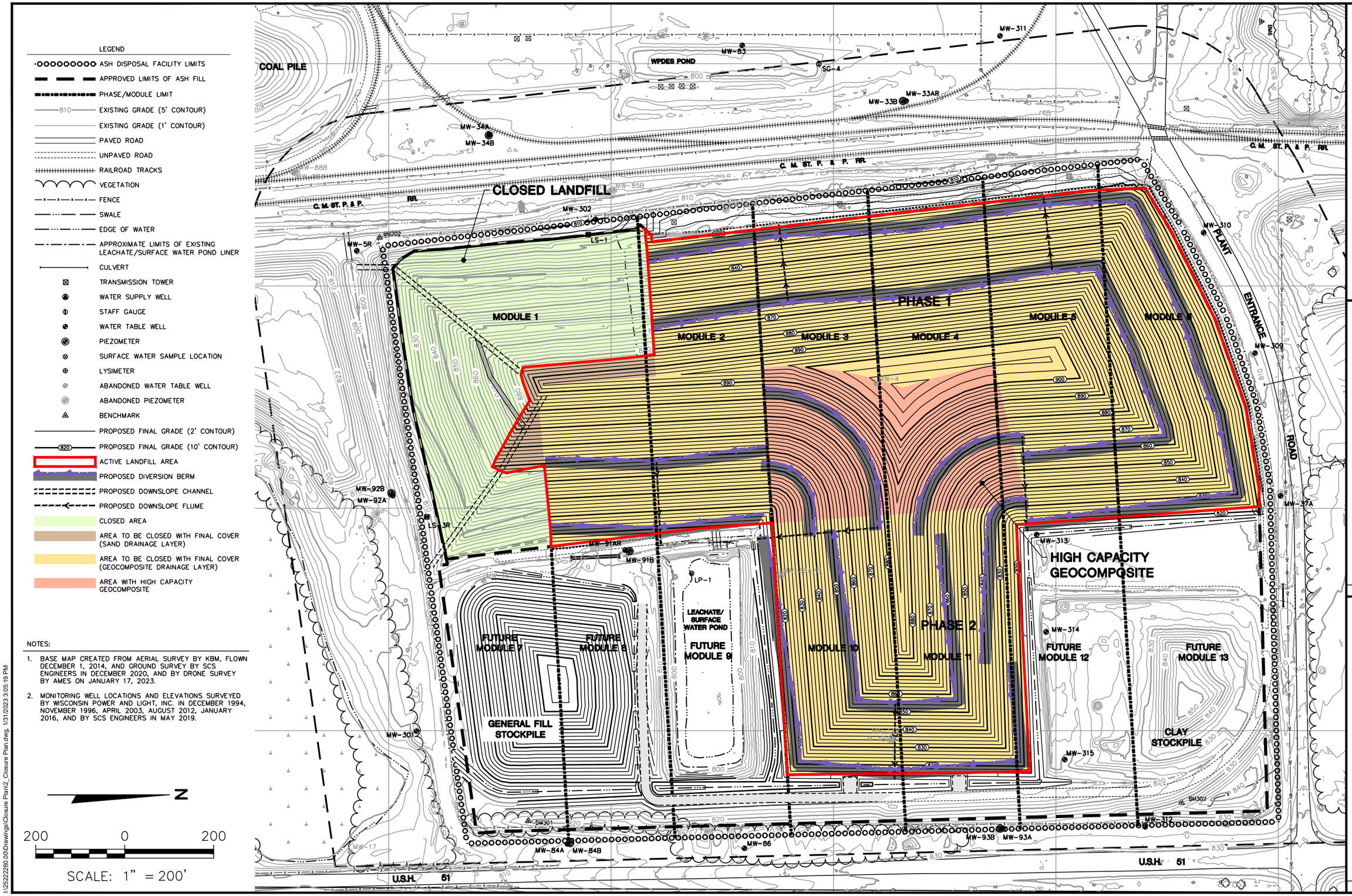



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FIGURE 2

CLOSURE PLAN

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLOSURE PLAN
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

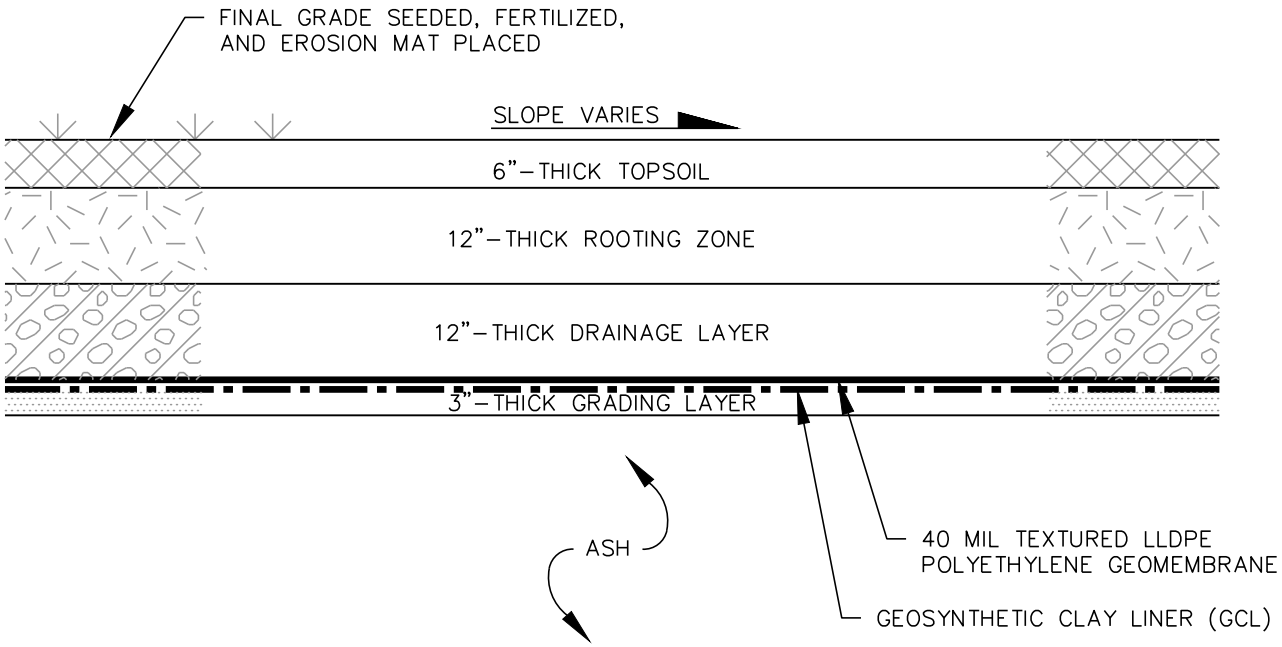
SITE

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT

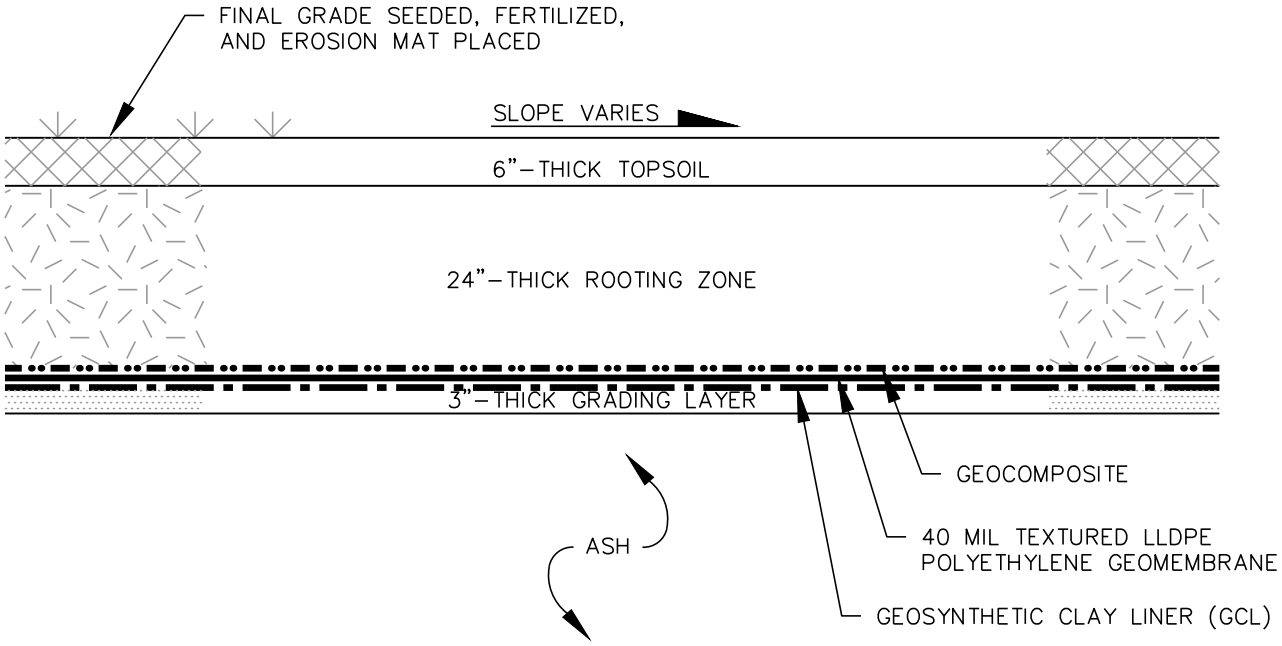
| ENGINEER | |
|---|---|
| DRAWN BY: | KP/MJT |
| CHECKED BY: | RJG |
| APPROVED BY: | PEG 01/31/23 |

| | |
|---|---|
| PROJECT NO. | 252222260.00 |
| DRAWN: | 11/30/2021 |
| REVISED: | 01/25/2023 |




## FINAL COVER SYSTEM (SAND DRAINAGE LAYER)

SCALE: 1" = 2'




## FINAL COVER SYSTEM (GEOCOMPOSITE DRAINAGE LAYER)

SCALE: 1" = 2'

| | | | | | |
|---|---|---|---|---|---|
| CLIENT | WISCONSIN POWER AND LIGHT<br>COLUMBIA ENERGY CENTER<br>W8375 MURRAY ROAD<br>PARDEEVILLE, WISCONSIN 53954 | SITE | CLOSURE PLAN<br>COLUMBIA DRY ASH DISPOSAL FACILITY<br>TOWN OF PACIFIC, WISCONSIN | FINAL COVER SYSTEM | |
| PROJECT NO. | 25222260.00 | DRAWN BY: | KP/MJT | ENGINEER | FIGURE |
| DRAWN: | 08/17/2016 | CHECKED BY: | RJG | SCS ENGINEERS<br>2830 DAIRY DRIVE MADISON, WI 53718-6751<br>PHONE: (608) 224-2830 | 3 |
| REVISED: | 01/25/2023 | APPROVED BY: | PEG 01/31/23 | | |

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# Appendix A

# Stability Calculations

# Appendix A1

# Existing Final Cover Stability Calculations

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CIVIL & ENVIRONMENTAL ENGINEERING

| | | | |
|---|---|---|---|
| Sheet No. 1 | | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 4071 | Job: Columbia Ash Generation Landfill | By: PEG | Date 9/23/10 |
| Client: Alliant | Subject: Liner Side Slope Drainage Layer Stability | Chk'd: DLN | Date 9/24/10 |

## EVALUATION:

**Evaluate the Phase 1 landfill liner side slope drainage layer for static veneer slope stability.**

The side slope on the modules base runs at a 3:1 slope for an approximate maximum of 80 feet.

The following calculations evaluate the static veneer slope stability of the 3:1 slope.

## REFERENCES:


1.) Koerner, Robert M. & Te-Yang Soong, Analysis and Design of Veneer Cover Soils, Geosynthetic Research Institute.

2.) U.S. Department of Transportation - Federal Highway Administration Recycled Materials, Coal Bottom Ash User's Guide


## EQUATIONS:

$FS = (-b+(b^2-4*a*c)^{1/2})/(2*a)$

$a = (W_A-N_A*\cos\beta)*\cos\beta$

$b = -((W_A-N_A*\cos\beta)*\sin\beta*\tan\phi+(N_A*\tan\delta+C_a)*\sin\beta*\cos\beta+(C+W_P*\tan\phi)*\sin\beta)$

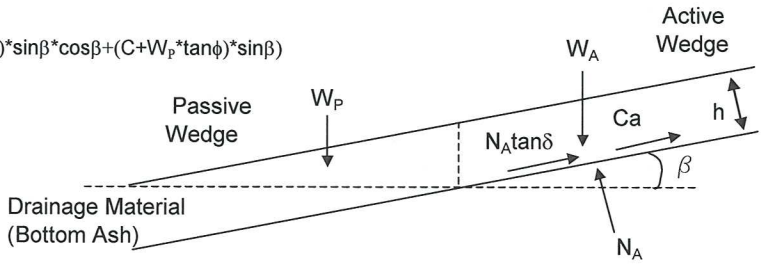
$c = (N_A*\tan\delta+C_a)*(\sin\beta)^2*\tan\phi$

$N_A = W_A*\cos\beta$

$W_A = \gamma*h^2*(L/h-1/\sin\beta-\tan\beta/2)$

$W_P = (\gamma*h^2)/\sin2\beta)$

$C_a = c_a(L-h/\sin\beta)$




## DEFINITIONS OF VARIABLES:

FS = Factor of Safety

a, b, & c = intermediate variables (= calculated variable)

$N_A$ = Effective force normal to the failure plane of the active wedge ( = calculated variable)

$W_A$ = Total weight of active wedge (= calculated variable)

$W_P$ = Total weight of passive wedge (= calculated variable)

$\beta$ = Soil slope angle beneath the geomembrane ( = 18.42 degrees or 0.322 radians based on liner slope of 3 to 1 )

$\phi$ = Friction angle of the drainage layer material ( = 35 degrees 0.611 radians based on Ref #2)

$\delta$ = Interface friction angle for liner system geosynthetics ( to be determined)

$c_a$ = Adhesion for liner system geosynthetics at active wedge ( to be determined) , Variable

$\gamma$ = Unit weight of the drainage layer material ( = 135 pcf based on conservative wet density of bottom ash).

C = Cohesive force along the failure plane of the passive wedge ( assumed 0 for drainage layer material)

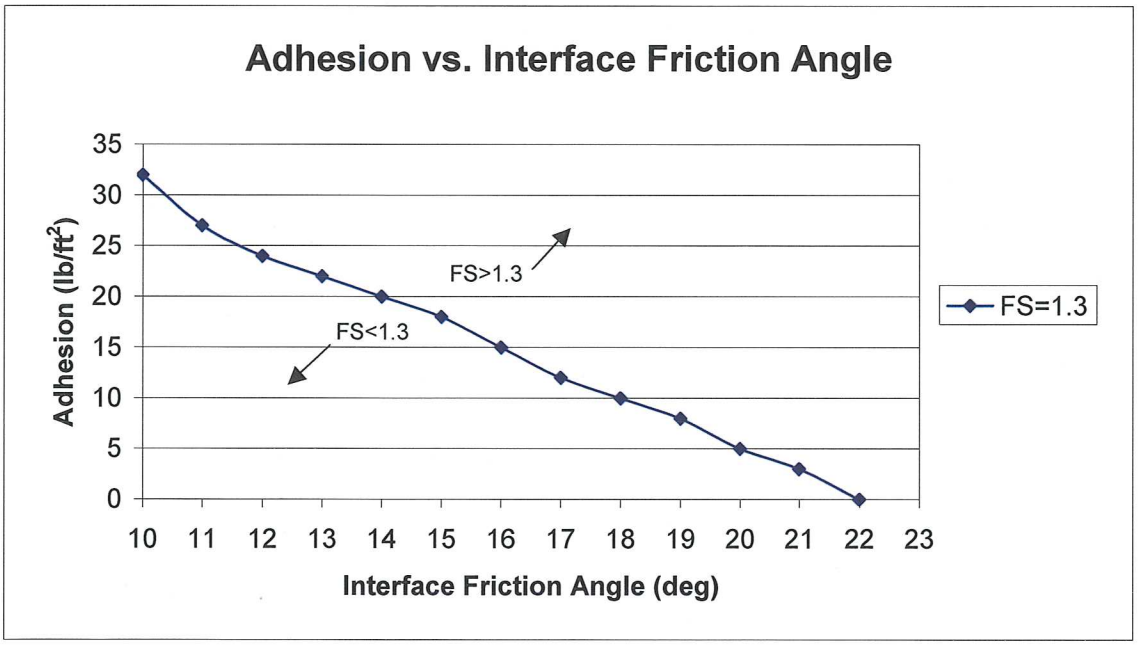
$C_a$ = Adhesive force of the active wedge for the liner system geosynthetics

h = Thickness of the drainage layer material(= 1.0 foot based on base design)

L = Length of slope measured along the geomembrane ( = 80 feet based on base design)

**CALCULATIONS:**

| δ | | $c_a$ | $W_A$ | $W_P$ | $N_A$ | $C_a$ | a | b | c | FS |
|---|---|---|---|---|---|---|---|---|---|---|
| (deg) | (rad) | ($lb/ft^2$) | (lb/ft) | (lb/ft) | (lb/ft) | (lb/ft) | (lb/ft) | (lb/ft) | (lb/ft) | |
| **10** | 0.175 | 32 | 10,350 | 225 | 9,820 | 2,459 | 981 | -1,535 | 293 | **1.3** |
| **11** | 0.192 | 27 | 10,350 | 225 | 9,820 | 2,075 | 981 | -1,473 | 279 | **1.3** |
| **12** | 0.209 | 24 | 10,350 | 225 | 9,820 | 1,844 | 981 | -1,457 | 275 | **1.3** |
| **13** | 0.227 | 22 | 10,350 | 225 | 9,820 | 1,690 | 981 | -1,465 | 277 | **1.3** |
| **14** | 0.244 | 20 | 10,350 | 225 | 9,820 | 1,537 | 981 | -1,473 | 279 | **1.3** |
| **15** | 0.262 | 18 | 10,350 | 225 | 9,820 | 1,383 | 981 | -1,482 | 281 | **1.3** |
| **16** | 0.279 | 15 | 10,350 | 225 | 9,820 | 1,153 | 981 | -1,468 | 277 | **1.3** |
| **17** | 0.297 | 12 | 10,350 | 225 | 9,820 | 922 | 981 | -1,455 | 274 | **1.3** |
| **18** | 0.314 | 10 | 10,350 | 225 | 9,820 | 768 | 981 | -1,465 | 277 | **1.3** |
| **19** | 0.332 | 8 | 10,350 | 225 | 9,820 | 615 | 981 | -1,477 | 279 | **1.3** |
| **20** | 0.349 | 5 | 10,350 | 225 | 9,820 | 384 | 981 | -1,465 | 277 | **1.3** |
| **21** | 0.367 | 3 | 10,350 | 225 | 9,820 | 231 | 981 | -1,478 | 280 | **1.3** |
| **22** | 0.384 | 0 | 10,350 | 225 | 9,820 | 0 | 981 | -1,468 | 277 | **1.3** |




**CONCLUSION:**

The landfill liner side slope drainage layer was evaluated for static veneer slope stability along its longest slope. Calculations were performed to determine the minimum adhesion necessary for a range of interface friction angles to reach a FS of 1.3 or greater. Each interface friction angle and the coinciding adhesion was graphed in order to easily determine if a material interface is acceptable along the side slope.

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| | | | |
|---|---|---|---|
| Sheet No. | 1 of 1 | | |
| Calc. No. | | | |
| Rev. No. | | | |
| Job No. 4071 | Job: Columbia Ash Generation Landfill | By PEG | Date 9/27/10 |
| Client: Alliant | Subject: GCL Internal Shear for Liner System | Chk'd DLN | Date 9/29/10 |

**Purpose:** Determine the maximum shear stress acting on a Geosynthetic Clay Liner (GCL) and the GCL internal shear strength required to provide a minimum slope stability safety factor (FS) of 1.5 for the liner system.

**Approach:** Use maximum shear stress formula and assumed values.

**References:** **Design of GCL Barrier for Final Cover Side Slope Applications**
**Gregory N. Richardson, Ph.D., P.E. Geosynthetics '97 - 541**

**Calculation:** The maximum shear stress acting on the GCL can be calculated as follows:

$$\tau_{act} = W_T \sin \beta$$

$$\beta = 18.4^{\circ}$$

$$W_T = \gamma * h$$

Where,

$\gamma$ = Ash Unit Weight = 135 pcf

h = drainage layer thickness = 1 ft

$$W_T = 135 \text{ psf}$$

$$\tau_{act} = 42.6 \text{ psf}$$

$$FS = \frac{\tau_{resist}}{\tau_{act}} = 1.5$$

$$\tau_{resist} = FS * \tau_{act} = 1.5 * 42.6 = 64 \text{ psf}$$

**Assumptions:** 1. Slope angle, $\beta$=18.4° (3:1 horizontal/vertical liner side slope).
2. Ash unit weight, $\gamma$ = 135 pcf

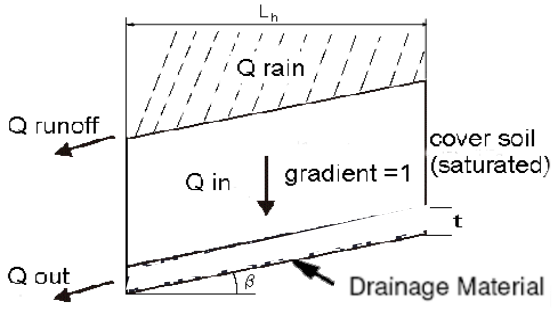
**Conclusions:** For a total weight of the leachate drainage layer of 135 psf and a slope angle of 3:1, the maximum shear stress will be 42.6 psf. A minimum GCL internal shear strength of 64 psf is required to provide a slope stability safety factor of 1.5.

**Purpose:** To determine the maximum length of slope that the final cover drainage layer (sand) can carry infiltrating water and remain stable.

**Approach:** Use the unit gradient method to determine the maximum slope length.

**References:**


1. Landfilldesign.com
2. "GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001
3. "Beyond a factor-of-safety value, i.e., the proabability of failure". GRI Newsletter/Report, Vol. 15, no. 3
4. "Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998
5. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J. P. Giroud, J. G. Zornberg and A. Zhao, Geosynthetics International, Vol. 7, Nos 4-5
6. "Lateral Drainage Design update - part 2". G. N. Richardson, J. P. Giroud and A. Zhao, Geotechnical Fabrics Report, March 2002
7. HELP Model "User's Guide", Table 4: Default Soil, Waste, and Geosynthetic Characteristics
8. SCS Engineers, Plan Modification Request/Plan of Operation Update, Dry Ash Disposal Facility, COL Energy Center, Final Grades Plan Sheet, May 2022


**With Darcy's Law:**

$$Q = k \times i \times A$$

Inflow of water in the Drainage Material

$$Q_{in} = k_{veg} \times i \times A = k_{veg} \times 1 \times L_h \times 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{drain} \times i \times A = k_{drain} \times t \times \sin\beta$$

This results in a required $k_{drain}$ of:

$$k_{drain} = \frac{k_{veg} \times L_h}{t \times \sin\beta} \times FS$$

**Assumptions:** 1. Soil hydraulic gradient $i$ = 1.0.

2. Top soil will be clay. Soil permeability is 4.2 x $10^{-5}$ cm/sec for a CL clay from HELP model user's guide.

3. Drainage Layer hydraulic gradient = sinβ where β=14˚ (4:1 horizontal/vertical final cover slope).

4. Maximum horizontal final cover slope length from crest to toe drain is 368 feet as shown in Module 1 on the final grades plan sheet.

5. The minimum hydraulic conductivity ($k_{drain,ave}$) is 1.0 x $10^{-2}$ cm/s for the sand.

6. Cover drainage layer thickness t = 1 foot.

**Calculation:** Constants

| | | | | | |
|---|---|---|---|---|---|
| $L_h$ | = | Drainage pipe spacing or length of slope measured horizontally | = | See Below | |
| $k_{veg}$ | = | Permeability of the vegetative supporting soil | = | 0.000042 | cm/sec |
| S | = | The liner's slope, **S** = tan **b** | = | 25% | b = 14˚ |
| $FS_{slope}$ | = | Minimum factor of safety against sliding, for drainage layer/geomembrane interface | = | 1.5 | |
| $\delta_{req'd}$ | = | Minimum interface friction angle = $\tan^{-1}$(FS*tan(b)) | = | 20.6 | degrees |

Determine the maximum slope length for the given minimum required drainage layer permeability

| $L_h$ (feet) | $L_h$ (meter) | $k_{drain, req}$ (cm/s) | |
|---|---|---|---|
| 30 | 9.1 | 7.69E-03 | Design |

**Conclusions:** The design has an intermediate pipe every 30 feet spaced evenly up the slope. The intermediate pipe spacing design with the sand material has a factor of safety of 1.95.

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 1 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Dry Ash Disposal Facility | By: MJT | Date: 04/25/22 |
| Client: WPL | Subject: GCL Internal Shear on Final Cover | Chk'd: DLN | Date: 04/26/22 |

**Purpose:** Determine the maximum shear stress acting on a Geosynthetic Clay Liner (GCL) and the GCL internal shear strength required to provide a minimum slope stability safety factor (FS) of 1.5 for the final cover.

**Approach:** Use maximum shear stress formula and assumed values.

**References:** Design of GCL Barrier for Final Cover Side Slope Applications, Gregory N. Richardson, Ph.D., P.E., Geosynthetics '97-541

**Calculation:** The maximum shear stress acting on the GCL can be calculated as follows:

$$\tau_{act} = W_T \sin \beta$$

$$\beta = 14^\circ$$

$$W_T = \gamma \times h$$

Where: $\gamma$ = Soil Unit Weight = 120 pcf

$h$ = Cover Thickness = 2.5 ft

$$W_T = 300 \text{ psf}$$

$$\tau_{act} = 72.6 \text{ psf}$$

$$FS = \frac{\tau_{resist}}{\tau_{act}} = 1.5$$

$$\tau_{resist} = FS \times \tau_{act} = 1.5 \times 72.6 = 109 \text{ psf}$$

**Assumptions:** Slope angle, $\beta = 14^\circ$ (4:1 horizontal / vertical final cover slope)

Soil unit weight, $\gamma = 120$ pcf

**Conclusion:** For a total weight of the final cover system of 300 psf and a slope angle of 4:1, the maximum shear stress will be 72.6 psf. A minimum GCL internal shear strength of 109 psf is required to provide a slope stability safety factor of 1.5.

# Appendix A2

# Alternative Final Cover Stability Calculations

SCS ENGINEERS

| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 2 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Dry Ash Disposal Facility | By: MJT | Date: 04/04/22 |
| Client: WPL | Subject: Liner Side Slope Drainage Layer Stability | Chk'd: DLN | Date: 04/13/22 |

**Purpose:** Evaluate the Module 10 and 11 landfill liner side slope drainage layer for static veneer slope stability. The following calculations evaluate the static veneer slope stability of the 3:1 slope.

**References:** 1. Koerner, Robert M. & Te-Yang Soong, Analysis and Design of Veneer Cover Soils, Geosynthetic Research Institute.
2. U.S. Department of Transportation - Federal Highway Administration Recycled Materials, Coal Bottom Ash User's Guide

**Calculation:**

$$FS = (-b + (b^2 - 4 * a * c)^{1/2}) / (2 * a)$$

$$a = (W_A - N_A * \cos\beta) * \cos\beta$$

$$b = -((W_A - N_A * \cos\beta) * \sin\beta * \tan\phi + (N_A * \tan\delta + C_a) * \sin\beta * \cos\beta + (C + W_P * \tan\phi) * \sin\beta)$$

$$c = (N_A * \tan\delta + C_a) * (\sin\beta)^2 * \tan\phi$$

$$N_A = W_A * \cos\beta$$

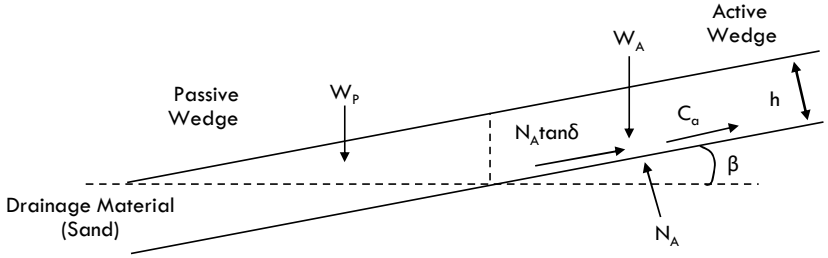
$$W_A = \gamma * h^2 * (L / h - 1 / \sin\beta - \tan\beta / 2)$$

$$W_P = (\gamma * h^2) / \sin 2\beta)$$

$$C_a = c_a (L - h / \sin\beta)$$

Where:

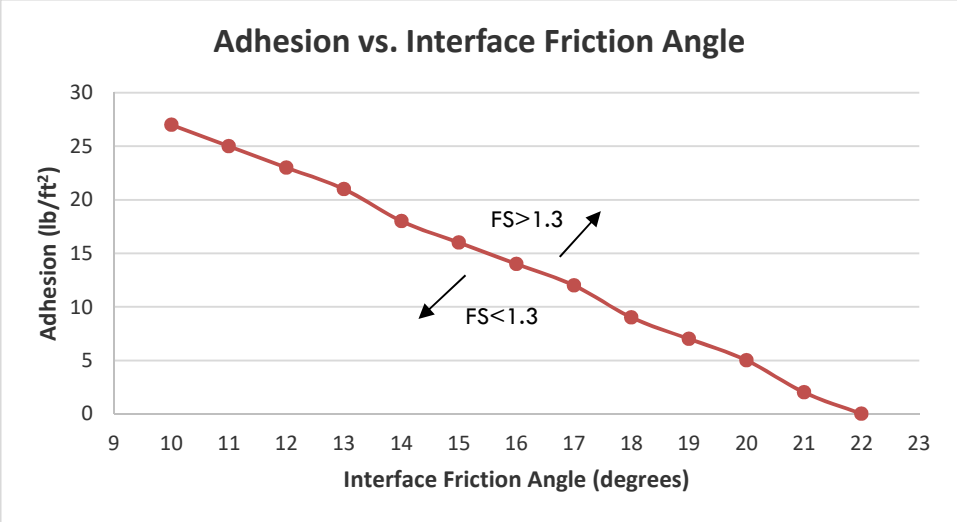
- $FS$ = Factor of Safety
- $a$, $b$, & $c$ = intermediate variables (calculated variable)
- $N_A$ = Effective force normal to the failure plane of the active wedge (calculated variable)
- $W_A$ = Total weight of active wedge (calculated variable)
- $W_P$ = Total weight of passive wedge (calculated variable)
- $\beta$ = Soil slope angle beneath the geomembrane = 18.421 degrees = 0.3215 radians, based on liner slope of 3 to 1
- $\phi$ = Friction angle of the sand drainage layer material = 30 degrees = 0.5236 radians, based on experience
- $\delta$ = Interface friction angle for liner system geosynthetics (to be determined)
- $c_a$ = Adhesion for liner system geosynthetics at active wedge (to be determined), Variable
- $\gamma$ = Unit weight of the drainage layer material = 125 pcf, based on conservative wet density of sand
- $C$ = Cohesive force along the failure plane of the passive wedge, assumed = 0 for drainage layer material
- $C_a$ = Adhesive force of the active wedge for the liner system geosynthetics
- $h$ = Thickness of the drainage layer material = 1 foot, based on base design
- $L$ = Length of slope measured along the geomembrane = 49 feet, based on base design



**Calculation:**

**(cont.)**

| δ (deg) | δ (rad) | $c_a$ (lb/ft$^2$) | $W_A$ (lb/ft) | $W_P$ (lb/ft) | $N_A$ (lb/ft) | $C_a$ (lb/ft) | a (lb/ft) | b (lb/ft) | c (lb/ft) | FS |
|---|---|---|---|---|---|---|---|---|---|---|
| **10** | 0.1745 | 27 | 5,709 | 208 | 5,416 | 1237.6 | 541 | -799 | 126 | 1.3 |
| **11** | 0.192 | 25 | 5,709 | 208 | 5,416 | 1,146 | 541 | -801 | 127 | 1.3 |
| **12** | 0.2094 | 23 | 5,709 | 208 | 5,416 | 1,054 | 541 | -803 | 127 | 1.3 |
| **13** | 0.2269 | 21 | 5,709 | 208 | 5,416 | 963 | 541 | -805 | 128 | 1.3 |
| **14** | 0.2443 | 18 | 5,709 | 208 | 5,416 | 825 | 541 | -794 | 125 | 1.3 |
| **15** | 0.2618 | 16 | 5,709 | 208 | 5,416 | 733 | 541 | -797 | 126 | 1.3 |
| **16** | 0.2793 | 14 | 5,709 | 208 | 5,416 | 642 | 541 | -800 | 127 | 1.3 |
| **17** | 0.2967 | 12 | 5,709 | 208 | 5,416 | 550 | 541 | -803 | 127 | 1.3 |
| **18** | 0.3142 | 9 | 5,709 | 208 | 5,416 | 413 | 541 | -793 | 125 | 1.3 |
| **19** | 0.3316 | 7 | 5,709 | 208 | 5,416 | 321 | 541 | -797 | 126 | 1.3 |
| **20** | 0.3491 | 5 | 5,709 | 208 | 5,416 | 229 | 541 | -802 | 127 | 1.3 |
| **21** | 0.3665 | 2 | 5,709 | 208 | 5,416 | 92 | 541 | -793 | 125 | 1.3 |
| **22** | 0.384 | 0 | 5,709 | 208 | 5,416 | 0 | 541 | -798 | 126 | 1.3 |




**Conclusion:** The landfill liner side slope drainage layer was evaluated for static veneer slope stability along its longest slope. Calculations were performed to determine the minimum adhesion necessary for a range of interface friction angles to reach a FS of 1.3 or greater. Each interface friction angle and the coinciding adhesion was graphed in order to easily determine if a material interface is acceptable along the side slope.

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| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 1 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Dry Ash Disposal Facility | By: MJT | Date: 03/02/22 |
| Client: WPL | Subject: GCL Internal Shear for Liner System | Chk'd: DLN | Date: 04/13/22 |

**Purpose:** Determine the maximum shear stress acting on a Geosynthetic Clay Liner (GCL) and the GCL internal shear strength required to provide a minimum slope stability safety factor (FS) of 1.5 for the liner system.

**Approach:** Use maximum shear stress formula and assumed values.

**References:** Design of GCL Barrier for Final Cover Side Slope Applications, Gregory N. Richardson, Ph.D., P.E., Geosynthetics '97-541

**Calculation:** The maximum shear stress acting on the GCL can be calculated as follows:

$$\tau_{act} = W_T \sin \beta$$

$$\beta = 18.4^{\circ}$$

$$W_T = \gamma \times h$$

Where: $\gamma$ = Sand Unit Weight = 125 pcf

$h$ = Drainage Layer Thickness = 1 ft

$$W_T = 125 \text{ psf}$$

$$\tau_{act} = 39.5 \text{ psf}$$

$$FS = \frac{\tau_{resist}}{\tau_{act}} = 1.5$$

$$\tau_{resist} = FS \times \tau_{act} = 1.5 \times 39.5 = 59 \text{ psf}$$

**Assumptions:** Slope angle, $\beta = 18.4^{\circ}$ (3:1 horizontal / vertical liner side slope

Sand unit weight, $\gamma = 125$ pcf

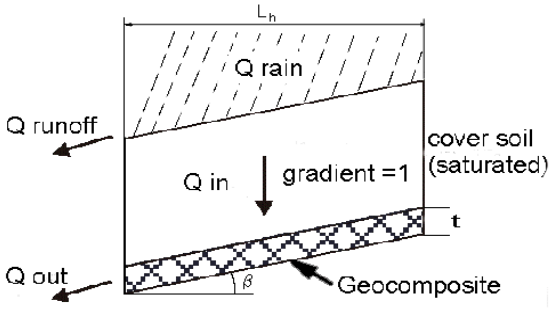
**Conclusion:** For a total weight of the leachate drainage layer of 125 psf and a slope angle of 3:1, the maximum shear stress will be 39.46 psf. A minimum GCL internal shear strength of 59.19 psf is required to provide a slope stability safety factor of 1.5.

**Purpose:** To determine the maximum length of slope that the final cover drainage geocomposite can carry infiltrating water and remain stable. Also determine the recommended minimum friction angle for final cover side slope stability. Note: This calculation does not include the flow convergence areas where a separate calculation is required.

**Approach:** Use the unit gradient method to determine the maximum slope length.

**References:**


1. Landfilldesign.com - Lateral Drainage System - Single Slope, Unit Gradient Method
2. "GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.
3. "Beyond a factor-of-safety value, i.e., the proabability of failure". GRI Newsletter/Report, Vol. 15, no. 3.
4. "Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.
5. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J. P. Giroud, J. G. Zornberg and A. Zhao, Geosynthetics International, Vol. 7, Nos 4-5.
6. "Lateral Drainage Design update - part 2". G. N. Richardson, J. P. Giroud and A. Zhao, Geotechnical Fabrics Report, March 2002.
7. Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International
8. SCS Engineers, Plan Modification Request/Plan of Operation Update, Dry Ash Disposal Facility, COL Energy Center, Final Grades Plan Sheet, May 2022
9. HELP Model "User's Guide" in conjunction with GRI report #19, pages 34-37 (Leachate Collection System)


**With Darcy's law:**

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin\beta \quad = \theta * i * 1 \text{ where } \theta = k_{comp} * t$$

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin\beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

**Assumptions:** 1. Soil hydraulic gradient $i$ = 1.0.

2. Top soil will be clay. Soil permeability is 4.2 x $10^{-5}$ cm/sec for a CL clay from HELP model user's guide.

3. Geocomposite hydraulic gradient = sinβ where β=14˚ (4:1 horizontal/vertical final cover slope).

4. Factor of safety and transmissivity reduction factors are from recommended values in GRI report #19 (Leachate collection system example) and HELP model "Users Guide"

5. Maximum horizontal final cover slope length from crest to toe drain is 397 feet as shown on Module 10 and 11 Final Grades plan sheet. This includes 58' of 10:1 slope length at the peak.

**Calculation:** Constants

| | | | | | |
|---|---|---|---|---|---|
| $L_h$ | = | Drainage pipe spacing or length of slope measured horizontally | = | See Below | |
| $k_{veg}$ | = | Permeability of the vegetative supporting soil | = | 0.000042 | cm/sec |
| S | = | The liner's slope, **S** = tan **b** | = | 25% | b = 14˚ |
| $FS_{slope}$ | = | Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces | = | 1.5 | |
| $\delta_{req'd}$ | = | Minimum interface friction angle = $\tan^{-1}$(FS*tan(b)) | = | 20.6 | degrees |
| $FS_d$ | = | Overall factor of safety for drainage | = | 2.0 | |
| $RF_{in}$ | = | Intrusion Reduction Factor | = | 1.1 | |
| $RF_{cr}$ | = | Creep Reduction Factor | = | 1.2 | |
| $RF_{cc}$ | = | Chemical Clogging Reduction Factor | = | 1.1 | |
| $RF_{bc}$ | = | Biological Clogging Reduction Factor | = | 1.4 | |

Determine the maximum slope length for a given ultimate transmissivity

| $\Theta_{ult}$ ($m^2$/sec) | $L_h$ (meter) | $L_h$ (feet) |
|---|---|---|
| 1.00E-03 | 141.7 | 465 |

Determine the ultimate transmissivity based on a given slope length

| $L_h$ (feet) | $L_h$ (meter) | $\Theta_{ult}$ ($m^2$/sec) | |
|---|---|---|---|
| 397 | 121.0 | 8.55E-04 | ~ Total slope length |
| 199 | 60.5 | 4.27E-04 | ~ 1/2 of total slope length |
| 132 | 40.3 | 2.85E-04 | ~ 1/3 of total slope length |

**Conclusions:** If no intermediate drainage outlets were constructed on the final cover, a minimum transmissivity of 8.55 x $10^{-4}$ $m^2$/sec would need to be obtained.

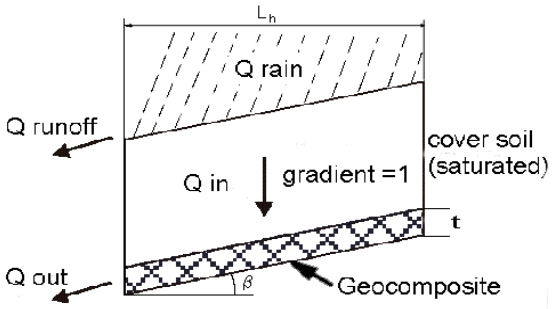
A minimum interface friction angle of 20.6 degrees between cover soil and geocomposite is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.

**Purpose:** To determine the geocomposite drainage requirements in the final cover where flow converges in the north and south corners of Modules 10 and 11so the final cover drainage geocomposite can carry infiltrating water and remain stable. Also to determine the recommended minimum interface friction angle for final cover stability.

**Approach:** Use the unit gradient method and flow path geometry to determine the geocomposite transmissivity required at locations within the converging flow area.

**References:**


1. Landfilldesign.com - Lateral Drainage System - Single Slope, Unit Gradient Method
2. "GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.
3. "Beyond a factor-of-safety value, i.e., the proabability of failure". GRI Newsletter/Report, Vol. 15, no. 3.
4. "Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.
5. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J. P. Giroud, J. G. Zornberg and A. Zhao, Geosynthetics International, Vol. 7, Nos 4-5.
6. "Lateral Drainage Design update - part 2". G. N. Richardson, J. P. Giroud and A. Zhao, Geotechnical Fabrics Report, March 2002.
7. Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International
8. SCS Engineers, Plan Modification Request/Plan of Operation Update, Dry Ash Disposal Facility, COL Energy Center, Final Grades Plan Sheet, April 2022
9. HELP Model "User's Guide" in conjunction with GRI report #19, pages 34-37 (Leachate Collection System)


**With Darcy's law:**

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin\beta$$

= θ*i*1 where θ = $k_{comp}$ * t (minimum allowable outflow to keep head within geocomposite)

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin\beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

**Assumptions:** 1. Soil hydraulic gradient $i$ = 1.0.

2. Top soil will be clay. Soil permeability is 4.2 x $10^{-5}$ cm/sec for a CL clay from HELP model user's guide.

3. Geocomposite hydraulic gradient = sinβ where β=14˚ (4:1 horizontal/vertical final cover slope).

4. Factor of safety and transmissivity reduction factors are from recommended values in GRI report #19 (Leachate collection system example) and HELP model "Users Guide"

5. Flow paths A-E and F-J are as shown on attached drawing. Assume circular arc with radius measured from the corner of the toe drain.

6. Intermediate drainage piping will be used at 3 locations along the slope in each area to divert flow from the drainage layer to the diversion berms and downslope flume.

**Calculation:** Constants

| | | | | | |
|---|---|---|---|---|---|
| $L_h$ | = | Drainage pipe spacing or length of slope measured horizontally | = | See Below | |
| $k_{veg}$ | = | Permeability of the vegetative supporting soil | = | 0.000042 | cm/sec |
| S | = | The liner's slope, **S** = tan **b** | = | 25% | b = 14˚ |
| $FS_{slope}$ | = | Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces | = | 1.5 | |
| $\delta_{req'd}$ | = | Minimum interface friction angle = $\tan^{-1}$(FS*tan(b)) | = | 20.6 | degrees |
| $FS_d$ | = | Overall factor of safety for drainage | = | 2.0 | |
| $RF_{in}$ | = | Intrusion Reduction Factor | = | 1.1 | |
| $RF_{cr}$ | = | Creep Reduction Factor | = | 1.2 | |
| $RF_{cc}$ | = | Chemical Clogging Reduction Factor | = | 1.1 | |
| $RF_{bc}$ | = | Biological Clogging Reduction Factor | = | 1.4 | |
| w | = | Geocomposite width at drainage outlet | | | |
| A | = | Final cover plan area upslope of geocomposite drainage outlet | | | |

Determine the maximum slope length for a given ultimate transmissivity

Min. $\Theta_{req}$ = A X $k_{veg}$ / ( w X sinβ )

For the outlet at the corner, use minimum 5 foot width and 2 foot width of geocomposite to connect the toe drain to drain the converging flow area:

| Area | A (sq. feet) | w (feet) | w (meter) | Min. $\Theta_{ult}$ ($m^2$/sec) | Proposed $\Theta_{ult}$ ($m^2$/sec) |
|---|---|---|---|---|---|
| 1 | 420 | 5 | 1.52 | 1.81E-04 | 1.00E-03 |
| 4 | 70 | 2 | 0.61 | 7.53E-05 | 1.00E-03 |

The toe drainage areas, Area 1 and Area 4, include only converging flow below the lowest intermediate drainage piping, as flow above this area is diverted. There are intermediate drainage pipes in Areas 1 and 4 which divert flow from the outlet corner to the downslope flume.

For converging flow in a circular arc, from radius R-top to radius R-bottom:

L = R-top - R-bottom

w-bot = w-top * (R-bot/R-top)

A = L* ( 1+ (R-bot/R-top))/2 (assuming unit width at top and trapezoid vs arc to simplify)

Θult-bot = (Θult calculated for L) * R-top/R-bot * ( 1+ (R-bot/R-top))/2

**Calculation: (Cont.)** For the southern convergence area, flow paths A-E, calculate Θult for selected R-bot values to determine appropriate geocomposite products as flow converges down the slope:

| Flow Path | R-top (feet) | R-bot (feet) | $L_h$ (feet) | $L_h$ (meters) | $\Theta_{ult}$ ($m^2$/sec) | Proposed $\Theta_{ult}$ ($m^2$/sec) |
|---|---|---|---|---|---|---|
| Area 1 | | | | | | |
| A1 | 138 | 26 | 112 | 34 | 7.57E-04 | 1.00E-03 |
| B1 | 132 | 24 | 108 | 32 | 7.34E-04 | 1.00E-03 |
| C1 | 129 | 23 | 106 | 32 | 7.47E-04 | 1.00E-03 |
| D1 | 126 | 21 | 105 | 32 | 7.91E-04 | 1.00E-03 |
| E1 | 122 | 20 | 102 | 31 | 7.77E-04 | 1.00E-03 |
| Area 2 | | | | | | |
| A2 | 306 | 138 | 168 | 51 | 5.79E-04 | 1.00E-03 |
| B2 | 294 | 132 | 162 | 49 | 5.58E-04 | 1.00E-03 |
| C2 | 286 | 129 | 157 | 47 | 5.34E-04 | 1.00E-03 |
| D2 | 278 | 126 | 152 | 46 | 5.21E-04 | 1.00E-03 |
| E2 | 270 | 122 | 148 | 45 | 5.11E-04 | 1.00E-03 |
| Area 3 | | | | | | |
| A3 | 328 | 306 | 22 | 6 | 4.39E-05 | 1.00E-03 |
| B3 | 357 | 294 | 63 | 19 | 1.49E-04 | 1.00E-03 |
| C3 | 419 | 286 | 133 | 40 | 3.48E-04 | 1.00E-03 |
| D3 | 319 | 278 | 41 | 12 | 9.10E-05 | 1.00E-03 |
| E3 | 285 | 270 | 15 | 4 | 2.91E-05 | 1.00E-03 |

**Conclusions:** For the southern area proposed design with intermediate slope outlets and a toe-of-slope drainage outlet, placement of geocomposite with the required transmissivities to the minimum lengths/areas shown in the table above and on the attached drawing will provide adequate drainage for the converging flow.

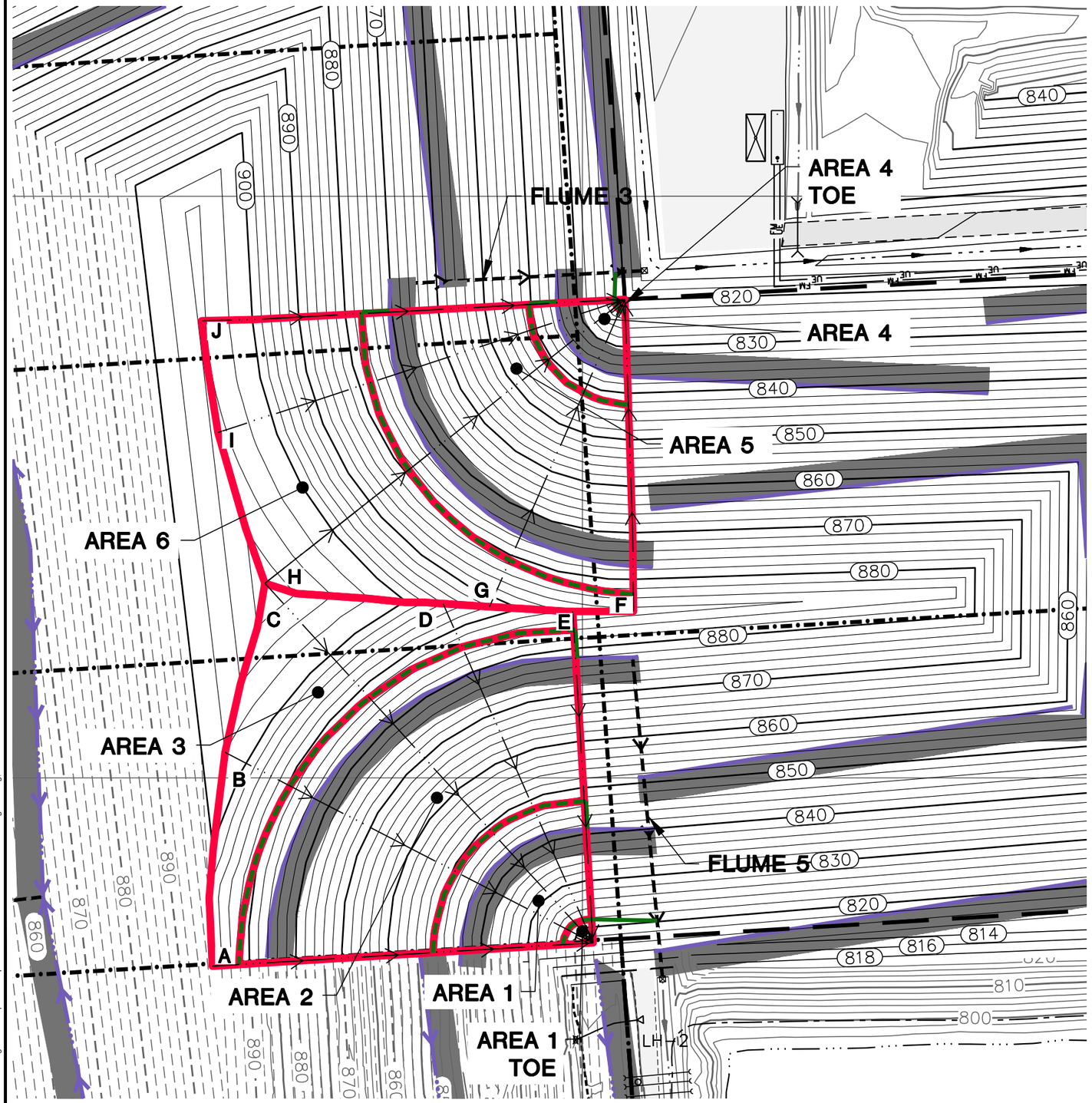
A minimum interface friction angle of 20.6 degrees for the geocomposite, geomembrane, and GCL interfaces is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.

**Calculation: (Cont.)** For the northern convergence area, flow paths F-J, calculate Θult for selected R-bot values to determine appropriate geocomposite products as flow converges down the slope:

| Flow Path | R-top (feet) | R-bot (feet) | $L_h$ (feet) | $L_h$ (meters) | $\Theta_{ult}$ ($m^2$/sec) | Proposed $\Theta_{ult}$ ($m^2$/sec) |
|---|---|---|---|---|---|---|
| Area 4 | | | | | | |
| F4 | 91 | 11 | 80 | 24 | 7.86E-04 | 1.00E-03 |
| G4 | 87 | 10 | 77 | 23 | 7.88E-04 | 1.00E-03 |
| H4 | 86 | 9 | 77 | 23 | 8.57E-04 | 1.00E-03 |
| I4 | 84 | 9 | 75 | 22 | 8.03E-04 | 1.00E-03 |
| J4 | 83 | 9 | 74 | 22 | 7.94E-04 | 1.00E-03 |
| Area 5 | | | | | | |
| F5 | 254 | 91 | 163 | 49 | 6.56E-04 | 1.00E-03 |
| G5 | 245 | 87 | 158 | 48 | 6.47E-04 | 1.00E-03 |
| H5 | 237 | 86 | 151 | 46 | 6.10E-04 | 1.00E-03 |
| I5 | 231 | 84 | 147 | 44 | 5.83E-04 | 1.00E-03 |
| J5 | 227 | 83 | 144 | 43 | 5.67E-04 | 1.00E-03 |
| Area 6 | | | | | | |
| F6 | 268 | 254 | 14 | 4 | 2.90E-05 | 1.00E-03 |
| G6 | 289 | 245 | 44 | 13 | 1.00E-04 | 1.00E-03 |
| H6 | 395 | 237 | 158 | 48 | 4.52E-04 | 1.00E-03 |
| I6 | 368 | 231 | 137 | 41 | 3.75E-04 | 1.00E-03 |
| J6 | 365 | 227 | 138 | 42 | 3.87E-04 | 1.00E-03 |

**Conclusions:** For the northern area proposed design with intermediate slope outlets and a toe-of-slope drainage outlet, placement of geocomposite with the required transmissivities to the minimum lengths/areas shown in the table above and on the attached drawing will provide adequate drainage for the converging flow.

A minimum interface friction angle of 20.6 degrees for the geocomposite, geomembrane, and GCL interfaces is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.




**LEGEND**

- LIMITS OF WASTE
- LINER PHASE/MODULE LIMIT
- 810 — EXISTING GRADE (10' INTERVAL)
- EXISTING GRADE (2' INTERVAL)
- SWALE
- EDGE OF WATER
- WETLAND
- 840 — PROPOSED PHASE 1 FINAL GRADE (10' INTERVAL)
- PROPOSED PHASE 1 FINAL GRADE (2' INTERVAL)
- 840 — PROPOSED GRADE (10' INTERVAL)
- PROPOSED GRADE (2' INTERVAL)
- PROPOSED PERIMETER ROAD
- PROPOSED SWALE
- PROPOSED CULVERT
- PROPOSED LEACHATE COLLECTION SYSTEM CLEANOUT
- PROPOSED LEACHATE VAULT
- FM — PROPOSED LEACHATE FORCEMAIN
- UE — PROPOSED UNDERGROUND ELECTRIC
- PROPOSED DIVERSION BERM
- PROPOSED DOWNSLOPE FLUME
- PROPOSED ENERGY DISSIPATOR
- PROPOSED RIPRAP
- CONVERGENCE FLOW PATH
- PERFORATED SUBSURFACE PIPING
- SOLID SUBSURFACE PIPING

N

10 0 10

SCALE: 1" = 10'

GEOTECHNICAL CALCULATION – FLOW CONVERGENCE

PLAN OF OPERATION
2022 UPDATE
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SITE

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT

FIGURE 1

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

| | |
|---|---|
| PROJECT NO. | 25220183.00 |
| DRAWN: | 01/25/2022 |
| REVISED: | 05/02/2022 |
| DRAWN BY: | KP/MJT |
| CHECKED BY: | DN |
| APPROVED BY: | |

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| | | | |
|---|---|---|---|
| | | Sheet No. | 1 of 1 |
| | | Calc. No. | |
| | | Rev. No. | |
| Job No. 25220183.00 | Job: Columbia Dry Ash Disposal Facility | By: MJT | Date: 04/25/22 |
| Client: WPL | Subject: GCL Internal Shear on Final Cover | Chk'd: DLN | Date: 04/26/22 |

**Purpose:** Determine the maximum shear stress acting on a Geosynthetic Clay Liner (GCL) and the GCL internal shear strength required to provide a minimum slope stability safety factor (FS) of 1.5 for the final cover.

**Approach:** Use maximum shear stress formula and assumed values.

**References:** Design of GCL Barrier for Final Cover Side Slope Applications, Gregory N. Richardson, Ph.D., P.E., Geosynthetics '97-541

**Calculation:** The maximum shear stress acting on the GCL can be calculated as follows:

$$\tau_{act} = W_T \sin \beta$$

$$\beta = 14^\circ$$

$$W_T = \gamma \times h$$

Where: $\gamma$ = Soil Unit Weight = 120 pcf

$h$ = Cover Thickness = 2.5 ft

$$W_T = 300 \text{ psf}$$

$$\tau_{act} = 72.6 \text{ psf}$$

$$FS = \frac{\tau_{resist}}{\tau_{act}} = 1.5$$

$$\tau_{resist} = FS \times \tau_{act} = 1.5 \times 72.6 = 109 \text{ psf}$$

**Assumptions:** Slope angle, $\beta = 14^\circ$ (4:1 horizontal / vertical final cover slope)

Soil unit weight, $\gamma = 120$ pcf

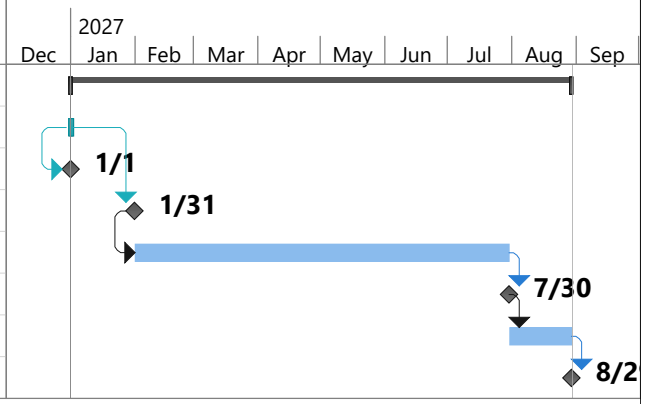
**Conclusion:** For a total weight of the final cover system of 300 psf and a slope angle of 4:1, the maximum shear stress will be 72.6 psf. A minimum GCL internal shear strength of 109 psf is required to provide a slope stability safety factor of 1.5.

# Appendix B

# Schedule

# Closure Plan - Columbia Ash Disposal Facility

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Closure of Columbia Ash Disposal Facility** | **241 days** | **Fri 1/1/27** | **Sun 8/29/27** |
| 2 | Ash Filling Ceases | 1 day | Fri 1/1/27 | Fri 1/1/27 |
| 3 | Other Regulatory Permits - None | 0 days | Fri 1/1/27 | Fri 1/1/27 |
| 4 | Notification of Intent to Close | 0 days | Sun 1/31/27 | Sun 1/31/27 |
| 5 | Construction Activities | 180 days | Mon 2/1/27 | Fri 7/30/27 |
| 6 | Notification of Closure Completion | 0 days | Fri 7/30/27 | Fri 7/30/27 |
| 7 | Documentation of Closure | 30 days | Sat 7/31/27 | Sun 8/29/27 |
| 8 | State Submittal of Documentation Report | 0 days | Sun 8/29/27 | Sun 8/29/27 |




Date: Tue 1/31/23

| | | | | | |
|---|---|---|---|---|---|
| Task | | Inactive Summary | | External Tasks | |
| Split | | Manual Task | | External Milestone | |
| Milestone | | Duration-only | | Deadline | |
| Summary | | Manual Summary Rollup | | Progress | |
| Project Summary | | Manual Summary | | Manual Progress | |
| Inactive Task | | Start-only | | | |
| Inactive Milestone | | Finish-only | | | |

# Appendix C4

# Written Long–Term Care Plan

# Post-Closure Care Plan

Columbia Dry Ash Disposal Facility
Phase 1 Module 1
Phase 1 Module 2
Phase 1 Module 3
Phase 1 Module 4
Phase 1 Module 5
Phase 1 Module 6
Phase 2 Module 10
Phase 2 Module 11

Prepared for:

Wisconsin Power and Light Company
Columbia Energy Center
W8375 Murray Road
Pardeeville, Wisconsin 53954

SCS ENGINEERS

25222260.00 | February 1, 2023

2830 Dairy Drive
Madison, WI 53718-6751
608-224-2830

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Figures

Figure 1. Site Location Map
Figure 2. Post-Closure Care Plan

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# PE CERTIFICATION

I, Phillip Gearing, hereby certify that I am a licensed professional engineer in the State of Wisconsin in accordance with the requirements of ch. A–E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A–E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code.

Specifically,

- This Post-Closure Care Plan was prepared by me or under my direct supervision and meets the requirements of 40 CFR 257.104(d) and NR 514.07(10)(d)

February 1, 2023

(signature) (date)

Phillip E. Gearing

(printed or typed name)

License number _____E-45115_____

My license renewal date is ___July 31, 2024_____.

Pages or sheets covered by this seal:

ALL

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# 1.0 INTRODUCTION AND PROJECT SUMMARY

On behalf of Wisconsin Power and Light Company (WPL), SCS Engineers (SCS) has prepared this Post-Closure Care Plan for the Columbia (COL) Dry Ash Disposal Facility Phase 1, Modules 1 through 6 and Phase 2, Modules 10 and 11 as required by 40 Code of Federal Regulations (CFR) 257.104 and Wisconsin Administrative Code NR 514.07(10)(d), as stated below.

40 CFR 257.104(d). *"Written post-closure plan – (1) Content of the plan. The owner or operator of a CCR unit must prepare a written post-closure plan that includes, as a minimum, the information specified in paragraphs (d)(1)(i) through (iii) of this section."*

NR 517.07 (10)(d). *"A written long–term care plan that addresses all of the following: 1. A description of the monitoring and maintenance activities and the frequency at which those activities will be performed. The activities shall include, at a minimum, all of the following:"*

The COL facility includes an active coal combustion residual (CCR) landfill, which currently consists of the following modules, located in Phase 1 and Phase 2 of the facility.

- **Phase 1, Module 1** – This module has received final cover over outer sideslope areas that will no longer receive additional CCR; intermediate cover has been placed over remaining areas. The final cover placed complies with the CCR Rule.

- **Phase 1, Module 2** – This module has received intermediate cover over a majority of the in-place CCR.

- **Phase 1, Module 3** – This module has received intermediate cover over a majority of the in-place CCR.

- **Phase 1, Module 4** – This module is currently being filled.

- **Phase 1, Module 5** – This module is currently being filled.

- **Phase 1, Module 6** – This module is currently being filled.

- **Phase 2, Module 10** – Construction of the Module 10 liner began in 2022. The new module will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for Wisconsin Department of Natural Resources (WDNR) review early in 2023. Filling is anticipated to begin in 2023.

- **Phase 2, Module 11** – Construction of the Module 11 liner began in 2022. The new module will be used for disposal following approval of the liner Construction Documentation Report, which will be submitted for WDNR review early in 2023. Filling is anticipated to begin in 2023.

Phase 1, Modules 1-3 were previously described as separate existing CCR landfills although they are contiguous and are managed as a single landfill by the facility and by the WDNR. WPL has clarified in the operating record for the Columbia facility that Modules 1-3 are one existing CCR landfill as defined in 40 CFR 257.53 of the federal CCR Rule. Phase 1, Modules 4-6 are considered to be a new CCR landfill that initiated construction after October 19, 2015, and is therefore managed as a separate CCR unit under the CCR Rule even though they are contiguous to the existing CCR landfill

(Modules 1-3). In addition, the new CCR landfill will include Phase 2, Modules 10 and 11, once the liner construction documentation is approved by the WDNR in 2023. Construction of additional modules is not currently planned prior to retirement of the Columbia Energy Center, which is currently scheduled to occur no later than June 1, 2026.

The site location is shown on **Figure 1**. **Figure 2** shows proposed final cover grades and monitoring locations.

Phase 1, Module 1 has been partially closed with a final cover as described in the Closure Plan for the existing CCR landfill. The remaining open areas of this module will be closed when CCR materials reach final waste grades, as described in the Plan of Operations approved by the WDNR. The future final cover system is planned to differ from the existing final cover system, as explained in the Closure Plan. Following the closure of the CCR units at COL, WPL will conduct post-closure care in accordance with 40 CFR 257.104(b) for the required 30 years and with NR 514.07(10)(d) for the required 40 years per NR 506.084(2).

# 2.0 MONITORING AND MAINTENANCE ACTIVITIES

40 CFR 257.104(d)(1)(i). *"A description of the monitoring and maintenance activities required in paragraph (b) of this section for the CCR unit, and the frequency at which these activities will be performed."*

NR 514.07(10)(d)(1). *"A description of the monitoring and maintenance activities and the frequency at which those activities will be performed."*

| Monitoring and Maintenance Activities | Frequency |
|---|---|
| Mowing | Semi-Annually |
| Inspections by Owner/Operator | Quarterly |
| Repair to Final Cover for Erosion Concerns | As needed, determined by inspection |
| Sedimentation Basin Cleaning | As needed, determined by inspection |
| Leachate Collection Line Cleaning | Annually |
| Environmental Monitoring (groundwater, leachate) | Semi-Annually |

The owner/operator will perform quarterly inspections of the landfill surface, leachate control system, and groundwater monitoring systems. If issues are noticed during the inspection, action will be taken to remedy the situation. Eroded areas will be repaired and reseeded. Repairs or replacement will be performed on the groundwater monitoring system as needed.

## 2.1 FINAL COVER MAINTENANCE

Mowing will be performed semi-annually during the growing season unless additional mowing is required in response to the vegetation growth rate. During quarterly inspections, if eroded areas are noted, WPL will repair and reseed the area.

## 2.2 LEACHATE COLLECTION AND REMOVAL SYSTEM MAINTENANCE

The leachate collection and removal system for the existing CCR landfill and existing / future units will be maintained to meet state requirements including leachate collection line cleaning, leachate collection video inspection, and any needed repairs to the existing system.

Phase 1, Module 4 was constructed and opened in 2018. Module 4 is a new CCR landfill as defined in 40 CFR 257.53. Phase 1, Modules 5 and 6 were constructed in 2021. Phase 2, Modules 10 and 11 began construction in 2022. These modules are defined as lateral expansions of the new CCR landfill. Phase 1, Modules 4, 5, and 6 and Phase 2, Modules 10 and 11 are in compliance with the requirements of 40 CFR 257.70, as demonstrated in the Liner and Leachate Collection System Design Compliance Demonstrations. Phase 1, Modules 4, 5, and 6 and Phase 2, Modules 10 and 11 are in compliance with the requirements of NR 504.12, as demonstrated in the Plan of Operation Modification Request WDNR CCR Code Update Report.

## 2.3 GROUNDWATER MONITORING AND SYSTEM MAINTENANCE

All CCR Wells, as defined by NR 500.03(26y) and approved by the Department, will be maintained and sampled semi-annually for the parameters listed in Appendix III to Part 257 and listed in Appendix I, Table 1A to NR 507, and in accordance with 40 CFR 257.90-98 and NR 507.15 (3).

Non-CCR monitoring wells at the site will be maintained and sampled as approved by the Department in writing.

# 3.0 POST-CLOSURE PERIOD CONTACTS

40 CFR 257.104(d)(1)(ii). *"The name, address, telephone number, and email address of the person or office to contact about the facility during the post-closure period."*

NR 514.07(10)(d)(2). *"The name, address, telephone number, and email address of the person or office to contact about the facility during long–term care."*

Currently, the contact information for COL during the post-closure/long-term care period is as follows:

Columbia Energy Center
Attn: Plant Manager
W8375 Murray Road
Pardeeville, WI 53954
(608) 742-0711
CCRProgram@alliantenergy.com

# 4.0 POST-CLOSURE PERIOD SITE USE

40 CFR 257.104(d)(1)(iii). *"A description of the planned uses of the property during the post-closure period. Post-closure use of the property shall not disturb the integrity of the final cover, liner(s), or any other component of the containment system or the function of the monitoring systems unless necessary to comply with the requirements of the subpart…"*

NR 514.07(10)(d)(3). *"A description of the planned uses of the property during long–term care. Post–closure uses may not disturb the integrity of the final cover, liner, or any other component of*

*the landfill, or the function of the monitoring systems unless approved in writing by the department…."*

The final use of the COL Dry Ash Disposal Facility will be privately owned green space. With this use, there will be no disturbance of the final cover or any other landfill-related components.

# 5.0 CERTIFICATIONS

40 CFR 257.104(d)(4). *"The owner or operator of the CCR unit must obtain a written certification from a qualified professional engineer that the initial and any amendment of the written post-closure plan meets the requirements of this section."*

NR 500.05. *"Unless otherwise specified, all submittals for review and approval of any initial site report, feasibility report, plan of operation site investigation report, remedial action options report, construction documentation report, or closure plan, or any modifications to those plans, shall include all of the following:*

*(4) CERTIFICATION. (a) The reports and plan sheets shall be under the seal of a licensed professional engineer."*

Phillip Gearing, PE, a licensed profession engineer in the State of Wisconsin, has overseen the preparation of this Post-Closure Care Plan. A certification statement is provided on **page iii** of this plan.

# 6.0 RECORDKEEPING AND REPORTING

40 CFR 257.104(b)(2)(iii). "*The owner or operator has completed the written post-closure plan when the plan including the certification required by paragraph (d)(4) of this section, has been placed in the facility's operating record as required by Section 257.105(i)(4)."*

NR 506.17(2)(e). *"The written operating record shall contain the plan of operation, plan modifications, construction documentation, department approvals, annual reports, inspection records, monitoring and corrective action records, notifications to the department, and records of public comments received during any public comment period."*

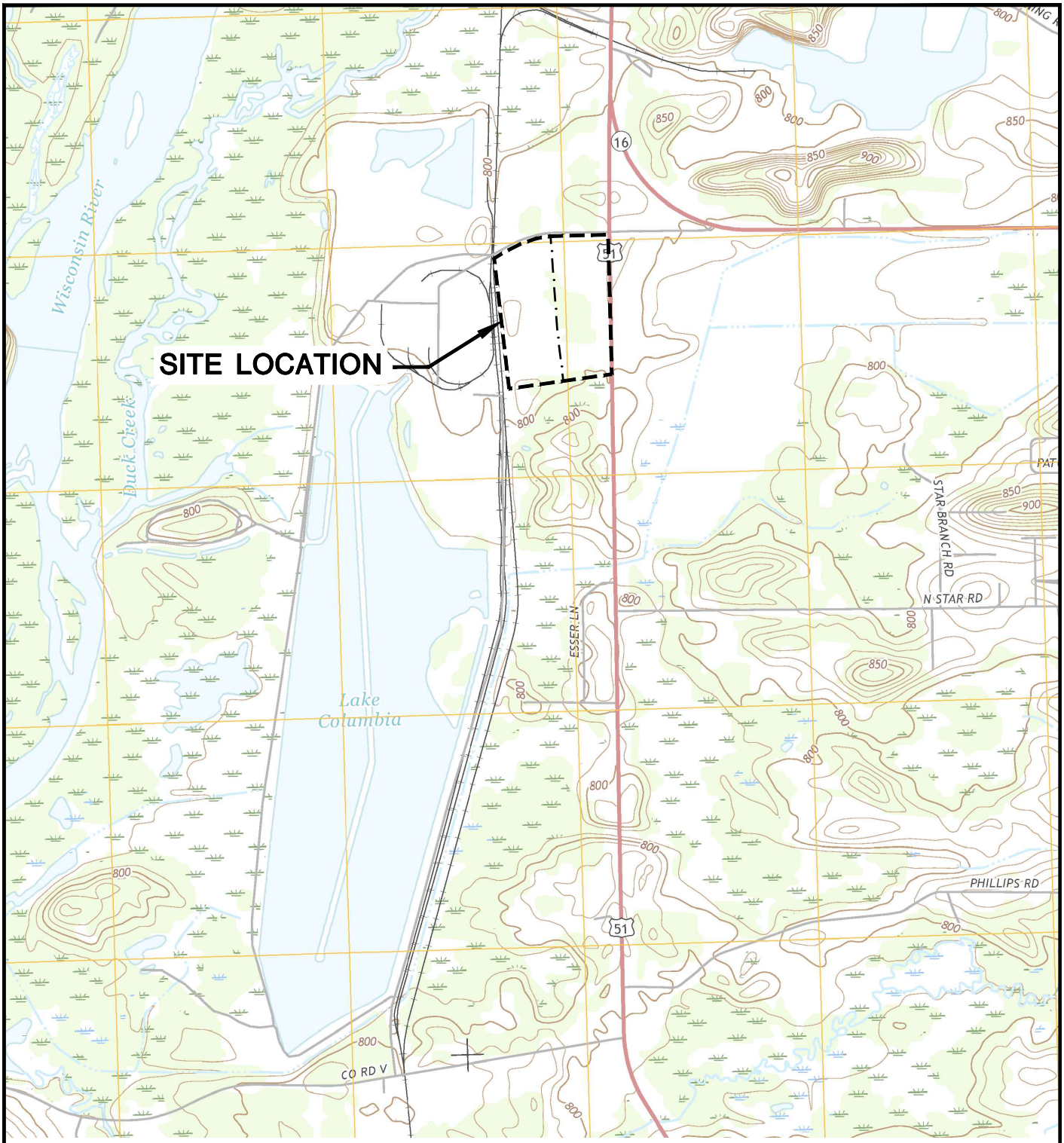
The Post-Closure Care Plan will be placed in the facility's operating record and on Alliant Energy's CCR Rule Compliance Data and Information website, as will all amendments.

WPL will amend the Post-Closure Care Plan if there is a change in operation of the CCR unit that affects the written Post-Closure Care Plan or, if after post-closure activities have started, unexpected events cause a revision of the plan.

WPL will provide notification of completion of the post-closure care no later than 60 days following the completion of the post-closure care period. The notification will include certification by a qualified professional engineer verifying that post-closure care has been completed in accordance with the plan. The notification will be placed in the facility's operating record and on the website.

Figures

1 Site Location Map
2 Post-Closure Care Plan




N

POYNETTE QUADRANGLE
WISCONSIN–COLUMBIA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
2016
SCALE: 1" = 2,000'

| | | | |
|---|---|---|---|
| CLIENT | WISCONSIN POWER AND LIGHT<br>COLUMBIA ENERGY CENTER<br>W8375 MURRAY ROAD<br>PARDEEVILLE, WISCONSIN 53954 | SITE | POST CLOSURE CARE PLAN<br>COLUMBIA DRY ASH DISPOSAL FACILITY<br>TOWN OF PACIFIC, WISCONSIN |

SITE LOCATION MAP

| | | | |
|---|---|---|---|
| PROJECT NO. | 25222260.00 | DRAWN BY: | AHB |
| DRAWN: | 08/09/2016 | CHECKED BY: | RJG |
| REVISED: | 12/28/2022 | APPROVED BY: | PEG 01/31/23 |

ENGINEER
SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

FIGURE
1

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LEGEND

- ASH DISPOSAL FACILITY LIMITS
- APPROVED LIMITS OF ASH FILL
- PHASE/MODULE LIMIT
- 810 EXISTING GRADE (10' CONTOUR)
- EXISTING GRADE (2' CONTOUR)
- PAVED ROAD
- UNPAVED ROAD
- RAILROAD TRACKS
- VEGETATION
- FENCE
- SWALE
- EDGE OF WATER
- APPROXIMATE LIMITS OF EXISTING LEACHATE/SURFACE WATER POND LINER
- CULVERT
- TRANSMISSION TOWER
- WATER SUPPLY WELL
- WATER TABLE WELL
- PIEZOMETER
- SURFACE WATER SAMPLE LOCATION
- LYSIMETER
- LEACHATE HEADWELL
- BENCHMARK
- 820 PROPOSED FINAL GRADES (10' CONTOUR)
- PROPOSED FINAL GRADES (2' CONTOUR)

NOTES:

1. BASE MAP CREATED FROM AERIAL SURVEY BY KBM, FLOWN DECEMBER 1, 2014, AND GROUND SURVEY BY SCS ENGINEERS IN DECEMBER 2020, AND BY DRONE SURVEY BY AMES ON JANUARY 17, 2023.
2. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY WISCONSIN POWER AND LIGHT, INC. IN DECEMBER 1994, NOVEMBER 1996, APRIL 2003, AUGUST 2012, JANUARY 2016, AND BY SCS ENGINEERS IN MAY 2019.

N

400 0 400

SCALE: 1" = 400'

CLOSED PRIMARY ASH POND
CLOSED SECONDARY ASH POND
CLOSED ASH PONDS LANDFILL (LICENSE NO. 02325)
ASH EXPANSION AREA (LICENSE NO. 02325)
POWER GENERATING STATION
WPDES POND
SUBSTATION
COOLING POND
COOLING POND
EXISTING LANDFILL (LICENSE #03025)
LANDFILL SURFACE WATER RUNOFF/ LEACHATE COLLECTION POND
HIGHWAY 51
MURRAY RD.
BM200
HC-1
HC-2
HC-3
MW-301
MW-302
MW-309
MW-310
MW-311
MW-312
MW-313
MW-314
MW-315
MW-33AR
MW-33BR
MW-34A
MW-34B
MW-37A
MW-5R
MW-83
MW-84A
MW-84B
MW-86
MW-91AR
MW-91B
MW-92A
MW-92B
MW-93A
MW-93B
LH-1A
LH-1B
LH-2
LH-3A
LH-3B
LH-5
LH-6
LP-1
LS
LS-3R

POST-CLOSURE CARE PLAN
COLUMBIA DRY ASH DISPOSAL FACILITY
TOWN OF PACIFIC, WISCONSIN

SITE

WISCONSIN POWER AND LIGHT
COLUMBIA ENERGY CENTER
W8375 MURRAY ROAD
PARDEEVILLE, WISCONSIN 53954

CLIENT

FIGURE 2

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

| | |
|---|---|
| PROJECT NO. | 252222260.00 |
| DRAWN: | 12/18/2017 |
| REVISED: | 1/25/2023 |
| DRAWN BY: | BJM/KP |
| CHECKED BY: | PEG |
| APPROVED BY: | PEG 01/31/23 |

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