



Inver Grove Heights Environmental Commission
Thursday, October 26, 2023 at 7:00 PM
8150 Barbara Avenue, Inver Grove Heights, MN 55077

AGENDA

NOTICE TO RESIDENTS: Individuals may submit written public comments in advance of the meeting by emailing comments to Rebecca Kiernan (rkiernan@ighmn.gov). Comments received prior to 4:00 p.m. on Thursday, October 26, 2023, will be provided to the Council at or before the October 26, 2023 meeting.

1. **Call to Order**
2. **Roll Call**
3. **Presentations**
 - A. Environmental Advisory Commission Meeting Guidance
4. **Approval of Minutes**
5. **Regular Agenda**
 - A. Submittal of City of Inver Grove Heights' Review of Pine Bend Landfill's 2022 Request for Major Modification of Permit to the Minnesota Pollution Control Agency
6. **Public Comment**

Public comment provides an opportunity for the public to address the Commission on items that are not on the agenda. Comments will be limited to three (3) minutes per person.
7. **Commission and Staff Comments**
8. **Adjourn**

This document is available upon a three (3) business day request in alternate formats such as braille, large print, audio recording, etc. Please contact Rebecca Kiernan, City Clerk, at 651.450.2513 or rkiernan@ighmn.gov.



Environmental Advisory Commission Staff Report

SUBJECT: **Environmental Advisory Commission Meeting
Guidance**

MEETING DATE: October 26, 2023

ITEM TYPE: Presentations

CONTACT: Ally Sutherland, Environmental Specialist, 651.604.8511

PURPOSE/ACTION REQUESTED

Staff will review new Environmental Advisory Commission meeting guidance.

BACKGROUND

City Advisory Commissioners are appointed by the City Council to review and approve items presented by staff according to the duties of their advisory commission defined by city code. The City of Inver Grove Heights values the expertise, dedication and time provided by city volunteer Commissioners.

Robert's Rules of Order ("Robert's Rules") is a set of guiding principles for facilitating group discussions and decision-making. These guidelines help ensure that meetings are fair, efficient, democratic, and orderly. To ensure Commission meetings are respectful and productive for all volunteer Commissioners, staff, applicants and the public, the City requests Commissioners follow the new guidance based on Robert's Rules. Staff will review new Environmental Advisory Commission meeting guidance with the Commission.

FISCAL IMPACT

This item has no financial cost.

RECOMMENDATION

N/A

ATTACHMENTS

1. EAC Meeting Guidance

City of Inver Grove Heights Environmental Advisory Commission Meeting Guidance

City Advisory Commissioners are appointed by the City Council to review and approve items presented by staff according to the duties of their advisory commission defined by city code. The City of Inver Grove Heights values the expertise, dedication and time provided by city volunteer Commissioners.

Robert's Rules of Order ("Robert's Rules") is a set of guiding principles for facilitating group discussions and decision-making. These guidelines help ensure that meetings are fair, efficient, democratic, and orderly. To ensure Commission meetings are respectful and productive for all volunteer Commissioners, staff, applicants and the public, the City requests Commissioners follow the guidance below based on Robert's Rules.

The Chair will:

- Review the item packet in full prior to the meeting.
- Facilitate the meeting. This includes calling the meeting to order, facilitating discussions, and requesting motions.
- Lead the commission through the agenda to keep moving forward.
- Model courtesy and respect and insist that others do the same for all Commissioners, staff, applicants, and the public.
- Request comments from the public for each item and during public comment. Request all public speakers state their name and address for the record and limit comments to three minutes per person.
- Request comments from the applicant after staff report is presented. Request the applicant state their name for the record.
- Reiterate the staff request prior to the item discussion. Request Commissioners share comments or questions related to the staff request. Call on Commissioners in order of the seating chart. Alternate first Commissioner called upon throughout agenda.
- Encourage all Commissioners to provide their perspective. Let all members speak once before allowing anyone else to speak a second time. Give each speaker your undivided attention.
- Listen to Commissioner comments. Broadly summarize perspectives with the goal of finding consensus between the majority of Commissioners.
- Keep an emotional pulse on the discussions. When discussions get off-track, gently guide the group back to the agenda.
- Request Commissioners make a first and second motion after the item discussion. Encourage members to present motions positively rather than negatively.
- Request staff calls role after motion is seconded.
- Request a 5-minute recess if needed between items.

Commissioners will:

- Review the item packet in full prior to the meeting.
- Be respectful to all Commissioners, staff, applicants, and the public.

- Make comments directly focused on the staff request. State comments and questions clearly by specifying if you are in favor, not in favor, or need more information such as:
 1. **In favor:** "I would recommend the action as stated." or "I would recommend the action as stated in the packet because..."
 2. **Not in favor:** "I would not recommend the action as stated because..."
 3. **Clarification/Change requested:** "This action should be updated to include/remove/etc..." or "I have a question regarding..."
- Present thoughts clearly and precisely during item discussion. Thoughts should be summarized and prioritized in a comment limited to 3-5 minutes.
- Let all members speak once before requesting to speak a second time during the item discussion. Raise hand and request floor from Chair to make second comment or pose additional question to staff or the applicant.
- Request the floor to make a motion. When granted, state "I move to...". Another member must second the motion by stating, "I second the motion." Once someone seconds the motion, the group votes on the motion. Motion will pass with majority vote.
- Commissioners are encouraged to share non-agenda comments during the "commissioner comments" agenda item. To adhere to open meeting laws and best practices, Commissioners are advised to direct all emails to the staff liaison without replying or copying other Commissioners. Staff liaison will share the information with the full commission via email as requested.



Environmental Advisory Commission Staff Report

SUBJECT: **Submittal of City of Inver Grove Heights' Review of Pine Bend Landfill's 2022 Request for Major Modification of Permit to the Minnesota Pollution Control Agency**

MEETING DATE: October 26, 2023

ITEM TYPE: Regular Agenda

CONTACT: Ally Sutherland, Environmental Specialist, 651.604.8511

PURPOSE/ACTION REQUESTED

The Environmental Advisory Commission is asked to recommend submittal of the City's Review of the Pine Bend Landfill's 2022 Request for Major Modification of Permit to the Minnesota Pollution Control Agency.

BACKGROUND

Pine Bend Landfill (Landfill), operated by BFI Waste Systems of North America LLC (BFI), is a Municipal Solid Waste (MSW) landfill located at 2495 117th St E in Inver Grove Heights. Pine Bend Landfill remains one of the largest mixed municipal solid waste landfills within the Twin Cities Metro Area (TCMA), resulting in disposal of several hundred thousand tons of regional waste in Inver Grove Heights annually. Although landfilling is designated as the State of Minnesota's least favorable solid waste disposal method, the [draft Metropolitan Solid Waste Policy Plan 2022–2042](#) confirms that landfilling will remain a necessary form of disposal for TCMA waste through 2042. In 2021, Pine Bend Landfill received [the largest allocation of preliminary TCMA certificate of need \(CON\)](#) from the MPCA, in the amount of 2,398,746 tons, for additional MSW disposal capacity. Acceptance of this additional CON and waste not requiring CON would require the Landfill to vertically expand and extend the approved duration to operate.

The Landfill is currently operating under existing permits and approvals issued by the Minnesota Pollution Control Agency (MPCA), Metropolitan Council Environmental Services (MCES), Dakota County and the City of Inver Grove Heights (City). On September 15, 2022, BFI submitted an addendum to its June 6, 2022 Request for Major Modification of Permit #SW-45 for Pine Bend Landfill to the MPCA. This request details a proposed vertical expansion over the existing Landfill footprint by raising the permitted peak elevations of the Landfill by extending the existing 3:1 slopes. No footprint increase is being proposed as part of the major modification request for vertical expansion. The request includes an additional 8.2 million cubic yards of airspace which would provide an additional 10-12 years of operational capacity. The existing elevation would increase an additional 85 feet at the highest point.

The application and approval process for a vertical expansion at Pine Bend Landfill requires the applicant complete the following tasks listed in the table below. BFI is currently working with the MPCA to complete Tasks 2 and 3:

Task	Status
1. Submit a Request for Major Modification of Permit #SW-45 for Pine Bend Landfill to the MPCA.	Completed
2. Submit Environmental Assessment Worksheet (EAW) application to the Environmental Quality Board.	Pending
3. Submit request to MPCA to amend existing Air Quality Permit (AQP).	Pending
4. Receive negative declaration for EAW.	<i>(not initiated)</i>
5. Receive approval for the AQP amendment.	<i>(not initiated)</i>
6. Submit expansion request to the City to amend existing city agreements including the Non-Conforming Use Certificate, Host Community Agreement and a Conditional Use Permit with the City.	<i>(not initiated)</i>
7. Receive approval for City agreement amendments.	<i>(not initiated)</i>
8. Submit expansion request to Dakota County to amend existing County agreements.	<i>(not initiated)</i>
9. Receive approval for County agreement amendments.	<i>(not initiated)</i>
10. Receive approval of the Request for Major Modification of Permit #SW-45 for Pine Bend Landfill from the MPCA.	<i>(not initiated)</i>

The City has hired Barr Engineering Co. (Barr) to review the Landfill's submittals to the MPCA and the City. Barr has reviewed BFI's Request for Major Modification of Permit #SW-45 for Pine Bend Landfill submitted to the MPCA on June 6, 2022 and September 15, 2022. The requests contain the following items and revisions to the existing #SW-45 permit:

- An Introduction, which includes the MPCA Application Form and Checklists.
- A Design Report, which includes a detailed description of the design revisions and supporting calculations for the vertical expansion, and the following:
 - Updated description of design revisions to incorporate the vertical expansion of the 3:1 final cover slopes over mainly Phase 5 but also portions of Phase 6.
 - Updated volumes table to reflect the current remaining volume and the proposed increase on a phase-by-phase basis.
 - Revisions required for gas system modifications to incorporate the vertical expansion of the 3:1 final cover slopes over Phase 5 and Phase 6.
 - Updated surface water calculations to incorporate the vertical expansion of the 3:1 final cover slopes and for the Atlas 14 rainfall data.
 - Updated technical specifications to reflect current ASTM references and MnDOT standards.
 - Updated geotechnical calculations that reflect the vertical expansion of the 3:1 final cover slope buildout and also to reflect the pipe trench settlement potential for the proposed leachate collection system.
- Operations and Maintenance Plan, which includes a Leachate Management Plan with an updated description, and Gas Management and Monitoring Plan
- Closure, Post-Closure, and Contingency Action Plan and Financial Assurance including:
 - Updated cost estimates for closure, post-closure, and contingency action based on costs actually incurred for construction work at the site.
 - Updated financial assurance calculations based on 2021 MPCA inflation factor and updated cost estimates.

Barr has proposed recommendations included in the attached draft of the City's review of Pine Bend Landfill's 2022 Request for Major Modification of Permit #SW-45 submitted to the MPCA. The City requests the MPCA consider incorporating these recommendations into the MPCA solid waste permit process. The review also notes that changes or additions to the recommendations may be made by the City after review of PBL's response to the proposed recommendations and during the EAW and AQP public comment period. The review will be submitted to the MPCA upon City Council approval.

FISCAL IMPACT

This item has no financial cost.

RECOMMENDATION

Staff recommend submittal of the City's review of the Pine Bend Landfill's 2022 Request for Major Modification of Permit to the Minnesota Pollution Control Agency.

ATTACHMENTS

1. City Review of Landfill Request and Addendum Submitted to MPCA
2. Landfill Request Submitted to MPCA on 06/02/2022
3. Landfill Addendum Submitted to MPCA on 09/15/2022

November XX, 2023

Mr. Abdi Hassan
Staff Engineer
Resource Management & Assistance Division
Minnesota Pollution Control Agency
520 Lafayette Road North
St Paul, MN 55155

Re: City of Inver Grove Heights' Review of Pine Bend Landfill's 2022 Request for Major Modification of Permit #SW-45 Submitted to the Minnesota Pollution Control Agency

Dear Mr. Hassan:

This letter provides the City of Inver Grove Heights' recommendations resulting from review of the Pine Bend Landfill (PBL) "Request for Major Modification of Permit #SW-45", prepared by Stantec Consulting Services Inc. (Stantec), dated June 2, 2022, including the addendum dated September 15, 2022 (June 2022 Application and September 2022 Addendum).

The June 2022 Application and September 2022 Addendum proposes an airspace capacity expansion over the existing landfill footprint by extending the existing 3:1 (horizontal:vertical) sideslopes around the entire existing landfill footprint including filling over the liner and leachate collection system previously installed over old unlined waste.

These recommendations were developed by Barr Engineering Co. (Barr). The City requests that the MPCA consider incorporation of these recommendations into the MPCA solid waste permit process. These recommendations will also be shared with Pine Bend Landfill and Dakota County. **Please note:** Changes or additions to these comments may be made by the City during the Environmental Assessment Worksheet and Air Quality Permit public comment period related to this application.

The City also requests that the MPCA responds to this letter and indicate whether the MPCA concurs with the recommendations below.

In addition to the June 2022 Application and September 2022 Addendum, information used as part of the City's review included:

- The "Application for Permit Renewal," prepared by Wenck Associates, Inc., dated November 2013 (November 2013 Application)
- Request for Major Modification of Permit #SW-45", prepared by Wenck Associates, Inc., dated August 2015 (August 2015 Application)

- SW-45 Pine Bend Landfill 2022 Annual Report
- 2022 Annual Water Quality and Natural Attenuation Monitoring Report
- Republic Services letter dated July 31, 2014 to the City of Inver Grove Heights (Tom Link) regarding air quality concerns associated with the proposed organic waste composter and acknowledging the need to comply with City ordinances and PBL's Non-Conforming Use Certificate
- PBL's MPCA Solid Waste Permit (SW-45) dated July 30, 2015 modified May 31, 2019 (May 2019 Modified MPCA Permit)

Our review of the June 2022 Application and September 2022 Addendum focused on these twelve technical areas:

- I. Waste Acceptance
- II. Groundwater Monitoring System
- III. Leachate Recirculation
- IV. Solid Waste Composting
- V. Groundwater Quality
- VI. Surface Water Management
- VII. Waste Capacity
- VIII. Liner and Leachate Collection System Design
- IX. Gas Monitoring and Gas Extraction/Treatment Systems
- X. Final Cover Design
- XI. Closure, Post Closure, Contingency Action, and Operations and Maintenance Plans
- XII. Financial Assurance Cost Estimates

The recommendations are provided at the end of each topic and are numbered sequentially.

I. Waste Acceptance

The City assumes that the 2014 Solid Waste Management Plan that is approved in the May 2019 Modified MPCA Permit is still the plan being referenced in the June 2022 Application and September 2022 Addendum. If that is the case, then there are no changes being proposed in the June 2022 Application and September 2022 Addendum regarding waste acceptance.

The 2014 Solid Waste Management Plan describes the procedures that PBL uses to manage its mixed municipal and non-hazardous industrial solid waste. More specifically, the 2014 Solid Waste Management Plan describes:

- A customer notification procedure for review and acceptance of waste,
- A list of acceptable and unacceptable wastes plus a list of wastes that PBL does not accept,

- Waste categorization,
- Waste evaluation procedures,
- Use of waste as daily cover,
- Waste inspection and rejection procedures, and
- Numerous appendices including Dakota County Ordinance 110 and a Household Hazardous Waste Management Plan.

Barr recommendations:

1. The Operations and Maintenance Manual, dated August 2015 is listed as an approved plan in the May 2019 Modified MPCA Permit, and the July 2014 Solid Waste Management Plan is an appendix to the Operations and Maintenance Manual. The June 2022 Application and September 2022 Addendum should indicate that the July 2014 Solid Waste Management Plan version is still current.
2. The Operations and Maintenance Plan, dated June 2, 2022 should include the July 2014 Solid Waste Management Plan as an Appendix.

II. Groundwater Monitoring System

Based on the City's review, there are no changes being proposed in the June 2022 Application and September 2022 Addendum relating to the groundwater monitoring system.

Groundwater samples are collected from 22 monitoring wells located upgradient and downgradient from the landfill and two springs located downgradient from the landfill. Groundwater monitoring of flow direction and quality has been ongoing since the landfill began operating in 1971. Routine monitoring is conducted on a quarterly basis to facilitate the detection of releases to groundwater from the landfill in accordance with a sampling and analysis plan (SAP). The SAP establishes sampling methodologies, analytes, and quality assurance/quality control procedures. The SAP also provides for contingencies to increase monitoring intervals if certain water-quality levels are exceeded. Based on the contingency monitoring results, corrective action may be required.

Groundwater flows approximately southwest to northeast underneath the landfill, becoming primarily easterly along the northeast edge of the Crosby-American demolition landfill area located immediately north of PBL. The depth to the groundwater is considerable (over 100 feet in some locations). The water table is in glacial drift. Monitoring wells are completed both shallow and deep in the glacial drift and in the Prairie du Chien Group (limestone). Groundwater underneath the site eventually discharges into the Mississippi River, east of PBL.

Barr recommendations:

- None

III. Leachate Recirculation

Based on the City's review there are no changes being proposed in the June 2022 Application and September 2022 Addendum relating to leachate recirculation.

If implemented, leachate would be performed over lined areas of PBL as described in the November 2013 Application. The leachate would be sprayed onto the waste working surface via tanker truck.

Barr recommendations:

- None

IV. Solid Waste Composting

Solid waste composting was previously proposed as a January 2014 addendum to PBL's November 2013 Application.

City recommendations to model the potential odor and other air emissions from the proposed composting operation were not performed by PBL during the 2013 MPCA permitting process. However, based on discussions between the City and PBL and Republic Services' July 31, 2014 letter to the City, the City agreed that air quality modeling can be delayed until such time as PBL is ready to begin implementing plans to construct the organic waste compost facility. City approval is needed prior to SSOM composting implementation.

Based on the City's review it unclear if solid waste composting is being proposed in the June 2022 Application and September 2022 Addendum.

Barr recommendations:

3. Please clarify if solid waste composting is proposed to be performed as part of the June 2022 Application and September 2022 Addendum.
4. If solid waste composting is not being proposed, please confirm that PBL will obtain City and County approval prior to initiating any solid waste composting activities.

V. Groundwater Quality

As mentioned above, groundwater samples are collected from 22 monitoring wells located upgradient and downgradient from the landfill and two springs located downgradient from the landfill. Samples are analyzed for volatile organic compounds (VOCs), metals, per- and polyfluoroalkyl substances (PFAS), 1,4-dioxane, and general geochemical parameters, such as temperature, specific conductance, and pH.

As has been the case for many years, intervention limits (ILs) are occasionally exceeded for some chlorinated organic compounds that are common in municipal solid waste (e.g., trichloroethylene, tetrachlorethylene, and biogenic breakdown products of these chlorinated compounds). Microbial reduction of the chlorinated compounds takes place in the groundwater and the geochemical indicators of this process are part of the monitoring program. The final reductive breakdown product is vinyl chloride, which is oxidized to carbon

dioxide and water in the more oxidizing conditions downgradient of the landfill. Total concentrations of VOCs have generally shown a downward trend over the past several years. Some temporal increases are observed for individual parameters, which are expected.

Some PFAS concentrations in groundwater have been increasing and some have exceeded their ILs. PFAS concentrations in groundwater are expected to remain elevated in the future and may increase slightly from current levels. In addition, 1,4-dioxane concentrations have increased at several wells, in several cases exceeding the IL. 1,4-dioxane is considered a persistent organic pollutant and is expected to remain elevated in the future and may increase slightly from current levels.

The proposed leachate recirculation system is not expected to have an adverse impact on groundwater quality because the total mass of contaminants in the landfill is not expected to change as a result of leachate recirculation and because leachate recirculation will take place only over lined portions of the landfill.

The proposed solid waste composting operation is anticipated to generate leachate that will be ultimately captured by the landfill composite liner. The solid waste composting operation is not expected to generate any unique water quality parameters when compared to municipal solid waste leachate. Therefore, no modifications are needed to the leachate or groundwater monitoring programs.

Barr recommendations:

- None

VI. Surface Water Management

Barr reviewed the surface water management plan (Section 4.6 and Appendix C of the Design Report). The proposed design uses benches placed generally at 40-foot (vertical) intervals along the 3:1 sideslopes to direct runoff from the build-out expansion area to cable-concrete-lined trapezoidal channels, which discharge through existing and proposed junction vaults, pipes, and culverts to existing stormwater ponds. HydroCAD was used to simulate rainfall-runoff from the site. According to the proposed plan, the existing ponds would not overflow from the site during the 100-year, 24-hour runoff event.

Barr recommendations:

5. Please provide the HydroCAD model files for review with the next submittal.
6. Design Report, Section 4.6.3.1. Provide an explanation for the choices of curve numbers B and C for the sloped and flat areas, respectively. These curve numbers will result in steeper sloped areas producing less runoff volume than flatter areas. Is the cover soil different? It seems that if the cover soil were the same, the steeper sloped areas would produce greater runoff volume than the flatter areas.
7. Design Report, Section 4.6.3.5, Infiltration subheading. New impervious area is not quantified. If new impervious is created by the project, provide a drainage area figure

showing the new impervious area locations, and a table quantifying new impervious area, by drainage area.

8. Design Report, Section 4.6.3.5, Infiltration subheading. Ponds used to meet infiltration requirements must be designed to meet MPCA requirements, e.g., they must draw down within 48 hours following the event and runoff must be pretreated before entering the infiltration area. If new impervious is being created by the project (see above comment) then provide pond details showing that MPCA design guidelines are met.
9. Design Report, Appendix C, Peak Run-off subheading. Sample calculations for sloped and flat areas appear to indicate that sloped areas would be HSG C while flat would be HSG B, which contradicts the earlier text.
10. Design Report, Appendix C, Peak Run-off subheading. Sheet flow lengths up to 300 feet are used to calculate times of concentration. This is "allowed" in HydroCAD, but some agencies (e.g., NRCS) limit sheet flow length to a maximum of 100 ft. The City recommends that sheet flow lengths be limited to 100 feet as a conservative assumption.
11. Design Report, Appendix C, HydroCAD model output. There are several warnings where water depth exceeded reach inlets or outlets. Warnings should be resolved and/or it should be confirmed whether the 100-year event is appropriately contained within each reach as stated within the report.

VII. Waste Capacity

The June 2022 Application and September 2022 Addendum proposes to add 8,185,800 cubic yards of new capacity to PBL (including cover soils).

A review of the design drawings was completed to verify the accuracy of the capacity information for the proposed expansion. Based on review of the design drawings in AutoCAD Civil3D software, it appears that the volumes shown in the June 2022 Application and September 2022 Addendum are accurate.

The September 15, 2022 Addendum last page includes information comparing the remaining permitted airspace to the remaining Certificate of Need (CON).

Barr recommendations:

12. Introduction Section, page 3 table. The permitted and proposed elevations are reported using "Local Landfill Datum". Additionally, the Design Report Section 3.1, Section 4.3.1, and Section 4.6.1 refers to elevation as "NGVD", "MSL, and "AMSL" respectively. The City assumes all elevations should be using the NGVD 29 vertical datum. Please clarify and make consistent throughout the application.

13. Design Report, Disposal Area Summary table on page 3. The Ultimate Design Capacity and Remaining Permitted Design Capacity values are different than the corresponding values on page 3 of the Introduction Section. Please reconcile.
14. Update the values in the Design Report, Section 2.2 (Waste Flows / Site Capacity / Phasing) to provide information from 2022.

VIII. Liner and Leachate Collection System Design

Barr's review of the Liner and Leachate Collection System Design had an emphasis on consideration of construction of the system on top of the old unlined waste deposit. Barr's review was concentrated on differential settlement in regard to the liner system, leachate collection system, slope stability, and liner penetrations for gas recovery and leachate collection and piping. In review of the permit application and the permit drawings, the following recommendations regarding the liner and leachate collection system have been developed.

Barr recommendations:

15. Design Report, Section 4.5.1, Historical Leachate Collection Data. The quantity of leachate collected for year 2017 through 2020 do not appear to match the annual reports for those years. Please address.
16. Design Report, Section 4.5.1, Historical Leachate Collection Data Update the leachate collection data to include year 2022.
17. Provide a summary of what areas have yet to receive a liner from Phase 5 and 6.
18. Provide a summary of which areas will have subgrade prepared on natural soil surface as described in the Design Report, Section 4.2 (Subbase Preparation).
19. Provide analysis of additional strain on the existing liner and the potential for failure due to differential settlement from the Phase 7 vertical expansion (there seems a relatively high probability that the liner will experience excess strain at locations due to increased load from Phase 7 and resulting increased differential consolidation of waste below the liner).
20. The Geotechnical Evaluation provided as Application Appendix D is generally inadequate and should include:
 - a. Demonstration of effectiveness (technical papers or other) of the suggested "drain liner with an overlying geotextile" as substitute for a geonet composite. For the former, a geotextile that is not bonded to the geonet could yield excessively and fill gaps in the geonet thereby reducing the geonet's flow transmission capability.
 - b. Literature and site-specific test data that supports the cohesion values and friction angles used in the stability analyses that are presented. The factors of safety appear unreasonably high for a 3H:1V slope and are likely the result of cohesion

values and friction angles for which supporting literature and test data is not provided.

- c. A veneer stability analyses of an isolated segment of the cover system on a 3H:1V slope appears to be absent from the analysis but is required to confirm stability of the proposed cover system.
- d. The overall slope stability analysis lacks evaluation of alternate failure surface entry and exit points and does not include analyses that treat the “existing cover liner” as an impenetrable surface. These additional analyses are critical to understanding overall stability of the proposed slope system.
- e. The slope stability analysis outcomes are based on cohesion being present in all of the soil layers and at the interface between soils and geomembrane. This is potentially not a realistic assumption (non-cohesive soils may be used for construction) and it does not represent a conservative approach to the analyses. The stability analyses should be expanded by analyzing stability with zero cohesion.

IX. Gas Monitoring and Gas Extraction/Treatment Systems

As indicated in Operations and Maintenance Plan, Appendix B-Gas Management and Monitoring Plan, which is included in the June 2022 Application and September 2022 Addendum, “Minnesota Rule 7035.2815 Subp. 11 requires that the concentration of any explosive gas not exceed the LEL at the property boundary or 25 percent of the LEL in or around facility structures.” LEL is an abbreviation for Lower Explosive Limit.

The existing gas management system at PBL consists of:

- Gas extraction wells and piping,
- The gas monitoring system, and
- The Renewable Natural Gas (RNG) facility that was planned to start up in Spring 2022.

Based on the review of the Operations and Maintenance Plan in the June 2022 Application and September 2022 Addendum, the gas extraction system currently includes 190 gas extraction wells at the site and additional gas extraction wells are planned for Phase 5 and 6. Also, new gas extraction wells and piping are planned to be installed for Phase 7 as shown on the Plan Drawings included as Appendix A in the Design Report. The construction and installation of the additional gas extraction wells will be in accordance with the MPCA-approved design and PBL design standards. Extracted gas is currently piped through laterals, sub-headers, and header piping to RNG facility that was planned to startup in Spring 2022.

The gas monitoring system is comprised of the three continuous electronic monitoring devices located in occupied buildings at PBL and 39 methane (gas) monitoring probes completed at varying depths around the perimeter of the landfill. The Gas Management and Monitoring Plan indicates the probes are monitored quarterly unless a positive gas reading is recorded, in which case, monitoring is increased to monthly until two consecutive passing months readings are recorded.

Historically, elevated concentrations of methane have been detected in several of the subsurface gas monitoring probes located along the eastern, southern, and western boundaries of PBL. Methane concentrations in the gas monitoring probes around the facility exceeded the LEL on numerous occasions in 2022 and previous years. Based on these monitoring results, it does not appear that the existing controls at the PBL meet the requirements of Minnesota Rule 7035.2815 Subp. 11. PBL has been working with the MPCA and City to address gas migration concerns for many years and has most recently submitted the "2022 Gas Migration Remedial Action Report" dated February 2023 as Attachment 6 to the 2022 Annual Report.

Based on review of the June 2022 Application and September 2022 Addendum, proposed augmentations to the gas extraction systems includes:

- Vertical extension of existing gas extraction wells in the Phases 6 and 7 footprint
- Installation of pumping stations (e.g., PS-5) that will be used for the extraction of leachate and may be retrofitted for gas extraction from the unlined waste beneath the Phase 6 build out. Seven pumping stations have been installed as of 2022 with two of those operating with leachate pumps. Six additional pumping stations are planned to be installed for a total of 11.
- Installation of a horizontal gas collection system beneath the final cover system in the Phases 6 and 7 build out where the proposed waste thickness is too thin for additional gas wells
- Completion of a gas header (18-inch diameter) loop around the landfill once final grades have been reached

Barr recommendations:

21. Design Report, Section 4.7.1 should include a discussion that subsurface landfill gas is migrating beyond the property boundary at concentrations above the LEL and a brief summary of the efforts to mitigate.
22. Design Report, Section 4.7.4.2 describes the horizontal gas collectors installed in the Phase 6 expansion area. However, no discussion is included about any horizontal gas collectors as part of the Phase 7 expansion although Plan Drawings 8 and 9 seem to indicate that horizontal collectors will be installed as part of Phase 7. Please address this apparent discrepancy.

X. Final Cover Design

Barr's review of the final cover design was concentrated on differential settlement regarding the cover system and surface water drainage system, slope stability, and liner penetrations for the gas and leachate system components. In review of the June 2022 Application and September 2022 Addendum and the associated permit drawings, the following questions regarding the final cover system have been developed.

The slope stability factors of safety are computed based on assumed friction angles with no supporting data provided. The factors of safety seem unreasonably high and several potential failure scenarios are not evaluated (i.e., additional strain on the liner and the potential for failure due to differential settlement from the Phase 7 vertical expansion). See Section VIII of this letter for additional comments regarding slope stability.

Barr recommendations:

23. Update the text to describe the current conditions in the Design Report, Section 1.1 (Introduction).
24. Provide a summary of which portions of the 3H:1V slope area has final cover in place, how long it has been in place, and how has it performed from an infinite slope stability and erosion control standpoint.
25. If there is no on-site demonstration of suitable performance of this cover design, then provide evidence of adequate performance of this 3H:1V cover design from similar sites.
26. Clarify the thickness of the Buffer Soils beneath the final cover section (12" thickness shown in the Drawings on Drawing No. 13 whereas a 6" thickness is specified in the Design Report, Section 4.6.1 – Design Overview).

XI. Closure, Post Closure, Contingency Action, and Operations and Maintenance Plans

The Operations and Maintenance plan in the June 2022 Application and September 2022 Addendum does not appear to have any significant changes from the August 2015 Application.

The Closure, Post Closure, Contingency Action Plan in the June 2022 Application and September 2022 Addendum does not appear to have any significant changes from the August 2015 Application, with the exception of:

- updated normal operating hours of the facility,
- removal of discussion on tires, e-waste, and white goods removal from waste acceptance
- removal of landfill design volumes and estimated dates for each phase closure
- removal of a closure phasing plan

Barr recommendations:

27. Section 3.5 (Waste Placement Techniques) of the Operations and Maintenance Plan gives consideration to the proposed Phase 7 expansion, provide consideration for all areas yet to be constructed.
28. Provide landfill design volumes and estimated dates for each phase closure within the Closure, Post-Closure, Contingency Action Plan Section 2.2 (Notification of Cell Closure).

29. Provide a closure phasing plan within the Closure, Post-Closure, Contingency Action Plan Section 2.4 (Closure Schedule).
30. Section 2.9 (Closure Cost Estimate) within the Closure, Post-Closure, Contingency Action Plan reports an area of 69.4 acres whereas Table 1 lists 32.6 acres. Please reconcile or provide rationale for the difference.

XII. Financial Assurance Cost Estimates

The MPCA requires financial assurance for all mixed municipal solid waste landfills in Minnesota, including PBL. Financial assurance is intended to provide funds for closure, post-closure, and contingency action activities in the event that the landfill owner goes out of business.

Based on the City's review, the approach and most unit costs appear to be reasonable and are consistent with the financial assurance updates provided in the annual reports.

Barr recommendations:

31. The total financial assurance value should be updated to match the 2022 Annual Report value of \$20,846,216.
32. Please provide the value of the bond to Dakota County.

In addition to submitting the June 2022 Application and September 2022 Addendum to the MPCA, Pine Bend Landfill will also need to submit an application to the City of Inver Grove Heights for the proposed project. The City will need to consider an Ordinance Amendment, Conditional Use Permit Amendment, and Non-Conforming Use Certificate Amendment for this proposed project. It is the City's understanding is that the MPCA will not reissue the solid waste permit until these City approvals are complete.

Thank you for the opportunity to provide comments and recommendations. The City appreciates your consideration of the recommendations and looks forward to your reply. If

the MPCA has any questions, please contact City of Inver Grove Heights Environmental Specialist Ally Sutherland at 651-604-8511 or asutherland@ighmn.gov.

Sincerely,

CITY OF INVER GROVE HEIGHTS

c: Ally Sutherland, City of Inver Grove Heights
Aaron Janusz, Pine Bend Landfill
Tyler Kraft, Pine Bend Landfill
Tom Shustarich, Stantec Consulting Services Inc.
Terry Muller, Dakota County
Dave Magnuson, Dakota County
Bryan Pitterle, Barr Engineering Co.
Jeff Ubl, Barr Engineering Co.



**REQUEST FOR MAJOR MODIFICATION OF
PERMIT SW-45**
Pine Bend Landfill

June 2, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359

Project Number:
227704791

Table of Contents

MPCA FORMS AND CHECKLISTS

INTRODUCTION

DESIGN REPORT

OPERATIONS AND MAINTENANCE PLAN

**CLOSURE, POST CLOSURE, CONTINGENCY ACTION AND
FINANCIAL ASSURANCE PLAN**



MPCA FORMS AND CHECKLISTS

Permit application for issuance,
reissuance, or major modification

Solid Waste Permit Program

Doc Type: Permit Application

Print or type application: Before submitting, make a photocopy for your records. The Minnesota Pollution Control Agency (MPCA) will review the application for completeness and provide an official response to the permittees within 30 business days of receipt of the application.

MPCA Use Only	
AI number:	
Activity ID:	

Permit application assembly: To expedite the processing and review of your application, **put this form at the beginning** of your submittal package. Please place all checklists directly behind this application form in order by the number found on the bottom left hand corner of each checklist. **Do not place forms and checklist in an appendix** as this makes it difficult and time consuming for staff to locate them.

Completeness instructions: Without properly completed forms, an application cannot be processed and will be determined to be incomplete. All sections of this form must be completed. If portions do not apply to this facility, please indicate so with "n/a".

The completed form is to be returned to: **Solid Waste Permit Document Coordinator**
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Submittal: You must submit one (1) paper copy **and** one (1) electronic copy (i.e., disc or thumb drive) of your application.

Application is for (check appropriately): ☐ New permit ☐ Permit reissuance ☒ Major modification
☐ Resubmittal of 'Incomplete' application originally submitted on: _____

Note: Different forms are available for Minor Modifications or Change in Ownership/Operation. (Found on the MPCA's Solid Waste Permitting website at <https://www.pca.state.mn.us/waste/solid-waste-permitting>.)

(mm/dd/yyyy)

Facility name and addressFacility name: Pine Bend LandfillAddress: 2495 East 117th StreetCity: Inver Grove Heights State: MN Zip: 55077MPCA Region (check one): ☐ Brainerd ☐ Detroit Lakes ☐ Duluth ☐ Marshall ☒ Metro ☐ Rochester

Applications for metro facilities must include information to demonstrate the proposed facility is in accordance with the metropolitan policy plan (Minn. Stat. 473.823).

Is there an existing solid waste permit for the facility? ☒ Yes ☐ NoIf yes, what is the permit number: PBR _____ or SW 45Permit expiration date (mm/dd/yyyy): 07/30/2025**Checklists required** (Please check all that are included with this application.)

All applicable checklists must be completed and submitted with this application. The MPCA will not process an application that does not include all of the required checklists. All checklists can be found on the MPCA's website at <https://www.pca.state.mn.us/waste/solid-waste-permitting>.

All solid waste facilities☒ [Solid Waste Facility Application Checklist](#)☒ [Metro permit review application checklist \(w-sw7-44\)](#)
(Required for metro facilities only)**Activity specific checklist**

- ☒ [MSW Landfill Application Checklist](#)
- ☐ [MSW Combustor Ash Landfill Application Checklist](#)
- ☐ [Demolition Debris Landfill Application Checklist](#)
- ☐ [Industrial Solid Waste Landfill Application Checklist](#)
- ☐ [Solid Waste Transfer Station Application Checklist](#)
- ☐ [Solid Waste Compost Facility Application Checklist](#)

- ☐ [SSOM Compost Facility Application Checklist](#)
- ☐ [Checklist for a Site Suitability Workplan for a Source-Separated Compost Facility](#)
- ☐ [Refuse-Derived Fuel Processing Facilities Application Checklist](#)

I. Facility information

A. Legal description of property (acreage includes the entire area of the facility)

255 Acres $\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$ Section 33 T 27 N R 22 W
Township name: _____ MN Legislative District: _____
County: Dakota
Latitude: 44 Deg 46 Min 59 Sec North
Longitude: 93 Deg 3 Min 15 Sec West

B. General information

1. Directions to the facility (physical location) [Minn. R. 7001.3300, item A]:
Approximately 4,000 feet West of Highway 52 on north side of 117th Street
2. Current land use [Minn. R. 7001.3300, item N]:
MSW Landfill
3. Current zoning designation of the site and the surrounding areas within a quarter mile radius [Minn. R. 7001.3300, item N]:
Industrial site surrounded by mostly industrial usage and some agriculture to the west
4. Describe the key topographic features at and around the facility [Minn. R. 7001.0050, item F]:
See Section C below.
5. a) Has either an Environmental Assessment Worksheet (EAW) or Environmental Impact Statement (EIS) been completed in the past? [Minn. R. 7001.0050, item G] ☒ Yes ☐ No
If yes, please provide date of completion:
An EAW was prepared as part of the previous major modification (3:1 slopes vertical expansion) and submitted in the spring of 2016, the document was published in June of 2016.
b) Does this application require a new Environmental Assessment Worksheet (EAW) [Minn. R. 4410.4300] or Environmental Impact Statement (EIS) [Minn. R. 4410.4400]? ☒ Yes ☐ No
Explain:
Minnesota Environmental Review Rules, Section 4410, 4300, Subp. 17, state that an EAW is mandatory for the expansion of a mixed municipal solid waste project by at least 10 percent but less than 25 percent of the previous disposal capacity for 100,000 cubic yards or more of waste fill per year.
6. a) Have variances been approved in the past for this facility? ☐ Yes ☒ No
If yes, please list and provide approval dates and documentation:
b) Are there new variances requested in this application in accordance with Minn. R. 7000.7000? ☐ Yes ☒ No
If yes, list/explain (this should include the applicable rule citation for the requested variance(s)):
7. Is this facility in an environmental justice area? Please use the link below to identify ☐ Yes ☒ No
<http://mpca.maps.arcgis.com/apps/MapSeries/index.html?appid=f5bf57c8dac24404b7f8ef1717f57d00>
If yes, which areas apply?
☐ At least 40% of people reported income less than 185% of the federal poverty level
☐ 50% or more people of color
☐ Federally recognized tribal areas
8. a) Has Certificate of Need (CON) been granted in the past for this facility? ☒ Yes ☐ No
If yes, please list and provide approval dates and amounts issued:
2,398,746 tons approved on Decemebr 15, 2021.

b) Is additional CON requested in this application in accordance with Minn. Stat. 115A.917
Metropolitan Policy Plan?

☐ Yes ☒ No

C. Identify the following features within a one mile radius of the site

Feature	Name of feature	Distance	Units
Current and former water supply or monitoring wells	See attached CWI		
Airports (Minn. R. 7035.2815, subp 2(C))	N/A		
Lakes or ponds (Minn. R. 7035.2555, subp 2(A))	N/A		
Rivers, streams or springs (Minn. R. 7035.2555, subp 2(A))	Mississippi River	5,000 feet from NE corner of site	
Wetlands (Minn. R. 7035.2555, subp 2(B))	Various wetlands located on west 100 acre property	Adjacent	
Floodplains (Minn. R. 7035.2555, subp 1)	N/A		
Karst features (sinkholes, caves) (Minn. R. 7035.2815, subp 2(1); Minn. R. 7035.2825, subp 2(A))	N/A		
Parks or wildlife refuges	N/A		
Present or proposed access and major haul roads, and their weight restrictions	Highway 52	3,000 feet East of Site	
Easements or right-of-way	N/A		
Recreational areas	N/A		
Historical or archeological areas	N/A		

II. Waste activity information

A. Waste Activities that occur at the facility (complete a row for each waste activity area and each waste type)

[illegible]

B. Land disposal (complete a row for each separate waste disposal area, closed and active areas)

[illegible]

III. Operational information

- A. The facility will have capacity to receive 400 vehicles per day and expects to receive an average of 150 vehicles per day.** List the vehicle types (i.e., packer trucks, roll-off boxes, private citizen vehicles) using the facility including those that transport special wastes, such as tires or white goods.

Vehicle type	Vehicle capacity	Waste type transported
Transfer Trailer	80 to 100 CY	MSW
Packer Trucks	25 to 35 CY	MSW, Industrial
Private Citizen Vehicles	Varies	MSW
Side dumps, Roll-offs	10 to 15 CY	Contaminated soils

- B. Describe the equipment to be located and used on site at the facility, or the availability and arrangement for use of equipment kept off-site, managing the waste:**

836G and 836H Landfill Compactor, D8-T Dozer, Motor Grader, Wheel Loader 930, skid steer, 2 farm tractors with mower decks, water truck and other equipment as necessary

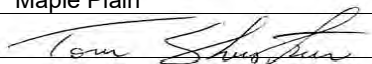
IV. Solid waste annual report contact

Print name: Aaron Janusz Title: Environmental Manager
Email: ajanusz@republicservices.com Phone: 651-434-9843
Organization: BFI Waste System of North America, LLC
Address: 2495 E 117th Street
City: Inver Grove Heights State: MN Zip: 55077

V. Signature and certification

A. Engineer (Consultant)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Print name: Thomas J. Shustarich License number: 21210
Title: Project Manager State licensed: MN
Email: thomas.shustarich@stantec.com Phone: (763) 479-4226
Organization: Stantec
Address: 1800 Pioneer Creek Center
City: Maple Plain State: MN Zip: 55359
Signature:  Date (mm/dd/yyyy): 6/1/2022

B. Permittees

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

I further certify that the construction and operation of the above described facility will be in accordance with the plans, specifications, reports and related communications accepted by the MPCA and on file in its office; and in accordance with conditions imposed in the permit issued by the MPCA.

I certify that the facility is consistent with local solid waste management plans. I am aware an MPCA permit must be obtained before construction or operation of the facility may begin and all local permits, licenses or other government approval must be obtained before an MPCA permit can be issued.

I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

Landowner

Print name: Tyler Kraft Title: General Manager
Email: tkraft2@republicservices.com Phone: 651-403-2200
Organization: BFI Waste Systems of North America, LLC
Address: 11380 Courthouse Blvd
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Tyler Kraft* Date (mm/dd/yyyy): 06/02/2022

Activity owner (Applicant)

Print name: Tyler Kraft Title: General Manager
Email: tkraft2@republicservices.com Phone: 651-403-2200
Organization: BFI Waste Systems of North America, LLC
Address: 11380 Courthouse Blvd
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Tyler Kraft* Date (mm/dd/yyyy): 06/02/2022

Operator*

Print name: Ross Ziegenhagen Certification No: _____
Title: Operations Supervisor Expiration date: _____
Email: rziegenhagen@republicservices.com Phone: 651-308-1064
Organization: BFI Waste Systems of North America, LLC
Address: 2495 E 117th Street
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Ros Ziegenhagen* Date (mm/dd/yyyy): 06/02/2022

***Provide the same information for other certified operators.**

Aaron Janusz
Type II Operator
Cert # 53794014
Expires 11/15/2022

Drake Vocovich
Type II Operator
Cert # 77732252
Expires 3/4/2025

VI. Local acknowledgment

This section is primarily meant to notify the county and local authorities of the applicant's intent so that all county and local ordinances and plans can be met. It is intended to validate that counties and local authorities were properly notified of this permit application for construction and operation. Signature by the county or local authority is not meant to imply approval.

A. County acknowledgment/permission (to be completed by County Solid Waste Administrator or County Zoning Administrator)

Print name: Dave Magnuson Title: Waste Regulations Supervisor
Email: dave.magnuson@co.dakota.mn.us Phone: 952-891-7551
Organization: Dakota County
Address: 14955 Galaxie Avenue
City: Apple Valley State: MN Zip: 55124
Signature: *Dave Magnuson* Date (mm/dd/yyyy): 06/02/2022

B. Local acknowledgment/permission (to be completed by local building or zoning office)

Print name: Ally Sutherland Title: Environmental Specialist
Email: asutherland@ighmn.gov Phone: 651-604-8511
Organization: City of Inver Grove Heights
Address: 8150 Barbara Avenue
City: Inver Grove Heights State: MN Zip: 55077
Signature: _____ Date (mm/dd/yyyy): _____

In lieu of completion of this part of the application, the applicant may submit documentation that the applicant has sent appropriate notification to the county and local authorities. Documentation must consist of copies of letters sent to the county and local authorities via certified mail, return receipt requested and copies of the signed return receipt.

C. Local approvals

Have all local licenses/approvals been acquired? ☐ Yes ☒ No

If yes, please list all approvals, include issuances and expiration dates (include a copy of each approval)

If no, please explain:

The Pine Bend Landfill is currently permitted and licensed, and in good standing with the City of Inver Grove Heights and Dakota County. Pine Bend will be working with the City and County to ensure that all permits and licenses are updated.

D. Solid waste transfer facilities and source-separated organic material (SSOM) compost facilities

The applicant for a transfer facility or SSOM compost facility must attach copies of all required municipal licenses/approvals, unless the applicant is a municipality. The MPCA will not process an application without these approvals. See Minn. R. 7001.3400, item C, or 7001.3375 item L for more details. If no municipal approvals are required the owner or operator must sign the statement below stating that no municipal approvals are required.

I certify, no municipal approvals are required:

Print name: _____ Title: _____
Signature: _____ Date (mm/dd/yyyy): _____

E. Land disposal facilities

The MPCA may not issue a permit for a new disposal area or an expansion of an existing disposal area prior to local units of government granting approval. All local approval will need to be obtained prior to issuance of the MPCA solid waste permit for disposal activities. See Minn. Stat. § 116.07, subd. 4j, item d(1) for more details.

VI. Local acknowledgment

This section is primarily meant to notify the county and local authorities of the applicant's intent so that all county and local ordinances and plans can be met. It is intended to validate that counties and local authorities were properly notified of this permit application for construction and operation. Signature by the county or local authority is not meant to imply approval.

A. County acknowledgment/permission (to be completed by County Solid Waste Administrator or County Zoning Administrator)

Print name: Dave Magnuson Title: Waste Regulations Supervisor
Email: dave.magnuson@co.dakota.mn.us Phone: 952-891-7551
Organization: Dakota County
Address: 14955 Galaxie Avenue
City: Apple Valley State: MN Zip: 55124
Signature: _____ Date (mm/dd/yyyy): _____

B. Local acknowledgment/permission (to be completed by local building or zoning office)

Print name: Ally Sutherland Title: Environmental Specialist
Email: asutherland@ighmn.gov Phone: 651-604-8511
Organization: City of Inver Grove Heights
Address: 8150 Barbara Avenue
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Ally Sutherland* Date (mm/dd/yyyy): 06/02/2022

In lieu of completion of this part of the application, the applicant may submit documentation that the applicant has sent appropriate notification to the county and local authorities. Documentation must consist of copies of letters sent to the county and local authorities via certified mail, return receipt requested and copies of the signed return receipt.

C. Local approvals

Have all local licenses/approvals been acquired? ☐ Yes ☒ No

If yes, please list all approvals, include issuances and expiration dates (include a copy of each approval)

If no, please explain:

The Pine Bend Landfill is currently permitted and licensed, and in good standing with the City of Inver Grove Heights and Dakota County. Pine Bend will be working with the City and County to ensure that all permits and licenses are updated.

D. Solid waste transfer facilities and source-separated organic material (SSOM) compost facilities

The applicant for a transfer facility or SSOM compost facility must attach copies of all required municipal licenses/approvals, unless the applicant is a municipality. The MPCA will not process an application without these approvals. See Minn. R. 7001.3400, item C, or 7001.3375 item L for more details. If no municipal approvals are required the owner or operator must sign the statement below stating that no municipal approvals are required.

I certify, no municipal approvals are required:

Print name: _____ Title: _____
Signature: _____ Date (mm/dd/yyyy): _____

E. Land disposal facilities

The MPCA may not issue a permit for a new disposal area or an expansion of an existing disposal area prior to local units of government granting approval. All local approval will need to be obtained prior to issuance of the MPCA solid waste permit for disposal activities. See Minn. Stat. § 116.07, subd. 4j, item d(1) for more details.



Solid Waste Facility Application Checklist

Solid Waste Permit Program

Doc Type: Permit Application

Purpose: This checklist has been developed as a guide for permit application preparers and reviewers in order to assist with the submittal of a substantially complete permit application. Thoroughly review all applicable rules, statutes and guidance documents for further details and requirements. Minnesota Rules can be found at: <https://www.revisor.mn.gov/rules/>. All guidance documents can be found on the Minnesota Pollution Control Agency (MPCA) Solid Waste Publications webpage at: <http://www.pca.state.mn.us/lupg880>.

Many items listed below must be discussed in depth within the permit application submittal package. Be sure to include the most recently updated information, drawings and plans. Previously submitted documents **cannot** be referenced; all necessary documents must be included in this package. The permit application submittals should discuss all applicable MPCA Guidance Documents; include justification if the facility does not follow the guidance provided.

Instructions for permit application preparers: The following checklist must be completed and included with a permit application for all solid waste facilities. In the table below, indicate in the far left column the name and page number(s) of the document where the specified rule requirement is addressed. If the rule requirement does not apply, please indicate with "n/a" for not applicable. **The permit application will be determined to be incomplete if there are any blank spaces in this column.**

Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
MPCA Permit Application Forms	7001.0050, item A Name, address, and telephone number of the owner of the facility for which the application is submitted and identification of the status of the owner as a federal, state, public, private, or other entity			
MPCA Permit Application Forms	7001.0050, item B If the operator of the facility for which the application is submitted is different from the owner, the name, address, and telephone number of the operator and identification of the status of the operator as a federal, state, public, private, or other entity			
MPCA Permit Application Forms	7001.0050, item C Name, address, and telephone number of the person who prepared the application			
MPCA Permit Application Forms	7001.0050, item D Description including the location of the business, plant, system, facility, or activity for which the permit is sought			
MPCA Permit Application Forms and Introduction	7001.0050, item E General description of the materials handled, processed, stored, or disposed of by the applicant; and a statement of the nature and quantity of the materials proposed to be stored, processed, discharged, emitted, or disposed of during the period of the required permit, and proposed methods for control of these materials			

Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
MPCA Permit Application Forms	7001.0060, item A For a corporation, the permit application must be signed by a principal executive officer of at least the level of vice-president or the duly authorized representative or agent of the executive officer if the representative or agent is responsible for the overall operation of the facility that is the subject of the permit application			
Not Applicable	7001.0060, item B For a partnership or sole proprietorship, the permit application must be signed by a general partner or the proprietor, respectively			
Not Applicable	7001.0060, item C For a municipality, state, federal, or other public agency, the permit application must be signed by either a principal executive officer or ranking elected official			
Not Applicable	7001.0060, item D If the operator of the facility for which the application is submitted is different from the owner, the permit application must be signed by both the owner according to items A through C above			
Not Applicable	7001.0060, item E For solid waste management facilities, the permit application must be signed by the facility owner and landowner under items A to C if the landowner is different from the owner of the facility for which the application is submitted			
MPCA Permit Application Forms	7001.0060, item F For a firm preparing the necessary reports and plans for a solid waste management facility permit application, the permit application must be signed by an engineer registered in Minnesota			
MPCA Permit Application Forms	7001.0070 A person who signs a permit application shall make the following certification: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information. The information is, to the best of my knowledge and belief, true, accurate, and complete."			

Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
NA	7001.3150 A person who signs a permit application or any portion of it, or any report required by a permit to be submitted to the commissioner or agency must make the certification required by part 7001.0070 and shall make the following additional certification: "I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment." An engineer registered in Minnesota must certify all technical documents, such as design drawings and specifications, engineering reports, and hydrogeologic studies, required to be submitted as part of a permit application or by a permit condition. The hydrogeologic report and all related groundwater and surface water monitoring reports must be signed by a person knowledgeable in the field of hydrogeology. This person must certify the quality of work performed and must have been responsible for the gathering and interpretation of the hydrogeologic data and the preparation of the reports.			
Design Report, pg2-1	7001.3300, item A General description of the facility			
O&M Plan App. A	7001.3300, item B Industrial solid waste management plan in accordance with 7035.2535			
O&M Plan multiple pages	7001.3300, item C Description of security procedures and equipment			
O&M Plan pg 4-1	7001.3300, item D Inspection schedule			
Closure, post-closure, Contingency Action Plan	7001.3300, item E Contingency action plan			
O&M Plan multiple pages	7001.3300, item F(1) Description of procedures, structures or equipment to prevent operational hazards			
O&M Plan multiple pages	7001.3300, item F(2) Description of procedures, structures or equipment to prevent run-off, run-on			
O&M Plan pg 3-5	7001.3300, item F(3) Description of procedures, structures or equipment to prevent ground and surface water contamination			
O&M Plan pg 3-4	7001.3300, item F(4) Description of procedures, structures or equipment to mitigate effects of equipment failure			
O&M Plan Section 2.0	7001.3300, item G Description of precautions to prevent			

	ignition or explosions and emergency response plan			
Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
O&M Plan pg 3-1	7001.3300, item H Traffic patterns and control			
O&M Plan multiple pages	7001.3300, item I Storage descriptions			
Closure, post-closure, Contingency Action Plan	7001.3300, item J Closure and Postclosure Plan			
Closure, post-closure, Contingency Action Plan	7001.3300, item K Closure cost estimates and evidence of financial assurance			
Closure, post-closure, Contingency Action Plan	7001.3300, item L Postclosure cost estimates and evidence of financial assurance			
Closure, post-closure, Contingency Action Plan	7001.3300, item M Corrective action cost estimates and evidence of financial assurance			
Introduction, Figures 1 & 2	7001.3300, item N(1 to 18) Topographic and development map			
Design Report, pg 3-1	7001.3300, item O Geologic and location information			
O&M Plan	7001.3300, item P(1 to 9) Operations and maintenance manual			
Design Report Appendix B	7001.3300, item Q Construction QA/QC plan			
NA	7001.3300, item R Household hazardous waste management plan			
Design Report, Attached	7001.3300, item S Full size copies of all engineering plan sheets			
Design Report, Appendix A	7001.3300, item S Reduced copies of all engineering plan sheets (11" x 17")			
Introduction, Appendix A	7001.3300, item S Address labels for all adjacent properties owners and interested parties			
Introduction, Figure 3	7001.3300, item S Plan sheet with adjacent land owner information			
NA	7001.3300, item S Discussion of all previously granted variances			
NA	7001.3300, item S Variance application according to Minn. R. 7000.7000 for all new requests			
NA	7001.3300, item S Description of how and why the facility does or does not operate according to all applicable MPCA Guidance			

	Documents			
O&M Plan, Appendix D	7001.3300, item S Inspection Form			



Mixed Municipal Solid Waste (MSW) Landfill Application Checklist

Solid Waste Permit Program

Doc Type: Permit Application

Purpose: This checklist has been developed as a guide for permit application preparers and reviewers in order to assist with the submittal of a substantially complete permit application. Thoroughly review all applicable rules, statutes and guidance documents for further details and requirements. Minnesota Rules can be found at: <https://www.revisor.mn.gov/rules/>. All guidance documents can be found on the Minnesota Pollution Control Agency (MPCA) Solid Waste Publications webpage at: <http://www.pca.state.mn.us/lupg880>.

Many items listed below must be discussed in depth within the permit application submittal package. Be sure to include the most recently updated information, drawings and plans. Previously submitted documents **cannot** be referenced; all necessary documents must be included in this package. The permit application submittals should discuss all applicable MPCA Guidance Documents; include justification if the facility does not follow the guidance provided.

Instructions for permit application preparers: The following checklist must be completed and included with a permit application for all MSW land disposal facilities. In the table below, indicate in the far left column the name and page number(s) of the document where the specified rule requirement is addressed. If the rule requirement does not apply, please indicate with "n/a" for not applicable. **The permit application will be determined to be incomplete if there are any blank spaces in this column.**

Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
To Be Completed	7001.3475, item A Certificate of Need (CON)			
MPCA Permit Application Forms	7001.3475, item B Description of waste types			
To Be Completed	7001.3475, item C EAW/EIS Status			
Design Report	7001.3475, item D(1) Detailed plans and engineering report addressing liner system, leak detection, leachate collection and removal			
Design Report, Appendix A	7001.3475, item D(2) Detailed plans and engineering report addressing control of run-off, run-on			
Design Report	7001.3475, item D(3) Detailed plans and engineering report addressing management of collection, conveyance and holding facilities			
O&M Plan, pg 3-6	7001.3475, item D(4) Detailed plans and engineering report addressing wind dispersion control			
Design Report, Appendix A	7001.3475, item D(5) Detailed plans and engineering report addressing treatment of run-on, run-off and leachate			
Design Report	7001.3475, item D(6) Detailed plans and engineering report addressing phase development plan			
Design Report	7001.3475, item E Detailed site evaluation report			
O&M Plan	7001.3475, item F Operation and maintenance manual			

Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
O&M Plan	7001.3475, item G Description of inspection plan			
Closure, Post-Closure, Contingency Action Plan	7001.3475, item H Final cover report, postclosure care			
Design Report	7001.3745, item I Gas monitoring, collection and treatment system			
Closure, Post-Closure, Contingency Action Plan	7035.2665 to 7035.2805 Financial assurance requirements			
Design Report	7035.2815, subp. 2 Location			
Previously Completed	7035.2815, subp. 3(A to D) Hydrogeological evaluation			
Previously Completed	7035.2815, subp. 3(E) Phase I hydrogeologic evaluation			
Previously Completed	7035.2815, subp. 3(F) Phase II hydrogeologic evaluation			
Previously Completed	7035.2815, subp. 3(G) Phase II hydrogeologic evaluation report			
Previously Completed	7035.2815, subp. 3(H) Phase III hydrogeologic evaluation			
Previously Completed	7035.2815, subp. 3(I)(1) Phase IV hydrogeologic evaluation work plan			
Previously Completed	7035.2815, subp. 4 Groundwater performance standards			
Design Report	7035.2815, subp. 5(A) Engineering report			
Design Report	7035.2815, subp. 5(B) Phase development plan			
Design Report	7035.2815, subp. 5(C) Buffer zone			
Design Report	7035.2815, subp. 5(D) Surface water drainage			
Design Report	7035.2815, subp. 5(E) Design and maintenance of slopes and drainageways			
Design Report, Appendix D	7035.2815, subp. 5(F) Sediment settling pond			
Design Report Appendix A	7035.2815, subp. 5(G) Final contours			
Design Report Appendix A	7035.2815, subp. 6 Cover system design			
Design Report Appendix A	7035.2815, subp. 7 Liner system design			

Design Report	7035.2815, subp. 8 Cover and liner evaluation			
Document and page number	Minn. R. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
Design Report	7035.2815, subp. 9 Leachate collection and treatment design			
Design Report	7035.2815, subp. 10 Water monitoring system design			
Design Report	7035.2815, subp. 11 Gas monitoring and collection system design			
Design Report	7035.2815, subp. 12 Construction requirements			
O&M Plan	7035.2815, subp. 13 Operation and maintenance requirements			
Previously completed	7035.2815, subp. 14 Sampling and analysis plan			
Closure, Post- Closure, Contingency Action Plan	7035.2815, subp. 15 Contingency action plan			
Closure, Post- Closure, Contingency Action Plan	7035.2815, subp. 16 Closure and postclosure plan			

Metro permit review application checklist

Solid Waste Permit Program

Doc Type: Permit Application

Purpose: This checklist has been developed as a guide for permit application preparers and reviewers in order to assist with the submittal of a substantially complete permit application. Thoroughly review all applicable rules, statutes and guidance documents for further details and requirements. Minnesota Statutes can be found on the Minnesota Legislature's Office of the Revisor of Statutes website at <https://www.revisor.mn.gov/statutes/>. All guidance documents can be found on the Minnesota Pollution Control Agency's (MPCA) Solid Waste Publications webpage at <https://www.pca.state.mn.us/waste/solid-waste-publications>.

Many items listed below must be discussed in depth within the permit application submittal package. Be sure to include the most recently updated information, drawings and plans. Previously submitted documents **cannot** be referenced; all necessary documents must be included in this package. The permit application submittals should discuss all applicable MPCA guidance documents; include justification if the facility does not follow the guidance provided.

Instructions for permit application preparers: The following checklist must be completed and included with a permit application for all solid waste transfer facilities. In the table below, indicate in the far left column the name and page number(s) of the document where the specified rule requirement is addressed. If the rule requirement does not apply, please indicate with "n/a" for not applicable. **The permit application will be determined to be incomplete if there are any blank spaces in this column.**

Document and page number	Minn. R./Minn. Stat. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
Introduction	§473.823 Subd. 3 (a) Geographic area and population served. Highlighting environmental justice areas			
Introduction	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) (b) (c) Need for Facility			
Introduction	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) (d) Effect of facility on existing facilities			
Introduction	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) Effectiveness of Proposed Buffer Areas			
Introduction	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) and 473.813 Subd. 1 & 2, 115A.471 Anticipated public costs and benefits of the facility			
Introduction	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) and Minn. Stat. 473.151 Anticipated rates and charges			
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) Manner of financing			
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) (d) (c) Effect on Metro Plans, specifically recycling goals and landfill abatement			
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) (c) Supply of waste			

Document and page number	Minn. R./Minn. Stat. citation	MPCA use only		
		Completeness review		Comments
		Admin	Technical	
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) and 473.813 Subd. 1 & 2, 115A.471 Solid waste supply contracts subject to 473.813			
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) Anticipated markets for any product			
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) Alternative means of disposal or energy production			
Closure, Post-Closure, CA - Section 5	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) and Minn. Rules 7035. Waste composition analysis			
Introduction, Section 1.4	§§ 473.149 Subd. 1 and 473.823 Subd. 3 (a) Additional information required by the commissioner – Environmental Justice criteria (Appendix B of Metro Policy Plan)			

INTRODUCTION



INTRODUCTION

Request for Major Modification of
Permit #SW-45
Pine Bend Landfill

June 2, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359

Project Number:
227704791

Table of Contents

1	INTRODUCTION.....	1
1.1	Purpose	1
1.2	Background	2
1.3	Permit Application Form and Completeness Checklists	4
1.4	Metro Permit Review Application Checklist.....	4

LIST OF FIGURES

1	Site Location
2	USGS Topographic Map
3	Adjacent Property Owners

LIST OF APPENDICES

APPENDIX A	Adjacent Property Owner Address List
APPENDIX B	Water Well Inventory



1 Introduction

1.1 Purpose

Stantec Consulting Services Inc. (Stantec) was retained by BFI Waste Systems of North America, LLC. (BFI) to develop this Application for a Major Modification to Minnesota Pollution Control Agency (MPCA) permit #SW-45 for the Pine Bend Landfill (PBL). This request for a major modification details a proposed vertical expansion over the existing landfill footprint by raising the permitted peak elevations of the landfill (vertical expansion) by extending the existing 3:1 slopes. This vertical expansion and associated volume increase will be designated as Phase 7. The landfill is currently permitted with 3:1 cover slopes around the entire landfill. No footprint increase is being proposed as part of this major modification request. The following information is included as part of this permit modification application:

- An Introduction, which includes the MPCA Application Form and Checklists,
- A Design Report, which includes a detailed description of the design revisions and supporting calculations for the vertical expansion.
- Operations and Maintenance Plan, which includes a Leachate Management Plan, and Gas Management and Monitoring Plan
- A Closure, Post-Closure, Contingency Action and Financial Assurance Plan

Specifically, this request for major modification contains the following revisions to the above referenced documents that were most recently submitted with a Major Modification submitted in August 2015.

- Design report
 - o Updated description of design revisions to incorporate the vertical expansion of the 3:1 final cover slopes over mainly Phase 5 but also portions of Phase 6.
 - o Updated volumes table to reflect the current remaining volume and the proposed increase on a phase-by-phase basis
 - o Revisions required for gas system modifications to incorporate the vertical expansion of the 3:1 final cover slopes over Phase 5 and Phase 6.
 - o Updated surface water calculations to incorporate the vertical expansion of the 3:1 final cover slopes and for the Atlas 14 rainfall data
 - o Updated technical specifications to reflect current ASTM references and MnDOT standards
 - o Updated geotechnical calculations that reflect the vertical expansion of the 3:1 final cover slope buildout and also to reflect the pipe trench settlement potential for the proposed leachate collection system
- Operations and Maintenance Plan
 - o Updated description of Leachate Management Plan
- Closure, Post-Closure, and Contingency Action Plan and Financial Assurance
 - o Updated cost estimates for closure, post-closure, and contingency action based on costs actually incurred for construction work at the site
 - o Updated financial assurance calculations based on 2021 MPCA inflation factor and updated cost estimates

Previously approved design details for Cell 5F, Phase 6 and currently permitted closure have not been resubmitted. The following sections of the previously approved permit renewal document remained unchanged from that submitted in August 2015:

- Leachate Recirculation Plan
- HELP model calculations



1.2 Background

PBL is a mixed municipal solid waste (MSW) landfill, located in Inver Grove Heights, Minnesota. The landfill facility consists of 255 acres located in Township 27 North, Range 22 West, Section 33, city of Inver Grove Heights, Dakota County. A site location map and a USGS topographic map are provided as Figures 1 and 2, respectively. The landfill has been in operation since 1971, under the Minnesota Pollution Control Agency (MPCA) Solid Waste Permit #SW-45. The landfill is owned and operated by BFI Waste Systems of North America, LLC (BFI). The landfill is generally comprised of three areas. The first is a closed unlined MSW disposal area in the northern-most part of the Facility, designated as Phases 1 and 2. This area has an existing airspace utilized volume of approximately 15,500,000 cubic yards. The second area is the open, lined, MSW disposal area. This area has a total airspace of 14,300,000 cubic yards and includes Phases 3, 4, and 5. The third is a lined, MSW disposal area piggybacking over the existing Phases 1, 2 and 3. Phase 6 has 4,137,400 cubic yards of capacity bringing the total site capacity to 33,937,400 cubic yards and is currently the active disposal area. The proposed vertical expansion (Phase 7) will add 8,185,800 cubic yards of airspace capacity (includes final cover) bringing the total site capacity to 42,123,200 cubic yards.

The following is a brief summary of regulatory activities at the Facility:

On April 23, 1985, PBL and the MPCA entered into a Response Order by Consent (order) under Section 17 and 18 of the Minnesota Environmental Response and Liability Act of 1983. Minn. Stat. Ch. 115B. The Order required PBL to perform a Remedial Investigation and Feasibility Study (RI/FS) to investigate the source or sources of groundwater contamination at and near the facility; to assess actual and potential impacts of the releases or threatened releases of hazardous substances, pollutants and contaminants from the facility on public health, welfare and the environment; and to identify, assess, design, develop and implement response action alternatives.

On October 23, 1990, PBL and the MPCA entered into an Amended Response Order by Consent (Amended Order). The scope of the Amended Order required PBL to redesign and complete the remedial investigation agreed to in the 1985 Order, conduct a feasibility study; develop a plan to provide an alternative drinking water source for certain residential wells adversely affected by the release(s) from the facility and the neighboring Crosby American Demolition Landfill; and to develop a response action plan and implement the approved response actions.

On September 23, 1991, the MPCA approved the Updated Remedial Investigation Report for the facility. In regard to the alternative drinking water source, PBL developed a plan and the MPCA issued a Record of Decision in September 1991 which required the residences with affected wells to be connected to the city's water supply system. The City of Inver Grove Heights completed the connections supplying municipal water to the residences in December 1994.

On November 21, 1994, the MPCA approved No Action Alternatives under the Superfund process for the source control and the remediation of groundwater contamination as recommended in the Updated Detailed Remedial Analysis Report. The Minnesota solid waste management rules require more stringent levels for cleanup and remediation than the Superfund program, therefore, the source control and the remediation of groundwater contamination was previously and will be managed in accordance with this Permit.

On March 4, 2003, PBL was granted a Certificate of Need (CON) capacity as part of the Phase 5 vertical expansion of the facility. The CON capacity granted was 6 million cubic yards and brought the total facility disposal capacity to 29,800,000 cubic yards.



Introduction

1 Introduction

On July 30, 2015, the MPCA approved the request for a major modification to allow for increased air space by allowing to increase the final cover slope to 3:1 around the entire existing landfill footprint, including the north and east sides and is referred to as Phase 6.

BFI was granted additional CON (2,398,746 tons), which was approved on December 15, 2021.

	Pine Bend Landfill
Location:	255-acre parcel in Section 33, T27N, R22W, City of Inver Grove Heights, in Dakota County, Minnesota
Permittee / Operator:	BFI Waste Systems of North America, LLC. 2495 East 117th Street, Inver Grove Heights, Minnesota 55077
Expected Waste Types:	Municipal solid waste, non-hazardous industrial solid waste, demolition and construction debris, and other approved waste.
Estimated Waste Quantities Per Year:	Approximately 420,000 tons of MSW, industrial solid waste, and demolition and construction debris (or approximately 600,000 cubic yards assuming an in-place waste density of 1,400 lbs/cy).
Current Permitted and Ultimate Capacity:	33,937,400 cy (includes final cover)
Proposed Permitted and Ultimate Capacity:	42,123,200 cy (approximately 8,185,800 cy requested for Phase 7 vertical expansion) including cover materials
Remaining Permitted Capacity:	3,503,536 cy for MSW, industrial, and demolition debris as of December 31, 2021 (includes cover materials)*
Proposed Remaining Permitted Site Capacity:	11,758,582 cy
Permitted Final Elevation:	Current - 1,020.0 feet (Local Landfill Datum)
Proposed Final Elevation:	1,105.8 feet (Local Landfill Datum)
Current Zoning:	City of Inver Grove Heights: Nonconforming Use Certificate Conditional Use Permit Dakota County: Operating License
Submittal Prepared by:	Stantec Consulting Services Inc. 1800 Pioneer Creek Center, P.O. Box 249 Maple Plain, Minnesota 55359-0249



Introduction

1 Introduction

All unchanged applicable information submitted in the previous August 2015 documents is referenced only and is not entirely resubmitted. All new information, revisions to existing documents, and additional design information and drawings related to the vertical expansion are included in this document.

The Design Report contains an updated summary of current conditions and applicable design information for those aspects of the site designs that have changed or require revision with this request for major modification. This includes a section detailing the geotechnical analysis of a vertical expansion continuing a 3:1 final cover slope build-out over the site as well as the proposed leachate collection and an overview of the existing and future active gas collection system.

The Operations and Maintenance Plan (O&M) has been updated and included in this application for permit modification. The O&M plan is designed to be used as a stand-alone document. A revised updated Leachate Management Plan has been prepared and included in the O&M plan. The plan describes current leachate management practices. There were no changes to the Industrial Solid Waste Management Plan titled Special Waste Management Plan, although it is included as an Appendix to the O&M Plan.

An updated Financial Assurance Plan for Closure, Post-Closure, and Contingency Action for the landfill has been included as part of this document and can also be utilized as a stand-alone document.

1.3 Permit Application Form and Completeness Checklists

This submittal includes or references information required for the completion of an application for major modification of an existing solid waste permit. The MPCA Permit Application Form (W-SW3-33) and checklists for Solid Waste Facility Application (W-SW7-32) and for Mixed Municipal Solid Waste (MSW), Disposal Facility (W-SW-37) and Metro Permit Review Application Checklist (W-SW7-44) are provided at the front of this document.

Updated figures and appendices include a site location map and topographic map showing the facility and surrounding area are presented as Figures 1 and 2, respectively. Figure 3 shows the surrounding property owners. A list of adjacent property owners with addresses is provided in Appendix A. A well search was also performed for all recorded wells within a one-mile radius of the landfill using the Minnesota Department of Health County Well Index. A Table and figure of verified wells and drilling information is also included in Appendix B. A total of three hundred and five (305) verified wells are located within the one-mile perimeter of the facility.

It is important to note that along with the submittal of this application to the MPCA, PBL will also be submitting an Environmental Assessment Worksheet (EAW). According to Minnesota Environmental Review Rules, Section 4410, 4300, Subp. 17, an EAW is mandatory for mixed municipal solid waste facility expansions by at least 10 percent but less than 25 percent of the previous disposal capacity for 100,000 cubic yards or more of waste fill per year. The complete vertical expansion would expand the existing facility disposal capacity by 8,185,800 cubic yards from approximately 33.94 million cubic yards to approximately 42.12 million cubic yards for an approximately 24 percent increase.

BFI has sufficient CON for the initial development of Phase 7 but will be requesting additional Certificate of Need (CON) capacity from the MPCA in the future.

1.4 Metro Permit Review Application Checklist

The following items are described in order to address the requirements of the Metro Permit Review Application Checklist.



Introduction

1 Introduction

Geographical Area and Population Served. Highlighting Environmental Justice Areas

The Facility is located in Inver Grove Heights, Dakota County, Minnesota and receives solid waste collected from Anoka, Benton, Carver, Dakota, Goodhue, Hennepin, Mille Lacs, Morrison, Ramsey, Rice, Scott, Sherburne, Stearns, Washington, and Wright. Below is a table of the counties that were served in 2021 as well as population for each County. The Facility (census tract #605.08) does not fall within an environmental justice area. Approximately 13.37% (+/-6.87%) reported income less than 185% poverty level. According to the “Understanding Environmental Justice in Minnesota” interactive map, approximately 16.12% (+/-3.76) are people of color and 6.87% reported as not being able to speak English well. It is of note that census tract #605.08 is adjacent (to the north) to census tract #605.05 in which, at least 40% of people reported income less than 185% of the federal poverty level.

County	County Population - 2022
Anoka	367,361
Benton	42,026
Dakota	440,964
Goodhue	46,463
Hennepin	1,289,597
Mille Lacs	26,808
Morrison	34,070
Ramsey	554,668
Rice	68,190
Scott	154,479
Sherburne	101,081
Stearns	165,332
Washington	273,063
Wright	144,569
Source: https://worldpopulationreview.com/us-counties/states/mn	



Introduction

1 Introduction

Need for Facility and Effect of Facility on Existing Facilities

The Facility accepts municipal solid waste, non-hazardous industrial solid waste, demolition and construction debris, and other approved waste from several counties in the metro area as listed above. This vertical expansion would allow the residents and businesses of the area to continue to properly dispose of waste materials. According to the Metropolitan Solid Waste Management Policy Plan for 2016-2036, the amount of MSW generated is expected to continue to increase from 3.365 million tons of MSW in 2015, to 3.98 million tons by 2035 in part by the expected increase in population therefore, the need for increase airspace capacity facilitated by this proposed vertical expansion.

The effects of this vertical expansion on the existing Facility will be minimal as this proposed vertical expansion would allow the for continued operations as usual per the latest permit.

A certificate of need (CON) was submitted to the MPCA for approval in July of 2020. The CON requested will serve Anoka County, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties. The additional CON granted was 2,398,746 tons and was approved on December 15, 2021.

Effectiveness of Proposed Buffer Areas

The surrounding areas to the Facility have been reviewed for water supply wells, natural water resources such as lakes, rivers, wetlands, flood plains, parks and wildlife refuge, historical and recreational areas, zoning, and surrounding usage. Operating procedures are designed to ensure control of materials and prospection of surrounding areas. Any impacts to the buffer areas are to be addressed in a timely manner and restored.

Anticipated Public Costs and Benefits of the Facility

There are no public costs associated with the development of this facility, as it is privately financed. The Facility and its beneficial location will continue to serve the increasing need for waste disposal of the metro area residents and businesses.

Anticipated Rates and Charges

This Facility is privately owned therefore, there have been no rates and charges associated with this Facility.

Manner of Financing

The Facility is privately financed with a surety bond for closure, post-closure, and contingency action.

Effect on Metro Plans, Specifically Recycling Goals and Landfill Abatement

The proposed vertical expansion would be in accordance with metropolitan plans. As previously mentioned, the amount of MSW generated is expected to increase. Also, please note that this vertical expansion will consist of adding new waste on top of existing waste without the need to open new cells or additional lateral footprint.



Introduction

1 Introduction

Supply of Waste and Solid Waste Supply Contracts

PBL accepts waste from an internal network of hauling companies and transfer stations as well as independent haulers located in the area. PBL also accepts bypass waste from the REC facility in Newport, Red Wing, and the Hennepin Energy Recovery Center.

Alternative Means of Disposal or Energy Production

PBL has partnered with Opal Fuels on the development of a Renewable Natural Gas (RNG) facility located adjacent to PBL on the “West 100”. This facility is currently under construction and plans to start up in the Spring of 2022. Landfill gas (LFG) generated at PBL will be sent to the RNG facility where it will be converted to pipeline quality natural gas.

Waste Composition Analysis

Waste accepted at the Facility is outlined in the permit application and include MSW, industrial, and demolition debris. The composition of waste is expected to be in line with residential MSW. Waste composition studies consistently show a large portion of MSW is organic waste. The MPCA has assembled a list of waste characterization studies from Minnesota and around the United States. The link to the list is: <https://www.pca.state.mn.us/waste/other-msw-composition-studies>

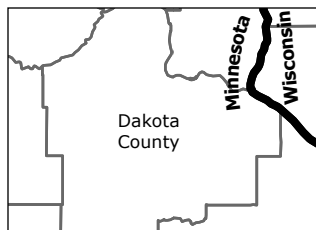
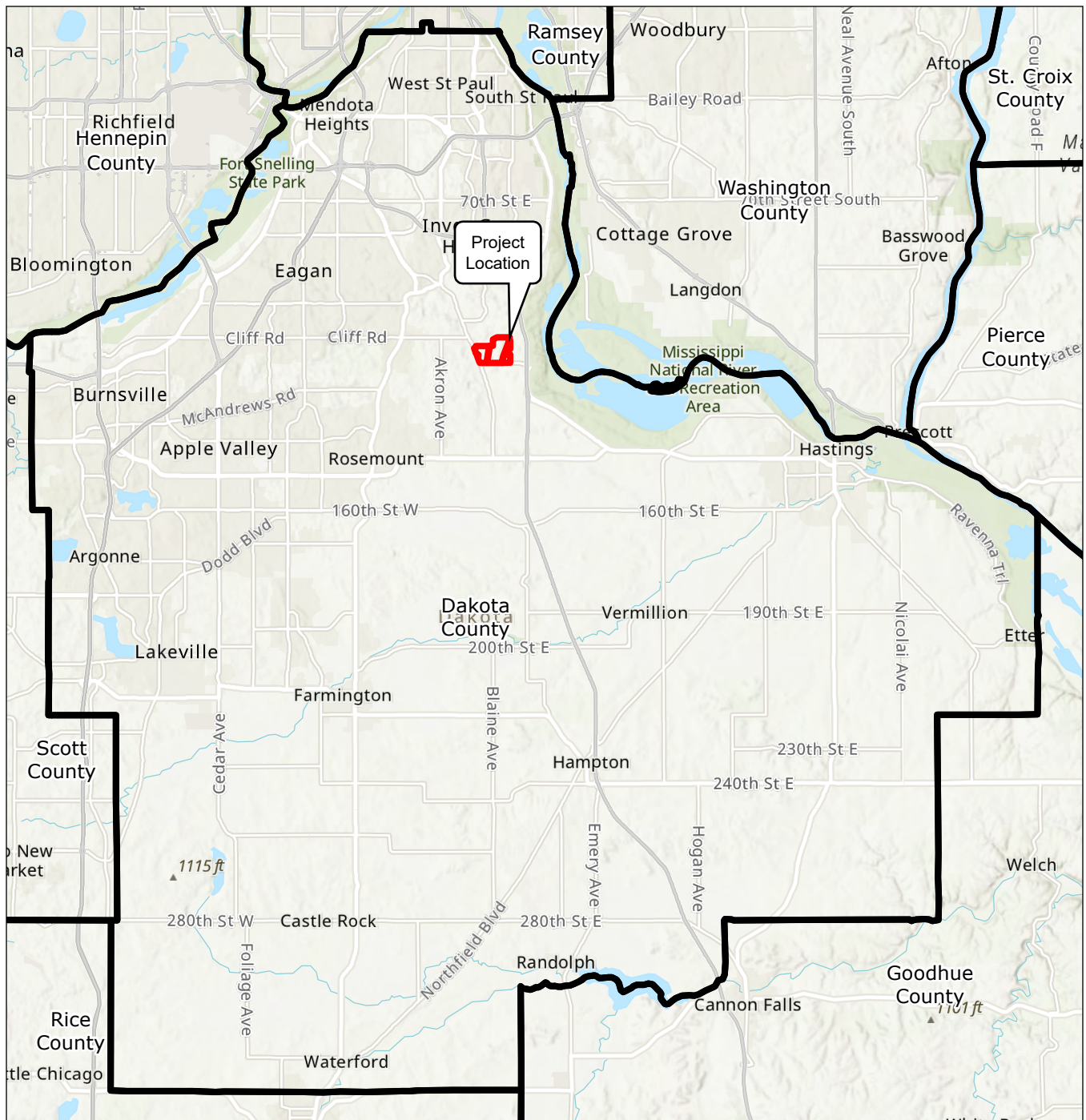


FIGURES

- 1 Site Location**
- 2 USGS Topographic Map**
- 3 Adjacent Property Owners**



V:\2277\active\227704791\03_data\gis\cad\gis\pro\permit_mod\permit_mod.aprx Revised: 2022-03-08 By: jshuck



- Legend
-  Project Location
 -  County Boundary

0 2 4 Miles
(At original document size of 8.5x11)
1:284,301



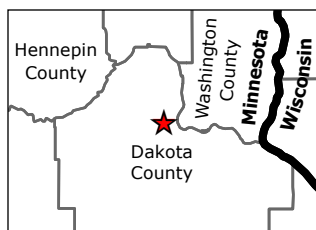
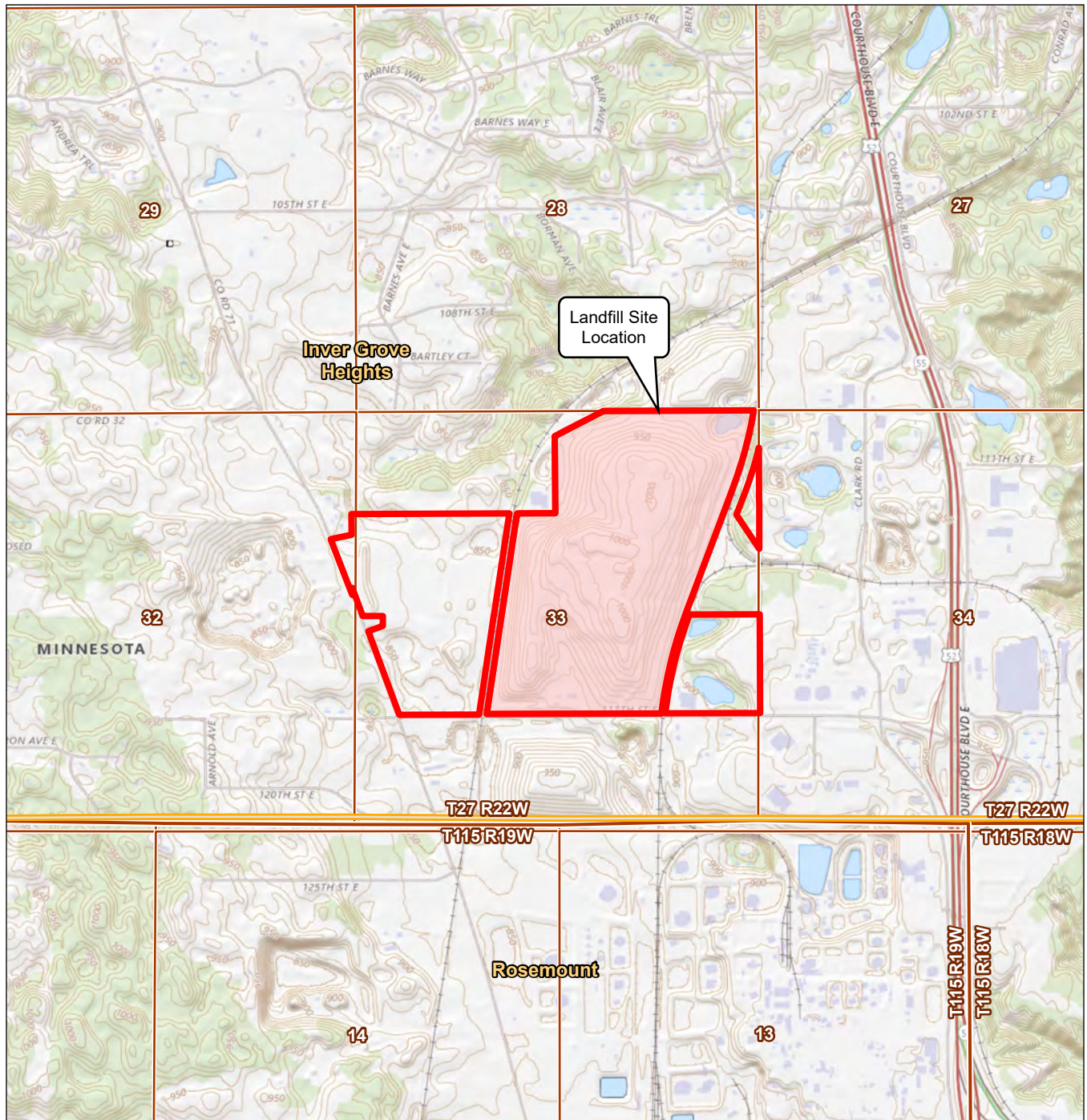
Project Location T27N, R22W, S33
Inver Grove Heights, Dakota Co., MN

Client/Project Republic Services 227704791
PBL Major Permit Mod

Figure No.

1

Title
Location Map



- Legend**
- Project Location
 - Municipal Boundary
 - Township, Range & Section Boundary

0 1,000 2,000 Feet
(At original document size of 8.5x11)
1:24,000



Project Location Prepared by JCS on 2022-03-08
T27N, R22W, S33
Inver Grove Heights, Dakota Co., MN

Client/Project 227704791
Republic Services
PBL Major Permit Mod

Figure No.
2

Title
USGS Topographic Map

V:\2277\active\22770479103_data\gis\proj\permit_mod\permit_mod.aprx Revised: 2022-03-08 By: jshuck

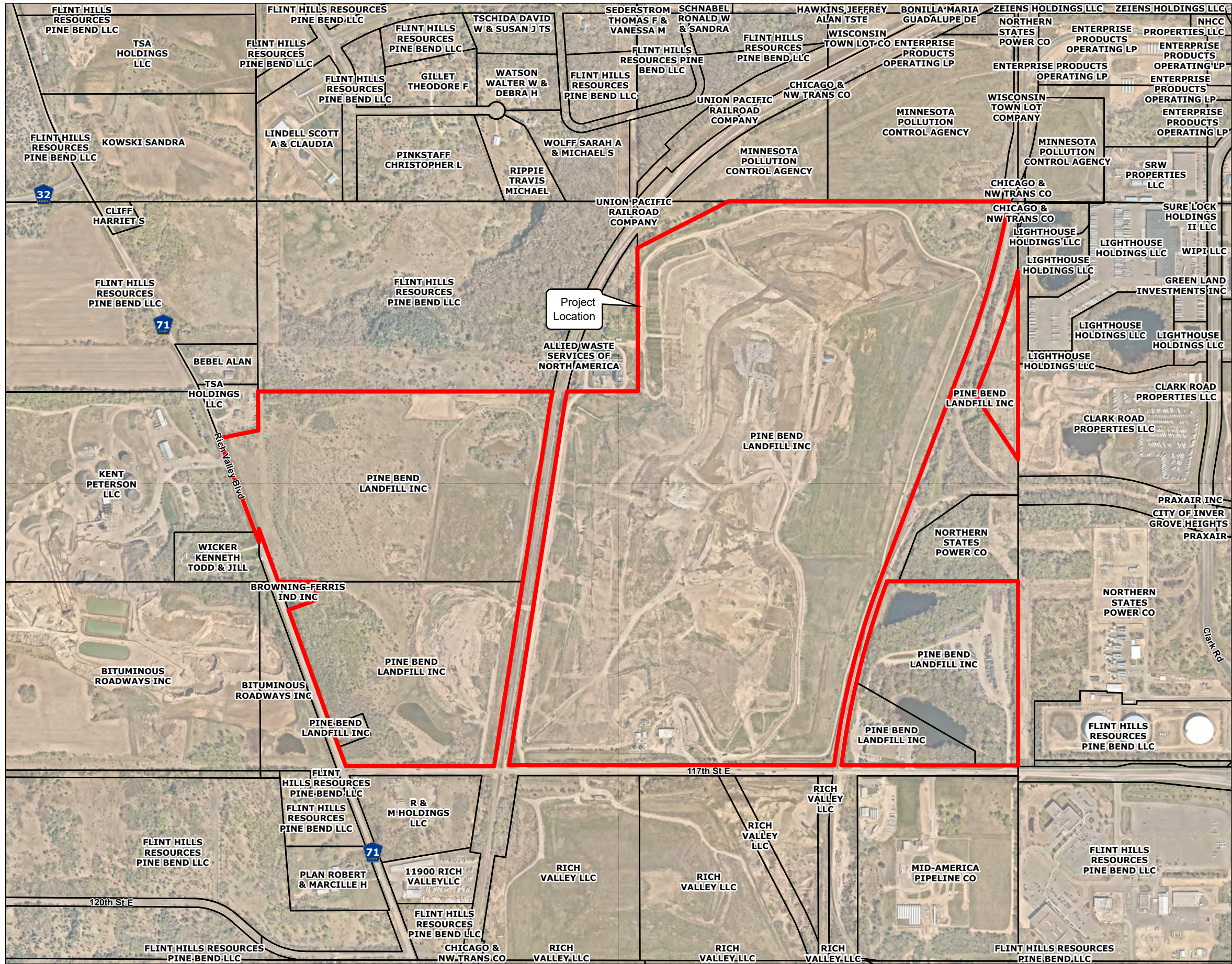


Figure No. **3**

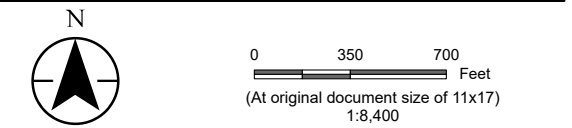
Title
Property Ownership Map

Client/Project
Republic Services
PBL Major Permit Mod

227704791

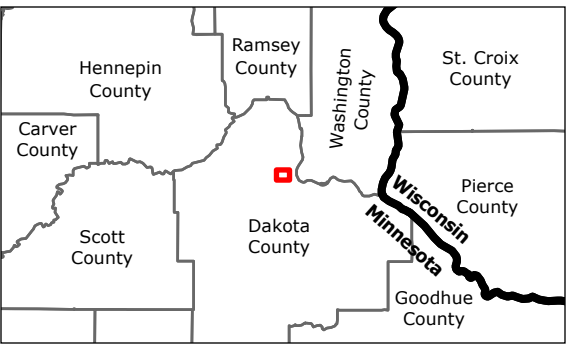
Project Location
T27N, R22W, S33
Inver Grove Heights, Dakota Co., MN

Prepared by JCS on 2022-03-08



Legend

- Project Location
- Parcels



Notes

1. Coordinate System: NAD 1983 UTM Zone 15N
2. Data Sources: Dakota County
3. Background: Dakota County 2021 Imagery



APPENDIX A

Adjacent Property Owners



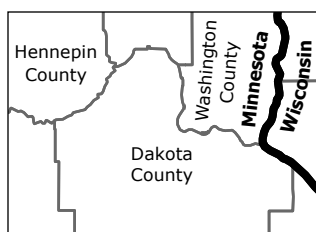
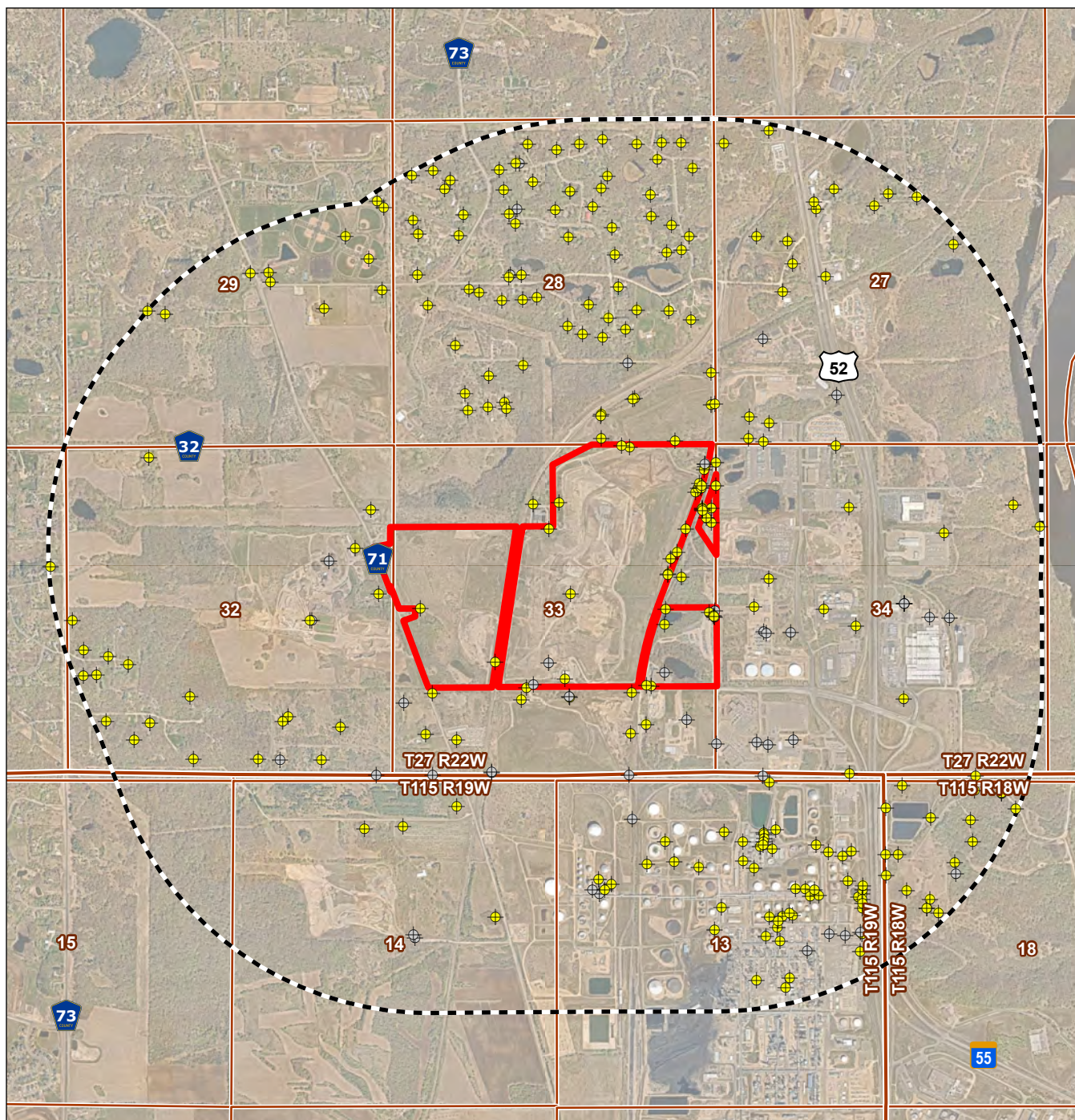
COUNTY ID	PIN	BLDG NUM	STREETNAME	STREETTYPE	SUFFIX	DIR	CITY	USPS	ZIP	PLAT NAME	ACRES	POLY	ACRES	DEED	USE1 DESC	USE2 DESC	USE3 DESC	USE4 DESC	MULTI USES	LANDMARK	OWNER NAME	OWN ADD L1	OWN ADD L2	OWN ADD L3	HOMESTEAD	ENV LAND	ENV BLDG	ENV TOTL	TAX CAPAC	TOTAL TAX	SPEC ASSES	TAX EXEMPT	NUSES DESC	DWELL TYPE	HOME STYLE	FIN SQ FT	GARAGESQFT	HEATING	COOLING	YEAR BUILT	NUM UNITS	SALE DATE	SALE VALUE	SCHOOL DIST	WHSID	GREEN ACRE	OPEN SPACE	AG PRESERV	PARC CODE	Shape Length	Shape Area
37	037-20027050600										0.22		0	EXEMPT					N		CHICAGO & NW TRAIN CO	1 N WSTN CTR	165 CANAL ST N	CHICAGO IL 60606-1549	N	2400	0	2400	48	0	0	Y	Exempt Railroad			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	147.589518	9721.63467
37	037-200270507000										8.46		0	EXEMPT					N		CONNELLY LANDFILL	MINNESOTA POLLUTION CONTROL AGENCY	520 LAFAYETTE RD N	SAINT PAUL MN 55155-4194	N	93100	0	93100	1842	0	0	Y	Metropolitan Waste Control Commission			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2472.54901	368771.831
37	037-200280070010	30108	105TH ST	E			INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		9.29		0	EXEMPT					N		CHICAGO & NW TRAIN CO	1 NW CENTER	165 CANAL ST N	CHICAGO IL 60606-1549	N	101200	0	101200	2084	0	0	Y	Exempt Railroad			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	6492.76565	404884.929
37	037-200280070012	10785	COURTHOUSE BLVD				INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		30.53		0	EXEMPT					N		CONNELLY LANDFILL	MINNESOTA POLLUTION CONTROL AGENCY	520 LAFAYETTE RD N	SAINT PAUL MN 55155-4194	N	93100	0	93100	1596	0	0	Y	Metropolitan Waste Control Commission			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	4546.739919	1129784.3
37	037-200280080010						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		11.88		0	EXEMPT					N		CONNELLY LANDFILL	MINNESOTA POLLUTION CONTROL AGENCY	520 LAFAYETTE RD N	SAINT PAUL MN 55155-4194	N	33000	0	33000	584	0	0	Y	Metropolitan Waste Control Commission			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	3333.60846	53738.36
37	037-200280083010						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		1.41		0	COMMERCIAL-PREFERRED					N		WISCONSIN TOWN LOT COMPANY	% UNION PACIFIC RAILROAD CO PR TAX	1400 DOUGLAS STOP 1640	OMAHA NE 68179-1640	N	11800	0	11800	131	238	0	0			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2977.14915	61494.1151	
37	037-2003200105011	11301	RICH VALLEY BLVD				INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		71.14		0	INDUSTRIAL-PREFERRED					N		KENT PETERSON LLC	1524 COMMERCIAL DR		MINNETOCHA HEIGHTS MN 55120	N	98040	27800	117600	14940	37124	0	N			2440	0	SPACE HTR	NONE	1986	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	7591.21124	209897.61	
37	037-2003200106010						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		3.23		0	INDUSTRIAL-PREFERRED					N		REBEL ALAN	8841 ALVERNO AVE		INVER GROVE HEIGHTS MN 55077	N	218700	213400	432100	1515	13216	0	N			3456	0	SPACE HTR	NONE	2015	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	1604.212608	146263.841	
37	037-2003200200200	11278	RICH VALLEY BLVD				INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		2.82		0	INDUSTRIAL-PREFERRED					N		TRU SEAL	TS&HOLDINGS LLC	11278 RICH VALLEY BLVD		INVER GROVE HEIGHTS MN 55077	N	276900	83100	360000	4136	10590	0	N			1500	0			2013	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	1429.024786	122734.397
37	037-200330030010						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		9.08		0	UTILITIES					N		NSP	% PROPERTY TAX DEPARTMENT	414 NICOLLET MALL	MINNEAPOLIS MN 55401-1991	N	302200	0	302200	3879	9950	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2581.376476	395441.031	
37	037-20033003082010	11479	RICH VALLEY BLVD				INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		4.79		0	RESIDENTIAL					AG		WICKER KENNETH TODD & JILL	% PROPERTY TAX DEPT	11479 RICH VALLEY BLVD		INVER GROVE HEIGHTS MN 55077	Y	153400	179300	332700	3382	4300	0	N			2236	0	FORCED AIR	FORCED AIR	1935	1	7/8/1989	83000	1935	1	7/8/1989	208634.615				
37	037-20033003083011						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		70.22		0	AG					Y		FLINT HILLS RESOURCES PINE BEND LLC	% PROPERTY TAX DEPT	PO BOX 2917	WICHITA KS 67201-2917	N	1142300	0	1142300	11481	10950	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	7477.514316	3058467.67	
37	037-20033003083010	11516	RICH VALLEY BLVD				INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		0.87		0	RESIDENTIAL					N		BROWNING FARMS AND INC	% REPUBLIC SERVICES	PO BOX 29246	PHOENIX AZ 85038	N	59800	132400	193200	1954	2518	7	N			1248	624	FORCED AIR	FORCED AIR	1960	1	10/8/1994	120000	1960	1	10/8/1994	37811.9504					
37	037-20033003090010						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		9.06		0	RESIDENTIAL					N		BITUMINOUS ROADWAYS INC	1524 COMMERCIAL DR		MINNETOCHA HEIGHTS MN 55120	N	202700	0	202700	2413	2965	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	3321.945375	294770.85	
37	037-2003300310101						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		0.88		0	INDUSTRIAL					N		PINE BEND LANDFILL INC	% LALLED WASTE AND INC - PROP TAX DIV	18000 NORTH ALLIED WAY		INVER GROVE HEIGHTS MN 55077	N	42100	0	42100	540	1470	84	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	798.499465	38279.9279
37	037-2003300320100						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		0.83		0	RESIDENTIAL					N		FLINT HILLS RESOURCES PINE BEND LLC	% PROPERTY TAX DEPT	PO BOX 2917	WICHITA KS 67201	N	74100	0	74100	881	1084	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	777.59548	3552.6464	
37	037-2003300320201						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		5		0	RESIDENTIAL					N		FLINT HILLS RESOURCES PINE BEND LLC	411 E EAST 37TH ST N	251 STANLEY ST	WICHITA KS 67220	N	153700	0	153700	1890	2250	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2508.288121	217754.573	
37	037-20033003401015						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		9.91		0	INDUSTRIAL-PREFERRED					N		R&M HOLDINGS LLC	% RICHARD L OGARA		SAINT PAUL MN 55107	N	483700	0	483700	5081	12614	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2708.102081	431781.067	
37	037-20033003401016	2480	117TH ST	E			INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		29.18		0	INDUSTRIAL					N		RICH VALLEY LLC	% HANDLING & CARBONE INC	1235 NORTH LOOP W STE 205	HOUSTON TX 77008	N	180700	0	180700	2157	5844	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	4642.151651	117080.9	
37	037-20033003701010	2790	117TH ST	E			INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		31.13		0	MACHINERY					Y		TERMOGAS CO	MID-AMERICA PRELINE CO	1025 EVERETT RD W	LAKE FOREST IL 60045-2697	N	1449900	3299200	4749100	55092	144628	0	N			4400	0	FORCED AIR	CENTRAL	1988	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	4801.251475	144318.19	
37	037-20033003701011						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		33.59		0	INDUSTRIAL-PREFERRED					N		RICH VALLEY LLC	% HANDLING & CARBONE INC	1235 NORTH LOOP W STE 205	HOUSTON TX 77008	N	841300	0	841300	10507	24735	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	7497.16697	144234.02	
37	037-20033003701012						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		2.32		0	INDUSTRIAL					N		RICH VALLEY LLC	% HANDLING & CARBONE INC	1235 NORTH LOOP W STE 205	HOUSTON TX 77008	N	9200	0	9200	118	288	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2759.302724	100994.341	
37	037-20033003701013						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		3.24		0	INDUSTRIAL					N		RICH VALLEY LLC	% HANDLING & CARBONE INC	1235 NORTH LOOP W STE 205	HOUSTON TX 77008	N	73000	0	73000	595	2292	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	3643.81838	140934.07	
37	037-20034003001012	11548	CLARK RD	RD			INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		49.21		0	UTILITIES					Y		NSP	% PROPERTY TAX DEPARTMENT	414 NICOLLET MALL	MINNEAPOLIS MN 55401-1991	N	2014600	3845400	3682300	449231	922646	0	Y			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	7808.0887	214817.88	
37	037-200340030010201	3098-3300	COURTHOUSE BLVD				INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55076		48.32		0	INDUSTRIAL					Y		FLINT HILLS-ADMIN BLDG	% PROPERTY TAX DEPT	PO BOX 2917	WICHITA KS 67201-2917	N	3795000	28955700	3750700	41908	1027730	0	N			4998	0			1975	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	6072.327889	2104937.38	
37	037-2013300301011						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55076		5.86		0	RESIDENTIAL					N		KOCH	% REAL ESTATE DEPARTMENT	1400 DOUGLAS ST STOP 1680	OMAHA NE 68179-1680	N	5280	0	5280	429	774	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	1712.483713	253305.128	
37	037-20173003010122						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		6.88		0	RESIDENTIAL					N		KOCH	% PROPERTY TAX DEPT	PO BOX 2917	WICHITA KS 67201-2917	N	62000	0	62000	739	908	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	4207.082204	29885.493	
37	037-20034003001010	11305	CLARK RD	RD			INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		24.64		0	INDUSTRIAL-PREFERRED					N		CLARK ROAD PROPERTIES GRAVEL	% MARK STEINBERGER CONSTRUCTION INC	3070 LENOXTON AVE S	EAGAN MN 55121-3121	N	1177300	147500	1274800	15866	35342	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	4286.98072	1047384.66	
37	037-20034600101010	11626	CLARK RD	RD			INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		13.64		0	INDUSTRIAL					N		FLINT HILLS	% RESC VY OPERATIONS	4111 EAST 37TH NCK	WICHITA KS 67220	N	1071500	3798600	4870100	62447	152840	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	3185.024863	594360.173	
37	037-2044950000100						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		2.06		0	INDUSTRIAL					N		LIGHTHOUSE HOLDINGS ADDITION	10001 KYLITE ST NE		BLAINE MN 55449	N	17100	0	17100	219	536	0	N			0	0			0	0	<Nub>	0	199	LOWER MISSISSIPPI RIVER	N	N	N	1	2503.73051	89633.3337	
37	037-2044950000400						INVER GROVE HEIGHTS	INVER GROVE HEIGHTS	55077		3.																																								

APPENDIX B

Water Well Inventory



V:\2277\active\227704791\03_data\gis\proj\permit_mod\permit_mod.aprx Revised: 2022-03-08 By: jshuck



Notes
1. Coordinate System: NAD 1983 HARN Adj MN
Dakota Feet
2. Data Sources: Stantec, Dakota County
3. Background: USGS Inver Grove Heights 7.5
Minute Quadrangle

Legend

- Project Location
- 1 Mile Radius
- Active Wells (Field Verified Only)
- Sealed Wells (Field Verified Wells Only)
- Township, Range & Section Boundary

0 1,250 2,500
Feet
(At original document size of 8.5x11)
1:30,000



Project Location
T27N, R22W, S33
Inver Grove Heights, Dakota Co., MN

Prepared by JCS on 2022-03-08

Client/Project
Republic Services
PBL Major Permit Mod

227704791

Appendix
B

Title
Water Well Inventory

Water Well Inventory
BFI Pine Bend Landfill Inver Grove Heights, MN
SW-45

UNIQUE_NO	WELL NAME	TOWNSHIP	RANGE	RANGE_DIR	SECTION	USE	DEPTH_COMP
104127	FELTON, TOM	27	22	W	32	DO	290
471702	BFI RECYCLERY	27	22	W	33	CO	470
451947	KEATLEY, MEL	27	22	W	28	DO	252
441890	MAHER, KEVIN	27	22	W	28	DO	408
149796	A.W. MARTIN ASSOC., INC.	27	22	W	27	TW	200
190492	WENCEL, JIM	27	22	W	28	DO	426
178503	KURTH, WAYNE	27	22	W	32	DO	280
129284	GILBERT, ROBERT	27	22	W	32	DO	300
249051	N.S.P.	27	22	W	34	DO	350
426997	PERRON, JAMES	27	22	W	28	DO	245
426938	OLSON, MARK	27	22	W	28	DO	274
1000002642	NIELAND, HENRY	27	22	W	32	DO	248
594998	TK505-BVW3A	115	19	W	13	OT	168
509068	KOCH REFINING RW-4	115	19	W	13	RC	184
198344	HALL, PETER R.	27	22	W	28	DO	319
174673	BITUMINOUS ROADWAYS INC.	27	22	W	32	PP	380
612663	W-35 KOCH REFINERY	115	19	W	13	MW	161
208391	GREAT NORTHERN OIL CO. 5	115	19	W	13	IN	1029
240190	PHOENIX INC. M-5A	27	22	W	33	EN	188
240192	M-7 PHOENIX INC.	27	22	W	33	MW	326
194293	HENNIG, PETER	27	22	W	28	DO	223
1000002106	ANDREASEN, MINDY	27	22	W	32	DO	320
408264	NIEDLAND, DEE	27	22	W	32	DO	248
1000002331	MALLEY, R.	27	22	W	32	DO	265
410938	TSCHIDA, DAVID	27	22	W	28	DO	351
208393	GREAT NORTHERN OIL NO.2	115	19	W	13	IN	433
190493	ELLER, BOB	27	22	W	28	DO	428
429889	WULF, JERRY	27	22	W	28	DO	320
435174	BIBELBACH, PAUL	27	22	W	28	DO	320
451595	CZECK, LEROY N	27	22	W	27	DO	358
186325	MADDEN, WM	27	22	W	28	DO	425
612014	TK88/EW-2	115	19	W	13	OT	105
159487	QUALITY PAINT SHOP	27	22	W	27	DO	285
426249	MW-26 PINE BEND LANDFILL	27	22	W	34	MW	225
198326	WAYNE TRANSPORT	27	22	W	34	PP	420
402554	SIELENI, TOM	27	22	W	27	DO	260
412379	WOODS, ROGER	27	22	W	28	DO	283
124321	BAGGE, RUSSEL	115	19	W	14	DO	94
426264	MW-30 PINE BEND LANDFILL	27	22	W	33	MW	223
188001	BIERMAIER, DENNIS	27	22	W	32	DO	250
429890	GILLET, TED	27	22	W	28	DO	300
101185	FRENCH, JEANNE + JAMES	27	22	W	29	DO	160
509070	KOCH REFINING RW-6	115	19	W	13	PS	185
136513	POLKINGHORNE, RICHARD	27	22	W	34	DO	290
437944	PINKSTAFF, CHRIS	27	22	W	28	DO	335
194296	NICKERSON, LANCE	27	22	W	28	DO	275
208395		115	19	W	14	DO	192
216474	MEIER, EUGENE	115	19	W	14	DO	225
145931	HOBBS, AGNES	27	22	W	27	DO	257
568553	IW-3 PINE BEND LANDFILL	27	22	W	33	RM	218
496285	OEHRLEIN & SONS & DAUGH.	27	22	W	27	CO	840
426266	MW-32 PINE BEND LANDFILL	27	22	W	28	MW	115

240191	M-6 PHOENIX INC.	27	22	W	33	MW	440
568552	IW-2 PINE BEND LANDFILL	27	22	W	33	RM	237
509066	KOCH REFINING RW-3	115	19	W	13	RC	183
426265	MW-31 PINE BEND LANDFILL	27	22	W	28	MW	198
509063	KOCH REFINING RW-1	115	19	W	13	RC	178
425209	STRAKA, STEPHEN	27	22	W	28	DO	300
612003	BDP/EVW-3	115	19	W	13	OT	182
410930	NELSON, RANDY	27	22	W	28	DO	420
198280	WEISE, KEITH	27	22	W	28	DO	374
240193	PHOENIX INC. M-8	27	22	W	33	OT	140
666490	W-54 FLINT HILLS REFINERY	115	19	W	13	MW	164
208389	CENEX FIRE WELL	27	22	W	34	PP	821
208394	GREAT NORTHERN OIL NO.4	115	19	W	13	PP	1019
554202	PR12-1	115	19	W	13	RM	180
426260	MW-27A PINE BEND LANDFILL	27	22	W	34	MW	273
426263	MW-27B2 PINE BEND LDF	27	22	W	34	MW	221
426267	MW-33 PINE BEND LANDFILL	27	22	W	34	MW	409
207297	NSP INVER HILLS PLANT	27	22	W	34	PS	1000
509065	KOCH REFINING RW-2	115	19	W	13	RC	180
425245	PICKA, DAVE	27	22	W	28	DO	362
149793	A.W. MARTIN ASSOC., INC.	27	22	W	27	TW	200
149795	WELL 7 A.W. MARTIN ASSOC., INC.	27	22	W	33	TW	152
426270	MW-36 PINE BEND LANDFILL	27	22	W	33	MW	395
427041	MOORHOUSE, JOHN	27	22	W	28	DO	225
207293	MW-3 PINE BEND DEVELOPMENT	27	22	W	33	MW	227
501451	ZABEL, LARRY	27	22	W	28	DO	405
608018	BITUMINOUS ROADWAYS INC 2	27	22	W	32	PP	185
190479	VIVANT, GENE	27	22	W	28	DO	411
429885	JEFFRIES, JOHN	27	22	W	27	DO	380
425296	BERG, JOHN	27	22	W	28	DO	340
412499	CZECK, PAUL	27	22	W	28	DO	360
441888	MID AMERICA PIPELINE CO	27	22	W	33	PN	650
612015	MP-1	115	19	W	13	RM	173
427051	WHEELER	27	22	W	28	DO	225
208392	GREAT NORTHERN OIL NO.1	115	19	W	13	IN	436
185296	EDDY, MERLIN	115	19	W	14	DO	171
426272	MW-38 PINE BEND LANDFILL	27	22	W	34	MW	237
408247	GRIMES, MARTIN	27	22	W	28	DO	273
434096	JASPER, BILL & KATHLEEN	27	22	W	27	DO	287
412479	CZECH, STEVE	27	22	W	28	DO	250
198256	FREEDMAN, DAVID	27	22	W	32	DO	280
265255	ROSEPORT DEPOT 1	27	22	W	33	PN	0
159480	CLIFF, HERMAN	27	22	W	32	DO	245
420005	NEETZEL, RAYMOND	27	22	W	28	DO	307
612004	PW-1	115	19	W	13	RM	85
151553	PABST MEAT SUPPLY	27	22	W	34	PP	989
170767	VAN SCHOOTER, MALVIN	27	22	W	27	DO	318
171820	COPE, LARRY	27	22	W	28	DO	350
207295	MW-1 PINE BEND LAND FILL	27	22	W	33	MW	227
435171	HAWKINS, JEFF	27	22	W	28	DO	321
441949	JOHNSTON, BILLY	27	22	W	28	DO	300
617783	W-33A	115	19	W	13	MW	196
591294	MW-52 PINE BEND LANDFILL	27	22	W	33	MW	185
122276	KELLER, EVERETT	27	22	W	28	DO	465
100014	PHOENIX INC LAND FILL	27	22	W	33	CO	466
441914	KRECK, WILLIE	27	22	W	27	DO	347
127289	UNION CARBIDE - LINDE DI	27	22	W	34	PP	680

142060	MCCARTHER	27	22	W	28	DO	290
159538	SCHNABEL, RON	27	22	W	28	DO	352
418604	BERNDT, TOM	27	22	W	28	DO	328
150192	DENT, DOUG	27	22	W	28	DO	403
437946	HASSEBROCK, STAN	27	22	W	28	DO	300
198319	SEYMOUR, CHUCK	27	22	W	28	DO	340
404812	GROENJES, GREG	27	22	W	28	DO	356
194266	KOURY, LAURENCE	27	22	W	32	DO	245
435231	HEIBURGER, EUGENE	27	22	W	28	DO	348
190488	HILTON, MIKE	27	22	W	33	DO	236
186039	TRIPLE S RANCH	27	22	W	28	DO	203
509071	KOCH REFINING RW-5	115	19	W	13	RC	184
194255	BRANDT, PHILLIP	27	22	W	32	DO	243
207292	DONOVAN CONSTRUCTION	27	22	W	34	PN	508
207294	PINE BEND LANDFILL	27	22	W	33	TW	377
451529	WEGMAN, DAN	27	22	W	28	DO	279
208386	BRAND, ARVID	27	22	W	28	DO	289
207296	PLAN, CLIFFORD	27	22	W	33	DO	100
129266	FEGLES POWER SERVICE	27	22	W	34	PP	506
612010	PW-2	115	19	W	13	RM	180
213584	KOCH REFINING NO.7	115	19	W	13	PP	1038
100961	WESTPHAL, MICHAEL	27	22	W	28	DO	302
435249	SLAHERTY, THOMAS	27	22	W	28	DO	297
208390	GREAT NORTHERN OIL CO. 3	115	19	W	13	IN	444
643923	MW-50	115	19	W	13	MW	205
418836	RICH VALLEY PARK	27	22	W	29	PN	178
149794	WELL-6 A.W. MARTIN ASSOC., INC.	27	22	W	28	TW	185
568551	IW-1 PINE BEND LANDFILL	27	22	W	33	RM	220
612729	MW-1	115	19	W	13	MW	114
402559	SANTEMA, MICHAEL	27	22	W	28	DO	180
434095	PERKINS, THOMAS & LYNN	27	22	W	27	DO	308
441916	HARRISE, MERLE	27	22	W	28	DO	300
612008	MP-1	115	19	W	13	RM	85
272766	BITUMINOUS ROADWAYS	27	22	W	32	EN	541
780331	BITUMINOUS ROADWAY'S	27	22	W	32	IN	645
767890	RICH VALLEY ATHLETIC ASSOC.	27	22	W	29	PN	392
243746	PINE BEND CEMETERY DNR OB 19015	115	18	W	18	OB	189
1000020426	GC4	115	18	W	18	MW	216
804956	MW-124 CITY OF INVER GROVE HEIGHTS	27	22	W	29	MW	43
591624	MW- PAB ENTERPRISES	27	22	W	33	MW	80
594938	MW-1	115	19	W	13	MW	153
594993	EW-3	115	18	W	18	RM	198
594995	TK505 BVW-2	115	19	W	13	OT	170
594996	EW-1	115	18	W	18	RM	198
594997	EW-2	115	18	W	18	RM	191
595000	PW-1	115	18	W	18	RM	196
612001	TK 505 BVW-4	115	19	W	13	OT	164
612006	PW-3	115	19	W	13	RM	91
612007	PW-4	115	19	W	13	RM	85
612011	BDP/MP-2	115	19	W	13	OT	161
612012	PW-1	115	19	W	13	RM	180
612016	EW-1	115	19	W	13	RM	175
612019	EW-1	115	19	W	13	RM	175
612024	PW-4	115	19	W	13	RM	180
612025	PW-5	115	19	W	13	RM	180
612666	W-44 KOCH REFINERY	115	18	W	18	MW	186
612671	MW	115	18	W	18	MW	190

612695	API-BVW-6	115	19	W	13	EN	102
612730	MW-2	115	19	W	13	MW	122
623390	PZ-1 BFI WASTE SYSTEMS OF NOR	27	22	W	33	MW	73
627214	MW-48 KOCH REFINERY	115	19	W	12	MW	170
627215	MW-46	115	18	W	18	MW	134
627218	MW-49	115	19	W	13	MW	144
564057	MW-5B PINE BEND LANDFILL	27	22	W	33	MW	181
666488	W-53 FLINT HILLS REFINERY	115	19	W	13	MW	140
643922	MW-51	115	19	W	13	MW	191
624056	RC	115	19	W	13	RC	184
506612	MW	27	22	W	33	MW	108
511904	CAP-6B CROSBY AMERICAN PROPERTIES	27	22	W	27	TW	245
511914	M-42 PINE BEND LANDFILL	27	22	W	34	MW	256.5
511919	GW-2 PINE BEND LANDFILL	27	22	W	33	MW	193
511936	CAP-9 CROSBY AMERICAN PROPERTIES	27	22	W	28	TW	135
235965	MW-2A PINE BEND LANDFILL	27	22	W	33	AB	102.5
235988	W30 FLINT HILLS RESOURCES, L.P.	115	18	W	18	MW	360
415938	M-12A PINE BEND LANDFILL	115	19	W	11	MW	93
415939	M-12B PINE BEND LANDFILL	115	19	W	11	MW	117.35
612005	PW-2	115	19	W	13	RM	86
612009	EW-4	115	19	W	13	RM	181
612670	MW-37	115	18	W	7	MW	207
627213	MW-38	115	18	W	18	MW	169
627217	MW-36	115	18	W	18	MW	169
715853	W-57 FLINT HILLS	115	19	W	13	MW	154
715854	W-58 FLINT HILLS	115	19	W	13	MW	149
415940	PINE BEND LANDFILL	27	22	W	33	TW	178
415941	PINE BEND LANDFILL	27	22	W	33	TW	173
416161	CAP-3 PINE BEND LANDFILL	27	22	W	28	MW	125.5
447845	MW-40 PINE BEND LANDFILL	27	22	W	33	MW	341.5
447846	M41 PINE BEND LANDFILL	115	19	W	12	MW	169.5
457201	MW	27	22	W	33	MW	66
457203	MW	27	22	W	33	MW	129
457204	MW	27	22	W	33	MW	136
469296	P-5 PINE BEND LANDFILL	27	22	W	33	MW	185
529488	MW-44 PINE BEND LANDFILL	27	22	W	33	MW	176
529489	MW-45 PINE BEND LANDFILL	27	22	W	33	MW	167.5
529490	MW-46 PINE BEND LANDFILL	27	22	W	33	MW	219
529491	MW-47 PINE BEND LANDFILL	27	22	W	33	MW	223
469297	P-6 PINE BEND LANDFILL	27	22	W	33	MW	185
189936	PHOENIX LAND-FILL	27	22	W	33	TW	440
194079	PHOENIX INC, #2	27	22	W	33	DO	132
194080	PHOENIX INC. #3	27	22	W	33	TW	188
194078	PHOENIX INC, #1	27	22	W	33	TW	140
415937	PINE BEND LANDFILL	27	22	W	33	TW	94.66
415942	PINE BEND LANDFILL	27	22	W	33	TW	158
416164	CAP 6 PINE BEND LANDFILL	27	22	W	27	MW	191
426250	MW-15 PINE BEND LANDFILL	27	22	W	34	MW	204
426261	MW-28 PINE BEND LANDFILL	27	22	W	33	MW	144
426262	MW-29 PINE BEND LANDFILL	27	22	W	34	MW	211
727718	W-59 FLINT HILLS	115	19	W	13	MW	125
727719	W-60 FLINT HILLS	115	19	W	13	MW	126
457202	MW	27	22	W	33	MW	94
666489	W-52 FLINT HILLS	115	19	W	13	MW	140
677965	W-34A	115	18	W	18	MW	204
734072	94 WELL 1	115	19	W	13	RM	145
734073	94 WELL 2	115	19	W	13	RM	140

734074	94 WELL 3	115	19	W	13	RM	144
734075	94 WELL 4	115	19	W	13	RM	140
742726	94 WELL 5	115	19	W	13	RM	144
742727	FLINT HILLS RESOURCES, L.P.	115	19	W	13	RM	170
564058	MW-50 PINE BEND LANDFILL	27	22	W	33	MW	173
564059	MW-51 PINE BEND LANDFILL	27	22	W	33	MW	173
564063	M-48 PINE BEND LANDFILL	27	22	W	33	MW	149
416162	CAP-4 PINE BEND LANDFILL	27	22	W	28	MW	154
416163	CAP-5 PINE BEND LANDFILL	27	22	W	28	MW	169.5
426248	MW-25 PINE BEND LANDFILL	27	22	W	33	MW	113
426268	MW-34 PINE BEND LANDFILL	27	22	W	34	MW	228
426269	MW-35 PINE BEND LANDFILL	27	22	W	28	MW	164
426271	MW-37 PINE BEND LANDFILL	27	22	W	34	MW	215
426273	MW-39 PINE BEND LANDFILL	27	22	W	33	MW	210
433263	KOCK REFINING MW-10	115	18	W	18	DO	213
433265	KOCH REFINING MW-12	115	18	W	18	MW	194
511903	CAP-5B CROSBY AMERICAN PROPERTIES, INC	27	22	W	28	TW	237
511905	CAP-1B CROSBY AMERICAN PROPERTIES	27	22	W	28	TW	183
511911	CAP-8 CROSBY AMERICAN PROPERTIES	27	22	W	27	TW	190
511918	P-4 PINE BEND LANDFILL	27	22	W	33	PZ	183
464089	JOHNSON, MARK	27	22	W	28	DO	340
243763	USGS 12B/ DNR OBWELL 19038	115	19	W	14	TW	150
435227	WICKER, JOHN	27	22	W	32	DO	183
235978		27	22	W	34		0
235962		27	22	W	33		0
485593	MOHR, MILO & CINDY	27	22	W	32	DO	305
497455	BOURGOIN, TONY	27	22	W	28	DO	314
243761	USGS TW1 (DNR OB 19036)	115	19	W	13	TW	106
189937	PHOENIX LAND-FILL	27	22	W	33	TW	326
240703	TH-2 RANNEY METHOD WATER SUPP	27	22	W	34	TW	131
429858	ANDERSON, GLEN	27	22	W	32	DO	280
240189	M-4A PHOENIX INC.	27	22	W	33	OT	132
426388	PLAN, LARRY	27	22	W	33	DO	320
554725	PARTRIDGE, CHARLES	27	22	W	28	DO	380
540361	NUMRICH, BETSY	27	22	W	32	DO	280
250019	CAP-1 CROSBY AMERICAN PROPERTIES	27	22	W	28	EN	70
466824	DORNIDEN, FRANK	27	22	W	28	DO	355
457198	WEIS, JOHN	27	22	W	28	DO	382
441870	HOSCHPTE, DAVE	27	22	W	32	DO	260
460104	SCHRAFF, BUD	27	22	W	29	DO	225
460151	KIRCHNER, HARRY	27	22	W	32	DO	280
464098	KENT, JERRY	27	22	W	28	DO	302
145733	KOUGHAN, WILLIAM	27	22	W	28	DO	290
489202	MW-23	115	19	W	13	MW	148
425714	DUANE TOLLO CONST	27	22	W	29	DO	423
426968	JIM MCNEARNY CONST	27	22	W	32	DO	275
418677	WICKER, JAY	115	19	W	11	DO	260
506730	NUORALA, KEN	27	22	W	27	DO	200
502128	WATRUD, STEVE	27	22	W	27	DO	520
580554		27	22	W	28	DO	342
591076	VANSCHOOTEN, MALVIN	27	22	W	27	DO	340
524107	MOTILLAL, RAM	27	22	W	28	DO	360
494825	GILLET, BILL	27	22	W	28	DO	356
481453	NOHAVA, MIKE	27	22	W	28	DO	265
481444	PERRON, KEVIN	27	22	W	28	DO	375
495819	HOFFMAN, KEVIN & LUCY	27	22	W	29	DO	230
593242	GILBERTSON, DARRIN & KAREN	27	22	W	31	DO	265

634223	HILLER, KEITH	27	22	W	28	DO	280
679291	RICHARDSON, TOM	27	22	W	28	DO	280
745826	BIGGS, ANDY	27	22	W	29	DO	345
686269	INVER GROVE HEIGHTS 2	27	22	W	29	IR	195
686270	INVER GROVE HEIGHTS WELL 3	27	22	W	29	PN	175
594994	MW-33	115	19	W	13	MW	187
594999	EW-4	115	18	W	18	RM	191
612020	EW-2	115	19	W	13	RM	172
511917	P-3 PINE BEND LANDFILL	27	22	W	33	PZ	189
511916	P-2 PINE BEND LANDFILL	27	22	W	33	MW	189.5
511915	P-1 PINE BEND LANDFILL	27	22	W	33	MW	190
751101	VEGA, JOSE	27	22	W	28	DO	308
748755	SHAFFER CONTRACTING CO, INC.	115	19	W	14	CO	245
768790	TSCHOHL	27	22	W	29	DO	420
777611	BROWN, MARCUS	27	22	W	27	DO	419
768774	JOHNSTON, BILLY	27	22	W	28	DO	285
790267	BARR, LORI	27	22	W	28	DO	295
797582	MW 67	115	18	W	18	MW	215
797583	MW 68	115	18	W	18	MW	209
797584	MW	115	18	W	18	MW	195
795488	SCHNEIDER, TOM	27	22	W	27	DO	295
821155	BABEL, PAC/AL	27	22	W	32	DO	166
832184	NOHAVA, JAMES & KARI	27	22	W	28	DO	386
341832	B-1-02	115	19	W	12	EN	70
341833	B-2-02	115	19	W	11	EN	70

DESIGN REPORT



DESIGN REPORT

Request for Major Modification of
MPCA Permit #SW-45

June 2, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359

Project Number:
227704791

Table of Contents

1	SUMMARY	1
1.1	INTRODUCTION	1
2	FACILITY INFORMATION	2
2.1	LOCATIONAL STANDARDS	2
2.2	WASTE FLOWS/SITE CAPACITY/PHASING	2
3	SITE HYDROGEOLOGY	4
3.1	SITE HYDROGEOLOGY	4
4	DESIGN REPORT	5
4.1	SOILS FOR CONSTRUCTION	5
4.1.1	Introduction	5
4.1.2	Soil Components	5
4.2	SUBBASE PREPARATION	6
4.3	BASE GRADES	7
4.3.1	Design	7
4.4	LINER DESIGN	7
4.5	LEACHATE COLLECTION SYSTEM	8
4.5.1	Introduction	8
4.5.2	Drainage Layer System	9
4.5.3	Collection Pipes	9
4.5.4	Leachate Sump, Head Build-Up, and Removal	10
4.5.5	Leachate Leak Detection	10
4.5.6	Dual Extraction System	11
4.6	FINAL COVER	12
4.6.1	Design Overview	12
4.6.2	Final Cover Grades	12
4.6.3	Surface Water Management	14
4.7	LANDFILL GAS MANAGEMENT	16
4.7.1	Background	16
4.7.2	Gas Probe Management	17
4.7.3	Future Gas System Installation	18
4.7.4	Proposed Gas System Design	18

LIST OF TABLES

Table 1: Landfill Design Volumes	3
--	---

LIST OF APPENDICES

APPENDIX A	11" x 17" Plan Sheets
APPENDIX B	Technical Specifications and CQA Plan
APPENDIX C	Surface Water Management
APPENDIX D	Geotechnical Evaluation



LIST OF PLAN SHEETS (Full Size 22" x 34" Attached Separately)

1. Title and Index Sheet
2. Existing Conditions Map (East Side)
- 2A Existing Conditions Map (West Side)
3. Phasing Plan
4. Phase 7 – Vertical Expansion Final Cover Grading Plan
5. Phase 7 – Vertical Expansion Surface Water Management Plan
6. Existing Gas Piping Plan North Half
7. Existing Gas Piping Plan South Half
8. Proposed Gas Piping Plan North Half
9. Proposed Gas Piping Plan South Half
10. Cross-Section A
11. Cross-Section B
12. Cross-Section C
13. Liner System Details
14. Leachate Riser Manhole Details
15. Surface Water Management Details
16. Gas System Details
17. Gas System Details
18. Gas System Detail



1 Summary

1.1 INTRODUCTION

This Design Report has been prepared by Stantec Consulting Services Inc. (Stantec) for BFI Waste Systems of North America LLC. (BFI) and the Pine Bend Landfill (PBL). The Design Report is intended to fulfill MPCA requirements for MSW facilities as well as describe, in detail, the design of the PBL vertical expansion. The design detailed within proposes to raise the permitted elevations of the landfill by extending the 3:1 slopes vertically around the existing top of the landfill (vertical expansion). This proposed vertical expansion will be called Phase 7. The design provides for increased airspace capacity without increasing the footprint. The 3:1 final cover slope design has been shown to be stable from a geotechnical standpoint and efficient at surface water management. The proposed and current landfill design includes environmental controls that meet or exceed the regulatory requirements for this type of facility. It is important to note that a vertical expansion (Phase 6) including new cells overlying existing waste in the unlined area was approved as part of a previous permit application, prepared by Wenck, dated August 2015. This Phase 6 expansion is currently being implemented at the site. Phases 6C, 6D, and 6B-1 of the previously permitted Phase 6 expansion are currently operational at the site, and Phase 6B-2 will be constructed in 2022. Phase 6A is yet to be constructed. Phases 6D and 6B-1 were certified to begin waste filling in August 2021. There are no proposed major design changes as part of this application for major permit modification.

As previously mentioned, all applicable information submitted as part of the previous permitting process is sometimes referenced only and is not entirely resubmitted. This is an effort to minimize the volume of this submittal by not including unchanged information. Some specific items referenced within that are not being resubmitted include the following:

- Leachate Recirculation Plan
- HELP Model Results

A summary of hydrogeologic conditions and most recent findings as well as the site's environmental monitoring system are discussed in the next section. The Plan Sheets, reduced to 11"x 17" format, are included in Appendix A.



2 Facility Information

2.1 LOCATIONAL STANDARDS

In accordance with MPCA rules, an MSW disposal facility must be located as specified in 7035.2815, subpart 2. Previous and current operations, as well as past site investigations demonstrate that the site is suitable as an MSW land disposal facility.

In general, the ground surface elevations at the site range from approximately 850 feet National Geodetic Vertical Datum (NGVD) to 950 feet NGVD. The Mississippi River is located approximately one mile east of the landfill at an elevation of approximately 687 feet NGVD.

Land use in the vicinity of the site is primarily mixed industrial and agricultural. PBL is bordered to the north by the closed Crosby American Properties Demolition landfill (CADL) and to the east by vacant property and commercial businesses. Locations further to the east include a Xcel Energy generating facility, food processing plant, chemical plants, a former CENEX warehouse, and a trucking terminal. East of this is a State of Minnesota Scientific and Natural Area (SNA) that adjoins the Mississippi River. The SKB Rich Valley Demolition Landfill is located south of PBL. Residential property, farmland, and vacant property are found to the west of PBL.

2.2 WASTE FLOWS/SITE CAPACITY/PHASING

According to the 2021 Annual Report prepared for this facility and submitted to the MPCA, the PBL utilized approximately 472,263 cubic yards of solid waste capacity in 2021.

For the purposes of cell phasing, an annual fill rate of approximately 600,000 cubic yards per year will be used. The 600,000 cubic yard annual fill rate is based upon approximately 420,000 tons per year received and assumes an in-place density of approximately 1,400 pounds per cubic yard, as well as PBL's knowledge and experience in the solid waste collection marketplace.

PBL is currently filling in the Phase 6 area of the landfill. The Phase 4 development, which consists of Phases 4A, 4B, and 4C is approximately 36.8 acres in size, and was designed and permitted to allow for approximately 4 million cubic yards of capacity. Phase 5 is the vertical expansion over previously filled areas and is to be developed with a total of 6 cells designated Phase 5A through 5F of which Phases 5A through 5E have been constructed. As of January 2021, the remaining permitted/ultimate landfill capacity is approximately 2,643,316 cubic yards (which includes final cover requirements). The Phase 6 major permit modification application requested an additional 4,137,400 cubic yards of airspace capacity for the Phase 6 development. The total ultimate disposal capacity of the site was increased from 29,800,000 cubic yards to 33,937,400 cubic yards.

The Phase 7 development for which this major modification application is being submitted will allow for the vertical expansion of airspace capacity over the existing Facility footprint. No horizontal footprint increase is included as part of this proposed vertical expansion. The Project will increase the permitted design capacity by 8,185,800 cubic yards (cy), for a total capacity of 42,123,200 cy and extend the life of the Facility by approximately thirteen (13) years.



Design Report

2 Facility Information

Disposal Area Summary:

Disposal Area	Ultimate Design Capacity (cy)	Proposed Additional Capacity (cy)	Current Permitted Design Capacity (cy)	Remaining Permitted Design Capacity (cy)
MSW	42,122,900	8,185,800	33,937,400	3,839,691

(1) The above volumes include final cover requirements.

A summary of the design volumes is provided in Table 1: Landfill Design Volumes. As shown, the landfill will be constructed and closed in phases.

Table 1: Landfill Design Volumes

Phase	Remaining Airspace (cy) ⁽¹⁾⁽²⁾	Status	Site Life (year) ⁽³⁾	Site Life (months)	Open Date
5F-2	826,300	Future	1.34	16.08	Future
6	989,082	Constructed	1.65	19.80	2019-2021
6	1,757,400	Future	2.92	35.04	2022-Future
7	8,185,800	Future	13.64	163.68	Future
Total	11,758,582		19.55	234.60	

(1) Based on 2021 Annual Report.

(2) Includes Final Cover requirements.

(3) Based on Annual waste flow of 600,000 cubic yards.



3 Site Hydrogeology

3.1 SITE HYDROGEOLOGY

Site geology and hydrogeology has been extensively evaluated since the facility began operations in 1971. A groundwater monitoring network has been in-place since 1972 and more than 35 years of groundwater monitoring data has been collected.

The 2021 Annual Water Quality and Natural Attenuation Monitoring Report prepared by Groundwater and Environmental Services, Inc. (GES) represents the most recent compilation of site hydrogeologic information available. The above 2021 Annual Report should be referred to for a more detailed discussion. A brief overview of the site hydrogeology is presented below.

The uppermost aquifer underneath the site consists of the glacial deposits that are hydraulically connected to the Prairie du Chien Group and the Jordan bedrock formations. In the bedrock valley, the glacial deposits are also hydraulically connected with the Franconia Formation. Prairie du Chien and Jordan collectively comprise the major aquifer in the Twin Cities metropolitan area. The Franconia Formation can provide small amounts of water, but is usually considered to be, along with the St. Lawrence Formation, a confining unit (Schoenberg, 1990). The Ironston and Galesville Sandstones serve as a regional aquifer above the Eau Claire formation, which acts as a major aquitard. The deepest aquifer in the area is generally considered to be the Mt. Simon Sandstone.

An extensive monitoring well network is used for water-level measurements and water-quality sampling at PBL. The water table in glacial deposits is encountered between 725 to 800 feet NGVD. Groundwater flow direction is to the northeast with the northeast flow becoming more easterly as it approaches the bedrock valley along the northern boundary of PBL.

The average horizontal hydraulic gradient in the uppermost aquifer has been calculated to be 0.010 feet per foot. Historically, the gradient has been steeper along the eastern boundary of PBL. Adjacent to and east of PBL, the hydraulic gradient becomes more gradual until about U.S. Highway 52/Minnesota Highway 55 where the hydraulic gradient increases once again due to the proximity of the Mississippi River Valley.



4 Design Report

4.1 SOILS FOR CONSTRUCTION

4.1.1 INTRODUCTION

Stantec has evaluated the various soils and soil materials required during construction and development of the reconfigured landfill. The following materials required have been implemented for the various lining systems which have been already constructed or are currently planned to be constructed. The soils and aggregates required for a majority of the construction and development are as follows:

- Controlled fill - subgrade and berm construction;
- Clay barrier layer - required for composite liner system;
- Drainage layer - required for base drainage layer;
- Coarse aggregate - for leachate pipe bedding and leachate collection sump;
- Intermediate aggregate - for leachate pipe collection trench and sump;
- Cover soils - required between the final cover, geonet geocomposite drainage layer and topsoil layer;
- Topsoil- required for top 6 inches of final cover and berms; and
- Class 5 aggregate - required for roadway surfaces.

The materials must meet the requirements and be placed according to the technical specifications and construction quality assurance (CQA) program, which are provided in Appendix B. The critical soil components listed above are discussed in more detail below. It is important to note that for Phase 7, the composite base liner system is in-place so clay barrier layer, sand drainage layer, and the aggregates will not be needed. The clay, sand and aggregates will however be needed for the remaining Phase 6 cells to be constructed and future cell 5F-2.

4.1.2 SOIL COMPONENTS

4.1.2.1 Controlled Fill

Controlled fill is utilized for the construction of the subgrade and berms. The majority is brought in from off-site sources. Soils classified as SC, SM, SP, SW, ML, or CL are used for this purpose.

4.1.2.2 Clay Barrier Layer

The clay barrier layer should consist of soils classified as SC, CL or CH. The clay barrier layer material is obtained from an off-site source. Criteria for the clay barrier layer is as follows:

- Hydraulic conductivity of 1×10^{-7} cm/sec or less;
- Compacted to at least 95 percent Standard Proctor Dry Density (D-698), at a moisture content at, or within 5 % above, optimum;
- Atterberg Limits
 - Liquid Limit greater than 25 percent
 - Plasticity Index of 12 or greater;
- Minimum P-200 content approximately 50 percent; and
- Clay content ≥ 25 percent (clay particles ≤ 2 microns).



4.1.2.3 Drainage Layer

PBL uses granular material for the drainage layer in the leachate collection system. The material must meet the following drainage (design) criteria for use:

- Hydraulic conductivity of greater than 1×10^{-3} cm/sec
- 100% passing the 3/8-inch sieve or greater.
- Maximum 5% passing the #200 sieve.

4.1.2.4 Coarse and Intermediate Filter Aggregate

Coarse aggregate is required at the site for placement in the leachate collection trenches. It provides a highly permeable drainage media, and a bedding material for the leachate collection pipes, as well as bedding for the gas extraction well casings. Specifications for the coarse aggregate are:

- Maximum size 1 1/2 inches
- Minimum size 5/8 inch
- Sub-angular to rounded material
- Durable (no limestone)

The specifications for the intermediate filter aggregate are detailed in Section 02202 of the Technical Specifications provided as Appendix B of this Design Report.

4.1.2.5 Cover Soils

Cover soils are required between the drainage layer and topsoil in the final cover. These soils must be able to provide a rooting zone for the final cover vegetation. PBL is also proposing to use yard waste compost or a mix of yard waste and organic waste compost as intermediate cover at the site.

4.1.2.6 Topsoil

Topsoil is required as the top layer (6 inches) of the final cover, and for the top layer on berms, embankments, drainage ditches, etc. This soil will meet MnDOT 3877.2A or an approved equal.

4.1.2.7 Class 5 Aggregate

Class 5 aggregate is required as a surface stabilizer for the site access roads.

4.2 SUBBASE PREPARATION

The following section describes subgrade preparation for liner construction over existing waste (Phase 6). Please note that the proposed vertical expansion (Phase 7) will consist of placing new waste on top of existing waste vertically which, naturally uses the Phase 5 and 6 base liner systems currently constructed and previously approved to collect leachate.

Site preparation for continued construction and vertical expansion of the MSW facility begins with grading and shaping to the required grades. Soft or loose soils, organic material, rocks, roots, etc. are replaced with more suitable fill material as needed and compacted to a minimum of 95 percent Standard Proctor Dry Density (ASTM D-698). In general, a majority of the remaining subgrade preparation is completed on waste filled slopes of the existing landfill. Subgrade is then prepared natural soil surface on which liner construction will begin. The subgrades for the disposal area have been designed to maximize site life, minimize environmental impacts, and blend into existing site grades.



The following is a description of the subgrade preparation that has already been implemented, and is currently implemented for ongoing construction in the 3:1 vertical expansion areas:

Over a majority of the Phase 6 area, there is an existing 2-foot clay barrier serving as the final cover cap and no synthetic membrane. For development of Phase 6, the existing final cover is removed down to the top of the clay barrier layer. The new liner system for this area (GCL and 60-mil HDPE) is placed directly on the 2-foot clay barrier layer. BFI is proposing to utilize the existing clay cap as part of the base liner system for expansion over this area.

Over a portion of proposed Phase 6A in the southeast corner of the site, the proposed expansion area is final covered with a 12-inch layer of cover soil, 12-inch sand drainage layer, and 40-mil synthetic geomembrane. In developing this Phase 6A area, the top 12-inch soil cover layer will be removed and stockpiled for utilization as part of final cover on other disposal areas at the site. The 12-inch sand drainage layer and 40-mil geomembrane will be left to serve as a protective layer. The 12 inches of material left in-place over the synthetic membrane will help ensure that the membrane is not damaged.

Use of low-ground-pressure tracked dozers will be employed and downslope movement will be prohibited. The final cover topsoil and cover layers will only be removed as the filling proceeds, thus limiting open area to a small section. Non-contact surface water from the upper slopes will be diverted away from the fill areas by the use of temporary berms as needed.

4.3 BASE GRADES

4.3.1 DESIGN

Base grade is defined as the top of the liner surface. The base grades for the currently permitted MSW facility have been designed to maximize site life, and yet minimize environmental impacts. The grades range from 33 percent on the internal sideslopes (3 horizontal to 1 vertical) to a minimum of 3 percent on the base, with leachate flow being directed to collection sumps within each phase.

The base grades for the Phase 6 expansion design are set by the current grade on the overfill areas but no less than 3 percent and no greater than 20 percent, with the exception of the 3:1 containment berm slope. A containment berm is constructed around the perimeter of the existing landfill to contain the overfill waste area (Phase 6) and provide for leachate collection.

The base grades in the currently permitted area are set at a minimum elevation of 872 feet, MSL. While the MPCA Solid Waste Rules do not require a groundwater separation for MSW facilities, MPCA policy is to request a minimum groundwater separation of 5 feet. Since the water table exists beneath the site at an elevation between 730 to 800 feet, the 5-foot separation from groundwater will exceed 5-feet for all newly constructed areas.

4.4 LINER DESIGN

The liner system for MSW disposal areas, according to MPCA solid waste rules, must be designed to have a minimum collection efficiency of 95 percent. In addition, the liner system in combination with the final cover must have a minimum collection efficiency of 98.5 percent.

The approved liner system designs for the existing and remaining landfill development vary for the different areas of the site depending upon the existing liner system in-place below the vertical expansion. The proposed liner designs are as follows:



1. The western fill area or what basically constitutes Phase 4 development has been constructed with a composite liner consisting of one 60-mil (0.060 inch) high density polyethylene (HDPE) liner, overlying a 2-foot compacted clay liner. The clay liner has a maximum permeability of 1×10^{-7} cm/sec and was compacted to a minimum of 95 percent Standard Proctor Dry Density, with a moisture content 0 to 5 percent wet of optimum moisture content.
2. The Central Fill Area or the valley between Phases 1, 2, and 3 and Phase 4 development is generally on virgin ground and a composite liner is currently permitted for this area. The composite liner is the same design as presented above and what is currently being utilized in Phase 4, & Phases 5A through 5 E and permitted for 5F.
3. The southeast fill area is the portion of Phase 3 landfill development which has received final cover with a 40-mil flexible membrane liner. The permitted liner design for overfill in this area is one 60- mil HDPE liner, overlying a geosynthetic clay liner (GCL).
4. The majority of the Phase 6 expansion area is over Phases 1 and 2 which were constructed over an unlined area. The permitted liner design for overfill in this area and for that being proposed for this expansion is one 60- mil HDPE liner, overlying a GCL. Also, PBL will utilize the existing 2-foot clay cap as part of the base liner system for this area and not incorporate a GCL should the existing 2-foot clay cap be shown to meet base liner quality clay standards.

The HELP Model calculations for the above liner designs were prepared as part of the previous permit application process and verify that these liner designs have an efficiency approaching 100 percent, which is exceeding MPCA rule requirements. The potential for the HDPE membrane to be punctured by a particle from the sand drainage layer was also evaluated. The factor of safety from puncture by this mechanism was shown to be 1.5.

4.5 LEACHATE COLLECTION SYSTEM

4.5.1 INTRODUCTION

The leachate collection system for the 3:1 overfill buildout and vertical expansion, as proposed in this request for modification, is designed to collect and convey leachate from the overfill area to one of 6 leachate collection sumps located as shown on the drawings. The leachate collection sumps are created by excavating low points in the designated areas and the proposed perimeter berm that is constructed to serve as containment for the proposed 3:1 overfill area. The containment berm is constructed so that the alignment creates a trench slope along the inside toe that directs leachate to the respective sumps. The trench area is filled with coarse aggregate and a perforated leachate collection pipe will direct leachate to the sumps.

Leachate collected in the sumps is then be pumped via a submersible sideslope riser pump to the existing forcemain that encircles the perimeter of the landfill. Each sump incorporates a sideslope riser to eliminate penetration of the liner. A submersible pump capable of pumping approximately 80 to 120 gpm of leachate is installed at the bottom of each sideslope riser. Leachate from the sumps will continue to be pumped to the leachate tanks by double-wall, solid HDPE forcemain, which has been buried at a minimum 5-foot depth to prevent freezing.

Currently, the site is served by two leachate storage tanks as follows:

- One 101,000-gallon tank in southern portion of site near office building;
- One 80,000-gallon tank in southern portion of site near office building.



Historical leachate collection data is presented below.

Year	Leachate Collection Volumes (Gallons)
2017	6,642,340
2018	9,670,009
2019	7,610,212
2020	5,148,812
2021	9,188,290

Based on the data, it is reasonable to estimate that the leachate generation will continue to be about 8 to 9 million gallons per year in upcoming years as PBL plans to final close portions of the landfill as soon as final grade is reached and open areas should remain approximately the same as current. The real variability is a function of seasonal precipitation and the amount of open landfill surface area, rather than total landfill area.

4.5.2 DRAINAGE LAYER SYSTEM

The HDPE liner is overlain by 12 inches of granular drainage layer material. In compliance with the MPCA Solid Waste Rules, the permeability of the drainage layer is specified to be 1×10^{-3} cm/sec, or greater. On all sideslopes steeper than 10 percent, a textured HDPE membrane is utilized to improve stability of the geomembrane/clay interface, geomembrane/drainage layer interface and the geomembrane/GCL interface.

The granular drainage layer collects leachate and provide drainage along the liner to the leachate collection trench. Coarse aggregate (5/8 inch to 1 1/2 inch) is embedded around the collection pipes to protect them from damage and provide increased flow performance. An intermediate filter aggregate overlies the coarse aggregate. The granular drainage layer also functions as a protective layer to prevent equipment from damaging the HDPE liner. The potential for the HDPE membrane to be punctured by a particle from the pipe bedding material was evaluated. These calculations were previously completed and the factor of safety from puncture by this mechanism (coarse aggregate) was shown to be 1.5.

4.5.3 COLLECTION PIPES

Construction of the leachate collection trench begins with the placement of a geotextile in the pipe trenches above the HDPE liner. A layer of coarse aggregate 3 inches thick is placed in the trench, and the pipe is placed and aligned. The remaining coarse aggregate is placed after the pipe is fully installed. A graded filter aggregate 12 inches thick, is placed over the coarse aggregate to provide a filter from the overlying granular drainage layer. This filter helps stop migration of particles that might otherwise clog the collection pipe. The granular drainage layer material is then placed over the trench. Special care is taken to properly align the pipes, according to the invert elevations and locations. The perforations are oriented to be on the bottom.



The collection pipes are 6-inch diameter, perforated, Standard Dimension Ratio (SDR) 11, HDPE pipe. Pipe strength calculations were previously completed for the Phase 5 vertical expansion and the pipe deflection due to maximum loading by waste is determined to be less than 5 percent. Failure due to buckling or wall crushing was also evaluated and safety factors were shown to be 11.6 and 6.8, respectively. The Phase 7 expansion area will not have any fill depths and maximum loading conditions greater than those used in the above calculations.

4.5.4 LEACHATE SUMP, HEAD BUILD-UP, AND REMOVAL

As previously described, there is a significant amount of historical leachate collection data for this site. This historical data shows that, approximately 8 to 9 million gallons of leachate will likely be generated and collected per year while this site is in operation.

For the proposed overfill area, leachate sumps have been created by the intersection of the proposed perimeter berm and the existing final cover. Approximately 4,000 gallons of leachate may be contained in the leachate sump, which is designed to be 2 feet deep and assuming the porosity of coarse aggregate to be 0.4. During regular operations, leachate head is maintained at 12 inches or less over the sump area by setting the start/stop limits of the leachate pump to reflect these elevations. The pumps transfer the leachate to one of the two existing leachate tanks via the existing forcemain.

Leachate can be controlled during initial filling of the vertical expansion area by limiting the area constructed and by diverting surface water, prior to contact with the waste, and directing to the surface water downslope structures if possible or directly off the waste footprint. However, in the event of an extreme rainfall event during the filling of an overfill phase, the following scenario was analyzed:

Assuming an open area of 20 acres (approximate size of one Cell of Phase 6 expansion) draining to the area between the proposed perimeter berm and existing landfill final cover, an approximate 8.5-inch rainfall could be contained within the leachate collection trench area and maintain a foot of freeboard below the top of the perimeter berm. This analysis is conservative for the following reason:

- No waste was considered in any of the open 20 acres
- An 8.5-inch rainfall exceeds even the 100-year event in this location
- PBL intends to limit the open area of the Phase 6 expansion to less than 20 acres and use operational berms to the extent possible to minimize the leachate that needs to be managed.

4.5.5 LEACHATE LEAK DETECTION

With regards to a leak detection system (lysimeter) installed beneath the low point of the Phase 6 fill area, MPCA Solid Waste Rules part 7035.2815, subp. 9 states:

A. The owner or operator must install the detection system at the lowest elevation of the fill area and throughout the fill area, as necessary, to monitor leachate build-up and for use as a part of the collection system. The detection system must be capable of monitoring leachate build-up in the fill area and consist of collection lysimeters and standpipes capable of monitoring, detecting, and collecting leachate movement through the liner. The detection system must consist of materials compatible with the leachate. The commissioner may approve a detection system without collection lysimeters or standpipes provided the owner or operator shows either to be unnecessary based on the liner system, subsurface soil conditions, ground and surface water flow patterns, depth to ground water, and the amount of leachate generated. The detection system must be designed and constructed to monitor the effectiveness of the leachate storage area.



For the Phase 6 development, which included an enhanced liner system in the sump areas (60 mil, GCL, 2 feet of clay), PBL conducted liner leak location testing following each phase of liner system construction in lieu of lysimeters. Historically, PBL sees little to no liquid and no detection of leachate indicator parameters in their current lysimeters. PBL is committing to providing enhanced design and construction activities for this overfill development; above and beyond what has been performed in the past for their liner system that is showing no indication of loss of integrity. PBL is aware that the MPCA has approved the elimination of lysimeters in other composite lined facilities.

4.5.6 DUAL EXTRACTION SYSTEM

The leachate extraction system at the Pine Bend Landfill (PBL) in Inver Grove Heights, Minnesota was installed in 2002 to collect leachate from the unlined portion of the landfill. Fifty (50) gas extraction wells were reconfigured to allow for dual use for landfill gas and leachate recovery. Because this portion is unlined, successful leachate extraction is vital in source control of the groundwater and in reducing leachate from the closed portion of the landfill mound. An evaluation of the system shows an overall reduction in leachate head levels from 2002 to the present during the time the system has been operational. The number of dual extraction wells has decreased due to extraction wells being removed from the system because of the Phase 5 and 6 expansions, as well as miscellaneous pump issues (silted in or unremovable from well). It should be noted that 17 pumps have been temporarily removed in 2019, 2020, and 2021 due to the “piggy-back” expansions (Phase 6C, 6D and 6B-1), allowing for active waste filling activities in the vicinity of those wells. The remaining pumps in the current system will be temporarily removed in 2022 for additional cell construction activity, at which point the dual extraction system will be redesigned.

The Grundfos SQE pumps installed in the dual extraction wells are equipped with an onboard electronic motor that records pump starts and stops, hours of operation, and speed of the pump along with a number of other operating features. The pump supplier for the site has indicated that the SQE pumps are the top-of-the-line pumps to be used in this application and are the only constant pressure pumps on the market fully equipped with built-in electronic controls which allow for advanced computer-controlled performance and state of the art protection features including sophisticated diagnostics. This information is stored in the pump motor and collected via a CU300; a motor-controlled equipment monitors at each individual well. Each well is also equipped with a bubbler tube and reference port for liquid level measurements.

In the past, pumps have been pulled from the wells for general maintenance and cleaning and in some cases, the pumps are not able to be returned to their original position. To address this concern, as well as the potential to add additional wells to the dual extraction system, PBL installed four pumping stations prior to Cell 5C construction in 2010. Another pumping station was installed prior to Cell 6C-1 construction in 2019, and two more prior to Cell 6D construction in 2021. The pumping stations are constructed with 10-inch riser pipes rather than the 6 to 8-inch wells typically installed at landfills. This was done to more easily allow for the removal and reinstallation of pumps over time. PBL installed pumps in two of the pumping stations, PS-1 and PS-2 in October of 2013. The two pumping stations were electrically connected to node 1 and the forcemain was connected to the existing forcemain installed adjacent to PS-1. New electrical was run to pumping stations PS-1, PS-2 and PS-3 in 2020, and new pumps and appurtenances were installed in PS-2 and PS-3.

Due to the above experience, PBL has committed to install six (6) additional pumping stations throughout the Phase 6 3:1 build-out area. A total of 11 pumping stations are planned to be installed, a total of 7 have been installed so far with 2 stations currently operating with pumps. The pumping stations are installed in the same manner as those in the Phase 5 overfill area and help maintain access for removing leachate from the old unlined Phase 1 and 2 fill areas at the site. The locations and construction details for the proposed pumping stations are provided in the Plan Drawings.



4.6 FINAL COVER

4.6.1 DESIGN OVERVIEW

The final cover is designed to contain or divert precipitation from filled areas of the site. The efficiency of the cover system is defined as the amount of precipitation that is rejected or contained in the cover system and must be at least 90 percent (Minnesota Rules Part 7035.2815 Subp. 6.D.(2)). The previously completed HELP model calculations show the cover system design efficiency to be approximately 100 percent.

One of the design features of the proposed expansion is to continue the 3:1 benched final cover slope vertically by increasing the permitted elevations. This design provides for increased capacity without increasing site footprint or elevation. In addition, the design has been shown to be stable and very efficient at surface water management. The MPCA guidance document for 3:1 final cover systems was utilized in completing the design for PBL.

As shown on the plan sheets, benched sideslope final cover system is constructed on all areas that are covered at a 3:1 slope. A benched system will be stable, efficient, and maintainable. The benches are 12 feet wide to incorporate access roads and surface water management. The benches are sloped at 12.5 to 16.6 percent into the sideslopes with a long axis grade of 3 to 5 percent. The final cover sideslopes will be 33 percent for a maximum length of 40 vertical feet and a flow distance of 120 feet. The majority of the final cover will be at a three percent grade.

The final cover barrier layer will consist of a 40-mil LLDPE liner, or equivalent. For increased stability, all final cover slopes will utilize a textured liner material. A synthetic geonet drainage layer with geotextile bonded on both sides will overlie the liner. A cross-section of the final cover profile is described below.

The cover material will consist of 24 inches of cover soil and/or topsoil. The upper 6 inches will be topsoil capable of sustaining vegetation. The final cover topsoil layer will be mulched and seeded with shallow-rooted, drought-tolerant grasses.

A cross section of the final cover system is provided below.

- 6 inches Topsoil
- 18 inches Cover Soil
- Geonet geocomposite
- 40-mil LLDPE Geomembrane
- 6 inches Smoothing or Buffer Layer

Slopes on the final cover of the facility will be constructed at up to 33 percent grade. The final cover then peaks at a 3 percent grade at the top to a maximum proposed elevation of 1,105.8 feet above mean sea level (AMSL). The new peak elevation is 85.8 feet higher than the previous permitted peak elevation of 1,020 feet AMSL.

4.6.2 FINAL COVER GRADES

4.6.2.1 Slope Stability

The stability of the landfill was evaluated for both a circular failure within the waste mass and for a block-slide type failure along the interfaces within the existing final cover system and the proposed base liner system.



Detailed explanation of the methodology and assumptions is presented in Appendix D and the results are summarized below.

Analysis	Factor of Safety
Overall System	1.81
Lower Liner	1.91

The sensitivity of the analysis with respect to the interface strength along the existing final cover system/proposed base liner interface (and all components therein) was also evaluated. Appendix D presents a summary of the sensitivity analysis and shows that the minimum interface friction angle required in any of the various material interfaces is 8 degrees. Given the various materials proposed for the liner system and materials in place for the existing cover system (whether geomembrane or clay was used as the barrier layer component), an interface friction angle of greater than 8 would be expected. Again, this analysis is conservative in that it neglects any adhesion that would occur along each interface.

4.6.2.2 Veneer Cover Stability

Benches will be incorporated at intervals of 40 vertical feet or 120 feet flow distance. The benches are 12 feet wide and are designed for use as access roads with surface water control on the inboard side. Benching provides for a buttressing effect at the toe for each 40 vertical feet of slope. This buttressing effect contributes greatly to the stability of the veneered cover system. Each bench will also serve as an anchor for the geosynthetic materials. This anchoring effect was neglected (conservative) in slope analysis. The final cover design includes the use of textured LLDPE geomembrane and a synthetic geonet drainage layer. This combination of features greatly enhances removal of infiltrated surface water while providing a high friction angle and resulting stability in the final cover components.

Overlying the drainage media is a 24-inch layer of cover soils/topsoil. This layer, once vegetated, provides significant moisture holding and evapotranspiration capability, which also enhances overall final cover performance.

An analysis of the veneer stability of the final cover system was previously performed during the phase 5 expansion permitting and demonstrated that the stability of the final cover design will meet the design safety factor criteria of 1.5. The proposed final cover profile is consistent with what was proposed in that permitting document, so no additional analysis is warranted.

4.6.2.3 Pipe Strength and Deflection

Stresses and strains on the existing leachate collection pipe were analyzed to verify that the appropriate factor of safety would still be achieved with the additional waste mass above the pipe. The calculations resulted in a factor of safety of 3.6 against wall crushing and a factor of safety of 6.5 against wall buckling, both greater than the recommended factor of safety of 2.0.

4.6.2.4 Surface Water Management

The 3:1 benched design provides improved performance in surface water management. The details of this are discussed in the next section.



4.6.2.5 Final Cover Access

The current and approved benches provide for more designed access roadway surface than typically provided on landfill covers. The larger amount of final cover access roadway results in better access to the final cover, surface water control features, and many of the landfill gas well heads for operation, maintenance, and inspection.

4.6.3 SURFACE WATER MANAGEMENT

The surface water system has been designed to manage a 100-year, 24-hour MSE 24-hr 3 storm event of 7.43 inches. The system consists of benches, catch basins, drainage piping, downslope structures, junction vaults, diversion structures, and sedimentation ponds. The components of the surface water system are described below.

4.6.3.1 Peak Run-off

HydroCAD 10.10 – 6a was the model used to determine the maximum discharge from the final cover system to each of the stormwater management ponds. Peak runoff was estimated using calculated runoff CN's for each subcatchment. Composite Curve Numbers were calculated using B and C soil groups. Soil B was assumed for sloped areas and C for flat areas. The slope area composite was calculated by assigning 30% to the newly graded condition (CN 91) and 70% to a fair, 50%-70% grass cover condition (CN 79). Similarly, the flat area composite was calculated by assigning 30% to the newly graded condition (CN 86) and 70% to a fair, 50%-70% grass cover condition (CN 69). These percentages are representative of the proposed construction phasing since the entire final cover area will not be in the newly graded condition at the same time. The percent of each sub catchment in a sloped vs flat region was multiplied by the respective composite curve number to get the final CN for that sub catchment.

All subcatchments were renamed with the same letter on which pond its directed to and numbering down from top to bottom with odd numbers to the left of downslopes and even numbers to the right. Double letters used for area's not directly adjacent to the main downslope.

Atlas 14 Rainfall values for Dakota county were used in setting the storm events. Time of concentrations were calculated using sheet flow and shallow concentrated flow for the longest flow path for each subwatersheds. To be conservative in the analysis, no infiltration is modeled in swales or downslopes. The 100-yr high water level was also set by modeling no infiltration in the swales and downslopes.

4.6.3.2 Bench and Drainage Swale Design

Benches are placed on all 3:1 slopes. They are sloped into final cover and V shaped with right and left side slopes 3:1 and 8:1 respectively. The benches are placed in order to intercept and direct flow, as well as minimize erosion. The drainage channel at the interior of the bench was designed with the following characteristics:

Height= 22" (typical)

Slope= 3% to 5% (typical)

Manning "n" value= 0.035

The drainage benches were designed to handle the 100yr flow for each subarea and are spaced 40' vertically around the perimeter of the landfill. The peak flow depth will not exceed the depth of the bench. Benches will have category 4 erosion control matting installed to protect against erosion until vegetation is established.



4.6.3.3 Downslope Structures

Each bench discharges into one of seven cable concrete lined downslope structures located around the perimeter of the site. Each downslope structure is a trapezoidal channel with design characteristics summarized below:

Depth = 2.0' (typical)
Bottom width = 9 feet
Manning "n" value= 0.040

Runoff is contained during the back-to-back 100-year rainfall event.

4.6.3.4 Junction Vaults

The downslope piping systems in the southwest and northeast corners of the currently permitted design discharge to concrete junction vaults. In the junction vaults, flow is combined to a single pipe that outlets to the existing railroad crossing culverts, a 48-inch RCP on the southwest and a 96-inch RCP on the northwest.

4.6.3.5 Sedimentation Ponds

Surface water from the proposed vertical expansion final cover area is also directed to existing sedimentation ponds.

Routing

Discharge to the southwest pond (8P) is directed from the downslope through a 100' 48-inch pipe to the final outfall.

Discharge to the existing east pond (6P) is directed through an existing low area into a set of culverts beneath the railroad tracks prior to final outfall. There is currently one 36-inch culvert in place beneath the tracks. To accommodate additional stormwater flows per the design, two additional 36-inch culverts will be installed in this area. It should be noted that this will require installation by horizontal drilling methods due to the adjacent railroad tracks.

Discharge to the northeast pond (4P) is directed through existing low areas directly into the pond.

Discharge to the northwest pond (3P) is directed through existing low areas to a 60' downslope into the final outfall.

Discharge to the west pond (1P) is directed through an existing concrete diversion structure to a 60" pipe, to an existing 96" pipe which discharges to the final outfall.



Design Report

4 Design Report

Infiltration

By City requirement all ponds must be able to infiltrate 1" runoff over new impervious surfaces. This site exceeds requirements and infiltrates 1" over the full area, not just impervious, as seen in the calculations below:

Area A (directed to 8P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 524,154\text{ ft}^2 = \mathbf{43,680\text{ ft}^3}$$

Area B (directed to 5P then 6P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 518,933\text{ ft}^2 = \mathbf{43,244\text{ ft}^3}$$

Area C (directed to 4P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 991,908\text{ ft}^2 = \mathbf{82,659\text{ ft}^3}$$

Area D (directed to 3P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 418,623\text{ ft}^2 = \mathbf{34,885\text{ ft}^3}$$

Area E (directed to 1P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 530,006\text{ ft}^2 = \mathbf{44,167\text{ ft}^3}$$

Below is a summary of the ponds:

Pond	Existing 100-Yr HWL	Proposed 100-Yr HWL	Proposed 100-Yr Discharge (cfs)	Infiltration Volume Required (AF)	Storage Provided (AF)
1P (E)	(2013) 853.45	851.48	0	1.01	36.0
3P (D)	(2015) 869.88	863.15	0	0.80	25.3
4P (C)	(2015) 890.69	886.64	0	1.90	25.2
6P (B)	(2015) 893.05	890.34	0	0.99	24.8
8P (A)	(2013) 843.77	845.03	0	1.00	5.7

The ponds were designed to serve as infiltration ponds. The sandy soils at the landfill are conducive to infiltration.

4.7 LANDFILL GAS MANAGEMENT

4.7.1 BACKGROUND

The EPA and MPCA require that landfill gas (LFG) generated at MSW landfills be controlled. This control requirement is to achieve two objectives. First, the methane component of LFG is combustible in the concentration range of 5 to 15 percent by volume in air. Five percent is considered the lower explosive limit or LEL and 15 percent is considered the upper explosive limit or UEL. Consequently, migration and concentration of methane into enclosed spaces could result in an explosive atmosphere. Therefore, Minnesota Rule 7035.2815 Subp. II requires that the concentration of any explosive gas not exceed the LEL at the property boundary or 25 percent of the LEL in or around facility structures. PBL has an MPCA-approved gas collection and monitoring system to address concerns with migration of combustible gas.



The second objective in controlling LFG is for maintenance of air quality standards. In March of 1996, the EPA promulgated air emissions regulations for large new and existing MSW landfills. These are the New Source Performance Standards and Emission Guidelines (NSPS). Under these regulations, affected facilities that emit more than 50 megagrams per year (Mg/yr) of non-methane organic compounds (NMOC) must install controls. The installed controls must be capable of reducing the NMOC in the collected LFG by at least 98 percent by weight. PBL has been proactive in the installation of landfill gas control equipment.

PBL employs a comprehensive monitoring program for early detection of landfill gas (LFG) in on-site structures and at adjacent properties, as well as gas collection and a landfill gas to energy plant. Occupied buildings and structures located at the facility are continuously monitored using electronic monitoring devices. These devices allow for detection of concentrations of LFG well below the concentrations at which the gas reaches an explosive range. Landfill gas migration from the landfill is monitored with permanent landfill gas monitoring probes around the perimeter of the facility.

4.7.2 GAS PROBE MANAGEMENT

As stated above, PBL employs a comprehensive monitoring program for early detection of landfill gas (LFG) in on-site structures and at adjacent properties, as well as gas collection and a landfill gas to energy plant. Minnesota Rule 7035.2815 Subp.11 also requires that occupied buildings and structures located at the facility are continuously monitored using electronic monitoring devices. These devices allow for detection of concentrations of LFG well below the concentrations at which the gas reaches an explosive range. Landfill gas migration from the landfill is monitored with permanent landfill gas monitoring probes around the perimeter of the facility. These probes are monitored in accordance with the Gas Management and Monitoring Plan which is included in the Facility Operations and Maintenance Plan.

Currently, PBL has been actively working with the MPCA and the City of Inver Grove Heights to address gas migration concerns. A Gas Migration Remedial Action Report was submitted to the MPCA, City of Inver Grove Heights and Dakota County in December 2021. This report included a proposed 2022 Remedial Action Work Plan. A proposed schedule for future work items and submittals related to gas migration in 2022 include the following:

	<u>Task to be Completed</u>	<u>Anticipated Completion Date</u>
1.	Relocate passive wind turbines from GV-3 through -5 to GV-6 through -8.	Spring/Summer 2022
2.	Complete temporary active gas collection near MMP-17 (GV-1 through -5) in accordance with the work plan, collecting data throughout the process.	Spring/Summer 2022
3.	Monthly visual inspection of cover for distressed vegetation near EW-320 and EW-10.	Ongoing
4.	Submit next report to MPCA, City, and County including a summary of work performed, and an evaluation of data, and recommendation for additional remedial measures.	December 2022



4.7.3 FUTURE GAS SYSTEM INSTALLATION

The Pine Bend Landfill gas extraction system is currently being augmented in the Phase 6 area to include a horizontal gas collector system as well as the installation of six (6) new pumping stations. Although the pumping station's primary purpose is to remove leachate from the unlined landfill area, they may also be retrofitted to serve as dual extraction wells and also provide for landfill gas collection. Lateral subheader piping (8-inch HDPE) are connected to the existing header piping system to provide vacuum to the new horizontal gas collection system. Horizontal collector piping (6-inch HDPE) is installed as shown on the Drawings. The proposed system has been designed to provide effective control of landfill gases in the Phase 6 expansion, and vertical expansion areas upon completion of filling. Horizontal collectors are identified as HC-1. All new wells/horizontal collectors are given an identification number when installed. The system is installed in phases as filling progresses with the use of temporary controls to keep the existing system active during the construction of the proposed vertical expansion.

In addition, new vertical gas extraction wells are proposed to be installed in the Phase 7 vertical expansion area once final waste grades are reached. A plan for the vertical gas wells is shown on Plan Sheets No. 8 and 9.

4.7.4 PROPOSED GAS SYSTEM DESIGN

4.7.4.1 Existing Extraction Wells

The existing gas wells are extended as filling progresses during Phase 6 development and vertical expansion. This means that periodically the well head assembly will require repositioning as development dictates. This may include remotely locating the wellhead away from the filling area. It is also possible that certain wells may be extended, but temporarily taken out of service. The existing gas wells in areas where overfilling occurs are extended vertically by fusing piping to the existing well pipe and also to the subheader connection to maintain the wellheads at 48 inches above the landfill surface during operations. The existing wellhead assembly are removed prior to fusing the well and subheader extensions and are reinstalled after the extension is made. A bentonite mixture is used to seal the annular space between the outer pipe and well casing, if applicable.

It is anticipated that gas well extension process will take approximately two (2) hours per well to complete. The existing gas system is set up such that individual gas wells can be isolated from the active gas system by valves. Therefore, the entire active gas system does not need to be shut down during the extension process. Only a portion of the system is isolated as a preventive measure against excessive oxygen intrusion during the extension work.

4.7.4.2 Horizontal Collectors

As previously discussed, horizontal collectors are currently installed in the areas of the Phase 6 expansion where the overfill waste thickness will be too shallow for practical installation of vertical extraction wells. The horizontal collectors will consist of 6-inch HDPE piping and the proposed layout is shown on the Drawings. Coarse aggregate is installed below, above, and on each side of the perforated horizontal collector piping and geotextile is placed over the coarse aggregate. The solid piping portion of the collectors is covered with sand. Condensate from the horizontal gas collection piping drain to existing condensate pumps. The minimum pipe slope will be 3% to promote condensate drainage. Each horizontal gas collector is connected to the gas lateral subheader piping via a wellhead. Valves to regulate vacuum and gas flow are installed. A detail is provided on the Drawings.

4.7.4.3 Gas System Piping



Gas from the existing wells will continue to be extracted through existing or temporarily installed laterals, subheaders, and header piping until final grades are reached. At that time, new laterals are installed from the existing wells to new subheaders that drain to either the existing header or the new header to be completed along the southern boundary. This will complete a loop of the 18-inch header around the entire site. A new header system continuing around the west side of the landfill with subheader extensions to provide several gas collection loops across the entire facility was constructed in 2006. All piping within the waste will be installed at a minimum grade of 3 percent to allow for proper drainage of condensate liquids into low point collection sumps and eliminating any flow disturbances which may affect the performance of the overall extraction system.

4.7.4.4 Gas Generation Estimate

The previous peak generation rate for the landfill was estimated at approximately 3,700 CFM when the GCCS Plan was updated in 2022. During the plan update a LandGEM (Landfill Gas Emissions Model) was performed on the waste mass to predict the future gas generation of the facility. The GCCS Plan and LandGEM model should be referred to for additional information on the landfill gas generation.

4.7.4.5 Condensate

Condensate generated as a result of the landfill gas extraction system is conveyed in the subheader and head piping to low points in the system where an inverted tee allows for the liquids to gravity flow into an existing or newly constructed sump structure. Valving is installed to isolate the sumps from the header for maintenance purposes. A submersible pump removes all liquids collected from the condensate sumps and pumps them into the forcemain piping for subsequent discharge into the leachate storage facility.



APPENDIX A

11 x 17 Plan Drawings



BFI Waste Systems
of North America, LLC
Pine Bend Landfill
Inver Grove Heights, Minnesota
2022 Major Permit Modification

Prepared By:



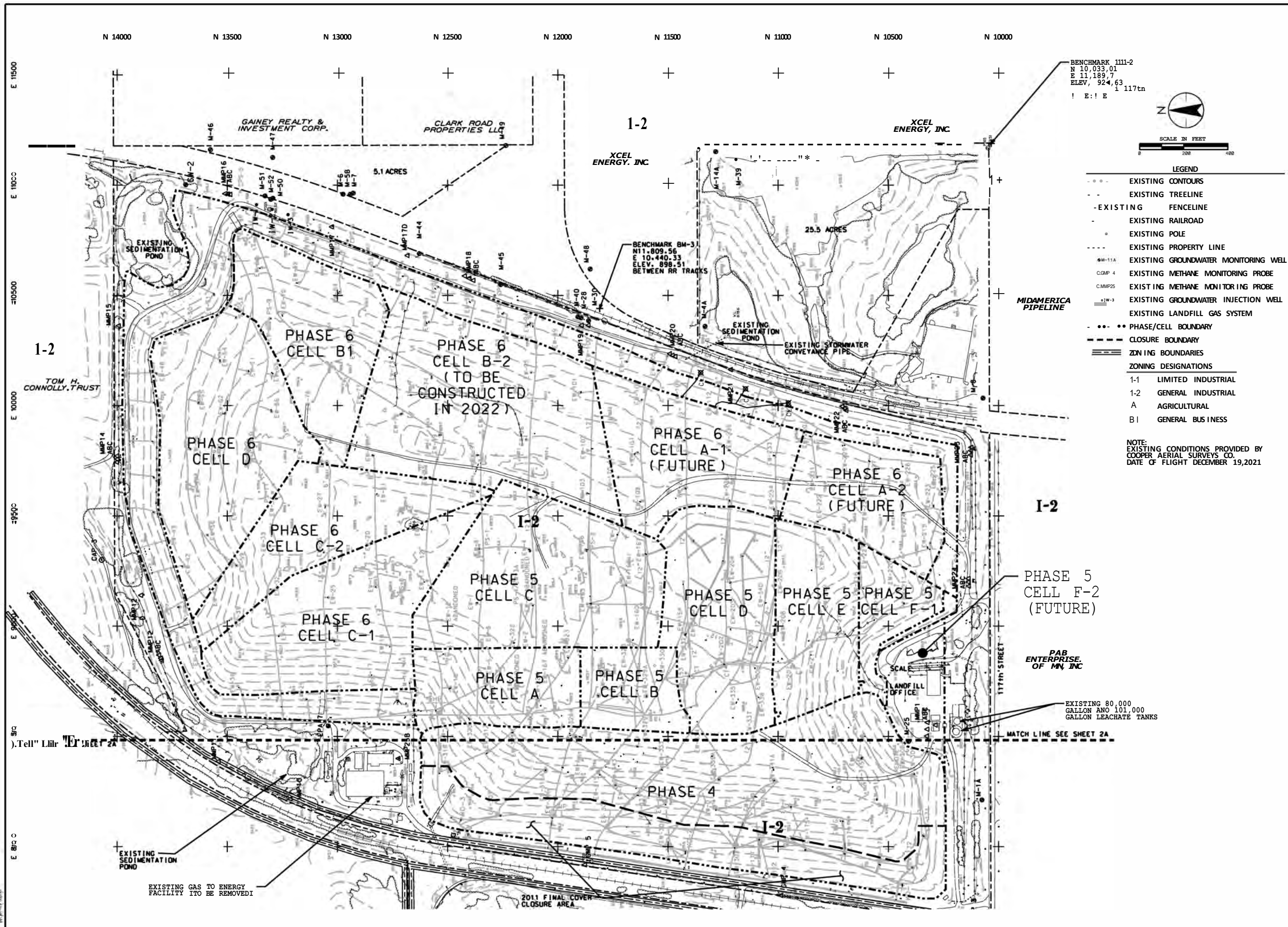
Stantec Consulting Services, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359

2022.02.21

PROJECT NUMBER: 22704791

INDEX

1. TITLE AND INDEX SHEET
2. EXISTING CONDITIONS MAP (EAST SIDE)
- 2A. EXISTING CONDITIONS MAP (WEST SIDE)
3. PHASING PLAN
4. PHASE 7-VERTICAL EXPANSION
FINAL COVER GRADING PLAN
5. PHASE 7-VERTICAL EXPANSION
SURFACE WATER MANAGEMENT PLAN
6. EXISTING GAS PIPING PLAN NORTH HALF
7. EXISTING GAS PIPING PLAN SOUTH HALF
8. PROPOSED GAS PIPING PLAN NORTH HALF
9. PROPOSED GAS PIPING PLAN SOUTH HALF
10. CROSS-SECTION A
11. CROSS-SECTION B
12. CROSS-SECTION C
13. LINER SYSTEM DETAILS
14. LEACHATE RISER MANHOLE DETAILS
15. SURFACE WATER MANAGEMENT DETAILS
16. GAS SYSTEM DETAILS
17. GAS SYSTEM DETAILS
18. GAS SYSTEM DETAILS

[illegible]

Permit-Seal

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY CLOSE SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINTNAME TH oMAS JH ugh AR_K H - -

SIGNATURE _____

DATE _____ yy/mm/dd LICENSE# _____ III J L _

ProjectNumber: 22770-4791

04791e_sp_02.dgn

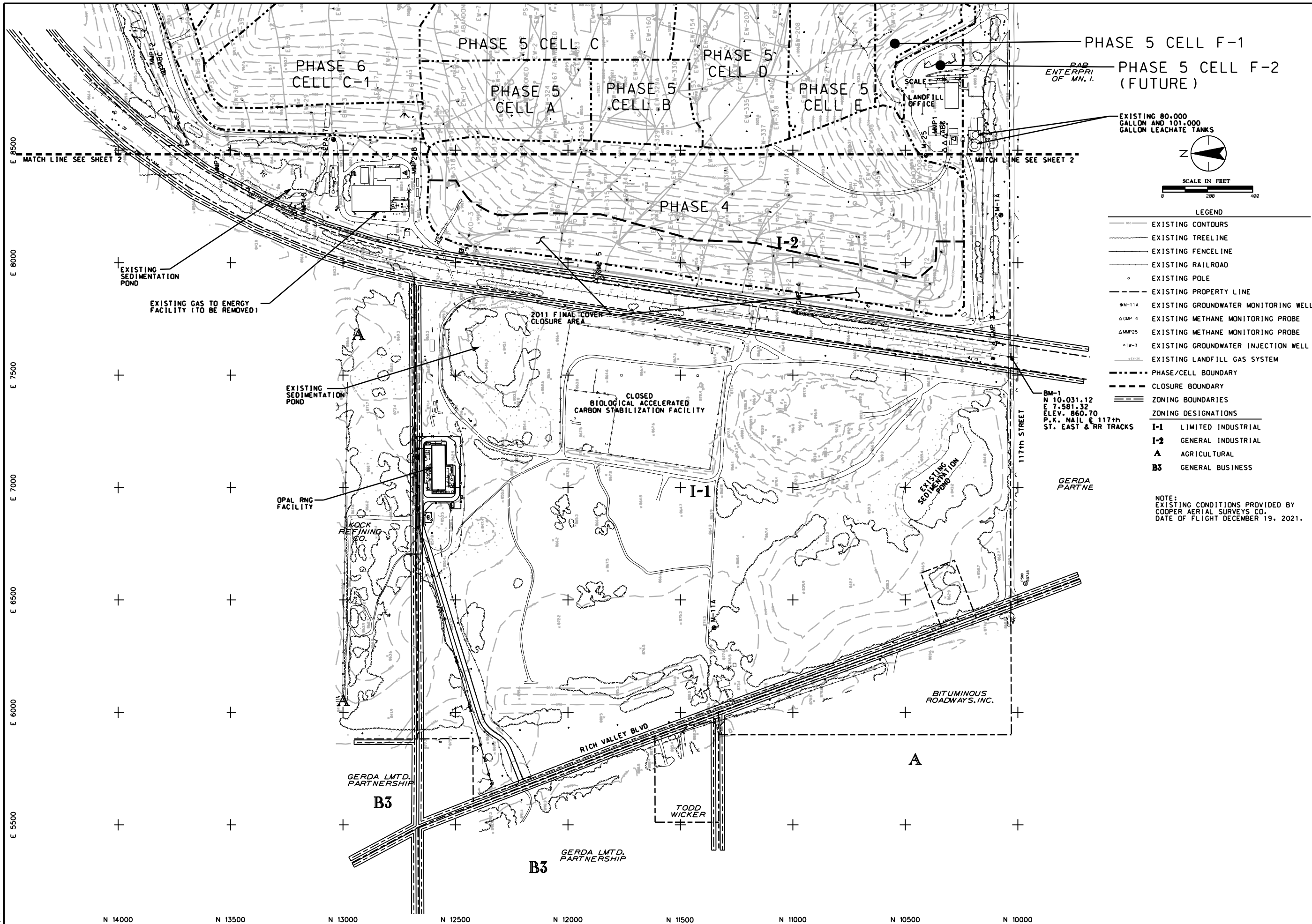
JWT 2022.02.25

Drawing No. 2

Revision Sheet

0 2 of 8

U:\227704791\cadd\dwg\04791e_sp_02a.dgn
By: jstusarich 10/25/2022



Client/Project	By	App'd	Issued
BH WASTE SYSTEMS OF NORTH AMERICA, LLC PINE BEND LANDFILL			YJW/JDO
2022 MAJOR PERMIT MODIFICATION INVER GROVE HEIGHTS, MINNESOTA			
Existing Conditions Map (West Half)			

Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

2022 MAJOR PERMIT MODIFICATION
INVER GROVE HEIGHTS, MINNESOTA

Existing Conditions Map (West Half)

Permit-Seal
I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION,
OR REPORT WAS PREPARED BY ME OR UNDER
MY DIRECT SUPERVISION AND THAT I AM A DULY
LICENSED PROFESSIONAL ENGINEER UNDER THE
LAWS OF THE STATE OF MINNESOTA.

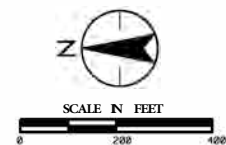
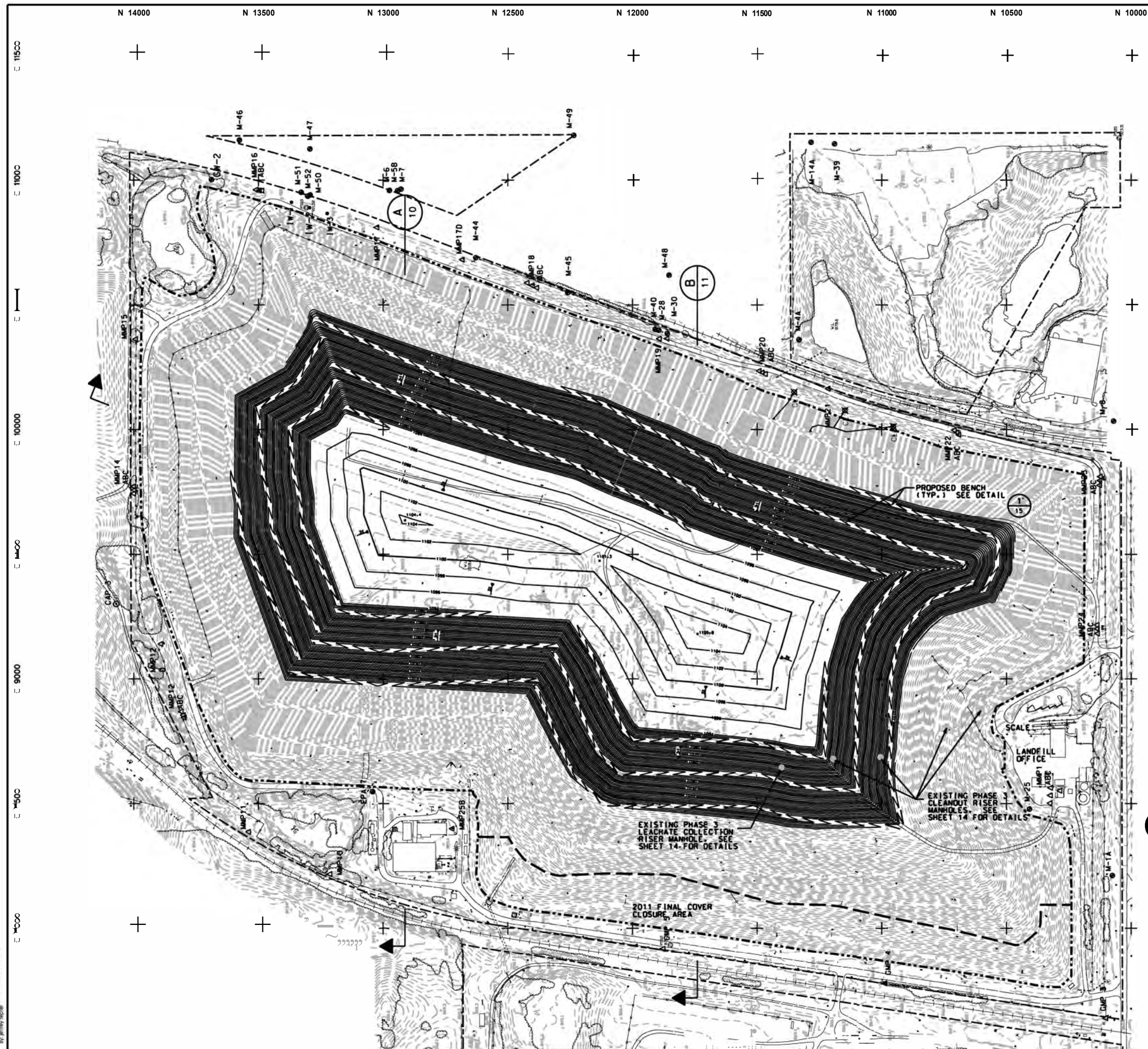
PRINT NAME THOMAS J. SHUSTARICH
SIGNATURE
DATE yy/mm/dd LICENSE # 21210
Project Number: 227704791
04791e_sp_02a.dgn

JWT 2022.02.25

Drawing No. 2A
Revision Sheet
0 3 of 18

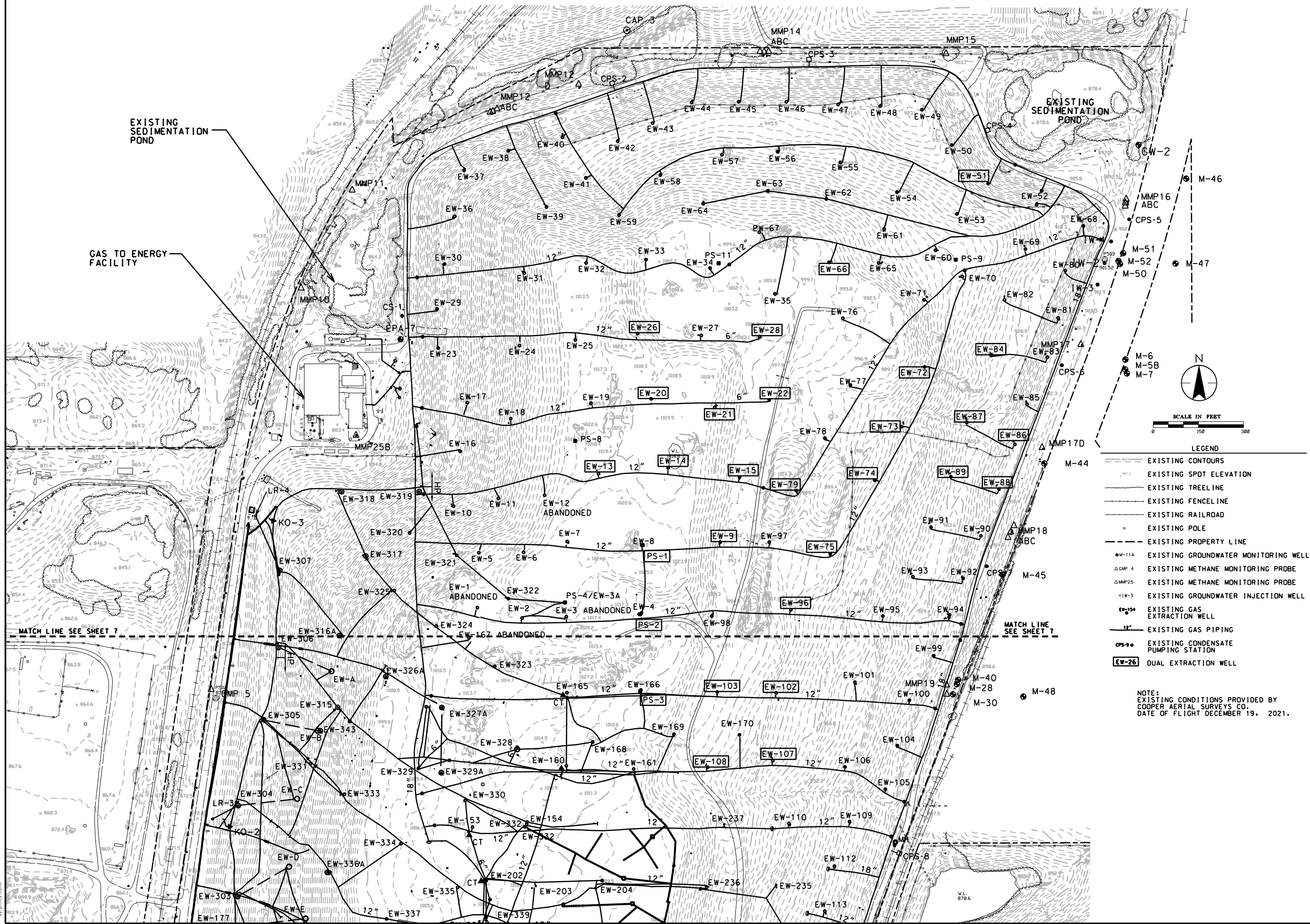
U:\2022\2471\locating\04791e_pp_03.dgn
By: jstustar





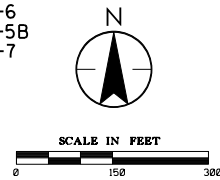
1000

U:\2022\2471\locating\0471e_gp_06.dgn
By: jstustarich



- LEGEND
- EXISTING CONTOURS
 - EXISTING SPOT ELEVATION
 - EXISTING TREELINE
 - EXISTING FENCELINE
 - EXISTING RAILROAD
 - EXISTING POLE
 - EXISTING PROPERTY LINE
 - EXISTING GROUNDWATER MONITORING WELL
 - EXISTING METHANE MONITORING PROBE
 - EXISTING METHANE MONITORING PROBE
 - EXISTING GROUNDWATER INJECTION WELL
 - EXISTING GAS EXTRACTION WELL
 - EXISTING GAS PIPING
 - EXISTING CONDENSATE PUMPING STATION
 - DUAL EXTRACTION WELL

NOTE:
EXISTING CONDITIONS PROVIDED BY
COOPER AERIAL SURVEYS CO.
DATE OF FLIGHT DECEMBER 19, 2021.

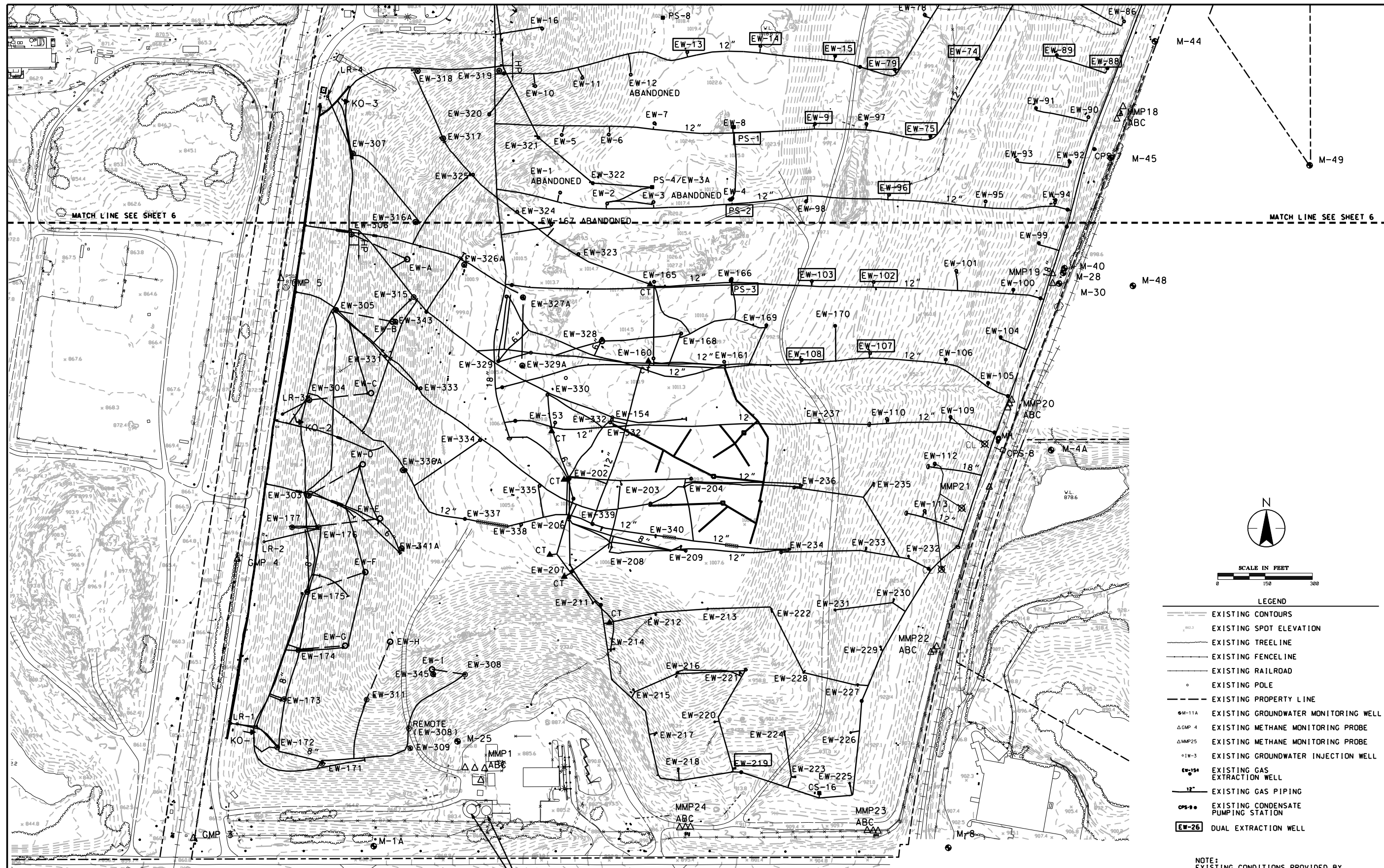


Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

2022 MAJOR PERMIT MODIFICATION
INVER GROVE HEIGHTS, MINNESOTA
Existing Gas Piping Plan - North Half

Permit-Seal
I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION,
OR REPORT WAS PREPARED BY ME OR UNDER
MY DIRECT SUPERVISION AND THAT I AM A DULY
LICENSED PROFESSIONAL ENGINEER UNDER THE
LAWS OF THE STATE OF MINNESOTA.

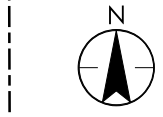
PRINT NAME: THOMAS J. SHUSTARICH
SIGNATURE: _____
DATE: yy/mm/dd LICENSE # 21210
Project Number: 227704791
04791e_gp_06.dgn
JW1 2022.03.11
Drawing No. 6
Revision Sheet
0 6 of 18



NOTE:
EXISTING CONDITIONS PROVIDED BY
COOPER AERIAL SURVEYS CO.
DATE OF FLIGHT DECEMBER 19, 2021

Drawing No. 7	
Revision	Sheet
0	7 of 18

HORIZONTAL COLLECTION SYSTEM TRENCH POINT	APPROXIMATE DEPTH (FT)
①	8
②	14
③	8
④	7
⑤	7
⑥	7
⑦	9
⑧	8



- LEGEND**
- EXISTING CONTOURS
 - EXISTING SPOT ELEVATION
 - EXISTING TREELINE
 - EXISTING FENCELINE
 - EXISTING RAILROAD
 - EXISTING POLE
 - EXISTING PROPERTY LINE
 - EXISTING GROUNDWATER MONITORING WELL
 - EXISTING METHANE MONITORING PROBE
 - EXISTING METHANE MONITORING PROBE
 - EXISTING GROUNDWATER INJECTION WELL
 - EXISTING GAS EXTRACTION WELL
 - EXISTING GAS PIPING
 - EXISTING CONDENSATE PUMPING STATION
 - CURRENTLY PERMITTED CONTOURS
 - PROPOSED CONTOURS
 - PROPOSED 12" SUBHEADER
 - PROPOSED 6" SUBHEADER
 - PROPOSED GAS WELLS
 - PROPOSED CONTROL VALVE
 - PROPOSED HORIZONTAL COLLECTOR WELLHEAD
 - PROPOSED HORIZONTAL COLLECTOR PIPING (6" HDPE SDR 17)
 - PROPOSED LATERAL GAS SUBHEADER (8" HDPE SDR 17)
 - PROPOSED CONDENSATE SUMP
 - PROPOSED PUMPING STATION

NOTE:
EXISTING CONDITIONS PROVIDED BY
COOPER AERIAL SURVEYS CO.
DATE OF FLIGHT DECEMBER 19, 2021.



Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

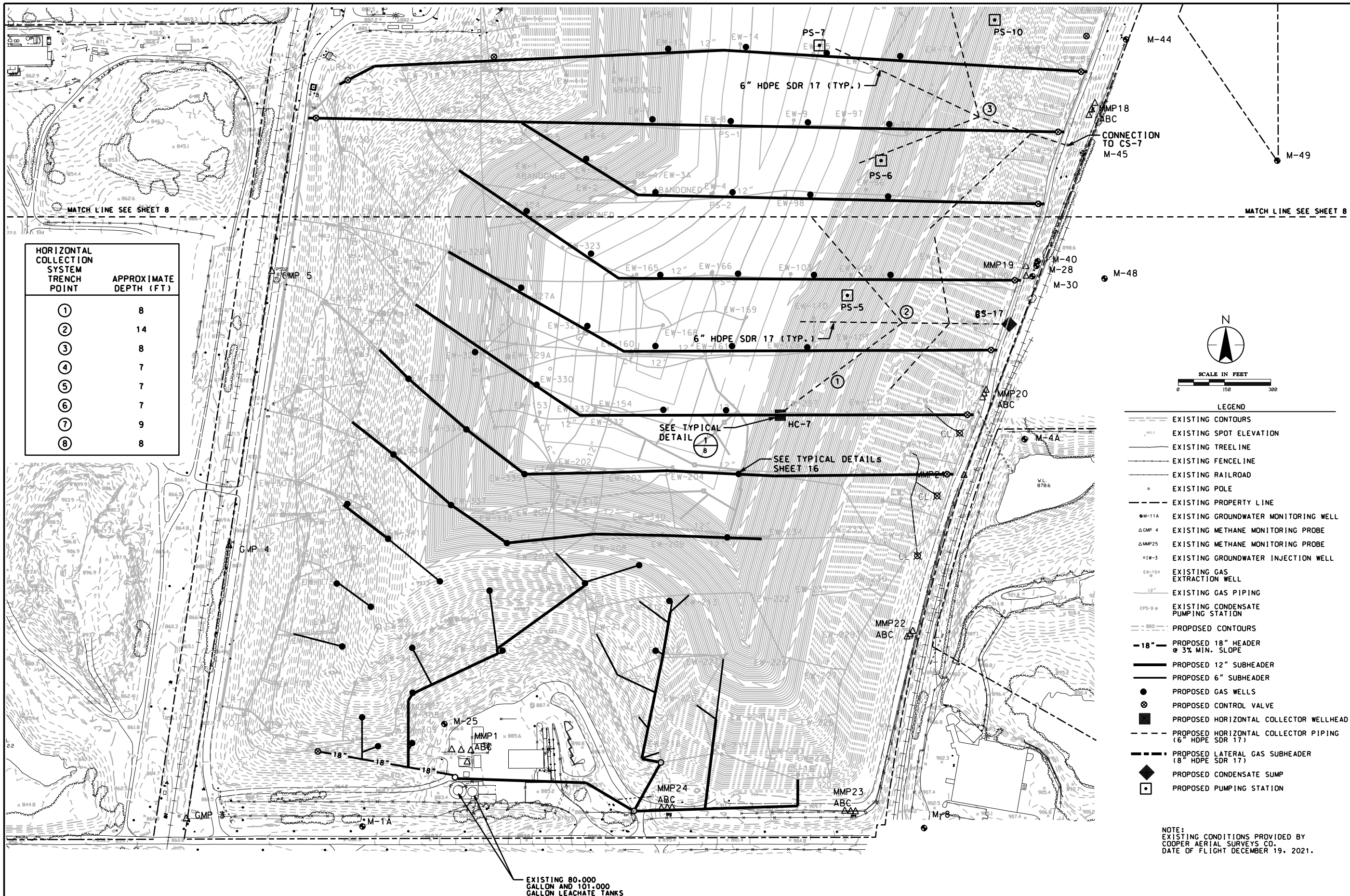
2022 MAJOR PERMIT MODIFICATION
INVER GROVE HEIGHTS, MINNESOTA
Proposed Gas Piping Plan - North Half

Permit-Seal
I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION,
OR REPORT WAS PREPARED BY ME OR UNDER
MY DIRECT SUPERVISION AND THAT I AM A DULY
LICENSED PROFESSIONAL ENGINEER UNDER THE
LAWS OF THE STATE OF MINNESOTA.

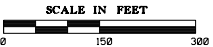
PRINT NAME: THOMAS J. SHUSTARICH
SIGNATURE: _____
DATE: yy/mm/dd LICENSE #: 21210
Project Number: 227704791
04791e_gp_08.dgn

JWT 2022.03.11
Drawing No. 8
Revision Sheet
0 8 of 18

U:\2277\2471\cadding\04791e_gp_09.dgn
By: jh1111 10/25/2022



HORIZONTAL COLLECTION SYSTEM TRENCH POINT	APPROXIMATE DEPTH (FT)
①	8
②	14
③	8
④	7
⑤	7
⑥	7
⑦	9
⑧	8



- LEGEND
- EXISTING CONTOURS
 - EXISTING SPOT ELEVATION
 - EXISTING TREELINE
 - EXISTING FENCELINE
 - EXISTING RAILROAD
 - EXISTING POLE
 - EXISTING PROPERTY LINE
 - EXISTING GROUNDWATER MONITORING WELL
 - EXISTING METHANE MONITORING PROBE
 - EXISTING METHANE MONITORING PROBE
 - EXISTING GROUNDWATER INJECTION WELL
 - EXISTING GAS EXTRACTION WELL
 - EXISTING GAS PIPING
 - EXISTING CONDENSATE PUMPING STATION
 - PROPOSED CONTOURS
 - PROPOSED 18" HEADER @ 3% MIN. SLOPE
 - PROPOSED 12" SUBHEADER
 - PROPOSED 6" SUBHEADER
 - PROPOSED GAS WELLS
 - PROPOSED CONTROL VALVE
 - PROPOSED HORIZONTAL COLLECTOR WELLHEAD
 - PROPOSED HORIZONTAL COLLECTOR PIPING (6" HDPE SDR 17)
 - PROPOSED LATERAL GAS SUBHEADER (8" HDPE SDR 17)
 - PROPOSED CONDENSATE SUMP
 - PROPOSED PUMPING STATION

NOTE:
EXISTING CONDITIONS PROVIDED BY
COOPER AERIAL SURVEYS CO.
DATE OF FLIGHT DECEMBER 19, 2021.



By	YJW/DD
App'd	
Issued	

Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

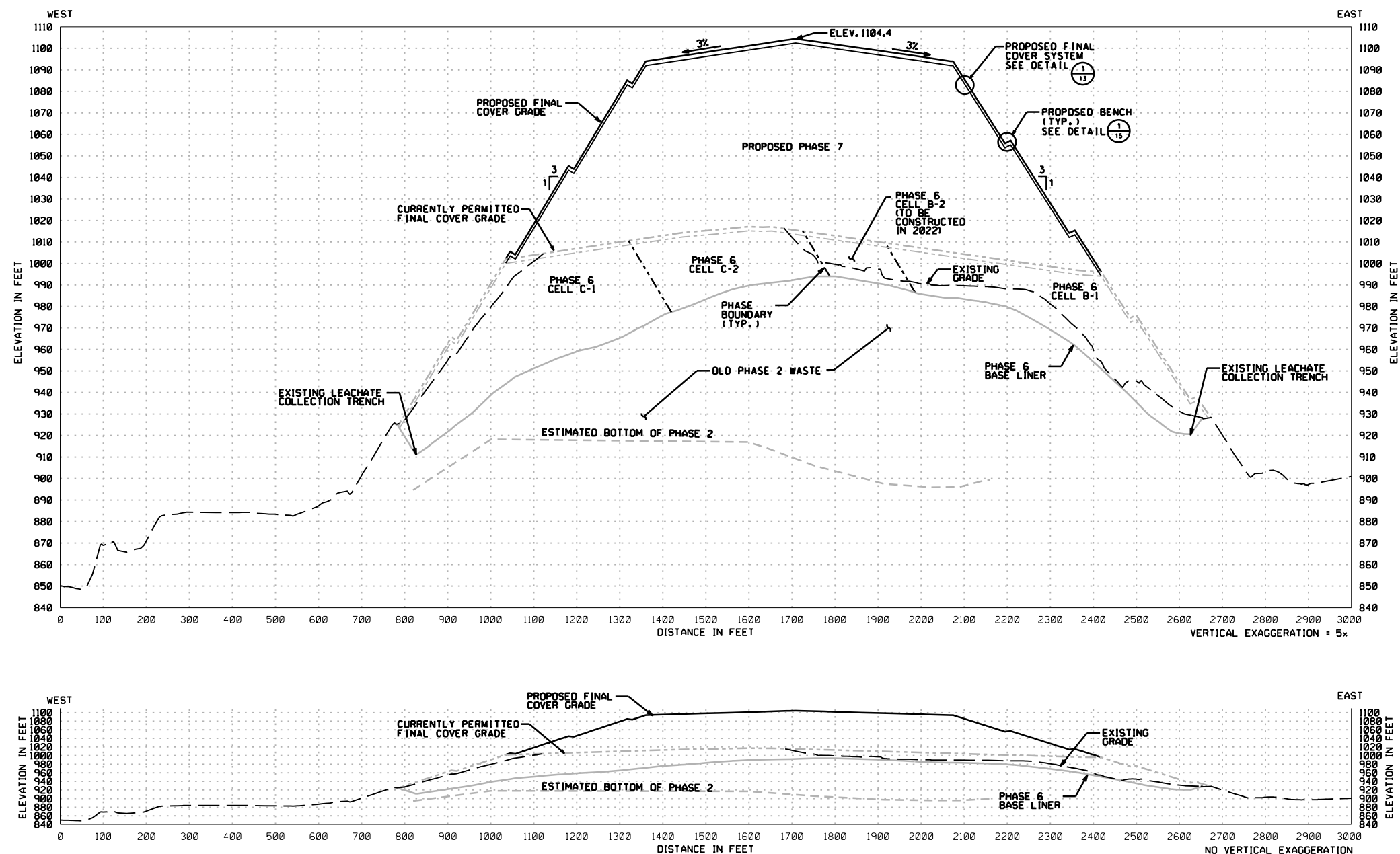
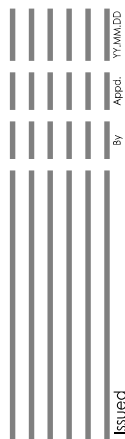
2022 MAJOR PERMIT MODIFICATION
INVER GROVE HEIGHTS, MINNESOTA
Proposed Gas Piping Plan - South Half

Permit-Seal
I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINT NAME THOMAS J. SHUSTARICH
SIGNATURE
DATE yy/mm/dd LICENSE # 21210
Project Number 227704791
04791e_gp_09.dgn

JWT 2022.03.11

Drawing No. 9
Revision Sheet
0 9 of 18



Permit-Seal

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DILIGENT LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINT NAME THOMAS J. SHUSTARICH

SIGNATURE

DATE yy/mm/dd LICENSE # 21210

Project Number 227704791

04791@_se_10.dgn

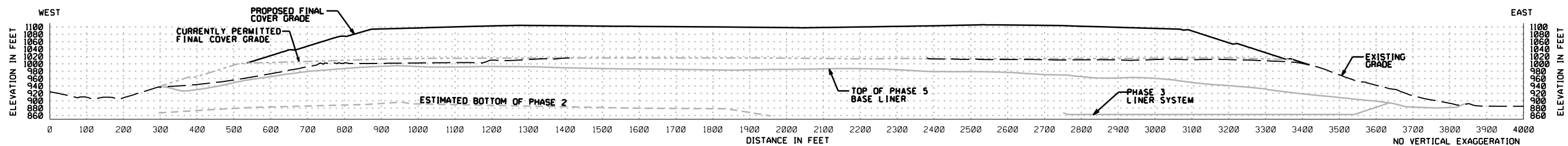
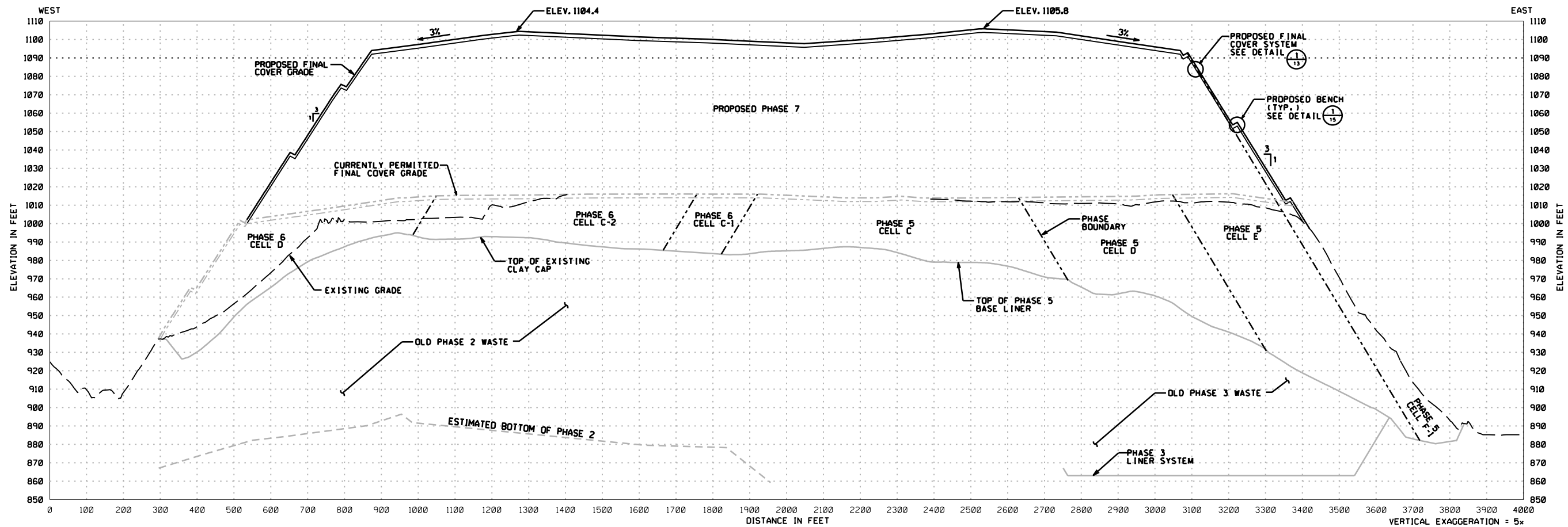
JWT 2022.03.31

Drawing No. 10

Revision Sheet

0 100f 18

U:\227704791\cadd\dwg\04791e_xs_12.dgn
By: jstuart



By	YY/MM/DD
App'd	
Issued	

Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

2022 MAJOR PERMIT MODIFICATION

INVER GROVE HEIGHTS, MINNESOTA

Cross-section C

Permit-Seal

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINT NAME: THOMAS J. SHUSTARICH

SIGNATURE: _____

DATE: yy/mm/dd LICENSE # 21210

Project Number: 227704791

04791e_xs_12.dgn

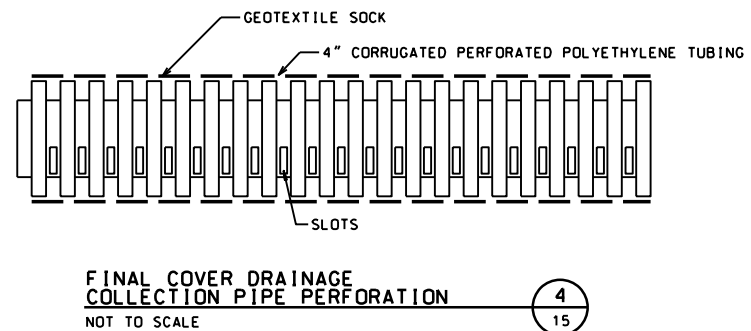
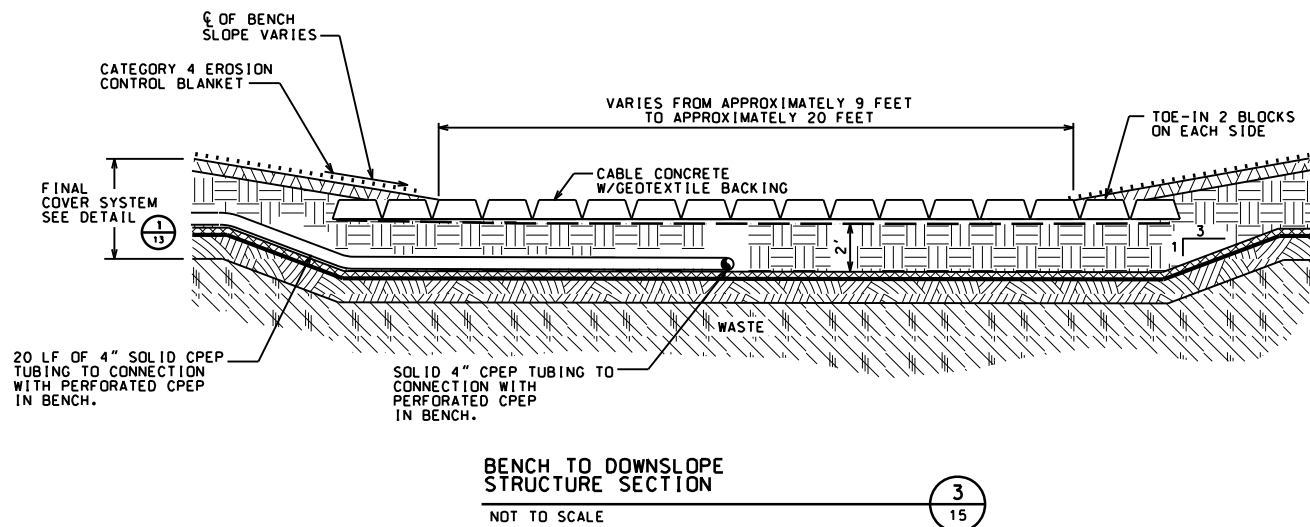
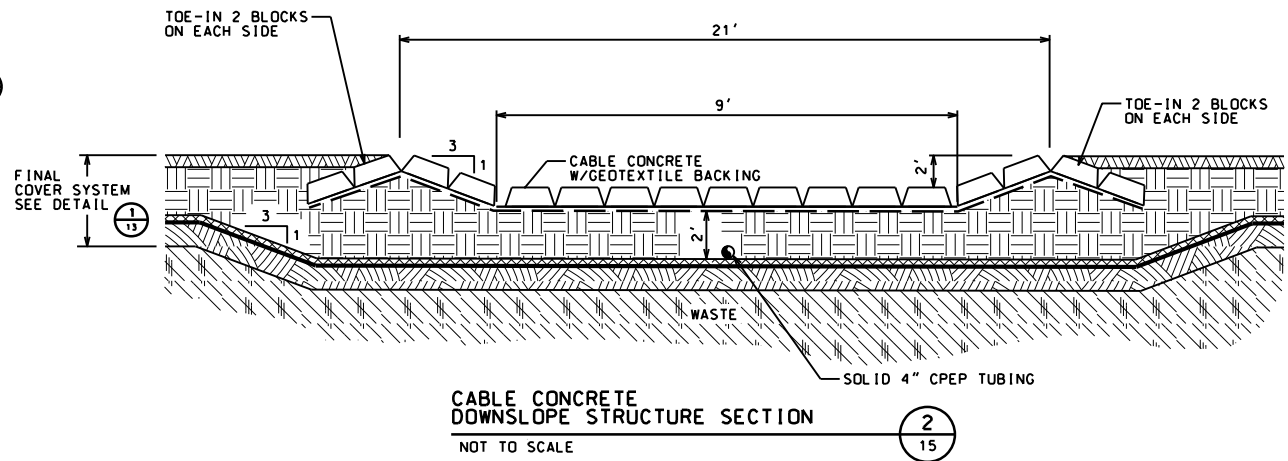
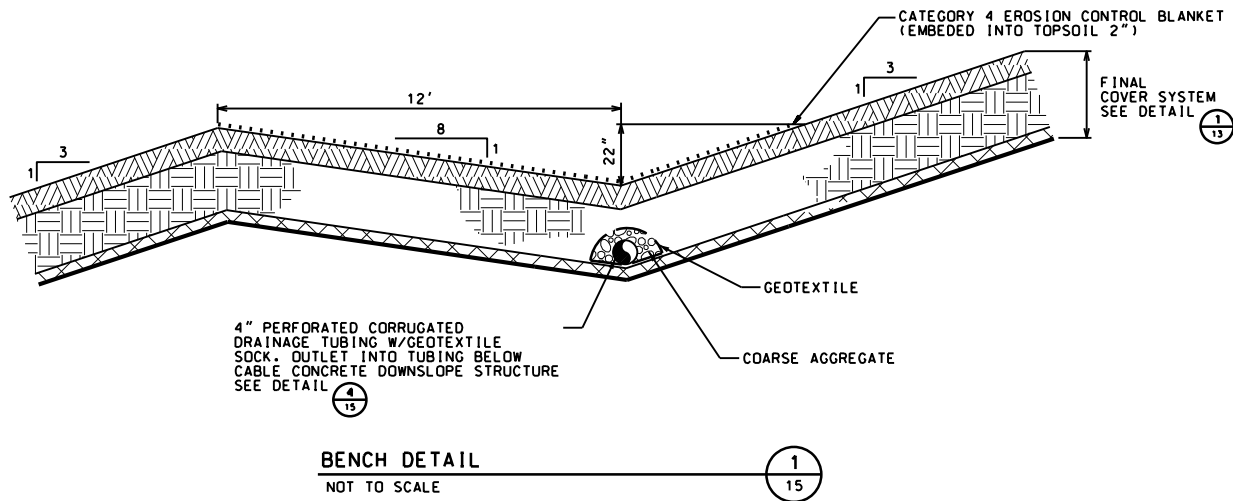
JWT 2022.03.11

Drawing No. 12

Revision Sheet

0 12 of 18





By	YJAW/DD
App'd	
Issued	

Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

2022 MAJOR PERMIT MODIFICATION
INVER GROVE HEIGHTS, MINNESOTA
Surface Water Management Details

Permit-Seal
I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINT NAME THOMAS J. SHUSTARICH

SIGNATURE

DATE yy/mm/dd LICENSE # 21210

Project Number: 227704791

04791e_sd_15.dgn

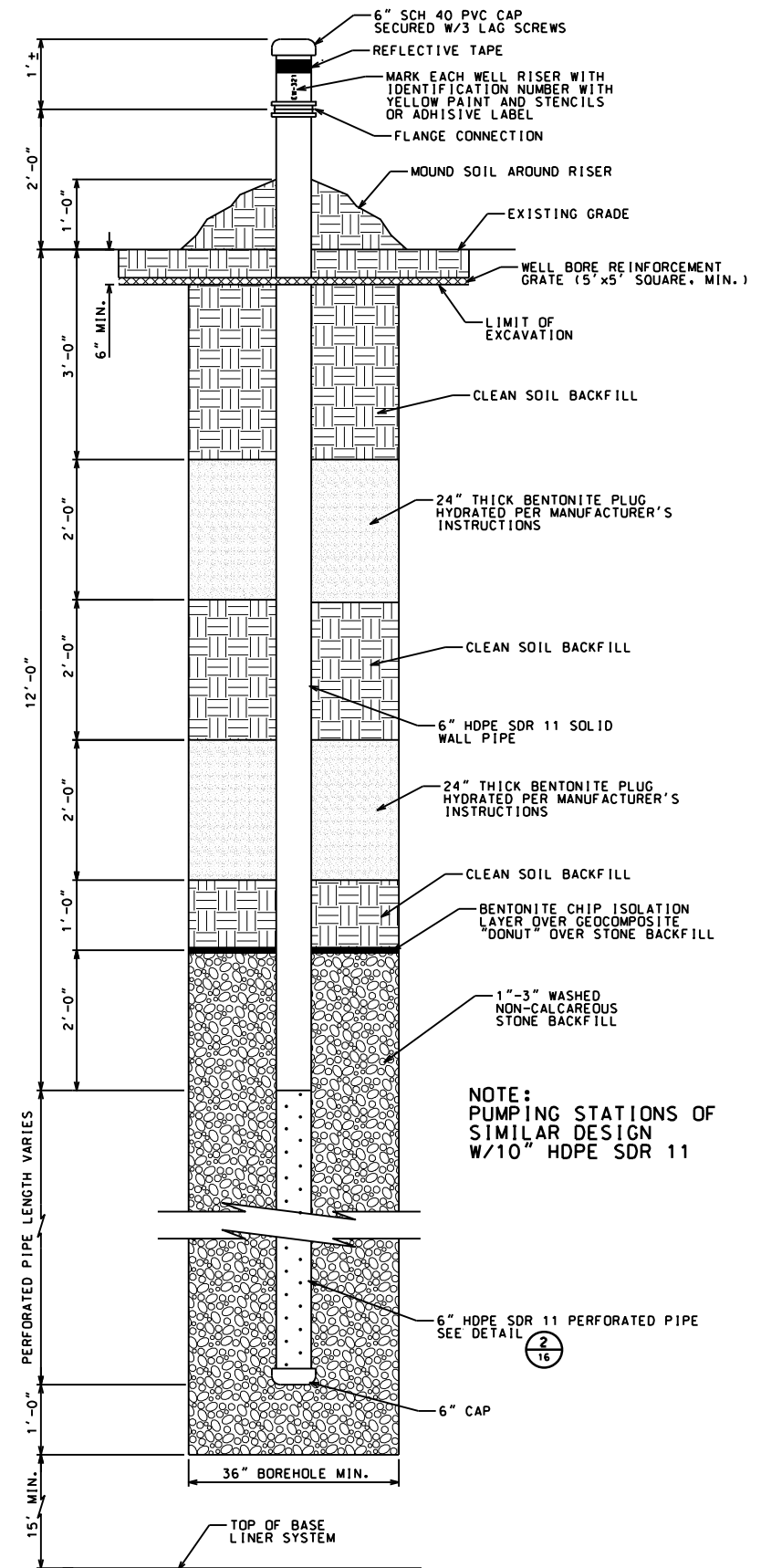
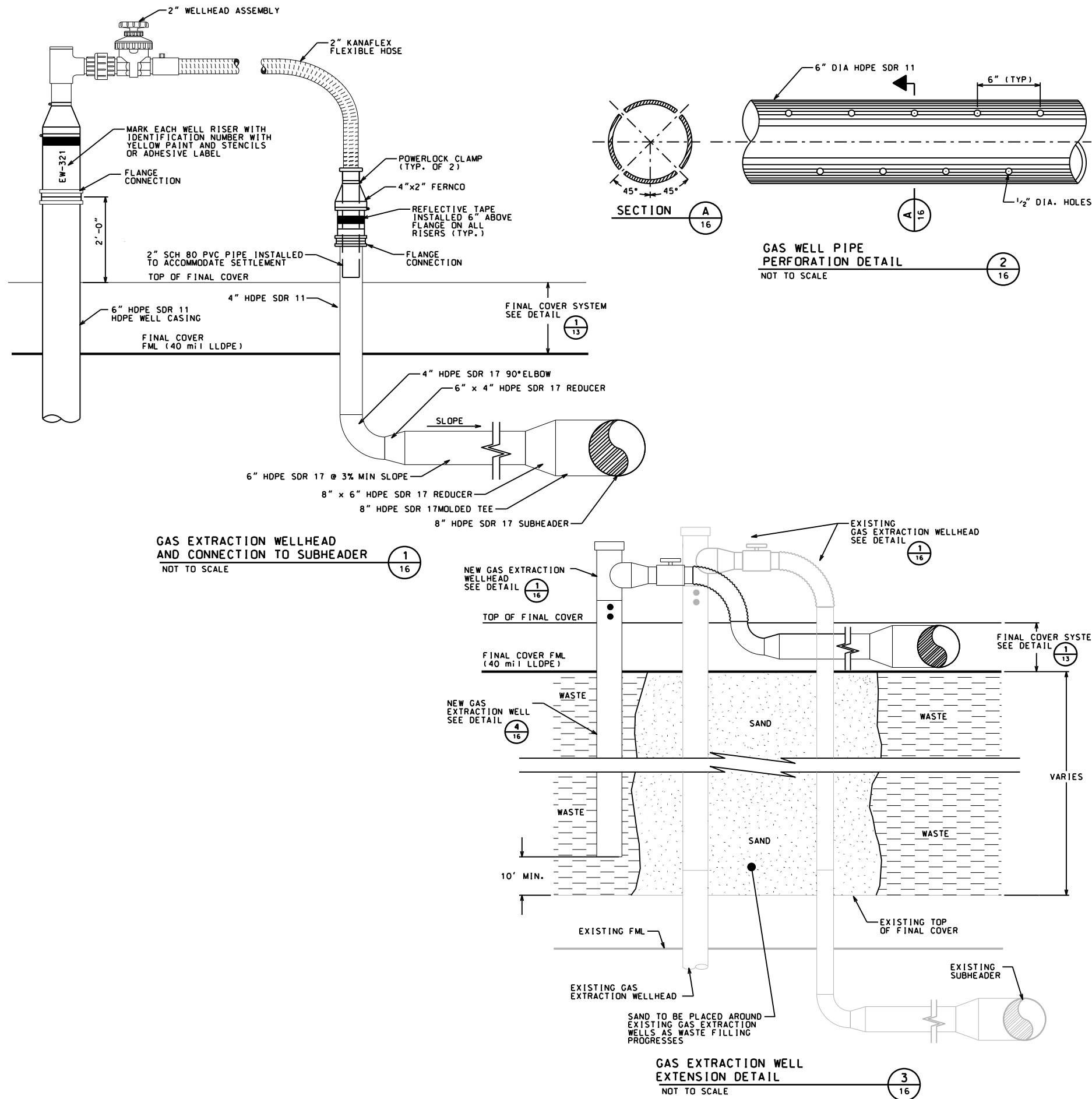
JWT 2022.03.14

Drawing No. 15

Revision Sheet

0 15 of 18

U:\2022\0471\0471.dwg
BY: JST/MSD



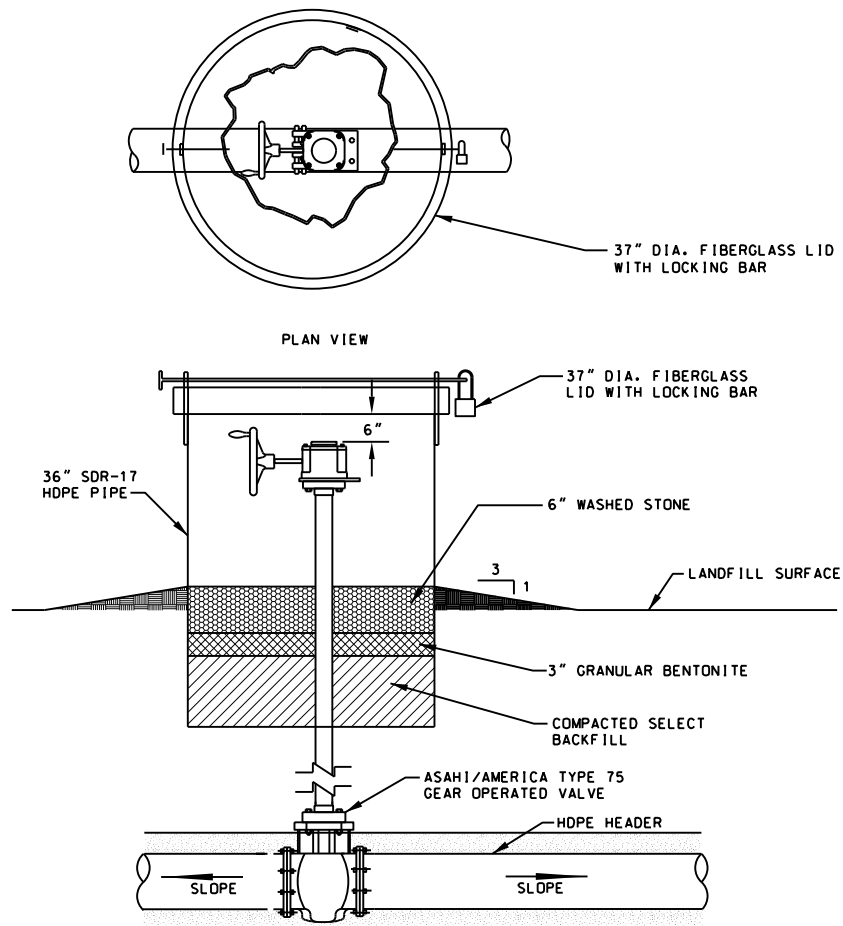
LANDFILL GAS EXTRACTION WELL DETAIL

NOT TO SCALE

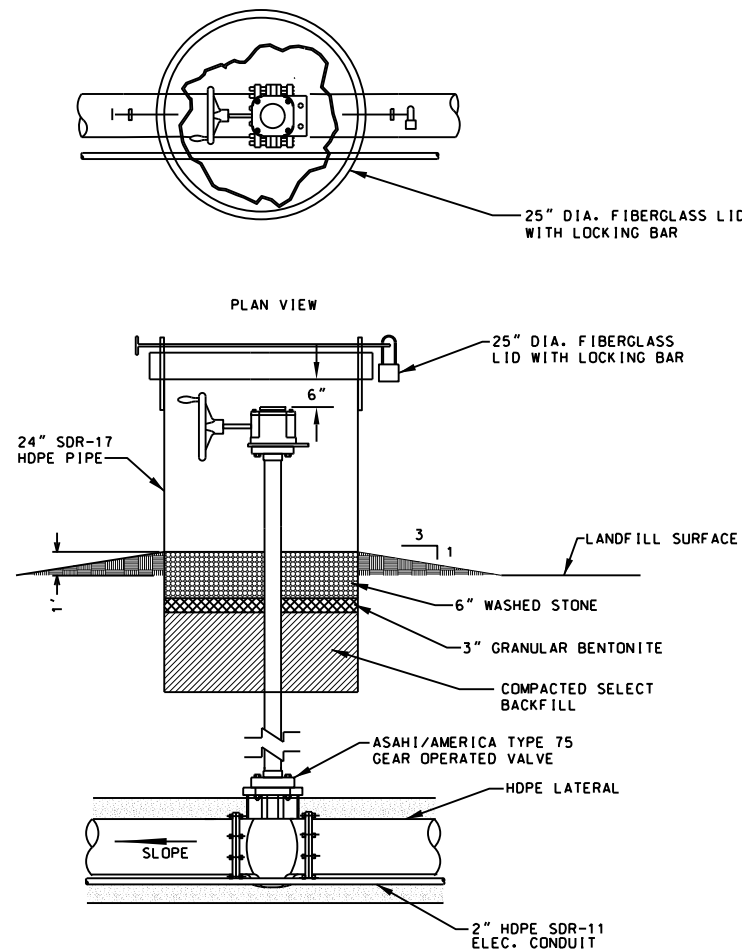
4

16

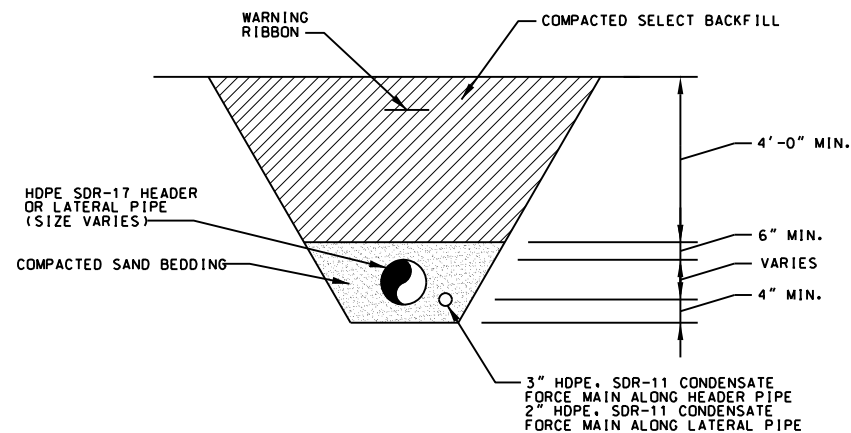
U:\22704791\cadd\04791e_sd_17.dgn
B:\pfiles\jst50



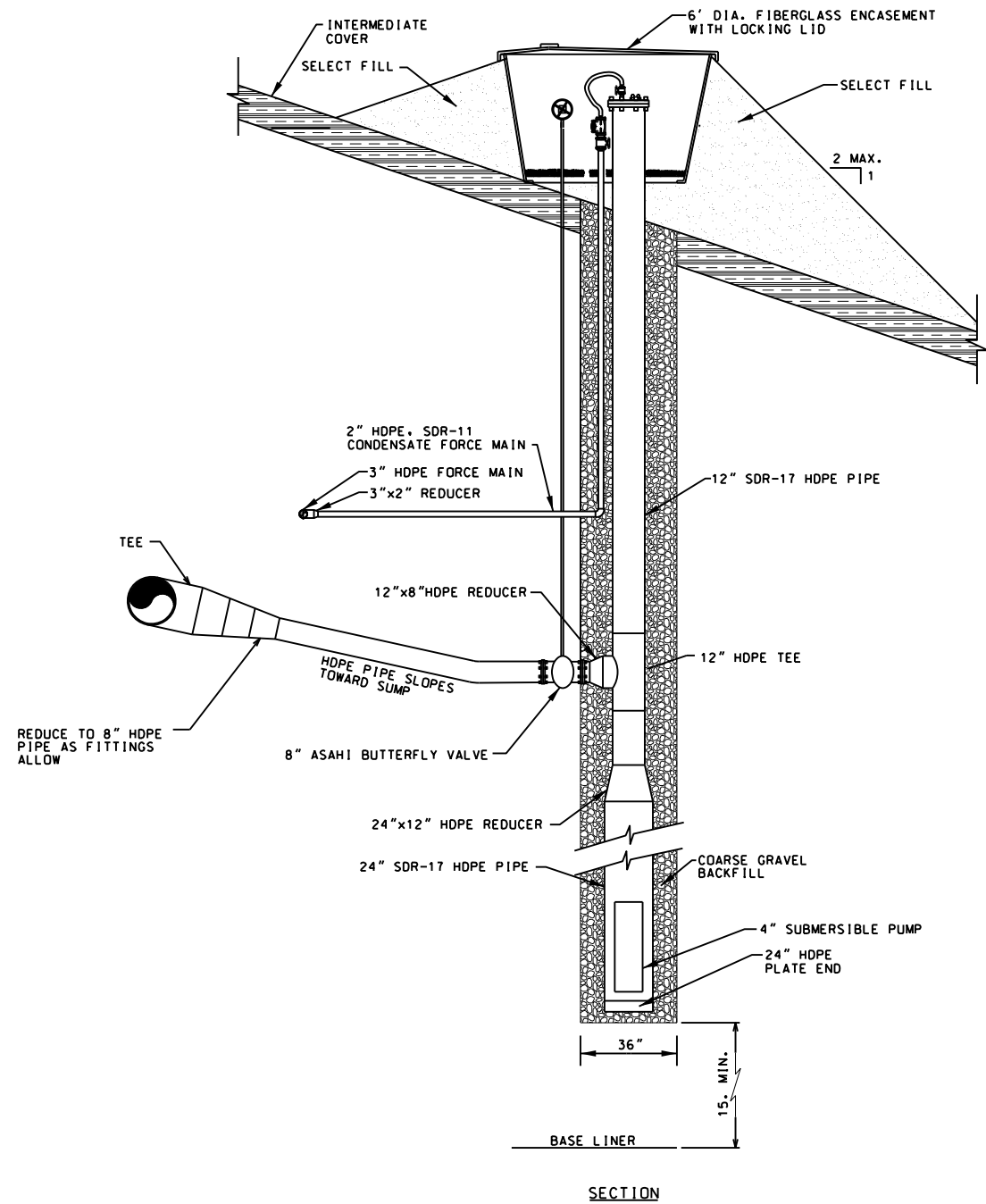
CONTROL VALVE DETAIL (GAS HEADER) 1
NOT TO SCALE 17



ISOLATION VALVE DETAIL (LATERAL) 2
NOT TO SCALE 17



TYPICAL PIPE TRENCH DETAIL 4
NOT TO SCALE 17



CONDENSATE SUMP DETAIL 3
NOT TO SCALE 17

APPENDIX B

Technical Specifications and CQA Plan



TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

DIVISION 2 - SITE CONSTRUCTION

Section 02201	Granular Drainage Layer
Section 02202	Coarse Aggregate
Section 02203	Intermediate Filter Aggregate
Section 02204	Rooting Zone
Section 02205	Clay Barrier Layer
Section 02206	Buffer Soils
Section 02207	Controlled Fill
Section 02208	Granular Bedding
Section 02211	Site Preparation
Section 02220	Excavation
Section 02221	Trenching
Section 02270	Articulated Precast Concrete Block Mat
Section 02273	Geosynthetic Clay Liner
Section 02276	Erosion and Sedimentation Control
Section 02486	Turf Restoration
Section 02511	Aggregate Road Surfacing
Section 02610	HDPE Piping
Section 02615	Testing HDPE Piping Systems
Section 02623	Perforated and Non-perforated Drain Pipe
Section 02630	Wellhead Assembly
Section 02640	Valves
Section 02750	Gas Extraction Wells
Section 02920	High Density Polyethylene Geomembrane (HDPE)
Section 02921	Geotextile
Section 02922	Liner Low Density Polyethylene Geomembrane (LLDPE)
Section 02924	Geonet Geocomposite
Section 15064	HDPE Pipe Manholes

SECTION 02201

GRANULAR DRAINAGE LAYER

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes descriptions and requirements for the installation of the granular drainage layer placed as shown on the drawings

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422 - Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 - 3. ASTM D1140 – Standard Test Method for Determining the Amount of Material Finer than 75- μ m (No. 200) Sieve in Soils by Washing.
 - 4. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in-Place by the Sand Cone Method.
 - 5. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³).
 - 6. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 7. ASTM D2434 – Standard Test Method for Permeability of Granular Soils (Constant Head)

1.03 SUBMITTALS

- A. Location of off-site source of materials.
- B. Name, address, telephone number and contact person of independent soils laboratory.
- C. Method of off-site source soils material sampling and analyses.
- D. Off-site source material analyses; shall be provided at least 21 days prior to installation.
- E. Proposed haul route planned for transportation of all off-site materials to the project site.

1.04 SOIL MATERIAL QUALITY ASSURANCE

- A. Independent soils laboratory shall be approved by OWNER.

- B. Source testing to be performed by CONTRACTOR at no cost to the OWNER.
- C. Provide the following test results for granular drainage layer material test requirements:

Property	Test Method	Frequency
Constant Head Permeability	ASTM D2434	1 test/2,000 cy
Grain Size Analysis	ASTM D422/D1140	1 test/2,000 cy
USCS Soil Classification	ASTM D2487	1 test/2,000 cy

PART 2 – PRODUCTS

2.01 Granular Drainage Layer: Durable, washed, coarse rounded to subangular gravel exhibiting the following:

- A. Grain Size: 100% passing 3/8-inch sieve and maximum 5% by weight which passes the #200 Sieve.
- B. Minimum permeability: 1×10^{-2} cm/sec when compacted to 95% of standard proctor dry density for base liner system. Minimum permeability of 1×10^{-3} cm/s for cover system.
- C. Uniformity Coefficient: Less than 6.

PART 3 - EXECUTION

3.01 FILL USAGE

- A. Cell construction: Directly over primary geomembrane and primary sideslope riser trench as shown on Drawings, as applicable.

3.02 PREPARATION

- A. CONTRACTOR to receive OWNER'S permission to begin installation of granular drainage layer.
- B. CONTRACTOR shall be responsible for surface water control within construction limits and shall keep the construction and borrow areas well drained and minimize surface water ponding.
- c. Subgrade elevation shall be documented by ENGINEER prior to placement of granular drainage layer material.

3.03 PLACEMENT

- A. Placement of granular materials on geomembrane shall not proceed at ambient temperatures below 5°C (40°F).
- B. Spread with one pass of low ground pressure tracked equipment or equivalent as approved by ENGINEER prior to placement. Do not allow

rubber-tired vehicles on granular blanket after placement. Operation of hauling equipment will be allowed only on areas with a 3-foot minimum thickness on slopes. Spread upslope only.

- C. Do not compact material on geosynthetics.
- D. Protect buried pipes, geotextiles, geosynthetics, and similar installations.
- E. CONTRACTOR shall place granular material by such method as to prevent wrinkling and possible damage to the HDPE liner or geonet geocomposite. Once the geosynthetic lining system has been accepted by the ENGINEER, it shall be the CONTRACTOR'S responsibility to ensure that the geosynthetics are not damaged. Should they become damaged, the CONTRACTOR shall at his own expense:
 - 1. Immediately notify ENGINEER; and
 - 2. Have the geosynthetic installer make any necessary repairs at the CONTRACTOR'S expense.

3.04 FIELD QUALITY CONTROL

- A. Comply with approved Quality Assurance Manual. CONTRACTOR shall cooperate and assist ENGINEER with obtaining required documentation and testing.
- B. Specified soil layers shall be graded to the minimum thicknesses as shown on drawings and specified herein. Thickness tolerance of the soil layers must be between -0.0 and +0.2 feet.
- C. Testing:
 - 1. Granular drainage layer in-place testing will be performed by ENGINEER to monitor material parameters and assist CONTRACTOR in selection of appropriate borrow material for granular drainage layer construction.
 - 2. Tests to be performed and frequency of tests specified are in the Quality Assurance Manual.
 - 3. CONTRACTOR is responsible for all costs related to retests of materials not meeting specifications.

3.05 ADJUSTMENT AND CLEANING

- A. Remove excess material not suitable for use to OWNER designated stockpile area. Grade to drain.

END OF SECTION

SECTION 02202

COARSE AGGREGATE

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes descriptions and requirements for the installation of the coarse aggregate as shown on the Drawings.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422- Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D2487- Standard Test Method for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 3. ASTM D4373 – Standard Test Method for Rapid Determination of Carbonate Content of Soils.

1.03 SUBMITTALS

- A. Location of off-site source of materials.
- B. Name, address, telephone number and contact person of independent soils laboratory.
- C. Method of off-site source soils material sampling and analyses.
- D. Off site source material quality assurance analyses shall be submitted at least 21 days prior to installation.
- E. Proposed haul road planned for transportation of all off-site materials to the project site.

1.04 SOIL MATERIAL SOURCE QUALITY ASSURANCE

- A. Independent soils laboratory to be approved by OWNER.
- B. Source testing to be performed by CONTRACTOR at no cost to the OWNER.

C. Provide the following test results for material test requirements:

Property	Test Method	Frequency
Grain Size Analysis	ASTM D422	3 test results/source
USCS Soil Classification and Uniformity Coefficient	ASTM D2487	3 test results/source
Calcium Carbonate Content*	ASTM D4373	1 test result/source

*Test waived if CONTRACTOR can demonstrate the material source is from quartzite, granite, or other igneous non-limestone/dolomite formation.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Coarse Aggregate

Granular material, bank-run sand and bank-run gravel, consisting of rounded to sub-rounded, durable particles.

- a. Crushed aggregate not allowed.*
- b. Limestone not allowed.
- c. Grain Size: Range from maximum diameter of 1-1/2 inches to minimum diameter of 5/8 inch (maximum 5% by weight passing #4 Sieve).
- d. Uniformity coefficient: Less than 4.
- e. Calcium carbonate content: Less than 10%.

*Crushed aggregate may be used provided the gradation meets the requirements stated above and the underlying geotextile consists of 16-oz/sy fabric. ENGINEER will have final decision regarding the angularity/geotextile relationship.

PART 3 – EXECUTION

3.01 FILL USAGE

- A. Coarse Aggregate: Leachate collection line trenches and sumps as shown on Drawings.

3.02 PREPARATION

- A. CONTRACTOR shall receive OWNER'S permission to begin installation of coarse aggregate.

3.03 PLACEMENT

- A. Transport material into landfill cell in a manner that will not damage underlying soil or synthetic layers. Low ground pressure equipment shall be used and no sharp turns with tracked equipment shall be made.
- B. Do not compact.
- C. CONTRACTOR shall place coarse aggregate by such method as to prevent wrinkling and possible damage to the underlying geosynthetics. Once the geosynthetic lining system has been accepted by the OWNER, it shall be the CONTRACTOR'S responsibility to ensure that the geosynthetics are not damaged. Should they become damaged, the CONTRACTOR shall at his own expense:
 - 1. Immediately notify ENGINEER
 - 2. Have the geosynthetic installer make any necessary repairs at the CONTRACTOR'S expense.
- D. If a rock box is used, a granular drainage layer thickness of 3 feet shall be present below the box.

3.04 FIELD QUALITY CONTROL

- A. Comply with approved Quality Assurance Manual. Cooperate with quality control program.
- B. Testing:
 - 1. Tests performed and frequency of tests specified in the Quality Assurance Manual.
 - 2. CONTRACTOR is responsible for all costs related to retests of materials not meeting specifications.

3.05 ADJUSTMENT AND CLEANING

- A. Remove excess material not suitable for use from the site.

END OF SECTION

SECTION 02203

INTERMEDIATE FILTER AGGREGATE

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes descriptions and requirements for the installation of the intermediate filter aggregate as shown on the Drawings.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422- Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D2487- Standard Test Method for Classification of Soils for Engineering Purposes.
 - 3. ASTM D4373 – Standard Test Method for Rapid Determination of Carbonate Content of Soils

1.03 SUBMITTALS

- A. Location of off-site source of materials.
- B. Name, address, telephone number and contact person of independent soils laboratory.
- C. Method of off-site source soils material sampling and analyses.
- D. Off-site material source quality assurance analyses shall be submitted at least 21 days prior to installation. Intermediate filter aggregate relationship to coarse aggregate and granular drainage layer shall be submitted to show compliance with this spec section.
- E. Proposed haul route planned for transportation of all off-site materials to the project site.

1.04 SOIL MATERIAL SOURCE QUALITY ASSURANCE

- A. Independent soils laboratory to be approved by OWNER.
- B. Source testing to be performed by CONTRACTOR at no cost to the OWNER.

C. Provide the following test results for material test requirements:

Property	Test Method	Frequency
Grain Size Analysis	ASTM D422	3 test results/source
USCS Soil Classification	ASTM D2487	3 test results/source
Calcium Carbonate Content*	ASTM D4373	1 test result/source

*Test waived if CONTRACTOR can demonstrate the material source is from quartzite, granite, or other igneous non-limestone/dolomite formation.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

- A. Intermediate Filter Aggregate: Durable, washed, coarse rounded to subangular, durable gravel.
- B. The intermediate filter aggregate shall exhibit the following relationships to the coarse aggregate:

1.
$$\frac{D_{15} \text{ (coarse aggregate)}}{D_{85} \text{ (intermediate filter aggregate)}} \leq 5$$
2.
$$\frac{D_{50} \text{ (coarse aggregate)}}{D_{50} \text{ (intermediate filter aggregate)}} \leq 25$$
3.
$$\frac{D_{15} \text{ (coarse aggregate)}}{D_{15} \text{ (intermediate filter aggregate)}} \leq 20$$

- C. The intermediate filter aggregate shall exhibit the following relationships to the granular drainage material:

1.
$$\frac{D_{15} \text{ (intermediate filter aggregate)}}{D_{85} \text{ (granular drainage material)}} \leq 5$$
2.
$$\frac{D_{50} \text{ (intermediate filter aggregate)}}{D_{50} \text{ (granular drainage material)}} \leq 25$$
3.
$$\frac{D_{15} \text{ (intermediate filter aggregate)}}{D_{15} \text{ (granular drainage material)}} \geq 5$$

Where D_{15} , D_{50} , and D_{85} are the diameters with which 15%, 50%, and 85% by weight are finer than, respectively.

- D. Crushed aggregate and/or limestone are not allowed.

PART 3 - EXECUTION

3.01 FILL USAGE

- A. Intermediate Filter Aggregate: Leachate collection trenches and sumps between coarse aggregate and granular drainage layers as shown on the Drawings.

3.02 PREPARATION

- A. CONTRACTOR to receive OWNER'S permission to begin installation of intermediate filter aggregate.

3.03 PLACEMENT

- A. Transport material into landfill cell in a manner that will not damage underlying soil or synthetic layers. Low ground pressure equipment shall be used and no sharp turns with tracked equipment shall be made.
- B. Do not compact.
- C. CONTRACTOR shall place material by such method as to prevent wrinkling and possible damage to the underlying geosynthetics. Once the geosynthetic lining system has been accepted by the OWNER, it shall be the CONTRACTOR'S responsibility to ensure that the geosynthetics are not damaged. Should they become damaged, the CONTRACTOR shall at his own expense:
 - 1. Immediately notify ENGINEER
 - 2. Have the geosynthetic installer make any necessary repairs at the CONTRACTOR'S expense.
- D. If a rock box is used, a granular drainage layer thickness of 3 feet shall be present below the box.

3.04 FIELD QUALITY CONTROL

- A. Comply with approved Quality Assurance Manual. Cooperate with quality control program.
- B. Testing:
 - 1. Tests performed and frequency of tests specified in the Quality Assurance Manual.
 - 2. CONTRACTOR is responsible for all costs related to retests of materials not meeting specifications.

3.05 ADJUSTMENT AND CLEANING

- A. Remove excess material not suitable for use from the site.

END OF SECTION

Filename: 65BE3B4C.DOC
Directory: C:\Users\jmarketon\AppData\Local\Microsoft\Windows\IN
etCache\Content.MSO
Template: C:\Users\jmarketon\AppData\Roaming\Microsoft\Templat
e\Normal.dotm
Title: _Technical Specifications
Subject:
Author: Norman C. Wenck
Keywords:
Comments:
Creation Date: 9/29/2003 11:58:00 AM
Change Number: 25
Last Saved On: 2/10/2022 10:20:00 AM
Last Saved By: Ortega, Felipe
Total Editing Time: 88 Minutes
Last Printed On: 4/21/2022 3:18:00 PM
As of Last Complete Printing
Number of Pages: 3
Number of Words: 629
Number of Characters: 3,588

SECTION 02204

ROOTING ZONE

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes the placement of the rooting zone soils.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422 - Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 μ m) Sieve.
 - 3. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

1.03 SUBMITTALS

- A. Documentation survey information as outlined in Part 3 of this Section.
- B. Location of off-site source of materials.
- C. Proposed haul road planned for transportation of all off-site materials to the project site.
- D. Method of off-site source soils material sampling and analyses.
- E. Off-site source material quality assurance analyses shall be submitted at least 21 days prior to installation.
- F. Proposed haul road planned for transportation of all off-site materials to the project site.

1.04 SOIL MATERIAL SOURCE QUALITY ASSURANCE

- A. Independent soils laboratory to be approved by OWNER.
- B. Source testing to be performed by CONTRACTOR at no cost to the OWNER.
- C. Provide the following test results for material test requirements:

Property	Test Method	Frequency
Grain Size Analysis	ASTM D422	1 test result/source
USCS Soil Classification	ASTM D2487	1 test result/source

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Rooting Zone:

1. Friable soil; Horizon B soils, suitable for establishment of rooting system of grass and plants.
2. Free from gravel, cinders, stone over 1 inch in any dimension and other undesirable material.
3. CONTRACTOR shall be responsible for providing suitable rooting zone material.

PART 3 - EXECUTION

3.01 FILL USAGE

- #### A. Rooting zone material:
- Directly on top of granular drainage layer or geocomposite for final cover system construction.

3.02 PREPARATION

A. Surface Water Control:

1. CONTRACTOR responsible for surface water control within construction limits.
2. Keep construction and borrow areas well drained and minimize surface water pooling.

3.03 PLACEMENT OF ROOTING ZONE

- #### A. Construct to limits and thicknesses as shown on Drawings.
- #### B. Spread with one pass using tracked equipment.
- #### C. Spread uphill only.
- #### D. Rubber-tired vehicles only allowed on areas with a 3-foot minimum thickness when being placed over geosynthetics.

3.04 FIELD QUALITY CONTROL

- #### A. Comply with approved Quality Assurance Manual. Cooperate with quality control program.
- #### B. Specified soil layers shall be graded to the minimum thicknesses as shown on drawings and specified herein. Thickness tolerance of the soil layers must be between -0.0 and +0.2 feet.
- #### C. Testing:

1. Tests performed and frequency of tests specified in the Quality Assurance Manual.
2. CONTRACTOR is responsible for all costs related to retests of materials not meeting specifications.

D. Survey Requirements: CONTRACTOR shall be responsible for providing documentation survey performed by a qualified land surveyor in accordance with the approved Quality Assurance Manual.

3.05 ADJUSTMENT AND CLEANING

A. Remove excess material not suitable for use from the site.

*** END OF SECTION ***

SECTION 02205

CLAY BARRIER LAYER

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes descriptions and requirements for installation of the clay barrier layer as shown on the Drawings.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. AD422 - Standard method for particle size analysis of soils.
 - 2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 - 3. ASTM D1140 – Standard test methods for determining the amount of material finer than 75-µm (No. 200) sieve in soils by washing.
 - 4. ASTM D1556 - Standard test method for density of soil in-place by the sand cone method.
 - 5. ASTM D1587 - Standard practice for thin-walled tube sampling of soils for geotechnical purposes.
 - 6. ASTM D2167 - Standard test method for density and unit weight of soil in-place by the rubber balloon method.
 - 7. ASTM D2216 - Standard test method for laboratory determination of water (moisture) content of soil and rock by mass.
 - 8. ASTM D2487 - Standard test method for classification of soils for engineering purposes (Unified Soil Classification System).
 - 9. ASTM D2488 - Standard practice for description and identification of soils (visual-manual procedure).
 - 10. ASTM D4318 - Standard test method for liquid limit, plastic limit, and plasticity index of soils.
 - 11. ASTM D5084 - Standard test method for measurement of hydraulic conductivity of saturated porous materials using a flexible wall permeameter.
 - 12. ASTM D6938 – Standard test method for in-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth).
- B. U.S. Army Corps of Engineers/U.S. Department of Interior.
 - 1. Permeability test: U.S. Army Corps of Engineers (WES), 1970, "Laboratory Testing Manual," Engineering Manual 1110-2-190C.

1.03 SUBMITTALS

- A. Description of proposed blending equipment 7 days prior to clay placement.

- B. Name, address, telephone number and contact person of independent soils laboratory.
- C. Location of off-site source of materials.
- D. Method of off-site source material sampling and analysis.
- E. Off-site source material analyses.
- F. Proposed haul road planned for transportation of all off-site materials to the project site.

1.04 SOIL MATERIAL QUALITY ASSURANCE

- A. Independent soils laboratory shall be approved by OWNER.
- B. CONTRACTOR shall provide location and source testing of the clay barrier layer borrow source at least 14 days prior to installation at the following frequencies:

Property	Test Method	Frequency
Hydraulic Conductivity (Permeability)	ASTM 5084	1 per 5,000 cubic yards
Grain Size Analysis w/ Hydrometer	ASTM D422/D1140	1 per 3,000 cubic yards
Atterberg Limits	ASTM D4318	1 per 3,000 cubic yards
USCS Soil Classification	ASTM D2487	1 per 3,000 cubic yards
Standard Proctor	ASTM D698	1 per 3,000 cubic yards

PART 2 - PRODUCTS

2.01 SOURCE OF MATERIAL

- A. CONTRACTOR shall provide acceptable source and will be responsible for quality of liner material.

2.02 CLAY BARRIER LAYER

- A. Clay barrier layer material shall have a USCS classification of SC, ML, CL, or CH exhibiting the following:
 - 1. In-place permeability: 1×10^{-7} cm/sec or less when compacted to 95% of Standard Proctor dry density at a moisture content of 0 to 5% wet of optimum.
 - 2. Grain size: P200 content 50% by weight or greater, maximum gravel content 5% by weight.
 - 3. Clay content: 25% by weight or greater.
 - 4. Liquid limit: 25% or greater.

5. Plasticity index: 10 or greater.
 6. Compaction: 95% standard proctor density or greater.
- B. Clay barrier layer material shall contain no clods larger than 2 inches and be free of debris, roots, organic material, solid mineral material larger than 1 inch in diameter, angular stones of any diameter and other materials considered deleterious to the overlying geomembrane liner.

PART 3 – EXECUTION

3.01 FILL USAGE

- A. Clay barrier layer: Directly below geomembrane liner for cell construction. Compacted layer thickness as shown on Drawings.

3.02 PREPARATION

- A. Prepare surface to provide specified clay barrier layer thickness.
- B. CONTRACTOR shall be responsible for surface water control within construction limits and shall keep the construction and borrow areas well drained and minimize surface water ponding.
- C. Examine and/or proofroll subgrade areas within limits of excavation to determine existence of soft areas, areas loosened by frost action or softened by flooding, weather or of unsuitable materials.
1. Determination of soft, wet or loose areas will be based on ENGINEER'S judgement.
 2. Soft areas will generally be detected by soil deflection of greater than 2 inches and accompanied with stress cracks in soil when rolled over by heavy construction equipment intended for the placement and compaction of clay.
- D. Replace materials determined to be unsuitable or soft soils by sub-cutting 2 feet and replacing with controlled fill material.
- E. Subgrade elevation shall be documented by CONTRACTOR prior to placement of clay barrier layer material.

3.03 PLACEMENT

- A. Place clay barrier layer material as follows:
1. Maximum Compacted Lift Thickness: 6 inches.
 2. Minimum Compaction: 95% of dry density, ASTM D698 Standard Proctor.
 3. Moisture Content: 0 to 5% wet of optimum.
 4. Maximum Clod Size: 2 inches.
 5. Maximum Permeability: 1×10^{-7} cm/sec, laboratory falling head permeability test.

- B. The clay barrier material shall be at optimum moisture or greater prior to delivery and placement. Clay conditioning may be performed in the area designated by ENGINEER.
- C. Material distribution and gradation throughout clay barrier shall be such that material is free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation from surrounding material. Blend clay prior to compaction.
- D. Uniformly distribute moisture content of clay material prior to and during compaction throughout each lift of material. Dry excavated materials too wet for immediate compaction to permit compaction in liner at proper moisture content. Do not place clay liner at moisture content less than optimum as defined by ASTM D698. No additional payment will be made for drying or wetting materials for use in liner.
- E. Place layers of clay to form continuous monolithic material. Remove excessively dry or wet soil before placement of additional lifts. Knead each lift into previously placed lift.
- F. Compact with sheepsfoot roller, or similar kneading type compactor capable of influencing entire lift.
- G. Final surface shall be smooth-rolled prior to geosynthetic placement. Finished surface will be smooth and even with no sheepsfoot roller indentations.
- H. Construct sideslope liners by pushing clay material up the sideslope from the cell base. Placement or movement of clay down from the top of the sideslope will not be allowed. Placement and compaction of sideslope liner shall be performed in accordance with the specifications so as to avoid damage to or movement of the geomembrane or other geosynthetics.
- I. Protect buried pipes, geotextiles, geonets, and similar installations when constructing overlying portions of the liner system.
- J. Do not place clay below air temperatures of 32°F, unless CONTRACTOR can demonstrate fill material temperature is above freezing.
- K. CONTRACTOR shall be responsible for the integrity of the clay liner and shall not allow the surface to dry or desiccate.
- L. CONTRACTOR shall be responsible for maintaining the clay surface until it is covered by OWNER'S geosynthetic installation contractor.
- M. Surface of clay liner must be approved by the GEOSYNTHETIC INSTALLER prior to installation of any geomembrane or other geosynthetics. Surface rutting or drying will not be acceptable. Surface must be smooth and free of debris, roots, and angular or sharp rocks larger than 3/8 inches in diameter to a depth of 4 inches below surface to be lined.

3.04 FIELD QUALITY CONTROL

- A. Comply with approved Quality Assurance Manual. CONTRACTOR shall cooperate and assist ENGINEER with obtaining required documentation and testing.
- B. Specified soil layers shall be graded to the minimum thicknesses as shown on drawings and specified herein. Thickness tolerance of the soil layers must be between -0.0 and +0.2 feet.
- C. Testing:
 - 1. Clay barrier layer in-place testing will be performed through the Project by ENGINEER to monitor clay parameters and assist CONTRACTOR in selection of appropriate borrow material for barrier layer construction.
 - 2. Tests performed and frequency of tests specified are in the Quality Assurance Manual.
 - 3. CONTRACTOR is responsible for all costs related to retests of materials not meeting specifications.
 - 4. CONTRACTOR shall backfill all perforations of the clay layer by probe or sample tube with a 50-50 soil-bentonite mixture. The mixture shall be compacted in-place with a tamping rod, or hand tamper, depending on the size of the perforation.
- D. Survey Requirements:
 - 1. CONTRACTOR will perform documentation survey in accordance with the Quality Assurance Manual included in the Appendix for each segment of liner system.
 - 2. Elevation tolerances for the earthwork according to the design shall be +0.0' to -0.2' on the subgrade. Thickness tolerances for each layer shall be -0.0' to + 0.2'.
 - 3. The major components of the survey shall include the following on the landfill cell:
 - a. Top of subgrade
 - b. Top of clay liner
 - c. Base and top of all sumps and trenches, including lysimeter

3.05 ADJUSTMENT AND CLEANING

- A. Remove excess material not suitable for use from the site.

*** END OF SECTION ***

SECTION 02206

BUFFER SOILS

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes the placement of the buffer soils.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422 - Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 um) Sieve.
 - 3. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

1.03 SUBMITTALS

- A. Documentation survey information as outlined in Part 3 of this Section.
- B. Location of off-site source of materials.
- C. Proposed haul road planned for transportation of all off-site materials to the project site.
- D. Method of off-site source soils material sampling and analyses.
- E. Off-site source material quality assurance analyses shall be submitted 14 days prior to installation.
- F. Proposed haul route planned for transportation of all off-site materials to the project site.

1.04 SOIL MATERIAL SOURCE QUALITY ASSURANCE

- A. Independent soils laboratory to be approved by OWNER.
- B. Source testing to be performed by CONTRACTOR at no cost to the OWNER.
- C. Provide the following test results for material test requirements:

Property	Test Method	Frequency
Grain Size Analysis	ASTM D422	1 test result/acre
USCS Soil Classification and Uniformity Coefficient	ASTM D2487	1 test result/source

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Buffer Soils:

1. Free from gravel, cinders, stone over 1 inch in any dimension and other undesirable material.
2. CONTRACTOR shall be responsible for providing suitable buffer soil material.

PART 3 - EXECUTION

3.01 FILL USAGE

- #### A. Buffer soils: Directly on top of the waste fill within the closure area.

3.02 PREPARATION

A. Surface Water Control:

1. CONTRACTOR responsible for surface water control within construction limits.
2. Keep construction and borrow areas well drained and minimize surface water pooling.

3.03 PLACEMENT OF BUFFER SOILS

- A. Construct to limits and to the elevations as shown on Drawings.
- B. Compact using MN/DOT ordinary compaction method.
- C. Final surface must be firm and free of stones greater than ½ -inch diameter or any other material which would be deleterious to the overlying geomembrane liner.
- D. Smooth drum surface to provide smooth surface for geomembrane installation. Remove and replace excessively soft or wet areas.

3.04 FIELD QUALITY CONTROL

- A. Comply with approved Quality Assurance Manual. Cooperate with quality control program.

- B. Specified soil layers shall be graded to the minimum thicknesses as shown on drawings and specified herein. Thickness tolerance of the buffer soil layer must be between -0.2 and +0.0 feet.
- C. Testing:
 - 1. Tests performed and frequency of tests specified in the Quality Assurance Manual.
 - 2. CONTRACTOR is responsible for all costs related to retests of materials not meeting specifications.
- D. Survey Requirements: CONTRACTOR shall be responsible for providing documentation survey performed by a qualified land surveyor in accordance with the approved Quality Assurance Manual, included as Appendix A.

3.05 ADJUSTMENT AND CLEANING

- A. Remove excess material not suitable for use from the site.

*** END OF SECTION ***

SECTION 02207
CONTROLLED FILL

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes descriptions and requirements of the imported soils required for construction with controlled fill soils.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
1. ASTM D422 - Standard Method for Particle Size Analysis of Soils.
 2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 3. ASTM D1140- Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 um) Sieve.
 4. ASTM D1556- Standard Test Method for Density of Soil in-Place by the Sand Cone Method.
 5. ASTM D1587- Standard Practice for Thin-Walled Tube Sampling of Soils.
 6. ASTM D2167- Standard Test Method for Density and Unit Weight of Soil in-Place by the Rubber Balloon Method.
 7. ASTM D2216- Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
 8. ASTM D2487- Standard Test Method for Classification of Soils for Engineering Purposes.
 9. ASTM D4318- Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 10. ASTM D6938 – Standard test method for in-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth).
- B. U.S. Army Corps of Engineers/U.S. Department of Interior:
1. Permeability Test; U.S. Army Corp of Engineers (WES), 1970, "Laboratory Testing Manual," Engineering Manual 1110-2-190C.

1.03 SUBMITTALS

- A. Location of off-site source of materials.
- B. Name, address, telephone number and contact person of independent soils laboratory.
- C. Method of off-site source soils material sampling and analyses.
- D. Off site source material analyses.

- E. Proposed haul road plan for transportation of all off-site materials to the Project site.

1.04 SOIL MATERIAL SOURCE QUALITY ASSURANCE

- A. Three (3) of each of the following:
 - 1. USCS soil classification (ASTM D2487)
 - 2. Atterberg Limits (ASTM D4318)
 - 3. Standard Proctor (ASTM D698)

PART 2 - PRODUCTS

2.01 CONTROLLED FILL

- A. Natural soils classified as CL, GM, SM or SC in the Unified Soil Classification System, free of organic and other deleterious material.
- B. Native excavated subsoil from designated borrow and excavation areas to be used for embankments, backfill, and subgrade excavation replacement where applicable.
- C. Material free from roots, debris, and stones larger than six (6) inches.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine and verify acceptability of surface to receive installation of material.
- B. Proofroll and examine surfaces to receive fill and subgrades within influence zone to determine existence of soft areas, areas loosened by frost action or softened by flooding, groundwater or weather or existence of unsuitable materials.

3.02 PREPARATION

- A. Sample, test, and submit test results of off-site soils.
- B. Prepare surfaces to receive materials to lines and grades shown on Drawings prior to placement.

3.03 BACKFILLING AND COMPACTION

- A. Notify ENGINEER before placing fill material.
- B. Do not use frozen material or place fill on frozen subgrade.

- C. Where pipes or electrical conduits leave structures, protect by backfilling pipe or duct influence zone down to undisturbed soil with controlled fill.
- D. Place fill simultaneously on both sides of free-standing structures.
- E. Provide mechanical compaction for cohesive material and vibratory compaction for granular materials. When approved by ENGINEER, jetting, flooding, puddling, or vibroflotation methods may be used for compacting if CONTRACTOR furnishes test results to confirm required degree of compaction being obtained uniformly throughout entire mass.
- F. Lift Thickness and Compaction: Place and compact fill material in maximum lift thickness and to minimum densities listed below. Where "Quality Compaction Method" is listed, reference "Standard Specifications" Section 2105.F.2.

	Fill Placement	Maximum Compacted Lift Thickness (inches)	Standard Proctor (%)
A	Controlled Fill for Anchor Trench Backfill	8	95
B	Controlled Fill for Berm Construction	6	98
C	Controlled Fill for Drainage Swale	12	"Quality Compaction Method"
D	Controlled Fill for Subcut Replacement	6	95

3.04 FIELD QUALITY CONTROL

- A. In-place testing shall be performed by OWNER in accordance with the Construction Quality Assurance manual; any laboratory retesting due to test failure will be paid for by the CONTRACTOR.
- B. Perform field density testing on controlled fill at a rate of one test for each 5,000 cubic yards placed, minimum of one each lift.

3.05 TRANSPORTATION AND HAUL ROADS

- A. Observe State, County, and Local traffic rules and weight restrictions.
- B. All vehicle trips loaded or unloaded shall be on designated haul roads only.
- C. CONTRACTOR to coordinate selection of haul roads with the appropriate governing body and acquire any necessary permits.

END OF SECTION

SECTION 02208

GRANULAR BEDDING

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes descriptions and requirements of the granular bedding material required for construction as shown on the Drawings.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422 - Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 - 3. ASTM D1140- Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 um) Sieve.
 - 4. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.
 - 5. ASTM D6938 – Standard test method for in-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth).

1.03 SUBMITTALS

- A. Location of off-site source of materials.
- B. Name, address, telephone number and contact person of independent soils laboratory.
- C. Method of off-site source soils material sampling and analyses.
- D. Off site source material analyses.
- E. Source testing results shall be provided at least 21 days prior to installation.
- F. Proposed haul road plan for transportation of all off-site materials to the Project site.

1.04 SOIL MATERIAL SOURCE QUALITY ASSURANCE

- A. Independent soils laboratory shall be approved by OWNER.
- B. Source testing to be performed by CONTRACTOR at no cost to the OWNER.

- C. Provide the following test results for granular bedding material test requirements:

Property	Test Method	Frequency
Grain Size Analysis	ASTM D422/D1140	3 test results/source

PART 2 - PRODUCTS

2.01 GRANULAR BEDDING

- A. Granular material, consisting of durable particles ranging in size from fine to coarse in substantially uniform combination. Unwashed bank-run sand and crushed bank-run gravel will be considered.
- B. Graded aggregate product of which 100 percent will pass the 1-inch sieve and not more than 10 percent will pass the #200 sieve.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surfaces to receive fill to determine existence of areas loosened by frost action, softened by flooding or weather or of unsuitable materials.

3.02 PLACING FILL

- A. Notify ENGINEER before placing fill material.
- B. Do not use frozen material or place fill on frozen subgrade.
- C. Granular Bedding Material Limits for Pipe Bedding:
 - 1. Electrical Conduit: Minimum of 6 inches below, to spring line, and minimum 9 inches each side.
 - 2. Other Piping: Minimum of 6 inches below, to spring line, and entire trench width.
- D. Granular Bedding Material Limits for Pipe Cover:
 - 1. Electrical Conduit: Minimum 6 inches above and 9 inches each side.
 - 2. Other Piping: Minimum 12 inches above and 12 inches each side.
- E. Where pipes or electrical conduits cross, protect piping or conduits at higher elevation by backfilling trench within higher pipe or conduit influence zone down to bedding of lower pipe or conduit with structural or controlled fill.
- F. Where pipes or electrical conduits leave structures, protect by backfilling pipe or duct influence zone down to undisturbed soil with controlled fill.

- G. Do not backfill until new concrete has properly cured, coatings approved and required tests accepted.
- H. Place fill simultaneously on both sides of free-standing structures.
- I. Provide mechanical compaction for cohesive material and vibratory compaction for granular materials. When approved by ENGINEER, jetting, flooding, puddling, or vibroflotation methods may be used for compacting if CONTRACTOR furnishes test results to confirm required degree of compaction being obtained uniformly throughout entire mass.
- J. Lift Thickness and Compaction: Place and compact fill material in maximum lift thickness and to minimum densities listed below.

<u>Type of Fill Placement</u>	<u>Maximum Compacted Lift Thickness (inches)</u>	<u>Standard Proctor (%)</u>
Pipe Bedding	6	98
Pipe Cover	12	95

3.03 FIELD QUALITY CONTROL

- A. In-place testing shall be performed by OWNER in accordance with the Construction Quality Assurance manual; any laboratory retesting due to test failure will be paid for by the CONTRACTOR.

3.04 TRANSPORTATION AND HAUL ROADS

- A. Observe State, County, and Local traffic rules and weight restrictions.
- B. All vehicle trips loaded or unloaded shall be on designated haul roads only.
- C. CONTRACTOR to coordinate selection of haul roads with the appropriate governing body and acquire any necessary permits.

END OF SECTION

SECTION 02211
SITE PREPARATION

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes the requirements for clearing and grubbing, salvaged topsoil, demolition, and miscellaneous surface features.

1.02 DEFINITIONS

- A. Structures and Surface Features: For purpose of this section, shall mean existing structures and surface features, including but not limited to buildings, pavements, curb and gutter, signs, posts, fences, trees, shrubs, and other landscaped features.
- B. Salvaged Topsoil: Natural loam, sandy loam, silt loam, silty clay loam, or clay loam humus-bearing soils available from overlying portions of areas to be excavated for construction.
- C. Unsuitable Material: Topsoil, peat, organic soils, and materials containing slag, cinders, foundry sand, debris, and rubble or soil with less than required bearing capacity as determined by ENGINEER.
- D. Utilities: Existing gas mains; water mains; electric lines; conduits, telephone, and other communication lines; sewer pipe; cable television, other utilities, and appurtenances.

1.03 PROJECT/SITE CONDITIONS

- A. Provide 72 hour notice, prior to beginning construction, to OWNERS of utilities, structures, and surface features.

1.04 COORDINATION

- A. Coordinate work with others performing work at project site.
- B. Call Gopher One to check for utilities prior to beginning Work.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 PREPARATION

- A. Provide protection and support during construction for existing utilities, structures, and surface features adjacent to construction area or easements and rights-of-way.
- B. Remove obstructions such as mounds of dirt, stone or debris located within working limits.
- C. Obstructions such as street signs, small culverts, and guard posts located within construction easements of rights-of-way may be removed if promptly replaced to original condition unless otherwise specified.

3.02 CLEARING AND GRUBBING

- A. Clearing and grubbing consists of cutting and disposing of trees, brush, windfalls, logs, and other vegetation, and removing and disposing of roots, stumps, logs, and other timber.
- B. Clear areas within the construction limits as shown on the Drawings and as necessary for the successful completion of the construction.
- C. Do not remove or cut down trees unless located within limits of construction or unless removal indicated on Drawings.
- D. Dispose of materials removed by clearing and grubbing off-site.

3.03 SALVAGED TOPSOIL

- A. Excavate and temporarily stockpile salvaged topsoil in quantities adequate to restore areas disturbed by construction.
- B. All material stockpile areas shall be stripped of topsoil prior to stockpiling.
- C. Provide transportation of material and sites for stockpiles if adequate areas not available within the construction limits as shown on the Drawings.

3.04 DEMOLITION

- A. Demolition includes cutting and breaking out existing concrete and masonry, and removal of utilities, pavement, structures, and surface features in direct conflict with the Work or required to be demolished.

3.05 RESTORATION

- A. Restore existing utilities, surface feature, and structures to condition equal to or exceeding condition which existed prior to construction.

3.06 MAINTENANCE AND RESTORATION OF ON-SITE AND OFF-SITE HAUL ROADS

- A. While hauling operations are in progress, CONTRACTOR shall maintain haul roads in condition satisfactory to the ENGINEER. Work shall include any or all of the following items:

1. Application of water
 2. Bituminous material
 3. Calcium chloride
 4. Sweeping
 5. Others as necessary
- B. When hauling operations are completed, CONTRACTOR shall:
1. Restore to condition that existed at the time hauling operations were started; or
 2. Compensate the local road authority in the amount satisfactory to that road authority.
- C. The ENGINEER shall make the determination as to the kind and amount of Work required to restore the haul road to a condition equal to the time hauling operations began.
- D. When hauling operations are complete and restoration is complete to the satisfaction of the ENGINEER, the CONTRACTOR will be relieved of any additional obligation in connection to the maintenance and restoration of the haul road.

END OF SECTION

SECTION 02220

EXCAVATION

PART 1 - GENERAL

1.01 SUMMARY

- A. Work described in this section includes excavation for all excavations as shown on the Drawings. This section also includes any subgrade preparation required prior to backfilling.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D422 - Standard Method for Particle Size Analysis of Soils.
 - 2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 - 3. ASTM D1140- Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 um) Sieve.
 - 4. ASTM D1556- Standard Test Method for Density of Soil in-Place by the Sand Cone Method.
 - 5. ASTM D2487- Standard Test Method for Classification of Soils for Engineering Purposes.
 - 6. ASTM D6938 – Standard test method for in-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth).

1.03 SUBMITTALS

- A. Shoring, Bracing, and Sheet piling Layout and Details: ENGINEER will review submitted material to ascertain effect on new construction. ENGINEER will not review shoring, bracing, and sheet piling for structural integrity or effect on existing facilities.
- B. Additional soil testing results as may be required.

1.04 QUALITY ASSURANCE

- A. Sheet piling, Shoring, and Bracing:
 - 1. Sheet piling, shoring, and bracing shall be designed by a Professional Engineer registered in the state of Minnesota.
 - 2. Sheet piling, shoring, and bracing shall conform to safety requirements of federal, state, or local public agency having jurisdiction over such matters. Most stringent of these requirements shall apply.

1.05 DEFINITIONS

- A. Influence Zone Under Foundations, Pavements, or Sidewalks: Area below foundation or pavement and sidewalk bas bounded by 1 horizontal

to 2 vertical slope extending outward from 1 ft beyond outer edges of foundation, pavement, or sidewalk.

- B. Influence Zone Around Piping or Electrical Ducts: Area below limits bounded by line 12 in. above pipe or duct and by 1 horizontal to 2 vertical slope extending outward from that line 1 ft beyond outer edge of pipe or duct.
- C. Unsuitable Material: Topsoil, peat, organic soils, and materials containing slag, cinders, foundry sand, debris, and rubble or soil with less than required bearing capacity as determined by ENGINEER.

1.06 FIELD MEASUREMENTS

- A. Verify control monuments and intended elevations for Work as shown on Drawings.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine and verify acceptability and condition of surfaces to perform Work.

3.02 PREPARATION

- A. Identify required lines, grades, levels, contours, and datum.
- B. Protect benchmarks, structures, equipment, and partially completed Work.
- C. Over-excavate soft areas of subgrade not capable of in-situ compaction as directed by ENGINEER.
- D. Notify corporations, companies, individuals, or authorities owning above- or belowground conduits, wires, pipes, or other utilities running to property or encountered during excavating operations.
- E. Cap or remove and relocate services in accordance with instructions by owners of services.
- F. Protect, support, and maintain conduits, wires, pipes, and other remaining utilities in accordance with requirements of owners of said services.
- G. CONTRACTOR may encounter groundwater and upward seepage during construction and is responsible for dewatering:

1. Keep excavations free from water.
2. Maintain groundwater minimum of 12 inches below excavations.
3. Remove soil disturbed by pressure or flow of groundwater and replace with free-draining material.
4. Maintain dewatering system to prevent uplifting of structures.
5. Protect adjacent properties from damage resulting from dewatering operations.
6. Dewatering wells shall be drilled, maintained, and abandoned in accordance with federal, state, and local ordinances.
7. Keep surface water from flowing into existing leachate collection system.
8. Keep surface water from ponding near or flowing into subsoils below existing composite liner system.

H. Keep construction site free-draining.

I. Fill settled areas where excavations or trenches were backfilled and holes made by demolition, tree removal, and site preparation work.

J. Remove all topsoil, organic material, and soft, wet, or loose soils below proposed berm and roadway areas. During excavation or exposure of in-situ soils, the CONTRACTOR shall subcut 2 feet beneath plan subgrade if soft, wet, or loose soils are encountered. Replace unsuitable materials with controlled fill material. Soft, wet, loose, and competent soils will be determined by the ENGINEER.

K. Disc level surfaces.

L. The CONTRACTOR shall stage construction to prevent slippage or sloughing of the berms during construction.

3.03 COMMON EXCAVATION

A. Excavations shall conform to lines and grades as staked, and as shown on Drawings.

B. Excavations beyond those lines and grades without the ENGINEER's authorization will be considered unauthorized work.

C. Method of excavation shall be consistent with soil types encountered and result in competent subgrade.

D. Remove stumps, roots, debris, large stones or boulders, and any other deleterious material from excavated materials to be used in embankments.

E. Do not excavate within influence zone of existing footings or foundations without prior approval of ENGINEER.

F. Upon completion of excavation, notify ENGINEER before proceeding with further work.

3.04 ANCHOR TRENCH EXCAVATION

- A. Excavate anchor trench to elevations and dimensions necessary to anchor geomembrane as shown on Drawings.
- B. Coordinate all work with geomembrane installer.

3.05 FIELD QUALITY CONTROL

- A. Final subgrade surface to be smooth rolled with no visible roller indentations or rocks larger than 3/8 -inch or material which could harm overlying geosynthetics.
- B. Subgrade elevations shall be surveyed prior to placement of fill material. Elevations of subgrade to be as shown on Drawings.
- C. Subgrade elevations shall be between -0.2 and +0.0 feet.

3.06 ADJUSTMENT AND CLEANING

- A. Stockpile excavated material suitable for backfill on site in OWNER designated location and grade to drain.
- B. Place excavated material not suitable for backfilling and unsuitable materials in designated spoil areas and grade to drain.

3.07 STOCKPILE REQUIREMENTS

- A. All material stockpiles areas shall be stripped of topsoil prior to stockpiling.
- B. Stockpile excavated material suitable for backfill on designated site(s). Place no fill where trenches for forcemain or other utilities will be located.
- C. Stockpile areas shall conform to the following requirements:
 - 1. Stockpile areas shall be at least 50 feet from the edge of landfill slopes.
 - 2. Stockpile areas shall be at least 10 feet from the edge of access road.
 - 3. Grade stockpile areas to a maximum 3:1 slope.
 - 4. Provide drainage around stockpile areas.

END OF SECTION

SECTION 02221

TRENCHING

PART 1 - GENERAL

1.01 SUMMARY

- A. Work described in this section includes trenching for piping installation.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM):

1. ASTM D422 -Standard Method for Particle Size Analysis of Soils.
2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
3. ASTM D1140- Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 um) Sieve.
4. ASTM D1556- Standard Test Method for Density of Soil in-Place by the Sand Cone Method.
5. ASTM D2487- Standard Test Method for Classification of Soils for Engineering Purposes.
6. ASTM D6938 – Standard test method for in-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth).

1.03 SUBMITTALS

- A. None required.

1.04 QUALITY ASSURANCE

- A. Sheet piling, Shoring, and Bracing:

1. Sheet piling, shoring, and bracing shall be designed by a Professional Engineer registered in the state of Minnesota.
2. Sheet piling, shoring, and bracing shall conform to safety requirements of federal, state, or local public agency having jurisdiction over such matters. Most stringent of these requirements shall apply.

1.05 DEFINITIONS

- A. Influence Zone Under Foundations, Pavements, or Sidewalks: Area below foundation or pavement and sidewalk bounded by 1 horizontal to 2 vertical slope extending outward from 1 ft beyond outer edges of foundation, pavement, or sidewalk.
- B. Influence Zone Around Piping or Electrical Ducts: Area below limits bounded by line 12 in. above pipe or duct and by 1 horizontal to 2 vertical slope extending outward from that line 1 ft beyond outer edge of pipe or duct.

- C. Unsuitable Material: Topsoil, peat, organic soils, and materials containing slag, cinders, foundry sand, debris, and rubble or soil with less than required bearing capacity as determined by ENGINEER.

1.06 FIELD MEASUREMENTS

- A. Verify control monuments and intended elevations for Work as shown on Drawings.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine and verify acceptability and condition of surfaces to perform Work.

3.02 PREPARATION

- A. Identify required lines, grades, levels, contours, and datum.
- B. Protect benchmarks, structures, equipment, and partially completed Work.
- C. Overexcavate soft areas of subgrade not capable of in-situ compaction as directed by ENGINEER.
- D. Notify corporations, companies, individuals, or authorities owning above- or belowground conduits, wires, pipes, or other utilities running to property or encountered during trenching operations.
- E. Cap or remove and relocate services in accordance with instructions by owners of services.
- F. Protect, support, and maintain conduits, wires, pipes, and other remaining utilities in accordance with requirements of owners of said services.
- G. CONTRACTOR may encounter groundwater and upward seepage during construction and is responsible for dewatering:
 - 1. Keep trenches free from water.
 - 2. Maintain groundwater minimum of 12 inches below excavations.
 - 3. Remove soil disturbed by pressure or flow of groundwater and replace with free-draining material.
 - 4. Maintain dewatering system.
 - 5. Protect adjacent properties from damage resulting from dewatering operations.

6. Dewatering wells shall be drilled, maintained, and abandoned in accordance with federal, state, and local ordinances.
- H. Keep construction site free-draining.
- I. Fill settled areas where excavations or trenches were backfilled and holes made by demolition, tree removal, and site preparation work.
- J. Remove all topsoil, organic material, and soft, wet, or loose soils below proposed berm and roadway areas. During excavation or exposure of in-situ soils, the CONTRACTOR shall subcut 2 feet beneath plan subgrade if soft, wet, or loose soils are encountered. Replace unsuitable materials with controlled fill material. Soft, wet, loose, and competent soils will be determined by the ENGINEER.

3.03 TRENCHING

- A. Excavate to elevations and dimensions necessary to complete construction.
- B. Trenching Tolerances:
 1. Excavate so pipes, ducts, and conduits can be laid straight at uniform grade, without sags or humps, between elevations shown on Drawings.
 2. Maximum width of excavation on top of pipe shall be outside diameter of pipe plus 24 inches. When stringers and sheathing required, width of trench may be increased to allow for their use, provided provisions for this excess width of trench are met.
 3. Where trench width for that portion of trench depth between trench bottom and outside top of pipe barrel, for any reason within CONTRACTOR'S control, exceeds specified limits, CONTRACTOR, at his expense, shall furnish pipe with strength adequate for actual trench width.
 4. Excavate electrical conduit trenches as required so top of conduit shall be minimum of 36 inches below final grade or as shown on Drawings.
- C. Do not advance excavation of trenches more than 300 feet ahead of completed pipe installation.
- D. Do not excavate for manholes and other structures until scheduled for construction.
- E. Do not excavate within influence zone of existing footings or foundations without prior approval of ENGINEER.
- F. Excavation of Rigid Surfacing:
 - a. Remove width 1 foot beyond anticipated edge of excavation.
 - b. Saw to ensure straight joint.
 - c. Surface replacement shall match existing surfacing.

- G. Excavation Across Roadways: Excavation shall conform to the requirements of local highway authority. In no case shall surface replacement edges bear on less than 12 inches of undisturbed soil.

3.04 ADJUSTMENT AND CLEANING

- A. Stockpile excavated material suitable for backfill on site in OWNER designated location and grade to drain.
- B. Place excavated material not suitable for backfilling and unsuitable materials in designated spoil areas and grade to drain.

END OF SECTION

SECTION 02270

ARTICULATED PRECAST CONCRETE BLOCK MAT

PART 1 - GENERAL

1.01 SUMMARY

- A. Work described in this section includes furnishing and installing an articulated (cabled) connected concrete block erosion control mat system to be installed where shown on the Drawings.

1.02 REFERENCES

- A. Standard Specifications: Minnesota Department of Transportation "Standard Specifications for Construction", latest edition with revisions and supplements.
- B. ASTM D7277 - Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow.

1.03 SUBMITTALS

- A. Manufacturer's product data for the articulated precast concrete block mat system.
- B. Certification of materials indicating compliance with project specifications.
- C. Layout of site specific system showing details of the installation and anchorage system to be used for the mat system.
- D. Submit in accordance with Section 01300 – SUBMITTALS.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. The articulated precast concrete mats erosion control system shall consist of:
 - 1. 4' x 16' or 8' x 16' concrete mats placed side by side and clamped together to provide one homogeneous erosion protection system.
 - 2. The concrete blocks are held together by integrally woven stainless steel cables, which are poured within the block.
 - 3. A geotextile fabric shall be attached to the base of each concrete mat.
 - 4. The concrete blocks are a truncated pyramid shape and have 15.5 inches square bases and 11.5 inches square top faces, typical. Block heights for this project shall be 8.5 inch.
 - 5. Manufactured by Royal Erosion Control Systems, LLC, type CC70 cabled concrete mats, or approved equal.

B. Design mixes to provide normal weight concrete with the following properties:

1. Compressive strength: minimum 4,000 psi at 28 days.
2. Cement: Cement content shall not be less than 564 pounds per cubic yard. Portland cement used shall be Type II in conformance to ASTM C150.
3. Aggregate: Aggregate shall conform to ASTM C33. Coarse aggregate shall consist of natural gravel or crushed rock, maximum size of $\frac{3}{4}$ inch. Fine aggregate shall consist of natural sand.
3. Water-cement ratio: Maximum of 6 gallons of water per sack of cement.
4. Air content: Air content of concrete shall be between 4 to 6 percent.
5. Chloride ion: Maximum chloride ion (C1) concentration in concrete shall not exceed 1/10 of 1 percent chloride by weight of cement.

C. Cables:

1. The cables shall be stainless steel aircraft cable type 302, type 1 x 19 construction, 5/32" diameter.

D. Geotextile:

1. Use Geotex TM 801 geotextile made by Synthetics Industries, or pre-approved 8-ounce needle punched nonwoven fabric.
2. Attach the geotextile to the base of the concrete block mats. Overlap the fabric 2 feet to 3 feet on three sides of the mat. The overlap shall provide an area for the adjoining mats to be placed upon and prevent undermining of the erosion control system.

E. Clamps:

1. Sufficient stainless steel wire rope clamps shall be used to secure loops of adjoining cabled concrete mats. Follow manufacturers' recommendations for type of clamps. The number of loop connections are based on project specifics and shall be obtained from the manufacturer.

F. Anchoring:

1. Anchor cable concrete mats according to manufacturer's recommendations and specifications.

PART 3 - EXECUTION

3.01 SUBGRADE PREPARATION

- A. The subgrade surfaces on which the cabled concrete is to be placed shall be graded to the lines and grades shown on the Drawings.
- B. Cable concrete shall not be placed until the foundation preparation is completed and the subgrade surfaces have been inspected and approved by the OWNER.

3.02 INSTALLATION OF CABLED CONCRETE MATS

- A. The supplier shall have a technician experienced in the installation of the cabled concrete system available at the start of installation to assist in any special techniques needed to assure a proper installation.
- B. The mats shall be laid from the downstream end of project to the upstream end, so the geotextile joints are shingled to direct flow over the joint and to prevent undermining. The outside edges of the mat system shall be entrenched and buried at least one block into the final cover soil system. Compacted controlled fill or topsoil shall be used to fill the entrenched edges.
- C. Attached the mat to the concrete apron/end section by installing anchor bolts (epoxy type) into the lip of the concrete apron/end section to which the mat can be tied, and grout the area immediately adjacent to the concrete apron/end section to provide a solid, smooth transition from the apron/end section to the mat, all in accordance with the manufacturer's recommendations.
- D. Following installation and inspection, cover the mat system with suitable fill, or with topsoil and seeded with grass, as directed by the ENGINEER.

END OF SECTION

SECTION 02273

GEOSYNTHETIC CLAY LINER

PART 1 - GENERAL

1.01 SUMMARY

- A. Description of System
 - 1. Work covered under this section includes the manufacture, fabrication (if needed), and supply and installation of the geosynthetic clay liner (GCL). As part of the landfill composite liner system, all work shall be performed in strict accordance with the lines, grades, cross-sections, and dimensions on the DRAWINGS, or as directed by OWNER.
 - 2. Sufficient geosynthetic clay liner and accessory bentonite shall be furnished to cover all areas to be lined as shown on the DRAWINGS, including overlaps at field seams and anchor trenches.
 - 3. It is the intent of these specifications to ensure that the performance criteria for this project are achieved. It shall be the INSTALLER'S responsibility to ensure that these criteria are met.

1.02 SEQUENCING AND SCHEDULING

- A. Submit material delivery and installation schedule for incorporation into the project schedule.

1.03 SUBMITTALS

- A. INSTALLER shall submit certification in writing that the surface upon which the geosynthetic clay liner is to be installed is acceptable (complete form contained at the end of this Section).
- B. INSTALLER shall submit Certificate of Compliance from supplier for each roll of geosynthetic clay liner delivered to the site, indicating material compliance with the specified manufacturer specifications prior to or at the time of delivery of the material.
- C. INSTALLER shall submit certified test results from the supplier to OWNER to obtain approval for use of the product prior to mobilization of the product to the project site. Any proposed alternate geosynthetic clay liner not approved by OWNER shall not be used.
- D. Installation layout identifying placement patterns and overlap orientations.

PART 2 - PRODUCTS

2.01 GEOSYNTHETIC CLAY LINER (GCL)

- A. The geosynthetic clay liner shall be GSE Bentoliner NWL-35, as manufactured by GSE Environmental. If an alternate geosynthetic clay

liner is proposed, the INSTALLER shall submit certified test results from the supplier to OWNER to obtain approval for use of the product prior to mobilization of the product to the project site. Any proposed alternate geosynthetic clay liner not approved by OWNER shall not be used.

- B. The geosynthetic clay liner shall be formulated and manufactured from polypropylene geotextiles and bentonite.
- C. No disassociation of geotextile components from the bentonite core shall occur. A sample of the bentonite geosynthetic placed in 70°F tap water for one hour shall not delaminate.
- D. The geosynthetic clay liner shall be manufactured utilizing a minimum of one pound per square foot of high swelling sodium bentonite at a 20 percent moisture content. If the liner is manufactured at a higher moisture content, it shall have the minimum of one pound per square foot of bentonite when adjusted to a 20 percent moisture level.
- E. Rolls shall be manufactured a minimum of 12 feet wide and 80 feet long. A 6-inch lap line shall be printed or marked in the field on both edges of the upper geotextile of the GCL (as installed) to assist in overlap quality control.
- F. All rolls shall be labeled and bagged in packaging that is resistant to photo degradation by ultraviolet (UV) light.

PART 3 - EXECUTION

3.01 SUBGRADE INSPECTION

- A. INSTALLER shall certify in writing that the surface upon which the GCL is to be installed is acceptable (acceptance form contained at the end of this Section).
- B. After subgrade surface has been accepted by INSTALLER, it shall be INSTALLER'S responsibility to indicate to the OWNER any change in subgrade condition that may require repair work. Special care shall be taken to maintain prepared GCL subgrade (i.e., dry and free of foreign matter). Daily observations shall ascertain the integrity of subgrade. Damage to subgrade caused by INSTALLER shall be repaired at INSTALLER's expense. GCL placement over subgrades having damage or excessive moisture as determined by OWNER is not acceptable.

3.02 HANDLING, TRANSPORTATION, STORAGE, AND PLACEMENT

- A. Rolls shall be stored on a flat dry surface raised several inches above the ground. Tarping stored materials is suggested to avoid any unnecessary stress on the packaging and to protect materials from moisture in the event of rain.

- B. Rolls shall be handled utilizing a solid steel bar inserted through the core bar and slings or chains attached to the ends of the bar. The core bar shall be suspended from a spreader bar so that the edges of the GCL are not damaged by the suspending straps or chains. Where the GCL has a non-woven geotextile on one side and a woven geotextile on the other, panels shall be placed with the non-woven side against the subgrade, and the woven side oriented upwards.
- C. Edge seams shall be perpendicular to the toe of the slope at all times.
- D. Seam areas or runs shall also be flat and clear of any large rocks, debris or ruts. Contacting surfaces shall be clean and clear of dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases. Edge overlaps shall be a minimum of 6 inches and verified by OWNER. A proper seam shall cover the 6-inch lap line. End overlaps shall be a minimum of 3 feet and in a rainlap orientation and verified by OWNER.
- E. All seams shall be augmented with granular bentonite to ensure seam integrity as necessary or as required by manufacturer's recommendations. Granular bentonite, where required, shall be dispersed evenly from the panel edge to the lap line at a minimum rate of 1/4 pound per lineal foot continuously along all seams or overlap areas. Accessory bentonite shall be of the same type as the material within the geosynthetic clay liner.
- F. The INSTALLER shall only work on an area that can be completed in one working day or before an inclement weather condition. Completion can be defined as the full installation and anchoring of the bentonite blanket and placement of the geomembrane. Any GCL that is hydrated prior to placement of the geomembrane will be removed and replaced at the INSTALLER'S expense.
- G. Large rips or tears or thin worn areas shall be repaired by completely exposing the affected area, removing all foreign objects or soil, and by then placing a patch over the damage. The patch shall overlap the GCL at least 12 inches on all edges. Accessory bentonite shall be placed between the patch and the repaired material at a rate of 1/2 pound per lineal foot of edge, spread in a 6-inch width. The above procedures shall also be implemented in the event that a rip or tear or thin worn area occurs on a sloped surface. In this instance, the edges of the patch shall be fastened to the repaired liner with construction adhesive, as recommended by the GCL supplier in addition to the bentonite-enhanced seam.
- H. During start-up of the geosynthetic clay liner installation, an agent or representative of the manufacturer shall provide on-site assistance as needed and instruction to the INSTALLER and OWNER regarding product application techniques.

3.03 CLEANUP

- A. INSTALLER shall place ALL material scraps in OWNER designated area at the end of each working day. Disposal of scraps in the anchor trenches will not be acceptable. No scraps of materials will be allowed to be left on top of GCL.
- B. Once the installation is complete the INSTALLER shall:
 - 1. Remove all sand bags from site; or
 - 2. Remove all sand bags and place in OWNER designated area; or
 - 3. If sand in sand bags is acceptable as a drainage layer material the INSTALLER may empty each bag and remove and dispose of the empty bags. This will only be allowed if the material meets the criteria for a granular drainage layer. The INSTALLER must receive permission from OWNER prior to emptying the sand bags onto the liner.

PART 4 - WARRANTY

4.01 MATERIAL/WORKMANSHIP WARRANTY

- A. A 20-year material and 5-year workmanship warranty shall be provided by the INSTALLER.

END OF SECTION

**Certificate of Acceptance of
GCL Subgrade Surface by INSTALLER**

DESCRIPTION OF AREA TO BE CERTIFIED: _____

LOCATION: _____

PROJECT: _____

ADDRESS: _____

The undersigned, _____ certifies that he is a representative of _____, duly authorized to execute this certificate, that he visually inspected the subgrade surface described above on _____ and found the surface to be acceptable for installation of the geosynthetic clay liner (GCL).

This certification is based on observations of the surface of the subgrade only. No sub terrain inspections or tests have been performed and _____ (company) makes no representations or warranties regarding conditions which may exist below the surface of the subgrade.

Date: _____ Signature: _____

Name: _____ Title: _____

CERTIFICATE RECEIVED BY CONTRACTOR CERTIFICATE RECEIVED BY OWNER

Date: _____ Company: _____

Name: _____ Name: _____

Signature _____ Signature _____

Title _____ Title: _____

SECTION 02276

EROSION AND SEDIMENTATION CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes installation of erosion and sedimentation controls, including silt fence, erosion control blanket, rock construction entrances, riprap, inlet protection, ditch checks, sediment control logs, and other similar materials as shown on the Drawings.

1.2 SUBMITTALS

- A. Submit in accordance with Submittal Procedures.
- B. Product Data: Manufacturer's data sheets on each product to be used
 - 1. Preparation instructions and recommendations
 - 2. Storage and handling requirements and recommendations
 - 3. Manufacturer's certificates indicating specification conformance test results of furnished material.
- C. Erosion Control Schedule and Erosion Control Plan
 - 1. Conform to Mn/DOT Spec. 1717.2.B Erosion and Sediment Control Schedule and Mn/DOT Spec 1717.2.C Site Management Plan.
 - 2. Prepare and submit at the Pre-construction conference. Plan shall include, but is not necessarily limited to:
 - a. Limits of disturbance.
 - b. Type(s) of stabilization to be used.
 - c. Existing and proposed culverts, storm drains, and outfalls.
 - d. Location of stabilized construction entrance.
 - e. Location of proposed sediment control measures.
 - f. Details of sediment traps and basins and other sediment control measures.
 - g. Sequence of construction as it relates to installation, phasing, and removal of sediment control measures.

1.3 SEQUENCING AND SCHEDULING

- A. Sediment control measures (silt fence, bioroll, etc.) must be in place prior to removals and grading activities.
- B. Coordinate construction operations so that erosion and sediment control measures (temporary or permanent) are installed and maintained concurrently with the remaining work of the project.
- C. Infiltration areas and constructed infiltration systems should not be constructed until the contributing drainage area and/or adjacent construction has been completely stabilized. When the timing of construction is not possible, the

CONTRACTOR shall ensure sediment from exposed soil areas does not enter into the infiltration area or system.

- D. If the CONTRACTOR fails to install erosion or sediment measures, the ENGINEER may withhold payment from related work until the control measures are in place by the CONTRACTOR.
 - 1. If the CONTRACTOR fails to take action ordered by the ENGINEER to remedy erosion or sediment control problems, the ENGINEER shall issue a Written Order to the CONTRACTOR.
 - 2. The CONTRACTOR shall respond within 24 hours with sufficient personnel, equipment, materials, and conduct the required work or be subject to a \$1,000 per calendar day deduction for noncompliance.
- E. Establish permanent turf in accordance with Turf Restoration (Section 02486).

1.4 QUALITY ASSURANCE

- A. Erosion Control Contractor Qualifications:
 - 1. Erosion Control Supervisor
 - a. Provide a Supervisor responsible for directing the erosion control operations and ensure erosion and sedimentation controls are implemented according to the specifications and in compliance with all Federal, State, and Local Ordinances and regulations.
 - 2. Certified Installer
 - a. Provide a certified installer to install or direct installation of erosion and sediment control practices.
 - b. Certified by the University of Minnesota Erosion Control Inspector/Installer Certification Program or approved equal.

1.5 PERMITS AND LICENSES

- A. Project disturbs 1 or more acres of total land area. Co-submittal with OWNER of a completed NPDES application form for the MPCA's General Storm Water Permit for Construction Activity is required. Submit a copy of the completed, signed, and dated application to the OWNER. OWNER to pay required permit fee.
- B. Compliant with all Regulatory Requirements.

1.6 MEASUREMENT AND PAYMENT

- A. All work and costs associated with completing the work as specified on the Drawings and in the Specifications shall be included in the total project cost.
- B. All other work and costs associated with completing the work as specified on the Drawings and in the Specifications shall be included in the total project cost.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Silt Fence: Conform to Mn/DOT Specs 2573 Storm Water Management 3886 Silt Fence, Type MS Machine Sliced.

- B. Sediment Control Log (Bioroll): Conform to Mn/DOT Specs 2573 Storm Water Management and 3897 Sediment Control Log, Type Straw. Straw biorolls, 8 to 9 inches in diameter, minimum 10 feet long, filled with grain straw, free of seed bearing stalks of noxious grasses or weeds with natural fiber outer netting.
- C. Erosion Control Blanket: Conform to Mn/DOT Specs 2575 Establishing Vegetation and Controlling Erosion and 3885 Rolled Erosion Control Product, applicable category.
- D. Mulch: Conform to Mn/DOT Specs 2575 Establishing Vegetation and Controlling Erosion and 3882 Mulch Material, Type 3 , two tons per acre, disk anchored in areas that do not receive erosion control blanket.
 - 1. Certified by Minnesota Crop Improvement Association (MCIA).
 - 2. Hydraulic soil stabilizer may be used in lieu of mulch with the approval of the ENGINEER.
- E. Temporary Seed: Conform to Turf Restoration (Section 02486)
- F. Stabilized Construction Exit Temporary Construction Entrance: 1 inch to 2-inch washed rock Conform the details on the Drawings Conform to Mn/DOT Spec 2573.3.H Construction Exit Controls.
- G. Inlet Protection: Inlet protection for exposed surfaces and paved streets with concrete curb and gutter. Conform to the details on the Drawings and as required to for compatibility with each inlet type.
- H. Culvert Protection: Conform to the details on the Drawings.
- I. Riprap: Conform to Mn/DOT Specs 2511 Riprap and 3601 Riprap Material.
 - 1. Geotextile for riprap: Conform to Mn/DOT Spec 3733 Geotextiles.
- J. Bale Barriers: Material for bale barriers to conform to Mn/DOT 3882 Mulch Material, Type 1.
 - 1. Conform to the details on the Drawings.
- K. Turf Reinforcement Mat: Propex Landlok 435/450, Rollmax VMax SC250/C350/P550, or approved equal.
- L. Erosion Control Mat: Flexamat by Motz Enterprises, Inc. or approved equal.
- M. Coir Erosion Control Mat: BioD-Mat 40 woven bristle coir erosion control mat by Rolanka International, Inc. or approved equal.
- N. Hydraulic Bonded Fiber Matrix: Conform to Mn/DOT Spec 3884 Hydraulic Erosion Control Products, Bonded Fiber Matrix (BFM).
- O. Hydraulic Stabilized Fiber Matrix: Conform to Mn/DOT Spec 3884 Hydraulic Erosion Control Products, Stabilized Fiber Matrix (SFM).
- P. Hydraulic Reinforced Fiber Matrix: Conform to Mn/DOT Spec 3884 Hydraulic Erosion Control Products, Reinforced Fiber Matrix (RFM).

PART 3 - EXECUTION

3.1 GENERAL

- A. Conform to Mn/DOT Specs 2573.3.A General and 2575.3.A General.
- B. Install necessary erosion and sedimentation controls prior to beginning excavation and grading activities.
- C. Install erosion and sedimentation controls at the locations shown on the Drawings.
- D. Establish turf and vegetation in conformance with project specifications and Drawings.
- E. Comply with all applicable laws, ordinances, regulations, permit requirements, orders pertaining to erosion and sediment control and stormwater discharge.
- F. Take necessary precautions to prevent offsite damage resulting from work conducted on the project related to stormwater runoff.

3.2 INSTALLATION

- A. Install temporary stormwater management and sediment control devices in conformance with the details, typical sections, and elevations shown on the Drawings.
- B. The location of the temporary stormwater and sediment control devices may be adjusted to accommodate actual field conditions and increase the effectiveness of the installation.
- C. Slope (Cat) Tracking
 - 1. Slope tracking consists of operating a dozer up and down slopes so that the cleats of the tracks create grooves perpendicular to the slope.
 - 2. Required on all slopes equal to or greater than 3:1 (H:V).
- D. Silt Fence
 - 1. Conform to Mn/DOT Spec 2573.3.B Silt Fence Installation.
 - 2. Install at locations shown on the Drawings or as directed by the ENGINEER.
 - 3. Install silt fence downgradient of grading activities.
 - 4. Install silt fence or sediment control log around the perimeter of soil stockpiles.
 - 5. Use additional measures, such as rock, placed along the base of the silt fence when the geotextile cannot be properly trenched.
- E. Sediment Control Log (Bioroll)
 - 1. Conform to Mn/DOT Spec 2573.3.F Sediment Control Log Installation
 - 2. Install at locations shown on the Drawings or as directed by the ENGINEER.
 - 3. Install silt fence or sediment control log around the perimeter of soil stockpiles.
- F. Erosion Control Blanket
 - 1. Conform to Mn/DOT Spec 2575.3.G Erosion Control Blankets.

2. Install erosion control blanket on disturbed slopes greater than 5H:1V or as shown on the Drawings.
 3. Install blanket parallel to the direction of flow.
 4. Install in accordance with Manufacturer's recommendations.
 5. Wood stakes to be in accordance with Mn/DOT Spec 3897.2.H Anchoring.
 6. The CONTRACTOR shall place erosion control fabric with the longest dimension parallel to the direction of water flow and with a 12-inch minimum edge of fabric on the riprap. The CONTRACTOR may furnish and use a form to hold the erosion control fabrics.
 7. Where multiple erosion control blanket lengths are required, they shall be placed with the longest dimension parallel to the direction of water flow. If not seamed, splices and joints shall be overlapped a minimum of 18 inches, except underwater the overlap shall be 36 inches. The joint laps shall be shingled (both in the flow direction) so as to direct water flow over the joint without undermining. Upgrade edges of the fabric area shall be buried sufficiently to direct water flow over the fabric without undermining.
- G. Mulch
1. Conform to Mn/DOT Spec 2575.3.C Applying Mulch.
- H. Temporary Seed
1. Conform to Mn/DOT Spec 2575.3.B Placing Seed.
- I. Stabilized Construction Exit Temporary Construction Entrance
1. Conform to Mn/DOT Spec 2573.3.H Construction Exit Controls.
 2. Install at the locations shown on the Drawings or at other location(s) determined by CONTRACTOR with approval of the ENGINEER.
- J. Inlet Protection
1. Conform to Mn/DOT Spec 2573.3.J Storm Drain Inlet Protection.
 2. Provide effective storm drain inlet protection over the course of the project until all sources with potential for discharging to inlets have been stabilized.
 3. Place devices so the driving hazards or obstructions are minimized. The devices shall be cleaned regularly and all devices must have an emergency overflow to reduce the potential for local flooding.
 4. Install inlet protection at all storm sewer structures downgradient of grading activities which could receive stormwater discharge from construction areas.
- K. Culvert Protection
1. Conform to Mn/DOT Spec 2573.3.I Culvert End Controls.
 2. Install culvert end controls at all upstream culvert ends.
- L. Riprap
1. Conform to Mn/DOT Spec 2511 Riprap.
- M. Bale Barrier
1. Conform to Mn/DOT Spec 2573.3.C Bale Barrier Installation.
 2. Install at locations shown on the Drawings or as directed by the ENGINEER.
- N. Turf Reinforcement Mat

1. Install in accordance with Mn/DOT Spec 2575.3.G, and as modified herein.
 2. Install according to the details and at locations shown on the Drawings or as directed by the ENGINEER.
 3. Install blanket parallel to the direction of flow.
 4. Install per manufacturer requirements.
- O. Erosion Control Mat
1. Install per manufacturer requirements.
- P. Coir Erosion Control Mat
1. Install per manufacturer requirements.
- Q. Hydraulic Bonded/Stabilized/Reinforced Fiber Matrix
1. Conform to Mn/DOT Spec. 2575.3.E Placing Hydraulic Erosion Control Products.

3.3 MAINTENANCE

- A. Conform to Mn/DOT Spec. 2573.3.M Maintenance and 2575.3.K Maintenance and as follows:
1. Inspect, maintain, and repair any washouts or accumulations of sediment that occur as a result of construction.
 2. Inspection of all erosion and sediment control items shall take place in accordance with NPDES construction stormwater permit requirements, immediately after each runoff event and at least daily during prolonged rainfall. Any required repairs shall be made immediately.
 3. Sediment Removal: If an erosion control device has been reduced in capacity by 30 percent or more, the CONTRACTOR shall restore such features to their original condition.
 4. The CONTRACTOR shall maintain the items until they are no longer required and removed.

3.4 CLEANUP

- A. Acceptance of the work shall be in accordance with Mn/DOT Spec 2575.3.N Acceptance of Work.
- B. Upon final acceptance the CONTRACTOR shall remove temporary sediment control devices after completion of construction in accordance with Mn/DOT Spec 2573.3.O Removal of Temporary Devices.
- C. Restoration shall be in accordance with Mn/DOT Spec 2575.3.O Restoration.

END OF SECTION

SECTION 02486

TURF RESTORATION

PART 1 - GENERAL

1.01 SUMMARY

- A. This section contains requirements for topsoil, seeding, fertilizing, and mulching.
- B. Seed all areas disturbed by construction activities at the site.

1.02 REFERENCES

- A. Minnesota Department of Transportation Standard Specifications for Construction, latest edition. (Standard Specifications)

1.03 SUBMITTALS

- A. Test Results:
 - 1. Copy of soils test results including fertilizer and lime requirement before seeding work begins.
 - 2. Copy of soils test results after seeding work has been completed.
 - 3. Suppliers analysis for standard products.
- B. Submit in accordance with Section 01300.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Delivery:
 - 1. Deliver fertilizer to site in original, unopened containers bearing manufacturer's guaranteed chemical analysis, name, trade name, trademark, and conformance to state law.
 - 2. Deliver seed to site in unopened, original bags bearing supplier's name and address, type of seed contained, percentage of purity and germination, percentage of hard seed if any, and percentage of inert material.
 - 3. Fertilizer and seed delivered to site shall be stored in a waterproof location as directed by ENGINEER.
- 4. Locate mulch on site where indicated by ENGINEER.

1.05. GUARANTEE

- A. Guarantee seeded area for duration of one year after seeding to be alive and in satisfactory growth at end of guarantee period.
 - 1. For purpose of establishing acceptable standard, scattered bare spots, none larger than 1 square foot will be allowed up to maximum of 3 percent of seeded area.

2. Acceptance will be based upon meeting this standard one year after initial seeding or reseeding.

PART 2 - PRODUCTS

2.01 TOPSOIL

- A. Imported topsoil and/or amended topsoil shall meet requirements of "Standard Specification" 3877.2.A.

2.02 FERTILIZER

- A. In accordance with Standard Specification 3881 at the ratio recommended by the soil testing lab after submittal of a topsoil sample.

2.03 GRASS SEED

A. General

1. Local nursery grown seed sources in the specified seed mix.
2. Weeds shall not exceed 0.25%.
3. Comply with current U.S. Department of Agriculture rules and regulations.
4. Seed mix shall be in accordance with Standard Specification 3876 Seed mix MN DOT 25-141.

2.04 WATER

- A. CONTRACTOR shall be responsible for water.

2.05 MULCH

- A. Type 3 mulch, certified by the Minnesota Crop Improvement Association (MCIA), and in accordance with Standard Specifications 3882.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Do not begin ground preparation until boulders, debris, and similar materials have been removed, depressions and ruts filled, and area to be seeded is shaped, trimmed, and finished uniformly to grades and cross-sections shown on Drawings, or to match original grade.

3.02 SITE PREPARATION FOR SEEDING

A. Topsoil

1. Scarify subgrade to depth of 3 inches for bonding of subsoil with topsoil.
2. No topsoil shall be placed or worked in frozen or muddy condition.

3. Prepare areas to be seeded to required depth of approximately 3 inches by disking, rototilling, harrowing or other approved means.
4. Remove and dispose of rock, trash, or other materials brought to surface from preparation activities.

3.03 TOPSOIL/FINISH GRADING

- A. Topsoil/Finish grade is established final grade as shown on Contract Drawings. Grades not otherwise indicated are uniform levels or slopes between points where elevations are given or between such points and existing finished grades. Finish grade shall be approved by the ENGINEER prior to seeding.
- B. Grade, rake, and roll with roller weighing not more than 100 lbs./lf and not less than 25 lbs./lf.
- C. Maximum allowable variation from correct elevation is 2 in. in 10 ft.

3.04 APPLYING FERTILIZER

- A. Apply fertilizer uniformly over the designated area using mechanical spreading devices. Mix thoroughly with disk into upper 2 inches of soil. Apply in two passes at right angles to each other.
- B. Apply at a rate recommended by the soil testing as defined in Section 2.02.A.
- C. Apply fertilizer no more than 48 hours prior to seeding.

3.05 SEEDING

- A. Do not seed on saturated or frozen soil.
- B. Do not seed when wind velocity exceeds 6 mph.
- C. Seed all areas disturbed by construction.
- D. The grass seed shall be drilled horizontally across the slope.
- E. Do not seed if surface has been compacted by recent rain event.

3.06 MULCHING

- A. Mulch seeded areas within 24 hrs after seeding is complete.
- B. Application rate shall be 2 tons per acre or no more than 1 inch in depth.
- C. Mulch shall be spread uniformly in a continuous blanket. Mulch shall be started on the windward side of relatively flat area or on the upper part of a steep slope and continued uniformly until area is covered. The mulch shall not be bunched.

- D. Do not mulch during periods of excessively high winds.
- E. Immediately following the spreading of the mulch, the material shall be anchored securely into the soil a minimum of 3-inches by means of a mulch anchoring machine equipped with large coulter-type discs spaced on approximate 8-inch centers. All anchoring shall be at right angles to slope. Edges of the discs shall be dull to prevent cutting of the mulching and equipment operation shall be such as to embed the mulch to the required depth. In areas where equipment cannot be used, mulch shall be secured by shallow covering of earth or by embedding with approved hand methods, including straight-bladed spade with dull edge.
- F. Mulch in accordance with Section 3882 of the Standard Specifications.

3.07 CLEANUP

- A. Paved surface and other site areas shall be kept clean of seeding, fertilizing, and mulching materials.
- B. Clean up shall occur at the end of each work day or as required by OWNER. Pavement shall be swept with a street sweeper as directed by ENGINEER throughout the project.
- C. Restore existing utilities, surface features, and structures to condition equal to condition which existed prior to construction.
- D. Replace to original condition or better, damaged vegetation or landscape work.
- E. Complete project punch-list prepared by ENGINEER.

3.08 MAINTENANCE OF SEEDED AREA

- A. Maintenance of seeded areas shall begin immediately following last seeding application. Continue until Work is accepted.
- B. Maintain seeded area by watering, mowing, and replanting as necessary to produce uniform stand of grass until Work is accepted.
- C. Rework/replace topsoil where original topsoil has eroded or washed away as directed by ENGINEER.
- D. Remulch any areas where the original mulch has washed away as directed by the ENGINEER.
- E. Implement erosion control measures as required to keep area free of rutted and eroded soils and protection fences and barriers as necessary.

3.09 RESEEDING AND REPAIR

- A. Reseed areas that fail to show more than 75 plants/square feet and open areas or gaps larger than 6 inches in diameter.

- B. Where plant density is less than 50 plants/square foot, reill and reseed areas in accordance with seeding and maintenance requirements.

3.10 ACCEPTANCE OF SEEDED AREAS

- A. CONTRACTOR shall notify OWNER in writing 7 days prior to inspecting seeded area for acceptance.
- B. CONTRACTOR and OWNER shall inspect seeded areas for contract compliance and acceptance of work. Upon completion of inspecting seeded areas, OWNER shall provide written acceptance or rejection to CONTRACTOR with further requirement for completing the seeding work. Seeding work remaining to be completed shall be reinspected by OWNER before final acceptance.

END OF SECTION

SECTION 02511

AGGREGATE ROAD SURFACING

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes the furnishing and installation of aggregate road surfacing as shown on the Drawings.

1.02 REFERENCES

- A. Minnesota Department of Transportation Standard Specifications for Construction, latest edition, Section 3138.

1.03 SUBMITTALS

- A. CONTRACTOR to provide at least one sample and gradation report for each source of material prior to material being brought on-site.
- B. Provide haul route to the site prior to any materials being hauled.

1.04 PRODUCT DELIVERY, SEQUENCING, AND SCHEDULING

- A. Include road restoration construction activities in the project schedule.

PART 2 - PRODUCTS

2.01 AGGREGATE

- A. Material: Class 5, as specified in "Standard Specifications" Section 3138.2.
- B. Remove oversize material encountered in deposits from which material is taken by screening or crushing to required sizes.
- C. Composite material shall be substantially free from shale and lumps or balls of clay and shall conform to pertinent gradation requirements.

PART 3 - EXECUTION

3.01 GENERAL

- A. Construct to width of road, as shown on the Drawings, in 3 inch to 6 inch lifts to thickness as indicated on the Drawings.
- B. Place materials when surface is dry and atmospheric temperature is above 40 degrees F.

- C. Provide water, if necessary to achieve proper compaction as directed by ENGINEER.

3.02 SUBGRADE

- A. Prepare subgrade in conformance with Section 02207.
- B. Provide water, if required, for compaction.
- C. Install reinforcement geotextile, where required.

3.03 ROAD SURFACING

- A. Construct road surfacing in accordance with "Standard Specifications" Section 2211.3.
 - 1. Compaction shall be checked by specified density method.
 - 2. OWNER will perform field density, optimum moisture, and maximum density testing.

END OF SECTION

SECTION 02610

HDPE PIPING

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes all piping and fittings required as indicated on the Drawings.

1.02 REFERENCES

- A. American Water Works Association (AWWA).
- B. American Society for Testing and Materials (ASTM):
 - 1. ASTM D638 - Test Method for Tensile Properties of Plastics.
 - 2. ASTM D790 - Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating.
 - 3. ASTM D1238 - Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
 - 4. ASTM D1505 - Test Method for Density of Plastics by the Density-Gradient Technique.
 - 5. ASTM D1693 - Test Method for Environmental Stress Cracking of Ethylene Plastics.
 - 6. ASTM D2837 - Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
 - 7. ASTM D3350 - Standard Specification for Polyethylene Pipe and Fittings Material.
 - 8. ASTM D2122 - Standard Test Method of Determining Dimensions of Thermoplastic Pipe and Fittings.
 - 9. ASTM D3035 - Polyethylene Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter.
 - 10. ASTM D3261 - Standard Specification for Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

1.03 SUBMITTALS

- A. Manufacturer's certificates indicating conformance test results of furnished material to Specifications.
- B. Provide information where applicable as follows:
 - 1. Manufacturer's name.
 - 2. Nominal pipe size.
 - 3. High density polyethylene (HDPE) classification, ASTM D3350.
 - 4. Use for each type and size of pipe.
 - 5. Extrusion date.
 - 6. Lot number.
- C. Stock density, melt flow, flexural modulus tensile strength, coloration, resin type and cell classification where applicable.
- D. Provide instructions on special handling during transportation and storage.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Handle and protect product to ensure product is not damaged.
- B. Elevate material above grade.

- C. Store and handle in such a manner as to prevent soil or vermin from entering or becoming lodged in the pipe.
- D. Provide protection for flanges and fittings by storing inside or packaging with impermeable opaque material.

PART 2 - PRODUCTS

2.01 HDPE

- A. Resin; shall meet the requirements set forth in Table 1.

Property	Test Method	Value
Material Designation		PE 3408
Material Classification	ASTM D 3350	Type III: PE 34
Cell Classification	ASTM D 3350	345464C
Density	ASTM D-1505	0.955 gms/cm ³
Environmental Stress Cracking Resistance		
Condition A, B, & C F _o (molded specimen)	ASTM D-1693	>5000 hrs
Compressed Ring F _o (extruded specimen)	ASTM F-1248	>3500 hrs
Slow Crack Growth	Battelle Method	>64 Days
PENT	ASTM F 1473	> 100 hrs
Tensile Strength, Ultimate Type IV Specimen	ASTM D-638 (2"/min)	5000 psi
Tensile Strength, Yield Type IV Specimen	ASTM D-638 (2"/min)	3200 psi
Elongation Break Type IV Specimen	ASTM D-638 (2"/min)	>750 %
Impact Strength (IZOD) Specimen thickness 0.125"	ASTM D-256 Method A	>42 in. lb/in notch
Vicat Softening Temperature	ASTM D-1525	257 degrees F
Brittleness Temperature	ASTM D746	<-180 degrees F
Flexural Modulus	ASTM D-3350	110,000 psi
Modulus of Elasticity (Young's Modulus)	ASTM D 638	130,000 psi
Hardness	ASTM D-2240	65 Shore D 72 Rockwell R
Coeff. Of Linear Thermal Expansion	ASTM D-696	1.2 x 10 ⁻⁴ in/in/degree F
Thermal conductivity	ASTM D5930	2.7 BTU-in/ft ² /hrs/degree F
Long Term Strength 73 degree F 140 degree F	ASTM D-2837	1600 psi 800 psi
Material Cell Classification	ASTM D-3350	345464C
Material Designation	PPI Recommendation	PE3408

B. Pipe

1. Acceptable Manufacturers:
 - a. Phillips Driscopipe, Inc., Dallas, Texas.
 - b. Poly Pipe Industries, Gainesville, Texas.
 - c. Or approved equal.
2. High performance, high molecular weight, high density polyethylene pipe.
3. Marking: Intervals of 5 feet or less.
 - a. Manufacturer's name or trademark.
 - b. Nominal pipe size.
 - c. HDPE cell classification, ASTM D3350.

- d. Legend: SDR as indicated on Drawings.
 - e. ASTM F 714.
 - f. Extrusion date, period of manufacture or lot number.
4. Perforated pipe shall be perforated at factory.

C. Fittings

- 1. Molded from polyethylene compound having cell classification equal or exceeding compound used in pipe to insure compatibility of resins.
- 2. Be of same manufacture as pipe.
- 3. Markings:
 - a. Manufacturer's name or trademark.
 - b. Nominal size.
 - c. Material designation "HDPE".
 - d. ASTM 3261.
- 4. 8-inch diameter and smaller
 - a. Molded fully pressure rated elbows and tees
 - b. Wyes fabricated and able to withstand 48" w.c. vacuum and overburden loads.
- 5. 12-inch diameter and larger
 - a. Fabricated and able to withstand 48" w.c. vacuum and overburden loads.
- 6. Fusion weld joints.

PART 3 - EXECUTION

3.01 EXECUTION

- A. Examine and verify acceptability of surface to receive product.

3.02 HDPE PIPE INSTALLATION

- A. Location, lines, and grades as shown on Drawings.
- B. Welded joints.
- 1. Weld in accordance with manufacturer's recommendations for butt fusion methods.
 - 2. Butt fusion equipment used in joining procedures capable of meeting conditions recommended by manufacturer, including, but not limited to: temperature required, alignment, and fusion pressures.
- C. No defective pipe shall be installed. Defective pipe shall be removed from site and replaced at CONTRACTOR'S expense.
- D. Install cover and bedding for piping in accordance with Section 02208.

3.03 EXCAVATION AND PREPARATION OF SUBGRADE

- A. Excavate and prepare subgrade as specified in Section 02221 and as shown on Drawings.

3.04 BACKFILL

- A. Backfill as shown on Drawings or as indicated in Section 02208.

3.05 FIELD QUALITY CONTROL

A. Pipe may be rejected for failure to conform to specification, or:

1. Fractures or cracks passing through pipe wall, except single crack not exceeding 2 inches in length at either end of pipe which could be cut off and discarded. Pipes within one shipment will be rejected if defects exist in more than 5 percent of shipment or delivery.
2. Cracks sufficient to impair strength, durability or serviceability of pipe.
3. Defects indicating improper proportioning, mixing, and molding.
4. Damaged ends, where damage would prevent making satisfactory joint.
5. Noticeable variations from true alignment and grade sufficient cause for rejection of Work.

B. Acceptance of fittings, stubs or other specially fabricated pipe sections based on visual inspection at site and documentation that they conform to these specifications.

C. Piping Tests: Test piping in accordance with Section 02615.

3.06 GAS HEADER IDENTIFICATION AND DOCUMENTATION

A. For identification of underground header provide the following:

1. Trace wire; #2 copper wire, insulated.
2. Place above pipe in pipe bedding along entire pipeline length.

END OF SECTION

SECTION 02615
TESTING HDPE PIPING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes detailed requirements for hydrostatic pressure testing for pressure forcemain piping **and** low-pressure air testing for gas piping.
- B. High pressure air testing not allowed.

1.02 SUBMITTALS

- A. Manner, method, and equipment to be used for testing.
- B. Test report for each piping segment tested and for installed piping system.
- C. Submit in accordance with Section 01300.

PART 2 – PRODUCTS

2.01 Not Used

PART 3 - EXECUTION

3.01 General

- A. Pressure test in presence of ENGINEER.
- B. Furnish clean potable water required for testing and provide necessary piping connections between section of piping being tested and nearest available source of water or air supply, together with test pressure equipment, meters, pressure gauge, and other equipment, materials, and facilities necessary to perform specified tests.
- C. Provide bulkheads, flanges, valves, bracing, blocking or other temporary sectionalizing devices that may be required.
- D. Remove temporary sectionalizing device after tests complete.
- E. Perform tests on exposed piping in manhole after piping completely installed, including supports, hangers, and anchors.

- F. Perform tests on piping systems before completely backfilled in trench. Visually inspect to detect leakage at pipe joints.
- G. Perform tests on piping that is clean and free of dirt, sand, pipe **SHAVINGS** or other foreign material.
- H. Plug pipe outlets with test plugs. Brace each plug securely to prevent blowouts.
- I. Add test fluid slowly as specified herein to allow for initial pipe expansion.
- J. Include regulator set to avoid over-pressurizing and damaging piping.
- K. Perform pressure test in strict accordance with pipe manufacturer's written instructions, these Specifications, and in accordance with applicable local, state, and federal safety requirements.
- L. Correct leaks or defects and retest at no additional cost to OWNER.
- M. Pressure gauges used for testing purposes shall be marked in increments of 1 psi. Provide documentation of latest gauge calibration to verify accuracy of gauge in use.
- N. Test leachate monitoring riser pipes in conformance with requirements for containment pipe.

3.02 LOW-PRESSURE AIR TESTING

A. General:

- 1. Perform low-pressure air testing for containment pipe for forcemain system and for gas system piping.
- 2. Air test pressure testing for pipe shall be 10 psig at high point of section and shall not vary by more than 1% for one hour corrected for temperature.
- 3. Test medium shall be compressed air only; **pressurized gas not acceptable.**

B. Preparation:

- 1. Isolate pipe section to be tested by plugging each end with airtight plugs. Plug ends of branches, laterals, and wyes which are to be included in test section.
- 2. Brace plugs to prevent slippage and blowout due to internal pressure.
- 3. One plug shall have inlet tap or other provision for connecting supply air hose.
- 4. Connect one end of air hose to plug used for air inlet; other end to portable air control equipment.
- 5. Air Control equipment shall consist of valves and pressure gauges to control rate at which air flows into test section and gauges to monitor air pressure inside pipe.
- 6. Connect air hose between source of compressed air and control equipment.

C. Pre-Installation Testing:

1. Perform prior to perforating pipe.
2. If pipe to be tested is out of trench condition, provisions to temporarily restrain pipe test section shall be CONTRACTOR'S responsibility.
3. Lay test segment on ground surface and allow it to reach constant ambient air temperature before test.
4. Perform test during period when pipe segment will be out of direct sunlight to minimize pressure changes as result of temperature fluctuations.
5. Fill pipe section with air and gradually increase pressure to $\frac{1}{2}$ of specified test pressure, then increase pressure in small increments until required test pressure is reached.
6. Air Control equipment shall consist of valves and pressure gauges to control rate at which air flows into test section and gauges to monitor air pressure inside pipe.
7. Connect air hose between source of compressed air and control equipment.
8. Maintain pressure for minimum of 1 hour after pressure in pipe has stabilized and maintain for such time as required to examine the system for leaks.
9. Pipe segment considered to have failed pressure test if specified test pressure changes more than 1 psi at any time during testing.
10. Repair pipe and fused joint leaks by cutting out leaking area and refusing suitable segments.
11. Retest after leaks or defects are repaired.

D. Final Test (**Forcemain containment pipe only**):

1. Perform final test on installed pipeline.
 - a. Perform final test in accordance with procedures for pre-installation testing.
 - b. Provision for equalizing pressure on carrier pipe during containment pipe pressure testing shall be in accordance with pipe manufacturer's recommendations.
2. Piping system shall show no evidence of leakage.

3.03 HYDROSTATIC PRESSURE TESTING

- A. Perform hydrostatic pressure testing for inner forcemain on a dual contained system.
- B. Test pressure shall be 100 psig at high point in test section; test fluid shall be water.
- C. Open vents at high points to purge air pockets while piping system is filling. Venting may also be provided by loosening flanges or with equipment vents.
- D. Testing:
 1. After section of piping to be tested has been filled with water, apply test pressure by means of force pump of such design and capacity that

required pressure can be applied and maintained without interruption for duration of 3 hours for initial expansion phase while adding sufficient make-up water to maintain test pressure.

2. After initial expansion phase, begin system testing for 1 to 3 hours after which measured amount of make-up water shall be added to stabilize test pressure based on Table 1.
3. Measure test pressure by means of tested and properly calibrated pressure gauge acceptable to ENGINEER.
4. Maintain test pressure for sufficient length of time to permit ENGINEER to observe piping under test but not less than 1 hour.
5. If repairs are required, repeat pressure test until pipe installation conforms to specified requirements and is acceptable to ENGINEER.

TABLE 1 MAKE-UP WATER TEST VALUES			
Nominal Pipe Size (in.)	<u>Gallons / 100 Foot of Pipe</u>		
	1-hour Test	2-hour Test	3-hour Test
2	0.10	0.15	0.25
3	0.10	0.15	0.25
4	0.13	0.25	0.40
6	0.30	0.60	0.90
7	0.50	1.0	1.5
10	0.75	1.3	2.1

3.04 HDPE MANHOLE TESTING

- A. Test in presence of ENGINEER.
- B. Furnish water required for testing and provide bulkheads, flanges, valves, blocking, or other temporary sectionalizing devices that may be required.
- C. Test to consist of filling manhole with water and observing for any leakage or weeps for a minimum of two (2) hours per manhole.
- D. If repairs are required, repeat test.

3.05 TEST REPORT

- A. ENGINEER will witness and document final pressure test of dual containment forcemain system. Notify a minimum of 24 hours prior to conducting final testing. Do not begin test without ENGINEER present. Final pressure test shall not be considered valid unless entire test witnessed by OWNER.
- B. Test report for each piping system tested shall include following minimum information:
 1. Date of test.
 2. Description and identification of piping system tested.
 3. Type of test performed.
 4. Test fluid.

5. Test pressure.
6. Type and location of leaks detected.
7. Corrective action taken to repair leaks.
8. Results of retesting.

ATTACHMENT 1 TO SECTION 02615
FORM
PE PIPE AIR PRESSURE TEST REPORT

PROJECT NAME/NO.		TIME:	
CONTRACTOR:		DATE:	
PERSON PERFORMING TESTS:			
DESCRIPTION/LOCATION OF TEST SEGMENT (Pipe Diameter, Length, and SDRs):			
T_i = Initial temperature in °C = _____ °C P_i = Initial test pressure in psig = _____ psig P_c = Initial pressure in psig corrected for temperature (T_i) at time 't' T = Time in minutes from initiation of test T_1 = Temperature in °C at time 't' P_1 = Test pressure in psig at time 't' $P_c = \frac{(P_1 + 14.7)(T_1 + 273)}{(T_1 + 273)} - 14.7$ Percent Pressure Drop = $\frac{P_c - P_1}{P_c} \times 100$			
TIME (min.)	P_1 TEMP READING (°C)	P_1 GAUGE READING (psig)	P_c CORRECTED PRESSURE (psig)
0			
20			
30			
40			
50			
60			
PASS/FAILURE:		RETEST (yes/no):	
DESCRIPTION/NATURE OF LEAKS AND REPAIRS OF RETEST SEGMENT:			

EXAMPLE CALCULATION SHEET

GIVEN:

$$P_i = 10 \text{ psig}$$
$$T_i = 21.1^\circ\text{C} = 70^\circ\text{F}$$

And at time $t = 60$ minutes

$$P_1 = 10.05 \text{ psig}$$
$$T_1 = 23^\circ\text{C} = 73^\circ\text{F}$$

Calculated Corrected Initial Pressure

$$P_1 = \frac{(10.0 + 14.7) (23.0 + 273)}{(21.1 + 273)} - 14.7$$

$$P_c = 24.85 - 14.7 = 10.15 \text{ psig}$$

Calculate Percent Pressure Loss

$$\% \text{ Pressure Loss} = \frac{10.15 - 10.05}{10.15} \times 100 = 0.98\% < 1\% \text{ ok}$$

NOTE: The difference between the corrected pressure reading (P_c) and the gauge reading (P_1) cannot differ by more than 1% of the corrected pressure reading (P_c) (i.e., .015 @ 19.5 psig over a time interval of 60 minutes.

*** END OF SECTION ***

SECTION 02623

PERFORATED AND NON-PERFORATED DRAIN PIPE

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Furnish and install perforated and non-perforated corrugated polyethylene pipe (CPEP) and appurtenances as shown on Drawings.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO).
 - 1. AASHTO M252 - Corrugated Polyethylene Drainage Pipe.
- B. American Society for Testing and Materials (ASTM)
 - 1. ASTM F405 - Standard Specifications for Corrugated Polyethylene (PE) Pipe and Fittings.

1.03 SEQUENCING AND SCHEDULING

- A. Include piping activities in the project schedule.

1.04 SUBMITTALS

- A. The CONTRACTOR shall submit to the OWNER the manufacturer's literature that describes the physical characteristics of the pipe provided, the recommended installation procedures, and allowable pipe bend radius.

PART 2 - PRODUCTS

2.01 CORRUGATED POLYETHYLENE PIPE, DRAINAGE TUBING (CPEP), AND FITTINGS

- A. CPEP and fittings shall meet the requirements of ASTM F 405 or AASHTO M252. The pipe shall meet the dimensional requirements indicated on the Contract Drawings and be manufactured by Prinsco, ADS, Hancor, or other approved manufacturer.
- B. CPEP used for surface water control (culverts or piping) shall be of double-wall construction with a smooth inner bore, and shall have watertight gasketed joints.
- C. All CPEP used for surface water control (culverts) shall have flared end sections, both ends.

- D. Perforated pipe shall be factory perforated with a minimum inlet area of 1 square inch/ft.
- E. Fittings shall be from the same manufacturer as the pipe.

PART 3 - EXECUTION

3.01 CPEP AND FITTINGS

- A. Install perforated and non-perforated CPEP of the size and in the locations and to the elevations and grades shown on the Drawings.
- B. Do not install pipe with bends of smaller radius than the minimum recommended by the manufacturer.
- C. Install marker posts at each drainage tubing outlet.

3.02 FILL PLACEMENT AROUND PIPES

- A. CONTRACTOR shall mechanically tamp bedding material around the piping in lifts.
- B. The CONTRACTOR shall notify OWNER before placing fill around pipes.
- C. Do not use frozen fill material or place on frozen subgrade.
- D. Pipe installed outside the boundaries of the geomembrane:
 - 1. Install bedding and cover soils making sure pipe haunches are properly shaped.

3.03 FIELD QUALITY CONTROL

- A. Pipe and pipe installation will be subject to rejection for any of the following reasons:
 - 1. Failure to conform to the SPECIFICATIONS, particularly compaction under and around the pipe.
 - 2. Fractures or cracks passing through pipe wall or socket.
 - 3. Cracks which, in the opinion of OWNER or OWNER'S On-Site Representative, may impair strength, durability, or serviceability of pipe.
 - 4. Defects indicating improper proportioning, mixing, or molding.
 - 5. Damaged ends where such damage would prevent making a satisfactory joint.
- B. Survey Requirements:
 - 1. CONTRACTOR to provide survey information for all inverts and alignments of piping.

END OF SECTION

SECTION 02630

WELLHEAD ASSEMBLY

PART 1 – GENERAL

1.01 SCOPE

- A. This Section covers the minimum requirements for the supply and installation of gas system vertical wellheads.
- B. It is the intent of this Specification that the vertical wellhead be supplied as a prefabricated and shop tested assembly by an ISO 9001 certified/compliant manufacturer.

1.02 SUBMITTALS

- A. The following documentation shall be submitted by the CONTRACTOR to the ENGINEER for approval prior to construction.
 - 1. Manufacturer's Installation Instructions
 - 2. An isometric drawing showing the dimensions and components of the wellhead and adapters, where applicable
 - 3. Manufacturer's Installation and Operation Manual
 - 4. Manufacturer's Warranty Information

PART 2 – PRODUCTS

2.01 GENERAL PRODUCT DESCRIPTION

- A. The landfill gas (LFG) collection system wellheads shall be a CES-Landtec Accu-Flo™ or approved equipment wellhead assembly and shall consist of well head piping, flow control gate valve, gas temperature gauge port, quick connect gas sampling, static and impact pressure ports, flexible hose connector, PVC union disconnect and dust cap. Wellhead piping and fittings shall be Schedule 80 PVC. Adapters shall be Elastomeric Polyvinyl Chloride.
- B. The equipment shall be capable of withstanding the rigors of landfill gas recovery application including internal high vacuum, weathering, gas constituent and ultraviolet light exposure.
- C. The wellhead shall be air tight and leak free and shall be height adjustable in the field using adapter bushings.
- D. The wellhead assembly shall be capable of being used with the CES-Landtec GEM-500™ and GEM-2000™ Gas Extraction Monitor incorporating all GEM™ monitoring functions.
- E. Equipment manufacture shall be ISO 9001 certified/compliant and shall have a proven performance of not less than six (6) years in actual landfill service.
- F. It is the intent of this Specification that the wellhead assembly shall be supplied as a complete manufactured unit.

2.02 APPLICABLE CODES AND STANDARDS

A. Pipe Material and Fittings

1. PVC piping used in the manufacture and installation of the wellhead shall meet the requirements of ASTM D-1785 for schedule 80 PVC pipe.
2. PVC fittings used in the manufacture and installation of the wellhead shall meet the requirements of ASTM D-2467 for PVC socket-type fittings.
3. PVC joint connections shall meet the requirements of ASTM D-2855 for solvent-cemented PVC joints.
4. Adapters shall conform to applicable parts of ASTM C1173.

B. Valve Material

1. Material used to manufacture the flow control valve bodies shall meet the requirements of ASTM D-1784 for rigid PVC compounds.

2.03 MATERIALS

A. Measurement Tube

1. The measurement tube shall be Schedule 80 PVC pipe, and shall fit concentrically into the well casing.
2. The measurement tube shall be of sufficient length to allow gas to achieve a uniform velocity profile before being measured.

B. Impact Tube

1. The impact tube shall be type 316 stainless steel.
2. A stainless steel centralizer shall be installed on the impact tube.
3. The entrance of the impact tube shall be in an area of uniform gas flow.

C. Unions

1. The wellhead shall have a PVC union fitting immediately upstream of the flow control gate valve.

D. Fittings

1. PVC fittings shall be Schedule 80 socket fittings. Adapters shall be Elastomeric Polyvinyl Chloride.

E. Temperature Gauge

1. The temperature gauge shall have a stainless steel probe, watertight dial cover and calibration nut. It shall be connected to the wellhead with a quick connect fitting that is positive sealing and shall be constructed of polypropylene, stainless steel or chrome

plated brass. Additionally, the temperature gauge shall be removable.

F. Quick Connect Ports

1. Quick connect ports shall be positive sealing and shall be constructed of polypropylene, stainless steel or chrome plated brass.

G. Valve

1. The flow control gate valve shall have a PVC body with socket fittings, seats and seals of inert materials, and a polypropylene wedge.

H. Flex Connector

1. A flexible hose connector shall be used to connect the wellhead to the well lateral or collection header.
2. The flexible hose connector shall be PVC.
3. Positive drainage shall be maintained on the flexible connector.

I. Nuts, Bolts and Gaskets

1. Nuts and bolts shall be cadmium plated, galvanized steel, stainless steel or zinc plated.
2. Gasket for flange installation shall be neoprene rubber.

2.04 PERFORMANCE SPECIFICATIONS

A. Volumetric Flow Rating

1. The nominal flow capacity of the wellhead shall be:

<u>Wellhead Nominal Size</u> <u>(inches)</u>	<u>Minimum Flow (CFM)</u>	<u>Maximum Flow (CFM)</u>
2.0	5	150

B. Accuracy

1. The measurement tube assembly shall be pre-calibrated and lab certified. The measurement tube shall have an accuracy and repeatability of 5% through the recommended flow range when used and maintained in accordance with the Manufacturer's Instructions and recommendations.

C. Pressure Design Ratings

1. The wellhead shall be designed to withstand a vacuum of 100 inches of water.

2.05 EXPERIENCE

- A. The equipment must be supplied by an ISO 9001 certified/compliant supplier and have at least six (6) years of proven landfill gas performance.

PART 3 – EXECUTION

3.01 INSTALLATION INSTRUCTIONS

- A. Work shall be performed in accordance with the Manufacturer's Written Instructions and installation detail drawings.

3.02 INSTALLATION

- A. Above Grade Installation
 - 1. The wellhead shall be handled according to Written Instructions supplied by the Manufacturer.
 - 2. The wellhead shall be installed such that the measurement tube assembly is concentric with the well casing.
 - 3. The wellhead shall be installed on the well casing in accordance with the Manufacturer's Written Instructions. Where the well casing is made of PE or other material, matching 125 lb. or 150 lb flat face flanges conforming to ANSI B16.1, B-16.5 or the appropriate adaptor kit from the manufacturer, shall be installed between the casing and wellhead.
 - 4. Where a flex connection is used, the flex connection shall be installed in accordance with the Manufacturer's Written Instructions. A stainless steel hose clamp shall be used on both ends of the flex connection.

3.03 TESTING

- A. After installing the wellhead, the following minimum tests shall be performed:
 - 1. Test static and impact pressure ports.
 - 2. Test valve.

END OF SECTION

SECTION 02640

VALVES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes valves required for active gas extraction system operation.

1.02 SUBMITTALS

- A. Submit the following information on all valves for approval prior to ordering or installing:
 - 1. Manufacturer's name, address, and telephone number.
 - 2. Valve model number.
 - 3. Valve component materials.
 - 4. Valve manufacturer's installation, operation, and maintenance instructions.
 - 5. Certification that valves meet requirements.
- B. Information shall be submitted prior to ordering and at least 21 days prior to installation.

1.03 REFERENCES

- A. American Water Works Association
 - 1. AWWA C508-82 – Swing Check Valves for Waterworks Service, 2-inch through 24-inch.
 - 2. AWWA C509-87 – Resilient-Seated Gate Valves for Water and Sewerage Systems.
 - 3. AWWA C550-90 – Protective Epoxy Interior Coatings for Valves and Hydrants.
- B. American Society for Testing and Materials (ASTM):
 - 1. ASTM D1784 – Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
 - 2. ASTM D4101 – Standard Specification for Polypropylene Injection and Extrusion Materials

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle per manufacturer's recommendation.
- B. Protect from damage.

PART 2 - PRODUCTS

2.01 VALVES

- A. All valves of similar type to be by the same manufacturer.
- B. Ball valves
 - 1. Capable of blocking flow in both directions
 - 2. Full bore valve
 - 3. Body, PVC Type 1 ASTM D1784 Cell Classification 12454
 - 4. O-Rings; EPDM
 - 5. Union nuts to have buttress threads
 - 6. All components to be replaceable
 - 7. True-union type at both ends with double stop plastic.
- C. Gate Valves
 - 1. Body, PVC Type 1 ASTM D1784 Cell Classification 12454
 - 2. O-Rings; EPDM
 - 3. Non-rising stem and polypropylene handwheel
 - 4. Polypropylene wedge
 - 5. All components to be replaceable
 - 6. 4-inch and larger, flanged w/ 150# flanges and 2-inch square operating nut
- D. Butterfly Valves
 - 1. Body, PVC Type 1 ASTM D1784 Cell Classification 12454
 - 2. Disc, PP ASTM D4101 Cell Classification PP0210B67272
 - 3. Valve seats and O-Rings; Viton (FKM)
 - 4. Seat to be non-liner type and interlocked to body
 - 5. Disc to be offset design with SS316 stainless steel stem
 - 6. Flanged w/ 150# flanges
 - 7. Must be ASAHI Type 57 or approved equivalent
 - 8. Contractor to install piping in such a manner that full opening of the butterfly valve can occur without binding in the pipe.
- E. Valve Box and Stem Extensions
 - 1. Valves shall be equipped with valve boxes and extensions such that the gear actuator shall be extended as shown on Plan Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine and verify conditions to accept installation of valves.
- B. Verify size and location restrictions to place in and around structures.
- C. Submit required information and shop drawings for approval.

3.02 PREPARATION

- A. Prepare site and construction parts for installation.

3.03 INSTALLATION

- A. Coordinate placement of pipe openings to accommodate valves.
- B. Install valves in locations shown on Drawings.
- C. Valve installation per submitted manufacturer's recommendations.
- D. Test for leakage per Section 02615.

END OF SECTION

SECTION 02750

GAS EXTRACTION WELLS

PART 1 - GENERAL

1.01 SUMMARY

- A. The Work to be performed under this section includes the furnishing of all labor, equipment, materials, and other facilities and incidentals to perform the following Work for the landfill gas extraction wells:
 - 1. Drill boreholes of 36-inch diameter to a maximum depth as shown on Drawings.
 - 2. Construct 6-inch diameter PVC perforated extraction well pipes to a maximum depth as shown on the gas extraction well detail Drawing.
 - 3. Drilling equipment and tools will be steam cleaned prior to being mobilized onto the site and before leaving the site.
 - 4. Meet all health and safety requirements prior to beginning Work as well as for the duration of the project.
 - 5. Disposal of waste material on-site.
- B. These Specifications are intended to give a general description of what is required, but do not cover all variations that may occur during extraction well construction. The Specifications are intended to cover the successful completion of the gas extraction wells as herein specified, whether every detail is specifically mentioned or not.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM).
 - 1. ASTM D1785 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 - 2. ASTM D2464 - Standard Specification for Threaded Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80.
 - 3. ASTM D2466 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedule 40.
 - 4. ASTM D2467 - Standard Specification for Socket-Type Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80.
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03 SUBMITTALS

- A. Within 5 days following the preconstruction conference, the CONTRACTOR shall submit in writing:
 - 1. A complete list of construction materials and supplies including the name of the manufacturer, for the items listed below:

- a. PVC pipe and fittings
 - b. Perforated screen
 - c. Drilling fluid additives, if necessary
 - d. Gravel pack material samples
 - 2. The source and location of potable water supply, written authorization of the suppliers, method of transporting and containing the potable water, if necessary.
- B. During all gas extraction well drilling, a daily detailed driller's report shall be maintained and submitted as requested by the ENGINEER. The report shall give a complete description of all pilot boring information with continuous split-spoon sampling for depths indicated on Drawings, subsurface material encountered, number of feet drilled, number of hours on the job, shutdown due to breakdown, feet of screen and casing set and other pertinent data requested by the ENGINEER.
- C. During drilling of each borehole, the CONTRACTOR shall maintain at the extraction well site a complete log setting forth the following:
- 1. The reference point of all depth measurements.
 - 2. The depth at which each change of material occurs.
 - 3. The identification of the material.
 - 4. The depth interval of the material.
 - 5. Other pertinent data requested by the ENGINEER.
- D. Upon completion of each gas extraction well, the CONTRACTOR shall also submit to the ENGINEER a report to include the following:
- 1. The name and location of the job.
 - 2. The date of the borehole drilling (start and finish).
 - 3. Gas extraction well number and coordinates.
 - 4. Surface elevation.
 - 5. Sample numbers and depths of natural soil, if encountered, or saturated conditions.
 - 6. The depth or location of any lost drilling fluid, drilling materials, or tools.
 - 7. Amount of drilling fluid and additives, if used.
 - 8. The depth, diameter, and description of the gas extraction well casing and screen.
 - 9. The total depth of the completed gas extraction well.
 - 10. The nominal hole diameter of the pilot and borehole.
 - 11. Amount and size description of gravel pack and sand/bentonite used.
 - 12. The amount of grout (number of bags used).
 - 13. Other pertinent data requested by the ENGINEER.

1.04 QUALITY ASSURANCE

- A. The CONTRACTOR responsible for constructing the gas extraction wells shall employ only competent workers for the execution of this Work and all such Work shall be performed under the direct supervision of an experienced driller satisfactory to the ENGINEER.

- B. The driller shall be capable of identifying subsurface conditions and maintaining complete and current logs and daily notes for the gas extraction well completion reports.
- C. The OWNER may make any other investigations deemed necessary to determine the ability of the CONTRACTOR to perform the Work and the CONTRACTOR shall furnish to the OWNER all such information and data for this purpose as the OWNER may request.
- D. The CONTRACTOR shall complete the Work described in accordance with the applicable portions of the Rules per 29 CFR 1910, OSHA Standards for Hazardous Waste site workers.
- E. The driller shall be trained and experienced as required by OSHA for hazardous waste site workers.
- F. The driller's assistant(s) shall be trained and experienced as required by OSHA for hazardous waste site workers.
- G. The CONTRACTOR will provide a list of all personnel who will be involved in the project and their corresponding qualifications and experience.

1.05 DESCRIPTION OF THE GAS EXTRACTION WELL

- A. The gas extraction wells shall be 6 inches in diameter slotted PVC, installed at various depths shown on the Drawings in the 36-inch diameter boreholes.
- B. Gas extraction wells shall be drilled at the locations and depth as indicated on the Drawings, unless otherwise approved by the ENGINEER. Depths may vary depending on the findings of the pilot boring.
- C. Alternate drilling or construction methods may be approved by the ENGINEER where justified.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination will occur from time of shipment until installation is completed.
- B. If in the opinion of the ENGINEER, parts and materials are damaged, deteriorated, or contaminated before acceptance of the extraction well, the material and/or the gas extraction well will be rejected. The CONTRACTOR shall replace the labor, parts, and materials at no additional cost to the OWNER.
- C. Materials shall be stored to ensure preservation of their quality and fitness for Work. When deemed necessary, they shall be placed on wooden platforms or other hard clean surfaces and not on the ground. Stored materials shall be located so as to facilitate prompt inspection.

1.07 CONDITIONS AND HAZARDS AT THE SITE

- A. Typical subsurface conditions at the landfill may include very loose fine sands, municipal refuse, methane, leachate, and obstructions such as large buried items.
- B. The CONTRACTOR shall be aware that unfavorable subsurface geologic conditions may exist at the site selected for the gas extraction wells, which could cause loss of circulation and collapse of the formation.
- C. The information concerning the subsurface conditions and problems of which the CONTRACTOR is advised is for the sole purpose of assisting the CONTRACTOR in the preparation of his or her bid. The OWNER, ENGINEER, and their consultants do not guarantee the accuracy and the conditions and concerns stated above. These conditions and concerns may not be indicative of the conditions at the site.
- D. In the event subsurface conditions are found extraordinarily different from what has been indicated, the CONTRACTOR shall promptly and before such conditions are disturbed, notify the ENGINEER verbally and in writing of such conditions.
- E. The CONTRACTOR must take necessary precautions to prevent damage to any aboveground or below ground existing structures. Notify the ENGINEER of any damaged underground structures and make repairs or replacements before backfilling.
- F. During the progress of construction, it is expected that minor relocations of the Work will be necessary. Such relocations shall be made only by direction of the ENGINEER. If obstructions are encountered during drilling, notify the ENGINEER verbally and in writing before continuing with the construction in order that the ENGINEER may make such field revisions as are necessary. If the CONTRACTOR shall fail to so notify the ENGINEER when an obstruction is encountered and shall proceed with the construction despite this interference, he or she shall do so at his or her own risk.
- G. The CONTRACTOR is required to perform all required health and safety monitoring to comply with the Health and Safety Plan. The CONTRACTOR shall supply the results of all monitoring activities to the ENGINEER when requested.
- H. CONTRACTOR will stake proposed extraction wells locations prior to drilling. If the stakes are disturbed by the CONTRACTOR and require additional staking, this will be done by the CONTRACTOR, at no expense to the OWNER. If the stakes are disturbed by the OWNER, or subcontractor of the OWNER, and require additional staking, this will be done by the OWNER.

If necessary, record offset distance from survey stake to final location of borehole. Offset locations shall be approved by OWNER prior to drilling.

Some drilling may occur on steep side slopes of the landfill. CONTRACTOR will provide necessary soils and grading to construct work pad for drilling equipment. CONTRACTOR is responsible for hauling, placing, and removal of soil work pad; and for salvaging and replacing topsoil at work pad location. CONTRACTOR will provide equipment necessary to move drill rig if wet weather conditions encountered.

I. SPOILS DISPOSAL

Excavated Refuse Disposal: CONTRACTOR to load, haul, and dispose of drilling spoils on-site in the active landfill area as directed by the OWNER.

1.08 PERMITS

- A. The CONTRACTOR shall be responsible for obtaining any federal, state, or local permits required for constructing the gas extraction wells, discharging material from the site, or clearing the site for Work or access.
- B. The CONTRACTOR shall not perform any Work on the gas extraction wells until these permits are obtained.
- C. The CONTRACTOR shall furnish separate copies of all permits to the OWNER and the ENGINEER as the permits are received. Copies of all permits shall be furnished to the ENGINEER 10 days prior to mobilization.

1.09 NOTIFICATION

- A. The CONTRACTOR shall supply to the ENGINEER, in writing at the preconstruction conference, the proposed Work schedule, including the following:
 - 1. The starting date of the extraction well construction.
 - 2. The dates and order of drilling.
 - 3. The completion date of drilling.
 - 4. Any anticipated Work interruptions of duration greater than 24 hours with exception of weekends and holidays.
- B. The CONTRACTOR shall notify the ENGINEER, in writing, at the preconstruction conference, the number of drilling rigs and personnel to be used on the project. Any change in the number of rigs and personnel shall require written notification of the ENGINEER 48 hours prior to the change.
- C. The CONTRACTOR shall notify the ENGINEER 24 hours prior to start of any drilling activities.
- D. No Work shall be performed by the CONTRACTOR without completing the notification requirements specified above.

PART 2 - PRODUCTS

2.01 PIPE

A. Gas Extraction Well:

1. Solid Pipe: 6-inch diameter non-perforated Schedule 80 PVC.
2. Slotted Screen: 6-inch diameter slotted Schedule 80 PVC pipe with socket-type PVC cap.
3. Slots, as shown on the Drawings.

2.02 FITTINGS

- A. Fittings shall be as designated in ASTM D2467, D2466, or D2464 as shown on the Drawings and shall be compatible with the pipe where installed.
- B. Pipe shall be joined using flush thread joints or by using solvent welded couplings. If solvent welded couplings are used they shall be supplemented by the use of three (3) 3/8 inch diameter by 3/4 inch long stainless steel lag screws that are screwed into the coupling and each pipe end.

2.03 AGGREGATE

- A. As defined in Section 02202.

2.04 CAPS

- A. The bottom of each extraction well casing shall be fitted with a PVC cap.

2.05 BENTONITE

- A. Bentonite pellets will be used in the installation of the gas extraction well as shown on Drawings.

2.06 GEOMEMBRANE BOOT AND CLAMP

- A. As specified in Section 02922 as shown on Drawings.

PART 3 - EXECUTION

3.01 PILOT BORING

- A. Pilot borings may be conducted at each location prior to gas extraction well drilling.
- B. Pilot borings, if required, shall be advanced to the approximate depths as shown on the Drawings.

- C. Continuous split-spoon sampling shall be conducted on the lower 15 feet of the boring.
- D. The pilot boring shall be backfilled with bentonite slurry to the elevation of the bottom of the gas extraction well.

3.02 GAS EXTRACTION WELL BOREHOLE DRILLING

- A. A minimum 36-inch diameter borehole will be drilled at each site for a gas extraction well to the approximate depth as shown on Drawings, or determined from pilot borings, or 3 feet above the encountered water table, whichever is higher.
- B. The CONTRACTOR shall drill the 36-inch boreholes for the gas extraction wells using an open bucket method or other methods as approved by the ENGINEER. Material removed from this landfill as a result of borehole drilling will be disposed of at the open working face of the landfill.
- C. Drilling Obstruction Protocol: If there is a drilling obstruction or saturated conditions encountered in the landfill that, despite the best reasonable efforts of the CONTRACTOR, cannot be penetrated after one hour of drilling (a minimum of five (5) feet in vertical depth has not been reached in that hour), the CONTRACTOR shall request relief from the OWNER or ENGINEER from completion of the gas extraction well. The course of action shall be as follows at the sole authority of the OWNER or ENGINEER:
 - a. If 85% of the planned vent depth has been achieved, the well will be installed.
 - b. If less than 85% of the planned depth has been achieved, the OWNER or ENGINEER shall decide one of the following:
 - i. The borehole shall be abandoned. The CONTRACTOR shall backfill the borehole to the pre-drilled condition or to the satisfaction of the OWNER or ENGINEER. At this time, the drilling will commence for the same gas well at a new location in the vicinity of the current location. The new location shall be agreed upon by the ENGINEER.
 - ii. The gas well shall be accepted at the obstructed depth agreed upon by the ENGINEER. The well shall be completed at this new depth. Compensation shall be for the modified footage of the well.
 - iii. The CONTRACTOR will stay at the current location per the order of the OWNER. At this time, after the one hour time period, the CONTRACTOR will continue drilling at an hourly rate and the contract price for drilling of the borehole will no longer be taken into consideration.

3.03 EXTRACTION WELL PIPE INSTALLATION

- A. The string of 6-inch diameter pipe shall be secured approximately 12 inches above the bottom of the borehole to allow the gravel pack to

form beneath the screen as shown on the Drawings. The screen shall extend as shown on the Drawings.

- B. Every effort shall be made on the part of the CONTRACTOR to assure casing plumbness and centralization in the borehole.
- C. The installation of plastic pipe for casing and screen shall be strictly in accordance with the manufacturer's technical data and printed instructions.

3.04 AGGREGATE AND FILL MATERIAL INSTALLATION

- A. All gravel pack installation shall be performed in the presence of the ENGINEER. The gravel pack shall be installed in the annular space by tremie pipe or an alternate manner approved by the ENGINEER which will avoid bridging. The gravel pack shall have a minimum installed diameter of 30-inch. The CONTRACTOR shall tamp the top of the gravel pack before placing the bentonite plug.
- B. All installation of the gravel pack, and fill material must be performed in the presence of the ENGINEER.

3.05 PROTECTION AND SITE CLEAN-UP

- A. At all times during the progress of the site Work, the CONTRACTOR shall use all reasonable precautions to prevent either tampering with the gas extraction wells or the entrance of foreign material.
- B. All gas extraction wells shall be protected by the provision of temporary support or other means of protection approved by the ENGINEER. The CONTRACTOR shall replace any which are damaged by construction operations at the CONTRACTOR'S expense.
- C. Immediately upon completion of site Work, The CONTRACTOR shall remove all of his or her equipment, materials and supplies from the site of the Work, remove all surplus materials and debris, fill in all holes or excavations and restore any disturbed areas to their original condition. The CONTRACTOR shall properly dispose of the refuse and material removed from the borehole. The disposed material shall be covered daily with a minimum of 6 inches of soil. Failure to comply with these requirements shall give authority to other CONTRACTORS or WORKERS, required by the ENGINEER, to enter upon the site and complete the clean-up, grading, etc. The cost of this Work shall be deducted from money due or become due to the CONTRACTOR for construction of the extraction wells.

END OF SECTION

SECTION 02920

HIGH DENSITY POLYETHYLENE GEOMEMBRANE (HDPE)

PART 1 - GENERAL

1.01 SUMMARY

- A. Work includes manufacture, fabrication (if needed), supply, and installation of textured High Density Polyethylene (HDPE) geomembrane liner system. Textured geomembrane shall have a smooth edge for seaming.

1.02 DEFINITIONS/REFERENCES

- A. American Society for Testing and Materials (ASTM) Standards specifically referenced in this Section:
 - 1. ASTM D6693 Standard Test Method for Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
 - 2. ASTM D751 Standard Test Methods for Coated Fabrics
 - 3. ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
 - 4. ASTM D1004 Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
 - 5. ASTM D1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
 - 6. ASTM D1505 Standard Test Method for Density of Plastics by the Density Gradient Technique
 - 7. ASTM D1603 Standard Test Method for Carbon Black Content in Olefin Plastics
 - 8. ASTM D3895 Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry
 - 9. ASTM D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
 - 10. ASTM D4437 Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
 - 11. ASTM D4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
 - 12. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics
 - 13. ASTM D5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
 - 14. ASTM D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
 - 15. ASTM D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
 - 16. ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
 - 17. ASTM D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
 - 18. ASTM D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes

19. ASTM D6365 Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test
20. ASTM D6747 Standard Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes
21. ASTM D7002 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method
22. ASTM D7007 Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials
23. ASTM D 7238 Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
24. ASTM D7466 Standard Test Method for Measuring Asperity Height of Textured Geomembranes

B. Geosynthetic Research Institute (GRI) Standards:

1. GM 6: Pressurized Air Channel Test for Dual Seamed Geomembranes
2. GM 9: Cold Weather Seaming of Geomembranes
3. GM10: The Stress Crack Resistance of HDPE Geomembrane Sheet
4. GM13: Test Methods, Properties, and Testing Frequency for HDPE Smooth and Textured Geomembranes
5. GM 14: Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
6. GM 19: Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

C. U.S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

1.03 SUBMITTALS

- A. The following submittals shall be provided to and approved by OWNER prior to delivery of geomembrane to the site or mobilization of the geomembrane INSTALLER'S crew or equipment:
1. INSTALLER shall supply information from the resin manufacturer regarding the resin type, properties as specified herein, and production dates of the resin used for this project. The resin type identification shall include the cell classification of the resin in accordance with the requirements of the latest ASTM Designation D3350.
 2. INSTALLER shall submit from the geomembrane sheet manufacturer, test methods and results defining physical properties as specified herein, of the geomembrane to be used for this project. Test results at the frequency specified in the GRI standards of geomembrane furnished for this project shall be submitted, and test results shall be reported with corresponding roll identification numbers.
 3. INSTALLER shall supply a statement of the geomembrane manufacturer's quality control procedures, identification of any resin admixtures, frequency of sampling, methods of material transportation and storage, and acceptance criteria for roll goods delivered to the site.
 4. INSTALLER shall provide submittals describing the geomembrane sheet manufacturer's details of any factory seaming process proposed. Roll test results which may not be available prior to construction (i.e., environmental

- stress crack) shall be presented as preliminary prior to construction, with final test results submitted or affected rolls within the construction time frame.
5. INSTALLER shall submit from the extrudate weld rod manufacturer, verification that the weld rod was manufactured using the same resin as was used in the geomembrane sheets prior to using material.
 6. INSTALLER shall submit a proposed panel and seam layout diagram specifying the type and location of all field and factory seams. The layout diagram shall be to scale and used as a construction Plan and shall include all necessary dimensions and details. The layout diagram shall be compatible with the panel and seam layout requirements specified in this Section.
 7. INSTALLER shall submit an installation schedule.
 8. INSTALLER shall submit a list of personnel performing field supervision, and quality control, along with experience records and resumes.
 9. INSTALLER shall submit a list of equipment types proposed to be used in panel layout, membrane seaming, and destructive and nondestructive testing.
- B. The INSTALLER shall remit the following during geomembrane Installation:
1. INSTALLER shall, at the end of each working day provide a detailed report of work completed that day, including:
 - a) Panel Placement
 - b) Trial Welds Results
 - c) Subgrade Acceptance Form
 - d) Seams
 - e) Seam Testing (air and vacuum tests)
 - f) Destructive Tests
 - g) Repair Log
 2. OWNER shall review with the INSTALLER and sign the above report at the end of each day. OWNER shall be provided with a copy not more than 24 hours from the date of the report.
- C. INSTALLER shall update their liner layout drawings on a daily basis. The drawings shall include all panel locations and numbering, seam locations and numbering, and test locations and numbering. The INSTALLER shall maintain a current liner layout drawing on the construction site at all times. At the request of OWNER a copy of the current liner layout drawing will be submitted with 24 hours.
- D. INSTALLER shall submit final as-built liner layout drawing(s) to OWNER within 14 calendar days of completion of the liner work. Drawings shall be submitted in paper and digital form.
- E. Quality control certificates indicating resin type, properties as specified herein, and production dates shall be provided with each shipment of extrudate rods delivered to the site no later than the time of delivery.
- F. Prior to the installation of any geomembrane, the INSTALLER shall submit INSTALLER'S certification in writing that the surface upon which the geomembrane is to be installed is acceptable (complete form contained at end of this Section).
- G. Submit material delivery and installation schedule for incorporation into the Project schedule.

1.04 EXPERIENCE

- A. The geomembrane installation shall be performed under the direct supervision of a single field supervisor who must remain on-site throughout installation, including inspection of the surface upon which the geomembrane is to be installed, geomembrane handling and storage, panel layout and placement, seaming, seam testing, panel and seam repair, installation of appurtenances, anchorage and other geomembrane-related work. The field supervisor shall have a personal HDPE geomembrane installation record totaling at least 1 million square feet.

1.05 Pre-Installation Meeting

- A. Representatives of the INSTALLER shall attend a meeting prior to installation of the geomembrane to discuss details of the proposed design, installation, and schedule.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Raw Materials:

1. Smooth and textured HDPE geomembrane, and extrudate rods used for this project shall be manufactured of new, first quality resins, designed specifically for use in flexible membrane liner installations.
2. HDPE resin used in manufacturing geomembranes used for this Project shall meet requirements set forth in the latest revision of the Geosynthetics Research Institute (GRI) for HDPE (GRI GM 13).
3. Recycled Polymer shall not be added to the resin. However, the resin may contain polymer reclaimed during the manufacturing process if reclaimed polymer content does not exceed 10 percent by weight.

B. Geomembrane Roll Goods:

1. HDPE geomembrane sheets used for this project shall meet the requirements set forth in the latest revision of the Geosynthetics Research Institute (GRI) for HDPE, both smooth and textured (GRI GM 13).
2. The geomembranes shall consist of unreinforced high density polyethylene containing at a maximum 3 percent by weight additives, fillers, or extenders.
3. The geomembranes shall be free of holes, blisters, striations, undispersed raw material, and contamination by foreign matter.
4. The geomembranes shall be supplied as a continuous sheet with no factory seams in rolls. Each roll shall be identified and labeled with the thickness of the geomembrane, length and width, manufacturer, lot number, and roll identification number. This identification number shall be used to identify roll location on the panel layout record drawing.

- C. Extrudate: Resin used in the polyethylene extrudate shall be the same as that used to manufacture the geomembrane sheets. Extrudate rods are to be

delivered in original containers with the manufacturer's labeling. Extrudate rods shall be free of dirt, grease, moisture, other contaminants, and shall be free of damage.

- D. Neoprene Foam: Closed cell, weatherproof, black neoprene foam with adhesive backing suitable for long-term sun and liquid exposure. Dimensions shall be as specified on the DRAWINGS.
- E. Clamped Boots: Boots required to seal the HDPE geomembrane to the structures passing through it shall be made of the same materials as the geomembrane. The boots shall be fabricated so that all field assembly, welding, and seam testing can be accomplished using equipment and procedures regularly employed in the field for equipment and HDPE geomembrane installation. Smooth geomembrane shall be used in all geomembrane boots.
- F. Banding Straps: Type 302 stainless steel banding straps suitable for use on the pipe diameters shown on the DRAWINGS. Banding strap dimensions shall be as specified on the DRAWINGS. All surfaces of the banding straps shall be machined smooth to prevent tearing or puncturing of the HDPE pipe boots. Outer lip of boot shall be sealed with silicone sealant as shown on Drawings.
- G. Bentonite: Bentonite pellets shall be used to fill the annular space between the outer pipe and the gas well pipe at gas well extensions as shown on the Drawings.

2.02 EQUIPMENT

- A. Extruding equipment shall be equipped with a temperature gauge at the barrel and nozzle.
- B. Fusion equipment shall be equipped with a temperature gauge capable of continuous monitoring.
- C. Provide digital or dial continuous temperature recording instruments, in satisfactory working condition, with each welding unit. Welding equipment shall not be operated without functioning temperature recording instruments for measuring geomembrane sheet temperature.
- D. A coupon cutter and a calibrated tensiometer shall be provided for in-field seaming pre-qualification testing and destructive sample testing.
- E. Store, transport, and operate all equipment to avoid damage to geomembranes.
- F. Glass top of each vacuum box must be clear and free of scratches for easy reading of pressure gauge. The sealing gasket shall be intact and functioning to form close seals during testing.
- G. OWNER reserves the right to order the INSTALLER to remove any equipment that in OWNER'S opinion is not satisfactory. The INSTALLER will remove the equipment promptly from the construction site and replace the unsatisfactory equipment with suitable equipment within 24 hours.

PART 3 - EXECUTION

3.01 SUBGRADE INSPECTION

- A. INSTALLER shall certify in writing that the surface upon which the geomembrane is to be installed is acceptable (acceptance form contained at end of this Section).
- B. INSTALLER shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner during geomembrane installation to ensure subgrade suitability.
- C. After subsurface has been accepted by INSTALLER, it shall be INSTALLER'S responsibility to indicate to CONTRACTOR any change in subsurface conditions that may require repair work and perform required repair work. Damage to subsurface caused by work involved in installing geomembrane shall be repaired at INSTALLER'S expense. Geomembrane placement over damaged subsurface, as determined by ENGINEER or INSTALLER, is not acceptable. Nothing will waive INSTALLER'S and CONTRACTOR'S contractual requirements with respect to warranty on installed system.

3.02 CREST ANCHORAGE SYSTEM

- A. Backfilling of Anchor Trench:
 - 1. Backfill of anchor trench and compact will be performed by the earthwork CONTRACTOR.
 - 2. INSTALLER shall monitor the backfilling of anchor trench to ensure proper method is employed. Any damage noticed shall be reported to OWNER.

3.03 HANDLING, TRANSPORTATION, AND STORAGE

- A. Geomembrane rolls shall be packaged and labeled prior to transporting to the site. Geomembrane rolls delivered to the site shall be wrapped in a relatively impermeable and opaque protective cover which may consist of a sacrificial wrap of geomembrane. The sacrificial wrap shall be removed prior to geomembrane installation.
- B. Geomembrane transportation shall be in a manner that minimizes the possibility of material damage during shipment. When offloading geomembrane from the truck, straps and a spanbar shall be used. Direct contact with forklifts or front end loaders to offload the material will not be allowed without written consent from OWNER.
- C. On-site storage of the geomembrane rolls shall be in a safe manner, with rolls protected from grease, dirt, moisture, excessive heat, direct sunlight, vehicle traffic, and other possible sources of damage including theft and vandalism. The rolls will be placed in neat order and placed such that identification tags for each roll can be read. Storage areas shall be at the OWNER'S designated location.

- D. Geomembrane and appurtenant materials delivered to the site shall be checked for proper labeling and visually inspected for transport or manufacturing damage. OWNER reserves the right to reject any unacceptable material at no cost to OWNER. Any roll that arrives on site without factory roll identification will not be used for the work and will be removed from the site promptly.
- E. Only that quantity of geomembrane that is to be placed on a particular day shall be removed from the packaging. Geomembrane rolls shall be transported from the storage area to the construction area and deployed using wide lifting straps and properly sized forklifts, front end loaders, or other appropriate equipment.
- F. Under no circumstances shall any heavy equipment be allowed directly on the geomembranes unless approved by OWNER.
- G. Prior to placement, the geomembranes shall be visually inspected for compliance with this Section. Geomembrane material which, in the opinion of the OWNER is damaged or does not meet Specifications will be rejected by the OWNER. Minor damage may be repaired as specified in this Section. Damage to geomembranes caused by INSTALLER during handling shall be repaired or replaced at INSTALLER'S expense.

3.04 PANEL LAYOUT AND PLACEMENT

A. Panel and Seam Layout Diagram:

1. Prepare panel and seam layout diagram so that panel seams run parallel to the direction of maximum slope (i.e., down the slope).
2. All slopes steeper than or equal to 10H:1V shall use geomembrane textured on both sides, unless specifically identified otherwise on the DRAWINGS. Smooth or textured geomembrane may be used in the leachate collection trench. A single panel should run along the entire length of each trench and be centered about the trench centerline, minimizing seaming and/or repairs within the trench.
3. The textured slope panels shall extend past top or bottom grade-break lines as shown on the DRAWINGS, but no less than ten feet.
4. Slope panels shall not be constructed from more than two pieces of geomembrane (i.e., not more than one cross-seam shall be permitted on any one slope panel).
5. Cross seams in slope panels, where allowed, shall be oriented at 45°. Cross seams shall be located on at least the bottom half of the slope, wherever possible.
6. Cross seams in adjacent panels shall be staggered.
7. Assign identification number to each seam for reference to test results and record Drawings.
8. Seams shall not be located at low points in the subgrade unless required by site geometry and approved by OWNER.

B. PANEL PLACEMENT:

1. Panel size and placement shall be in general accordance with the panel layout diagram submitted to OWNER as defined in this Specification.

2. Geomembrane shall be anchored with sand bags or other approved methods to prevent uplift and damage by wind.
 3. A panel identification number shall be assigned to each panel for reference to test results and Record Drawings. The panel identification number and geomembrane roll number shall be written on each panel with a grease pencil, immediately following deployment of the panel.
 4. Smoking during placement of panels is prohibited. Wearing damaging shoes or engaging in any behavior which may damage the geomembrane is prohibited.
 5. Eating, drinking, disposal of food wraps, drinking bottles and cans on top of geomembrane is not allowed.
 6. Place panels with appropriate slack incorporated into geomembrane to accommodate expansion and contraction without jeopardizing the integrity of the geomembrane.
 7. Vehicle traffic over geosynthetics as a means of panel deployment is expressly prohibited without the consent of the OWNER.
- C. OWNER and INSTALLER will visually inspect in-place panels prior to seaming. Any damaged panels shall be repaired, and if requested by OWNER, replaced at no additional cost to OWNER. Repairs shall be performed as specified in this Section. All damages and repairs shall be recorded on the Record Drawings.

3.05 SEAMING

- A. Seaming Methods: All seams shall be joined using a heat extrusion or hot fusion (split wedge) weld process in accordance with the geomembrane manufacturer's recommendations. The INSTALLER shall maintain in working order at the site at least one spare seaming apparatus for each type of welder used. The hot fusion weld process will be used whenever possible. The use of extrusion welded seams shall be limited to repairs and any areas or seam configuration inaccessible to fusion welding equipment.
- B. Factory and field seams shall meet the minimum specifications set forth by the latest revision of the GRI GM 19.
- C. Seam Configuration and Preparation:
1. Overlap panels to be seamed at least 3 inches but not more than 6 inches. The loose end of the upper panel shall extend no more than 3 inches from the weld. All seams shall be made in a rainlap manner with the loose end of the upper panel downgradient of potential water flow.
 2. Cross seams on slopes, where allowed, shall be made at a 45 degree angle to the edge of the panel.
 3. The contact area between panels shall be clean and free of moisture, dust, dirt, debris, and foreign material. A protective layer of filter fabric or a sacrificial HDPE strip shall be used directly beneath each seam overlap to achieve proper support and a clean work surface, if necessary.
 4. Where extrusion welding is used, the contact surfaces between panels shall be ground to remove oxidation prior to welding. Grinding shall not result in grooving of the liner nor reduction of the liner thickness

by more than 10 percent. The grinding motion shall be made perpendicular to the seam. Grinding in a direction parallel to the seam shall not be permitted. All ground areas shall be covered completely with extrudate.

5. Seams shall be aligned to minimize the number and size of wrinkles.

D. Test Seam:

1. A prequalification test seam sample shall be prepared with each piece of seaming equipment/seamer approximately every four hours at the beginning of each seaming period (usually morning and afternoon), unless otherwise directed by OWNER. Each sample shall be prepared by the operator of the equipment for that seaming period and shall be at least 6 feet long (in the direction of the seam) by at least 1 foot wide and may be performed on scrap pieces of geomembrane.
2. Six 1-inch wide specimens (coupons) from each test seam sample shall be prepared for on-site field testing for shear and peel strength. Coupons shall be prepared using a sheet cutter so that consistent, uniform 1-inch wide coupons are obtained. Samples should be distributed evenly over the 6 feet length.
3. The INSTALLER will make these test seams in the presence of OWNER.
4. The extension rates for these tests will not exceed 2-inches per minute unless permission from the OWNER is given.
5. Three coupons shall be tested in shear and three in peel. All coupons shall exhibit the required strength at yield and failure mechanism FTB as set forth in *Paragraph 3.05B*. Seam separation equal to or greater than 10% of the track width shall be considered a failing test. If any of the coupons fail, the reason for the failure shall be identified and corrected prior to preparing another test seam. The new test seam shall be prepared reflecting adjustments made to the seamer/seaming equipment and a new set of coupons shall be cut and tested.
6. Seaming equipment shall not be used until satisfactory prequalification test seams have been prepared, witnessed by OWNER.
7. The test results on all prequalification test seams will be reported to OWNER.

E. Climatic Conditions for Seaming:

1. Seaming shall be performed only when panel temperatures are between 32°F and 170°F, unless otherwise approved by OWNER. If seaming is permitted to be performed at panel temperatures below 32°F, the panel contact surface shall be preheated and INSTALLER shall certify in writing that the low-temperature seaming procedures will not cause any short-term or long-term damage to the geomembrane or the welded seam. INSTALLER shall demonstrate to OWNER that field seams comply with project specifications using pre-qualification test seams. INSTALLER shall submit to OWNER, for approval, detailed procedures for seaming at low temperatures, including the following:
 - a. Preheating of the geomembrane
 - b. Provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.

- c. Number of additional test welds to determine appropriate seaming parameters.
 - 2. Seaming during rainy weather or when dew is present on panels shall not be allowed.
 - 3. INSTALLER shall provide any special lighting required for seaming during low-light or dark hours.
 - 4. INSTALLER shall leave slack in the geomembrane as necessary to account for thermal expansion or contraction of geomembrane. Stress on panels due to thermal expansion and contraction shall be minimized by performing field seaming operations during the coolest parts of the day or night, if necessary. Special scheduling or extended hours of operation require approval by OWNER.
- F. All welding shall provide a tight, leak proof, homogeneous bond between panels. All seams shall extend to ends of panels.
- G. Welding equipment shall be continuously monitored to control the temperature of extrudate and wedge. If recording equipment allows for a hard copy of the monitoring, a copy of the monitoring labeled with the weld identification number will be submitted to OWNER.

3.06 PIPE AND STRUCTURE PENETRATION SEALING SYSTEM

- A. Penetration sealing systems shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Drawings.
- B. All penetration sealing systems must be tested. Where field non-destructive testing cannot be performed, field spark testing shall be performed using standard holiday leak detectors in accordance with ASTM 6365. Spark testing should be performed in areas where both air pressure testing and vacuum testing are not possible.

3.07 NONDESTRUCTIVE TESTING OF PRODUCTION SEAMS

- A. All field seams shall be non-destructively tested by the INSTALLER over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of test, and outcome of all non-destructive testing shall be recorded and submitted to the OWNER.
- B. Testing shall be done as the seaming work progresses, not at the completion of all field seaming. All defects found during testing shall be numbered and marked immediately after detection. All defects found shall be repaired, retested and remarked to indicated acceptable completion of the repair.
- C. Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods.
- D. Visual Inspection: A visual inspection of all seams shall be performed. This inspection shall look for obvious flaws in seaming patches, penetration sealing, material defects, or other problems. Deviations from acceptable workmanship standards shall be noted and corrected.

- E. Pressure Testing (Double-Fusion Welds): Where a double-fusion weld seaming system is employed, the continuity of the seam shall be tested with air pressure in accordance with the following procedure. The flow channel must not be obstructed by foreign objects or geomembrane material throughout the length of seam being tested. The vacuum test described in *Paragraph 3.06C* must be employed for testing of all seams that do not have a continuous flow channel.
1. A test device consisting of an inflation needle and pressure gauge mounted on a "T" fitting shall be used for air pressure testing. Insert the needle into the flow channel and seal the end of the channel around the needle. Connect a pump (such as a small bicycle pump) to the test device.
 2. Ascertain that the flow channel is continuous by leaving the other end of the channel open and pumping air through the channel. If air does not pass through the channel the test length must be shortened until a continuous length of flow channel is found.
 3. Seal and clamp both ends of the flow channel to assure an airtight seal. Inflate the flow channel to 25 to 30 psig. Allow one minute for the seam to stabilize.
 4. Re-inflate as needed to achieve 25 to 30 psig on the seam and test for a period of five minutes.
 5. At the end of the test period, if the pressure has not dropped more than 2 psi, the test shall be considered a pass and the following procedure will be implemented;
 - a. Remove the test device and clamps.
 - b. Make any repairs, if necessary, to the area where the flow channel was clamped or inflated.
 - c. Record the test results, mark the seam as a pass, the date tested, and proceed to the next seam.
 6. If the pressure drops below the 2 psi allowance, the test shall be considered a failure and the following procedure shall be implemented to identify the failure:
 - a. Check to determine if there is excessive seepage around the inflation needle.
 - b. Check both ends of the seam to ensure the flow channel is completely sealed off.
 - c. Walk the length of the seam; look and listen for air leaks.
 - d. If either of these procedures fail to identify the leak, trim the seam overlap and vacuum test the seam to locate the leak.
 - e. Once the leak is identified, make the necessary repairs and retest the seam.
 7. Seam to be approved before testing by OWNER; test to be performed in presence of OWNER personnel.
- F. Vacuum Testing: Vacuum testing shall be used to test the continuity of extrusion welded and mechanical seams. A clear topped vacuum box, supplied by INSTALLER, shall be placed over the seam to be tested after application of a soapy solution. Upon evacuation, bubbles will be evident through the viewing window if the seam lacks integrity. The following procedure shall be followed:

1. Wet seam to be tested with a soapy solution mixed at a ratio of 1 ounce soap to 1 gallon water. No antifreeze solution is allowed to be added to the water.
2. Place vacuum box over seam to be tested, evacuate box to a vacuum equal to 3 to 5 inches water column, and tug up to ensure a leak tight seal has been developed.
3. Examine the seam for 5 to 10 seconds to detect soap bubbles.
4. If the bubbles are not evident, move to next test location. Adjacent test sections are to overlap by at least 1 inch.
5. If bubbles are present, mark area clearly for repair.
6. If the vacuum testing indicates leakage, the area shall be spot patched; or if major leaks are detected, the entire seam shall be reworked.
7. Seam to be approved before testing by OWNER; test to be done in presence of OWNER personnel.

3.08 DESTRUCTIVE TESTING OF PRODUCTION SEAMS

- A. The purpose of destructive testing is to verify that the seaming process has produced seams of acceptable mechanical integrity. One seam sample shall be taken at random for each 500 feet of seam. Sample locations shall be designated by OWNER. Each sample shall be shown on the panel layout drawing. All holes in the installed geomembrane resulting from obtaining samples shall be repaired immediately. The sample ID number shall be marked on the patch. All repairs shall be 100 percent vacuum tested for continuity.
- B. *Maximum frequency of test locations shall be agreed upon by the INSTALLER and OWNER prior to commencement of installation.* Additional test locations, not to exceed agreed upon maximum frequency, shall be determined during seaming at OWNER'S discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds or other potential cause of imperfect welding.
- C. INSTALLER shall not be informed in advance of locations where seam samples will be taken.
- D. Cut samples as seaming progresses in order to obtain documentation test results prior to completion of liner installation. Number each sample and identify sample number and location on panel layout drawing.
- E. Samples shall be 0.4 m (16 in.) wide by 2.1 m (44 in.) long with seam centered lengthwise. Cut one 25 mm (1 in.) wide strip from each end of sample and test in field, by hand or tensiometer, for peel and shear respectively. The tested sample shall not fail through the seam. If tensiometer is not available and if 25 mm (1.0 in.) wide specimen is too difficult to test by hand, 10 mm (0.5 in.) wide specimen is acceptable. Cut remaining sample into 3 parts and distribute as follows.
 1. One portion to INSTALLER for field documentation testing, 0.40 m by 0.38 m (16 in. by 15 in.).
 2. One portion to OWNER independent laboratory testing, 0.40 m by 0.38 m (16 in. by 15 in.) if required.

3. One portion to OWNER for archive storage, 0.40 m by 0.30 m (16 in. by 12 in.).
- F. For field testing, the INSTALLER shall cut 10 identical 1-inch wide replicated specimens from his sample. The INSTALLER shall test five specimens for seam shear strength and five for peel strength. Peel tests shall be performed on both inside and outside weld tracks. To be acceptable four out of five specimens must pass the test criteria with less than 10% separation. The INSTALLER shall submit field documentation test results to the OWNER as soon as they become available, but no later than 2 working days after the sample was taken. Field seams shall meet the minimum specifications of GRI GM 19.

Note: All seams must exhibit a film tear bond (FTB).
- G. All testing equipment required for these quality control tests shall be provided by INSTALLER. Any seams failing the quality control tests shall be repaired at INSTALLER'S expense until passing test results are obtained. At all times, care shall be exercised to avoid damaging the geomembrane.
- H. ENGINEER shall be present for all field documentation testing of seam strength.
- I. INSTALLER shall submit results of test it performs as a result of its quality control assurance program to OWNER.

3.09 PROCEDURES FOR DESTRUCTIVE TEST FAILURE

- A. The following procedures shall apply when sample fails lab destructive test.
 1. Obtain additional destructive test samples at locations approximately 10 feet on either side of the failed test location.
 2. Perform destructive tests.
 3. If test passes, the seam shall be considered adequate.
 4. If tests fail, all seams represented by the original destructive test shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively tested until adequacy of the seams is achieved. Cap strip seams exceeding 150 feet in length shall be destructively tested.
- B. In any case, acceptable seams shall be bounded by 2 passed test locations (i.e., above procedure shall be followed in both directions from original failed location), and one sample for destructive testing shall be taken within reconstructed area.
- C. If sample fails laboratory destructive test (whether conducted by independent laboratory or by INSTALLER'S laboratory), above procedures shall be followed considering laboratory tests exclusively. Since final seam must be bounded by 2 passed test locations, it may be necessary to take one or more new samples for laboratory testing in addition to one required in reconstructed seam area.

3.10 DEFECTS AND REPAIRS

- A. Identification: Broom or wash geomembrane if amount of dust or mud inhibits inspection.
- B. Evaluation: Non-destructively test each suspect location in seam and non-seam areas. Repair each location failing nondestructive testing.
- C. Repair Procedures:
 - 1. Repair defective seams by reconstruction.
 - 2. Repair tears or pinholes by seaming or patching.
 - 3. Repair blisters, larger holes, undispersed raw materials, and contamination by foreign matter with patches.
 - 4. Surfaces of geomembrane to be patched shall be abraded no more than 1 hour prior to repair.
 - 5. Seams used in repairing patches shall be approved extrusion welded seams and may be subjected to same destructive test procedures as outlined for other seams.
 - 6. Patches shall be made of same geomembrane, extend minimum of 150 mm (6 in.) beyond edge of defects, and applied using approved extrusion welding methods only. Report areas of repair to OWNER immediately.
- D. SEAM RECONSTRUCTION PROCEDURES:
 - 1. Seam reconstruction for extrusion welding process shall be achieved by installing a cap strip over the defective weld a minimum of 6 inches either side of the weld and extrusion welding.
 - 2. Seam reconstruction for fusion process shall be achieved by cutting out existing seam and welding in replacement strip, or reseaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process, or welding a cap strip over the defective seam length.
- E. Verification of Repairs: Test each repair non-destructively. Repairs passing nondestructive test shall be taken as indication of adequate repair. Failed tests indicate repair shall be redone and retested until passing test results.

3.11 GEOMEMBRANE ACCEPTANCE

- A. INSTALLER shall retain ownership and responsibility for geomembrane until acceptance by OWNER. Geomembrane liner will be accepted by OWNER when:
 - 1. Written certification letter, including "as-built" drawings, is received by OWNER.
 - 2. Installation of the geomembrane is complete.
 - 3. All required documentation of installation is submitted to OWNER, including inspector's final report.
 - 4. Verification of adequacy of field seams and repairs, including associated testing, is complete and all paperwork accepted and approved by OWNER.
 - 5. The five year material and one-year workmanship warranties are received.

3.12 CLEANUP

- A. The INSTALLER shall place ALL material scraps in OWNER designated area at the end of each working day. Disposal of scraps in the anchor trenches will not be acceptable. No scraps of materials will be allowed to be left on top of liner.
- B. Once liner installation is complete the INSTALLER shall:
 - 1. Remove all sand bags from site; or
 - 2. Remove all sand bags and place in OWNER designated area; or
 - 3. If sand in sand bags is acceptable as a drainage layer material the INSTALLER may empty each bag and remove and dispose of the empty bags. This will only be allowed if the material meets the criteria for a granular drainage layer. The INSTALLER must receive permission from OWNER prior to emptying the sand bags onto the liner.

END OF SECTION

**Certificate of Acceptance of
Geomembrane Subgrade Surface by INSTALLER**

DESCRIPTION OF AREA TO BE CERTIFIED: _____

LOCATION: _____

PROJECT: _____

ADDRESS: _____

The undersigned, _____ certifies that he is a representative of _____, duly authorized to execute this certificate, that he visually inspected the subgrade surface described above on _____ and found the surface to be acceptable for installation of the geomembrane.

This certification is based on observations of the surface of the subgrade only. No sub terrain inspections or tests have been performed and _____ (company) makes no representations or warranties regarding conditions which may exist below the surface of the subgrade.

Date: _____

Signature: _____

Name: _____

Title: _____

CERTIFICATE RECEIVED BY CONTRACTOR CERTIFICATE RECEIVED BY OWNER

Date: _____

Date: _____

Contractor: _____

Company: _____

Name: _____

Name: _____

Signature _____

Signature _____

Title _____

Title: _____

SECTION 02921

GEOTEXTILE

PART 1 - GENERAL

1.01 SUMMARY

Under this section, Work includes manufacture; fabrication (if needed); furnishing; installation of geotextile as shown on the Drawings.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM D3776—Standard Test Method of Mass per Unit Area (Weight) of Fabric
2. ASTM D4491—Standard Test Method for Water Permeability of Geotextiles by Permittivity
3. ASTM D4533—Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
4. ASTM D4632—Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
5. ASTM D4751—Standard Test Method for Determining Apparent Opening Size of a Geotextile
6. ASTM D4833—Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

B. Geosynthetics Research Institute (GRI)

1. GT7 – Determination of Long-Term Design Strength of Geotextiles
2. GT8 - Fine Fraction Filtration Using Geotextile Filters.
3. GT12a – Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials
4. GT13a – Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate

C. Standard Specifications are defined as the "Standard Specifications for Construction", State of Minnesota Department of Transportation, 2020 Edition with latest supplements.

1.03 SUBMITTALS

- ###### **A. Manufacturer's certificates indicating conformance test results of furnished material to Specifications.**

1.04 QUALITY ASSURANCE AND MATERIAL HANDLING

- ###### **A. Roll Identification:**

1. Provide geotextiles in rolls wrapped in relatively impermeable and opaque protective covers and marked or tagged with following information:
 - a. Manufacturer's name
 - b. Product identification
 - c. Lot number
 - d. Roll number
 - e. Roll dimensions
 2. Indicate special handling marked on geotextile itself, e.g., "This Side Up".
 3. Conformance testing to indicated conformance with specifications.
- B. Handle geotextiles in such manner as to insure geotextiles are not damaged.

PART 2 - PRODUCT

2.01 GENERAL

- A. Unless otherwise noted on Drawings, furnish materials whose minimum average roll values as defined by Federal Highway Administration (FHWA), meet or exceed Geotextile Fabric Properties.
- B. Except when specifically authorized, supplier shall not furnish special run or value added products.
- C. Orient polymeric yarns or fibers into stable network to retain relative structure during handling placement, and long-term service.
- D. Unless longer durability is specified, geotextiles shall be capable of withstanding direct exposure to sunlight for 30 days with no measurable deterioration.

2.02 GEOTEXTILE FABRIC MINIMUM PROPERTIES: All properties listed are Minimum Average Roll Values (MARV)

- A. Coarse aggregate wrap and Riprap underlayment (10-ounce geotextile).
 1. Minimum general.
 - a. Nonwoven.
 - b. Polypropylene.
 2. Minimum dimensional.
 - a. Mass/unit area - 10 ounces per square yard (ASTM D3776).
 3. Minimum permeability/filtration.
 - a. Apparent opening size - 100 U.S. Standard Sieve (ASTM D4751).
 - b. Permittivity – 75 gal/min/square foot. (ASTM D4491)
 4. Minimum mechanical.
 - a. Puncture strength - 125 pounds (ASTM D4833) Rounded aggregate
- B. Drainage tubing wrap (4-ounce geotextile).
 1. Minimum general.
 - a. Nonwoven.
 - b. Polypropylene.
 2. Minimum dimensional.

- a. Mass/unit area – 4 ounces per square yard (ASTM D3776).
 - 3. Minimum permeability/filtration.
 - a. Apparent opening size – 70 U.S. Standard Sieve (ASTM D4751).
 - b. Permittivity – 140 gal/min/square foot (ASTM D4491)
 - 4. Minimum mechanical.
 - a. Puncture strength – 65 pounds (ASTM D4833).
- C. Woven Geotextile (reinforcement fabric)
- 1. Shall be a Type 5, Woven, Polypropylene Fabric in accordance with Standard Specifications Section 3733.

PART 3 - EXECUTION

3.01 GEOTEXTILES INSTALLATION

A. General

- 1. On Slopes, roll down slope in such manner as to continually keep geotextile sheet in tension.
- 2. In presence of wind, weight geotextiles with sandbags or equivalent. Install sandbags during placement and keep in place until replaced with cover materials.
- 3. Take necessary precautions to prevent damage to underlying layers during placement of geotextile.
- 4. During placement of geotextiles, care shall be taken not to entrap in geotextile, stones, excessive dust or moisture that could damage geomembrane or hamper subsequent seaming.
- 5. Do not expose geotextiles to precipitation prior to being installed and do not expose to direct sunlight for more than 15 days, unless otherwise specified.

B. Seams and Overlaps:

- 1. On slopes steeper than 10 horizontal/1 vertical, seam geotextiles.
 - a. Seam by sewing, adhesive, fusion or other approved means.
 - b. Continuously seam; do not spot seam.
 - c. Overlap geotextile 6 inches prior to seaming.
 - d. Sew horizontal seams along slope, not across slope.
 - e. Using polymeric thread with properties equal to or exceeding those of geotextile.
- 2. On slope less than 10 horizontal/1 vertical, seam or overlap geotextile.
 - a. Overlap 12 inches.
 - b. Spot seaming when overlapping may be considered as measure against wind uplift.
 - c. Orient overlaps in direction of earth filling.

C. Geotextile Repair:

- 1. On slopes:

- a. Sew fabric patch into place using double sewn lock stitch, seams 1/4 to 3/4 in. apart and no closer than 1 in. from any edge.
 - b. Should any tear exceed 10% of width of roll, remove roll from slope and replace.
2. On nonslopes: A spot seam fabric patch in place with minimum of 24 inch overlap in each direction.
3. Remove soil or other material that may have penetrated torn geotextile.

D. Appurtenances:

1. Install geotextile around appurtenances protruding through geotextile as shown on Drawings.
2. After material is placed and seamed, complete final field seam connection between appurtenance sleeve or shield or geotextile. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geotextile can be accommodated.
3. Care shall be taken while welding around appurtenances since both nondestructive and destructive testing might not be feasible. Do not damage geotextile while making connections to sumps and appurtenances.

END OF SECTION

SECTION 02922

LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE (LLDPE)

PART 1 - GENERAL

1.01 SUMMARY

- A. Work includes manufacture, fabrication (if needed), supply, and installation of textured and smooth Linear Low Density Polyethylene (LLDPE) geomembrane liner system. Textured geomembrane shall have a smooth edge for seaming.

1.02 DEFINITIONS/REFERENCES

- A. American Society for Testing and Materials (ASTM) Standards specifically referenced in this Section:
 - 1. ASTM D6693 Standard Test Method for Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
 - 2. ASTM D751 Standard Test Methods for Coated Fabrics
 - 3. ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
 - 4. ASTM D1004 Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
 - 5. ASTM D1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
 - 6. ASTM D1505 Standard Test Method for Density of Plastics by the Density Gradient Technique
 - 7. ASTM D1603 Standard Test Method for Carbon Black Content in Olefin Plastics
 - 8. ASTM D3895 Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry
 - 9. ASTM D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
 - 10. ASTM D4437 Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
 - 11. ASTM D4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
 - 12. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics
 - 13. ASTM D5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
 - 14. ASTM D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
 - 15. ASTM D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
 - 16. ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
 - 17. ASTM D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
 - 18. ASTM D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes

19. ASTM D6365 Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test
20. ASTM D6747 Standard Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes
21. ASTM D7002 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method
22. ASTM D7007 Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials
23. ASTM D 7238 Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
24. ASTM D7466 Standard Test Method for Measuring Asperity Height of Textured Geomembranes

B. Geosynthetic Research Institute (GRI) Standards:

1. GM 6: Pressurized Air Channel Test for Dual Seamed Geomembranes
2. GM 9: Cold Weather Seaming of Geomembranes
3. GM10: Specification for the Stress Crack Resistance of Geomembrane Sheet.
4. GM17: Test Methods, Properties, and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
5. GM 14: Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
6. GM 19: Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

C. U.S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

1.03 SUBMITTALS

A. The following submittals shall be provided to and approved by OWNER prior to delivery of geomembrane to the site or mobilization of the geomembrane INSTALLER'S crew or equipment:

1. INSTALLER shall supply information from the resin manufacturer regarding the resin type, properties as specified herein, and production dates of the resin used for this project. The resin type identification shall include the cell classification of the resin in accordance with the requirements of the latest ASTM Designation D3350.
2. INSTALLER shall submit from the geomembrane sheet manufacturer, test methods and results defining physical properties as specified herein, of the geomembrane to be used for this project. Test results at the frequency specified in the GRI standards of geomembrane furnished for this project shall be submitted, and test results shall be reported with corresponding roll identification numbers.
3. INSTALLER shall supply a statement of the geomembrane manufacturer's quality control procedures, identification of any resin admixtures, frequency of sampling, methods of material transportation and storage, and acceptance criteria for roll goods delivered to the site.
4. INSTALLER shall provide submittals describing the geomembrane sheet manufacturer's details of any factory seaming process proposed. Roll test results which may not be available prior to construction (i.e., environmental

- stress crack) shall be presented as preliminary prior to construction, with final test results submitted or affected rolls within the construction time frame
5. INSTALLER shall submit from the extrudate weld rod manufacturer, verification that the weld rod was manufactured using the same resin as was used in the geomembrane sheets prior to using material.
 6. INSTALLER shall submit a proposed panel and seam layout diagram specifying the type and location of all field and factory seams. The layout diagram shall be to scale and used as a construction Plan and shall include all necessary dimensions and details. The layout diagram shall be compatible with the panel and seam layout requirements specified in this Section.
 7. INSTALLER shall submit an installation schedule.
 8. INSTALLER shall submit a list of personnel performing field supervision, and quality control, along with experience records and resumes.
 9. INSTALLER shall submit a list of equipment types proposed to be used in panel layout, membrane seaming, and destructive and nondestructive testing.
- B. The INSTALLER shall remit the following during geomembrane Installation:
1. INSTALLER shall, at the end of each working day provide a detailed report of work completed that day, including:
 - a) Panel Placement
 - b) Trial Welds Results
 - c) Subgrade Acceptance Form
 - d) Seams
 - e) Seam Testing (air and vacuum tests)
 - f) Destructive Tests
 - g) Repair Log
 2. OWNER shall review with the INSTALLER and sign the above report at the end of each day. OWNER shall be provided with a copy not more than 24 hours from the date of the report.
- C. INSTALLER shall update their liner layout drawings on a daily basis. The drawings shall include all panel locations and numbering, seam locations and numbering, and test locations and numbering. The INSTALLER shall maintain a current liner layout drawing on the construction site at all times. At the request of OWNER a copy of the current liner layout drawing will be submitted with 24 hours.
- D. INSTALLER shall submit final as-built liner layout drawing(s) to OWNER within 14 calendar days of completion of the liner work. Drawings shall be submitted in paper and digital form.
1. Quality control certificates indicating resin type, properties as specified herein, and production dates shall be provided with each shipment of extrudate rods delivered to the site no later than the time of delivery.
 2. Prior to the installation of any geomembrane, the INSTALLER shall submit INSTALLER'S certification in writing that the surface upon which the geomembrane is to be installed is acceptable (complete form contained at end of this Section).
 3. Submit material delivery and installation schedule for incorporation into the Project schedule.

1.04 EXPERIENCE

- A. The geomembrane installation shall be performed under the direct supervision of a single field supervisor who must remain on-site throughout installation, including inspection of the surface upon which the geomembrane is to be installed, geomembrane handling and storage, panel layout and placement, seaming, seam testing, panel and seam repair, installation of appurtenances, anchorage and other geomembrane-related work. The field supervisor shall have a personal LLDPE or geomembrane installation record totaling at least 1 million square feet.

1.05 Pre-Installation Meeting

- A. Representatives of the INSTALLER shall attend a meeting prior to installation of the geomembrane to discuss details of the proposed design, installation, and schedule.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Raw Materials:

1. Smooth and textured LLDPE geomembrane, and extrudate rods used for this project shall be manufactured of new, first quality resins, designed specifically for use in flexible membrane liner installations.
2. LLDPE resin used in manufacturing geomembranes used for this Project shall meet requirements set forth in the latest revision of the Geosynthetics Research Institute (GRI) GM 17.
3. Recycled Polymer shall not be added to the resin. However, the resin may contain polymer reclaimed during the manufacturing process if reclaimed polymer content does not exceed 10 percent by weight.

B. Geomembrane Roll Goods:

1. LLDPE geomembrane sheets used for this project shall meet the requirements set forth in the latest revision of the Geosynthetics Research Institute (GRI) for LLDPE, both smooth and textured (GRI GM 17).
2. The geomembranes shall consist of unreinforced high density polyethylene containing at a maximum 3 percent by weight additives, fillers, or extenders.
3. The geomembranes shall be free of holes, blisters, striations, undispersed raw material, and contamination by foreign matter.
4. The geomembranes shall be supplied as a continuous sheet with no factory seams in rolls. Each roll shall be identified and labeled with the thickness of the geomembrane, length and width, manufacturer, lot number, and roll identification number. This identification number shall be used to identify roll location on the panel layout record drawing.

- C. Extrudate: Resin used in the polyethylene extrudate shall be the same as that used to manufacture the geomembrane sheets. Extrudate rods are to be delivered in original containers with the manufacturer's labeling. Extrudate rods shall be free of dirt, grease, moisture, other contaminants, and shall be free of damage.
- D. Neoprene Foam: Closed cell, weatherproof, black neoprene foam with adhesive backing suitable for long-term sun and liquid exposure. Dimensions shall be as specified on the DRAWINGS.
- E. Clamped Boots: Boots required to seal the LLDPE geomembrane to the structures passing through it shall be made of the same materials as the geomembrane. The boots shall be fabricated so that all field assembly, welding, and seam testing can be accomplished using equipment and procedures regularly employed in the field for equipment and LLDPE geomembrane installation. Smooth geomembrane shall be used in all geomembrane boots.
- F. Banding Straps: Type 302 stainless steel banding straps suitable for use on the pipe diameters shown on the DRAWINGS. Banding strap dimensions shall be as specified on the DRAWINGS. All surfaces of the banding straps shall be machined smooth to prevent tearing or puncturing of the LLDPE pipe boots. Outer lip of boot shall be sealed with silicone sealant as shown on Drawings.
- G. Bentonite: Bentonite pellets shall be used to fill the annular space between the outer pipe and the gas well pipe at gas well extensions as shown on the Drawings.

2.02 EQUIPMENT

- A. Extruding equipment shall be equipped with a temperature gauge at the barrel and nozzle.
- B. Fusion equipment shall be equipped with a temperature gauge capable of continuous monitoring.
- C. Provide digital or dial continuous temperature recording instruments, in satisfactory working condition, with each welding unit. Welding equipment shall not be operated without functioning temperature recording instruments for measuring geomembrane sheet temperature.
- D. A coupon cutter and a calibrated tensiometer shall be provided for in-field seaming pre-qualification testing and destructive sample testing.
- E. Store, transport, and operate all equipment to avoid damage to geomembranes.
- F. Glass top of each vacuum box must be clear and free of scratches for easy reading of pressure gauge. The sealing gasket shall be intact and functioning to form close seals during testing.
- G. OWNER reserves the right to order the INSTALLER to remove any equipment that in OWNER'S opinion is not satisfactory. The INSTALLER will remove the

equipment promptly from the construction site and replace the unsatisfactory equipment with suitable equipment within 24 hours.

PART 3 - EXECUTION

3.01 SUBGRADE INSPECTION

- A. INSTALLER shall certify in writing that the surface upon which the geomembrane is to be installed is acceptable (acceptance form contained at end of this Section).
- B. INSTALLER shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner during geomembrane installation to ensure subgrade suitability.
- C. After subsurface has been accepted by INSTALLER, it shall be INSTALLER'S responsibility to indicate to CONTRACTOR any change in subsurface conditions that may require repair work and perform required repair work. Damage to subsurface caused by work involved in installing geomembrane shall be repaired at INSTALLER'S expense. Geomembrane placement over damaged subsurface, as determined by ENGINEER or INSTALLER, is not acceptable. Nothing will waive INSTALLER'S and CONTRACTOR'S contractual requirements with respect to warranty on installed system.

3.02 CREST ANCHORAGE SYSTEM

- A. Backfilling of Anchor Trench:
 - 1. Backfill of anchor trench and compact will be performed by the earthwork CONTRACTOR.
 - 2. INSTALLER shall monitor the backfilling of anchor trench to ensure proper method is employed. Any damage noticed shall be reported to OWNER.

3.03 HANDLING, TRANSPORTATION, AND STORAGE

- A. Geomembrane rolls shall be packaged and labeled prior to transporting to the site. Geomembrane rolls delivered to the site shall be wrapped in a relatively impermeable and opaque protective cover which may consist of a sacrificial wrap of geomembrane. The sacrificial wrap shall be removed prior to geomembrane installation.
- B. Geomembrane transportation shall be in a manner that minimizes the possibility of material damage during shipment. When offloading geomembrane from the truck, straps and a spanbar shall be used. Direct contact with forklifts or front end loaders to offload the material will not be allowed without written consent from OWNER.
- C. On-site storage of the geomembrane rolls shall be in a safe manner, with rolls protected from grease, dirt, moisture, excessive heat, direct sunlight, vehicle traffic, and other possible sources of damage including theft and vandalism. The rolls will be placed in neat order and placed such that identification tags

for each roll can be read. Storage areas shall be at the OWNER'S designated location.

- D. Geomembrane and appurtenant materials delivered to the site shall be checked for proper labeling and visually inspected for transport or manufacturing damage. OWNER reserves the right to reject any unacceptable material at no cost to OWNER. Any roll that arrives on site without factory roll identification will not be used for the work and will be removed from the site promptly.
- E. Only that quantity of geomembrane that is to be placed on a particular day shall be removed from the packaging. Geomembrane rolls shall be transported from the storage area to the construction area and deployed using wide lifting straps and properly sized forklifts, front end loaders, or other appropriate equipment.
- F. Under no circumstances shall any heavy equipment be allowed directly on the geomembranes unless approved by OWNER.
- G. Prior to placement, the geomembranes shall be visually inspected for compliance with this Section. Geomembrane material which, in the opinion of the OWNER is damaged or does not meet Specifications will be rejected by the OWNER. Minor damage may be repaired as specified in this Section. Damage to geomembranes caused by INSTALLER during handling shall be repaired or replaced at INSTALLER'S expense.

3.04 PANEL LAYOUT AND PLACEMENT

- A. Panel and Seam Layout Diagram:
 - 1. Prepare panel and seam layout diagram so that panel seams run parallel to the direction of maximum slope (i.e., down the slope).
 - 2. All slopes steeper than or equal to 10H:1V shall use geomembrane textured on both sides, unless specifically identified otherwise on the DRAWINGS. Smooth or textured geomembrane may be used in the leachate collection trench. A single panel should run along the entire length of each trench and be centered about the trench centerline, minimizing seaming and/or repairs within the trench.
 - 3. The textured slope panels shall extend past top or bottom grade-break lines as shown on the DRAWINGS, but no less than ten feet.
 - 5. Slope panels shall not be constructed from more than two pieces of geomembrane (i.e., not more than one cross-seam shall be permitted on any one slope panel).
 - 6. Cross seams in slope panels, where allowed, shall be oriented at 45°. Cross seams shall be located on at least the bottom half of the slope, wherever possible.
 - 7. Cross seams in adjacent panels shall be staggered.
 - 8. Assign identification number to each seam for reference to test results and record Drawings.
 - 9. Seams shall not be located at low points in the subgrade unless required by site geometry and approved by OWNER.

B. PANEL PLACEMENT:

1. Panel size and placement shall be in general accordance with the panel layout diagram submitted to OWNER as defined in this Specification.
2. Geomembrane shall be anchored with sand bags or other approved methods to prevent uplift and damage by wind.
3. A panel identification number shall be assigned to each panel for reference to test results and Record Drawings. The panel identification number and geomembrane roll number shall be written on each panel with a grease pencil, immediately following deployment of the panel.
4. Smoking during placement of panels is prohibited. Wearing damaging shoes or engaging in any behavior which may damage the geomembrane is prohibited.
5. Eating, drinking, disposal of food wraps, drinking bottles and cans on top of geomembrane is not allowed.
6. Place panels with appropriate slack incorporated into geomembrane to accommodate expansion and contraction without jeopardizing the integrity of the geomembrane.
7. Vehicle traffic over geosynthetics as a means of panel deployment is expressly prohibited without the consent of the OWNER.

- C. OWNER and INSTALLER will visually inspect in-place panels prior to seaming. Any damaged panels shall be repaired, and if requested by OWNER, replaced at no additional cost to OWNER. Repairs shall be performed as specified in this Section. All damages and repairs shall be recorded on the Record Drawings.

3.05 SEAMING

- A. Seaming Methods: All seams shall be joined using a heat extrusion or hot fusion (split wedge) weld process in accordance with the geomembrane manufacturer's recommendations. The INSTALLER shall maintain in working order at the site at least one spare seaming apparatus for each type of welder used. The hot fusion weld process will be used whenever possible. The use of extrusion welded seams shall be limited to repairs and any areas or seam configuration inaccessible to fusion welding equipment.
- B. Factory and field seams shall meet the minimum specifications set forth by the latest revision of the GRI GM 19.
- C. Seam Configuration and Preparation:
1. Overlap panels to be seamed at least 3 inches but not more than 6 inches. The loose end of the upper panel shall extend no more than 3 inches from the weld. All seams shall be made in a rainlap manner with the loose end of the upper panel downgradient of potential water flow.
 2. Cross seams on slopes, where allowed, shall be made at a 45 degree angle to the edge of the panel.
 3. The contact area between panels shall be clean and free of moisture, dust, dirt, debris, and foreign material. A protective layer of filter fabric or a sacrificial LLDPE strip shall be used directly beneath each

seam overlap to achieve proper support and a clean work surface, if necessary.

4. Where extrusion welding is used, the contact surfaces between panels shall be ground to remove oxidation prior to welding. Grinding shall not result in grooving of the liner nor reduction of the liner thickness by more than 10 percent. The grinding motion shall be made perpendicular to the seam. Grinding in a direction parallel to the seam shall not be permitted. All ground areas shall be covered completely with extrudate.
5. Seams shall be aligned to minimize the number and size of wrinkles.

D. Test Seam:

1. A prequalification test seam sample shall be prepared with each piece of seaming equipment/seamer approximately every four hours at the beginning of each seaming period (usually morning and afternoon), unless otherwise directed by OWNER. Each sample shall be prepared by the operator of the equipment for that seaming period and shall be at least 6 feet long (in the direction of the seam) by at least 1 foot wide and may be performed on scrap pieces of geomembrane.
2. Six 1-inch wide specimens (coupons) from each test seam sample shall be prepared for on-site field testing for shear and peel strength. Coupons shall be prepared using a sheet cutter so that consistent, uniform 1-inch wide coupons are obtained. Samples should be distributed evenly over the 6 feet length.
3. The INSTALLER will make these test seams in the presence of OWNER.
4. The extension rates for these tests will not exceed 2-inches per minute unless permission from the OWNER is given.
5. Three coupons shall be tested in shear and three in peel. All coupons shall exhibit the required strength at yield and failure mechanism FTB as set forth in *Paragraph 3.05B*. Seam separation equal to or greater than 10% of the track width shall be considered a failing test. If any of the coupons fail, the reason for the failure shall be identified and corrected prior to preparing another test seam. The new test seam shall be prepared reflecting adjustments made to the seamer/seaming equipment and a new set of coupons shall be cut and tested.
6. Seaming equipment shall not be used until satisfactory prequalification test seams have been prepared, witnessed by OWNER.
7. The test results on all prequalification test seams will be reported to OWNER.

E. Climatic Conditions for Seaming:

1. Seaming shall be performed only when panel temperatures are between 32°F and 170°F, unless otherwise approved by OWNER. If seaming is permitted to be performed at panel temperatures below 32°F, the panel contact surface shall be preheated and INSTALLER shall certify in writing that the low-temperature seaming procedures will not cause any short-term or long-term damage to the geomembrane or the welded seam. INSTALLER shall demonstrate to OWNER that field seams comply with project specifications using pre-qualification test seams. INSTALLER shall submit to OWNER, for approval, detailed procedures for seaming at low temperatures, including the following:

- a. Preheating of the geomembrane
 - b. Provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.
 - c. Number of additional test welds to determine appropriate seaming parameters.
 - 2. Seaming during rainy weather or when dew is present on panels shall not be allowed.
 - 3. INSTALLER shall provide any special lighting required for seaming during low-light or dark hours.
 - 4. INSTALLER shall leave slack in the geomembrane as necessary to account for thermal expansion or contraction of geomembrane. Stress on panels due to thermal expansion and contraction shall be minimized by performing field seaming operations during the coolest parts of the day or night, if necessary. Special scheduling or extended hours of operation require approval by OWNER.
- F. All welding shall provide a tight, leak proof, homogeneous bond between panels. All seams shall extend to ends of panels.
- G. Welding equipment shall be continuously monitored to control the temperature of extrudate and wedge. If recording equipment allows for a hard copy of the monitoring, a copy of the monitoring labeled with the weld identification number will be submitted to OWNER.

3.06 PIPE AND STRUCTURE PENETRATION SEALING SYSTEM

- A. Penetration sealing systems shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Drawings.
- B. All penetration sealing systems must be tested. Where field non destructive testing cannot be performed, field spark testing shall be performed using standard holiday leak detectors in accordance with ASTM 6365. Spark testing should be performed in areas where both air pressure testing and vacuum testing are not possible.

3.07 NONDESTRUCTIVE TESTING OF PRODUCTION SEAMS

- A. All field seams shall be non-destructively tested by the INSTALLER over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of test, and outcome of all non-destructive testing shall be recorded and submitted to the OWNER.
- B. Testing shall be done as the seaming work progresses, not at the completion of all field seaming. All defects found during testing shall be numbered and marked immediately after detection. All defects found shall be repaired, retested and remarked to indicated acceptable completion of the repair.
- C. Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods.
- D. Visual Inspection: A visual inspection of all seams shall be performed. This inspection shall look for obvious flaws in seaming patches, penetration

sealing, material defects, or other problems. Deviations from acceptable workmanship standards shall be noted and corrected.

- E. Pressure Testing (Double-Fusion Welds): Where a double-fusion weld seaming system is employed, the continuity of the seam shall be tested with air pressure in accordance with the following procedure. The flow channel must not be obstructed by foreign objects or geomembrane material throughout the length of seam being tested. The vacuum test described in *Paragraph 3.06C* must be employed for testing of all seams that do not have a continuous flow channel.
1. A test device consisting of an inflation needle and pressure gauge mounted on a "T" fitting shall be used for air pressure testing. Insert the needle into the flow channel and seal the end of the channel around the needle. Connect a pump (such as a small bicycle pump) to the test device.
 2. Ascertain that the flow channel is continuous by leaving the other end of the channel open and pumping air through the channel. If air does not pass through the channel the test length must be shortened until a continuous length of flow channel is found.
 3. Seal and clamp both ends of the flow channel to assure an airtight seal. Inflate the flow channel to 25 to 30 psig. Allow one minute for the seam to stabilize.
 4. Re-inflate as needed to achieve 25 to 30 psig on the seam and test for a period of five minutes.
 5. At the end of the test period, if the pressure has not dropped more than 2 psi, the test shall be considered a pass and the following procedure will be implemented;
 - a. Remove the test device and clamps.
 - b. Make any repairs, if necessary, to the area where the flow channel was clamped or inflated.
 - c. Record the test results, mark the seam as a pass, the date tested, and proceed to the next seam.
 6. If the pressure drops below the 2 psi allowance, the test shall be considered a failure and the following procedure shall be implemented to identify the failure:
 - a. Check to determine if there is excessive seepage around the inflation needle.
 - b. Check both ends of the seam to ensure the flow channel is completely sealed off.
 - c. Walk the length of the seam; look and listen for air leaks.
 - d. If either of these procedures fail to identify the leak, trim the seam overlap and vacuum test the seam to locate the leak.
 - e. Once the leak is identified, make the necessary repairs and retest the seam.
 7. Seam to be approved before testing by OWNER; test to be performed in presence of OWNER personnel.
- F. Vacuum Testing: Vacuum testing shall be used to test the continuity of extrusion welded and mechanical seams. A clear topped vacuum box, supplied by INSTALLER, shall be placed over the seam to be tested after application of a soapy solution. Upon evacuation, bubbles will be evident

through the viewing window if the seam lacks integrity. The following procedure shall be followed:

1. Wet seam to be tested with a soapy solution mixed at a ratio of 1 ounce soap to 1 gallon water. No antifreeze solution is allowed to be added to the water.
2. Place vacuum box over seam to be tested, evacuate box to a vacuum equal to 3 to 5 inches water column, and tug up to ensure a leak tight seal has been developed.
3. Examine the seam for 5 to 10 seconds to detect soap bubbles.
4. If the bubbles are not evident, move to next test location. Adjacent test sections are to overlap by at least 1 inch.
5. If bubbles are present, mark area clearly for repair.
6. If the vacuum testing indicates leakage, the area shall be spot patched; or if major leaks are detected, the entire seam shall be reworked.
7. Seam to be approved before testing by OWNER; test to be done in presence of OWNER personnel.

3.08 DESTRUCTIVE TESTING OF PRODUCTION SEAMS

- A. The purpose of destructive testing is to verify that the seaming process has produced seams of acceptable mechanical integrity. One seam sample shall be taken at random for each 500 feet of seam. Sample locations shall be designated by OWNER. Each sample shall be shown on the panel layout drawing. All holes in the installed geomembrane resulting from obtaining samples shall be repaired immediately. The sample ID number shall be marked on the patch. All repairs shall be 100 percent vacuum tested for continuity.
- B. *Maximum frequency of test locations shall be agreed upon by the INSTALLER and OWNER prior to commencement of installation.* Additional test locations, not to exceed agreed upon maximum frequency, shall be determined during seaming at OWNER'S discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds or other potential cause of imperfect welding.
- C. INSTALLER shall not be informed in advance of locations where seam samples will be taken.
- D. Cut samples as seaming progresses in order to obtain documentation test results prior to completion of liner installation. Number each sample and identify sample number and location on panel layout drawing.
- E. Samples shall be 0.4 m (16 in.) wide by 2.1 m (44 in.) long with seam centered lengthwise. Cut one 25 mm (1 in.) wide strip from each end of sample and test in field, by hand or tensiometer, for peel and shear respectively. The tested sample shall not fail through the seam. If tensiometer is not available and if 25 mm (1.0 in.) wide specimen is too difficult to test by hand, 10 mm (0.5 in.) wide specimen is acceptable. Cut remaining sample into 3 parts and distribute as follows.

1. One portion to INSTALLER for field documentation testing, 0.40 m by 0.38 m (16 in. by 15 in.).
 2. One portion to OWNER independent laboratory testing, 0.40 m by 0.38 m (16 in. by 15 in.) if required.
 3. One portion to OWNER for archive storage, 0.40 m by 0.30 m (16 in. by 12 in.).
- F. For field testing, the INSTALLER shall cut 10 identical 1-inch wide replicated specimens from his sample. The INSTALLER shall test five specimens for seam shear strength and five for peel strength. Peel tests shall be performed on both inside and outside weld tracks. To be acceptable four out of five specimens must pass the test criteria with less than 10% separation. The INSTALLER shall submit field documentation test results to the OWNER as soon as they become available, but no later than 2 working days after the sample was taken. Field seams shall meet the minimum specifications of GRI GM 19:
- Note: All seams must exhibit a film tear bond (FTB).
- G. All testing equipment required for these quality control tests shall be provided by INSTALLER. Any seams failing the quality control tests shall be repaired at INSTALLER'S expense until passing test results are obtained. At all times, care shall be exercised to avoid damaging the geomembrane.
- H. ENGINEER shall be present for all field documentation testing of seam strength.
- I. INSTALLER shall submit results of test it performs as a result of its quality control assurance program to OWNER.

3.09 PROCEDURES FOR DESTRUCTIVE TEST FAILURE

- A. The following procedures shall apply when sample fails lab destructive test.
1. Obtain additional destructive test samples at locations approximately 10 feet on either side of the failed test location.
 2. Perform destructive tests.
 3. If test passes, the seam shall be considered adequate.
 4. If tests fail, all seams represented by the original destructive test shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively tested until adequacy of the seams is achieved. Cap strip seams exceeding 150 feet in length shall be destructively tested.
- B. In any case, acceptable seams shall be bounded by 2 passed test locations (i.e., above procedure shall be followed in both directions from original failed location), and one sample for destructive testing shall be taken within reconstructed area.
- C. If sample fails laboratory destructive test (whether conducted by independent laboratory or by INSTALLER'S laboratory), above procedures shall be followed considering laboratory tests exclusively. Since final seam must be bounded by 2 passed test locations, it may be necessary to take one or more new

samples for laboratory testing in addition to one required in reconstructed seam area.

3.10 DEFECTS AND REPAIRS

- A. Identification: Broom or wash geomembrane if amount of dust or mud inhibits inspection.
- B. Evaluation: Non-destructively test each suspect location in seam and non-seam areas. Repair each location failing nondestructive testing.
- C. Repair Procedures:
 - 1. Repair defective seams by reconstruction.
 - 2. Repair tears or pinholes by seaming or patching.
 - 3. Repair blisters, larger holes, undispersed raw materials, and contamination by foreign matter with patches.
 - 4. Surfaces of geomembrane to be patched shall be abraded no more than 1 hour prior to repair.
 - 5. Seams used in repairing patches shall be approved extrusion welded seams and may be subjected to same destructive test procedures as outlined for other seams.
 - 6. Patches shall be made of same geomembrane, extend minimum of 150 mm (6 in.) beyond edge of defects, and applied using approved extrusion welding methods only. Report areas of repair to OWNER immediately.
- D. SEAM RECONSTRUCTION PROCEDURES:
 - 1. Seam reconstruction for extrusion welding process shall be achieved by installing a cap strip over the defective weld a minimum of 6 inches either side of the weld and extrusion welding.
 - 2. Seam reconstruction for fusion process shall be achieved by cutting out existing seam and welding in replacement strip, or reseaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process or welding a cap strip over the defective seam length.
- E. Verification of Repairs: Test each repair non-destructively. Repairs passing nondestructive test shall be taken as indication of adequate repair. Failed tests indicate repair shall be redone and retested until passing test results.

3.11 GEOMEMBRANE ACCEPTANCE

- A. INSTALLER shall retain ownership and responsibility for geomembrane until acceptance by OWNER. Geomembrane liner will be accepted by OWNER when:
 - 1. Written certification letter, including "as-built" drawings, is received by OWNER.
 - 2. Installation of the geomembrane is complete.
 - 3. All required documentation of installation is submitted to OWNER, including inspector's final report.
 - 4. Verification of adequacy of field seams and repairs, including associated testing, is complete and all paperwork accepted and approved by OWNER.

5. The five year material and one-year workmanship warranties are received.

3.12 CLEANUP

- A. The INSTALLER shall place ALL material scraps in OWNER designated area at the end of each working day. Disposal of scraps in the anchor trenches will not be acceptable. No scraps of materials will be allowed to be left on top of liner.
- B. Once liner installation is complete the INSTALLER shall:
 1. Remove all sand bags from site; or
 2. Remove all sand bags and place in OWNER designated area; or
 3. If sand in sand bags is acceptable as a drainage layer material the INSTALLER may empty each bag and remove and dispose of the empty bags. This will only be allowed if the material meets the criteria for a granular drainage layer. The INSTALLER must receive permission from OWNER prior to emptying the sand bags onto the liner.

END OF SECTION

**Certificate of Acceptance of
Geomembrane Subgrade Surface by INSTALLER**

DESCRIPTION OF AREA TO BE CERTIFIED: _____

LOCATION: _____

PROJECT: _____

ADDRESS: _____

The undersigned, _____ certifies that he is a representative of _____, duly authorized to execute this certificate, that he visually inspected the subgrade surface described above on _____ and found the surface to be acceptable for installation of the geomembrane.

This certification is based on observations of the surface of the subgrade only. No sub terrain inspections or tests have been performed and _____ (company) makes no representations or warranties regarding conditions which may exist below the surface of the subgrade.

Date: _____

Signature: _____

Name: _____

Title: _____

CERTIFICATE RECEIVED BY CONTRACTOR CERTIFICATE RECEIVED BY OWNER

Date: _____

Date: _____

Contractor: _____

Company: _____

Name: _____

Name: _____

Signature _____

Signature _____

Title _____

Title: _____

SECTION 02924
GEONET GEOCOMPOSITE

PART 1 - GENERAL

1.01 SUMMARY

A. Description of System

1. Work includes manufacture, fabrication (if needed), supply, and installation of the Geonet Geocomposite in the final cover System.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM) Standards:

1. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
2. ASTM D1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
3. ASTM D1505 – Standard Test Method for Density of Plastics by the Density Gradient Technique
4. ASTM D1603 – Standard Test Method for Carbon Black Content in Olefin Plastics
5. ASTM D4491 – Standard Test Methods for Water Permeability of Geotextiles by Permittivity
6. ASTM D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
7. ASTM D4716 – Standard Test Method for Determining the (In plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
8. ASTM D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile
9. ASTM D4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
10. ASTM D5035 – Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
11. ASTM D5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles
12. ASTM D7005 – Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites
13. ASTM D7179 – Standard Test Method for Determining Geonet Breaking Force

1.03 SUBMITALLS

A. Raw Materials

1. Copy of quality control certificates issued by HDPE resin supplier.
2. Production date(s) of HDPE resin.
3. Statement that no reclaimed polymer added to resin during manufacture of Geonet for this project.

B. Copy of quality control certificates for each roll. The certificates to include:

1. Manufacturer's name.
2. Product identification.
3. Lot number.
4. Roll number.
5. Roll dimensions.
6. Installation layout, certifying placement patterns and seams delivery, storage, and handling.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Transportation

1. Handle rolls by appropriate means to prevent damage from occurring.

B. On-Site Storage

1. Storage of geonet geocomposite shall be INSTALLER'S responsibility.
2. Protect geonet geocomposite from damage, maintain roll package integrity, and keep rolls out of water, mud or dust. Geonet geocomposite that becomes clogged or damaged may be repaired or replaced at INSTALLER'S expense.

1.05 SEQUENCING AND SCHEDULING

A. Submit material delivery and installation schedule for incorporation into the Project schedule.

PART 2 - PRODUCTS

2.01 GEOCOMPOSITE

A. The geocomposite shall consist of an HDPE drainage net heat bonded to two layers (sandwiched) of geotextiles to create double-sided geocomposite. The geotextiles shall extend a minimum of 6 inches beyond the edges of drainage net on both sides of the geocomposite roll. The geotextile shall not be bonded to the drainage net within 6 inches from the edges of the rolls.

B. The compound of the geocomposite rolls shall meet the following specifications:

1. Drainage Net.

The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide for planar flow. The drainage net shall be manufactured of polyethylene resin produced in the United States and compounded and manufactured specifically for the intended application. The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.940 – 0.955
Melt Index, g/10 min.	ASTM D 1238 Condition E	< 1.0

Labels on each roll shall identify the thickness of the material, the width and length of the roll, lot and roll numbers, and name of the manufacturer. The drainage net rolls shall meet the requirements specified below.

Drainage Net Material Properties

Property	Test Method	English Units	Metric Units
Density, min.	ASTM D 1505	0.940 g/cc	0.940 g/cc
Carbon Black Content, min.	ASTM D 1603	2%	2%
Tensile Strength (MD)	ASTM D 5035 or ASTM D7179	45 lb/in	7.9 kN/m
Thickness		0.2 inches	200 mil

2. Geotextile.

The geotextile heat bonded to each side of the drainage net shall be an 8 oz/s.y. geotextile meeting the following requirements:

Geotextile Material Properties

Property	Test Method	English Units	Metric Units
Unit Weight	ASTM D 5261	8 oz/yd ²	271 g/m ²
Grab Tensile	ASTM D 4632	203 lb	900 N
Puncture	ASTM D 4833	120 lb	535 N
AOS	ASTM D 4751	80 sieve	.180 mm
Flow Rate	ASTM D 4491	95 gal/min. ft ²	3,870 L/min.m ²

3. Geocomposite.

The complete geocomposite shall meet the following properties:

Property	Test Method	English Units	Metric Units
Transmissivity, (MD), (1)/metal plate	ASTM D 4716	2.4 gal/min/ft.	5 x10 ⁻⁴ m ² /sec
Ply Adhesion, lb/in	ASTM D 7005	1 lb/in.	1.75 N/cm

NOTE 1: This hydraulic transmissivity shall be determined at a minimum compressive stress of 15,000 lbs/ft² (714 KPA), a minimum hydraulic gradient of .1, and a minimum test duration long enough to equalize flow. The hydraulic transmissivity test shall be performed with a metal plate against one boundary of the geonet geocomposite and a metal plate against the other.

PART 3 - EXECUTION

3.01 GEOCOMPOSITE HANDLING AND PLACEMENT

A. The INSTALLER shall handle all geocomposites in such a manner as to ensure the geocomposites are not damaged in any way. Comply with the following:

1. On slopes, the geocomposites shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the drainage net sheet in tension. If necessary, the geocomposites shall be positioned by hand after being unrolled to minimize wrinkles. Geocomposites can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., if an extra layer of geocomposite is required at the toe of a slope, this extra layer of geocomposite can be placed in the horizontal direction).
2. In the presence of wind, all geocomposite shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with overlying material.
3. The INSTALLER shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.
4. During placement of geocomposite, care shall be taken not to entrap in the geonet, dirt or excessive dust that could cause clogging of the geocomposite and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it shall be hosed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags to prevent rupture or damage of the sandbag.
5. Care shall be taken not to leave tools on or in the geocomposite.
6. Orient seams of fabric covering to overlap in the direction of earth filling.

3.02 TACKING AND JOINING

A. Adjacent geonet geocomposite panels shall be joined according to INSTALLER'S panel drawings and specifications. As a minimum, the following requirements will be met:

1. Adjacent rolls shall be overlapped by at least 4 inches.
2. Geonet overlaps shall be secured by tying.
3. Tying shall be achieved by strings, plastic fasteners, or polymer braid. Tying devices shall be white or yellow for easy observation. Metallic devices are not allowed.
4. Tying shall be every 5 ft along the slope greater than 5 percent, every 2 feet across the slope, and every 6 inches in the anchor trench. Tying shall be every 10 feet on slopes less than 5 percent.

5. In the corners of the side slopes of rectangular landfills, where overlaps between perpendicular geonet geocomposite strips are required, an extra layer of geonet geocomposite shall be unrolled along the slope, on top of the previously installed material, from top to bottom of the slope.
6. The fabric covering on the geonet shall be heat sealed (leistered) or stitched to adjacent panels to prevent foreign material from entering the geonet.
7. At bottom, minimum overlap shall be 2 inches in a shingle configuration.

3.03 GEOCOMPOSITE REPAIR

- A. Any holes or tears in the geocomposite shall be repaired by placing a patch extending 24 inches beyond edges of hole or tear with the same geocomposite. The patch shall secure the replacement geonet in place every 6 inches or a minimum of 4 nylon cable ties, whichever is greater, to the original geonet. The geotextile portion of the patch shall be adhered to the original geotextile using approved thermal bonding techniques.
- B. If a hole or tear exceeds 50% of the roll width, remove and replace panel.

3.04 CLEANUP

- A. The INSTALLER shall place ALL material scraps in ENGINEER designated area at the end of each working day. Disposal of scraps in the anchor trenches will not be acceptable. No scraps of materials will be allowed to be left on top of the geonet geocomposite.
- B. Once liner installation is complete the INSTALLER shall:
 1. Remove all sand bags from site; or
 2. Remove all sand bags and place in ENGINEER designated area; or
 3. If sand in sand bags is acceptable as cover soil material the INSTALLER may empty each bag and remove and dispose of the empty bags. This will only be allowed if the material meets the criteria for the rooting zone layer. The INSTALLER must receive permission from ENGINEER prior to emptying the sand bags onto the geonet geocomposite.

END OF SECTION

SECTION 15064

HIGH DENSITY POLYETHYLENE PIPE

PART 1 - GENERAL

1.01 SUMMARY

- A. Work under this section includes leachate gravity drain and leachate forcemain piping.
- B. Extent of pipe and fittings required by this section indicated on Drawings.

1.02 REFERENCES

- A. American Water Works Association (AWWA).
- B. American Society for Testing and Materials (ASTM):
 - 1. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.
 - 2. ASTM D790 – Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - 3. ASTM D1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
 - 4. ASTM D1248 – Standard Specification for Polyethelene Plastics and Extrusion Materials for Wire and Cable
 - 5. ASTM D1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique.
 - 6. ASTM D1693 – Standard Test Method for Environmental Stress Cracking of Ethylene Plastics.
 - 7. ASTM D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
 - 8. ASTM D3350 - Standard Specification for Polyethelene Plastics Pipe and Fittings Material.
 - 9. ASTM D2122 - Standard Test Method of Determining Dimensions of Thermoplastic Pipe and Fittings.
 - 10. ASTM D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
 - 11. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 - 12. ASTM F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
 - 13. ASTM F1473 – Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins

1.03 SUBMITTALS

- A. Manufacturer's certificates indicating conformance test results of furnished material to Specifications.
- B. Provide information where applicable as follows:
 - 1. Manufacturer's name.
 - 2. Nominal pipe size.
 - 3. High density polyethylene (HDPE) classification, ASTM D3350.
 - 4. Use for each type and size of pipe.
 - 5. Extrusion date.
 - 6. Lot number.
- C. Stock density, melt flow, flexural modulus tensile strength, coloration, resin type and cell classification where applicable.
- D. Provide instructions on special handling during transportation and storage.
- E. Aforementioned submittals provided to OWNER a minimum of 30 days prior to beginning work on Project.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Handle and protect product to ensure product is not damaged.
- B. Elevate material above grade.
- C. Store and handle in such a manner as to prevent soil from entering or becoming lodged in the pipe.
- D. Provide protection for flanges and fittings by storing inside or packaging with impermeable opaque material.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS/SUPPLIERS

- A. Substitutions: Others as approved by OWNER.
- B. Physical Properties - Dimensions as shown on Drawings.

Property	Specification ID	Specification
Density	ASTM D1505	Greater than 0.940 gms/cm ³
Melt Flow	ASTM D1238 – Condition E	not greater than 0.15 gm/10 min
Flexural Modulus	ASTM D790	Greater than 110,000 psi
Tensile Strength at Yield	ASTM D638	Greater than 3,000 psi
Environmental Stress Crack Resistance	ASTM F1473	Shall be in excess of 100 hrs
Hydrostatic Design Basis	ASTM D2837	1,600 psi at 23°C

- C. Pipe
 - 1. Acceptable Manufacturers:
 - a. Phillips Driscopipe, Inc., Dallas, Texas.
 - b. Poly Pipe Industries, Gainesville, Texas.
 - c. Or approved equal.
 - 2. High performance, high molecular weight, high density polyethylene pipe.
 - 3. ASTM D3350, minimum cell classification value 345464C.
 - 4. Marking: Intervals of 5 feet or less.
 - a. Manufacturer's name or trademark.
 - b. Nominal pipe size.
 - c. HDPE cell classification, ASTM D3350.
 - d. Legend: Industrial pipe SDR as indicated on Drawings.
 - e. ASTM F714.
 - f. Extrusion date, period of manufacturer or lot number.
 - 5. Perforated pipe perforated in field.
 - a. Pattern as shown on Drawings.
- D. Fittings
 - 1. Molded from polyethylene compound having cell classification equal or exceeding compound used in pipe to insure compatibility of resins.
 - 2. Be of same manufacturer as pipe.
 - 3. Fusion weld joints.
 - 4. Markings:
 - a. Manufacturer's name or trademark.
 - b. Nominal size.
 - c. Material designation "HDPE".
 - d. ASTM D3261.

PART 3 - EXECUTION

3.01 EXECUTION

- A. Examine and verify acceptability of surface to receive product.

3.02 HDPE PIPE INSTALLATION

- A. Location, lines, and grades as shown on Drawings.
- B. Welded joints.
 - 1. Weld in accordance with manufacturer's recommendations for butt fusion methods.
 - 2. Butt fusion equipment used in joining procedures capable of meeting conditions recommended by manufacturer, including, but not limited to: temperature required, alignment, and fusion pressures.
- C. No defective pipe shall be installed. Defective pipe shall be removed from site and replaced at CONTRACTOR'S expense.

- D. Install coarse aggregate and granular bedding as shown on Drawings and without damage to the geomembrane liner or geonet geocomposite.
- E. Attach HDPE flatstock with the following:
 - 1. Continuously weld to pipe and configure such that it will have full bearing contact onto sump bottom.
 - 2. Round edges of flatstock to prevent damage to underlying geosynthetics.
 - 3. Groove bottom of flatstock to provide smooth bottom.

3.03 EXCAVATION AND PREPARATION OF SUBGRADE

- A. Excavate and prepare subgrade as specified in Section 02211 and Section 02220 and as shown on Drawings.

3.04 BACKFILL

- A. Backfill with required pipe bedding and cover material to spring line of incoming pipe as shown on Drawings.

3.05 FIELD QUALITY CONTROL

- A. Pipe may be rejected for failure to conform to specification, or:
 - 1. Fractures or cracks passing through pipe wall, except single crack not exceeding 2 inches in length at either end of pipe which could be cut off and discarded. Pipes within one shipment will be rejected if defects exist in more than 5 percent of shipment or delivery.
 - 2. Cracks sufficient to impair strength, durability or serviceability of pipe.
 - 2. Defects indicating improper proportioning, mixing, and molding.
 - 3. Damaged ends, where damage would prevent making satisfactory joint.
 - 5. Noticeable variations from true alignment and grade sufficient cause for rejection of Work.
- B. Acceptance of fittings, stubs or other specially fabricated pipe sections based on visual inspection at site and documentation that they conform to these specifications.
- C. Pressure test forcemain pipe in accordance with Section 02615

3.06 GAS HEADER IDENTIFICATION AND DOCUMENTATION

- A. For identification of underground header provide the following:
 - 1. Trace wire; #2 copper wire, insulated.
 - 2. Place above pipe in pipe bedding along entire pipeline length.

END OF SECTION

**PINE BEND LANDFILL
CONSTRUCTION QUALITY ASSURANCE
PROGRAM**

MPCA Permit SW-45

April 29, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55363

Project Number:
227704792



Table of Contents

1	INTRODUCTION	1-1
2	FOUNDATION AND BERMS	2-1
2.1	General	2-1
2.2	Material Quality Control	2-1
2.3	Observation and Documentation	2-1
2.4	Testing	2-1
2.5	Survey.....	2-1
3	LOW PERMEABILITY SOIL LINER	3-1
3.1	General	3-1
3.2	Material Quality Control	3-1
3.3	Subgrade	3-1
3.4	Observation And Documentation	3-1
3.5	Testing	3-2
3.6	Damage And Repair	3-3
3.7	Survey.....	3-4
3.8	Conformance with Project Specifications	3-4
4	GEOSYNTHETIC CLAY LINER.....	4-1
4.1	General	4-1
4.2	Material Quality Control	4-1
4.2.1	Raw Material	4-1
4.2.2	Final Product	4-1
4.3	Subgrade	4-1
4.4	Observations and Documentation	4-2
4.4.1	Roll Inspections	4-2
4.4.2	Installation Equipment	4-2
4.4.3	Placement.....	4-2
4.4.4	Crest Anchorage System.....	4-2
4.4.5	Field Seaming.....	4-2
4.4.6	Damage and Repair	4-2
5	GEOMEMBRANE	5-1
5.1	General	5-1
5.2	Material Quality Control	5-1
5.2.1	Raw Material	5-1
5.2.2	Geomembrane Material Specifications	5-1
5.3	Subgrade	5-1
5.4	Observations and Documentation	5-2
5.4.1	Roll Inspections	5-2
5.4.2	Placement.....	5-2
5.4.3	Trial Seams	5-3
5.4.4	Field Seaming.....	5-3
5.5	Testing	5-4
5.5.1	Nondestructive Seam Continuity Testing	5-4
5.5.2	Destructive Testing.....	5-5
5.5.3	Field Testing	5-6
5.5.4	Laboratory Testing.....	5-6



5.5.5	Procedures for Destructive Test Failure	5-7
5.6	Defect and Repairs	5-7
5.6.1	Evaluation	5-8
5.6.2	Repair Procedures	5-8
5.6.3	Verification of Repairs	5-8
5.7	Final Acceptance	5-8
5.8	Conformance With Project Specifications	5-9
6	GRANULAR DRAINAGE MEDIA	6-1
6.1	General	6-1
6.2	Material Quality Control	6-1
6.3	Observation And Documentation	6-1
6.4	Testing	6-1
6.5	Damage And Repairs	6-1
6.6	Survey.....	6-1
6.7	Conformance With Project Specifications	6-2
7	PIPING SYSTEMS	7-1
7.1	General	7-1
7.2	Material Quality Control	7-1
7.3	Observation And Documentation	7-1
7.3.1	Installation	7-1
7.3.2	Pressure Testing	7-1
7.4	Damage And Repairs	7-2
7.5	Survey.....	7-2
7.6	Conformance With Project Specifications	7-2
8	DOCUMENTATION REPORT AND RECORD DRAWINGS	8-1

TABLES

1	System Grading Tolerances
2	Soils Quality Assurance Testing Requirements
3	Geomembrane Quality Assurance Testing Requirements



1 Introduction

This manual outlines Construction Quality Assurance (CQA) procedures for the construction of MSW landfill Phase 6 at the Pine Bend Landfill (PBL), owned and operated by BFI Waste Systems of North America, LLC (BFI). This manual addresses survey, soil, piping, and geomembrane components of the leachate collection, liner and cover systems, and is to be used as the basis of the overall CQA program.

The overall goal of this construction quality assurance program is to ensure that proper construction techniques and procedures are used and to verify that the materials and installation techniques used meet the project design requirements. At completion of the work, the program will culminate in a certification report which documents that the project has been constructed in accordance with design standards and specifications.



2 Foundation and Berms

2.1 General

The foundation and berms serve as the components on which the liner system is constructed.

2.2 Material Quality Control

Material for foundation and berms may either be on-site or imported, depending on use and material availability. Testing may be required prior to use, depending on the source and the designated use.

2.3 Observation and Documentation

No unsuitable material will be used in structural berms or in the subgrade of the liner system. Construction activities will be documented. The contractor shall document the grades and elevations after surface preparation.

2.4 Testing

The material will be tested in accordance with the project requirements. The surface will be prepared to be capable of supporting construction of the overlaying layers.

2.5 Survey

The survey of specific locations will provide the basis for record drawings. The survey will be performed by a qualified land surveyor. The survey will be conducted on a grid and at major breaks. Grading tolerances are provided in Table 1.



3 Low Permeability Soil Liner

3.1 General

The low permeability soil liner serves as the earthen barrier in a base liner system. This layer is often referred to as the clay barrier layer.

3.2 Material Quality Control

Samples of the material will be tested for USCS classification, moisture density relationship, and hydraulic conductivity. Testing parameters and frequencies are listed in Table 2.

3.3 Subgrade

The CONTRACTOR shall be responsible for preparing the soil liner, including scarifying and recompacting the existing clay barrier layer. Once complete, the ENGINEER shall examine the surface and verify the adequacy of the survey data provided. When the ENGINEER deems the surface acceptable, the ENGINEER shall prepare an acceptance certificate for the Owner. The acceptance certificate shall state the following at a minimum:

1. A qualified land surveyor has done the required survey and the results meet the specifications
2. The subgrade has been tested and meets the project requirements.

At any time during construction of the soil liner, the ENGINEER shall inform the Owner of any areas that are unacceptable. Such defects in the subgrade shall be corrected by the CONTRACTOR such that repaired areas meet the project specifications.

3.4 Observation And Documentation

The ENGINEER shall document the following during the construction of the soil liner:

Excavation: The ENGINEER shall document the slope and the depth of the excavation and document that the subgrade surface meets specification.

Borrow Sources: For each borrow source (if applicable) the ENGINEER shall document the following:

- Location;
- Description of soil;
- Moisture-density-hydraulic conductivity relationship;
- Removal of deleterious or off-specification material;
- Placed and compacted volume of soil.

The laboratory test requirements are given in Table 2.



Compaction: The following will be documented during compaction of the soil:

- Type and weight of compaction equipment;
- Method of surface preparation;
- Method of adjusting soil moisture and controlling desiccation;
- Compacted lift thickness;
- General number of passes and uniformity of coverage;
- Reduction in clod size;
- Repair;
- Observation of the thickness of lifts as loosely placed and as compacted;
- Observation of the action of the compaction and heavy hauling equipment on the construction surface (sheepsfoot penetration, pumping, cracking, etc.);
- Verification that all frozen soil is removed prior to placement of subsequent material;
- Verification that frozen soil is not placed.

3.5 Testing

Laboratory test methods and frequencies to develop data upon which acceptability evaluations can be based will be as provided in Table 2. Permeability tests shall be performed on remolded samples in order to establish the moisture-density-permeability characteristics of the soil.

Soil liner material will be thoroughly and uniformly compacted at a moisture content that is greater than or equal to optimum and shall be compacted to greater than or equal to 95% of standard proctor as outlined in the project specifications. Each lift will be integrated into the previous lift by techniques such as scarifying each lift and by using compaction equipment that is capable of penetrating the thickness of each compacted lift, except that such a compactor shall not be used in the first 2 lifts immediately above the synthetic liner, secondary collection system, or other sensitive liner system component.

CONTRACTOR shall compact with sheepsfoot roller, or similar kneading-type compactor. The feet of the compactor shall be greater than the thickness of each lift. CONTRACTOR shall compact the layers of clay to form continuous monolithic material with excessively dry or wet soil removed before placement of additional lifts; knead each lift into previously placed lift. Nuclear density methods will be preferred for moisture and density testing due to the ease of testing and the relatively large number of tests which can be run in a given period of time. Questions concerning the accuracy of any single test will be addressed by retesting in the same location until a passing test is obtained.

Final surface shall be smooth-rolled prior to geosynthetic placement. Finished surface will be smooth and even with no sheepsfoot roller indentations. Surface must be smooth and free of debris, roots, and stones or rocks larger than 3/8 inch in diameter or angular stone of any size or any other material that would be deleterious to the overlying geomembrane liner. CONTRACTOR shall be responsible for the integrity of the clay liner and shall not allow the surface to dry or desiccate. CONTRACTOR shall maintain the sub-base in an acceptable condition and make repairs, as needed, until the geosynthetic materials are placed, tested, and approved by the Owner.

CQA testing will be conducted on samples taken from the material during the course of construction. Sampling locations will be selected by ENGINEER according to the number of required tests. Locations of tests will be documented for report purposes.



A special testing frequency will be used when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- Lift thickness is greater than specified;
- Earthfill is at variable moisture content;
- Dirt-clogged rollers are used to compact the material;
- Rollers may not have used optimum ballast;
- The degree of compaction is questionable.

During construction, the frequency of testing may also be increased in the following situations:

- Adverse weather conditions;
- Breakdown of equipment;
- At the start and finish of grading;
- Material fails to meet specifications;
- The size of the work area is increased.

Perforations in the soil liner will occur during construction due to in-place testing. The perforation would be caused by:

1. Nuclear density test probe locations.
2. Permeability sampling locations.

Unless otherwise directed by the ENGINEER or Owner, all perforations of the soil liner by probe or sample tube shall be backfilled with a soil-bentonite mixture. The mixture shall be compacted in-place with a tamping rod, or hand tamper, depending on the size of the perforation.

Hydraulic conductivity testing will be performed at the frequencies provided in Table 2. The test locations will be on a grid that will maximize the coverage of the construction area, or as directed by the ENGINEER to test suspect areas. Soil density and moisture content will be documented for each lift on an offset grid to provide adequate coverage of the construction.

3.6 Damage And Repair

Should the clay barrier layer become damaged during construction, the unsuitable material will be removed. The Owner may choose to either; replace the removed material with native fill and document the grades; or, replace the material with the same material used in the soil liner documenting the additional thickness in the affected area.

Areas of the soil liner that become damaged due to precipitation or desiccation will be reworked and retested until satisfactory results are obtained. If it appears unlikely to correct the damage by reworking the soil, the affected area will be removed, replaced, and tested.



3.7 Survey

The survey of specific locations will provide the basis for the record drawings and provide documentation of soil liner thicknesses. The survey will be performed by a qualified LAND SURVEYOR. The major components of the survey will include the following at a minimum:

1. Top of subgrade.
2. Top of soil liner.

The survey will be conducted on a grid with survey points at major breaks in slope (i.e., top and toe of slope) and top and base of sumps. The grid will be extended vertically to enable calculation of vertical thicknesses of the liner or cover component. Grading tolerances are provided in Table 1.

3.8 Conformance with Project Specifications

The ENGINEER shall document that the clay liner installation was done in accordance with the project specifications.



4 Geosynthetic Clay Liner

4.1 General

A geosynthetic clay liner (GCL) is used as the earthen barrier layer in a composite base liner. This section applies to a GCL which consists of a sodium bentonite core encapsulated by a geotextile.

4.2 Material Quality Control

4.2.1 RAW MATERIAL

The GCL shall be manufactured with geotextile on each side of the bentonite. The bentonite shall meet the manufacturer's specifications as outlined by the GCL supplier for each batch of material. The material test reports on each batch shall accompany each roll.

4.2.2 FINAL PRODUCT

The GCL shall be tested to conform to the manufacturer's specifications. The GEOSYNTHETIC MANUFACTURER shall provide the ENGINEER with all GCL product certification sheets with each roll delivered to the site.

The ENGINEER shall examine the results and report any nonconformance to the Owner. QC results shall be reviewed and accepted or rejected by the ENGINEER prior to deployment.

4.3 Subgrade

When the GCL is placed on the clay barrier layer, the CONTRACTOR shall be responsible for preparing the clay for the GCL. Once complete, the ENGINEER shall examine the surface, and verify the adequacy of the survey data provided. When the ENGINEER deems the surface acceptable, the ENGINEER shall prepare an acceptance certificate for the Owner. The acceptance certificate shall state the following at a minimum:

1. The required survey has been performed by a qualified land surveyor and the results meet the specifications.
2. The subgrade has been tested and meets the project requirements.

At any time during construction of the soil liner, the ENGINEER shall inform the Owner of any areas which are unacceptable. Such defects in the subgrade shall be corrected by the appropriate contractor such that repaired areas meet the project specifications.



4.4 Observations and Documentation

4.4.1 ROLL INSPECTIONS

Prior to placement of the GCL, rolls shall be observed for defects by both the ENGINEER and the GEOSYNTHETIC INSTALLER. Rolls shall be wrapped in an impermeable, opaque cover material to prevent premature hydration and protect the rolls from UV radiation. Additional covering may be necessary during heavy precipitation events.

Each roll shall have a roll label which clearly identifies all standard manufacturer's information. This information should include: manufacturer's name, type of material, thickness, batch, date of fabrication, and physical dimensions. This information shall be recorded by the ENGINEER for each roll.

4.4.2 INSTALLATION EQUIPMENT

The GEOSYNTHETIC INSTALLER shall use equipment that will not damage the GCL or subgrade by handling, trafficking, excessive heat, and leakage of oils or other means.

4.4.3 PLACEMENT

The GEOSYNTHETIC INSTALLER shall cover the GCL each night with the overlying liner to prevent hydration of the GCL. No material shall be placed in areas of ponded water or excessively wet subgrade. If any material becomes hydrated it shall be removed and replaced.

The GEOSYNTHETIC INSTALLER shall inspect liner material for defects or flaws after installation.

4.4.4 CREST ANCHORAGE SYSTEM

The anchor trench is typically excavated by the CONTRACTOR according to the approved drawings. The GCL shall be placed in the anchor trench and the trench shall be backfilled and compacted by light compaction equipment to the required grade.

4.4.5 FIELD SEAMING

The GEOSYNTHETIC INSTALLER shall overlap the GCL panels edges as specified by the manufacturer. The overlap shall be inspected by the ENGINEER to ensure proper length of overlap. The GEOSYNTHETIC INSTALLER shall overlap the GCL panel roll in accordance with the manufacturer's specifications. All seaming shall conform to the manufacturer's installation specifications.

4.4.6 DAMAGE AND REPAIR

Areas of flaws or damage shall be repaired by the GEOSYNTHETIC INSTALLER. Repairs shall be made by placement of a patch of the same materials at least 1 foot beyond the edge of the flaw or damage. The GEOSYNTHETIC INSTALLER shall ensure that the patch conforms with the manufacturers installation specifications.



5 Geomembrane

5.1 General

Geomembranes are the geosynthetic component of the composite base lining system. This section is applicable to the High-Density Polyethylene (HDPE) geomembranes used in base liner system.

5.2 Material Quality Control

5.2.1 RAW MATERIAL

The resin used to make geomembrane sheet shall be tested in accordance with the manufacturer's guidelines. Material ingredients of the geomembrane shall be randomly sampled by the manufacturing plant to ensure compliance with these specifications. Test reports of quality control tests, such as specific grading, melt flow index and carbon black content will be provided.

5.2.2 GEOMEMBRANE MATERIAL SPECIFICATIONS

The GEOSYNTHETIC MANUFACTURER shall provide the ENGINEER with the following:

1. A quality control certificate indicating conformance with the Geosynthetics Research Institute's (GRI) GEOSYNTHETIC MANUFACTURER 13 for HDPE.
2. Certification that property values given in the properties sheet are guaranteed by the GEOSYNTHETIC MANUFACTURER.
3. Certification that 100 percent of every roll has been visually inspected for holes, cracks, thin spots, tears, punctures, blisters or any other foreign material.

The GEOSYNTHETIC MANUFACTURER shall provide the following information to the ENGINEER for each roll delivered to the site:

- Name of the manufacturer and fabricator;
- Name and type of liner;
- Thickness of liner;
- Batch code;
- Date of fabrication;
- Physical dimensions;
- Panel number;
- Location and method of storage at the site.

The ENGINEER will examine results and report any nonconformance to Owner. QC results will be reviewed and accepted or rejected by the ENGINEER prior to deployment.

5.3 Subgrade

When the geomembrane is placed on a geosynthetic subgrade, the GEOSYNTHETIC INSTALLER shall be responsible for preparing the subgrade for the geomembrane. Once complete, the ENGINEER shall examine the surface and verify the adequacy of the documentation completed and any test data required.



When the ENGINEER deems the surface acceptable, the ENGINEER shall prepare an acceptance certificate for the Owner. The acceptance certificate shall state the following at a minimum:

1. Documentation of the underlying geosynthetics is complete and any necessary tests show satisfactory results.

The GEOSYNTHETIC INSTALLER will also inspect the subgrade and will sign the subgrade acceptance forms.

At any time during installation of the geomembrane, the ENGINEER shall inform the owner of any areas that are unacceptable. Such defects in the subgrade shall be corrected by the appropriate contractor such that repaired areas meet the project specifications.

5.4 Observations and Documentation

5.4.1 ROLL INSPECTIONS

Prior to placement of any lining material, rolls shall be observed for defects and damage by both the ENGINEER and the GEOSYNTHETIC INSTALLER. Storage of the rolls shall be in a location that minimizes on-site handling and the possibility of damage.

Each roll shall have a roll label which clearly identifies the manufacturing information. This information along with the panel number and location/method of on-site storage, shall be recorded by the ENGINEER.

The ENGINEER shall also visually observe each roll for imperfections or damage including holes, cracks, thin spots, tears, punctures, blisters or the presence of foreign material.

5.4.2 PLACEMENT

5.4.2.1 Equipment

The installer shall use equipment that does not damage the geomembrane by handling, trafficking, excessive heat, leakage of oils or other means. The method and equipment used to unroll the material shall not cause scratches, crimps or any damage to the underlying GCL, or excessive rutting of the soil subgrade.

5.4.2.2 Method of Deployment

No personnel working on the geosynthetic liner shall smoke, wear damaging shoes or engage in other activities that could damage the geomembrane. The method used to place the panels shall minimize wrinkles.

Adequate temporary loading and/or anchoring shall be provided to prevent uplift of the liner by wind. The anchoring system shall not damage the liner.

The installer shall inspect each panel after placement and prior to seaming for damage. Damaged panels or portions of damaged panels that have been rejected shall be marked and their removal from the work area recorded.



5.4.2.3 Crest Anchorage System

The anchor trench shall be excavated to the lines and widths shown on the drawings prior to geomembrane placement. The trench shall be drained to prevent ponding or softening of adjacent soils where trench is open. The corners of the trench shall be slightly rounded to avoid sharp bends in the geomembrane. The trench shall be backfilled and compacted by light compaction equipment to the required grade.

Since backfilling the anchor trench can affect material bridging at the toe of slope, consideration should be given to backfilling the liner at its most contracted state; preferably during the cool of the morning or extended period of overcast skies. Care should be taken when backfilling the trenches to prevent damage to the geosynthetics.

5.4.3 TRIAL SEAMS

To verify that seaming conditions are adequate, trial seams shall be performed on fragmented pieces of geomembrane. Trial seams shall be made as follows:

1. Every 4-hours.
2. Anytime equipment is turned off.
3. For each seaming apparatus.
4. Other times as deemed necessary by the ENGINEER.

A test weld, long enough to obtain required samples shall be run at the frequency described above (typically at least 5 feet).

The test weld shall be recorded on the GEOSYNTHETIC INSTALLER's trial weld log with date, ambient temperature, and welding machine number.

Three adjoining specimens each 1-inch wide shall be cut from the trial seam sample. The specimens shall be tested respectively in shear and in peel using a field tensiometer and they shall not fail in the seam. If any specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial welds are achieved. The ENGINEER will observe and document results of trial seam procedures.

5.4.4 FIELD SEAMING

5.4.4.1 Seam Layout

Prior to liner installation, panel layout drawings shall be submitted and approved by the ENGINEER and Owner. Seams should typically be oriented parallel to the line of maximum slope. All seam-numbering and panel-numbering systems shall be agreed upon prior to installation. Individual liner panels shall be laid out and overlapped as required prior to welding. The area to be welded shall be cleaned prior to welding. Panel locations shall be recorded by the ENGINEER on the record drawings.



5.4.4.2 Seaming Equipment and Accessories

The fusion welding apparatus will be an automated, vehicle-mounted device that produces a double seam enclosing a void. This apparatus shall be equipped with gauges permitting a direct reading of the applicable temperatures.

The extrusion welding apparatus shall be equipped with gauges giving the temperatures of the apparatus at the nozzle.

5.4.4.3 Weather Conditions for Seaming

Seaming shall not take place during precipitation, in the presence of excess moisture or in the presence of excessive winds. Seaming shall not take place at ambient temperatures less than 40°F unless authorized by the Owner and ENGINEER.

5.4.4.4 General Seaming Procedures

The rolls of geomembrane shall be overlapped as required by the manufacturer's specifications.

A base T-seam shall not be closer than 10 feet from the toe of the slope. Seams shall be aligned with the least possible number of wrinkles and "fish mouths". Excessively large wrinkles and all fish mouths shall be relieved and cap-stripped.

The ENGINEER shall document field seam locations and panel overlaps. Panels that are factory fabricated or factory seamed will undergo the same observation and documentation as panels that are field seamed.

5.5 Testing

5.5.1 NONDESTRUCTIVE SEAM CONTINUITY TESTING

The installer shall nondestructively test all field fusion seams over their full length by air-pressure testing. Extrusion-welded seams shall be tested by vacuum gauge.

5.5.1.1 Air Pressure Testing

This type of testing will be performed on the majority of the seams, since the double fusion-seaming method is the method of choice.

Generally, the equipment shall be comprised of the following:

- An air pump capable of providing a pressure of 30+ pounds per square inch (psi);
- A rubber hose with fittings and connections;
- A sharp hollow needle or other approved pressure-feed device.

The following procedures shall be followed:

1. Seal both ends of the seam to be tested.
2. Insert needle or other approved pressure-feed device into the tunnel created by the fusion weld.



3. Energize the air pump to 30-32 psi; close the valve and sustain pressure for a minimum of five minutes.
4. If loss of pressure exceeds 2 psi or does not stabilize, locate the faulty area, repair, and retest (either vacuum or air test).

5.5.1.2 Vacuum Testing

The equipment shall be comprised of the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a gauge to indicate chamber vacuum;
- A pump assembly equipped with a pressure controller and pipe connections;
- A rubber pressure/vacuum hose with fittings and connections;
- A bucket and wide brush or spray assembly;
- A soapy solution.

The following procedures will generally be followed:

1. Wet a strip of geomembrane approximately 12 x 48 inches with the soapy solution.
2. Place the box over the wetted area.
3. Close the bleed valve and open the vacuum valve.
4. Ensure that a leak-tight seal is created.
5. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.
6. For a period of approximately 10 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of 1-inch overlap, and repeat the process. Areas where soap bubbles appear shall be marked and repaired in accordance with Section 5.6.

The ENGINEER shall document the following for each non-destructive seam test:

- Date;
- Seam number;
- Welder I.D.;
- Seamer;
- Air Pressure.

5.5.2 DESTRUCTIVE TESTING

Destructive seam tests, including extrusion weld seams, shall be performed every 500 lineal feet of seam, or at least one per seaming device per crew per day. This requirement will apply to all seams with the exception of the seam connecting the base liner to the cover system liner. The purpose of these tests is to check that welds are fully integrated with each other and to evaluate seam strength. Seam strength testing shall be done as the seaming work progresses, not at the completion of field seaming.



5.5.2.1 Location and Frequency

The ENGINEER shall select locations where seam samples will be cut. These locations shall be estimated as follows:

1. A minimum frequency of one test location per 500 feet of seam length, or at least one per seaming device per crew per day. This minimum frequency is to be determined as an average taken throughout the entire facility.
2. The seaming technician shall not be informed in advance of the locations where the seam samples will be taken.

5.5.2.2 Sampling Procedure

Sampling shall be cut by the installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The GEOSYNTHETIC INSTALLER shall:

1. Cut samples.
2. Assign a number to each sample that is to be based upon seam and sample number and mark it accordingly.
3. Record sample location on construction record drawings.
4. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section 5.6. The continuity of the new seams in the repaired area shall be tested according to this section.

5.5.2.3 Size of Samples

The samples for field-testing shall be taken by the installer. These samples shall be minimum 36 by 12 inches with the seam-centered perpendicular to the length.

If both samples pass the field tensiometer test, the initial samples shall be cut into two parts and distributed as follows:

1. One portion to the installer for field testing (12 x 12 inches)
2. One portion to the installer for laboratory testing (12 x 12 inches)
3. One portion to the Owner for archive storage (12 x 12 inches)

Final determination of the sample sizes shall be determined prior to liner installation at the preconstruction meeting.

5.5.3 FIELD TESTING

The 1-inch wide strips shall be tested in the field for peel and shear and shall not fail in the seam. If any field test sample fails to pass, then the procedures outlined in this section shall be followed.

5.5.4 LABORATORY TESTING

Passing tensiometer testing in the field qualifies the sample for laboratory testing.



Destructive test samples shall be packaged and shipped to the geomembrane testing laboratory consultants by overnight mail. The laboratory shall provide test results to the ENGINEER.

Destructive testing involves two techniques: 1) shear testing, and 2) peel testing. Shear testing applies a tensile stress from the top sheet through the weld and into the bottom sheet. Peel testing peels the top sheet back against the overlapped edge of the bottom sheet in order to observe how separation occurs. The peel test indicates whether or not the sheets are continuously and homogeneously connected through the seam. A total of 10 coupons will be subject to testing, for which five will be tested in shear and 5 in peel (ASTM 6392). Fusion seam specimens will have both tracks tested in peel.

Both tests (shear and peel) must have a Film Tearing Bond (FTB) type of separation to pass. With an FTB, the polymer material tears indicating a fully integrated connection between top and bottom sheets. It is important that no weld bead/sheet or sheet/sheet interface exists as such an interface might be separated by absorbed chemicals, causing failure of the seam. The criteria for pass/fail are outlined in Table 3.

The ENGINEER shall document the following for each non-destructive seam test:

- Location;
- Seam number;
- Welder I.D.;
- Seamer;
- Sample I.D.

5.5.5 PROCEDURES FOR DESTRUCTIVE TEST FAILURE

The following procedures shall apply whenever a sample fails a destructive test. The GEOSYNTHETIC INSTALLER has two options:

Reconstruct the seam between the two adjacent passed test locations.

Trace the welding path to intermediate locations (10 feet minimum from the point of the failed test in each direction) and take a sample for an additional field test at each location. If these additional samples pass the field test, then full laboratory samples shall be taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either laboratory sample fails, then the process is repeated to establish the zone in which the seam shall be reconstructed.

All acceptable seams must be bound by two locations from which samples passing laboratory destructive tests have been taken.

The GEOSYNTHETIC INSTALLER shall document all actions taken in conjunction with destructive test failures; e.g., capping of failed seam area.

5.6 Defect and Repairs

All seams and non-seam areas of the geomembrane shall be examined by the installer for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter.



5.6.1 EVALUATION

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in this section as appropriate. Each location that fails the nondestructive testing shall be marked by the GEOSYNTHETIC INSTALLER and repaired. Work shall not proceed with any materials that will cover locations that have been repaired until non-destructive test results are recorded.

5.6.2 REPAIR PROCEDURES

All portions of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the ENGINEER, GEOSYNTHETIC INSTALLER, and Owner. The procedures available include:

1. Patching: Used to repair large holes, tears, and contamination by foreign matter.
2. Buffing and re-welding: Used to repair small sections of extruded seams.
3. Spot welding or seaming: Used to repair small tears, pinholes, or other minor localized flaws.
4. Capping: Used to repair areas of inadequate seams that have an exposed edge.

In addition, the following provisions shall be satisfied:

1. Surfaces of the geomembrane that are to be repaired shall be abraded no more than one hour prior to the repair.
2. Surfaces must be clean and dry at the time of repair.
3. Seaming equipment used in repairing procedures must be approved.
4. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the ENGINEER.

Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches.

5.6.3 VERIFICATION OF REPAIRS

Each major repair requiring a patch or cap shall be identified in the GEOSYNTHETIC INSTALLER's repair log. Each repair shall use nondestructive test methods described in this section as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests indicate that the repair shall be re-done and re-tested until a passing test result is obtained. The ENGINEER may choose to take a destructive test in an area of repair. The ENGINEER shall document the location of each type of repair and the type of repair made.

5.7 Final Acceptance

The geomembrane must be final observed for completion of liner construction activities. The final inspection shall be performed by the ENGINEER, GEOSYNTHETIC INSTALLER and Owner. The ENGINEER and GEOSYNTHETIC INSTALLER shall document completion or incompleteness. The GEOSYNTHETIC INSTALLER shall repair or complete any testing that has been determined incomplete.



The ENGINEER and GEOSYNTHETIC INSTALLER shall then re-inspect the repairs or testings to complete final inspection.

Geomembrane material shall be final inspected prior to being covered by overlying geosynthetic materials or soil layers. Vehicle use directly over the geomembrane is prohibited as a standard means of deployment.

The geosynthetic lining system shall be accepted when the final observation and documentation is complete and approved by the ENGINEER and Owner.

5.8 Conformance With Project Specifications

The ENGINEER shall document that the installation and necessary repairs were done in accordance with the project specifications



6 Granular Drainage Media

6.1 General

The granular drainage media consists of natural material used as a drainage layer in a base liner system.

6.2 Material Quality Control

Samples of the granular drainage media will be tested for grain size distribution and hydraulic conductivity. Testing frequencies are provided in Table 2.

The ENGINEER shall examine the results and report any nonconformance to the Owner. QC results shall be reviewed and accepted or rejected by the ENGINEER prior to installation.

6.3 Observation And Documentation

Observation of the construction work by ENGINEER or Owner include the following:

- Hauling of material to ensure no damage to underlying geosynthetics;
- Spreading of granular drainage media material to ensure excess wrinkling of underlying geosynthetics does not occur;
- Placement of filter aggregates to ensure pipes are properly bedded and covered;
- Documentation will include; laboratory test data, material information, placement methods and thicknesses, and construction procedures used to prevent migration of fines by run-off into the leachate collection system.

6.4 Testing

Laboratory test methods and frequencies upon which acceptability evaluations can be based are as provided in Table 2.

CQA testing will be conducted on samples taken from the material during the course of construction. Sampling locations will be selected by ENGINEER or Owner according to the number of required tests. Locations of all tests will be documented for report purposes.

6.5 Damage And Repairs

Granular drainage media that does not meet the requirements of the CQA Plan or the Specifications will be removed and replaced with suitable material.

6.6 Survey

The minimum thickness of soil drainage media shall be as shown on the drawings and extending over the lining system. The thickness of granular drainage media shall be verified on a grid using methods that shall not damage the liner. Grading tolerances are provided in Table 1.



6.7 Conformance With Project Specifications

The ENGINEER shall document that the granular drainage media installation was done in accordance with the project specifications.



7 Piping Systems

7.1 General

This section addresses the HDPE piping installed in the leachate collection pipe trenches, collection sumps, and gravity fed and high pressure leachate forcemains.

7.2 Material Quality Control

The CONTRACTOR (or other piping contractor, if applicable) shall inspect all piping and fittings received at the site and shall verify that piping materials are:

- In accordance with drawings and specifications (size, SDR ratio, schedule, material).
- Free of material defects.
- Undamaged.

CONTRACTOR shall be responsible for storing piping materials in a protected location where they will not be damaged.

The ENGINEER shall examine the results and report any nonconformance to the Owner. QC results shall be reviewed and accepted or rejected by the ENGINEER prior to installation.

7.3 Observation And Documentation

7.3.1 INSTALLATION

CONTRACTOR shall install piping at locations and elevations as shown on drawings. All piping connections shall be made in accordance with manufacturer's recommendations. Installation of backfill around piping shall be done carefully to ensure damage to the piping does not occur. ENGINEER will document piping types installed, methods of connection/fitting types, and backfilling procedures. Documentation of the piping will include information on the method used to join sections of the pipe.

The sumps and any leachate removal/detection equipment will be documented by the ENGINEER, including; material and equipment, coatings and electrical/mechanical requirements.

7.3.2 PRESSURE TESTING

Pressure testing will be used to test all sections of HDPE piping. Testing must be performed in the presence of the ENGINEER. Testing will be performed on pipe sections prior to backfilling. Any leaks or defects shall be corrected by the GC and retest the section at no additional cost to the Owner.

The ENGINEER will witness and document the final test of all piping. The test report for each piping system tested and for each tank testing shall include the following information at a minimum:

- Date of test
- Description and identification of piping system tested
- Type of test performed



- Test pressure
- Type and location of leaks detected, if any
- Corrective action taken to repair leaks
- Results of retesting
- Video inspection results, if applicable

Following the final pressure tests, the Owner may choose to have the entire gas or leachate piping system video inspected using standard service inspection and equipment. If shavings or debris are found, a water (jet) flush of the entire system is required. The use of a video inspection will be at the sole discretion of the Owner.

7.4 Damage And Repairs

Damaged or defective portions of the piping, as determined by ENGINEER, will be removed and replaced.

7.5 Survey

The piping trenches will be surveyed for horizontal and vertical position. Critical points of the piping will be surveyed. Invert tolerances are provided in Table 1.

7.6 Conformance With Project Specifications

The ENGINEER shall document that the piping installation was done in accordance with the project specifications.



8 Documentation Report and Record Drawings

The documentation report is the summary of the construction activities that were documented throughout the project. The construction portion of the report will include discussion of all documented procedures. The report will include results from field and laboratory tests and summarize survey documentation. A summary of the documentation report is as follows:

1. All relevant construction specifications;
2. All shop drawings for prefabricated components (pumps, tanks, etc.);
3. Photo documentation of all critical aspects of construction;
4. Narrative description of all as-built variances from the plans and/or specifications;
5. Survey documentation of liner or cover system soils components;
6. As-built elevations for all pipe inlets and outlets and pump-on/pump-off controls;
7. All material testing results; and
8. Geomembrane installation information.

The documentation report will be certified by a professional engineer registered in the State of Minnesota.



TABLES



TABLE 1
System Grading Tolerances

Pine Bend Landfill

Base Lining System Grading Tolerances				
Soil Layer/Surface	Measurement	Method	Pass/Fail Criteria	Frequency
Top of perimeter berm inside slope (controlled fill subgrade)	Elevation	Survey	-0.2' to 0.0'	50' grid*
Top of clay barrier layer (base grade)	Elevation and Thickness	Survey	0.0' to +0.2', min. 2 feet thick	50' grid*
Granular drainage layer	Elevation and Thickness	Survey	0.0' to +0.2', min. 1 foot thick	50' grid*
Piping System Grading Tolerances				
Soil Layer/Surface	Measurement	Method	Pass/Fail Criteria	Frequency
Leachate Piping	Elevation	Survey	±0.2'	50' and changes in direction and all pipe fittings

* Also breaks in grade – same grid to be used for all layers of base liner system

TABLE 2
Soils Quality Assurance Testing Requirements
Pine Bend Landfill

Clay Liner Testing		
Test	ASTM Method	Frequency
Grain Size	D422 and D1140	1 per acre/foot
Atterberg Limits	D4318	
USCS Classification	D2487	
Standard Proctor	D698	
Permeability	D5084	
Dry Density and Moisture Content	D6938 (nuclear)	Test on 100-foot approximate grid pattern Offset every lift-min 5 tests/acre

Sand Drainage Layer Testing		
Test	Method	Number of Tests
Grain Size	D422 and D1140	1/2000 cubic yards (minimum 3)
USCS Classification	D2487	
Permeability	D2434	1 per acre

Controlled Fill for Perimeter Berm		
Test	Method	Number of Tests
Grain Size	D422 and D1140	1/2000 cubic yards (minimum 3)
USCS Classification	D2487	
Dry Density and Moisture Content	D6938 (nuclear)	Test on 100-foot approximate grid pattern Minimum one test per lift, minimum one test per 2000 cubic yards

Coarse and Intermediate Aggregate Testing		
Test	Method	Number of Tests
Grain Size	D422	1/1000 lineal foot pipe (minimum 3)
USCS Classification	D2487	1/1000 lineal foot pipe (minimum 3)

TABLE 3**Geomembrane Quality Assurance Testing Requirements****Pine Bend Landfill**

Geomembrane Testing		
Test	Reference	Frequency
Material Properties	GRI GM 17 and GM 13	By manufacturer Every roll provided
Visual Inspection	--	Entire sheet
Trial Seam Welding	--	Start of seaming process, any time equipment turned on, each seamer or seaming apparatus (two per day per machine)
Non-Destructive Seam Testing	--	All seams/patches
Destructive Seam Strength Test	ASTM D6392	1 test per 500 L.F. seam minimum

Geotextile/Geonet/Geonet Geocomposite		
Test	Reference	Frequency
Material Properties	Spec Section 02921 02924	By manufacturer Every Roll Provided
Visual Inspection of Material and Seams	Spec Section 02921 02924	Entire installation

APPENDIX C

Surface Water Management



To:	Tom Shustarich, PE	From:	Ali Stone Eileen Weigel, PE
Project/File:	Pine Bend Landfill	Date:	March 9, 2022

Reference: 227704791

Background

Stantec updated the approved 2016 Surface Water Management plan to include the proposed landfill expansion. The landfill expansion includes a vertical expansion, construction of drainage swales, downslope structures, terraces, and the development of the south-west corner. The stormwater requirements are met through the noted expansion features and the existing infrastructure and basins.

Surface Water Management

The stormwater management for this site consists of subcatchments, benches and downslopes which direct water from 5 distinct areas to infiltration basins. The sandy soils at the landfill are conducive to infiltration. The area's, labeled as A, B, C, D, and E are broken into subwatersheds, that get directed to sedimentation basins 8P, 5P/6P, 4P, 3P, 7P/1P respectively.

Discharge to the southwest pond (8P) is directed from the downslope through a 100' 48-inch pipe to the final outfall.

Discharge to the existing east pond (6P) is directed through an existing low area into a set of culverts beneath the railroad tracks prior to final outfall. There is currently one 36-inch culvert in place beneath the tracks. To accommodate additional stormwater flows per the design, two additional 36-inch culverts will be installed in this area. It should be noted that this will require installation by horizontal drilling methods due to the adjacent railroad tracks.

Discharge to the northeast pond (4P) is directed through existing low areas and cable concrete directly into the pond.

Discharge to the northwest pond (3P) is directed though existing low areas to a 60' downslope into the final outfall.

Discharge to the west pond (1P) is directed though an existing concrete diversion structure to a 60" pipe, to an existing 96" pipe which discharges to the final outfall.

For all storm events the 100-yr peak elevation of the ponds does not exceed the outlet, so all water is contained on site. Barr requests that the back-to-back 100-yr storm and 100-yr 10-day snowmelt also be modeled. The results from those two tests are summarized here, and the HydroCAD reports are available in PDF format upon request. Our model shows Pond 8P does discharge during the back-to-back 100-yr event.

Reference: 227704791

For all other results run (2-yr, 5-yr, 10-yr, 25-yr 24-hour events, and the 100-yr 10-day snowmelt) the model shows the infiltration basins have capacity to infiltrate all the water.

Peak Run-off

- Atlas 14 Rainfall values for Dakota county were used in setting the storm events
- Composite Curve Numbers were calculated using B and C soil groups. Soil B was assumed for sloped areas and C for flat areas. The slope area composite was calculated by assigning 30% to the newly graded condition (CN 91) and 70% to a fair, 50%-70% grass cover condition (CN 79). Similarly, the flat area composite was calculated by assigning 30% to the newly graded condition (CN 86) and 70% to a fair, 50%-70% grass cover condition (CN 69). These percentages are representative of the proposed construction phasing since the entire final cover area will not be in the newly graded condition at the same time. The percent of each sub catchment in a sloped vs flat region was multiplied by the respective composite curve number to get the final CN for that sub catchment. An example calculation and table of curve numbers for this site are provided below.

Example Calculation:

$$\text{Sloped Area CN} = 91 \times 0.3 + 79 \times 0.7 = 82.6$$

$$\text{Other Area CN} = 86 \times 0.3 + 69 \times 0.7 = 74$$

$$\text{Composite CN} = \text{Sloped Area Percent} \times 82.6 + \text{Other Area Percent} \times 74$$

Table 1. Pine Bend Curve Numbers

CN	Area(s)
83	A3, A5, A6, A7, A8, A9, A10, AA2, AA4, B3, B5, B7, B9, BB1, BBB3, C3, C4, C5, C6, C7, C8, C9, CC2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E14
81	C10
80	A4, CC4
79	BB3
78	A11
77	B1, C2
76	C1, D1, E2
75	A1, A2, C0, D2, E1

- Time of concentrations were calculated using sheet flow and shallow concentrated flow for the longest flow path for each subwatersheds
- To be conservative in the analysis, no infiltration is modeled in swales or downslopes.
- The 100-yr high water level was also set by modeling no infiltration in the swales and downslopes.
- All subcatchments were renamed with the same letter on which pond its directed to and numbering down from top to bottom with odd numbers to the left of downslopes and even numbers to the right. Double letters used for area's not directly adjacent to the main downslope.

Reference: 227704791

Bench and Drainage Swale Design

Benches are placed on all 3:1 slopes. They are sloped into final cover and V shaped with right and left side slopes 3:1 and 8:1 respectively. The benches are placed to intercept and direct flow, as well as minimize erosion. The drainage channel at the interior of the bench was designed with the following characteristics:

Height= 22" (typical)
Slope= 3% to 5% (typical)
Manning "n" value= 0.035

The drainage benches were designed to handle the flow for each subarea and are spaced 40' vertically around the perimeter of the landfill. The peak flow depth will not exceed the depth of the bench. Proposed benches will have category 4 erosion control matting installed to protect against erosion until vegetation is established.

Runoff contained during the 100 year, 24-hour rainfall event.

Downslope Structures

Each bench discharges into one of seven cable concrete lined downslope structures located around the perimeter of the site. Each downslope structure is a trapezoidal channel with design characteristics summarized below:

Depth = 2.0' (typical)
Bottom width = 9 feet
Manning "n" value= 0.040

Runoff is contained during the back-to-back 100-year rainfall event.

Junction Vaults

The downslope piping systems in the southwest and northeast corners of the currently permitted design discharge to concrete junction vaults. In the junction vaults, flow is combined to a single pipe that outlets to the existing railroad crossing culverts, a 48-inch RCP on the southwest and a 96-inch RCP on the northwest.

Sedimentation Ponds

By City requirement all ponds must be able to infiltrate 1" runoff over new impervious surfaces. This site exceeds requirements and infiltrates 1" over the full area, not just impervious, as seen in the calculations below:

Area A (directed to 8P)

Reference: 227704791

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 524,154\text{ ft}^2 = \mathbf{43,680\text{ ft}^3}$$

Area B (directed to 5P then 6P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 518,933\text{ ft}^2 = \mathbf{43,244\text{ ft}^3}$$

Area C (directed to 4P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 991,908\text{ ft}^2 = \mathbf{82,659\text{ ft}^3}$$

Area D (directed to 3P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 418,623\text{ ft}^2 = \mathbf{34,885\text{ ft}^3}$$

Area E (directed to 1P)

$$1\text{ in} * \frac{1\text{ ft}}{12\text{ in}} * 530,006\text{ ft}^2 = \mathbf{44,167\text{ ft}^3}$$

The ponds were designed to serve as infiltration ponds. The sandy soils at the landfill are conducive to infiltration.

All infiltration ponds were able to contain the 100 year storm. For the modeled back to back 100 year event the existing ponds 5P and 8P use emergency overflow discharge. Water from 5P is routed to 6P and water from 8P is routed to city storm sewer. In the proposed model, during the back to back 100 year storm, 5P contains all water and 8P discharges. However 8P discharges at a lower rate than in the existing model. Results can be seen in tables 2 and 3 below.

Results

Table 2. Existing and Proposed Pond HWL's, Discharge, and Required and Provided Storage

Pond	Existing 100-Yr HWL	Proposed 100-Yr HWL	Proposed 100-Yr Discharge (cfs)	Infiltration Volume Required (AF)	Storage Provided (AF)
1P (E)	(2013) 853.45	851.48	0	1.01	36.0
3P (D)	(2015) 869.88	863.15	0	0.80	25.3
4P (C)	(2015) 890.69	886.64	0	1.90	25.2
6P (B)	(2015) 893.05	890.34	0	0.99	24.8
8P (A)	(2013) 843.77	845.03	0	1.00	5.7

Table 3. Existing and Proposed Back to Back 100 Year Storm Event Discharge

Pond*	Existing back to back 100-Yr HWL	Proposed back to back 100-Yr HWL	Existing back to back 100-Yr Discharge (cfs)	Proposed back to back 100-Yr Discharge (cfs)
5P (B)	(2015) 905.29	897.08	38	0
8P (A)	(2013) 846.75	845.06	158	66

*only ponds with discharge included

Reference: 227704791

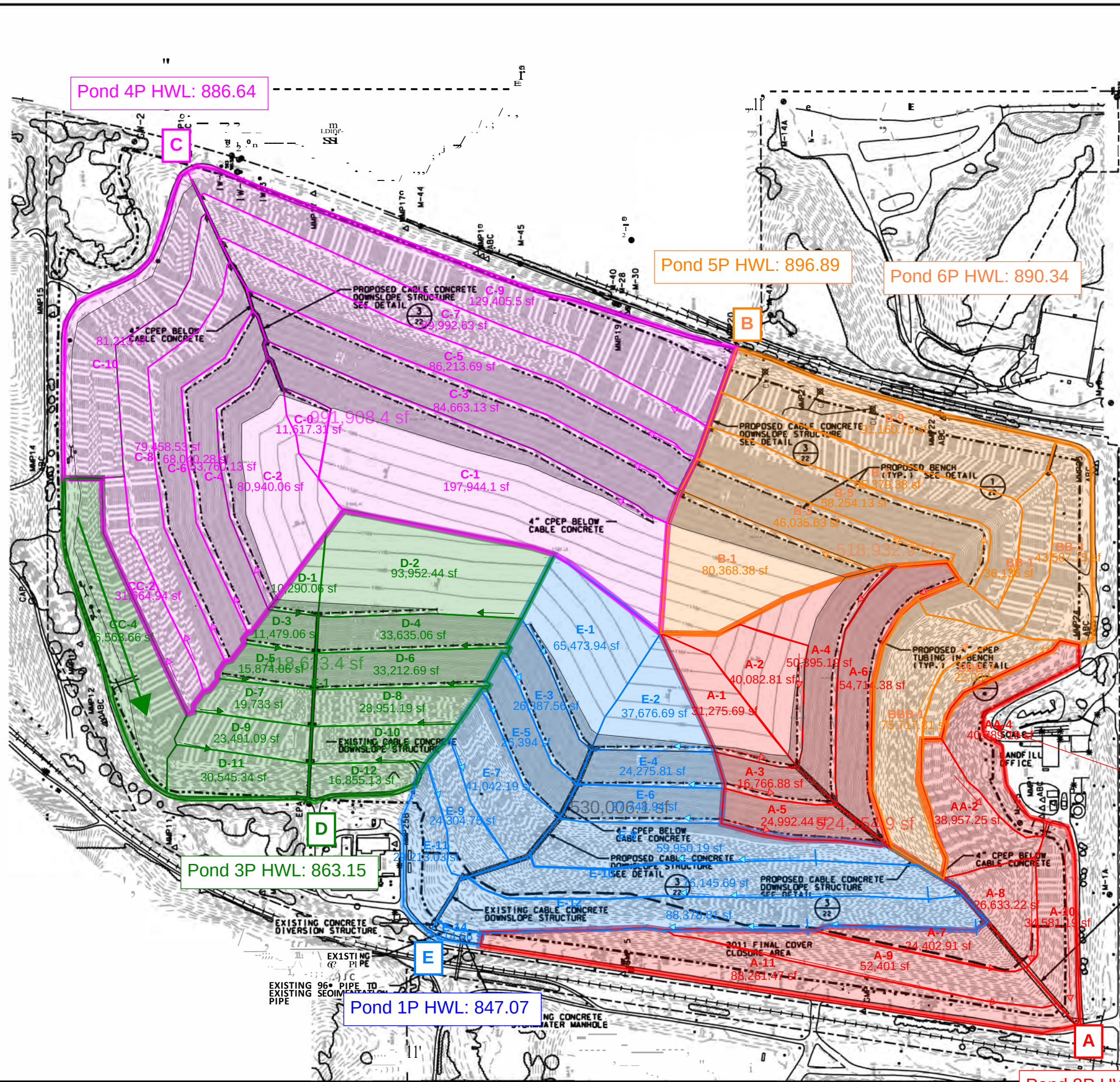
City of Inver Grove Heights Stormwater Management Requirements

- The table below lays out the relevant requirements as listed in [9-5-8: APPLICATION PROCEDURES: \(amlegal.com\)](#).

Requirement	
9-5-8 C Stormwater Management Criteria for Permanent Facilities: The applicant shall install or construct, on or for the proposed land disturbing or development activity, all stormwater management facilities necessary to manage increased runoff in compliance with design standards set forth in the "Inver Grove Heights Stormwater Manual - Northwest Area" (2006) and all subsequent revisions and as directed by the director of public works.	
1. Infiltration Of Runoff: Stormwater BMPs and IMPs shall infiltrate 1.0 inch of runoff from new impervious surfaces for new developments. For redevelopment projects, stormwater BMPs and IMPs shall infiltrate 1.0 inch of runoff from new and redeveloped impervious surfaces.	This criterion is met for the 100-yr storm
a. Post-development runoff volume must match predevelopment runoff volume for the 5-year, 24-hour event.	There is no runoff during the 5-yr, 24-hour event in the post-developed site which is less than the pre-developed site.
b. Proposed developments must use infiltration rain gardens, vegetated swales, parking lot bioretention, infiltration basins/trenches, disconnection of impervious surfaces, green roofs, and other LID techniques.	This project utilizes vegetated swales.
2. Storm Sewer Conveyance Systems: Storm sewer conveyance systems will be designed to provide discharge capacity for the 10-year frequency runoff event. The city may allow variances to this standard in areas where a new storm sewer system would connect to an existing storm sewer system that does not have and is not expected in the future to have a ten (10) year capacity. The portions of the system that convey outflows from ponding areas will be sized to convey the critical 10-year storm flow or the required 100-year outflow from upstream ponding areas, whichever is greater. The storm sewer systems shall be designed for 10-year storm events and their performance shall be analyzed for storms exceeding the design storm.	All water is treated on site so there will be no discharge.
3. Post development Peak Discharge Rates: Post development peak discharge rates shall not exceed existing discharge rates for the 2-year, 5-year, 10-year, and 100-year (50 percent, 20 percent, 10 percent, and 1 percent probability), 24-hour duration storm events.	All water is treated on site so there will be no discharge.

Reference: 227704791

Hydrologic modeling to calculate the flood levels resulting from the 2-year, 5-year, 10-year, and 100-year, 24-hour duration storm events shall be submitted for review.	
4. Emergency Overflow Structures: The city will require the incorporation of emergency overflow structures (e.g., swales, spillways), where feasible, into pond outlet structure designs to prevent undesired flooding resulting from storms larger than the 100-year (1 percent) event or plugged outlet conditions	Please see model for incorporated overflow structures.
5. Pond Flow: All ponds shall use multistage outlets where needed to control flows from smaller, less frequent storms and help maintain base flows in downstream open channels. Pipes entering wet ponds shall have the invert elevation set 0.5 feet below the pond normal water level.	This site proposes infiltration basins which do not have a NWL.
6. Landlocked Basins: For landlocked basin areas only, the existing tributary area will be allowed to discharge to a landlocked basin, unless provisions have been made for an outlet from the basin. The water quality and flooding impacts of proposed outlets from landlocked basins on downstream water resources shall be evaluated.	Pond 8P discharges during the back to back 100 year storm, but at a lower rate and volume than it does in the existing condition. See Table 3.
9-5-8 E Models/Methodologies/Computations: Hydrologic models and design methodologies used for determining runoff characteristics and analyzing stormwater management structures shall be as set forth in the "Inver Grove Heights Stormwater Manual - Northwest Area" (2006) and all subsequent revisions and as directed by the director of public works.	Our models and calculations satisfy the requirements of the "Inver Grove Heights Stormwater Manual - Northwest Area" (2006)



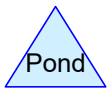
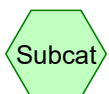
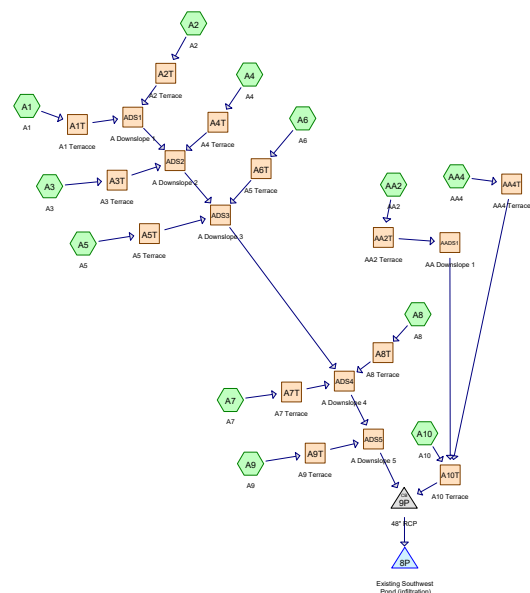
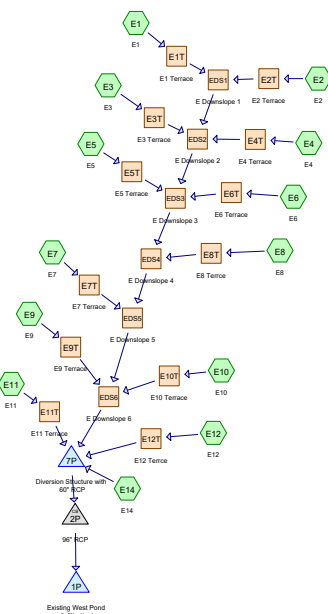
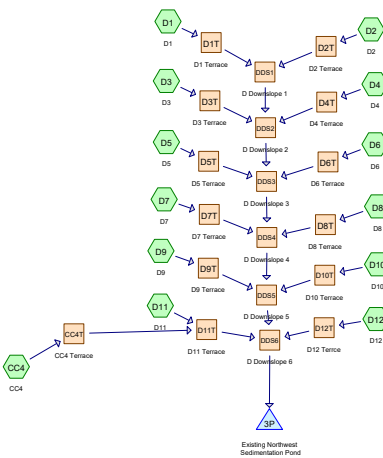
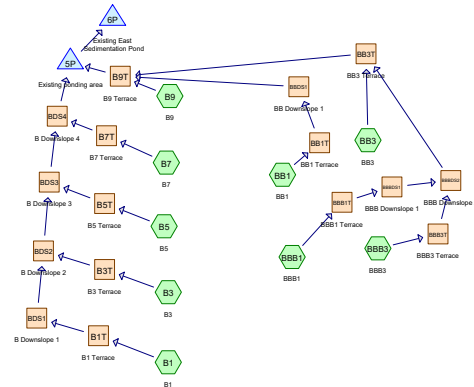
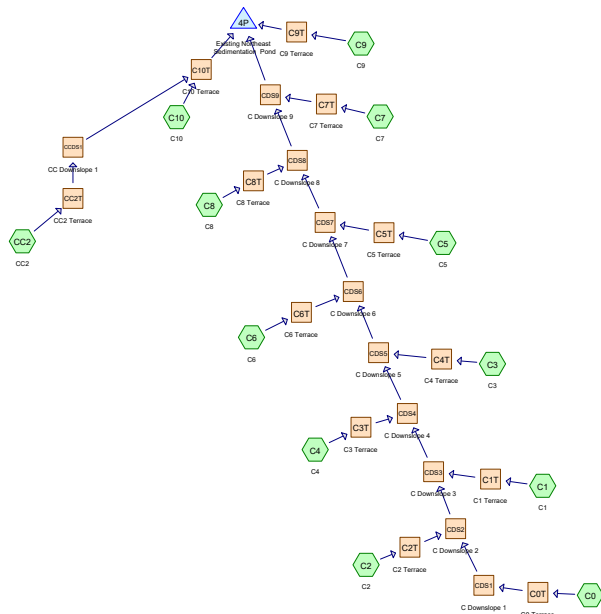
- LEGEND
- J11, J12 --- EXISTING CONTOURS
 - EXISTING TREELINE
 - EXISTING FENCELINE
 - EXISTING RAILROAD
 - EXISTING POLE
 - EXISTING PROPERTY LINE
 - 1A EXISTING GROUNDWATER MONITORING WELL
 - w < EXISTING METHANE MONITORING PROBE
 - m EXISTING METHANE MONITORING PROBE
 - w EXISTING GROUNDWATER INJECTION WELL
 - EXISTING WASTE BOUNDARY
 - CLOSURE BOUNDARY
 - =112_Q--- FUTURE FINAL COVER CONTOURS
 - 1020- PROPOSED FINAL COVER CONTOURS

NOTE:
EXISTING CONDITIONS PROVIDED BY
COOPER AERIAL SURVEYS CO.
DATE OF FLIGHT OCTOBER 31, 2020
AND UPDATED WITH FIELD SURVEY
BY WENCK JANUARY 2021.

EXISTING CABLE CONCRETE
DOWNSLOPE STRUCTURE
TO EXISTING CONCRETE
DIVERSION STRUCTURE
STORM WATER INFILTRATION
BASIN, SEE SHEET 2A

I HEREBY CERTIFY THAT THIS SURVEYING
OR SURVEYING AND ENGINEERING
PROFESSIONAL SEAL IS THE SEAL OF THE
STATE OF WISCONSIN.

PRINT NAME: THOMAS J. SHUSTARICH
SOLUTION: _____
121111 111111Q



Routing Diagram for sw model 2022
 Prepared by Stantec Consulting Ltd., Printed 3/25/2022
 HydroCAD® 10.00-20 s/n 02201 © 2017 HydroCAD Software Solutions LLC

sw model 2022

Prepared by Stantec Consulting Ltd.

Printed 3/25/2022

HydroCAD® 10.00-20 s/n 02201 © 2017 HydroCAD Software Solutions LLC

Page 2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
280,078	75	(A1, A2, C0, D2, E1, E2)
1,997,789	83	(A10, A3, A5, A6, A7, A8, A9, AA2, AA4, B3, B5, B7, B9, BB1, BBB1, BBB3, C3, C4, C5, C6, C7, C8, C9, CC2, D10, D11, D12, D3, D4, D5, D6, D7, D8, D9, E10, E11, E12, E14, E3, E4, E5, E6, E7, E8, E9)
126,959	80	(A4, CC4)
161,308	77	(B1, C2)
43,588	79	(BB3)
208,284	76	(C1, D1)
81,213	81	(C10)
2,899,219	81	TOTAL AREA

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
0	HSG D	
2,899,219	Other	A1, A10, A2, A3, A4, A5, A6, A7, A8, A9, AA2, AA4, B1, B3, B5, B7, B9, BB1, BB3, BBB1, BBB3, C0, C1, C10, C2, C3, C4, C5, C6, C7, C8, C9, CC2, CC4, D1, D10, D11, D12, D2, D3, D4, D5, D6, D7, D8, D9, E1, E10, E11, E12, E14, E2, E3, E4, E5, E6, E7, E8, E9
2,899,219		TOTAL AREA

sw model 2022

Prepared by Stantec Consulting Ltd.

Printed 3/25/2022

HydroCAD® 10.00-20 s/n 02201 © 2017 HydroCAD Software Solutions LLC

Page 4

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Subcatchment Numbers
0	0	0	0	2,899,219	2,899,219		A 1 , A 1 0 , A 2 , A 3 , A 4 , A 5 , A 6 , A 7 , A 8 , A 9 , A A 2 , A A 4 , B 1 , B 3 , B

sw model 2022

Prepared by Stantec Consulting Ltd.

Printed 3/25/2022

HydroCAD® 10.00-20 s/n 02201 © 2017 HydroCAD Software Solutions LLC

Page 5

Ground Covers (all nodes) (continued)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Subcatchment Numbers
0	0	0	0	2,899,219	2,899,219	TOTAL AREA	

sw model 2022

Prepared by Stantec Consulting Ltd.

Printed 3/25/2022

HydroCAD® 10.00-20 s/n 02201 © 2017 HydroCAD Software Solutions LLC

Page 6

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	2P	856.00	855.70	150.0	0.0020	0.011	96.0	0.0	0.0
2	5P	895.39	888.64	135.0	0.0500	0.011	36.0	0.0	0.0
3	5P	895.00	888.25	135.0	0.0500	0.011	36.0	0.0	0.0
4	7P	870.00	867.00	94.0	0.0319	0.011	96.0	0.0	0.0
5	9P	864.00	860.00	100.0	0.0400	0.011	48.0	0.0	0.0

Time span=0.00-62.00 hrs, dt=0.01 hrs, 6201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentA1: A1	Runoff Area=31,276 sf 0.00% Impervious Runoff Depth=4.53" Flow Length=285' Slope=0.0480 '/' Tc=24.8 min CN=75 Runoff=3.24 cfs 11,808 cf
SubcatchmentA10: A10	Runoff Area=34,581 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=40' Slope=0.6000 '/' Tc=1.9 min CN=83 Runoff=8.63 cfs 15,662 cf
SubcatchmentA2: A2	Runoff Area=40,083 sf 0.00% Impervious Runoff Depth=4.53" Flow Length=323' Tc=29.1 min CN=75 Runoff=3.80 cfs 15,133 cf
SubcatchmentA3: A3	Runoff Area=16,767 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=78' Slope=0.4360 '/' Tc=3.6 min CN=83 Runoff=4.04 cfs 7,594 cf
SubcatchmentA4: A4	Runoff Area=50,395 sf 0.00% Impervious Runoff Depth=5.09" Flow Length=300' Slope=0.1070 '/' Tc=18.8 min CN=80 Runoff=6.73 cfs 21,388 cf
SubcatchmentA5: A5	Runoff Area=24,909 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=70' Slope=0.4860 '/' Tc=3.2 min CN=83 Runoff=6.08 cfs 11,281 cf
SubcatchmentA6: A6	Runoff Area=54,714 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=154' Slope=0.2340 '/' Tc=8.1 min CN=83 Runoff=11.08 cfs 24,780 cf
SubcatchmentA7: A7	Runoff Area=24,403 sf 0.00% Impervious Runoff Depth=5.43" Tc=0.0 min CN=83 Runoff=6.15 cfs 11,052 cf
SubcatchmentA8: A8	Runoff Area=26,633 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=182' Slope=0.2530 '/' Tc=8.9 min CN=83 Runoff=5.22 cfs 12,062 cf
SubcatchmentA9: A9	Runoff Area=52,401 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=84' Slope=0.4760 '/' Tc=3.7 min CN=83 Runoff=12.59 cfs 23,732 cf
SubcatchmentAA2: AA2	Runoff Area=38,957 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=48' Slope=0.4170 '/' Tc=2.5 min CN=83 Runoff=9.63 cfs 17,644 cf
SubcatchmentAA4: AA4	Runoff Area=40,789 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=40' Slope=0.1500 '/' Tc=3.3 min CN=83 Runoff=9.94 cfs 18,473 cf
SubcatchmentB1: B1	Runoff Area=80,368 sf 0.00% Impervious Runoff Depth=4.75" Flow Length=450' Tc=30.6 min CN=77 Runoff=7.77 cfs 31,840 cf
SubcatchmentB3: B3	Runoff Area=46,036 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=170' Slope=0.1650 '/' Tc=10.0 min CN=83 Runoff=8.63 cfs 20,850 cf
SubcatchmentB5: B5	Runoff Area=58,254 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=77' Slope=0.3900 '/' Tc=3.8 min CN=83 Runoff=13.97 cfs 26,383 cf
SubcatchmentB7: B7	Runoff Area=65,379 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=70' Slope=0.5140 '/' Tc=3.1 min CN=83 Runoff=16.01 cfs 29,610 cf

SubcatchmentB9: B9	Runoff Area=91,161 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=159' Slope=0.4150 '/' Tc=6.6 min CN=83 Runoff=19.73 cfs 41,287 cf
SubcatchmentBB1: BB1	Runoff Area=36,136 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=170' Slope=0.4710 '/' Tc=6.6 min CN=83 Runoff=7.82 cfs 16,366 cf
SubcatchmentBB3: BB3	Runoff Area=43,588 sf 0.00% Impervious Runoff Depth=4.98" Flow Length=133' Slope=0.3310 '/' Tc=6.2 min CN=79 Runoff=8.93 cfs 18,087 cf
SubcatchmentBBB1: BBB1	Runoff Area=75,718 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=133' Slope=0.2260 '/' Tc=7.3 min CN=83 Runoff=15.88 cfs 34,292 cf
SubcatchmentBBB3: BBB3	Runoff Area=22,009 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=40' Slope=0.4000 '/' Tc=2.2 min CN=83 Runoff=5.47 cfs 9,968 cf
SubcatchmentC0: C0	Runoff Area=11,617 sf 0.00% Impervious Runoff Depth=4.53" Flow Length=150' Slope=0.0800 '/' Tc=12.1 min CN=75 Runoff=1.73 cfs 4,386 cf
SubcatchmentC1: C1	Runoff Area=197,994 sf 0.00% Impervious Runoff Depth=4.64" Flow Length=226' Slope=0.0520 '/' Tc=20.0 min CN=76 Runoff=23.61 cfs 76,593 cf
SubcatchmentC10: C10	Runoff Area=81,213 sf 0.00% Impervious Runoff Depth=5.21" Flow Length=76' Slope=0.5970 '/' Tc=3.1 min CN=81 Runoff=19.29 cfs 35,236 cf
SubcatchmentC2: C2	Runoff Area=80,940 sf 0.00% Impervious Runoff Depth=4.75" Flow Length=261' Slope=0.0540 '/' Tc=22.1 min CN=77 Runoff=9.31 cfs 32,067 cf
SubcatchmentC3: C3	Runoff Area=84,663 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=74' Slope=0.4860 '/' Tc=3.3 min CN=83 Runoff=20.64 cfs 38,344 cf
SubcatchmentC4: C4	Runoff Area=53,760 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=65' Slope=0.4620 '/' Tc=3.1 min CN=83 Runoff=13.16 cfs 24,348 cf
SubcatchmentC5: C5	Runoff Area=86,214 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=78' Slope=0.4620 '/' Tc=3.6 min CN=83 Runoff=20.79 cfs 39,046 cf
SubcatchmentC6: C6	Runoff Area=68,040 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=76' Slope=0.2630 '/' Tc=4.4 min CN=83 Runoff=16.00 cfs 30,815 cf
SubcatchmentC7: C7	Runoff Area=89,993 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=65' Slope=0.4920 '/' Tc=3.0 min CN=83 Runoff=22.12 cfs 40,758 cf
SubcatchmentC8: C8	Runoff Area=79,459 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=78' Slope=0.3590 '/' Tc=3.9 min CN=83 Runoff=19.00 cfs 35,987 cf
SubcatchmentC9: C9	Runoff Area=129,406 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=179' Slope=0.3800 '/' Tc=7.5 min CN=83 Runoff=27.01 cfs 58,608 cf
SubcatchmentCC2: CC2	Runoff Area=31,665 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=61' Slope=0.3280 '/' Tc=3.4 min CN=83 Runoff=7.68 cfs 14,341 cf

SubcatchmentCC4: CC4	Runoff Area=76,564 sf 0.00% Impervious Runoff Depth=5.09"
Flow Length=179' Slope=0.4690 '/' Tc=6.9 min CN=80	Runoff=15.53 cfs 32,494 cf
SubcatchmentD1: D1	Runoff Area=10,290 sf 0.00% Impervious Runoff Depth=4.64"
Flow Length=162' Slope=0.1170 '/' Tc=11.1 min CN=76	Runoff=1.61 cfs 3,981 cf
SubcatchmentD10: D10	Runoff Area=24,411 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=111' Slope=0.3960 '/' Tc=5.0 min CN=83	Runoff=5.63 cfs 11,056 cf
SubcatchmentD11: D11	Runoff Area=30,545 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=110' Slope=0.4910 '/' Tc=4.6 min CN=83	Runoff=7.13 cfs 13,834 cf
SubcatchmentD12: D12	Runoff Area=16,855 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=61' Slope=0.3280 '/' Tc=3.4 min CN=83	Runoff=4.09 cfs 7,634 cf
SubcatchmentD2: D2	Runoff Area=93,952 sf 0.00% Impervious Runoff Depth=4.53"
Flow Length=150' Slope=0.0490 '/' Tc=14.7 min CN=75	Runoff=12.71 cfs 35,471 cf
SubcatchmentD3: D3	Runoff Area=11,479 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=84' Slope=0.4290 '/' Tc=3.9 min CN=83	Runoff=2.74 cfs 5,199 cf
SubcatchmentD4: D4	Runoff Area=33,635 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=73' Slope=0.4380 '/' Tc=3.5 min CN=83	Runoff=8.14 cfs 15,233 cf
SubcatchmentD5: D5	Runoff Area=15,874 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=95' Slope=0.2320 '/' Tc=5.5 min CN=83	Runoff=3.59 cfs 7,189 cf
SubcatchmentD6: D6	Runoff Area=33,213 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=94' Slope=0.0426 '/' Tc=10.7 min CN=83	Runoff=6.07 cfs 15,042 cf
SubcatchmentD7: D7	Runoff Area=19,733 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=87' Slope=0.4140 '/' Tc=4.1 min CN=83	Runoff=4.70 cfs 8,937 cf
SubcatchmentD8: D8	Runoff Area=28,951 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=99' Slope=0.4040 '/' Tc=4.5 min CN=83	Runoff=6.80 cfs 13,112 cf
SubcatchmentD9: D9	Runoff Area=23,491 sf 0.00% Impervious Runoff Depth=5.43"
Tc=0.0 min CN=83	Runoff=5.92 cfs 10,639 cf
SubcatchmentE1: E1	Runoff Area=65,473 sf 0.00% Impervious Runoff Depth=4.53"
Flow Length=154' Slope=0.0470 '/' Tc=15.3 min CN=75	Runoff=8.73 cfs 24,719 cf
SubcatchmentE10: E10	Runoff Area=76,146 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=125' Slope=0.1920 '/' Tc=7.4 min CN=83	Runoff=15.89 cfs 34,486 cf
SubcatchmentE11: E11	Runoff Area=29,213 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=133' Slope=0.3010 '/' Tc=6.5 min CN=83	Runoff=6.32 cfs 13,230 cf
SubcatchmentE12: E12	Runoff Area=88,379 sf 0.00% Impervious Runoff Depth=5.43"
Flow Length=85' Slope=0.1650 '/' Tc=5.8 min CN=83	Runoff=19.70 cfs 40,027 cf

SubcatchmentE14: E14	Runoff Area=3,315 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=110' Slope=0.0360 '/' Tc=0.6 min CN=83 Runoff=0.83 cfs 1,501 cf
SubcatchmentE2: E2	Runoff Area=37,677 sf 0.00% Impervious Runoff Depth=4.53" Flow Length=267' Slope=0.0520 '/' Tc=22.8 min CN=75 Runoff=4.10 cfs 14,225 cf
SubcatchmentE3: E3	Runoff Area=26,387 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=94' Slope=0.4260 '/' Tc=4.3 min CN=83 Runoff=6.23 cfs 11,951 cf
SubcatchmentE4: E4	Runoff Area=24,276 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=80' Slope=0.4500 '/' Tc=3.7 min CN=83 Runoff=5.83 cfs 10,995 cf
SubcatchmentE5: E5	Runoff Area=26,394 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=90' Slope=0.4000 '/' Tc=4.2 min CN=83 Runoff=6.25 cfs 11,954 cf
SubcatchmentE6: E6	Runoff Area=27,749 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=78' Slope=0.4620 '/' Tc=3.6 min CN=83 Runoff=6.69 cfs 12,567 cf
SubcatchmentE7: E7	Runoff Area=41,042 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=128' Slope=0.4060 '/' Tc=5.6 min CN=83 Runoff=9.22 cfs 18,588 cf
SubcatchmentE8: E8	Runoff Area=60,350 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=82' Slope=0.0980 '/' Tc=6.9 min CN=83 Runoff=12.87 cfs 27,332 cf
SubcatchmentE9: E9	Runoff Area=24,304 sf 0.00% Impervious Runoff Depth=5.43" Flow Length=73' Slope=0.3840 '/' Tc=3.6 min CN=83 Runoff=5.86 cfs 11,007 cf
Reach A10T: A10 Terrace	Avg. Flow Depth=0.88' Max Vel=5.58 fps Inflow=24.65 cfs 51,778 cf n=0.035 L=486.0' S=0.0535 '/' Capacity=168.20 cfs Outflow=23.48 cfs 51,778 cf
Reach A1T: A1 Terrace	Avg. Flow Depth=0.46' Max Vel=2.82 fps Inflow=3.24 cfs 11,808 cf n=0.035 L=184.0' S=0.0326 '/' Capacity=131.31 cfs Outflow=3.23 cfs 11,808 cf
Reach A2T: A2 Terrace	Avg. Flow Depth=0.48' Max Vel=3.02 fps Inflow=3.80 cfs 15,133 cf n=0.035 L=228.0' S=0.0351 '/' Capacity=136.21 cfs Outflow=3.79 cfs 15,133 cf
Reach A3T: A3 Terrace	Avg. Flow Depth=0.47' Max Vel=3.20 fps Inflow=4.04 cfs 7,594 cf n=0.035 L=250.0' S=0.0400 '/' Capacity=145.44 cfs Outflow=3.94 cfs 7,594 cf
Reach A4T: A4 Terrace	Avg. Flow Depth=0.57' Max Vel=3.75 fps Inflow=6.73 cfs 21,388 cf n=0.035 L=556.0' S=0.0432 '/' Capacity=151.08 cfs Outflow=6.58 cfs 21,388 cf
Reach A5T: A5 Terrace	Avg. Flow Depth=0.54' Max Vel=3.67 fps Inflow=6.08 cfs 11,281 cf n=0.035 L=364.0' S=0.0440 '/' Capacity=152.46 cfs Outflow=5.84 cfs 11,281 cf
Reach A6T: A5 Terrace	Avg. Flow Depth=0.67' Max Vel=4.21 fps Inflow=11.08 cfs 24,780 cf n=0.035 L=687.0' S=0.0437 '/' Capacity=151.96 cfs Outflow=10.29 cfs 24,780 cf
Reach A7T: A7 Terrace	Avg. Flow Depth=0.55' Max Vel=3.63 fps Inflow=6.15 cfs 11,052 cf n=0.035 L=471.0' S=0.0425 '/' Capacity=149.85 cfs Outflow=5.90 cfs 11,052 cf

Reach A8T: A8 Terrace	Avg. Flow Depth=0.48'	Max Vel=4.04 fps	Inflow=5.22 cfs	12,062 cf
n=0.035	L=257.0'	S=0.0623 '/'	Capacity=181.44 cfs	Outflow=5.14 cfs 12,062 cf
Reach A9T: A9 Terrace	Avg. Flow Depth=0.82'	Max Vel=3.12 fps	Inflow=12.59 cfs	23,732 cf
n=0.035	L=544.0'	S=0.0184 '/'	Capacity=98.59 cfs	Outflow=11.42 cfs 23,732 cf
Reach AA2T: AA2 Terrace	Avg. Flow Depth=0.56'	Max Vel=5.44 fps	Inflow=9.63 cfs	17,644 cf
n=0.035	L=330.0'	S=0.0909 '/'	Capacity=219.26 cfs	Outflow=9.52 cfs 17,644 cf
Reach AA4T: AA4 Terrace	Avg. Flow Depth=0.65'	Max Vel=3.99 fps	Inflow=9.94 cfs	18,473 cf
n=0.035	L=590.0'	S=0.0407 '/'	Capacity=146.66 cfs	Outflow=9.23 cfs 18,473 cf
Reach AADS1: AA Downslope 1	Avg. Flow Depth=0.13'	Max Vel=7.74 fps	Inflow=9.52 cfs	17,644 cf
n=0.017	L=32.0'	S=0.1250 '/'	Capacity=1,152.39 cfs	Outflow=9.50 cfs 17,644 cf
Reach ADS1: A Downslope 1	Avg. Flow Depth=0.13'	Max Vel=5.48 fps	Inflow=6.95 cfs	26,941 cf
n=0.040	L=120.0'	S=0.3333 '/'	Capacity=799.79 cfs	Outflow=6.95 cfs 26,941 cf
Reach ADS2: A Downslope 2	Avg. Flow Depth=0.21'	Max Vel=6.94 fps	Inflow=14.07 cfs	55,922 cf
n=0.040	L=144.0'	S=0.3056 '/'	Capacity=765.74 cfs	Outflow=14.06 cfs 55,922 cf
Reach ADS3: A Downslope 3	Avg. Flow Depth=0.30'	Max Vel=7.78 fps	Inflow=23.25 cfs	91,983 cf
n=0.040	L=412.0'	S=0.2476 '/'	Capacity=689.26 cfs	Outflow=23.15 cfs 91,983 cf
Reach ADS4: A Downslope 4	Avg. Flow Depth=0.35'	Max Vel=8.74 fps	Inflow=30.63 cfs	115,097 cf
n=0.040	L=115.0'	S=0.2609 '/'	Capacity=707.53 cfs	Outflow=30.59 cfs 115,097 cf
Reach ADS5: A Downslope 5	Avg. Flow Depth=0.48'	Max Vel=8.32 fps	Inflow=41.71 cfs	138,829 cf
n=0.040	L=62.0'	S=0.1613 '/'	Capacity=556.34 cfs	Outflow=41.65 cfs 138,829 cf
Reach B1T: B1 Terrace	Avg. Flow Depth=0.59'	Max Vel=4.08 fps	Inflow=7.77 cfs	31,840 cf
n=0.035	L=451.0'	S=0.0488 '/'	Capacity=160.61 cfs	Outflow=7.72 cfs 31,840 cf
Reach B3T: B3 Terrace	Avg. Flow Depth=0.53'	Max Vel=5.48 fps	Inflow=8.63 cfs	20,850 cf
n=0.035	L=300.0'	S=0.1000 '/'	Capacity=229.96 cfs	Outflow=8.54 cfs 20,850 cf
Reach B5T: B5 Terrace	Avg. Flow Depth=0.54'	Max Vel=8.69 fps	Inflow=13.97 cfs	26,383 cf
n=0.035	L=154.0'	S=0.2468 '/'	Capacity=361.22 cfs	Outflow=13.91 cfs 26,383 cf
Reach B7T: B7 Terrace	Avg. Flow Depth=0.62'	Max Vel=7.57 fps	Inflow=16.01 cfs	29,610 cf
n=0.035	L=230.0'	S=0.1565 '/'	Capacity=287.70 cfs	Outflow=15.88 cfs 29,610 cf
Reach B9T: B9 Terrace	Avg. Flow Depth=1.90'	Max Vel=1.96 fps	Inflow=41.74 cfs	120,000 cf
n=0.035	L=426.0'	S=0.0023 '/'	Capacity=64.82 cfs	Outflow=39.16 cfs 120,000 cf
Reach BB1T: BB1 Terrace	Avg. Flow Depth=0.63'	Max Vel=3.40 fps	Inflow=7.82 cfs	16,366 cf
n=0.035	L=392.0'	S=0.0306 '/'	Capacity=127.23 cfs	Outflow=7.44 cfs 16,366 cf
Reach BB3T: BB3 Terrace	Avg. Flow Depth=1.22'	Max Vel=2.73 fps	Inflow=24.01 cfs	62,348 cf
n=0.035	L=488.0'	S=0.0082 '/'	Capacity=65.84 cfs	Outflow=22.38 cfs 62,348 cf

Reach BBB1T: BBB1 Terrace	Avg. Flow Depth=0.83'	Max Vel=3.85 fps	Inflow=15.88 cfs	34,292 cf
	n=0.035	L=660.0'	S=0.0273 '/'	Capacity=120.09 cfs Outflow=14.59 cfs 34,292 cf
Reach BBB3T: BBB3 Terrace	Avg. Flow Depth=0.52'	Max Vel=3.57 fps	Inflow=5.47 cfs	9,968 cf
	n=0.035	L=365.0'	S=0.0438 '/'	Capacity=152.25 cfs Outflow=5.30 cfs 9,968 cf
Reach BBBDS1: BBB Downslope 1	Avg. Flow Depth=0.18'	Max Vel=8.38 fps	Inflow=14.59 cfs	34,292 cf
	n=0.040	L=60.0'	S=0.5333 '/'	Capacity=1,011.66 cfs Outflow=14.57 cfs 34,292 cf
Reach BBBDS2: BBB Downslope 2	Avg. Flow Depth=0.23'	Max Vel=7.43 fps	Inflow=16.71 cfs	44,260 cf
	n=0.040	L=45.0'	S=0.3111 '/'	Capacity=772.67 cfs Outflow=16.70 cfs 44,260 cf
Reach BBDS1: BB Downslope 1	Avg. Flow Depth=0.13'	Max Vel=6.31 fps	Inflow=7.44 cfs	16,366 cf
	n=0.040	L=62.0'	S=0.4839 '/'	Capacity=963.60 cfs Outflow=7.42 cfs 16,366 cf
Reach BDS1: B Downslope 1	Avg. Flow Depth=0.14'	Max Vel=5.94 fps	Inflow=7.72 cfs	31,840 cf
	n=0.040	L=100.0'	S=0.3800 '/'	Capacity=719.18 cfs Outflow=7.72 cfs 31,840 cf
Reach BDS2: B Downslope 2	Avg. Flow Depth=0.16'	Max Vel=7.72 fps	Inflow=11.73 cfs	52,690 cf
	n=0.040	L=75.0'	S=0.5333 '/'	Capacity=1,011.66 cfs Outflow=11.72 cfs 52,690 cf
Reach BDS3: B Downslope 3	Avg. Flow Depth=0.24'	Max Vel=9.40 fps	Inflow=22.04 cfs	79,073 cf
	n=0.040	L=80.0'	S=0.4750 '/'	Capacity=954.73 cfs Outflow=21.97 cfs 79,073 cf
Reach BDS4: B Downslope 4	Avg. Flow Depth=0.37'	Max Vel=10.04 fps	Inflow=37.61 cfs	108,683 cf
	n=0.040	L=100.0'	S=0.3200 '/'	Capacity=783.63 cfs Outflow=37.46 cfs 108,683 cf
Reach C0T: C0 Terrace	Avg. Flow Depth=0.33'	Max Vel=2.93 fps	Inflow=1.73 cfs	4,386 cf
	n=0.035	L=110.0'	S=0.0545 '/'	Capacity=169.83 cfs Outflow=1.72 cfs 4,386 cf
Reach C10T: C10 Terrace	Avg. Flow Depth=0.96'	Max Vel=4.44 fps	Inflow=24.80 cfs	49,577 cf
	n=0.035	L=796.0'	S=0.0302 '/'	Capacity=126.27 cfs Outflow=22.33 cfs 49,577 cf
Reach C1T: C1 Terrace	Avg. Flow Depth=0.82'	Max Vel=6.24 fps	Inflow=23.61 cfs	76,593 cf
	n=0.035	L=636.0'	S=0.0723 '/'	Capacity=195.57 cfs Outflow=23.33 cfs 76,593 cf
Reach C2T: C2 Terrace	Avg. Flow Depth=0.64'	Max Vel=4.12 fps	Inflow=9.31 cfs	32,067 cf
	n=0.035	L=630.0'	S=0.0444 '/'	Capacity=153.30 cfs Outflow=9.16 cfs 32,067 cf
Reach C3T: C3 Terrace	Avg. Flow Depth=0.53'	Max Vel=8.32 fps	Inflow=13.16 cfs	24,348 cf
	n=0.035	L=227.0'	S=0.2291 '/'	Capacity=348.04 cfs Outflow=13.07 cfs 24,348 cf
Reach C4T: C4 Terrace	Avg. Flow Depth=0.83'	Max Vel=5.03 fps	Inflow=20.64 cfs	38,344 cf
	n=0.035	L=811.0'	S=0.0469 '/'	Capacity=157.41 cfs Outflow=18.89 cfs 38,344 cf
Reach C5T: C5 Terrace	Avg. Flow Depth=0.81'	Max Vel=5.03 fps	Inflow=20.79 cfs	39,046 cf
	n=0.035	L=1,158.0'	S=0.0484 '/'	Capacity=159.91 cfs Outflow=17.94 cfs 39,046 cf
Reach C6T: C6 Terrace	Avg. Flow Depth=0.01'	Max Vel=28.98 fps	Inflow=16.00 cfs	30,815 cf
	n=0.035	L=998.0'	S=0.0561 '/'	Capacity=3,419,688,261.92 cfs Outflow=15.81 cfs 30,815 cf

Reach C7T: C7 Terrace	Avg. Flow Depth=0.82' Max Vel=5.21 fps Inflow=22.12 cfs 40,758 cf n=0.035 L=1,182.0' S=0.0508 '/ Capacity=163.84 cfs Outflow=19.16 cfs 40,758 cf
Reach C8T: C8 Terrace	Avg. Flow Depth=0.76' Max Vel=5.19 fps Inflow=19.00 cfs 35,987 cf n=0.035 L=1,183.0' S=0.0558 '/ Capacity=171.76 cfs Outflow=16.43 cfs 35,987 cf
Reach C9T: C9 Terrace	Avg. Flow Depth=1.18' Max Vel=2.59 fps Inflow=27.01 cfs 58,608 cf n=0.035 L=1,290.0' S=0.0078 '/ Capacity=64.03 cfs Outflow=19.74 cfs 58,608 cf
Reach CC2T: CC2 Terrace	Avg. Flow Depth=0.54' Max Vel=4.44 fps Inflow=7.68 cfs 14,341 cf n=0.035 L=565.0' S=0.0637 '/ Capacity=183.56 cfs Outflow=7.23 cfs 14,341 cf
Reach CC4T: CC4 Terrace	Avg. Flow Depth=0.80' Max Vel=3.17 fps Inflow=15.53 cfs 32,494 cf n=0.035 L=1,555.0' S=0.0193 '/ Capacity=101.00 cfs Outflow=11.23 cfs 32,494 cf
Reach CCDS1: CC Downslope 1	Avg. Flow Depth=0.13' Max Vel=5.78 fps Inflow=7.23 cfs 14,341 cf n=0.035 L=69.0' S=0.2899 '/ Capacity=852.35 cfs Outflow=7.19 cfs 14,341 cf
Reach CDS1: C Downslope 1	Avg. Flow Depth=0.06' Max Vel=3.30 fps Inflow=1.72 cfs 4,386 cf n=0.040 L=77.0' S=0.3636 '/ Capacity=835.35 cfs Outflow=1.72 cfs 4,386 cf
Reach CDS2: C Downslope 2	Avg. Flow Depth=0.16' Max Vel=6.44 fps Inflow=10.05 cfs 36,453 cf n=0.040 L=39.0' S=0.3590 '/ Capacity=829.98 cfs Outflow=10.05 cfs 36,453 cf
Reach CDS3: C Downslope 3	Avg. Flow Depth=0.33' Max Vel=10.23 fps Inflow=33.21 cfs 113,046 cf n=0.040 L=72.0' S=0.3889 '/ Capacity=863.87 cfs Outflow=33.20 cfs 113,046 cf
Reach CDS4: C Downslope 4	Avg. Flow Depth=0.38' Max Vel=9.30 fps Inflow=35.80 cfs 137,394 cf n=0.040 L=60.0' S=0.2667 '/ Capacity=715.35 cfs Outflow=35.79 cfs 137,394 cf
Reach CDS5: C Downslope 5	Avg. Flow Depth=0.39' Max Vel=11.04 fps Inflow=43.21 cfs 175,737 cf n=0.040 L=65.0' S=0.3692 '/ Capacity=841.75 cfs Outflow=43.19 cfs 175,737 cf
Reach CDS6: C Downslope 6	Avg. Flow Depth=0.49' Max Vel=11.33 fps Inflow=58.52 cfs 206,552 cf n=0.040 L=62.0' S=0.2903 '/ Capacity=746.41 cfs Outflow=58.43 cfs 206,552 cf
Reach CDS7: C Downslope 7	Avg. Flow Depth=0.52' Max Vel=13.23 fps Inflow=73.09 cfs 245,598 cf n=0.040 L=65.0' S=0.3692 '/ Capacity=841.75 cfs Outflow=73.04 cfs 245,598 cf
Reach CDS8: C Downslope 8	Avg. Flow Depth=0.57' Max Vel=14.32 fps Inflow=87.44 cfs 281,585 cf n=0.040 L=41.0' S=0.3902 '/ Capacity=865.37 cfs Outflow=87.42 cfs 281,585 cf
Reach CDS9: C Downslope 9	Avg. Flow Depth=0.73' Max Vel=13.09 fps Inflow=106.12 cfs 322,343 cf n=0.040 L=89.0' S=0.2472 '/ Capacity=688.73 cfs Outflow=106.05 cfs 322,343 cf
Reach D10T: D10 Terrace	Avg. Flow Depth=0.54' Max Vel=3.48 fps Inflow=5.63 cfs 11,056 cf n=0.035 L=250.0' S=0.0400 '/ Capacity=145.44 cfs Outflow=5.50 cfs 11,056 cf
Reach D11T: D11 Terrace	Avg. Flow Depth=1.03' Max Vel=2.15 fps Inflow=12.86 cfs 46,327 cf n=0.035 L=310.0' S=0.0065 '/ Capacity=58.41 cfs Outflow=12.46 cfs 46,327 cf

Reach D12T: D12 Terrace	Avg. Flow Depth=0.40' Max Vel=4.61 fps Inflow=4.09 cfs 7,634 cf n=0.035 L=212.0' S=0.1038 ' ' Capacity=234.26 cfs Outflow=4.04 cfs 7,634 cf
Reach D1T: D1 Terrace	Avg. Flow Depth=0.34' Max Vel=2.49 fps Inflow=1.61 cfs 3,981 cf n=0.035 L=108.0' S=0.0370 ' ' Capacity=139.95 cfs Outflow=1.61 cfs 3,981 cf
Reach D2T: D2 Terrace	Avg. Flow Depth=0.32' Max Vel=3.95 fps Inflow=12.71 cfs 35,471 cf n=0.035 L=266.0' S=0.0451 ' ' Capacity=336.26 cfs Outflow=12.63 cfs 35,471 cf
Reach D3T: D3 Terrace	Avg. Flow Depth=0.13' Max Vel=2.16 fps Inflow=2.74 cfs 5,199 cf n=0.035 L=150.0' S=0.0400 ' ' Capacity=316.63 cfs Outflow=2.70 cfs 5,199 cf
Reach D4T: D4 Terrace	Avg. Flow Depth=0.59' Max Vel=4.09 fps Inflow=8.14 cfs 15,233 cf n=0.035 L=411.0' S=0.0487 ' ' Capacity=160.41 cfs Outflow=7.81 cfs 15,233 cf
Reach D5T: D5 Terrace	Avg. Flow Depth=0.38' Max Vel=4.40 fps Inflow=3.59 cfs 7,189 cf n=0.035 L=200.0' S=0.1000 ' ' Capacity=229.96 cfs Outflow=3.55 cfs 7,189 cf
Reach D6T: D6 Terrace	Avg. Flow Depth=0.53' Max Vel=3.82 fps Inflow=6.07 cfs 15,042 cf n=0.035 L=369.0' S=0.0488 ' ' Capacity=160.61 cfs Outflow=5.92 cfs 15,042 cf
Reach D7T: D7 Terrace	Avg. Flow Depth=0.44' Max Vel=4.30 fps Inflow=4.70 cfs 8,937 cf n=0.035 L=253.0' S=0.0791 ' ' Capacity=204.46 cfs Outflow=4.61 cfs 8,937 cf
Reach D8T: D8 Terrace	Avg. Flow Depth=0.56' Max Vel=3.80 fps Inflow=6.80 cfs 13,112 cf n=0.035 L=314.0' S=0.0446 ' ' Capacity=153.55 cfs Outflow=6.58 cfs 13,112 cf
Reach D9T: D9 Terrace	Avg. Flow Depth=0.48' Max Vel=4.65 fps Inflow=5.92 cfs 10,639 cf n=0.035 L=290.0' S=0.0828 ' ' Capacity=209.20 cfs Outflow=5.86 cfs 10,639 cf
Reach DDS1: D Downslope 1	Avg. Flow Depth=0.19' Max Vel=7.91 fps Inflow=14.06 cfs 39,451 cf n=0.040 L=82.0' S=0.4634 ' ' Capacity=943.02 cfs Outflow=14.05 cfs 39,451 cf
Reach DDS2: D Downslope 2	Avg. Flow Depth=0.23' Max Vel=9.26 fps Inflow=20.20 cfs 59,883 cf n=0.040 L=80.0' S=0.5000 ' ' Capacity=979.53 cfs Outflow=20.17 cfs 59,883 cf
Reach DDS3: D Downslope 3	Avg. Flow Depth=0.28' Max Vel=10.24 fps Inflow=28.48 cfs 82,115 cf n=0.040 L=82.0' S=0.4634 ' ' Capacity=943.02 cfs Outflow=28.43 cfs 82,115 cf
Reach DDS4: D Downslope 4	Avg. Flow Depth=0.33' Max Vel=11.81 fps Inflow=38.79 cfs 104,163 cf n=0.040 L=82.0' S=0.5122 ' ' Capacity=991.41 cfs Outflow=38.72 cfs 104,163 cf
Reach DDS5: D Downslope 5	Avg. Flow Depth=0.38' Max Vel=11.91 fps Inflow=46.08 cfs 125,858 cf n=0.040 L=78.0' S=0.4359 ' ' Capacity=914.59 cfs Outflow=46.03 cfs 125,858 cf
Reach DDS6: D Downslope 6	Avg. Flow Depth=0.43' Max Vel=13.03 fps Inflow=58.31 cfs 179,819 cf n=0.035 L=82.0' S=0.3415 ' ' Capacity=925.12 cfs Outflow=58.26 cfs 179,819 cf
Reach E10T: E10 Terrace	Avg. Flow Depth=0.75' Max Vel=4.45 fps Inflow=15.89 cfs 34,486 cf n=0.035 L=1,108.0' S=0.0415 ' ' Capacity=148.17 cfs Outflow=13.83 cfs 34,486 cf

Reach E11T: E11 Terrace	Avg. Flow Depth=0.58'	Max Vel=3.31 fps	Inflow=6.32 cfs	13,230 cf
	n=0.035 L=247.0'	S=0.0324 '/'	Capacity=130.87 cfs	Outflow=6.17 cfs 13,230 cf
Reach E12T: E12 Terrace	Avg. Flow Depth=0.81'	Max Vel=4.68 fps	Inflow=19.70 cfs	40,027 cf
	n=0.035 L=1,240.0'	S=0.0419 '/'	Capacity=148.91 cfs	Outflow=16.67 cfs 40,027 cf
Reach E1T: E1 Terrace	Avg. Flow Depth=0.63'	Max Vel=3.99 fps	Inflow=8.73 cfs	24,719 cf
	n=0.035 L=330.0'	S=0.0424 '/'	Capacity=149.78 cfs	Outflow=8.64 cfs 24,719 cf
Reach E2T: E2 Terrace	Avg. Flow Depth=0.47'	Max Vel=3.43 fps	Inflow=4.10 cfs	14,225 cf
	n=0.035 L=257.0'	S=0.0467 '/'	Capacity=157.13 cfs	Outflow=4.08 cfs 14,225 cf
Reach E3T: E3 Terrace	Avg. Flow Depth=0.55'	Max Vel=3.64 fps	Inflow=6.23 cfs	11,951 cf
	n=0.035 L=330.0'	S=0.0424 '/'	Capacity=149.78 cfs	Outflow=5.99 cfs 11,951 cf
Reach E4T: E4 Terrace	Avg. Flow Depth=0.53'	Max Vel=3.62 fps	Inflow=5.83 cfs	10,995 cf
	n=0.035 L=322.0'	S=0.0435 '/'	Capacity=151.63 cfs	Outflow=5.64 cfs 10,995 cf
Reach E5T: E5 Terrace	Avg. Flow Depth=0.54'	Max Vel=3.79 fps	Inflow=6.25 cfs	11,954 cf
	n=0.035 L=339.0'	S=0.0472 '/'	Capacity=157.98 cfs	Outflow=6.02 cfs 11,954 cf
Reach E6T: E6 Terrace	Avg. Flow Depth=0.56'	Max Vel=3.81 fps	Inflow=6.69 cfs	12,567 cf
	n=0.035 L=350.0'	S=0.0457 '/'	Capacity=155.48 cfs	Outflow=6.46 cfs 12,567 cf
Reach E7T: E7 Terrace	Avg. Flow Depth=0.56'	Max Vel=5.22 fps	Inflow=9.22 cfs	18,588 cf
	n=0.035 L=309.0'	S=0.0841 '/'	Capacity=210.94 cfs	Outflow=9.04 cfs 18,588 cf
Reach E8T: E8 Terrace	Avg. Flow Depth=0.72'	Max Vel=4.04 fps	Inflow=12.87 cfs	27,332 cf
	n=0.035 L=875.0'	S=0.0366 '/'	Capacity=139.06 cfs	Outflow=11.42 cfs 27,332 cf
Reach E9T: E9 Terrace	Avg. Flow Depth=0.48'	Max Vel=4.50 fps	Inflow=5.86 cfs	11,007 cf
	n=0.035 L=286.0'	S=0.0769 '/'	Capacity=201.69 cfs	Outflow=5.75 cfs 11,007 cf
Reach EDS1: E Downslope 1	Avg. Flow Depth=0.17'	Max Vel=7.67 fps	Inflow=12.28 cfs	38,943 cf
	n=0.040 L=81.0'	S=0.4938 '/'	Capacity=973.47 cfs	Outflow=12.27 cfs 38,943 cf
Reach EDS2: E Downslope 2	Avg. Flow Depth=0.56'	Max Vel=10.87 fps	Inflow=18.67 cfs	61,888 cf
	n=0.040 L=83.0'	S=0.4819 '/'	Capacity=559.79 cfs	Outflow=18.64 cfs 61,888 cf
Reach EDS3: E Downslope 3	Avg. Flow Depth=0.67'	Max Vel=12.31 fps	Inflow=30.80 cfs	86,410 cf
	n=0.040 L=104.0'	S=0.4808 '/'	Capacity=559.11 cfs	Outflow=30.72 cfs 86,410 cf
Reach EDS4: E Downslope 4	Avg. Flow Depth=0.35'	Max Vel=11.18 fps	Inflow=39.29 cfs	113,742 cf
	n=0.040 L=47.0'	S=0.4255 '/'	Capacity=903.65 cfs	Outflow=39.25 cfs 113,742 cf
Reach EDS5: E Downslope 5	Avg. Flow Depth=0.49'	Max Vel=9.37 fps	Inflow=47.98 cfs	132,330 cf
	n=0.040 L=100.0'	S=0.2000 '/'	Capacity=619.51 cfs	Outflow=47.87 cfs 132,330 cf
Reach EDS6: E Downslope 6	Avg. Flow Depth=0.49'	Max Vel=12.10 fps	Inflow=62.00 cfs	177,823 cf
	n=0.040 L=72.0'	S=0.3333 '/'	Capacity=799.79 cfs	Outflow=61.95 cfs 177,823 cf

sw model 2022*MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"*

Prepared by Stantec Consulting Ltd.

Printed 3/25/2022

HydroCAD® 10.00-20 s/n 02201 © 2017 HydroCAD Software Solutions LLC

Page 16

Pond 1P: Existing West Pond Peak Elev=847.07' Storage=184,178 cf Inflow=81.61 cfs 232,582 cf
Outflow=1.29 cfs 200,898 cf

Pond 2P: 96" RCP Peak Elev=859.27' Inflow=81.61 cfs 232,582 cf
96.0" Round Culvert n=0.011 L=150.0' S=0.0020 '/' Outflow=81.61 cfs 232,582 cf

Pond 3P: Existing Northwest Peak Elev=863.15' Storage=179,795 cf Inflow=58.26 cfs 179,819 cf
Outflow=0.00 cfs 0 cf

Pond 4P: Existing Northeast Peak Elev=886.64' Storage=430,519 cf Inflow=136.89 cfs 430,527 cf
Outflow=0.00 cfs 0 cf

Pond 5P: Existing ponding area Peak Elev=896.89' Storage=961 cf Inflow=58.42 cfs 228,683 cf
Outflow=58.40 cfs 228,683 cf

Pond 6P: Existing East Sedimentation Peak Elev=890.31' Storage=228,677 cf Inflow=58.40 cfs 228,683 cf
Outflow=0.00 cfs 0 cf

Pond 7P: Diversion Structure with 60" RCP Peak Elev=872.67' Storage=873 cf Inflow=81.62 cfs 232,582 cf
96.0" Round Culvert n=0.011 L=94.0' S=0.0319 '/' Outflow=81.61 cfs 232,582 cf

Pond 8P: Existing Southwest Pond Peak Elev=841.01' Storage=153,565 cf Inflow=62.78 cfs 190,608 cf
Discarded=0.84 cfs 144,012 cf Primary=0.00 cfs 0 cf Outflow=0.84 cfs 144,012 cf

Pond 9P: 48" RCP Peak Elev=867.39' Inflow=62.78 cfs 190,608 cf
48.0" Round Culvert n=0.011 L=100.0' S=0.0400 '/' Outflow=62.78 cfs 190,608 cf

Total Runoff Area = 2,899,219 sf Runoff Volume = 1,262,219 cf Average Runoff Depth = 5.22"
100.00% Pervious = 2,899,219 sf 0.00% Impervious = 0 sf

Summary for Subcatchment A1: A1

Runoff = 3.24 cfs @ 12.37 hrs, Volume= 11,808 cf, Depth= 4.53"

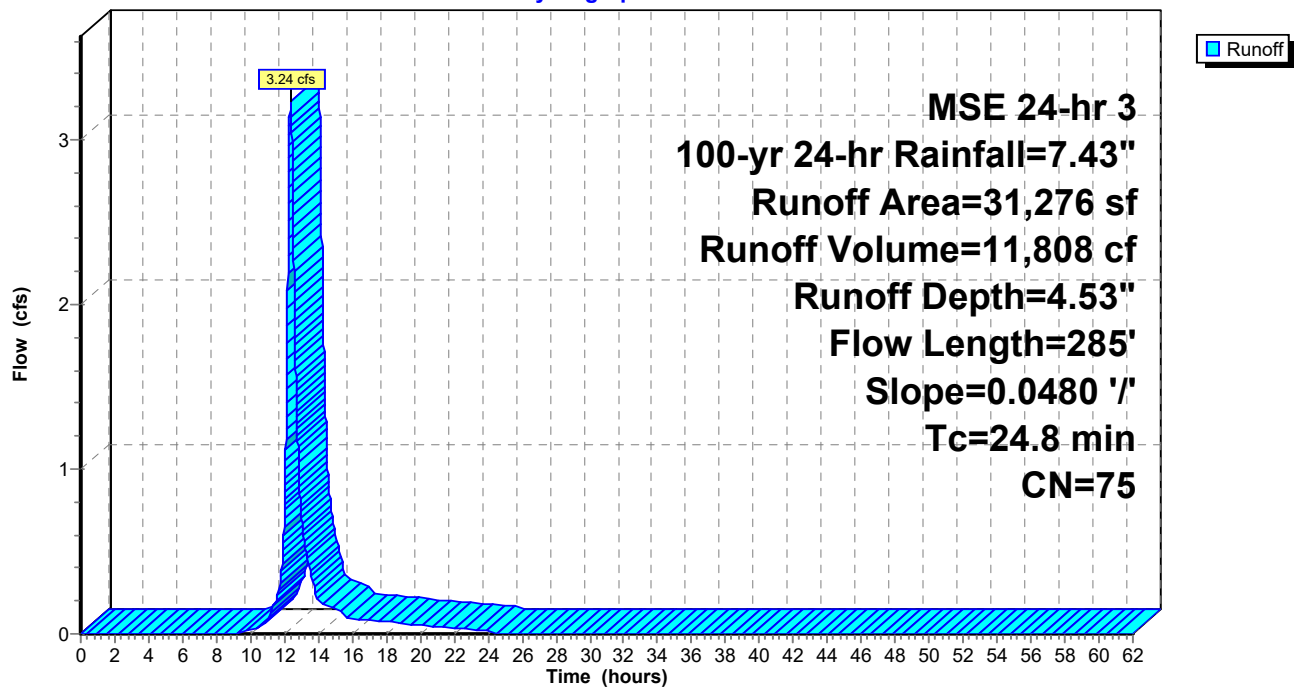
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	31,276	75	
	31,276		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.8	285	0.0480	0.19		Sheet Flow, A1 Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A1: A1

Hydrograph



Summary for Subcatchment A10: A10

Runoff = 8.63 cfs @ 12.10 hrs, Volume= 15,662 cf, Depth= 5.43"

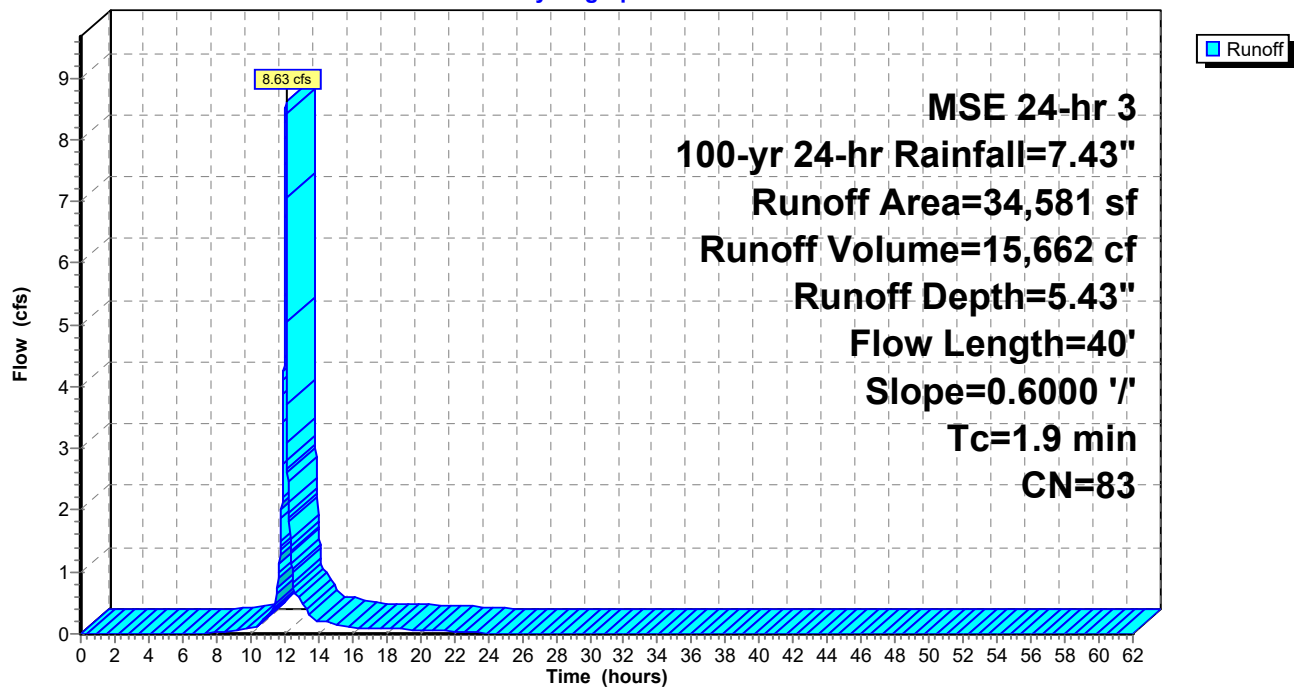
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	34,581	83	
	34,581		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.6000	0.35		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A10: A10

Hydrograph



Summary for Subcatchment A2: A2

Runoff = 3.80 cfs @ 12.41 hrs, Volume= 15,133 cf, Depth= 4.53"

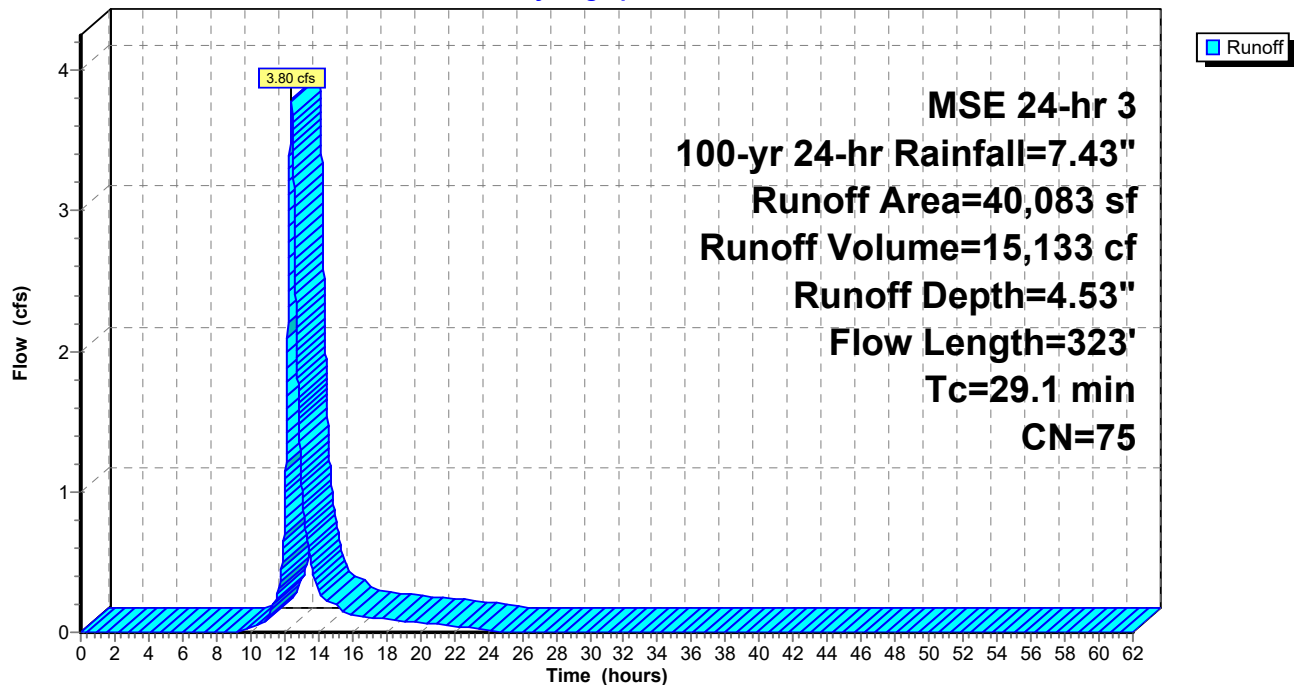
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 40,083	75	
40,083		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.0	300	0.0360	0.17		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"
0.1	23	0.0434	3.12		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
29.1	323	Total			

Subcatchment A2: A2

Hydrograph



Summary for Subcatchment A3: A3

Runoff = 4.04 cfs @ 12.11 hrs, Volume= 7,594 cf, Depth= 5.43"

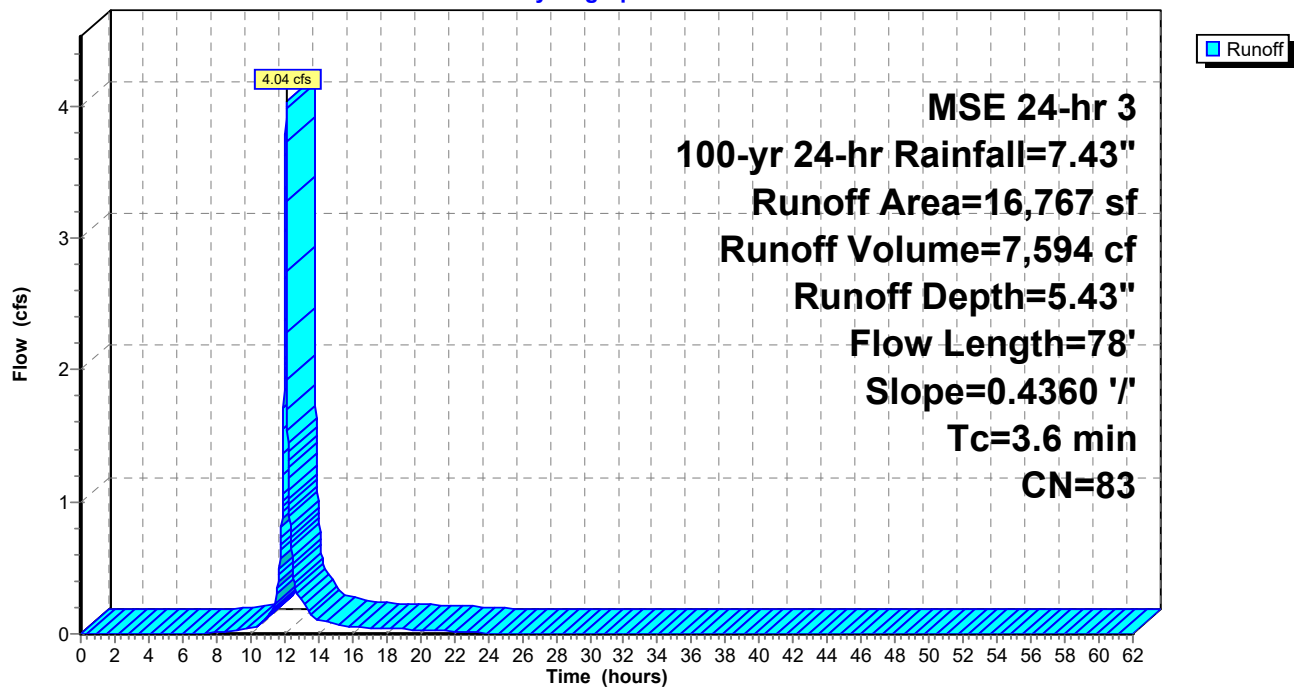
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 16,767	83	
16,767		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	78	0.4360	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A3: A3

Hydrograph



Summary for Subcatchment A4: A4

Runoff = 6.73 cfs @ 12.27 hrs, Volume= 21,388 cf, Depth= 5.09"

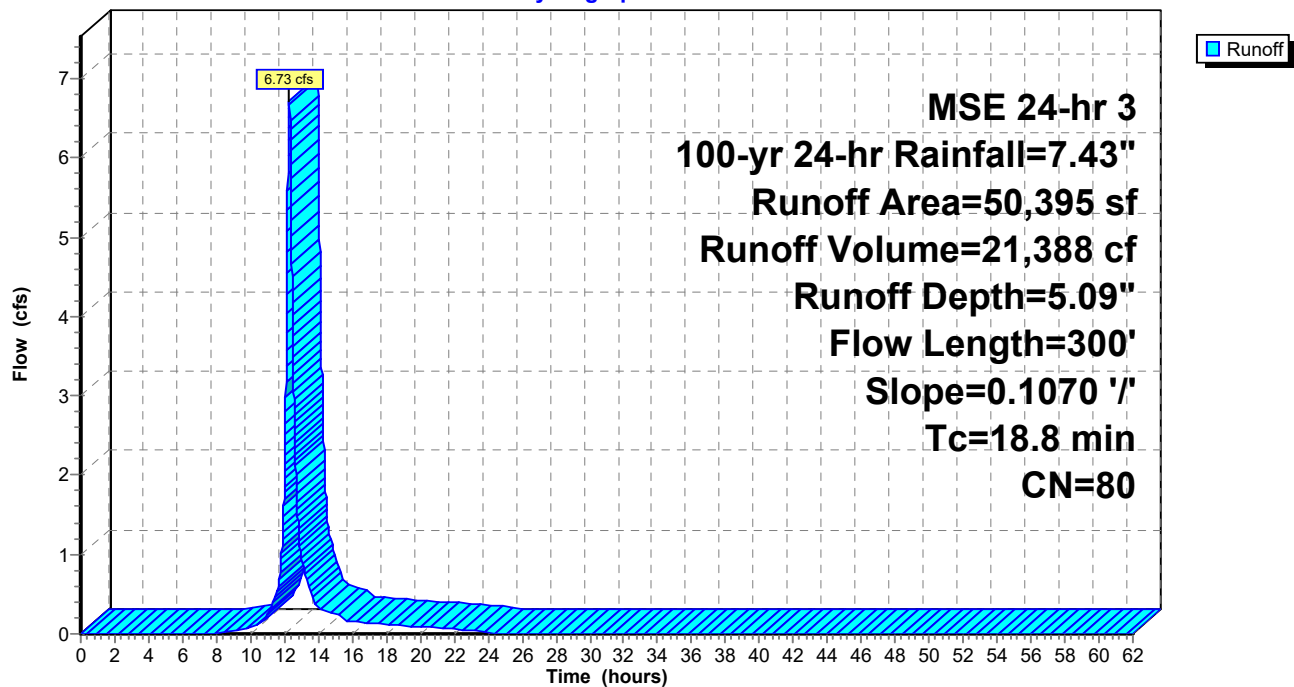
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	50,395	80	
	50,395		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.8	300	0.1070	0.27		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A4: A4

Hydrograph



Summary for Subcatchment A5: A5

Runoff = 6.08 cfs @ 12.11 hrs, Volume= 11,281 cf, Depth= 5.43"

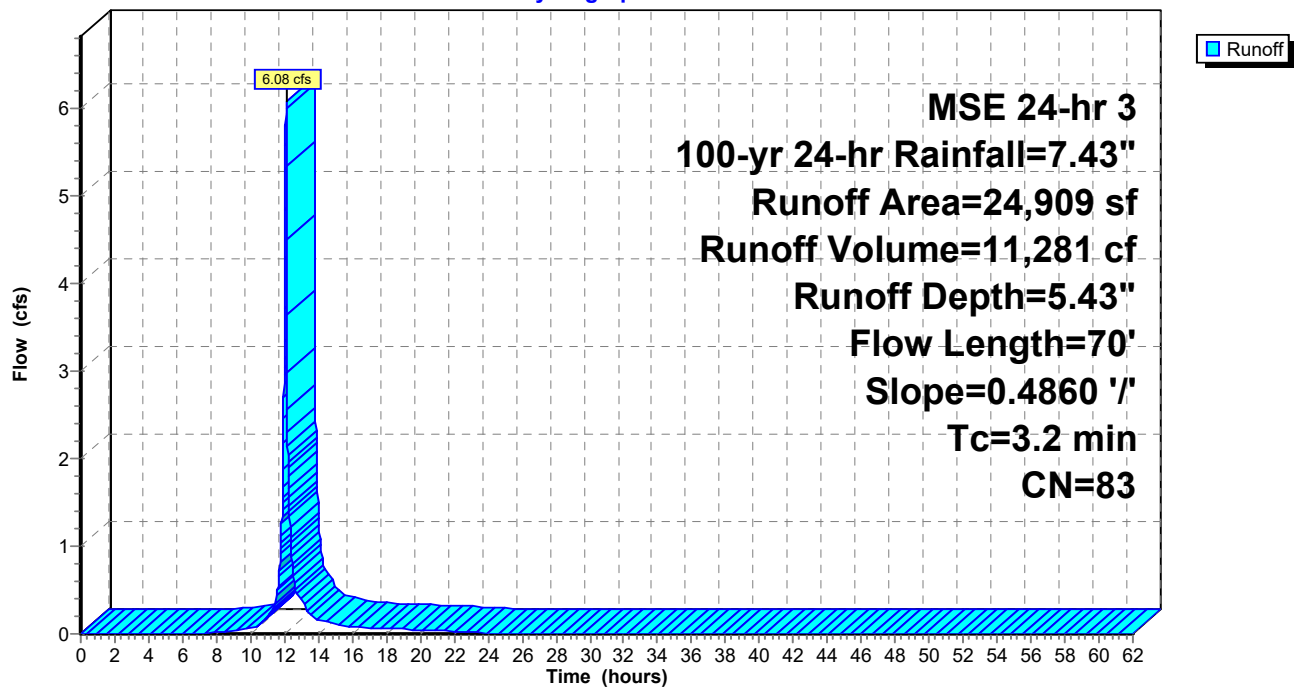
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	24,909	83	
	24,909		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.2	70	0.4860	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A5: A5

Hydrograph



Summary for Subcatchment A6: A6

Runoff = 11.08 cfs @ 12.15 hrs, Volume= 24,780 cf, Depth= 5.43"

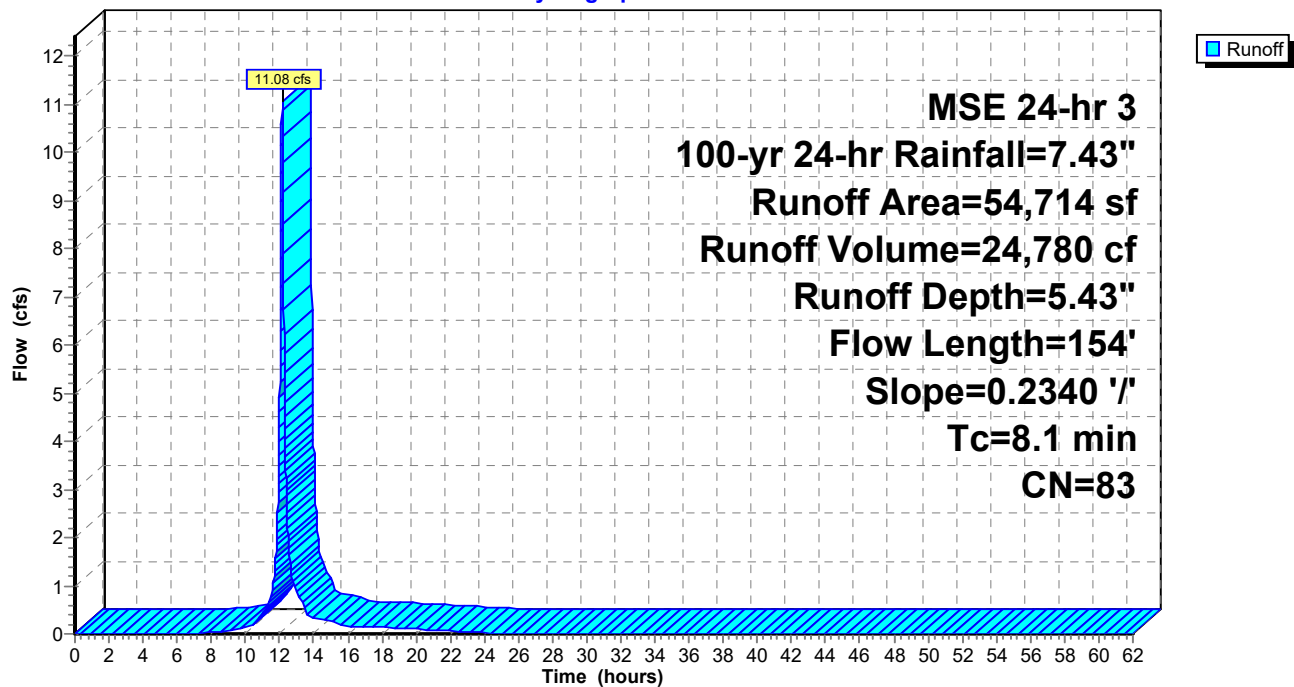
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	54,714	83	
	54,714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	154	0.2340	0.32		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A6: A6

Hydrograph



Summary for Subcatchment A7: A7

[46] Hint: $T_c=0$ (Instant runoff peak depends on dt)

Runoff = 6.15 cfs @ 12.09 hrs, Volume= 11,052 cf, Depth= 5.43"

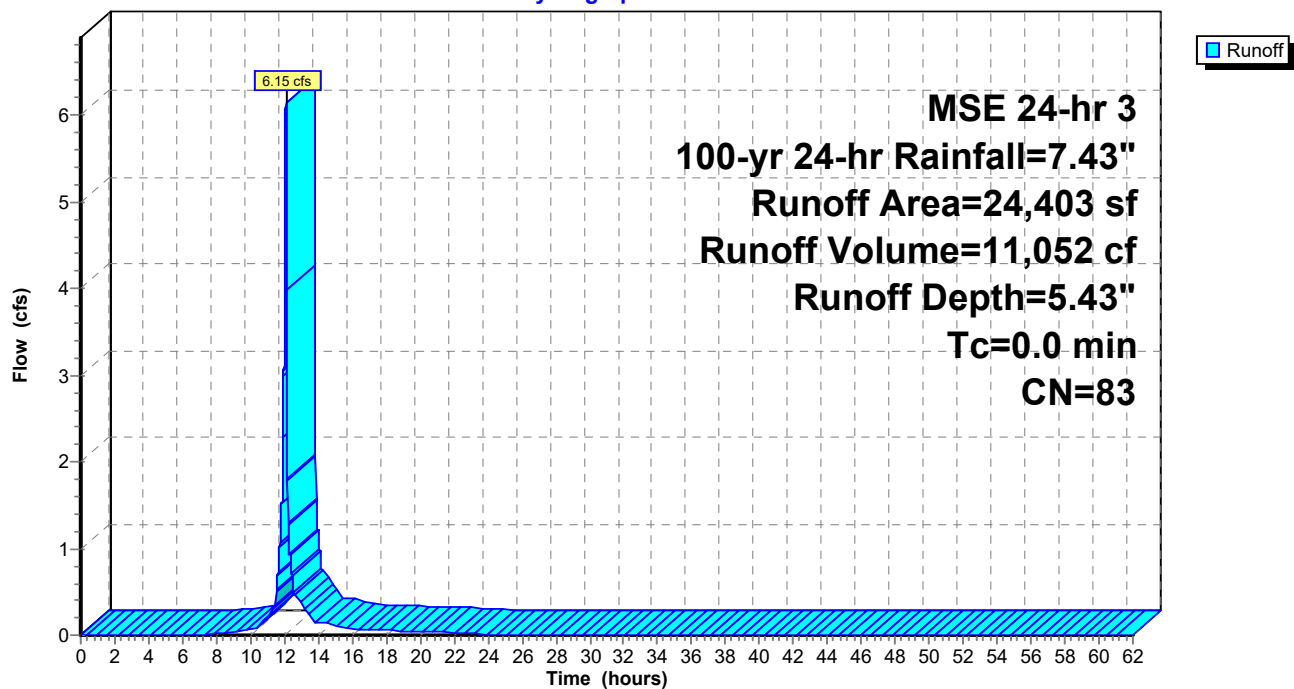
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, $dt=0.01$ hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	24,403	83	
	24,403		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry,

Subcatchment A7: A7

Hydrograph



Summary for Subcatchment A8: A8

Runoff = 5.22 cfs @ 12.16 hrs, Volume= 12,062 cf, Depth= 5.43"

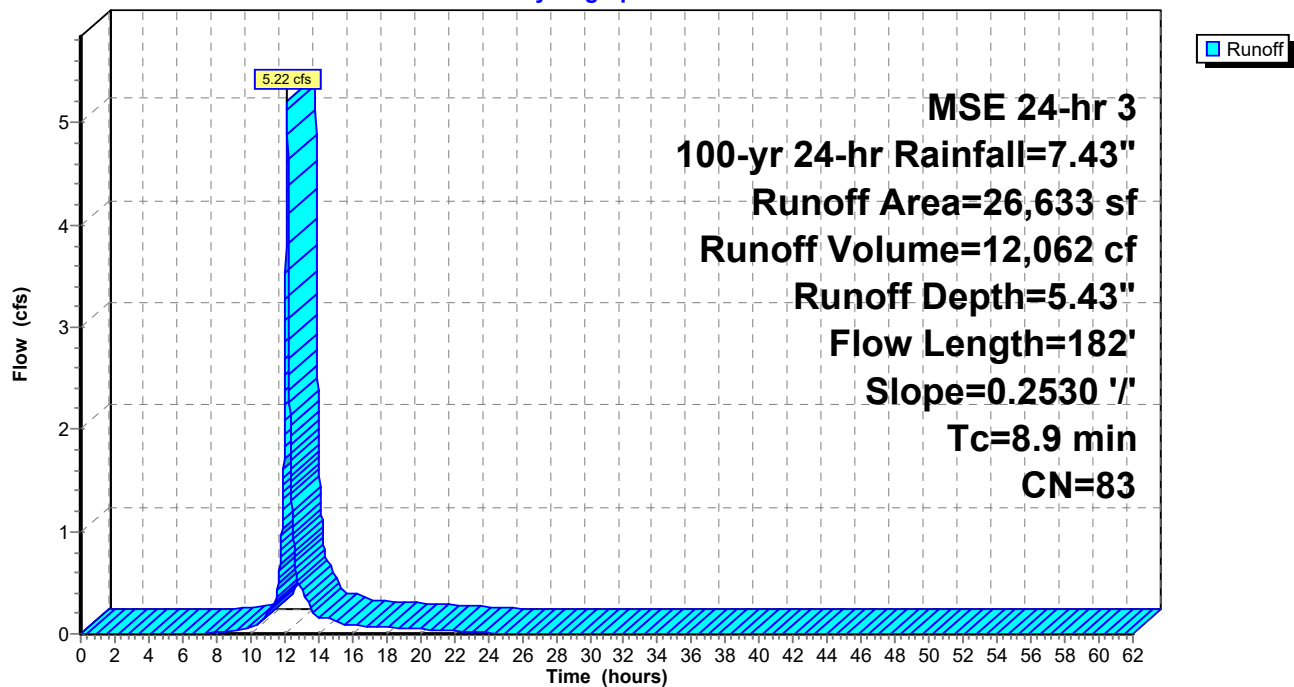
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	26,633	83	
	26,633		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9	182	0.2530	0.34		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A8: A8

Hydrograph



Summary for Subcatchment A9: A9

Runoff = 12.59 cfs @ 12.11 hrs, Volume= 23,732 cf, Depth= 5.43"

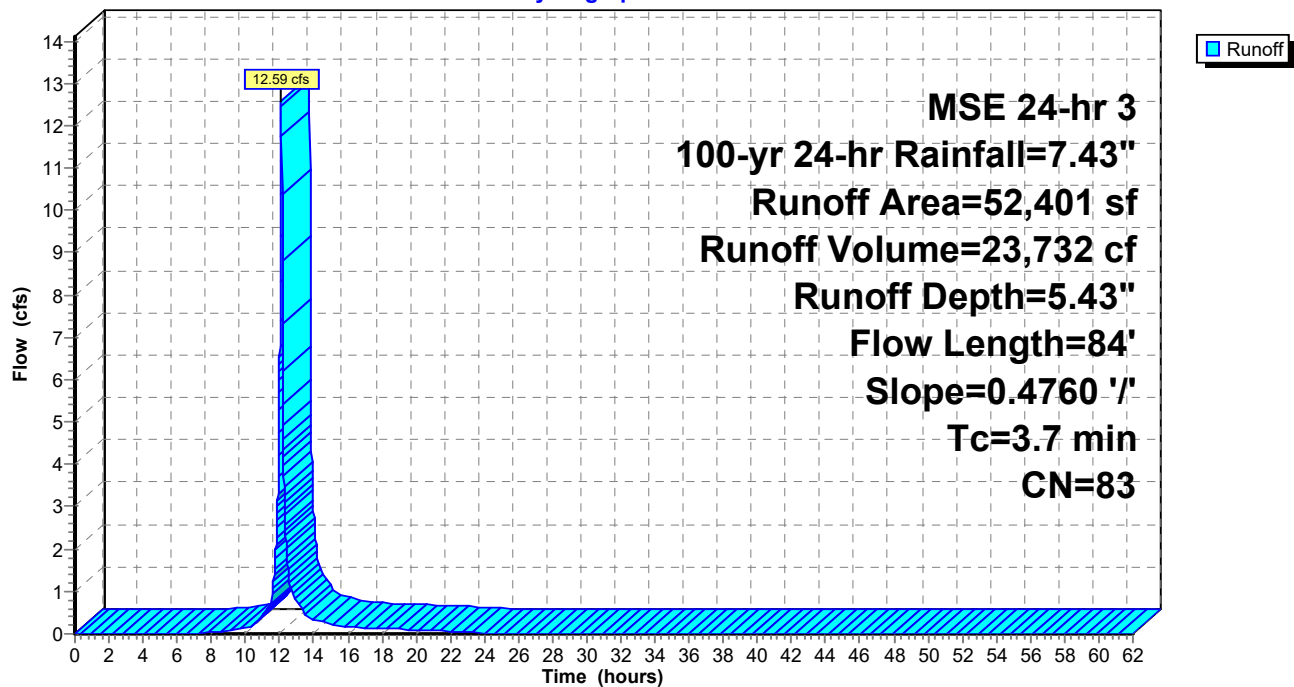
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	52,401	83	
	52,401		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	84	0.4760	0.37		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment A9: A9

Hydrograph



Summary for Subcatchment AA2: AA2

Runoff = 9.63 cfs @ 12.10 hrs, Volume= 17,644 cf, Depth= 5.43"

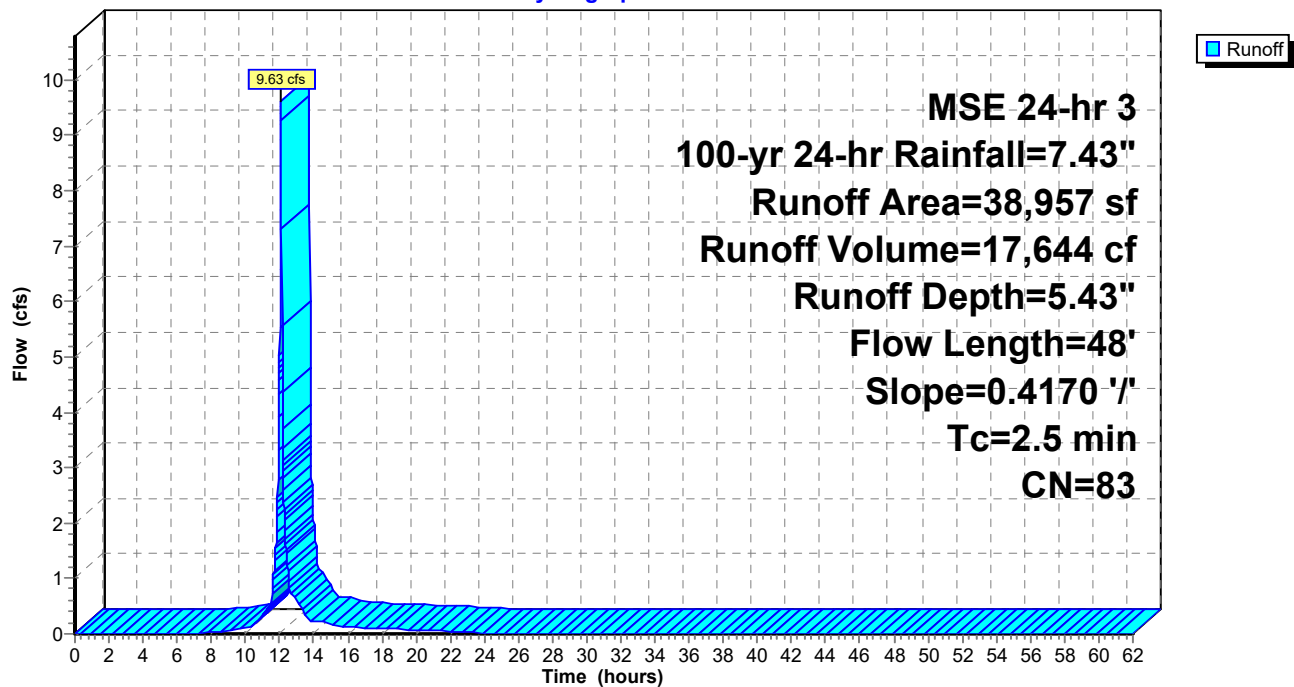
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 38,957	83	
38,957		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	48	0.4170	0.32		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment AA2: AA2

Hydrograph



Summary for Subcatchment AA4: AA4

Runoff = 9.94 cfs @ 12.11 hrs, Volume= 18,473 cf, Depth= 5.43"

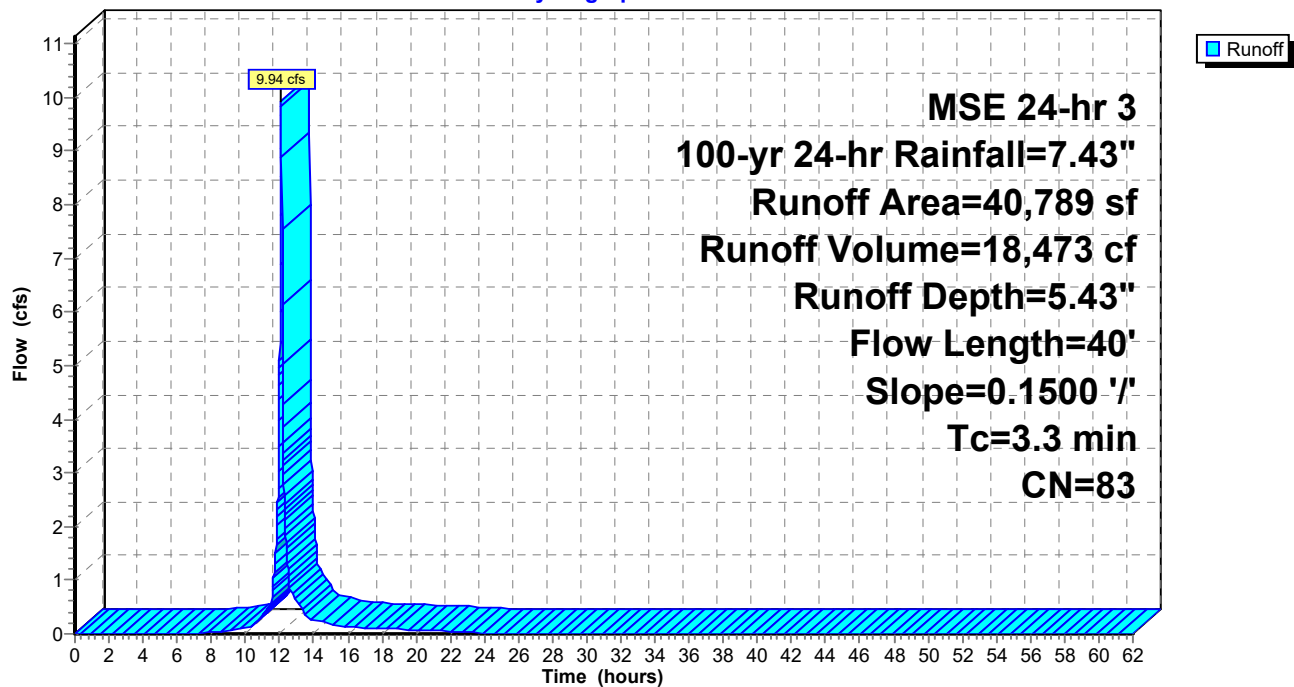
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	40,789	83	
	40,789		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	40	0.1500	0.20		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment AA4: AA4

Hydrograph



Summary for Subcatchment B1: B1

Runoff = 7.77 cfs @ 12.41 hrs, Volume= 31,840 cf, Depth= 4.75"

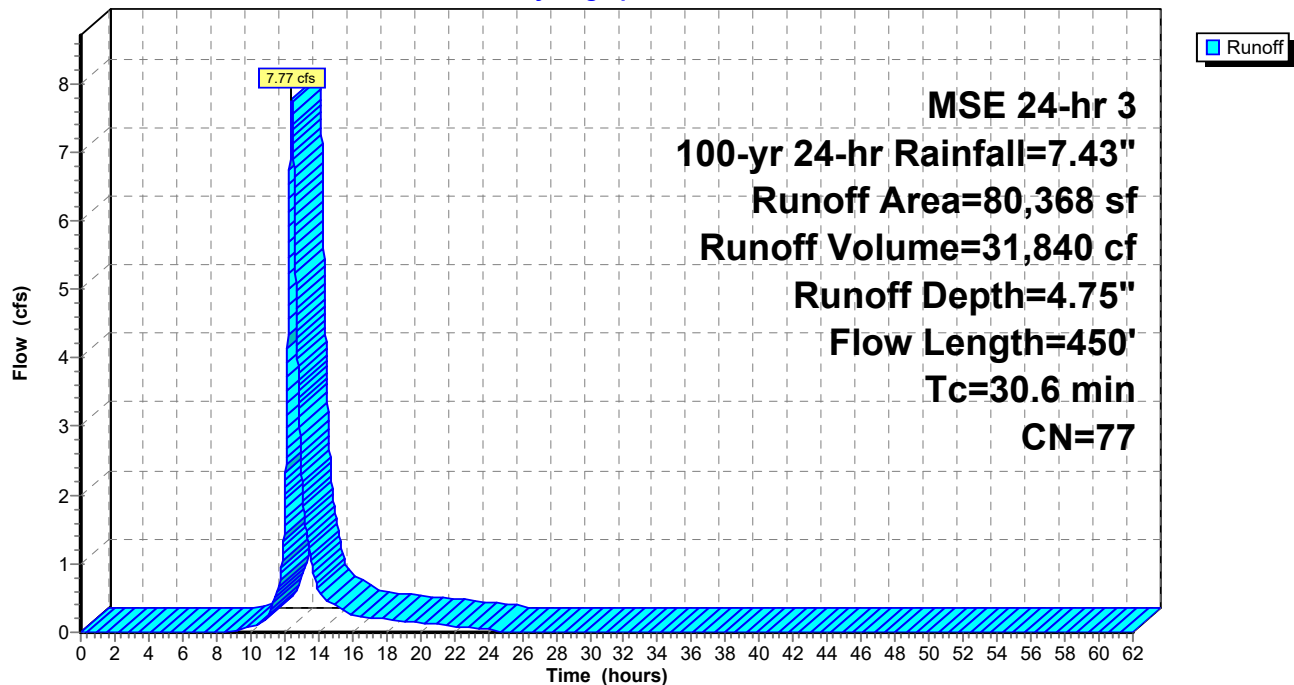
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 80,368	77	
80,368		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.1	300	0.0330	0.17		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"
0.5	150	0.1070	4.91		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
30.6	450	Total			

Subcatchment B1: B1

Hydrograph



Summary for Subcatchment B3: B3

Runoff = 8.63 cfs @ 12.17 hrs, Volume= 20,850 cf, Depth= 5.43"

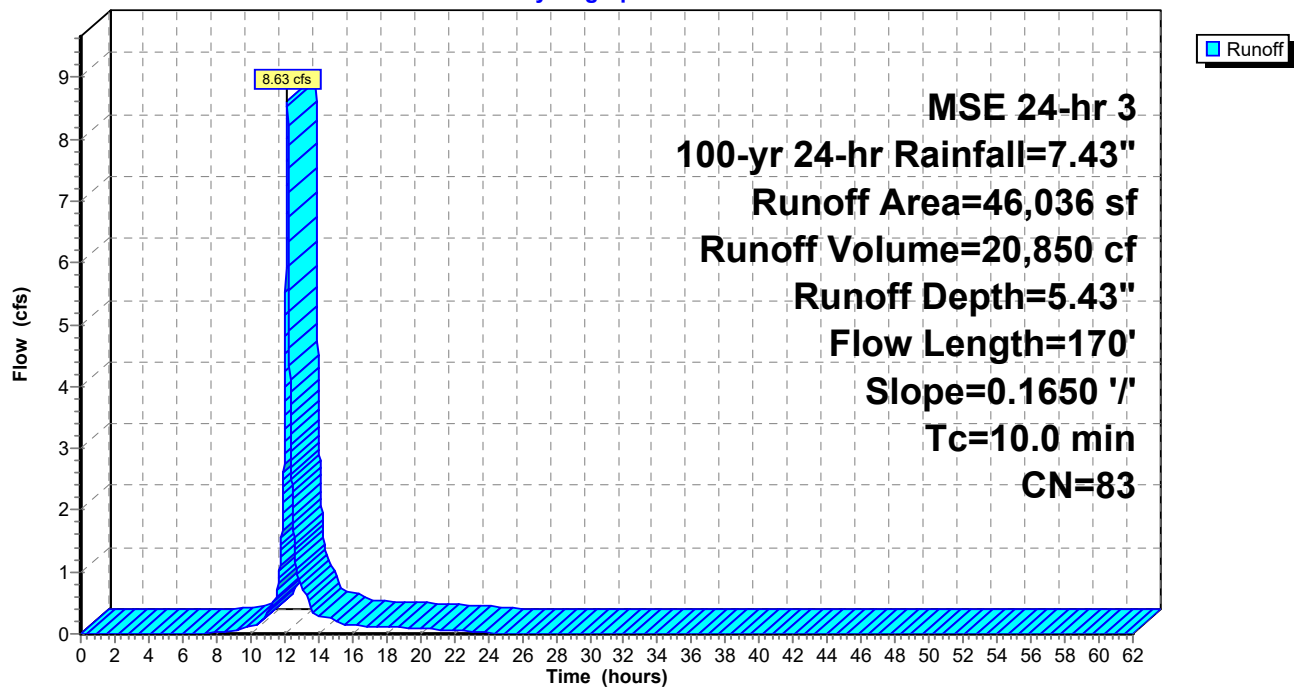
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	46,036	83	
	46,036		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0	170	0.1650	0.28		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment B3: B3

Hydrograph



Summary for Subcatchment B5: B5

Runoff = 13.97 cfs @ 12.11 hrs, Volume= 26,383 cf, Depth= 5.43"

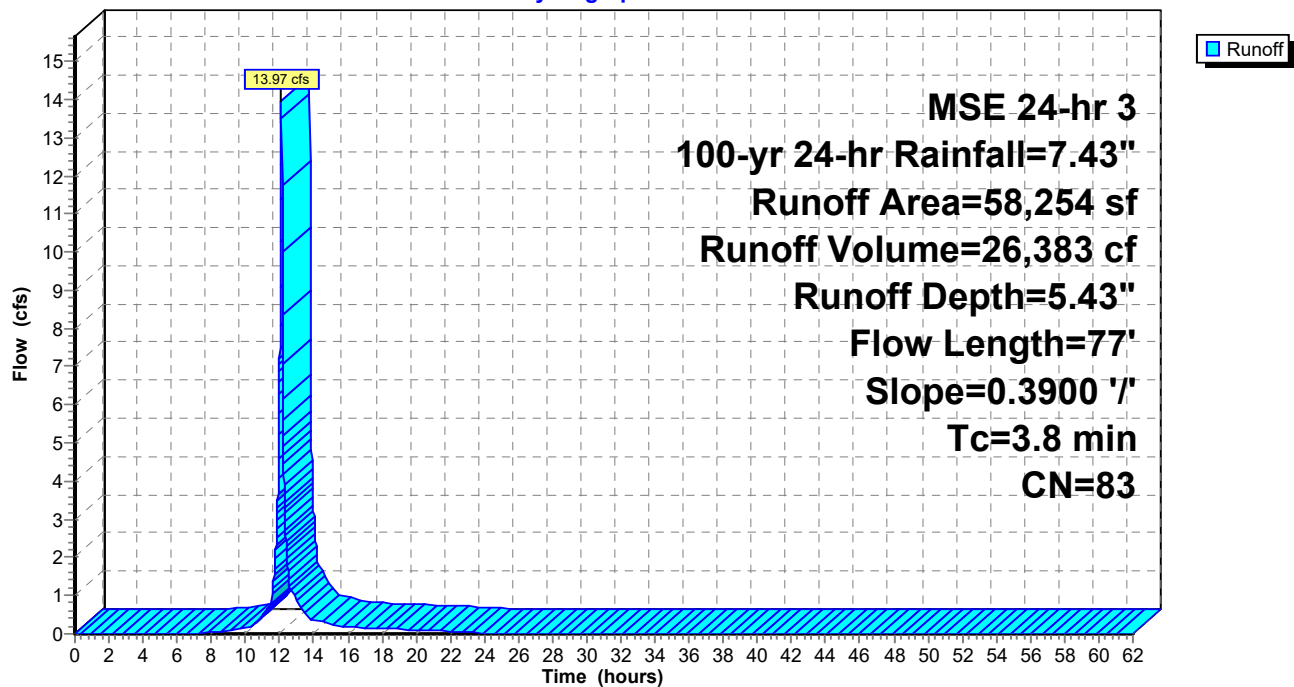
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	58,254	83	
	58,254		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	77	0.3900	0.34		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment B5: B5

Hydrograph



Summary for Subcatchment B7: B7

Runoff = 16.01 cfs @ 12.11 hrs, Volume= 29,610 cf, Depth= 5.43"

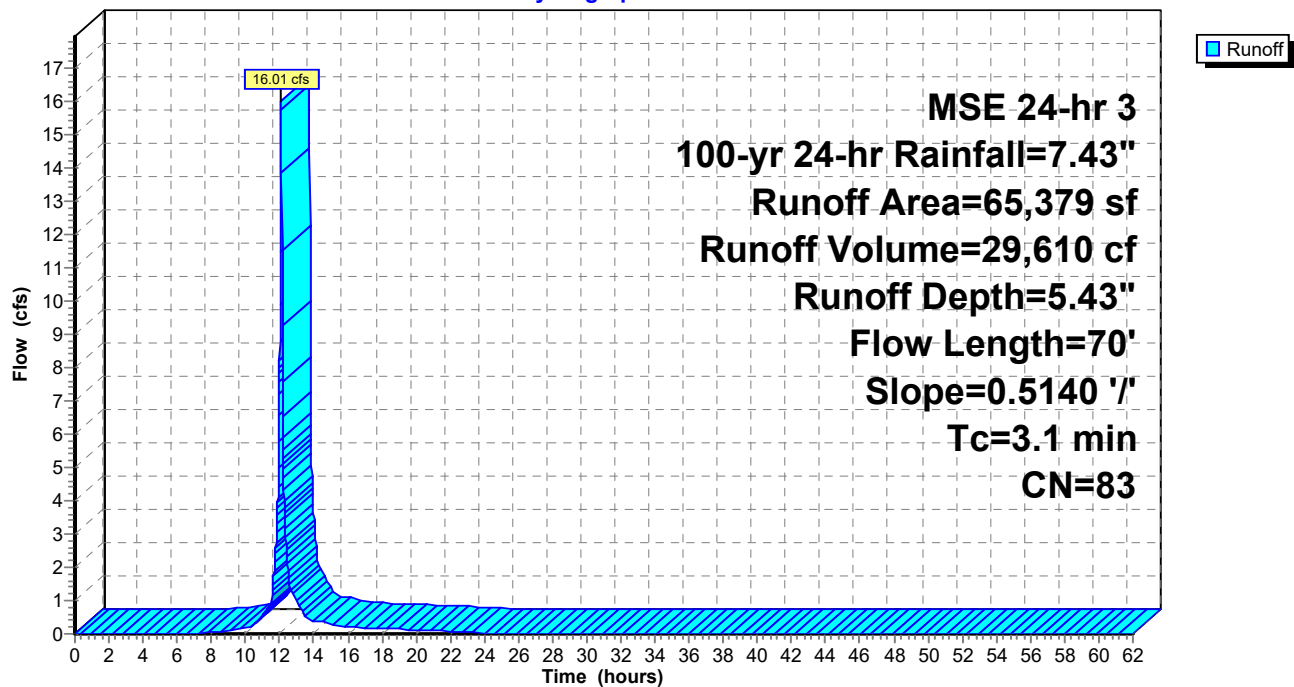
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	65,379	83	
	65,379		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	70	0.5140	0.37		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment B7: B7

Hydrograph



Summary for Subcatchment B9: B9

Runoff = 19.73 cfs @ 12.14 hrs, Volume= 41,287 cf, Depth= 5.43"

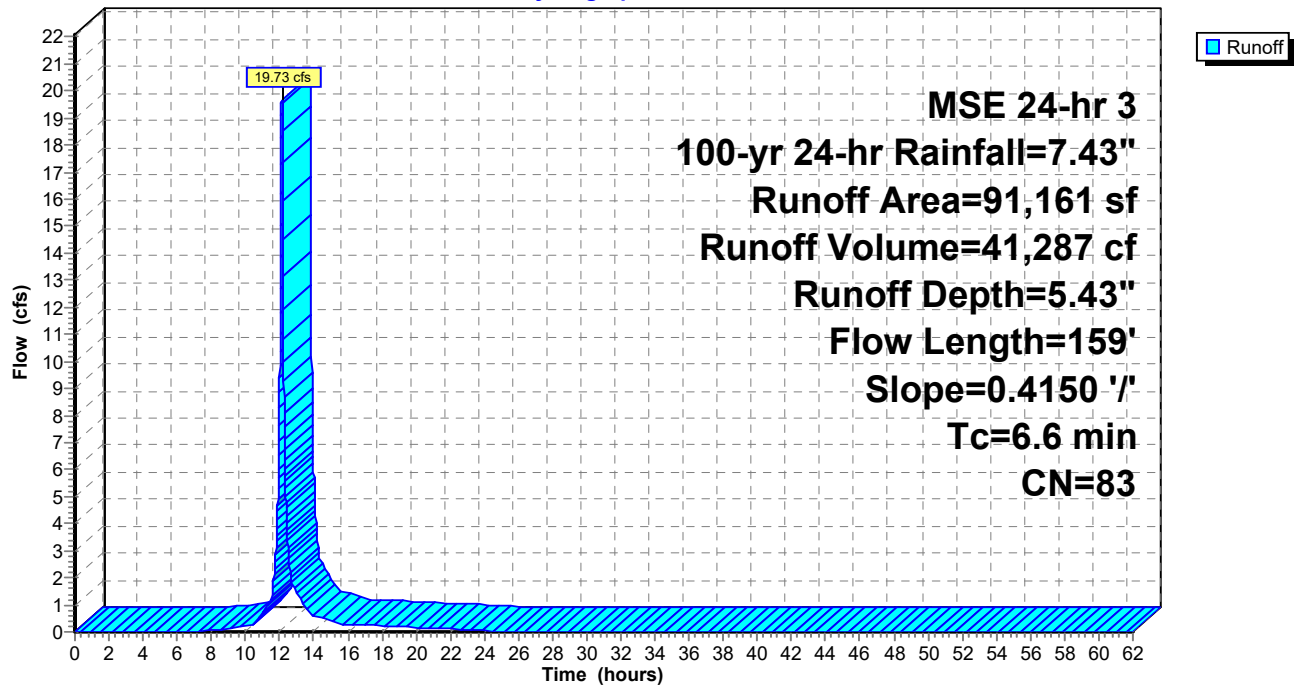
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	91,161	83	
	91,161		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	159	0.4150	0.40		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment B9: B9

Hydrograph



Summary for Subcatchment BB1: BB1

Runoff = 7.82 cfs @ 12.14 hrs, Volume= 16,366 cf, Depth= 5.43"

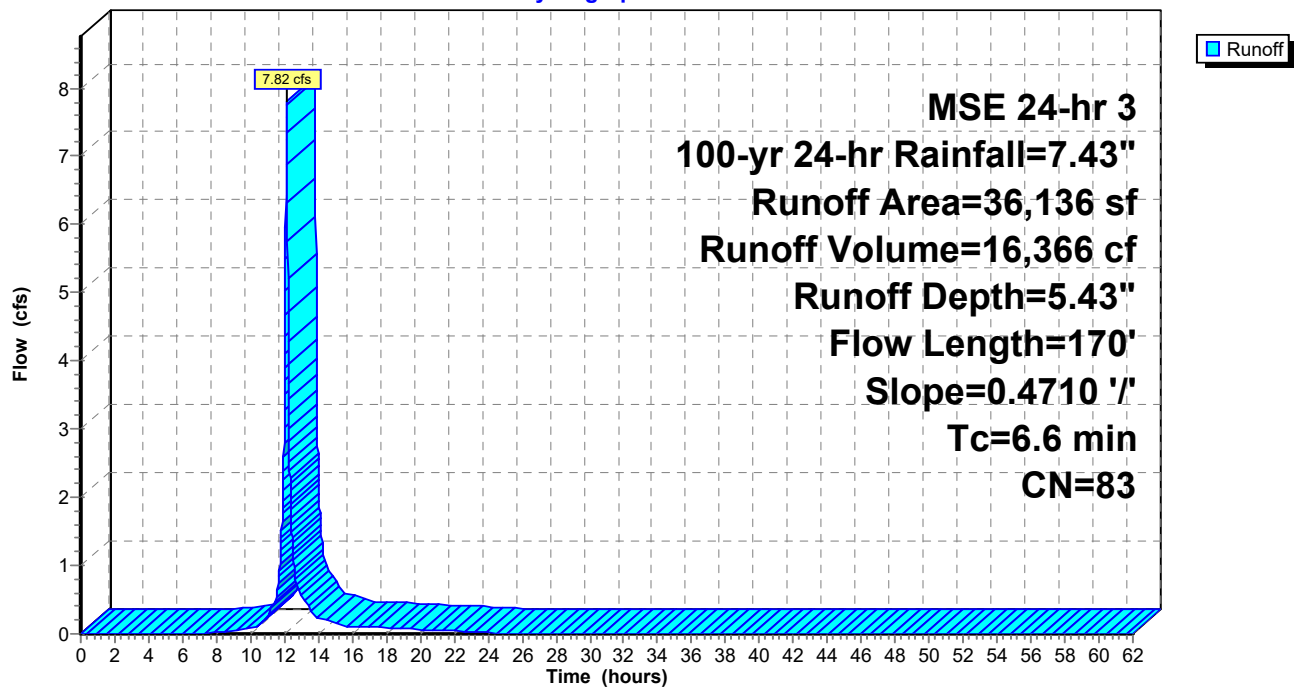
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	36,136	83	
	36,136		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	170	0.4710	0.43		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment BB1: BB1

Hydrograph



Summary for Subcatchment BB3: BB3

Runoff = 8.93 cfs @ 12.13 hrs, Volume= 18,087 cf, Depth= 4.98"

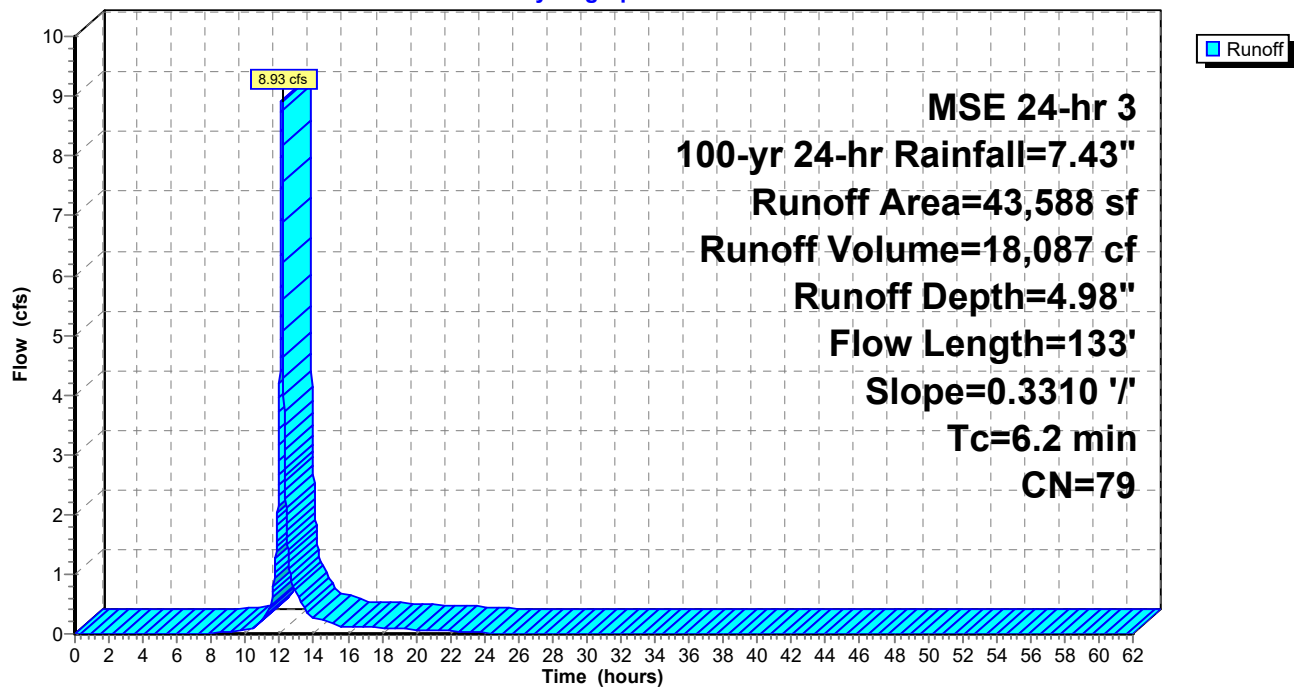
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	43,588	79	
	43,588		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	133	0.3310	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment BB3: BB3

Hydrograph



Summary for Subcatchment BBB1: BBB1

Runoff = 15.88 cfs @ 12.14 hrs, Volume= 34,292 cf, Depth= 5.43"

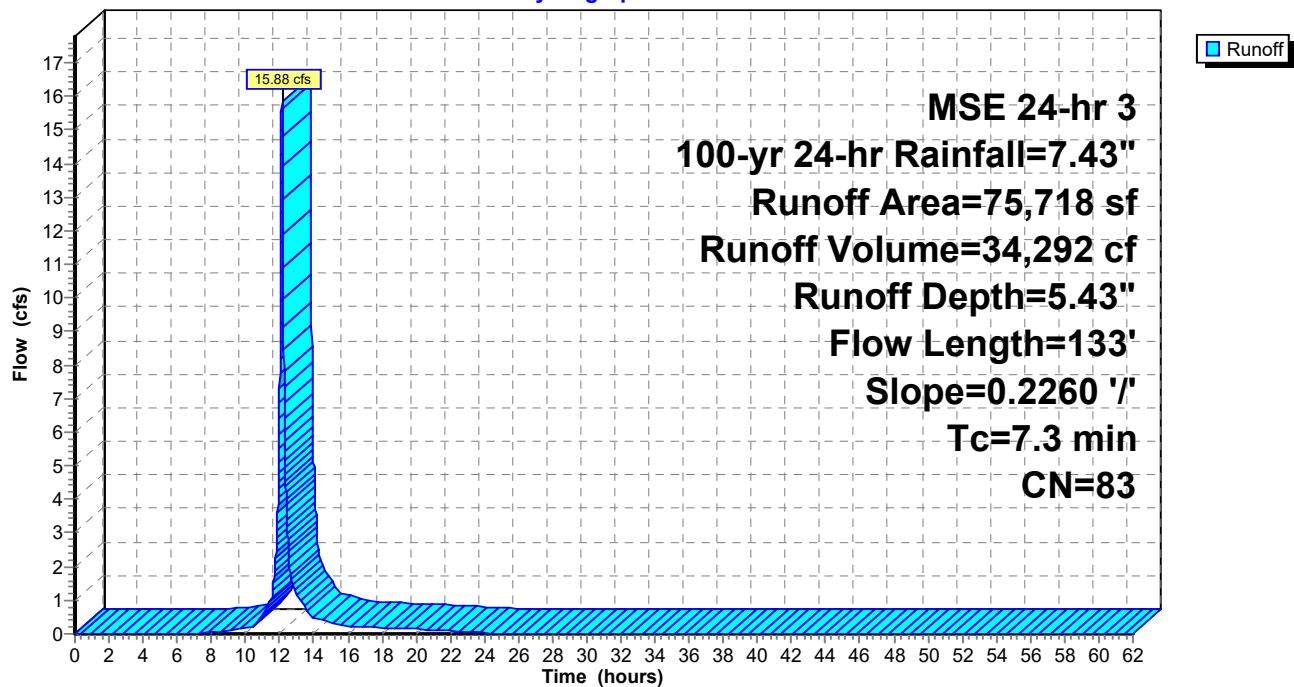
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 75,718	83	
75,718		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	133	0.2260	0.31		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment BBB1: BBB1

Hydrograph



Summary for Subcatchment BBB3: BBB3

Runoff = 5.47 cfs @ 12.10 hrs, Volume= 9,968 cf, Depth= 5.43"

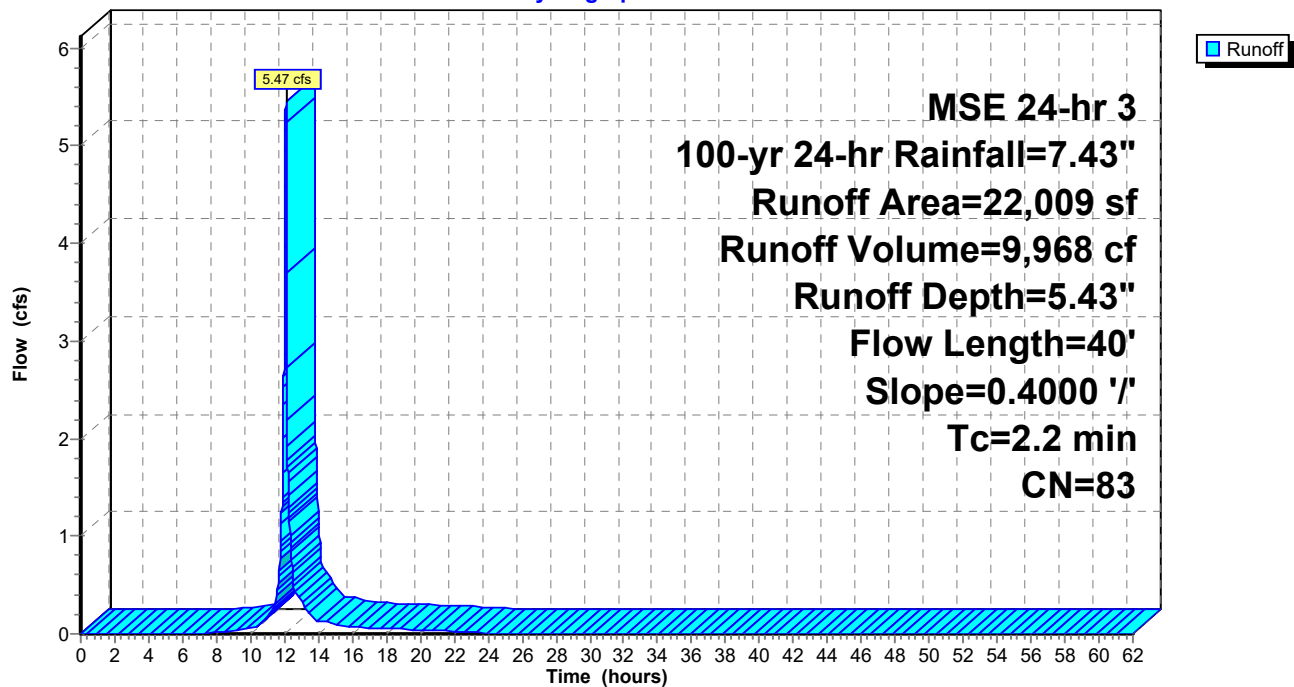
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 22,009	83	
22,009		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2	40	0.4000	0.30		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment BBB3: BBB3

Hydrograph



Summary for Subcatchment C0: C0

Runoff = 1.73 cfs @ 12.20 hrs, Volume= 4,386 cf, Depth= 4.53"

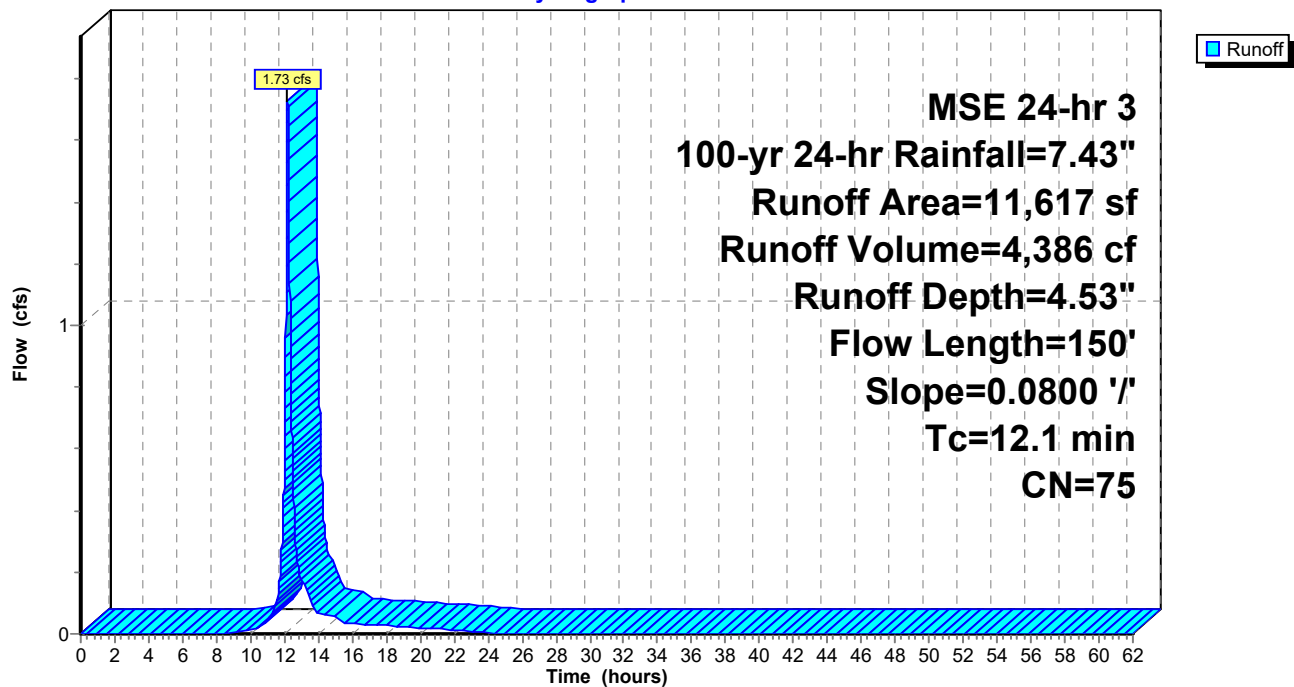
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	11,617	75	
	11,617		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.1	150	0.0800	0.21		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C0: C0

Hydrograph



Summary for Subcatchment C1: C1

Runoff = 23.61 cfs @ 12.29 hrs, Volume= 76,593 cf, Depth= 4.64"

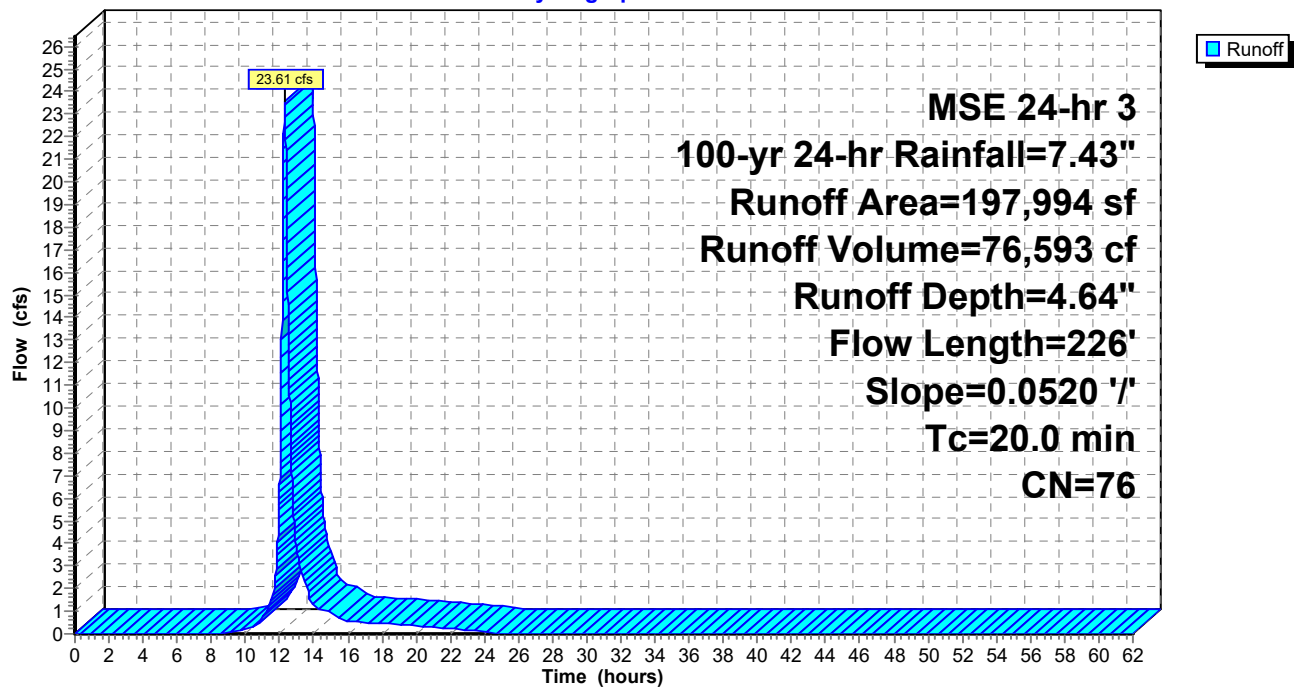
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 197,994	76	
197,994		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	226	0.0520	0.19		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C1: C1

Hydrograph



Summary for Subcatchment C10: C10

Runoff = 19.29 cfs @ 12.11 hrs, Volume= 35,236 cf, Depth= 5.21"

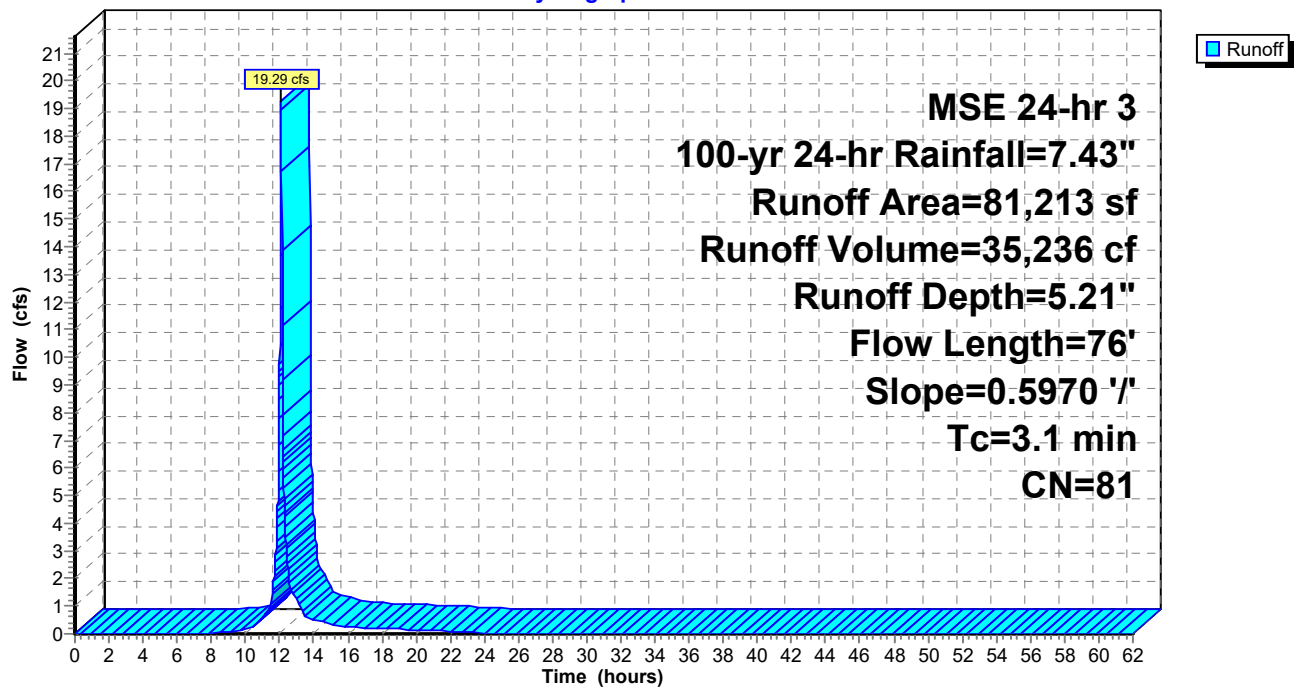
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	81,213	81	
	81,213		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	76	0.5970	0.40		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C10: C10

Hydrograph



Summary for Subcatchment C2: C2

Runoff = 9.31 cfs @ 12.32 hrs, Volume= 32,067 cf, Depth= 4.75"

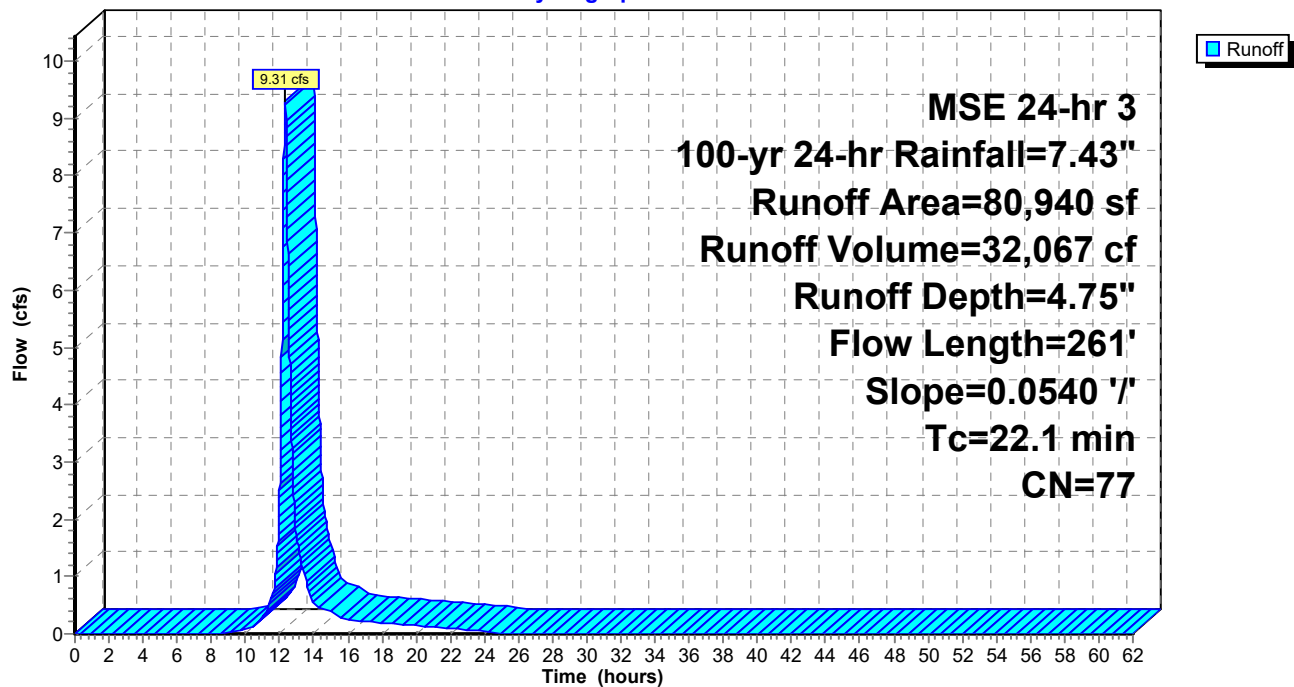
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	80,940	77	
	80,940		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.1	261	0.0540	0.20		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C2: C2

Hydrograph



Summary for Subcatchment C3: C3

Runoff = 20.64 cfs @ 12.11 hrs, Volume= 38,344 cf, Depth= 5.43"

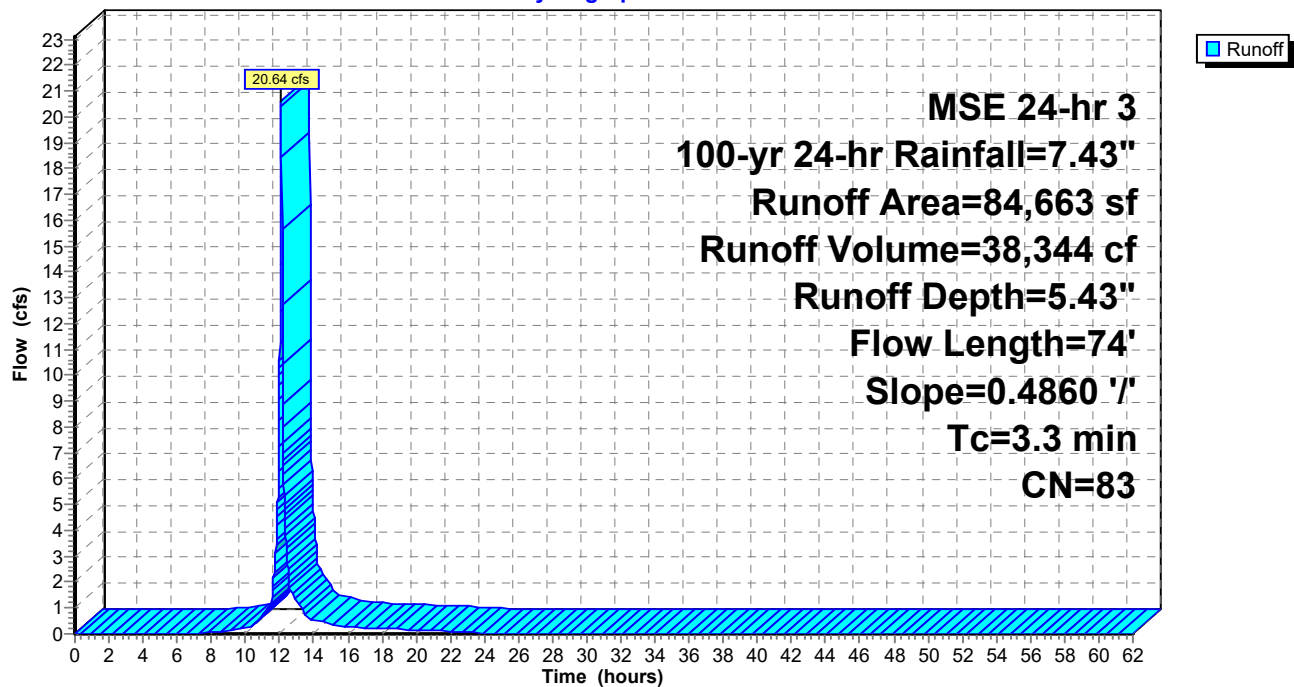
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	84,663	83	
	84,663		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	74	0.4860	0.37		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C3: C3

Hydrograph



Summary for Subcatchment C4: C4

Runoff = 13.16 cfs @ 12.11 hrs, Volume= 24,348 cf, Depth= 5.43"

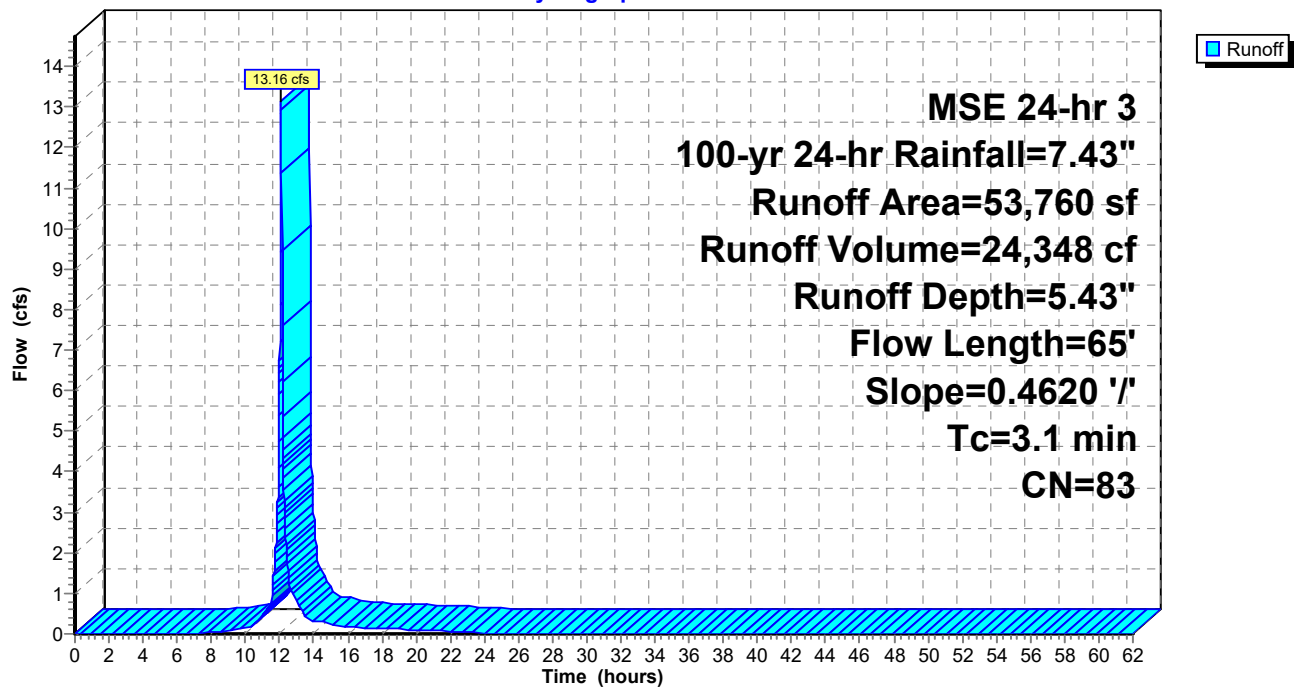
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 53,760	83	
53,760		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	65	0.4620	0.35		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C4: C4

Hydrograph



Summary for Subcatchment C5: C5

Runoff = 20.79 cfs @ 12.11 hrs, Volume= 39,046 cf, Depth= 5.43"

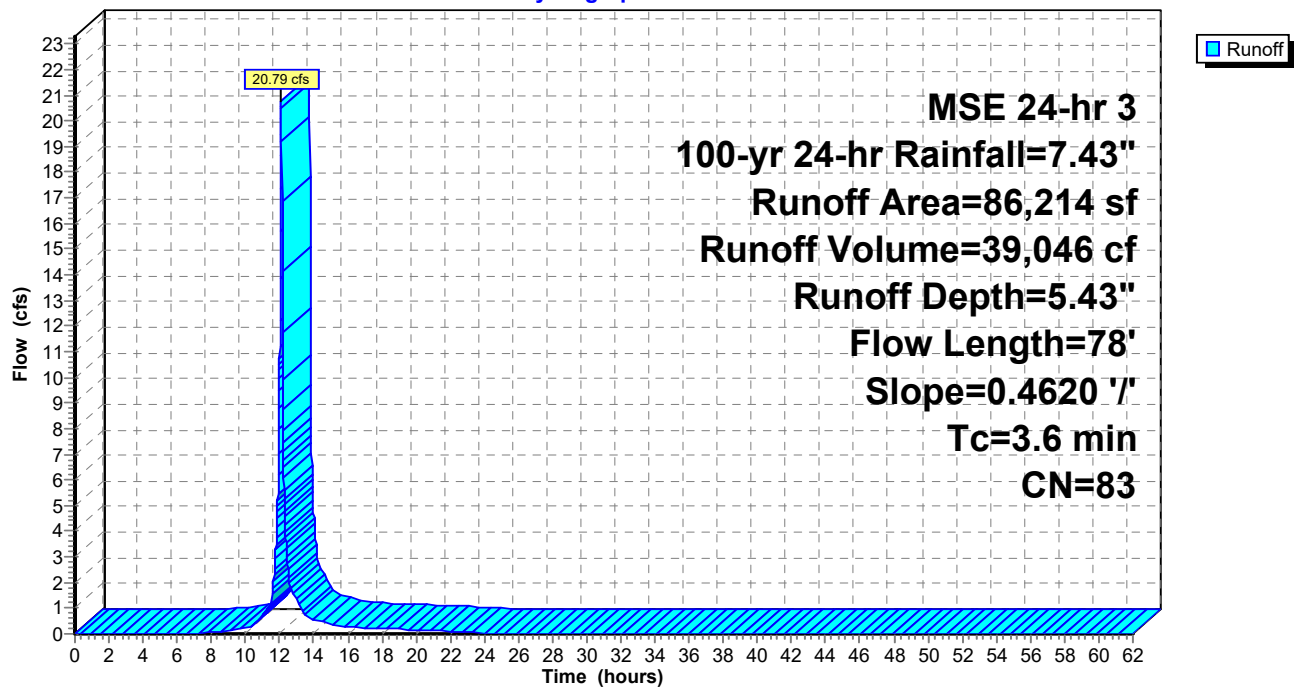
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	86,214	83	
	86,214		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	78	0.4620	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C5: C5

Hydrograph



Summary for Subcatchment C6: C6

Runoff = 16.00 cfs @ 12.12 hrs, Volume= 30,815 cf, Depth= 5.43"

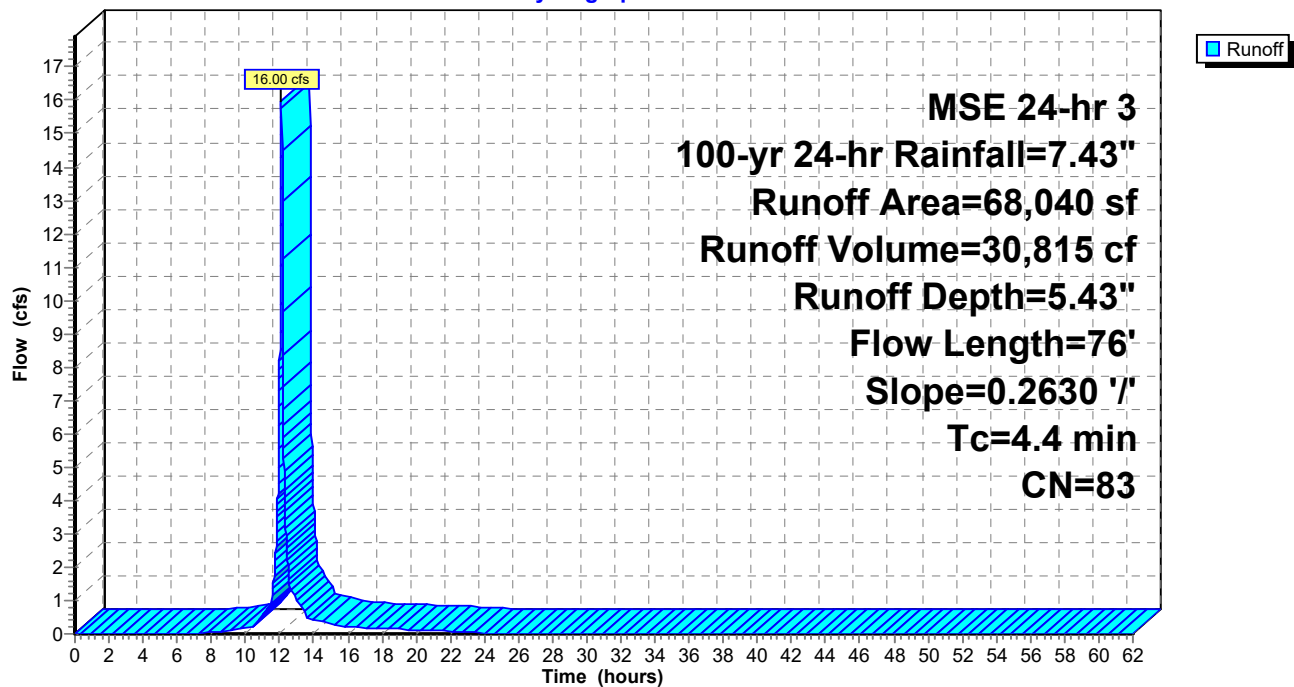
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 68,040	83	
68,040		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.4	76	0.2630	0.29		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C6: C6

Hydrograph



Summary for Subcatchment C7: C7

Runoff = 22.12 cfs @ 12.11 hrs, Volume= 40,758 cf, Depth= 5.43"

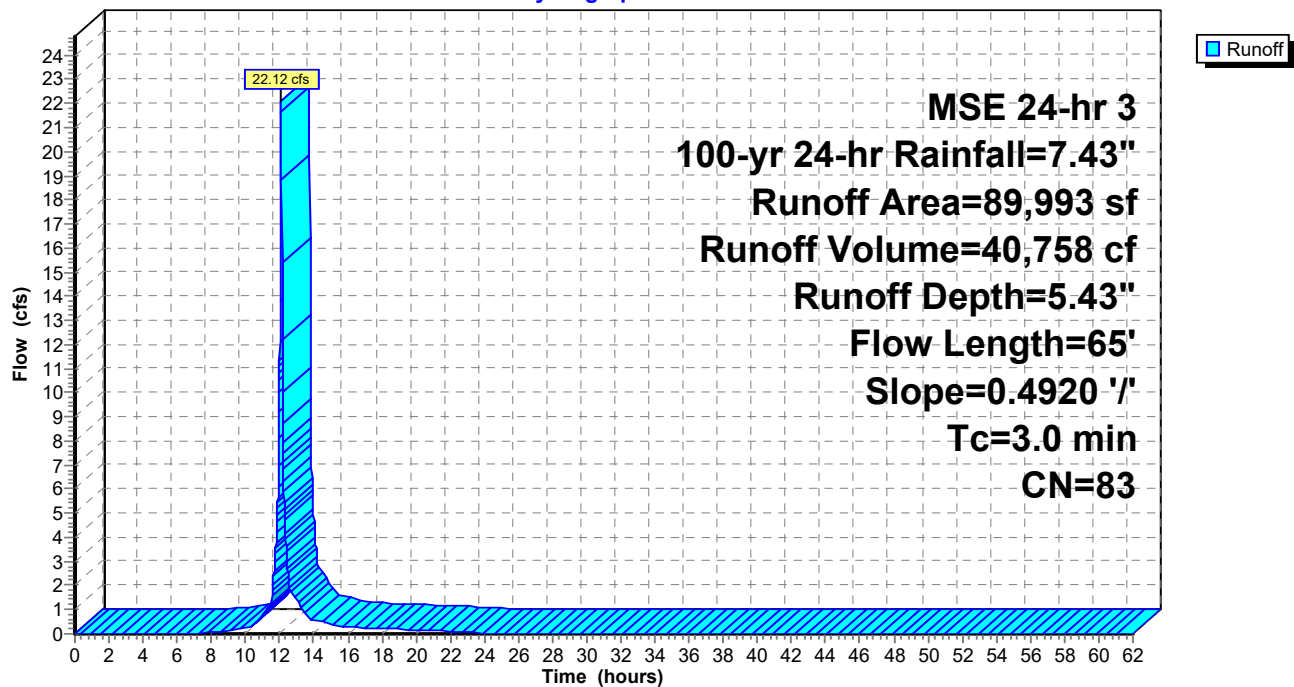
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	89,993	83	
	89,993		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	65	0.4920	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C7: C7

Hydrograph



Summary for Subcatchment C8: C8

Runoff = 19.00 cfs @ 12.11 hrs, Volume= 35,987 cf, Depth= 5.43"

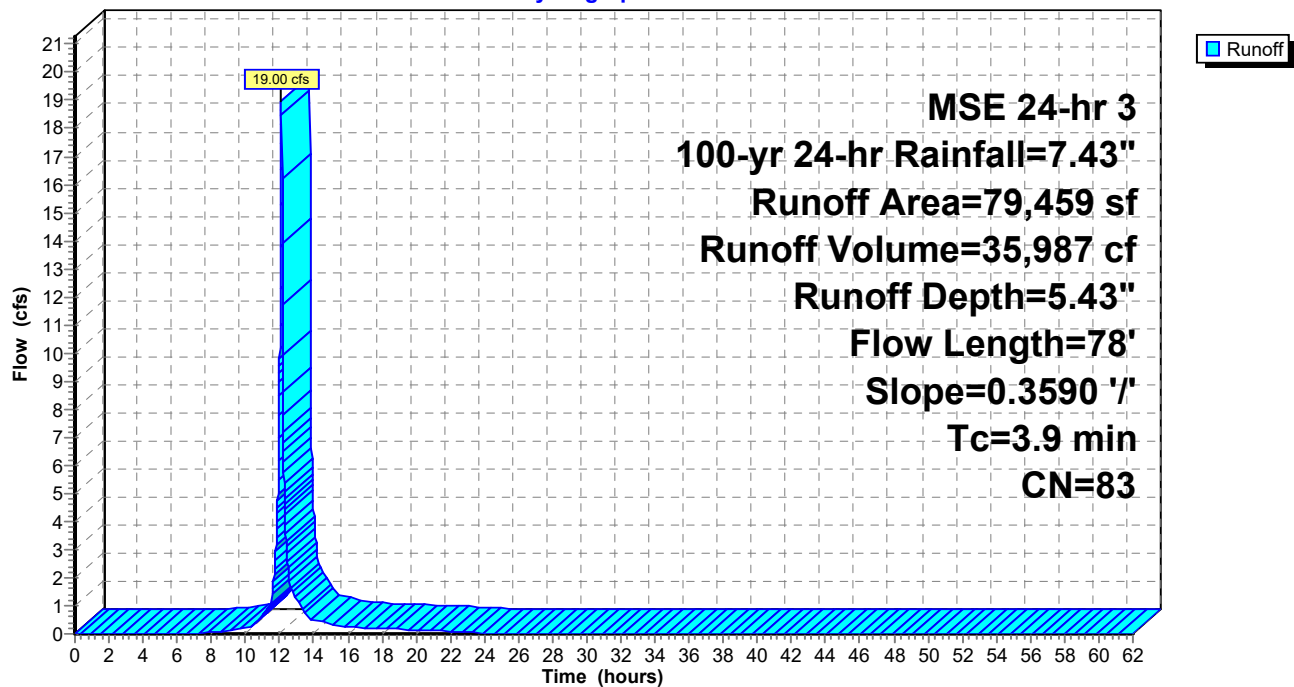
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 79,459	83	
79,459		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	78	0.3590	0.33		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C8: C8

Hydrograph



Summary for Subcatchment C9: C9

Runoff = 27.01 cfs @ 12.15 hrs, Volume= 58,608 cf, Depth= 5.43"

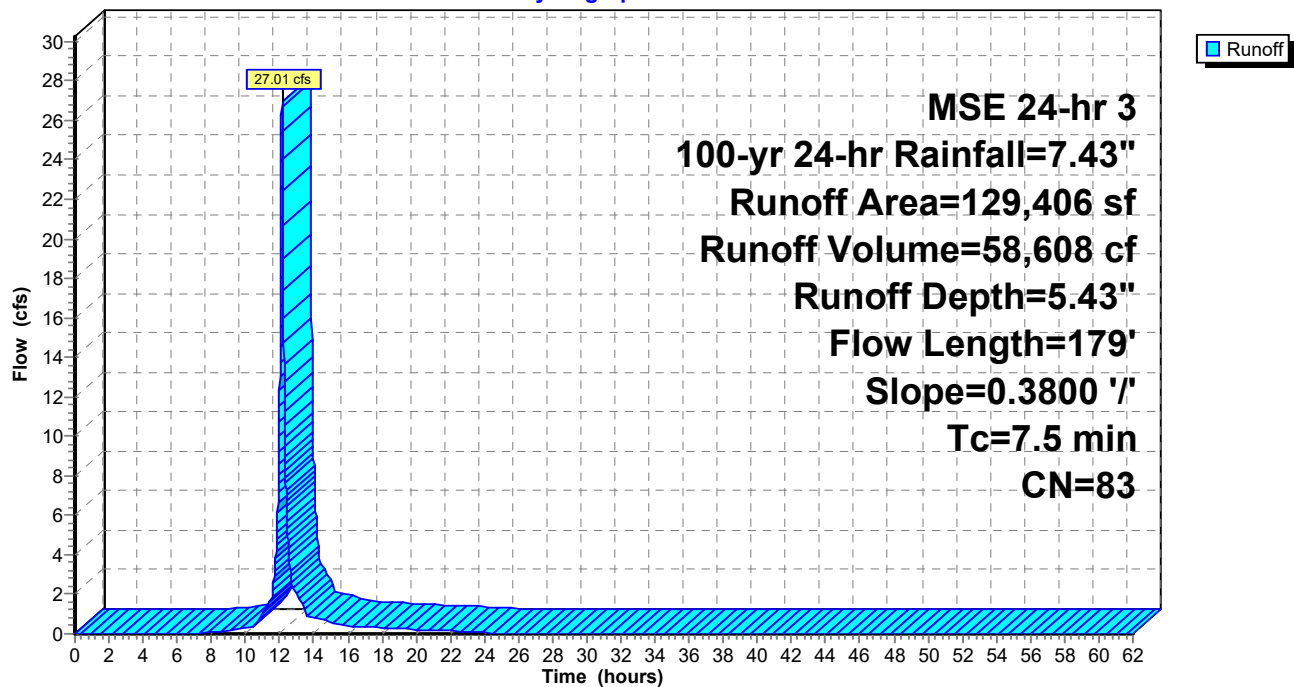
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 129,406	83	
129,406		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	179	0.3800	0.40		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment C9: C9

Hydrograph



Summary for Subcatchment CC2: CC2

Runoff = 7.68 cfs @ 12.11 hrs, Volume= 14,341 cf, Depth= 5.43"

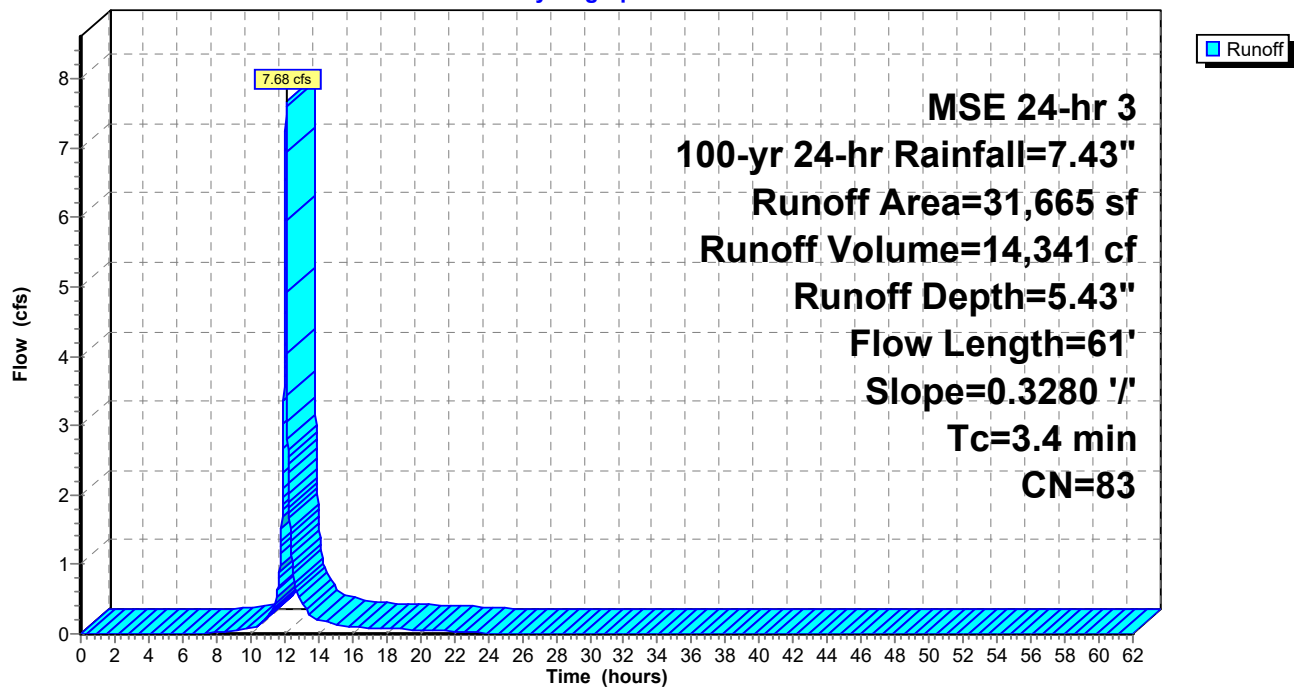
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 31,665	83	
31,665		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.4	61	0.3280	0.30		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment CC2: CC2

Hydrograph



Summary for Subcatchment CC4: CC4

Runoff = 15.53 cfs @ 12.14 hrs, Volume= 32,494 cf, Depth= 5.09"

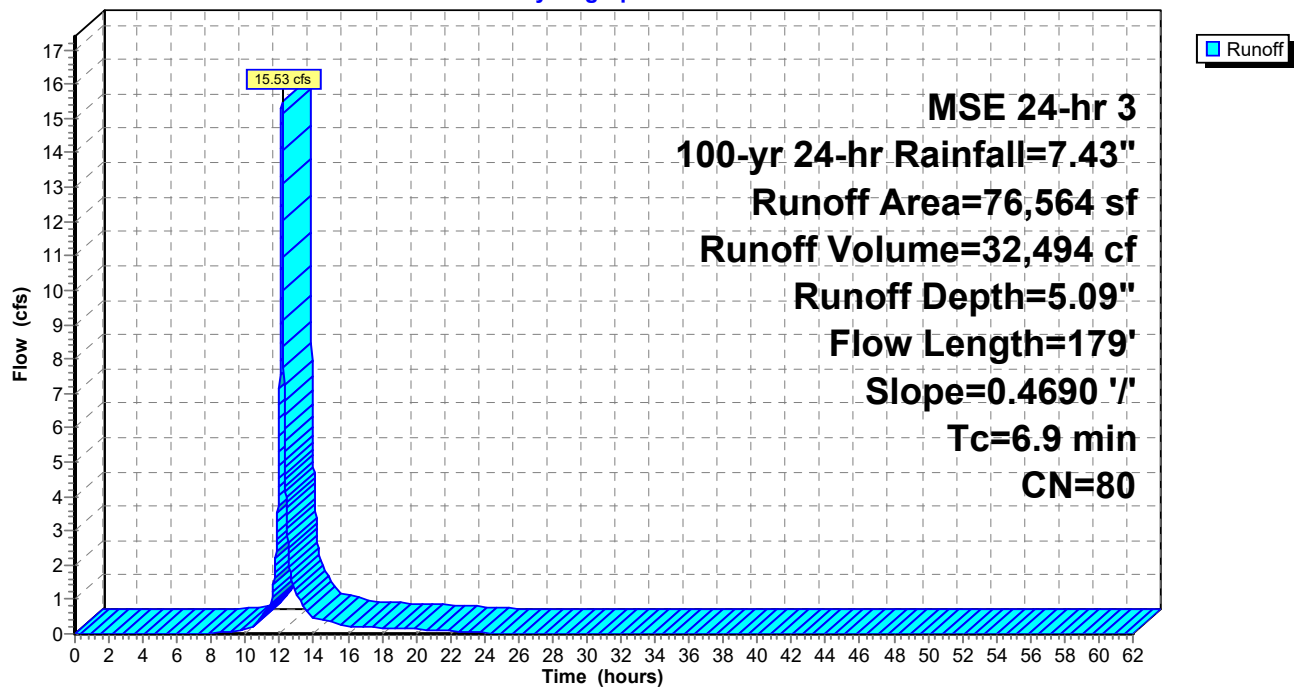
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	76,564	80	
	76,564		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	179	0.4690	0.43		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment CC4: CC4

Hydrograph



Summary for Subcatchment D1: D1

Runoff = 1.61 cfs @ 12.19 hrs, Volume= 3,981 cf, Depth= 4.64"

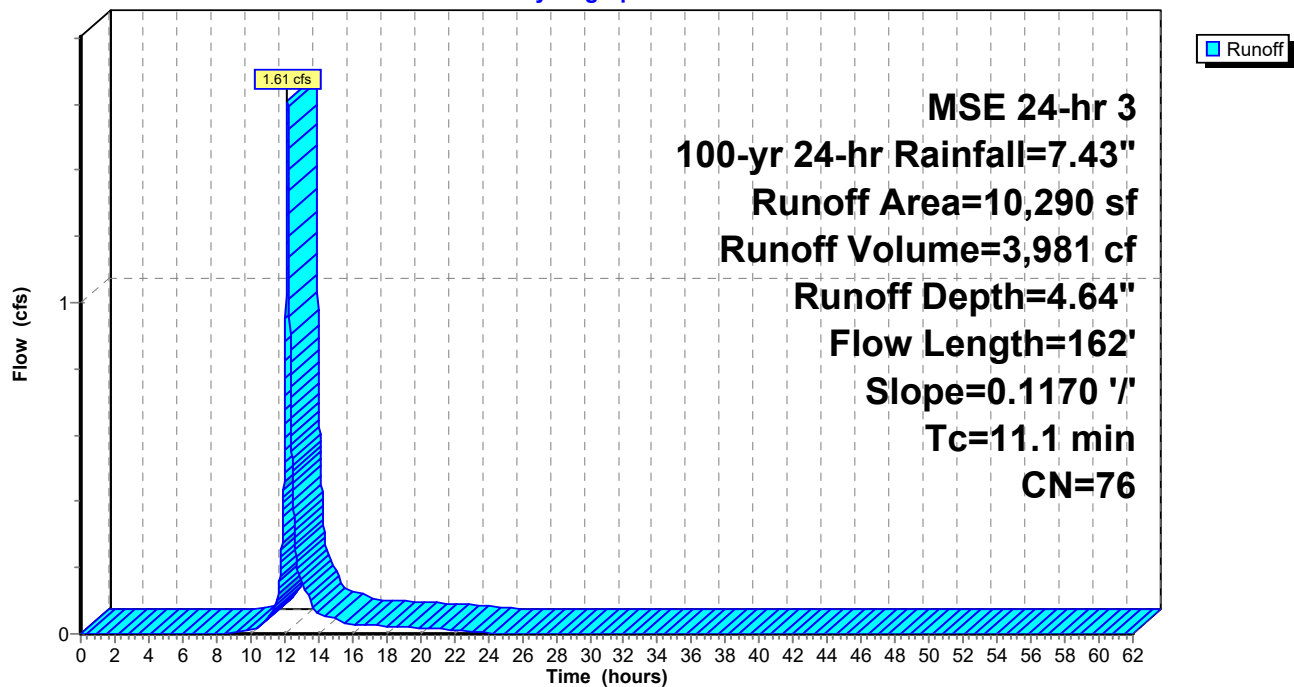
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	10,290	76	
	10,290		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1	162	0.1170	0.24		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D1: D1

Hydrograph



Summary for Subcatchment D10: D10

Runoff = 5.63 cfs @ 12.12 hrs, Volume= 11,056 cf, Depth= 5.43"

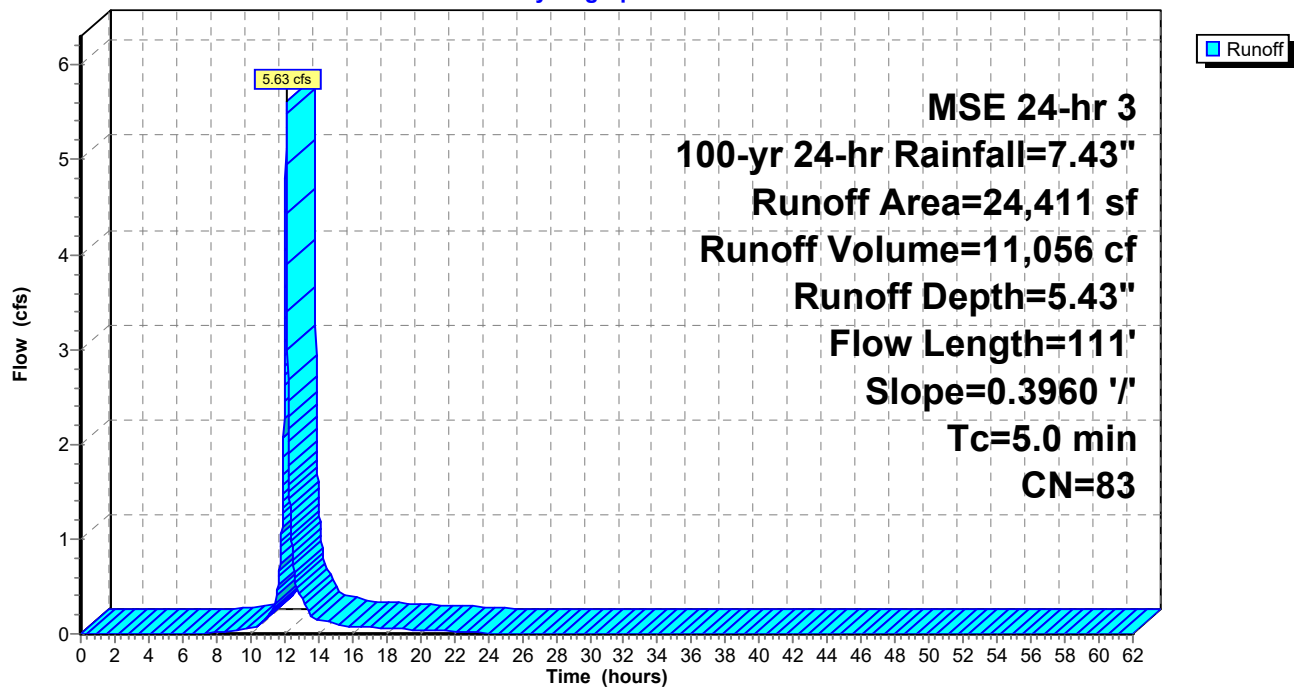
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 24,411	83	
24,411		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	111	0.3960	0.37		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D10: D10

Hydrograph



Summary for Subcatchment D11: D11

Runoff = 7.13 cfs @ 12.12 hrs, Volume= 13,834 cf, Depth= 5.43"

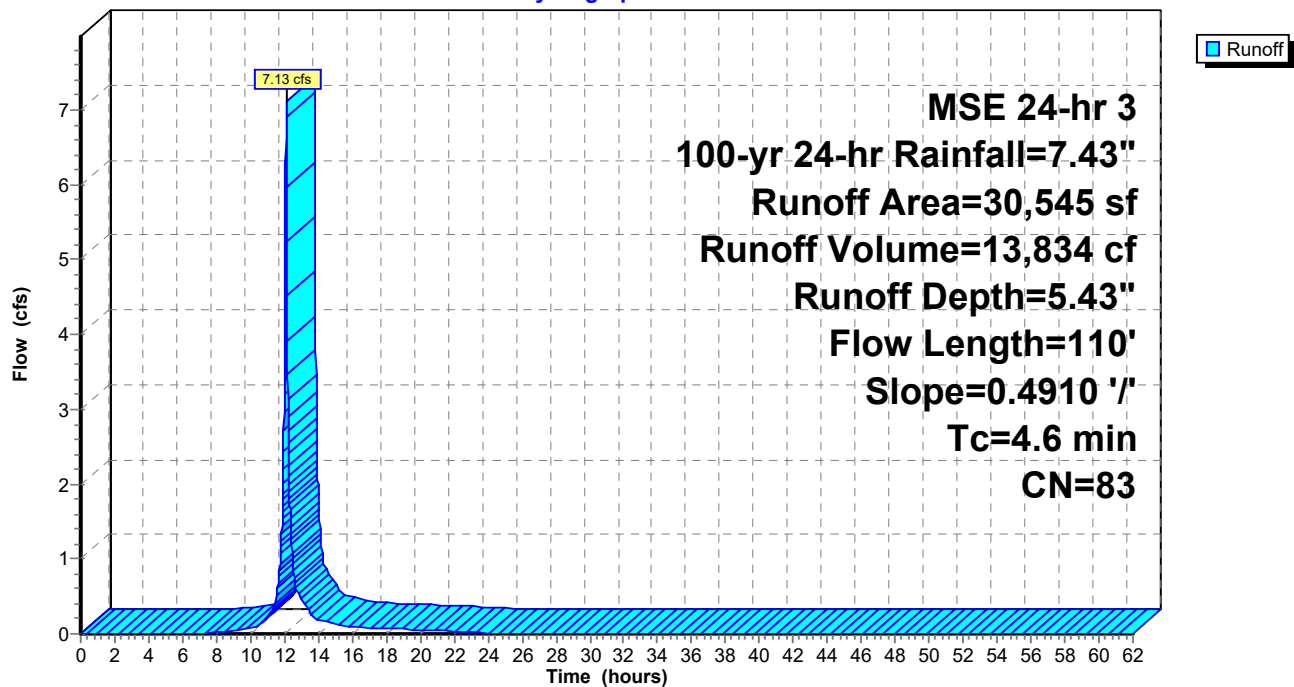
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 30,545	83	
30,545		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	110	0.4910	0.40		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D11: D11

Hydrograph



Summary for Subcatchment D12: D12

Runoff = 4.09 cfs @ 12.11 hrs, Volume= 7,634 cf, Depth= 5.43"

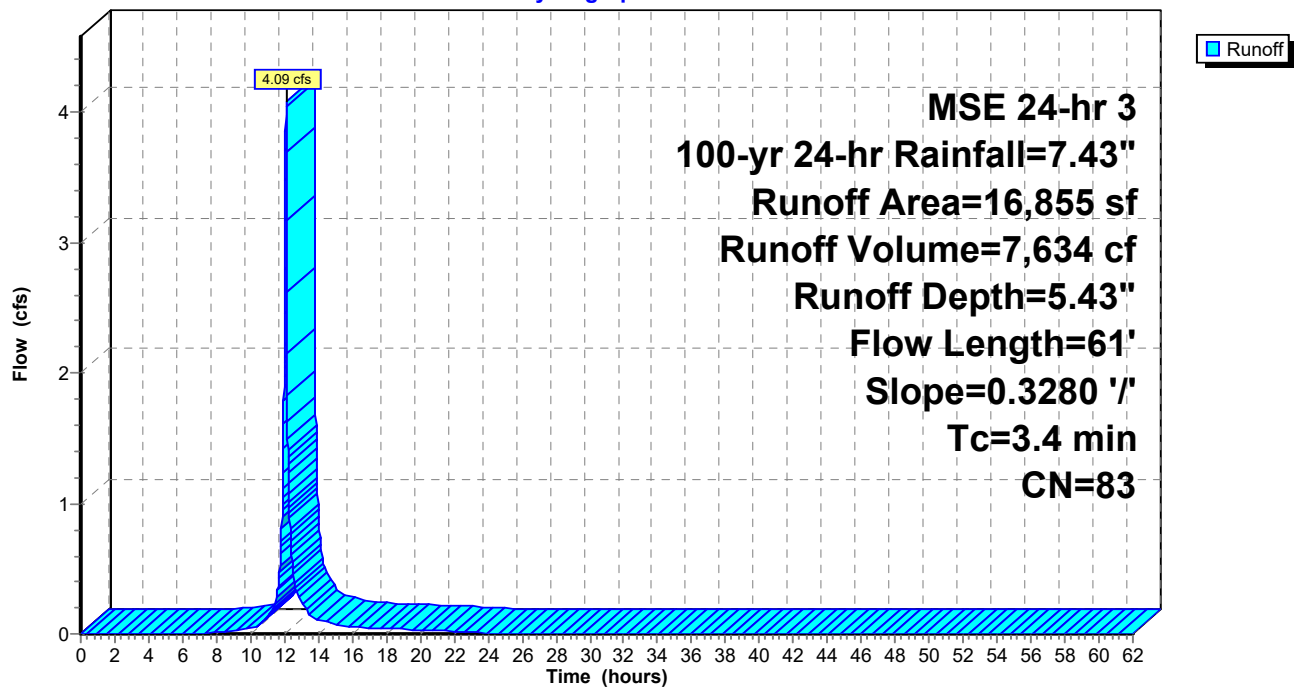
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 16,855	83	
16,855		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.4	61	0.3280	0.30		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D12: D12

Hydrograph



Summary for Subcatchment D2: D2

Runoff = 12.71 cfs @ 12.23 hrs, Volume= 35,471 cf, Depth= 4.53"

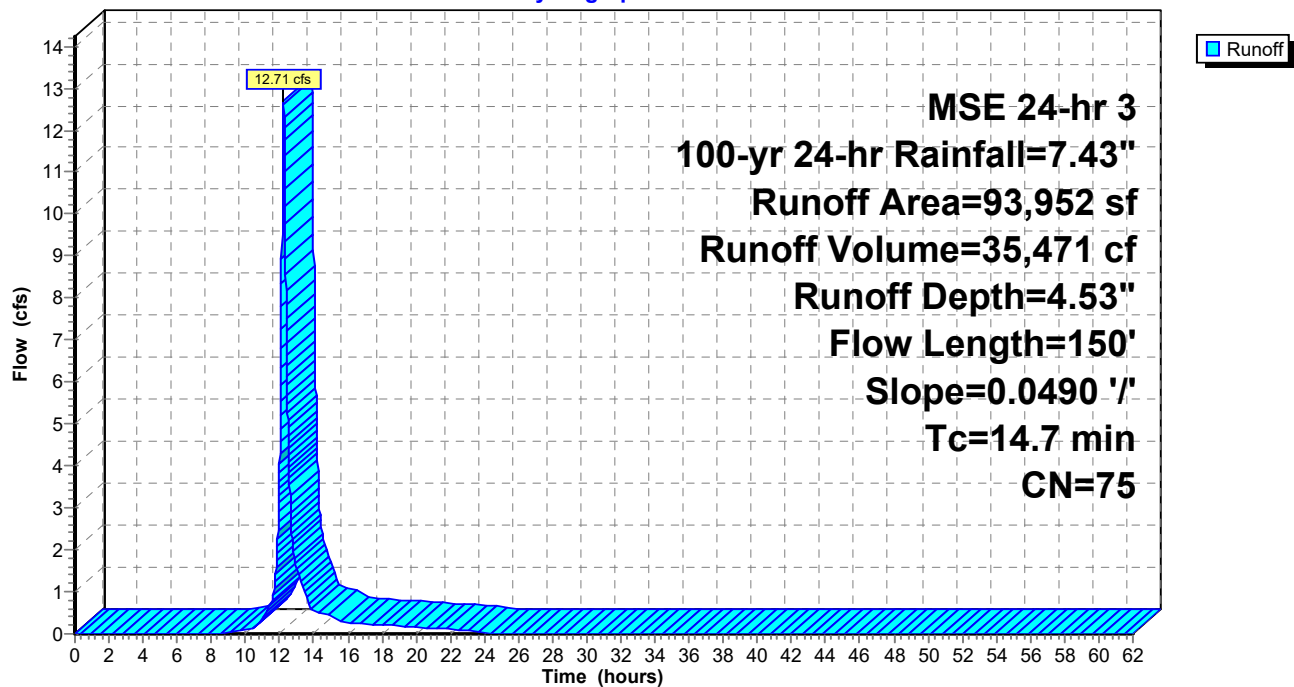
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	93,952	75	
	93,952		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.7	150	0.0490	0.17		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D2: D2

Hydrograph



Summary for Subcatchment D3: D3

Runoff = 2.74 cfs @ 12.11 hrs, Volume= 5,199 cf, Depth= 5.43"

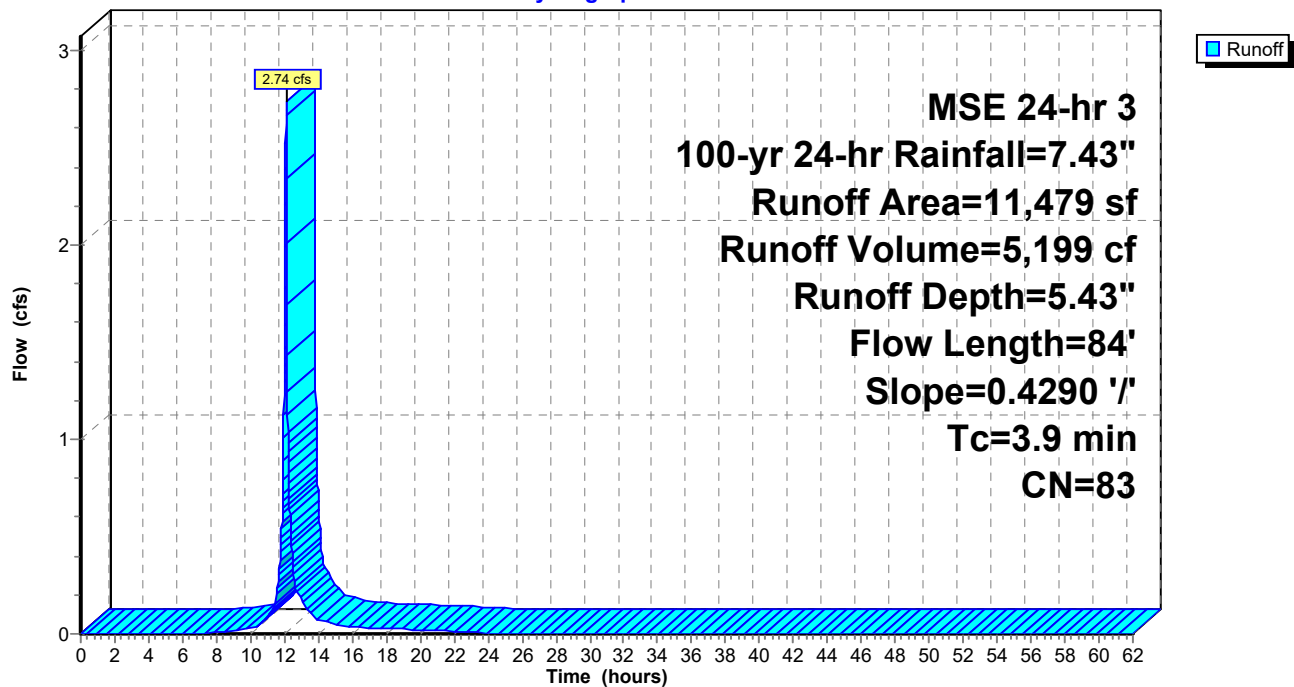
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 11,479	83	
11,479		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	84	0.4290	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D3: D3

Hydrograph



Summary for Subcatchment D4: D4

Runoff = 8.14 cfs @ 12.11 hrs, Volume= 15,233 cf, Depth= 5.43"

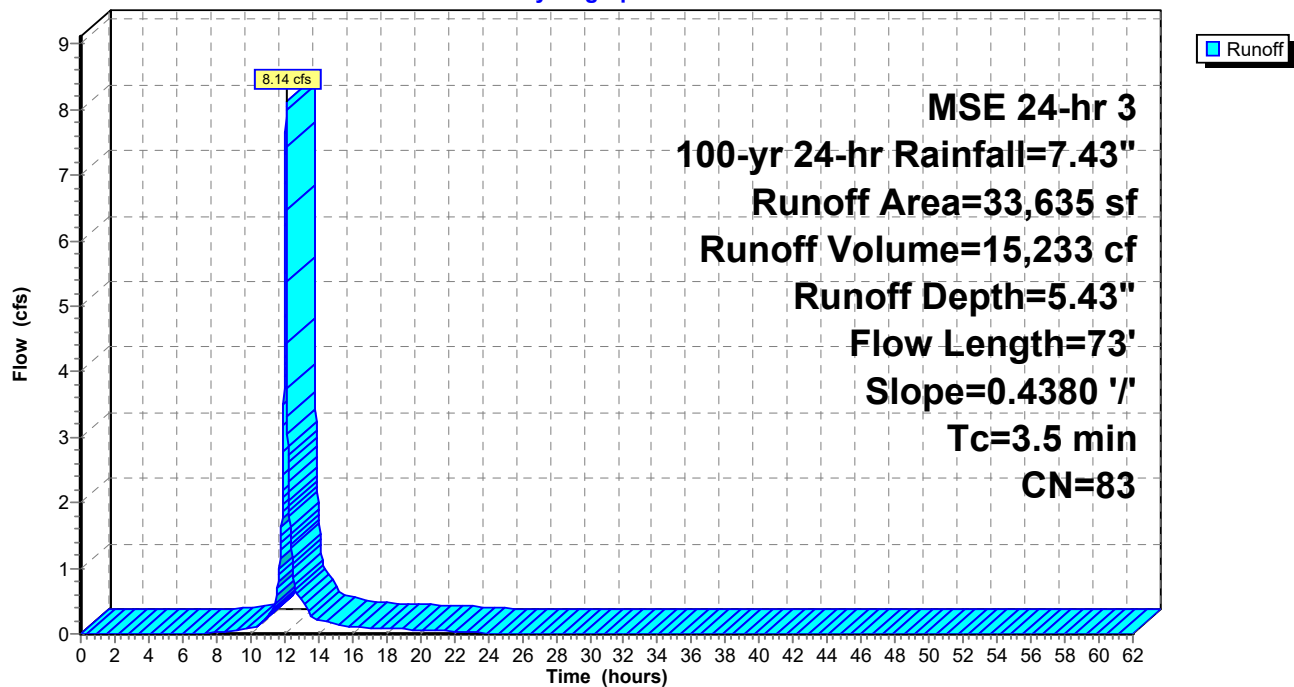
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	33,635	83	
	33,635		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	73	0.4380	0.35		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D4: D4

Hydrograph



Summary for Subcatchment D5: D5

Runoff = 3.59 cfs @ 12.13 hrs, Volume= 7,189 cf, Depth= 5.43"

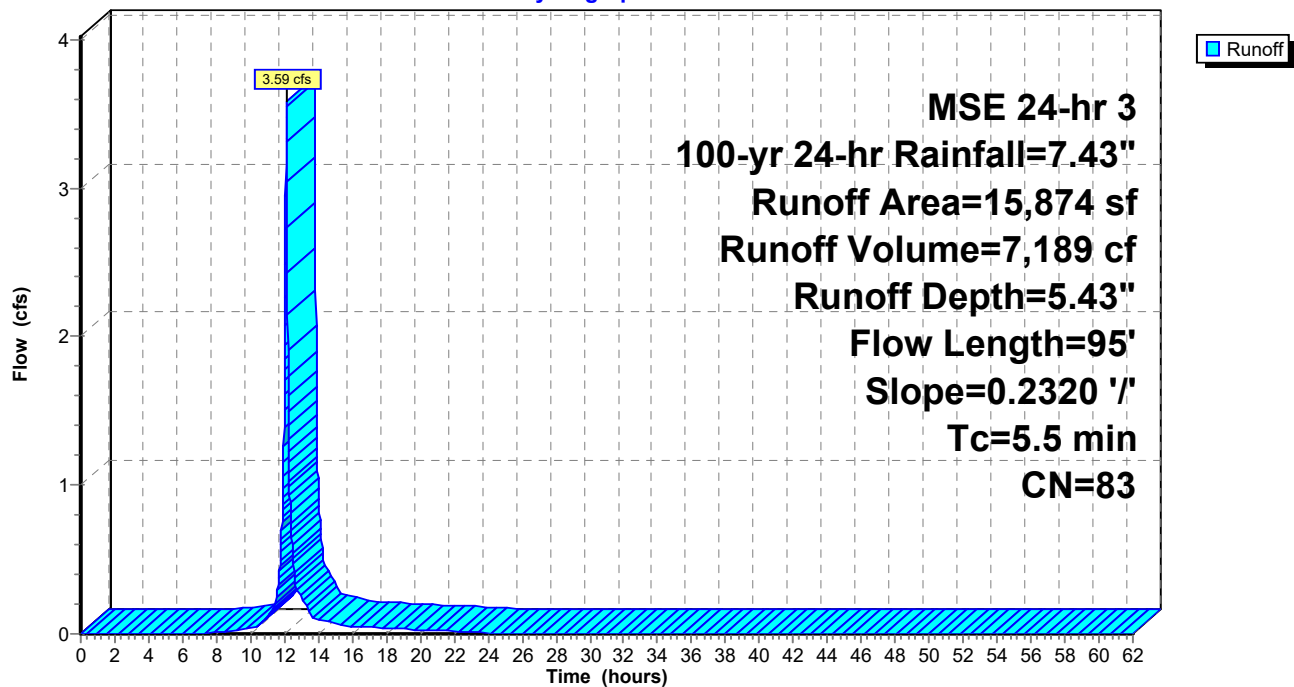
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 15,874	83	
15,874		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	95	0.2320	0.29		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D5: D5

Hydrograph



Summary for Subcatchment D6: D6

Runoff = 6.07 cfs @ 12.18 hrs, Volume= 15,042 cf, Depth= 5.43"

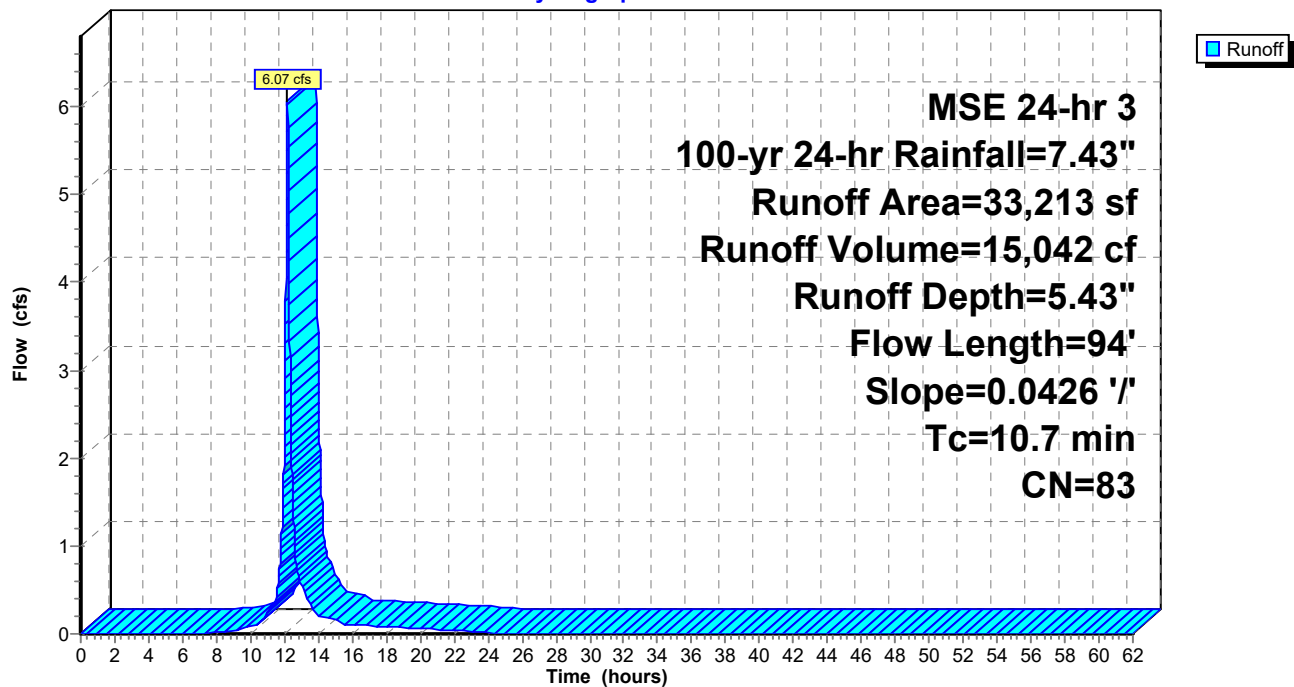
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	33,213	83	
	33,213		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.7	94	0.0426	0.15		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D6: D6

Hydrograph



Summary for Subcatchment D7: D7

Runoff = 4.70 cfs @ 12.12 hrs, Volume= 8,937 cf, Depth= 5.43"

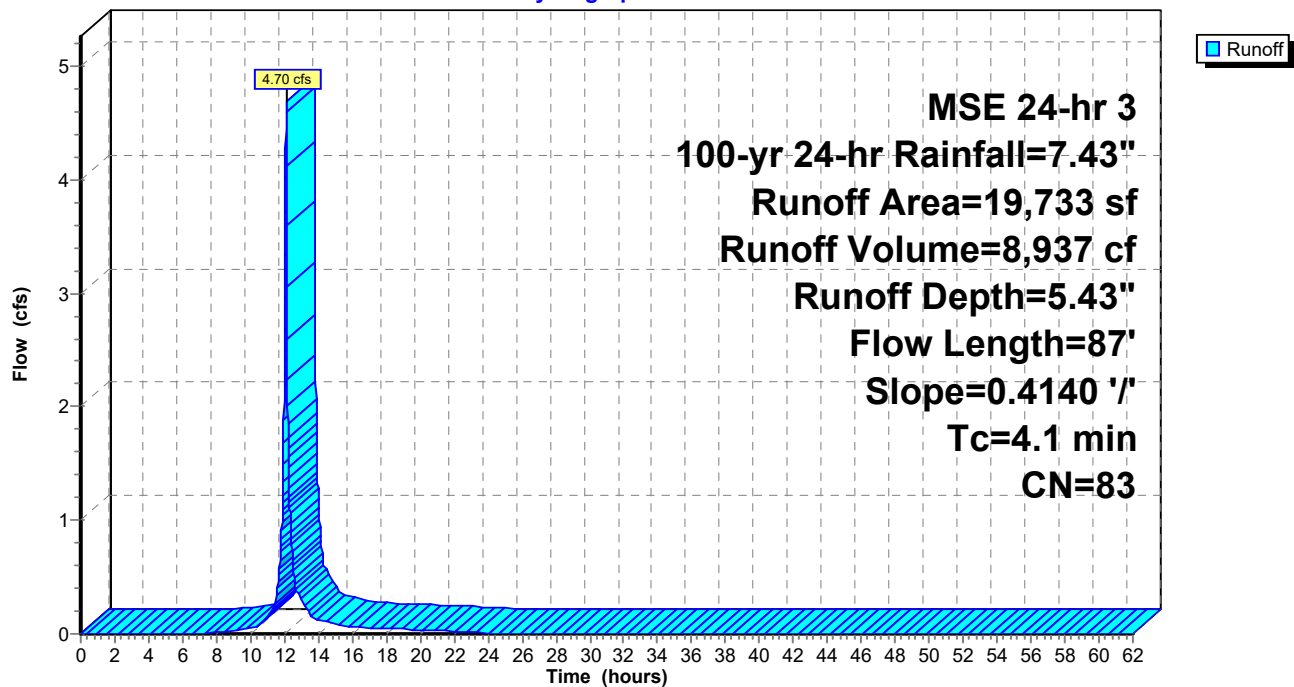
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 19,733	83	
19,733		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	87	0.4140	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D7: D7

Hydrograph



Summary for Subcatchment D8: D8

Runoff = 6.80 cfs @ 12.12 hrs, Volume= 13,112 cf, Depth= 5.43"

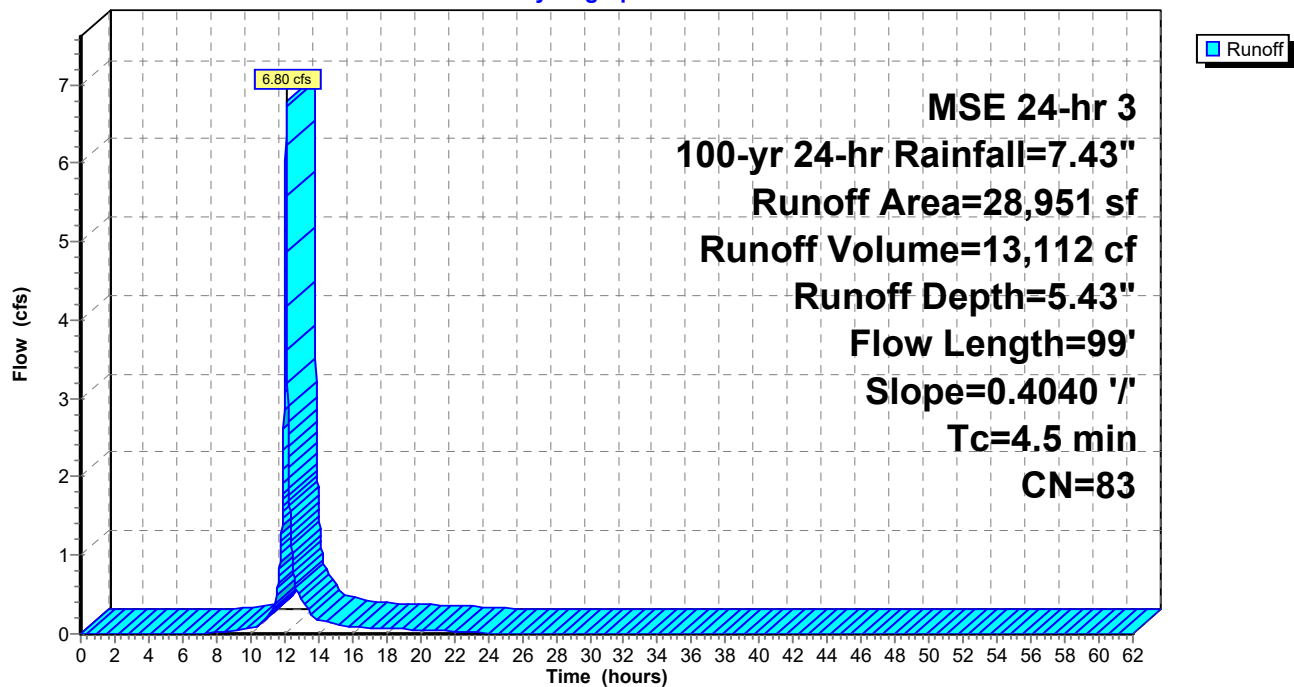
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	28,951	83	
	28,951		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.5	99	0.4040	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment D8: D8

Hydrograph



Summary for Subcatchment D9: D9

[46] Hint: $T_c=0$ (Instant runoff peak depends on dt)

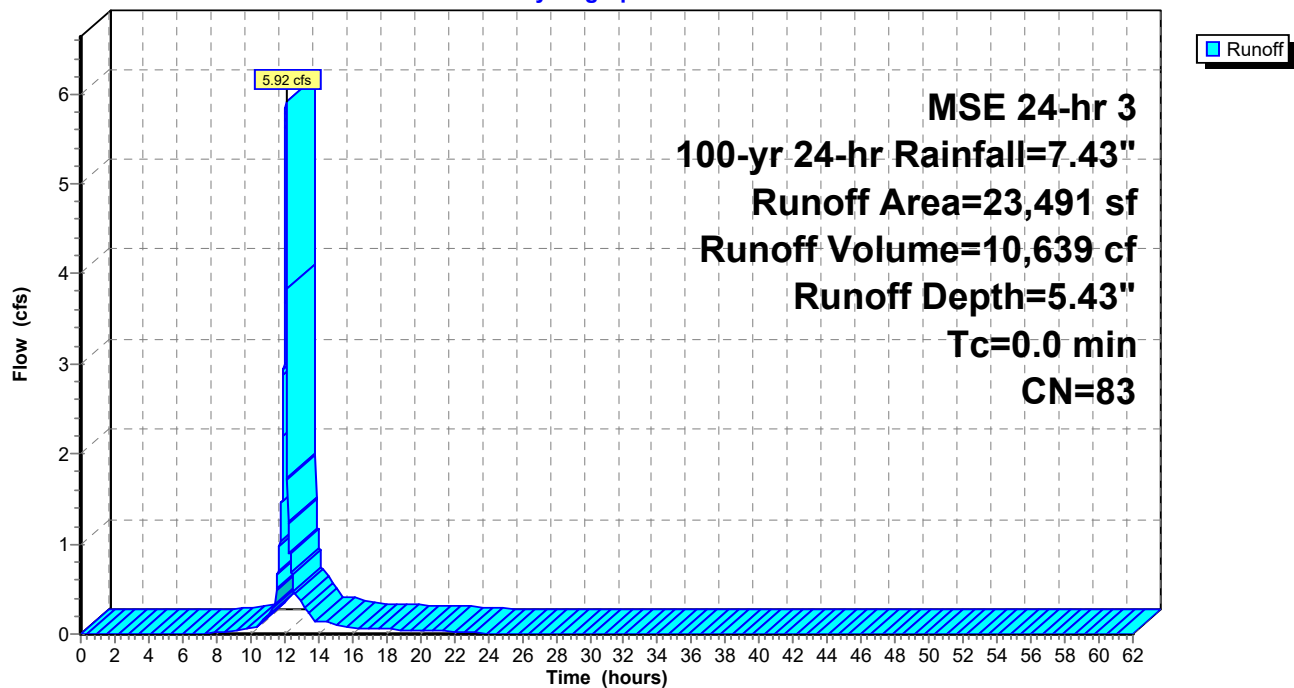
Runoff = 5.92 cfs @ 12.09 hrs, Volume= 10,639 cf, Depth= 5.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, $dt=0.01$ hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	23,491	83	
	23,491		100.00% Pervious Area

Subcatchment D9: D9

Hydrograph



Summary for Subcatchment E1: E1

Runoff = 8.73 cfs @ 12.23 hrs, Volume= 24,719 cf, Depth= 4.53"

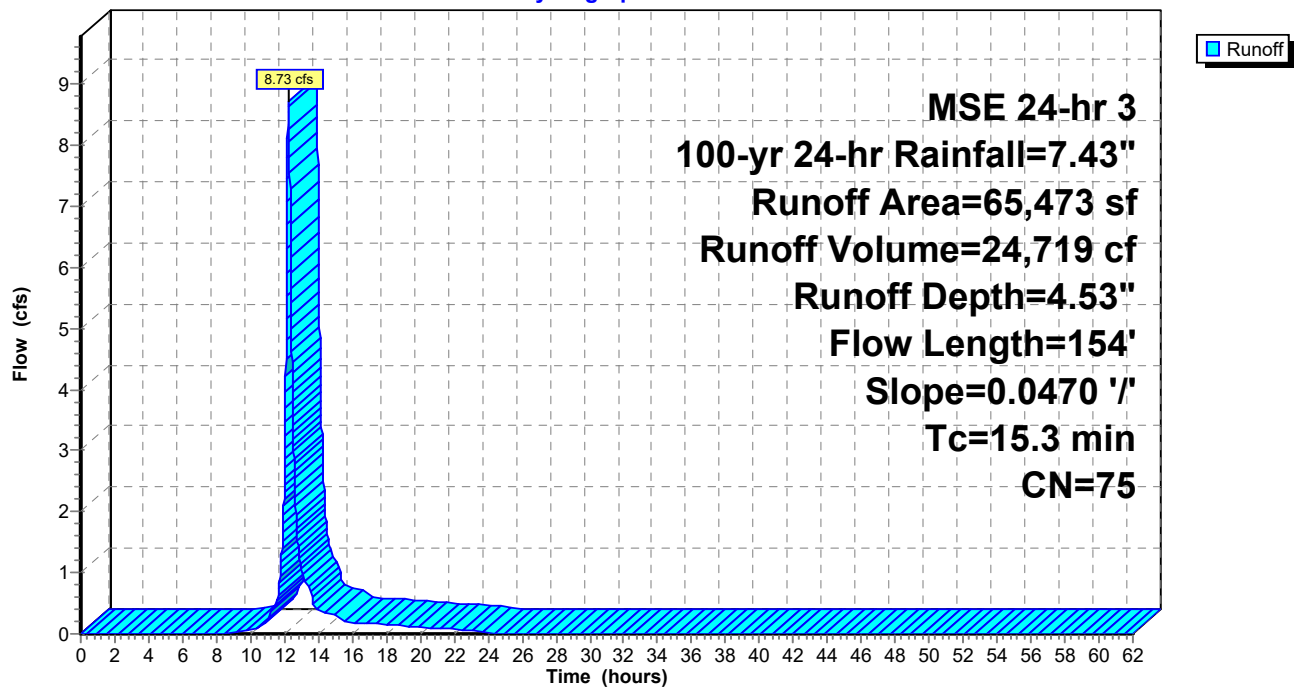
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	65,473	75	
	65,473		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.3	154	0.0470	0.17		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E1: E1

Hydrograph



Summary for Subcatchment E10: E10

Runoff = 15.89 cfs @ 12.15 hrs, Volume= 34,486 cf, Depth= 5.43"

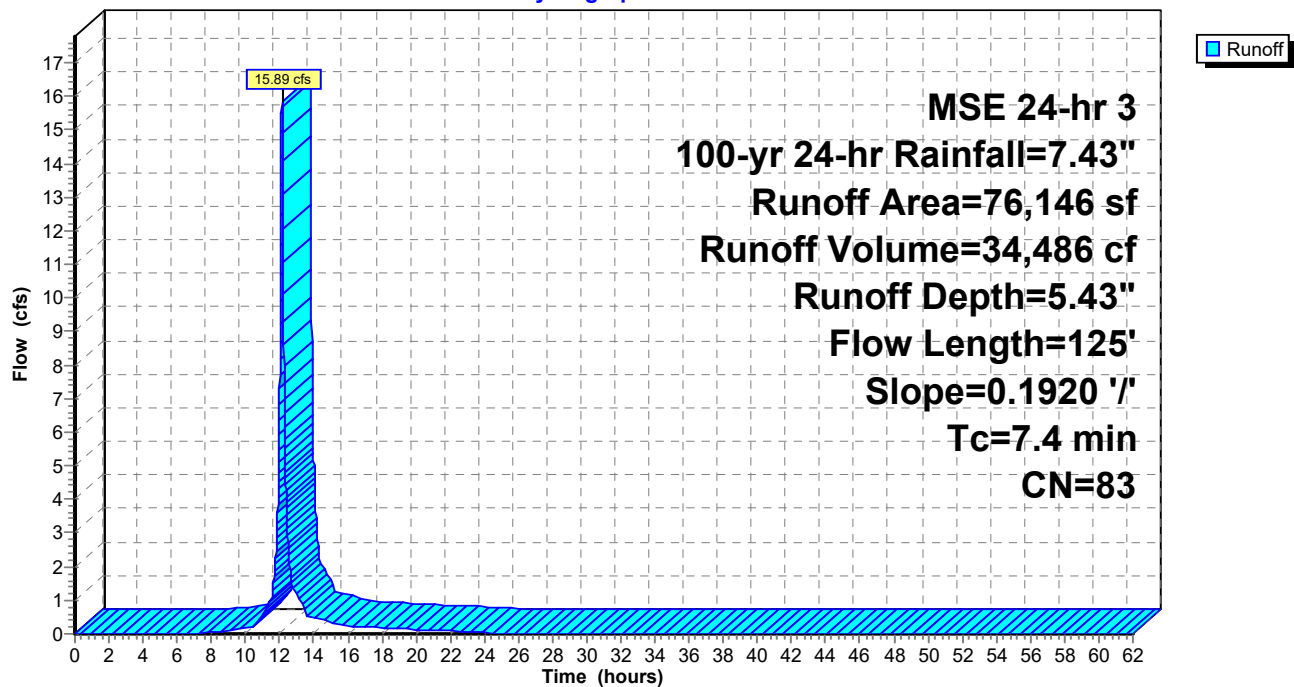
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	76,146	83	
	76,146		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.4	125	0.1920	0.28		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E10: E10

Hydrograph



Summary for Subcatchment E11: E11

Runoff = 6.32 cfs @ 12.14 hrs, Volume= 13,230 cf, Depth= 5.43"

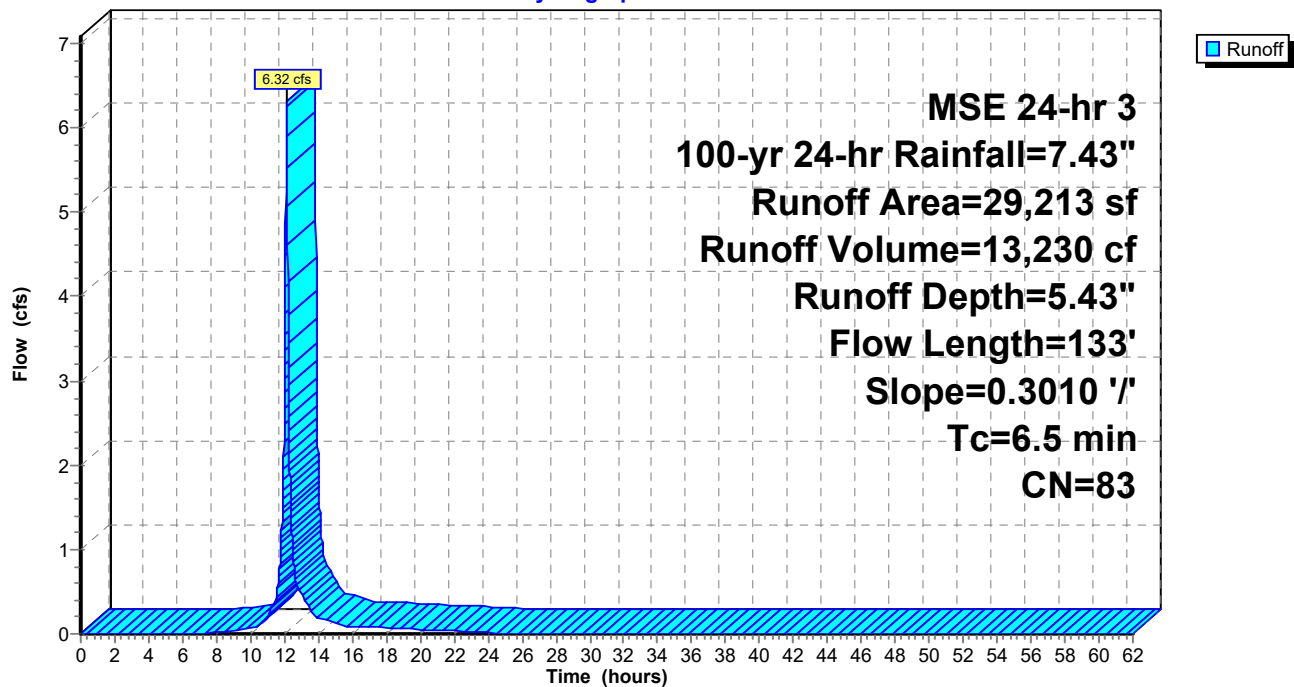
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 29,213	83	
29,213		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	133	0.3010	0.34		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E11: E11

Hydrograph



Summary for Subcatchment E12: E12

Runoff = 19.70 cfs @ 12.13 hrs, Volume= 40,027 cf, Depth= 5.43"

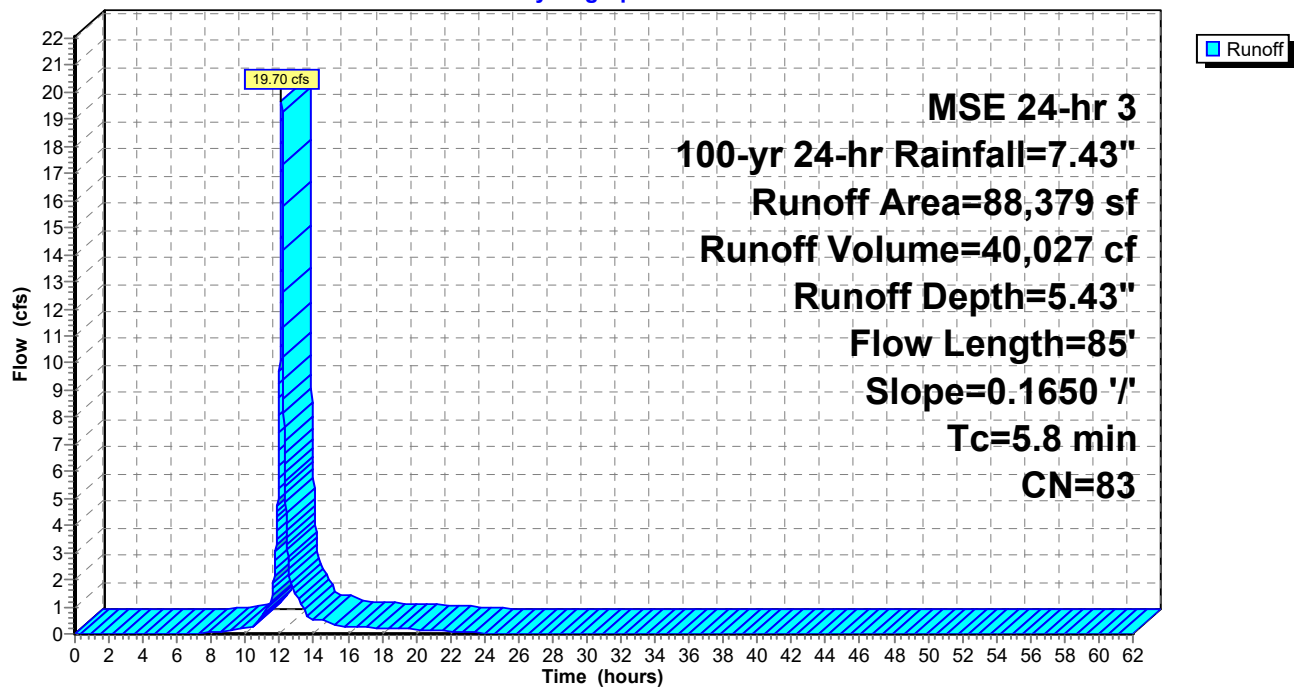
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	88,379	83	
	88,379		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	85	0.1650	0.25		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E12: E12

Hydrograph



Summary for Subcatchment E14: E14[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 0.83 cfs @ 12.09 hrs, Volume= 1,501 cf, Depth= 5.43"

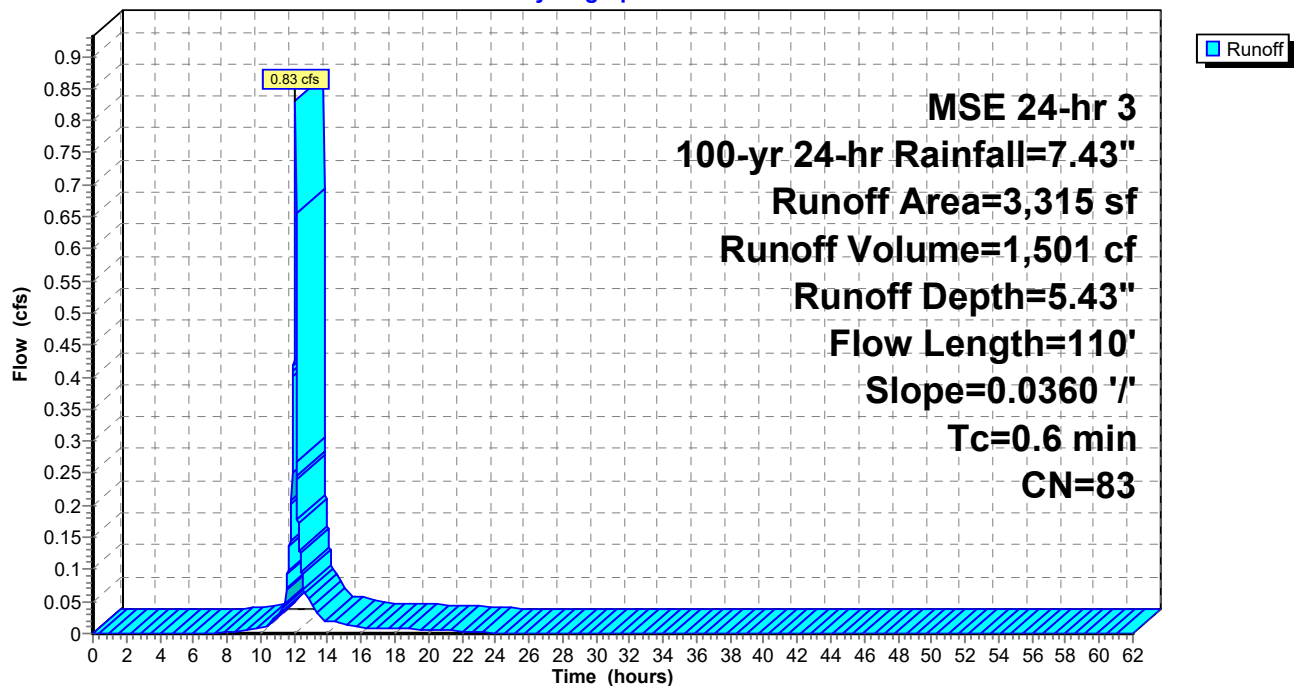
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, $dt=0.01$ hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	3,315	83	
	3,315		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	110	0.0360	2.85		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps

Subcatchment E14: E14

Hydrograph



Summary for Subcatchment E2: E2

Runoff = 4.10 cfs @ 12.33 hrs, Volume= 14,225 cf, Depth= 4.53"

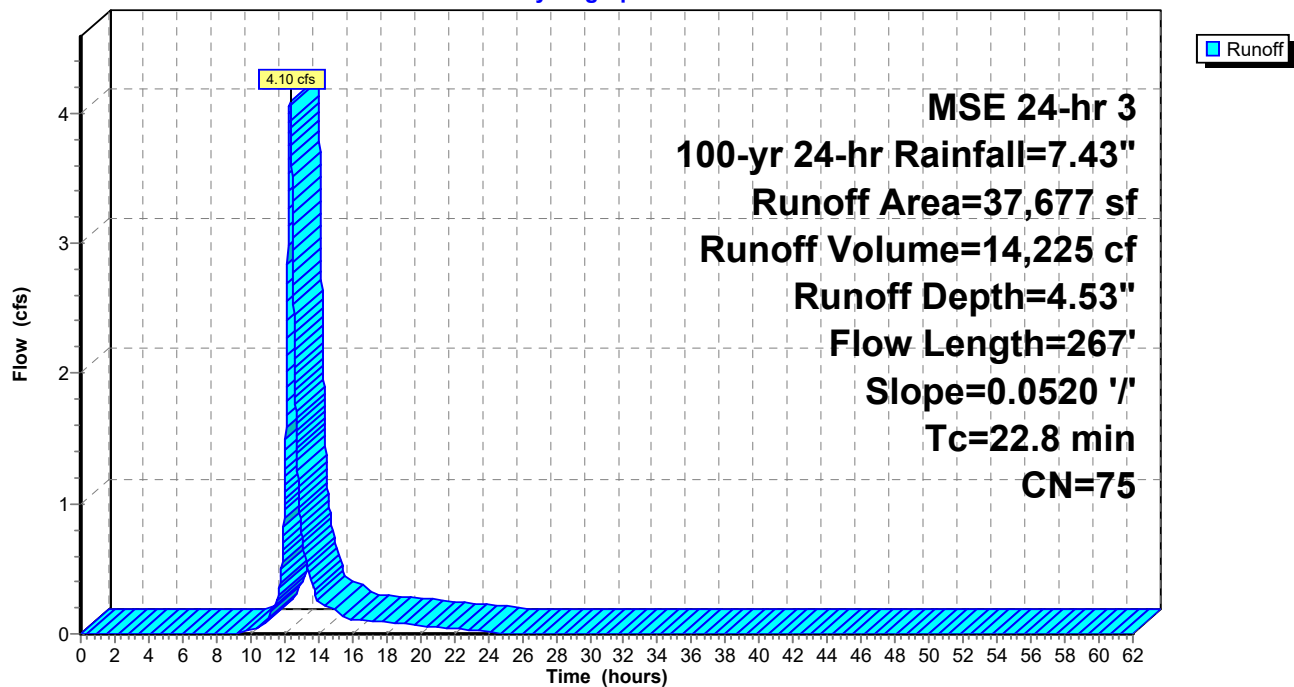
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	37,677	75	
	37,677		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.8	267	0.0520	0.19		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E2: E2

Hydrograph



Summary for Subcatchment E3: E3

Runoff = 6.23 cfs @ 12.12 hrs, Volume= 11,951 cf, Depth= 5.43"

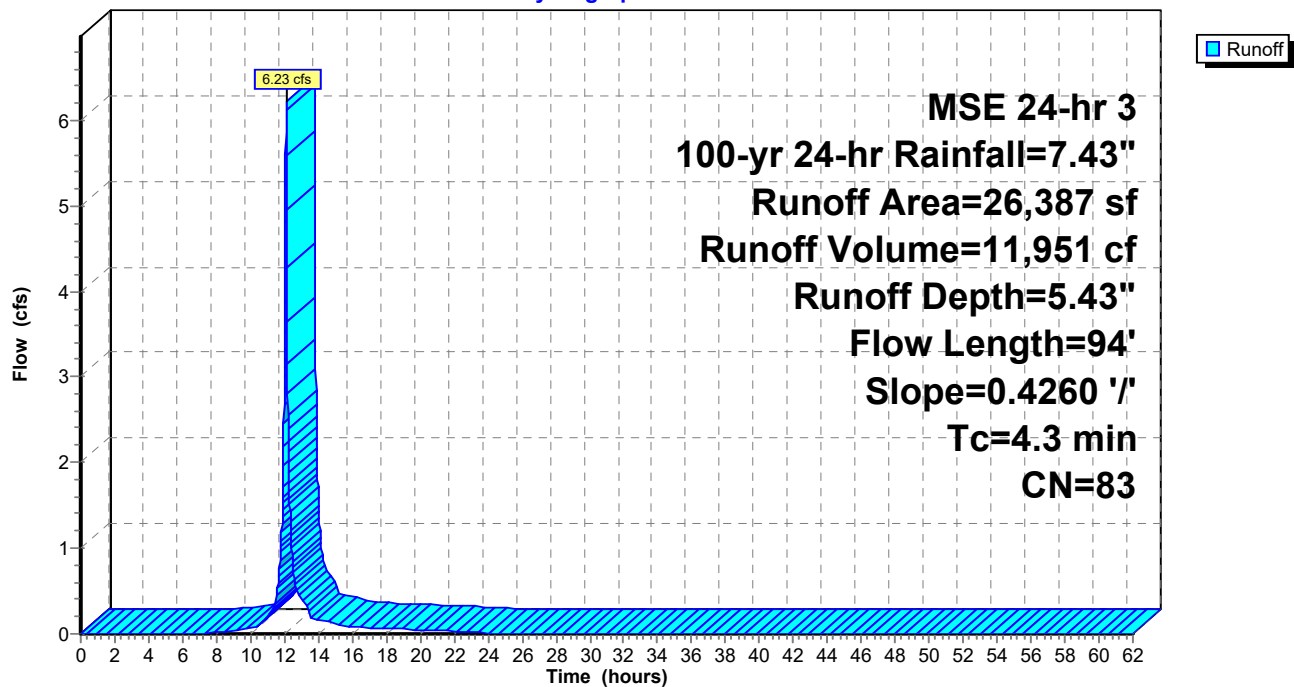
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 26,387	83	
26,387		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	94	0.4260	0.37		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E3: E3

Hydrograph



Summary for Subcatchment E4: E4

Runoff = 5.83 cfs @ 12.11 hrs, Volume= 10,995 cf, Depth= 5.43"

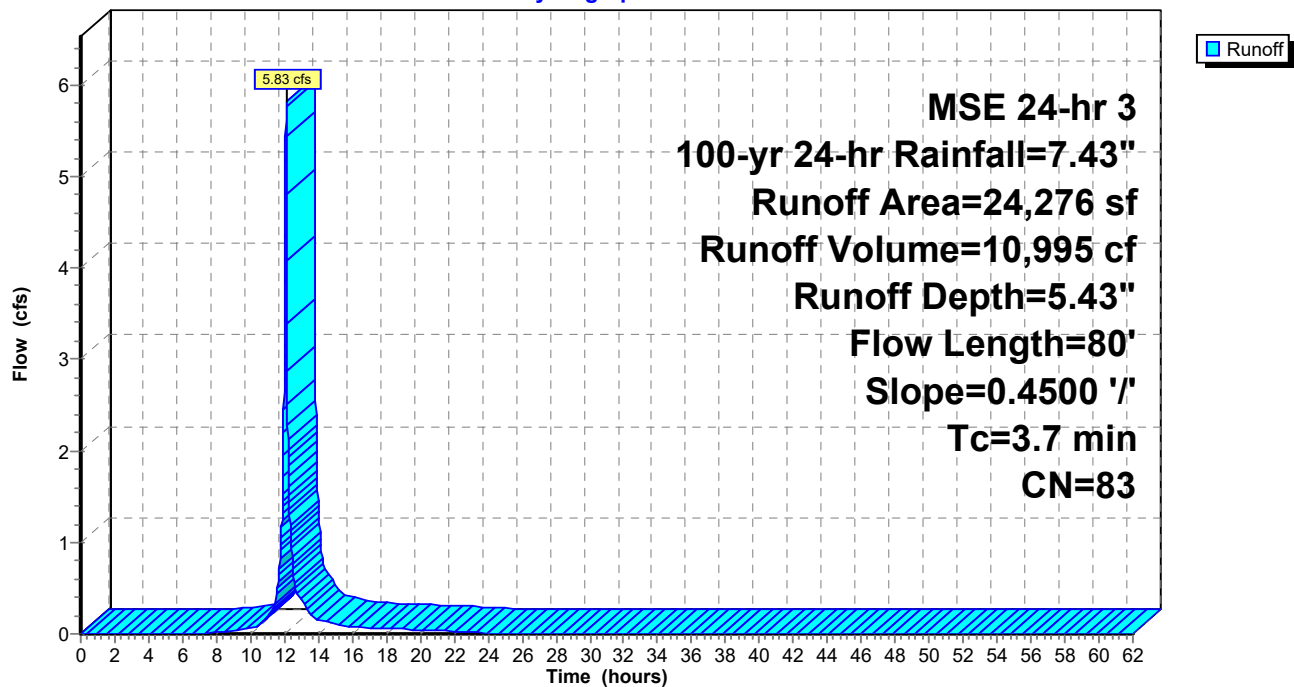
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 24,276	83	
24,276		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	80	0.4500	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E4: E4

Hydrograph



Summary for Subcatchment E5: E5

Runoff = 6.25 cfs @ 12.12 hrs, Volume= 11,954 cf, Depth= 5.43"

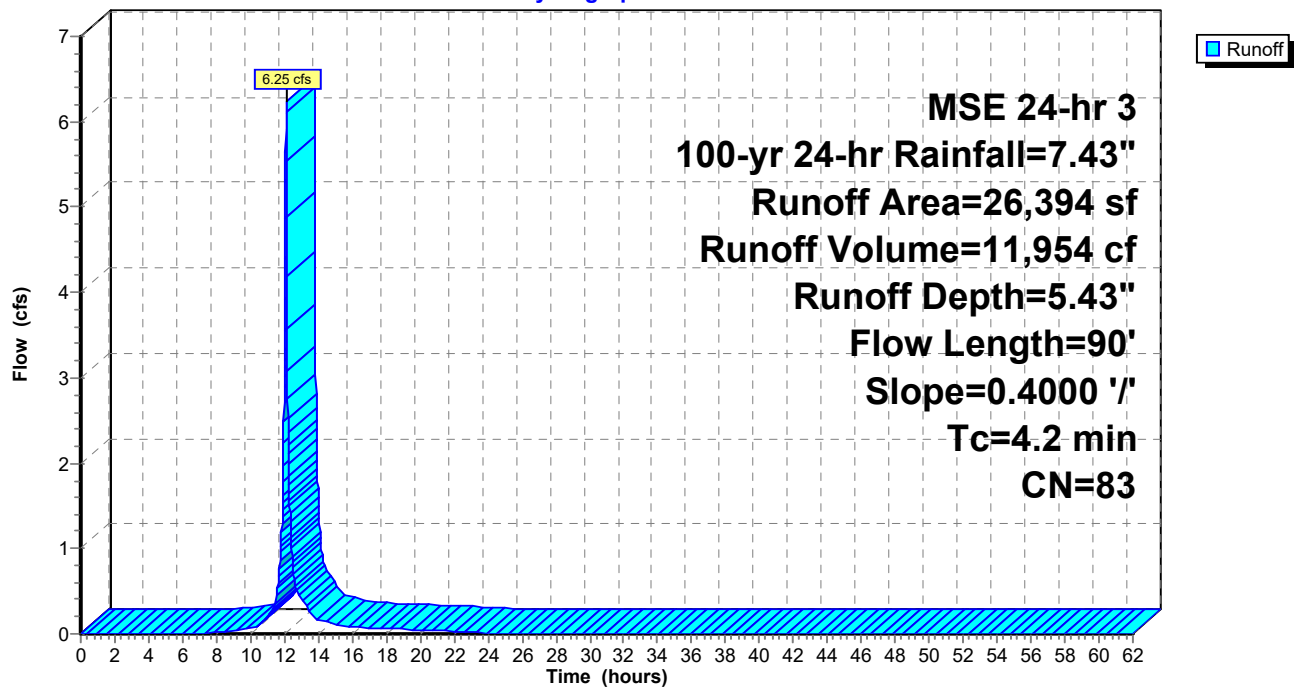
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	26,394	83	
	26,394		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	90	0.4000	0.35		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E5: E5

Hydrograph



Summary for Subcatchment E6: E6

Runoff = 6.69 cfs @ 12.11 hrs, Volume= 12,567 cf, Depth= 5.43"

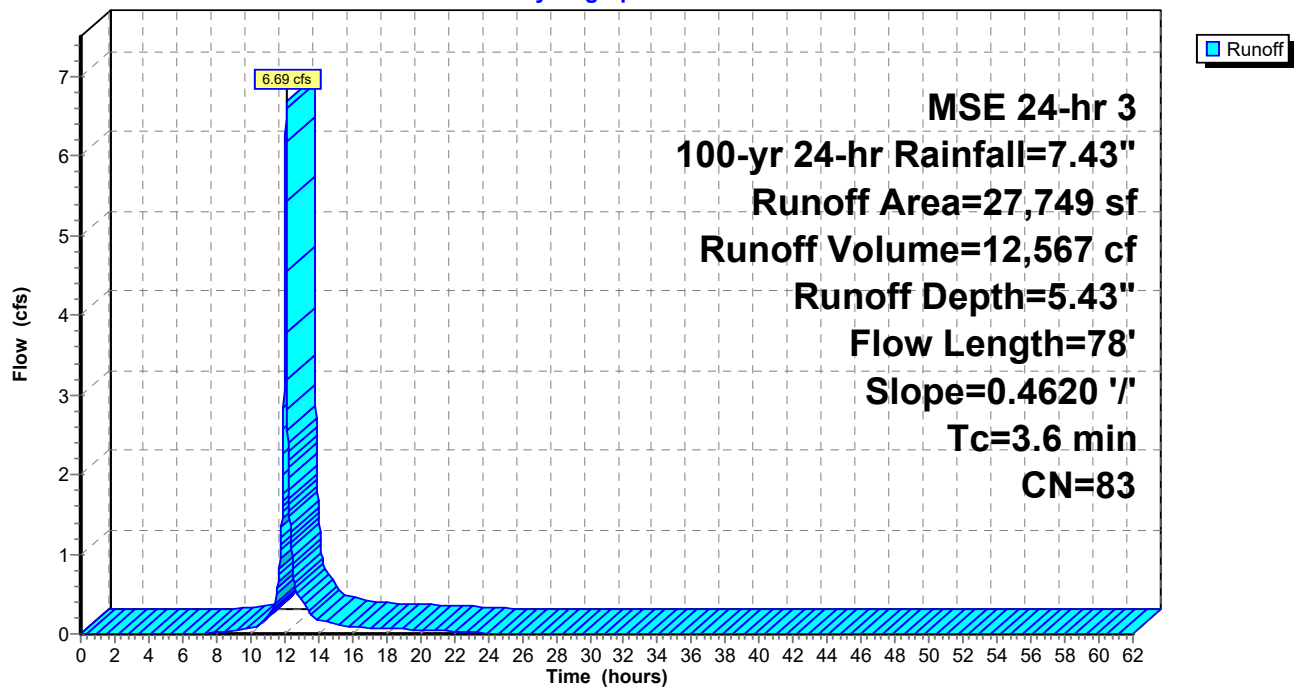
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	27,749	83	
	27,749		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	78	0.4620	0.36		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E6: E6

Hydrograph



Summary for Subcatchment E7: E7

Runoff = 9.22 cfs @ 12.13 hrs, Volume= 18,588 cf, Depth= 5.43"

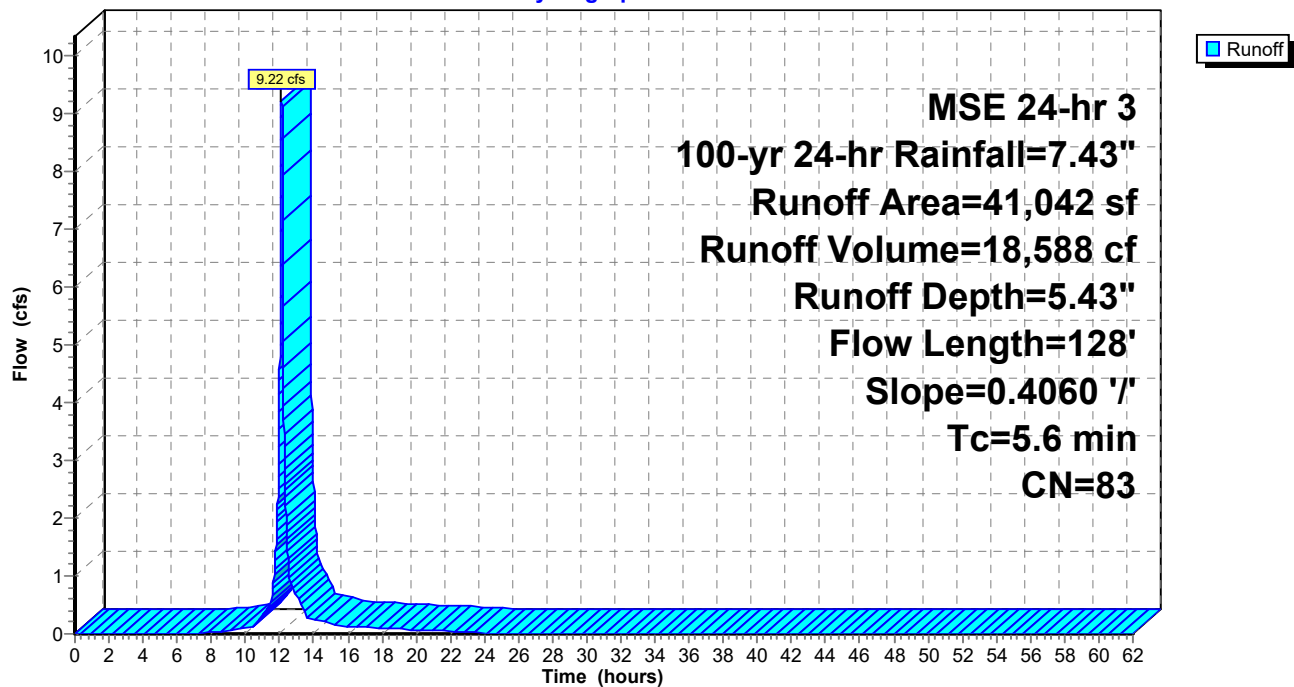
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 41,042	83	
41,042		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	128	0.4060	0.38		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E7: E7

Hydrograph



Summary for Subcatchment E8: E8

Runoff = 12.87 cfs @ 12.14 hrs, Volume= 27,332 cf, Depth= 5.43"

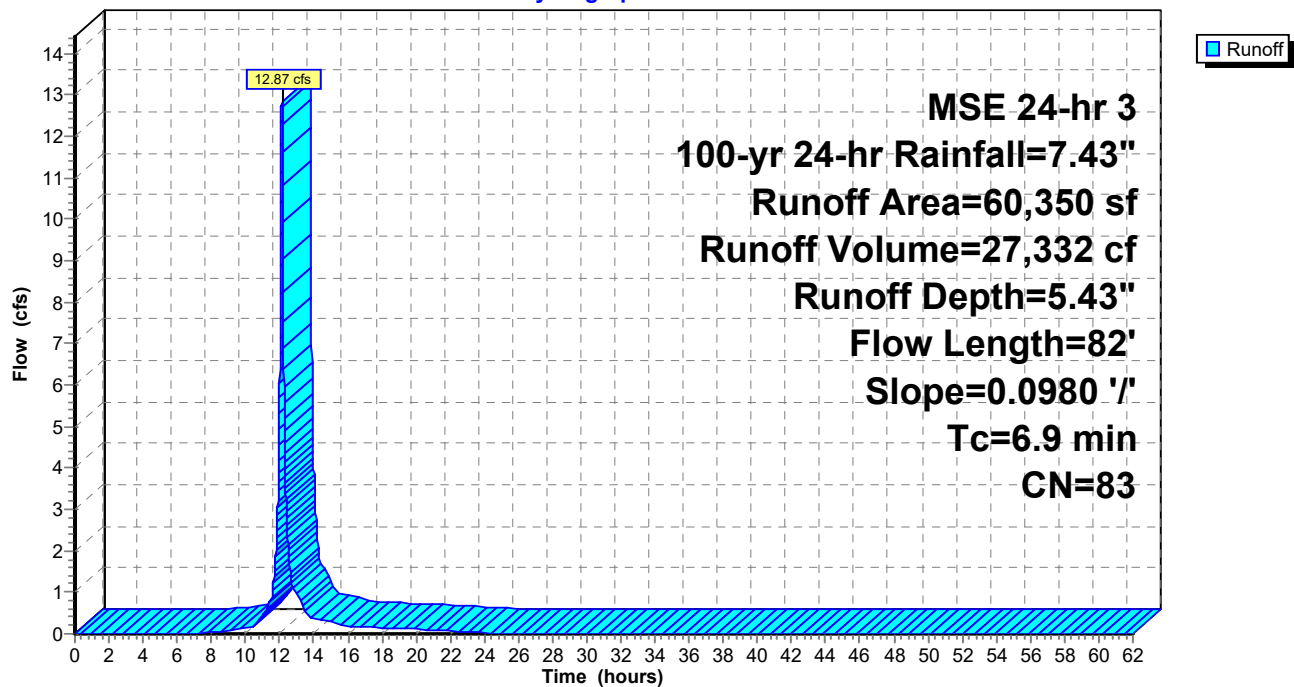
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

Area (sf)	CN	Description
* 60,350	83	
60,350		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	82	0.0980	0.20		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E8: E8

Hydrograph



Summary for Subcatchment E9: E9

Runoff = 5.86 cfs @ 12.11 hrs, Volume= 11,007 cf, Depth= 5.43"

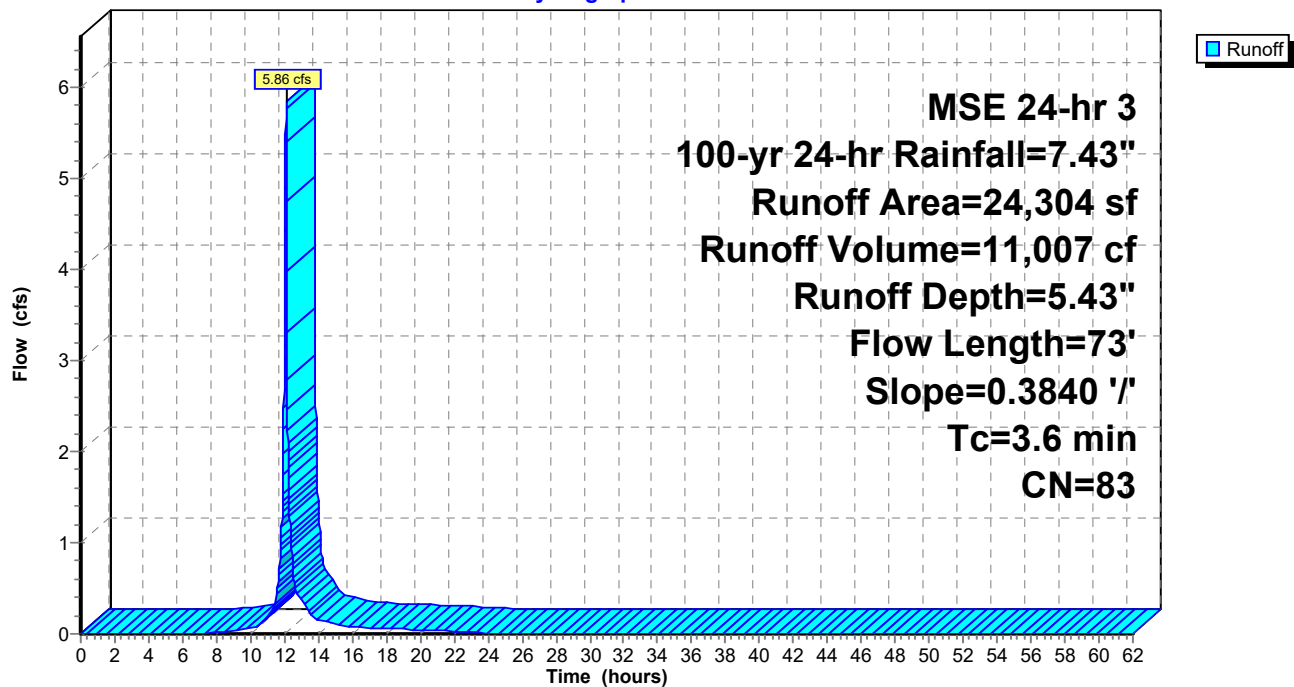
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-yr 24-hr Rainfall=7.43"

	Area (sf)	CN	Description
*	24,304	83	
	24,304		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	73	0.3840	0.33		Sheet Flow, Grass: Dense n= 0.240 P2= 2.80"

Subcatchment E9: E9

Hydrograph



Summary for Reach A10T: A10 Terrace

[62] Hint: Exceeded Reach AA4T OUTLET depth by 0.25' @ 12.19 hrs

Inflow Area = 114,327 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 24.65 cfs @ 12.11 hrs, Volume= 51,778 cf
 Outflow = 23.48 cfs @ 12.15 hrs, Volume= 51,778 cf, Atten= 5%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.58 fps, Min. Travel Time= 1.5 min

Avg. Velocity= 1.74 fps, Avg. Travel Time= 4.6 min

Peak Storage= 2,051 cf @ 12.12 hrs

Average Depth at Peak Storage= 0.88'

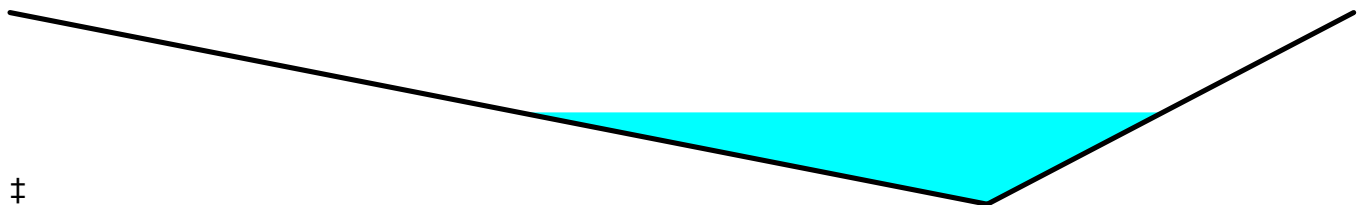
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 168.20 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

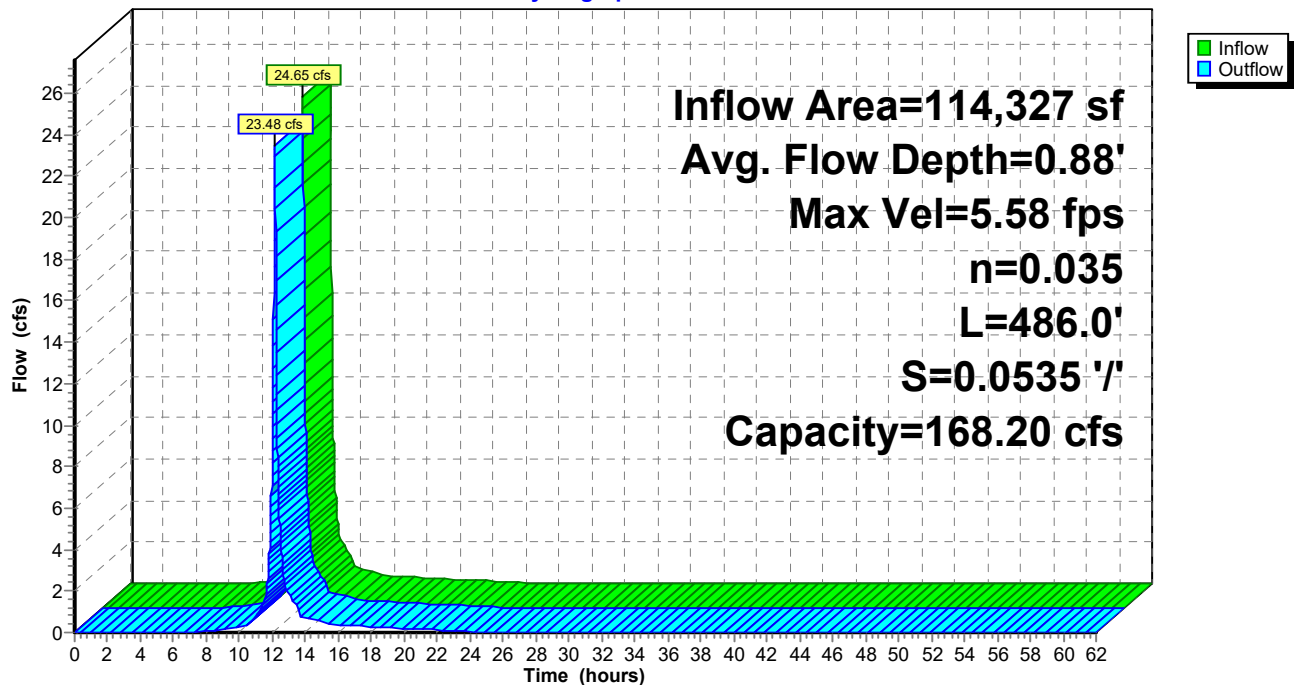
Length= 486.0' Slope= 0.0535 '/'

Inlet Invert= 886.00', Outlet Invert= 860.00'



Reach A10T: A10 Terrace

Hydrograph



Summary for Reach A1T: A1 Terracce

Inflow Area = 31,276 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
 Inflow = 3.24 cfs @ 12.37 hrs, Volume= 11,808 cf
 Outflow = 3.23 cfs @ 12.39 hrs, Volume= 11,808 cf, Atten= 0%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 2.82 fps, Min. Travel Time= 1.1 min

Avg. Velocity = 1.10 fps, Avg. Travel Time= 2.8 min

Peak Storage= 211 cf @ 12.37 hrs

Average Depth at Peak Storage= 0.46'

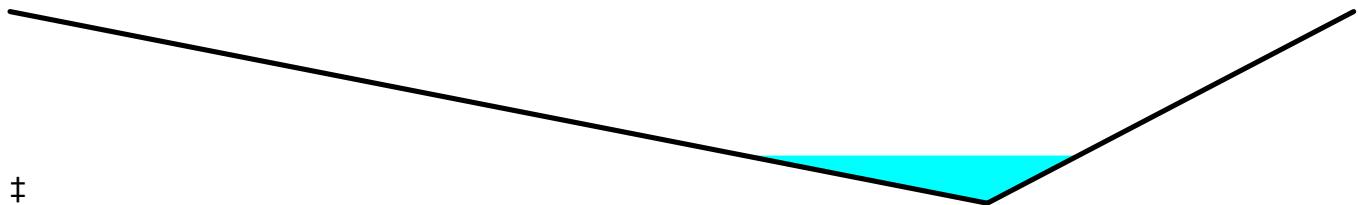
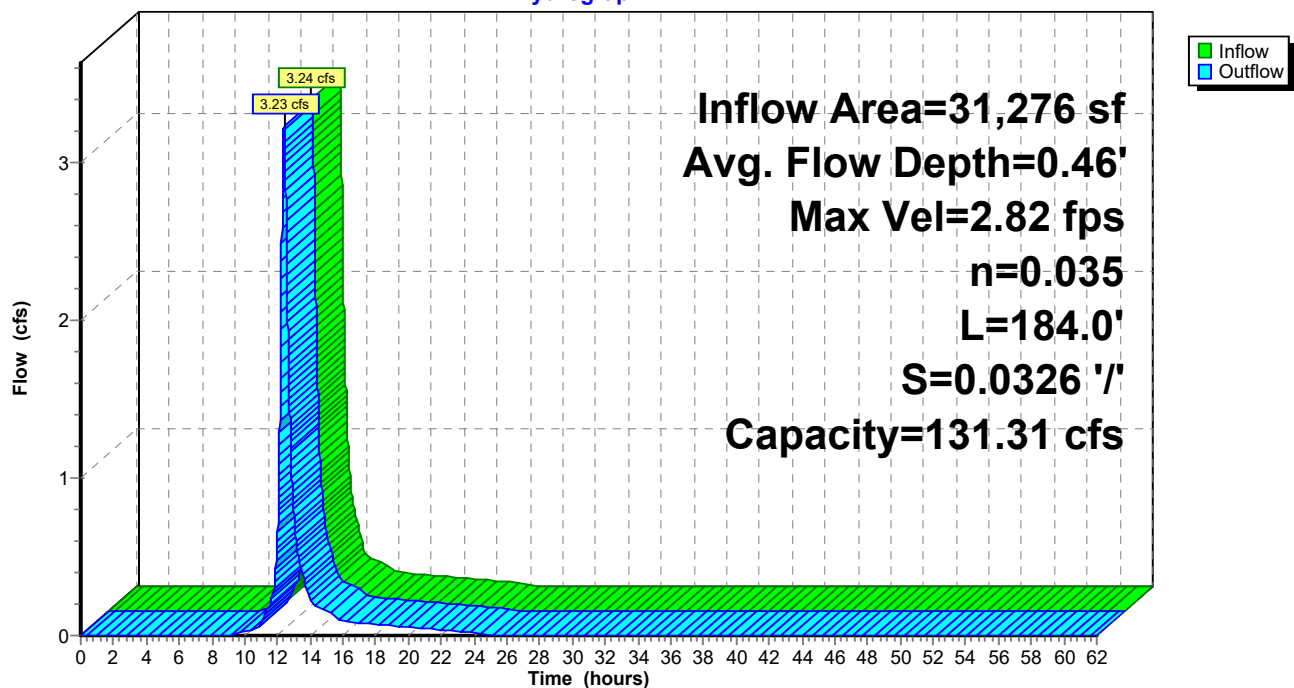
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 131.31 cfs

0.00' x 1.83' deep channel, n= 0.035 Earth, dense weeds

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 184.0' Slope= 0.0326 '/'

Inlet Invert= 1,092.00', Outlet Invert= 1,086.00'

**Reach A1T: A1 Terracce****Hydrograph**

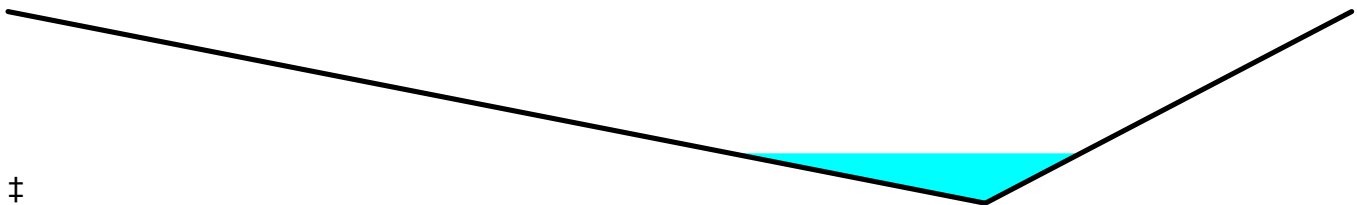
Summary for Reach A2T: A2 Terrace

Inflow Area = 40,083 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
 Inflow = 3.80 cfs @ 12.41 hrs, Volume= 15,133 cf
 Outflow = 3.79 cfs @ 12.45 hrs, Volume= 15,133 cf, Atten= 0%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.02 fps, Min. Travel Time= 1.3 min
 Avg. Velocity = 1.19 fps, Avg. Travel Time= 3.2 min

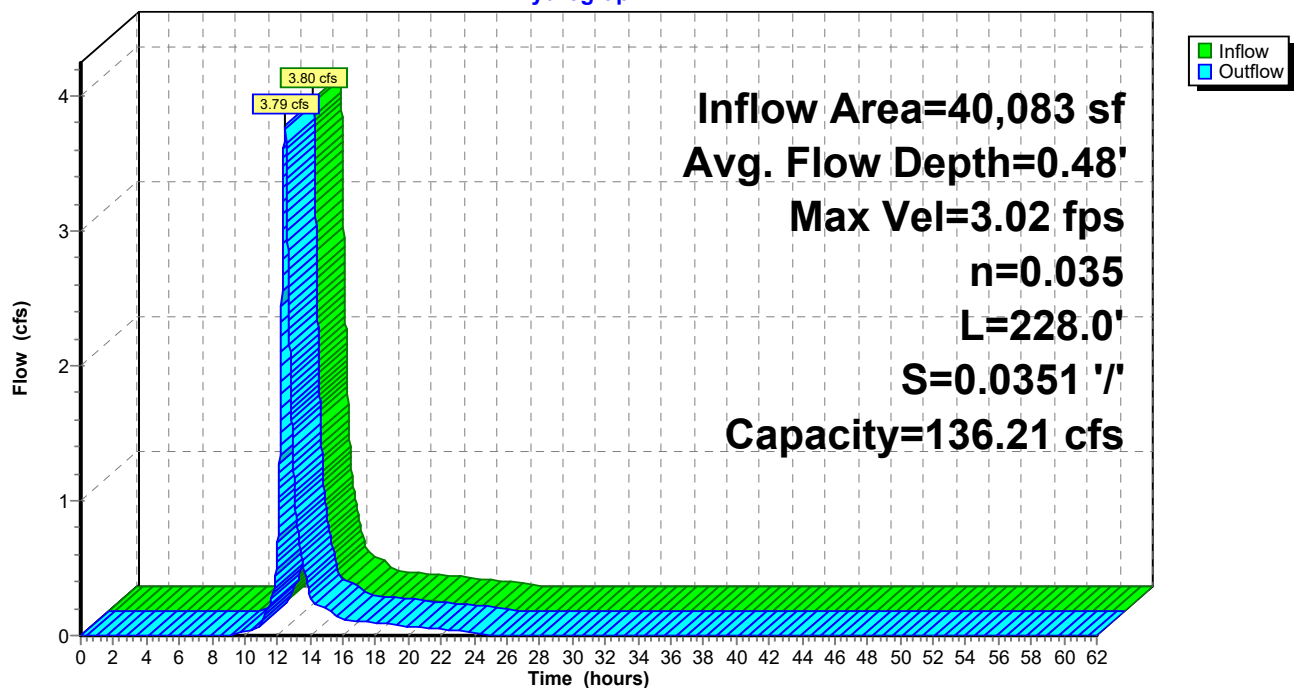
Peak Storage= 286 cf @ 12.43 hrs
 Average Depth at Peak Storage= 0.48'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 136.21 cfs

0.00' x 1.83' deep channel, n= 0.035 Earth, dense weeds
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 228.0' Slope= 0.0351 '/'
 Inlet Invert= 1,094.00', Outlet Invert= 1,086.00'



Reach A2T: A2 Terrace

Hydrograph



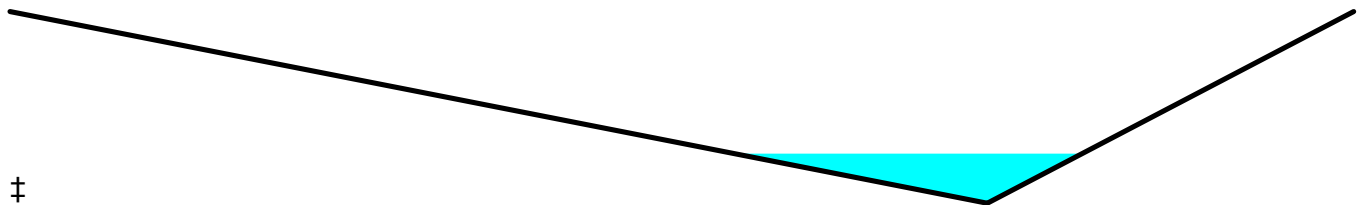
Summary for Reach A3T: A3 Terrace

Inflow Area = 16,767 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 4.04 cfs @ 12.11 hrs, Volume= 7,594 cf
 Outflow = 3.94 cfs @ 12.14 hrs, Volume= 7,594 cf, Atten= 3%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.20 fps, Min. Travel Time= 1.3 min
 Avg. Velocity = 1.04 fps, Avg. Travel Time= 4.0 min

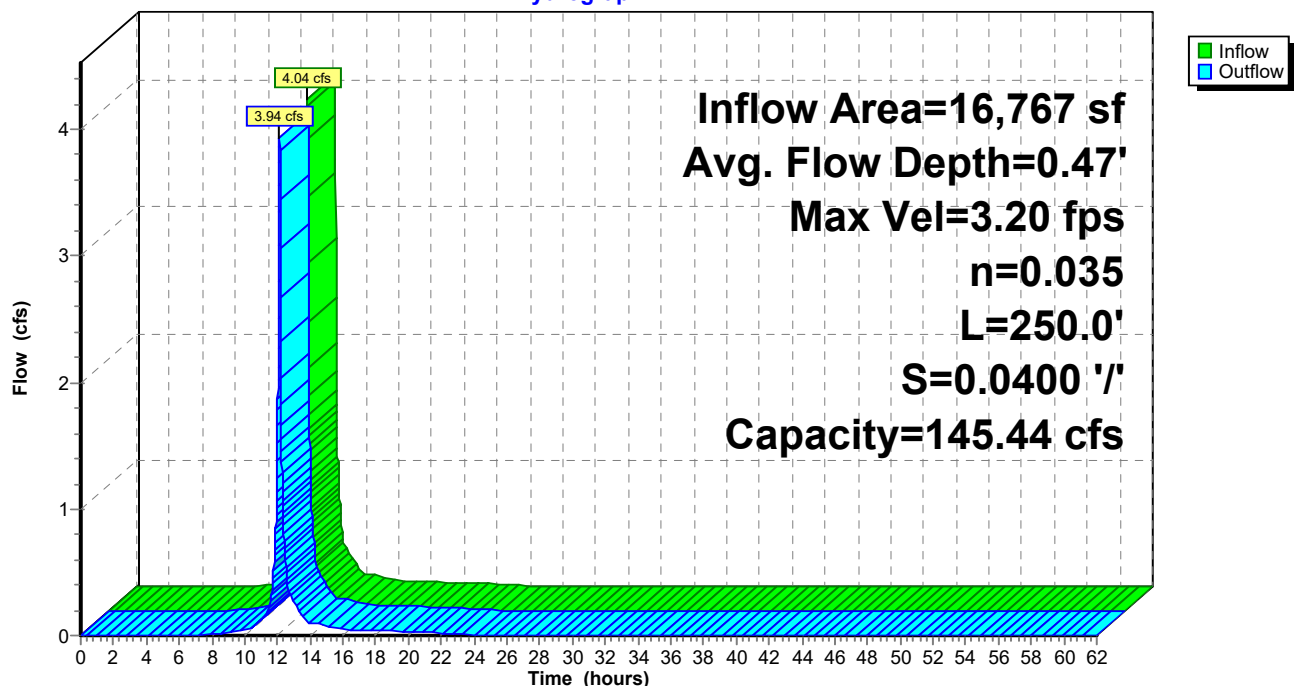
Peak Storage= 308 cf @ 12.12 hrs
 Average Depth at Peak Storage= 0.47'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 145.44 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 250.0' Slope= 0.0400 '/'
 Inlet Invert= 1,056.00', Outlet Invert= 1,046.00'



Reach A3T: A3 Terrace

Hydrograph



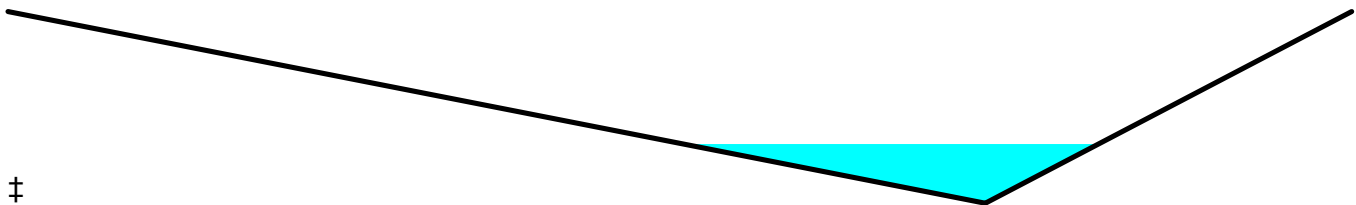
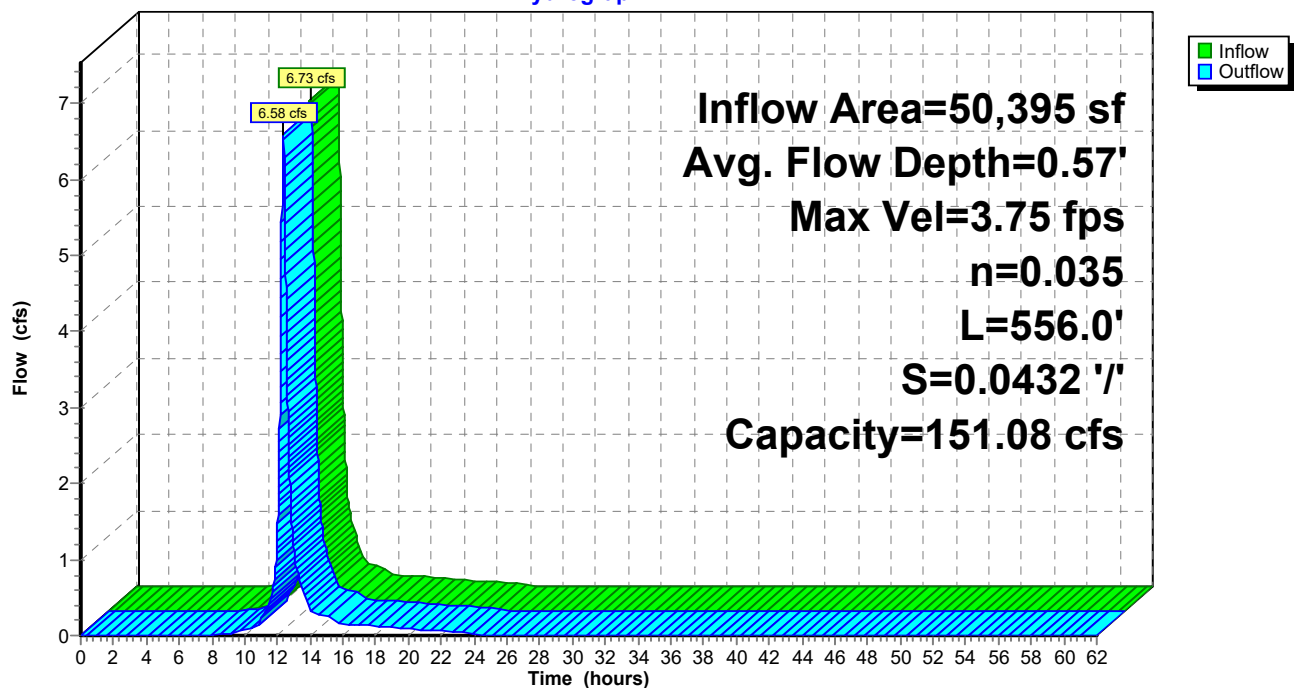
Summary for Reach A4T: A4 Terrace

Inflow Area = 50,395 sf, 0.00% Impervious, Inflow Depth = 5.09" for 100-yr 24-hr event
 Inflow = 6.73 cfs @ 12.27 hrs, Volume= 21,388 cf
 Outflow = 6.58 cfs @ 12.35 hrs, Volume= 21,388 cf, Atten= 2%, Lag= 4.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.75 fps, Min. Travel Time= 2.5 min
 Avg. Velocity = 1.34 fps, Avg. Travel Time= 6.9 min

Peak Storage= 977 cf @ 12.31 hrs
 Average Depth at Peak Storage= 0.57'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 151.08 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 556.0' Slope= 0.0432 '/'
 Inlet Invert= 1,070.00', Outlet Invert= 1,046.00'

**Reach A4T: A4 Terrace****Hydrograph**

Summary for Reach A5T: A5 Terrace

Inflow Area = 24,909 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.08 cfs @ 12.11 hrs, Volume= 11,281 cf
 Outflow = 5.84 cfs @ 12.15 hrs, Volume= 11,281 cf, Atten= 4%, Lag= 2.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.67 fps, Min. Travel Time= 1.7 min

Avg. Velocity = 1.17 fps, Avg. Travel Time= 5.2 min

Peak Storage= 582 cf @ 12.12 hrs

Average Depth at Peak Storage= 0.54'

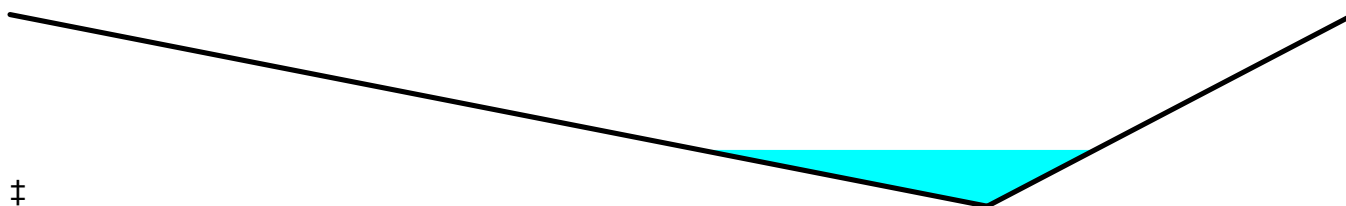
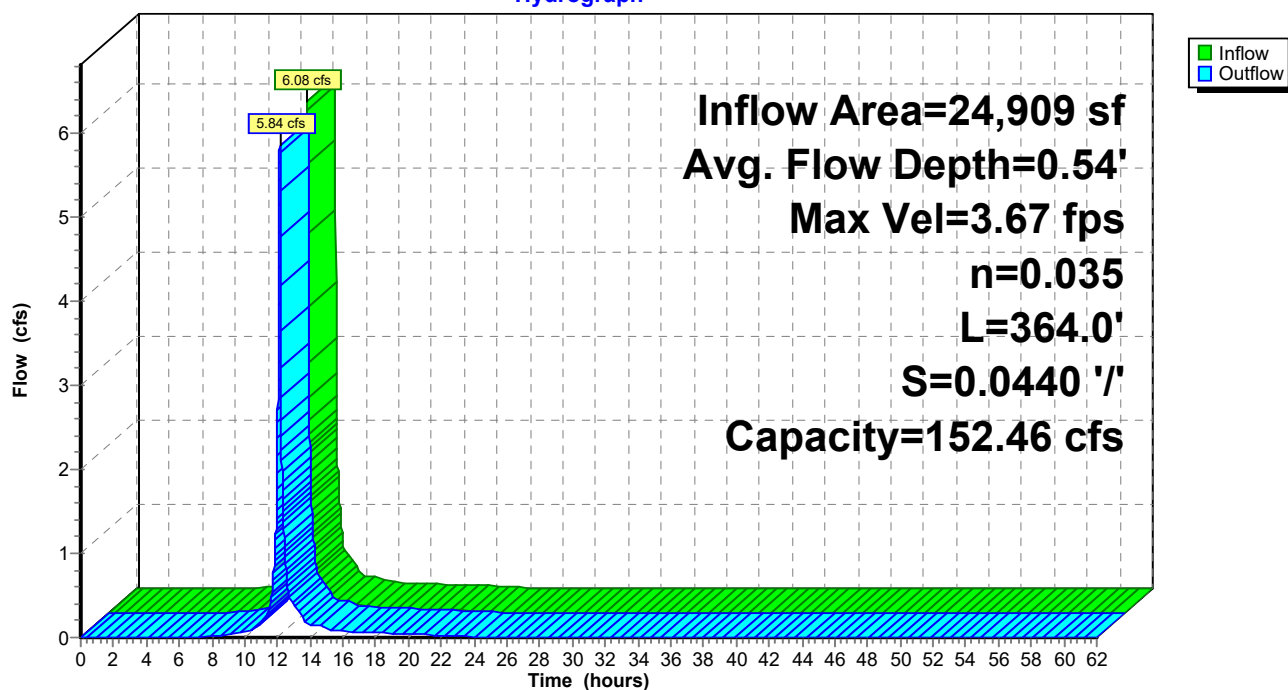
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 152.46 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 364.0' Slope= 0.0440 '/'

Inlet Invert= 1,018.00', Outlet Invert= 1,002.00'

**Reach A5T: A5 Terrace****Hydrograph**

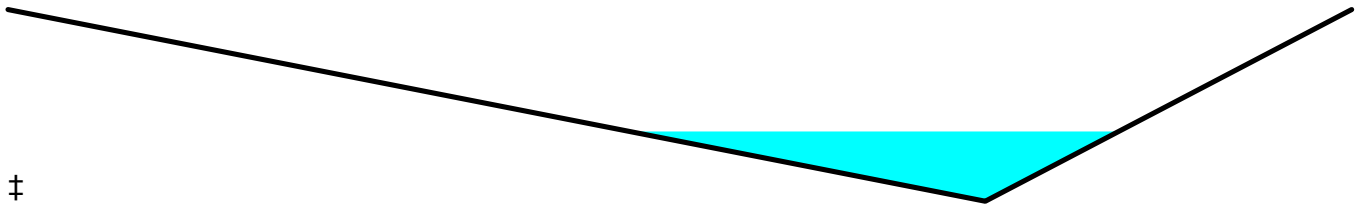
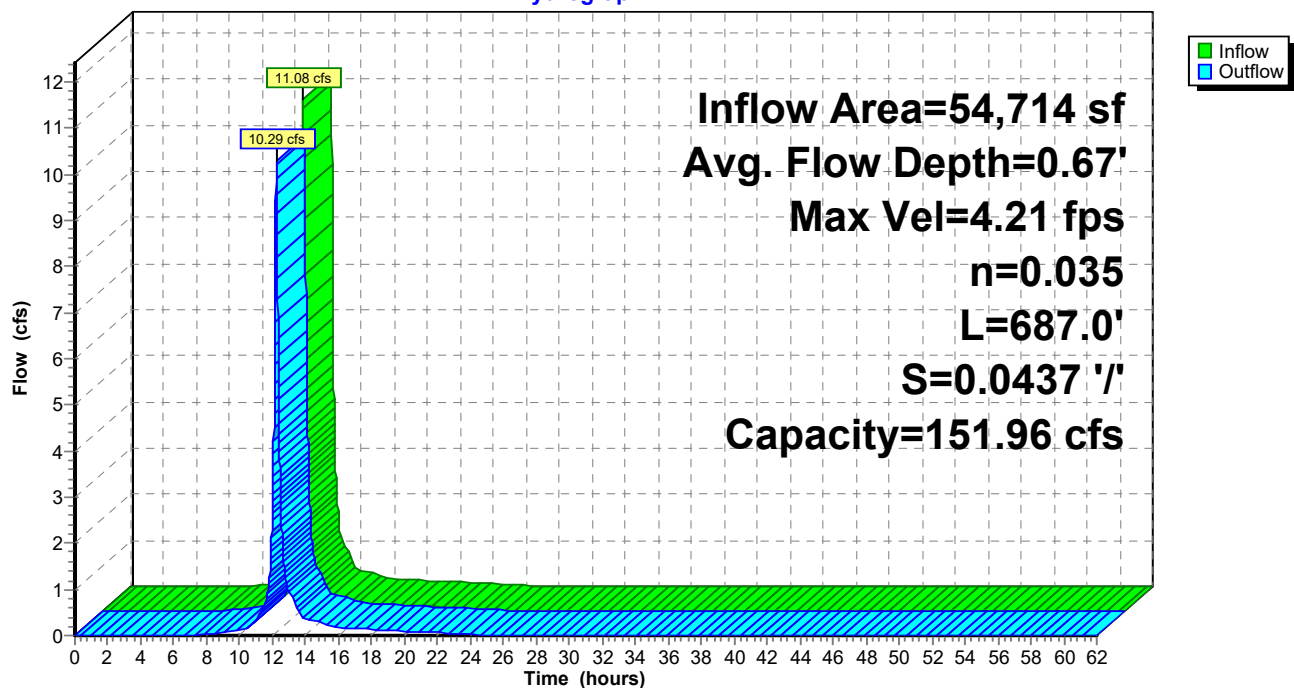
Summary for Reach A6T: A5 Terrace

Inflow Area = 54,714 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 11.08 cfs @ 12.15 hrs, Volume= 24,780 cf
 Outflow = 10.29 cfs @ 12.23 hrs, Volume= 24,780 cf, Atten= 7%, Lag= 4.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 4.21 fps, Min. Travel Time= 2.7 min
 Avg. Velocity = 1.36 fps, Avg. Travel Time= 8.4 min

Peak Storage= 1,682 cf @ 12.18 hrs
 Average Depth at Peak Storage= 0.67'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 151.96 cfs

0.00' x 1.83' deep channel, n= 0.035 Earth, dense weeds
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 687.0' Slope= 0.0437 '/'
 Inlet Invert= 1,032.00', Outlet Invert= 1,002.00'

**Reach A6T: A5 Terrace****Hydrograph**

Summary for Reach A7T: A7 Terrace

Inflow Area = 24,403 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.15 cfs @ 12.09 hrs, Volume= 11,052 cf
 Outflow = 5.90 cfs @ 12.12 hrs, Volume= 11,052 cf, Atten= 4%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.63 fps, Min. Travel Time= 2.2 min

Avg. Velocity = 1.14 fps, Avg. Travel Time= 6.9 min

Peak Storage= 772 cf @ 12.09 hrs

Average Depth at Peak Storage= 0.55'

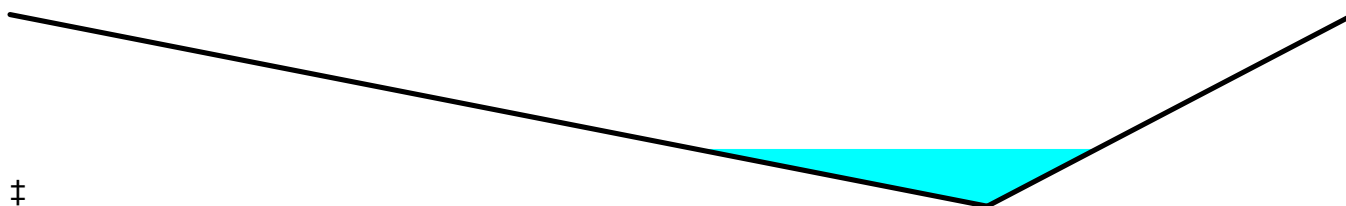
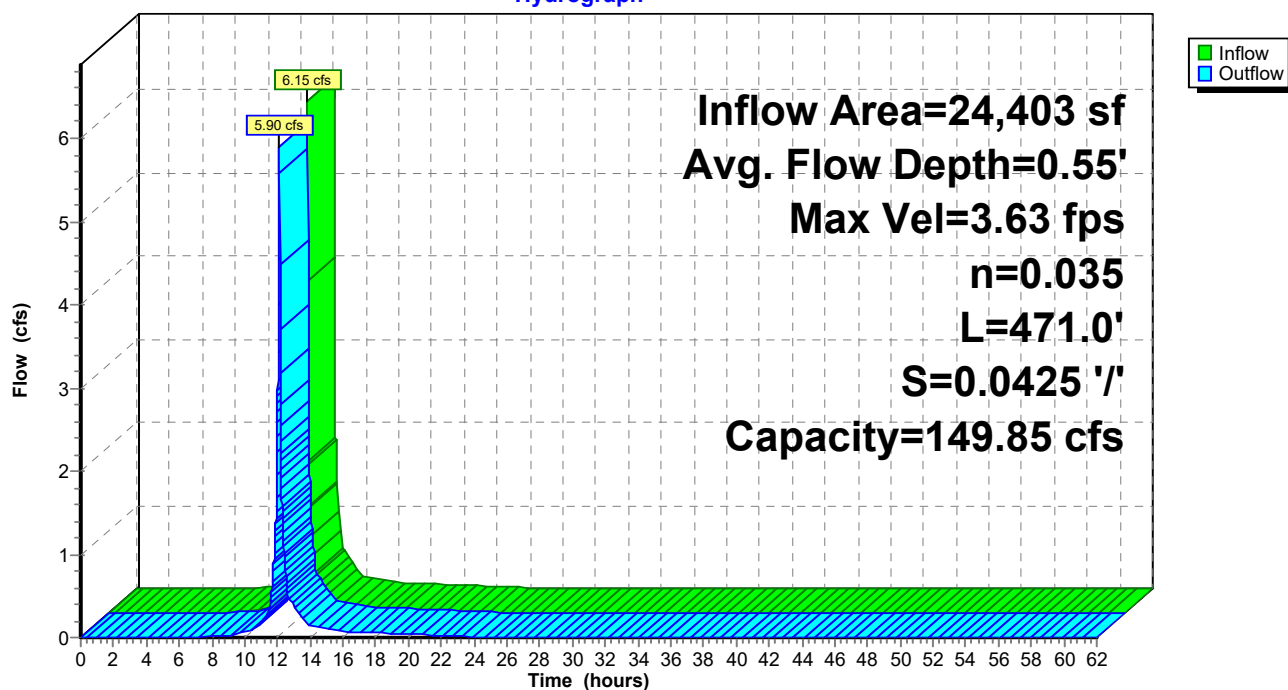
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 149.85 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 471.0' Slope= 0.0425 '/'

Inlet Invert= 920.00', Outlet Invert= 900.00'

**Reach A7T: A7 Terrace****Hydrograph**

Summary for Reach A8T: A8 Terrace

Inflow Area = 26,633 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 5.22 cfs @ 12.16 hrs, Volume= 12,062 cf
 Outflow = 5.14 cfs @ 12.19 hrs, Volume= 12,062 cf, Atten= 1%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.04 fps, Min. Travel Time= 1.1 min

Avg. Velocity= 1.38 fps, Avg. Travel Time= 3.1 min

Peak Storage= 327 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.48'

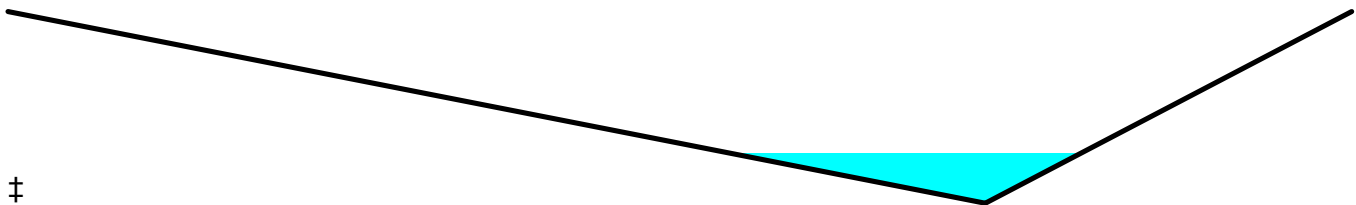
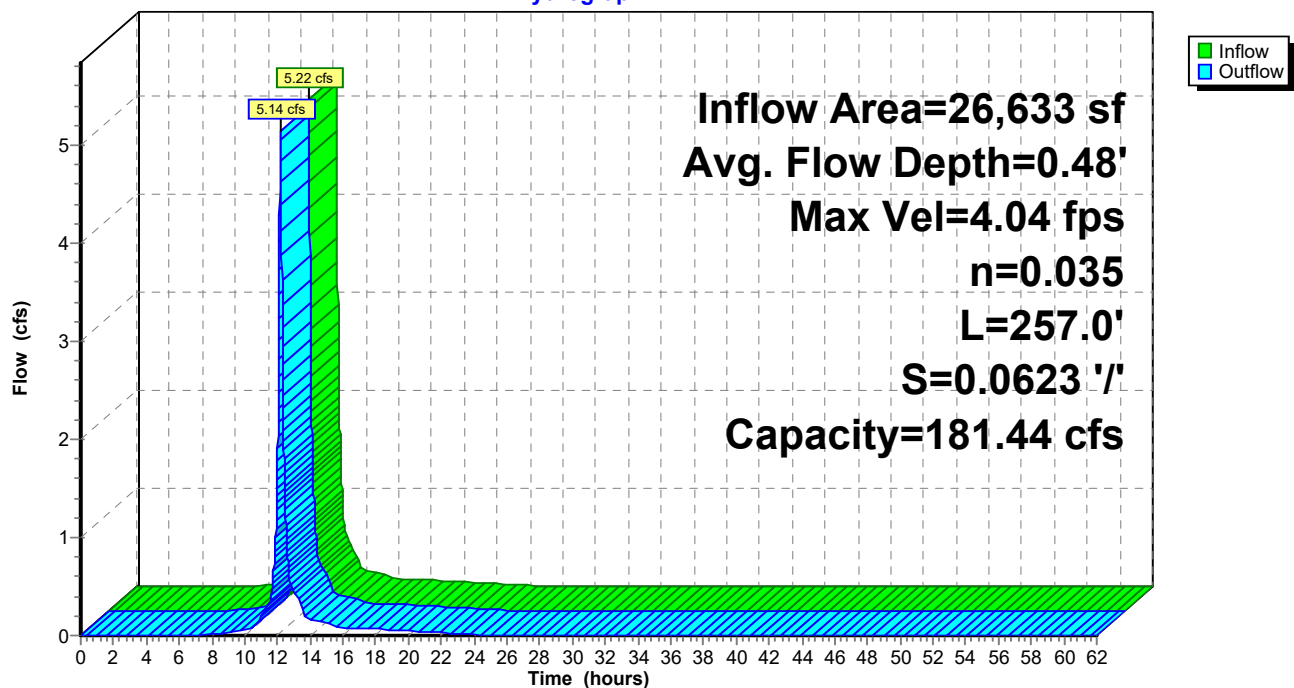
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 181.44 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 257.0' Slope= 0.0623 '/'

Inlet Invert= 916.00', Outlet Invert= 900.00'

**Reach A8T: A8 Terrace****Hydrograph**

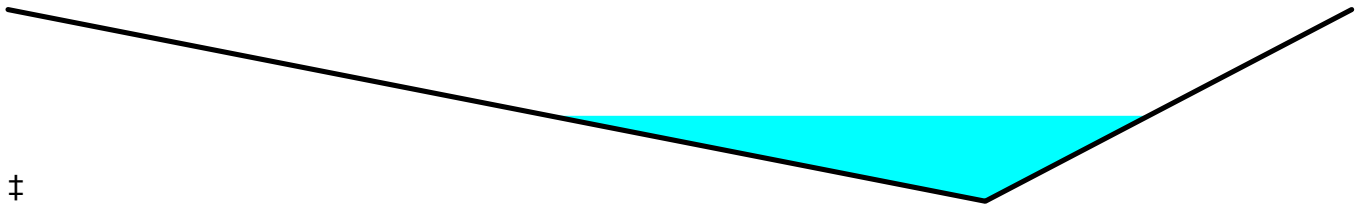
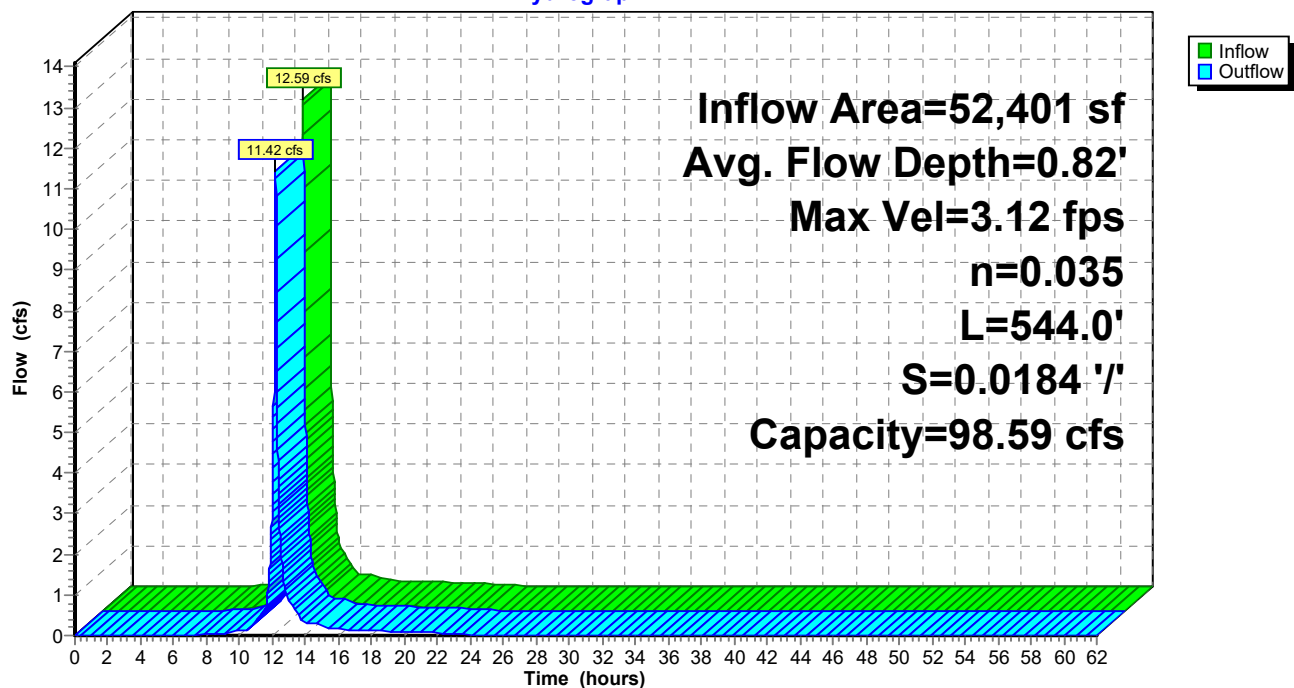
Summary for Reach A9T: A9 Terrace

Inflow Area = 52,401 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 12.59 cfs @ 12.11 hrs, Volume= 23,732 cf
 Outflow = 11.42 cfs @ 12.18 hrs, Volume= 23,732 cf, Atten= 9%, Lag= 4.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.12 fps, Min. Travel Time= 2.9 min
 Avg. Velocity = 0.95 fps, Avg. Travel Time= 9.5 min

Peak Storage= 1,992 cf @ 12.13 hrs
 Average Depth at Peak Storage= 0.82'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 98.59 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 544.0' Slope= 0.0184 '/'
 Inlet Invert= 880.00', Outlet Invert= 870.00'

**Reach A9T: A9 Terrace****Hydrograph**

Summary for Reach AA2T: AA2 Terrace

Inflow Area = 38,957 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 9.63 cfs @ 12.10 hrs, Volume= 17,644 cf
 Outflow = 9.52 cfs @ 12.13 hrs, Volume= 17,644 cf, Atten= 1%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.44 fps, Min. Travel Time= 1.0 min

Avg. Velocity = 1.75 fps, Avg. Travel Time= 3.2 min

Peak Storage= 579 cf @ 12.11 hrs

Average Depth at Peak Storage= 0.56'

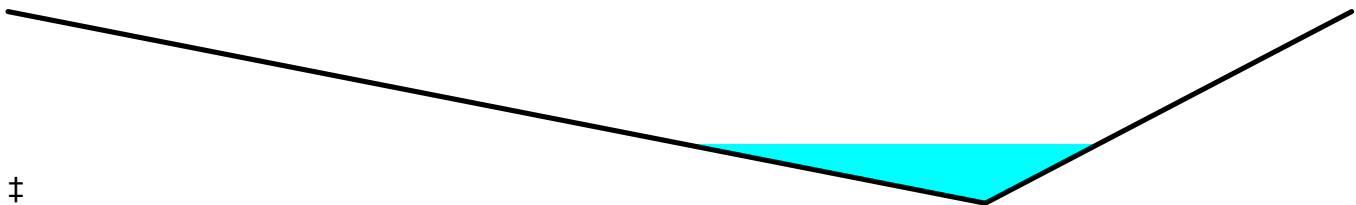
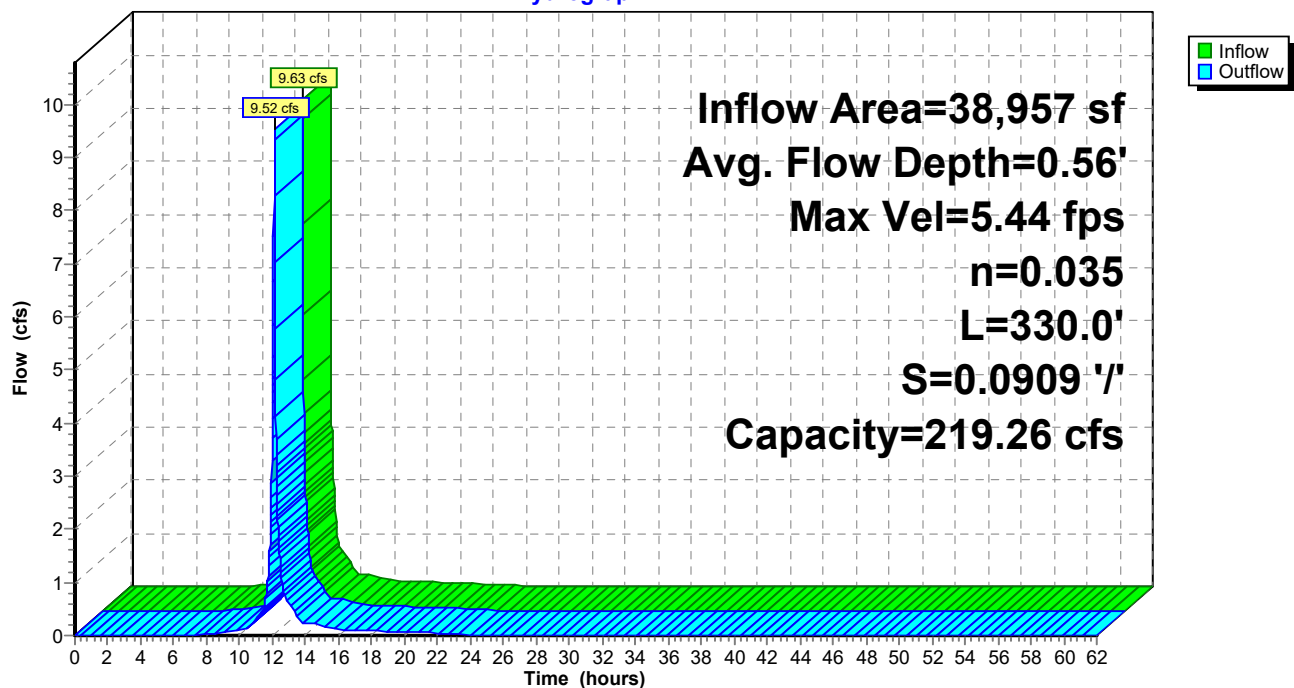
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 219.26 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 330.0' Slope= 0.0909 ' / '

Inlet Invert= 930.00', Outlet Invert= 900.00'

**Reach AA2T: AA2 Terrace****Hydrograph**

Summary for Reach AA4T: AA4 Terrace

Inflow Area = 40,789 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 9.94 cfs @ 12.11 hrs, Volume= 18,473 cf
 Outflow = 9.23 cfs @ 12.17 hrs, Volume= 18,473 cf, Atten= 7%, Lag= 3.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.99 fps, Min. Travel Time= 2.5 min

Avg. Velocity= 1.25 fps, Avg. Travel Time= 7.9 min

Peak Storage= 1,367 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.65'

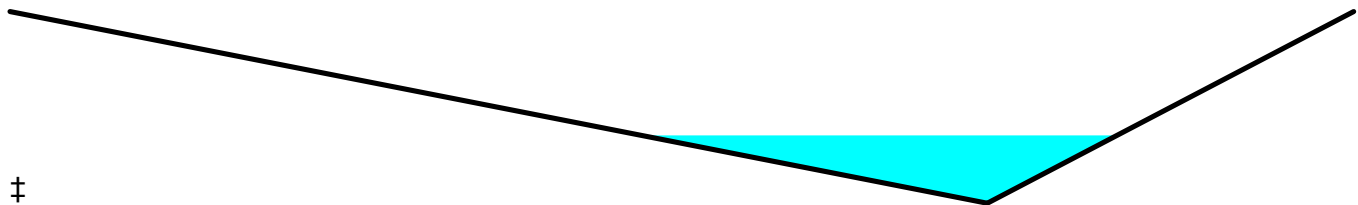
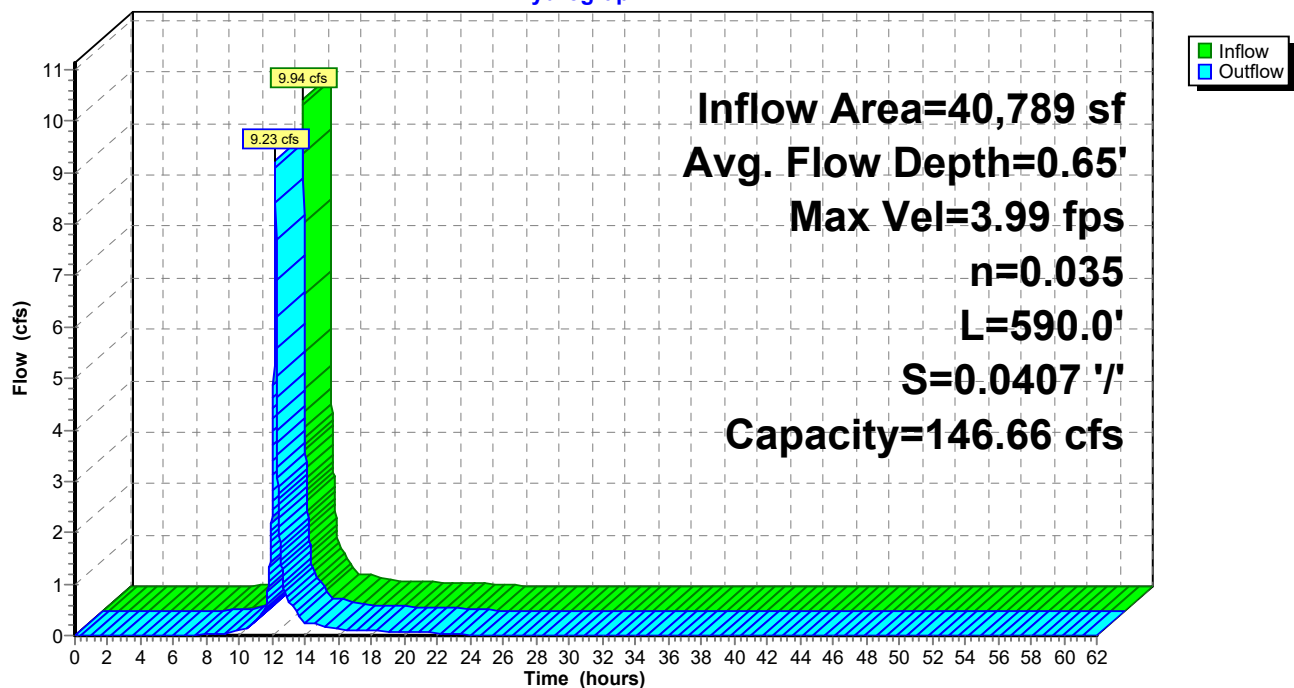
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 146.66 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 590.0' Slope= 0.0407 ' /'

Inlet Invert= 910.00', Outlet Invert= 886.00'

**Reach AA4T: AA4 Terrace****Hydrograph**

Summary for Reach AADS1: AA Downslope 1

[61] Hint: Exceeded Reach AA2T outlet invert by 0.13' @ 12.13 hrs

Inflow Area = 38,957 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 9.52 cfs @ 12.13 hrs, Volume= 17,644 cf
 Outflow = 9.50 cfs @ 12.13 hrs, Volume= 17,644 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 7.74 fps, Min. Travel Time= 0.1 min

Avg. Velocity= 2.42 fps, Avg. Travel Time= 0.2 min

Peak Storage= 39 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.13'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 1,152.39 cfs

9.00' x 2.00' deep channel, n= 0.017

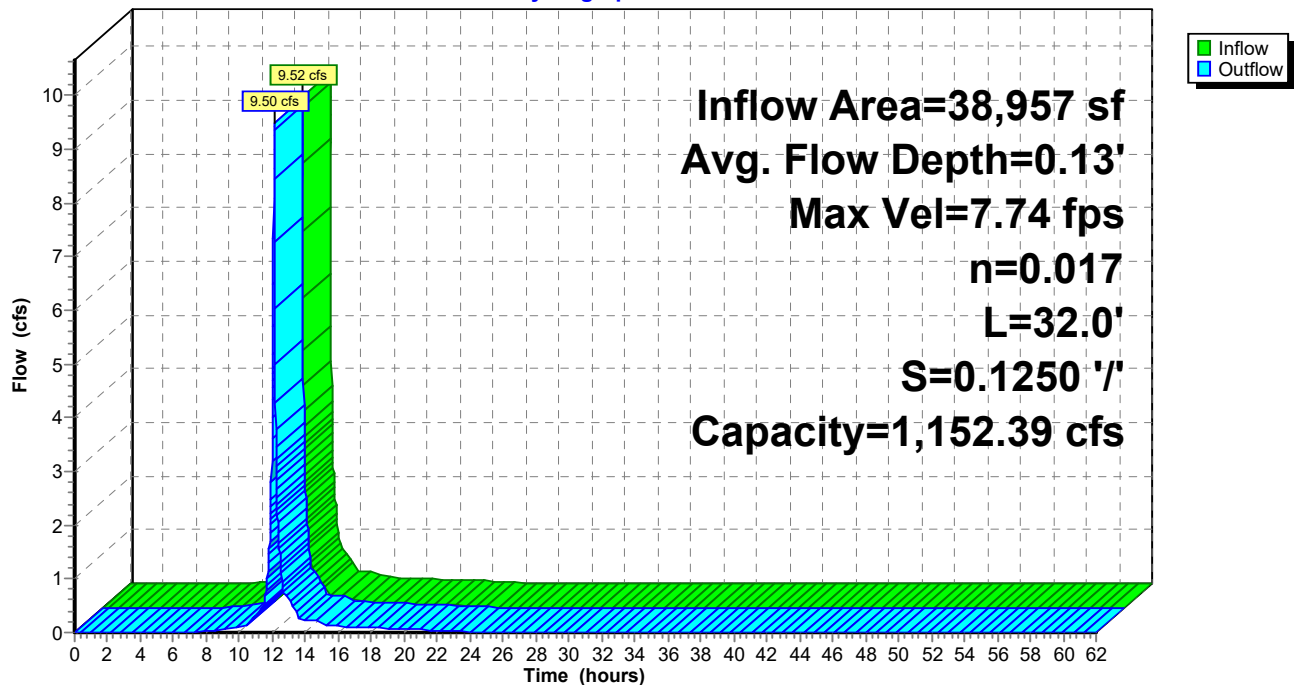
Side Slope Z-value= 3.0 '/' Top Width= 21.00'

Length= 32.0' Slope= 0.1250 '/'

Inlet Invert= 900.00', Outlet Invert= 896.00'

**Reach AADS1: AA Downslope 1**

Hydrograph



Summary for Reach ADS1: A Downslope 1

[61] Hint: Exceeded Reach A1T outlet invert by 0.13' @ 12.42 hrs

[61] Hint: Exceeded Reach A2T outlet invert by 0.13' @ 12.42 hrs

Inflow Area = 71,359 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
Inflow = 6.95 cfs @ 12.42 hrs, Volume= 26,941 cf
Outflow = 6.95 cfs @ 12.43 hrs, Volume= 26,941 cf, Atten= 0%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.48 fps, Min. Travel Time= 0.4 min

Avg. Velocity= 1.85 fps, Avg. Travel Time= 1.1 min

Peak Storage= 152 cf @ 12.42 hrs

Average Depth at Peak Storage= 0.13'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 799.79 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

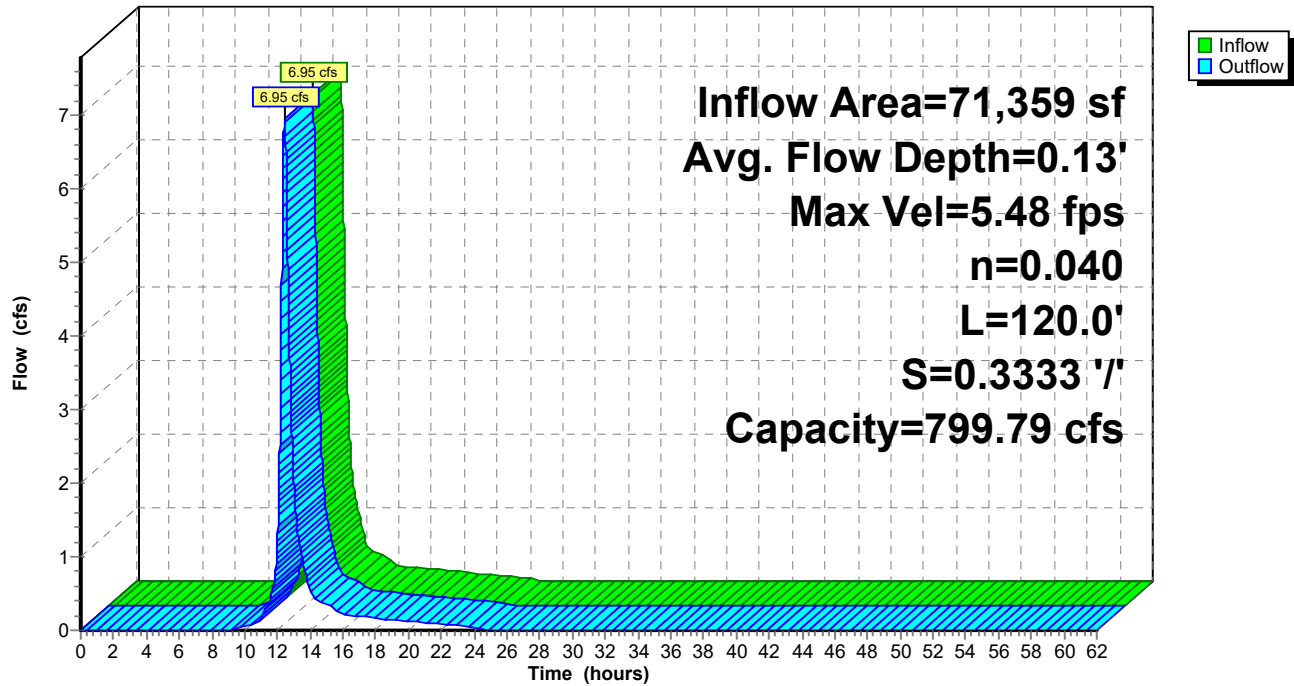
Length= 120.0' Slope= 0.3333 ' '

Inlet Invert= 1,086.00', Outlet Invert= 1,046.00'



Reach ADS1: A Downslope 1

Hydrograph



Summary for Reach ADS2: A Downslope 2

[61] Hint: Exceeded Reach A3T outlet invert by 0.21' @ 12.38 hrs

[61] Hint: Exceeded Reach A4T outlet invert by 0.21' @ 12.38 hrs

[62] Hint: Exceeded Reach ADS1 OUTLET depth by 0.09' @ 12.15 hrs

Inflow Area = 138,521 sf, 0.00% Impervious, Inflow Depth = 4.84" for 100-yr 24-hr event
 Inflow = 14.07 cfs @ 12.37 hrs, Volume= 55,922 cf
 Outflow = 14.06 cfs @ 12.38 hrs, Volume= 55,922 cf, Atten= 0%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 6.94 fps, Min. Travel Time= 0.3 min

Avg. Velocity= 1.98 fps, Avg. Travel Time= 1.2 min

Peak Storage= 292 cf @ 12.38 hrs

Average Depth at Peak Storage= 0.21'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 765.74 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' Top Width= 21.00'

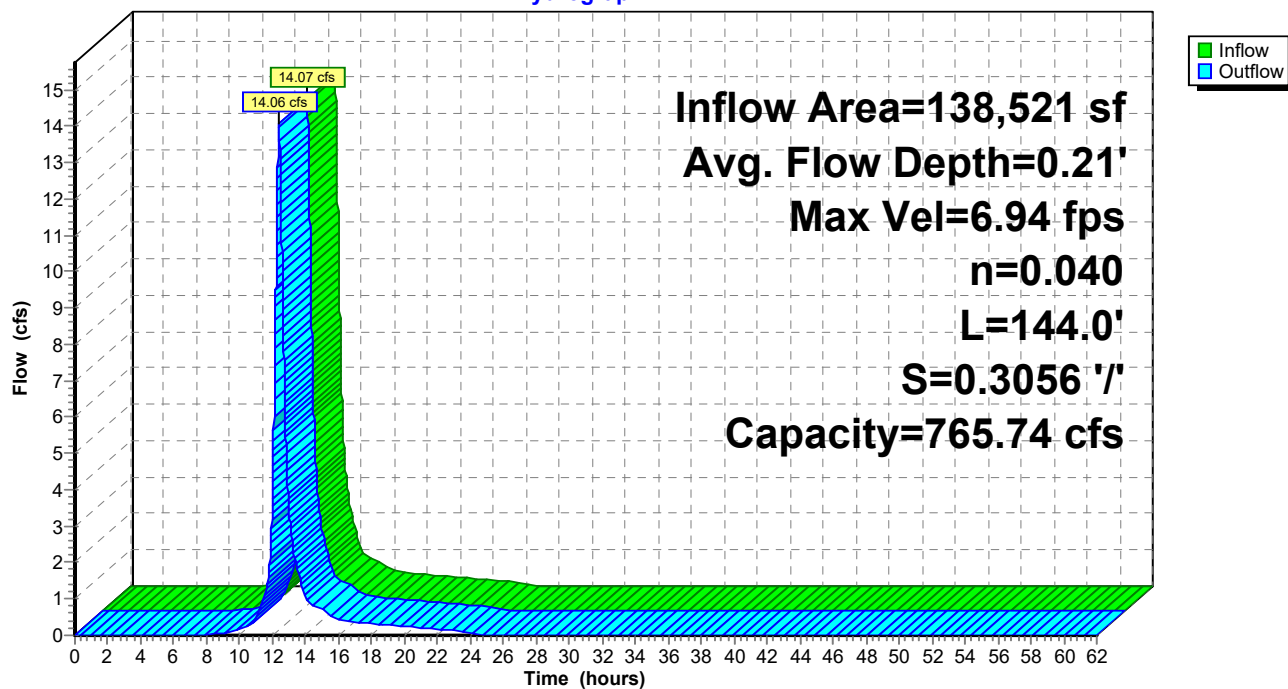
Length= 144.0' Slope= 0.3056 ' '

Inlet Invert= 1,046.00', Outlet Invert= 1,002.00'



Reach ADS2: A Downslope 2

Hydrograph



Summary for Reach ADS3: A Downslope 3

[61] Hint: Exceeded Reach A5T outlet invert by 0.30' @ 12.19 hrs

[61] Hint: Exceeded Reach A6T outlet invert by 0.30' @ 12.19 hrs

[62] Hint: Exceeded Reach ADS2 OUTLET depth by 0.13' @ 12.19 hrs

Inflow Area = 218,144 sf, 0.00% Impervious, Inflow Depth = 5.06" for 100-yr 24-hr event
 Inflow = 23.25 cfs @ 12.18 hrs, Volume= 91,983 cf
 Outflow = 23.15 cfs @ 12.21 hrs, Volume= 91,983 cf, Atten= 0%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 7.78 fps, Min. Travel Time= 0.9 min

Avg. Velocity = 2.08 fps, Avg. Travel Time= 3.3 min

Peak Storage= 1,227 cf @ 12.19 hrs

Average Depth at Peak Storage= 0.30'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 689.26 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

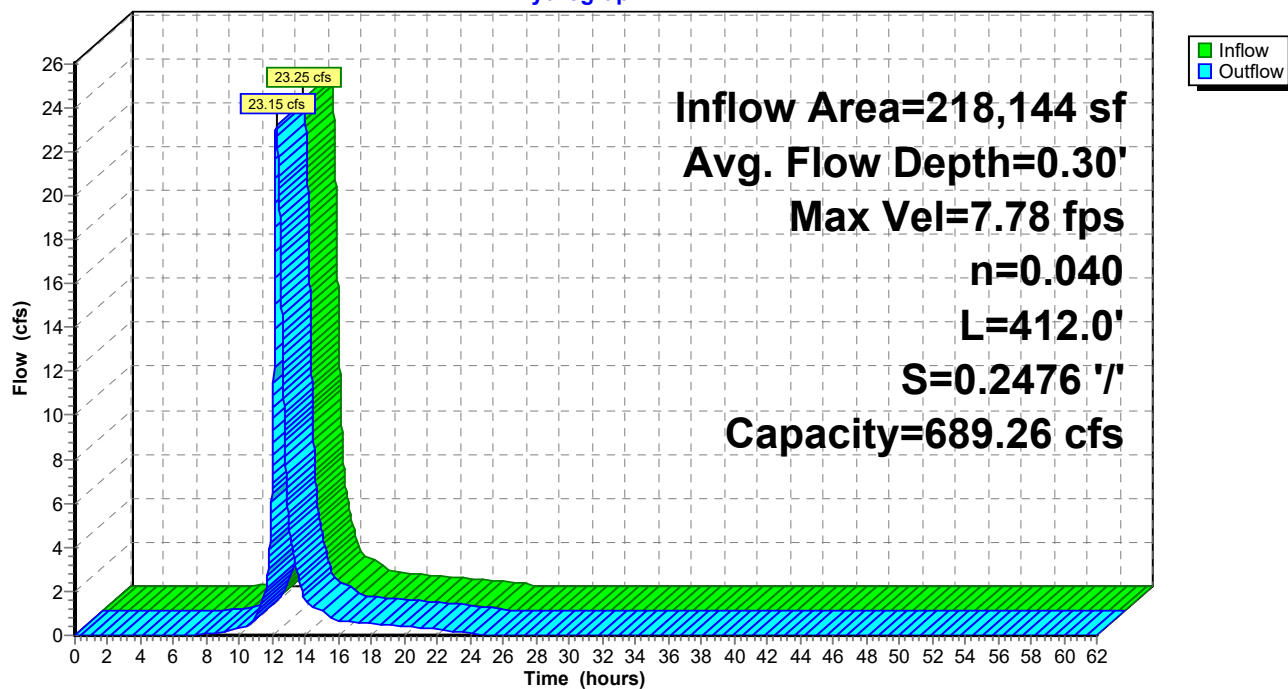
Length= 412.0' Slope= 0.2476 ' '

Inlet Invert= 1,002.00', Outlet Invert= 900.00'



Reach ADS3: A Downslope 3

Hydrograph



Summary for Reach ADS4: A Downslope 4

[62] Hint: Exceeded Reach A7T OUTLET depth by 0.03' @ 12.43 hrs

[61] Hint: Exceeded Reach A8T outlet invert by 0.35' @ 12.20 hrs

[62] Hint: Exceeded Reach ADS3 OUTLET depth by 0.05' @ 12.13 hrs

Inflow Area = 269,180 sf, 0.00% Impervious, Inflow Depth = 5.13" for 100-yr 24-hr event
 Inflow = 30.63 cfs @ 12.19 hrs, Volume= 115,097 cf
 Outflow = 30.59 cfs @ 12.20 hrs, Volume= 115,097 cf, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 8.74 fps, Min. Travel Time= 0.2 min

Avg. Velocity = 2.25 fps, Avg. Travel Time= 0.9 min

Peak Storage= 403 cf @ 12.20 hrs

Average Depth at Peak Storage= 0.35'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 707.53 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' Top Width= 21.00'

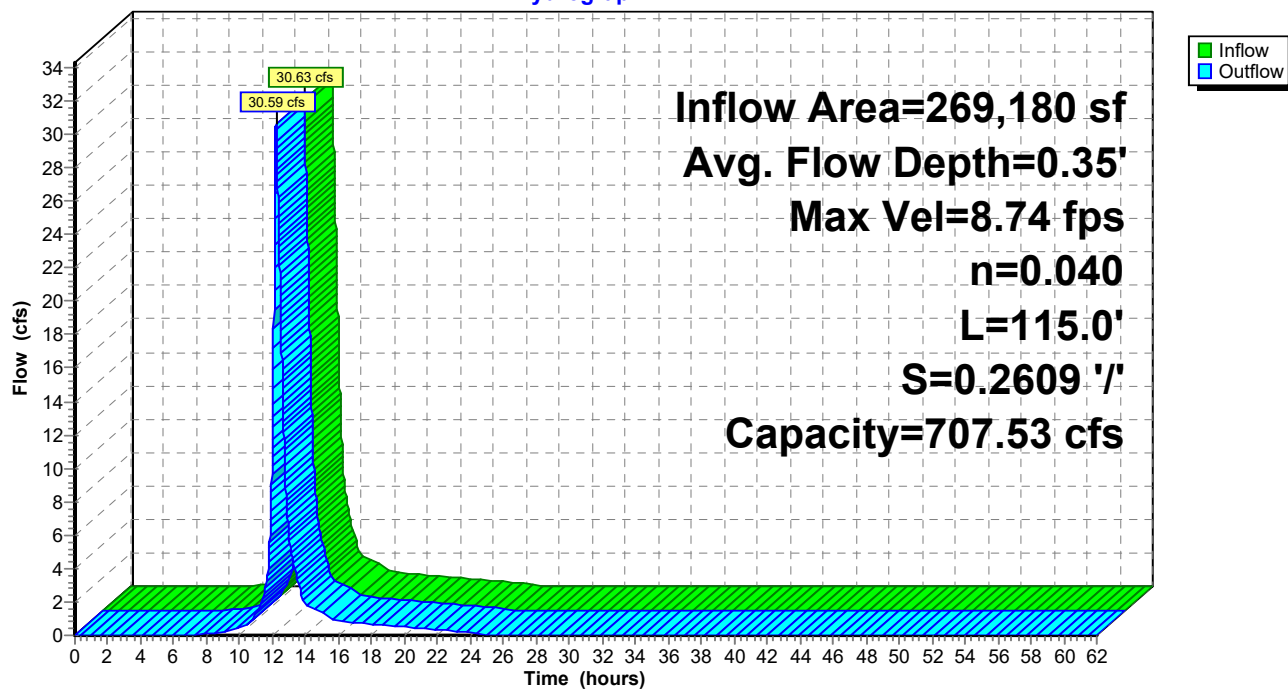
Length= 115.0' Slope= 0.2609 ' '

Inlet Invert= 900.00', Outlet Invert= 870.00'



Reach ADS4: A Downslope 4

Hydrograph



Summary for Reach ADS5: A Downslope 5

[61] Hint: Exceeded Reach A9T outlet invert by 0.48' @ 12.19 hrs

[62] Hint: Exceeded Reach ADS4 OUTLET depth by 0.13' @ 12.19 hrs

Inflow Area = 321,581 sf, 0.00% Impervious, Inflow Depth = 5.18" for 100-yr 24-hr event
 Inflow = 41.71 cfs @ 12.19 hrs, Volume= 138,829 cf
 Outflow = 41.65 cfs @ 12.19 hrs, Volume= 138,829 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 8.32 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.01 fps, Avg. Travel Time= 0.5 min

Peak Storage= 311 cf @ 12.19 hrs

Average Depth at Peak Storage= 0.48'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 556.34 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' Top Width= 21.00'

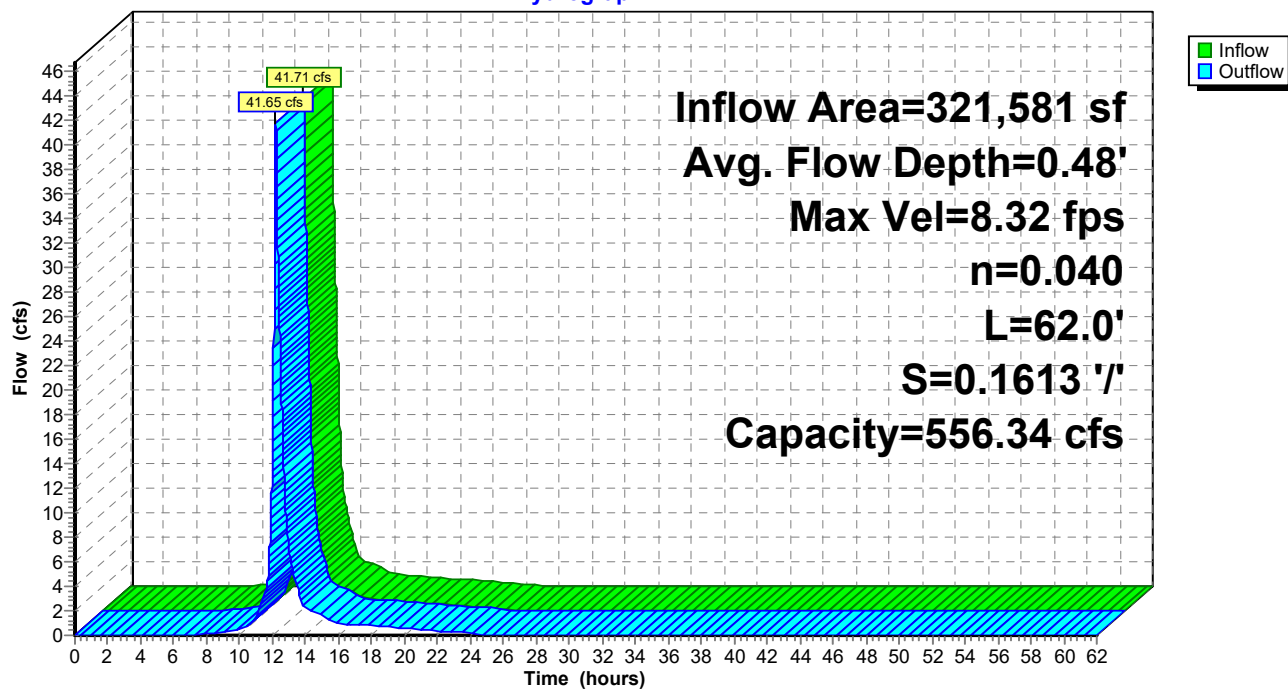
Length= 62.0' Slope= 0.1613 ' /'

Inlet Invert= 870.00', Outlet Invert= 860.00'



Reach ADS5: A Downslope 5

Hydrograph



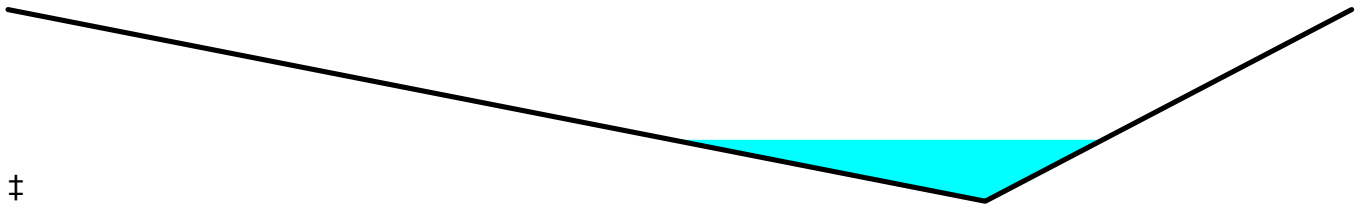
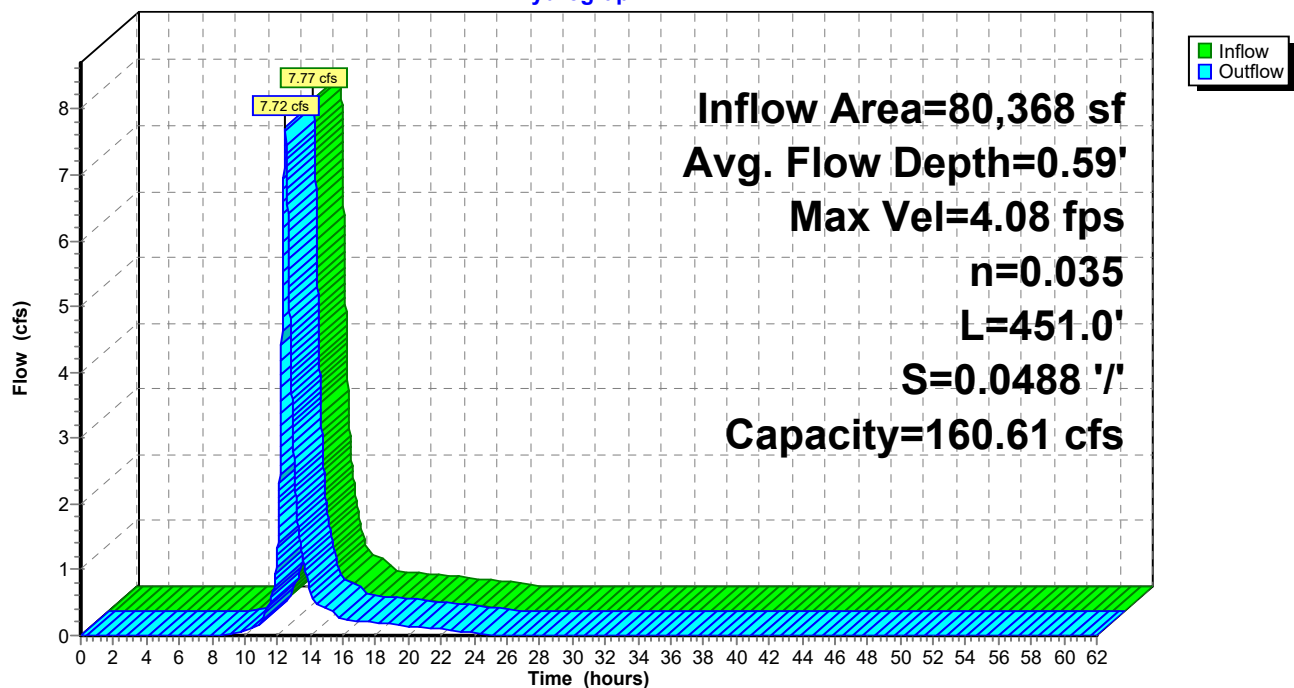
Summary for Reach B1T: B1 Terrace

Inflow Area = 80,368 sf, 0.00% Impervious, Inflow Depth = 4.75" for 100-yr 24-hr event
 Inflow = 7.77 cfs @ 12.41 hrs, Volume= 31,840 cf
 Outflow = 7.72 cfs @ 12.48 hrs, Volume= 31,840 cf, Atten= 1%, Lag= 3.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 4.08 fps, Min. Travel Time= 1.8 min
 Avg. Velocity = 1.57 fps, Avg. Travel Time= 4.8 min

Peak Storage= 853 cf @ 12.45 hrs
 Average Depth at Peak Storage= 0.59'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 160.61 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 451.0' Slope= 0.0488 '/'
 Inlet Invert= 1,080.00', Outlet Invert= 1,058.00'

**Reach B1T: B1 Terrace****Hydrograph**

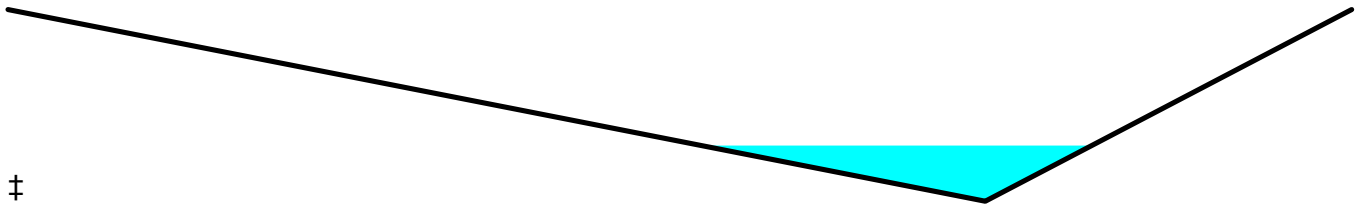
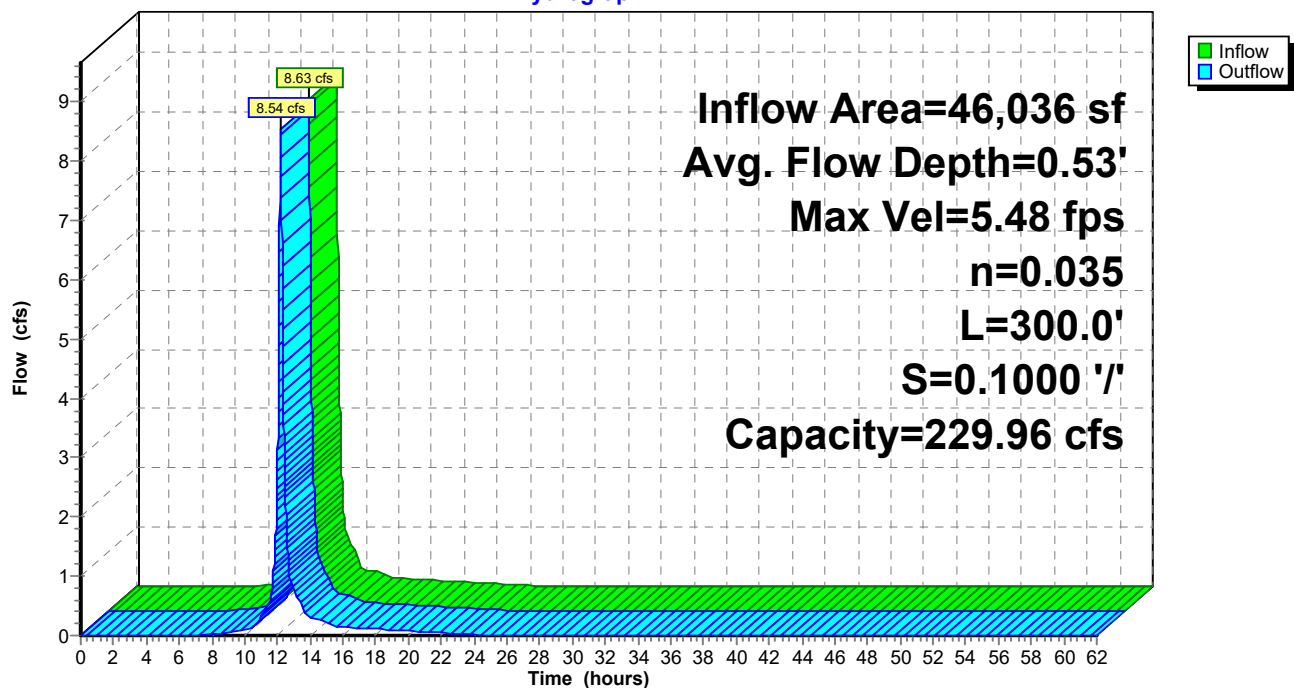
Summary for Reach B3T: B3 Terrace

Inflow Area = 46,036 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 8.63 cfs @ 12.17 hrs, Volume= 20,850 cf
 Outflow = 8.54 cfs @ 12.20 hrs, Volume= 20,850 cf, Atten= 1%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 5.48 fps, Min. Travel Time= 0.9 min
 Avg. Velocity = 1.89 fps, Avg. Travel Time= 2.7 min

Peak Storage= 468 cf @ 12.18 hrs
 Average Depth at Peak Storage= 0.53'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 229.96 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 300.0' Slope= 0.1000 '/'
 Inlet Invert= 1,050.00', Outlet Invert= 1,020.00'

**Reach B3T: B3 Terrace****Hydrograph**

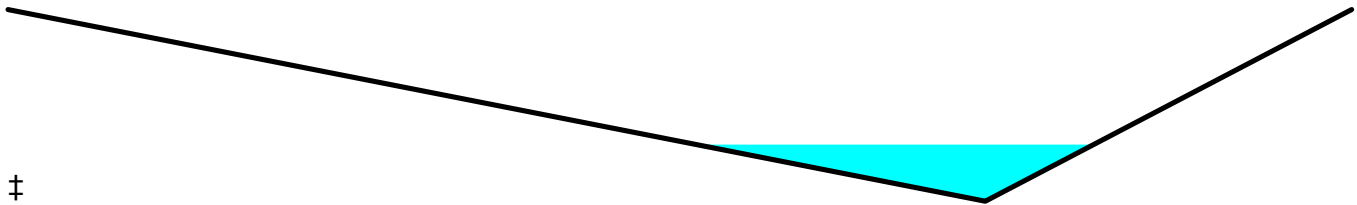
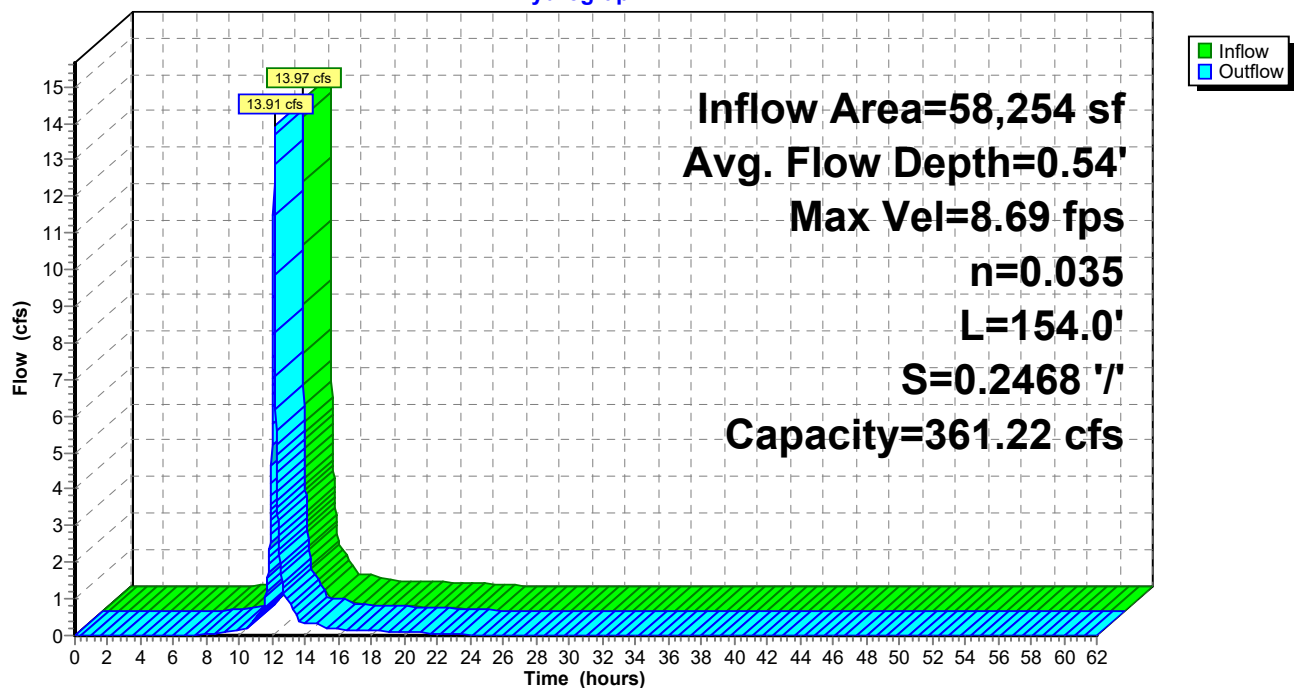
Summary for Reach B5T: B5 Terrace

Inflow Area = 58,254 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 13.97 cfs @ 12.11 hrs, Volume= 26,383 cf
 Outflow = 13.91 cfs @ 12.12 hrs, Volume= 26,383 cf, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 8.69 fps, Min. Travel Time= 0.3 min
 Avg. Velocity = 2.86 fps, Avg. Travel Time= 0.9 min

Peak Storage= 247 cf @ 12.12 hrs
 Average Depth at Peak Storage= 0.54'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 361.22 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 154.0' Slope= 0.2468 '/'
 Inlet Invert= 1,018.00', Outlet Invert= 980.00'

**Reach B5T: B5 Terrace****Hydrograph**

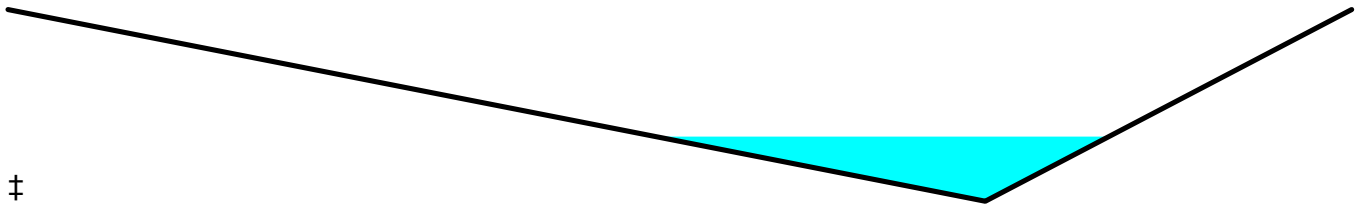
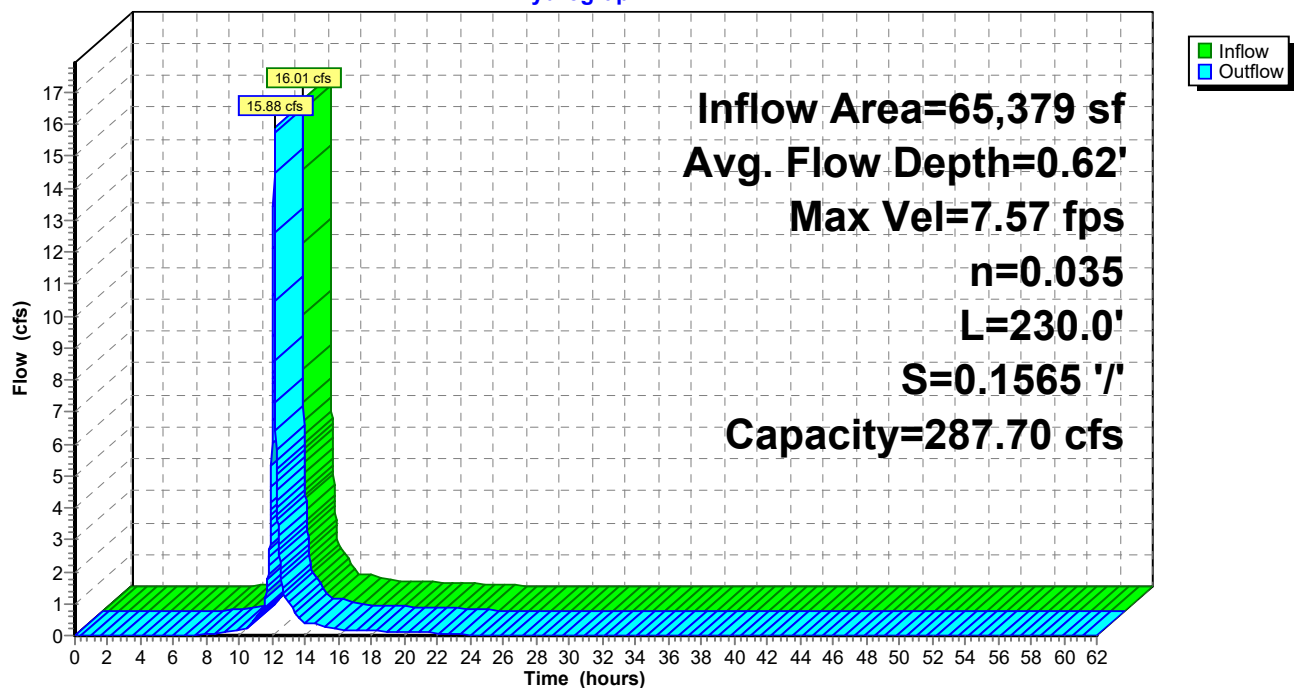
Summary for Reach B7T: B7 Terrace

Inflow Area = 65,379 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 16.01 cfs @ 12.11 hrs, Volume= 29,610 cf
 Outflow = 15.88 cfs @ 12.12 hrs, Volume= 29,610 cf, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 7.57 fps, Min. Travel Time= 0.5 min
 Avg. Velocity = 2.46 fps, Avg. Travel Time= 1.6 min

Peak Storage= 483 cf @ 12.11 hrs
 Average Depth at Peak Storage= 0.62'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 287.70 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 230.0' Slope= 0.1565 '/'
 Inlet Invert= 978.00', Outlet Invert= 942.00'

**Reach B7T: B7 Terrace****Hydrograph**

Summary for Reach B9T: B9 Terrace

[63] Warning: Exceeded Reach BB3T INLET depth by 0.71' @ 12.33 hrs

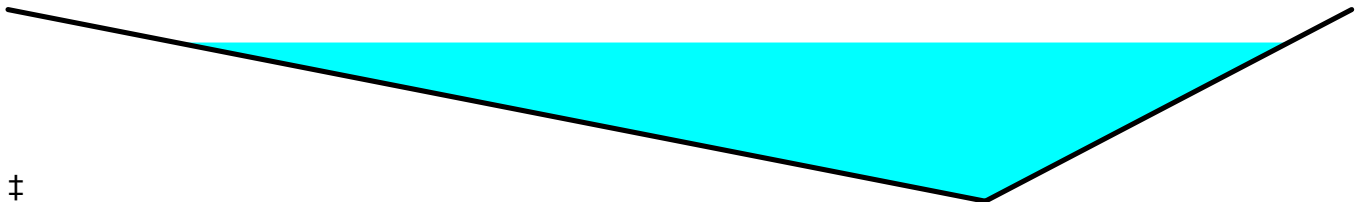
[62] Hint: Exceeded Reach BBDS1 OUTLET depth by 1.79' @ 12.24 hrs

Inflow Area = 268,612 sf, 0.00% Impervious, Inflow Depth = 5.36" for 100-yr 24-hr event
 Inflow = 41.74 cfs @ 12.18 hrs, Volume= 120,000 cf
 Outflow = 39.16 cfs @ 12.29 hrs, Volume= 120,000 cf, Atten= 6%, Lag= 6.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 1.96 fps, Min. Travel Time= 3.6 min
 Avg. Velocity = 0.55 fps, Avg. Travel Time= 13.0 min

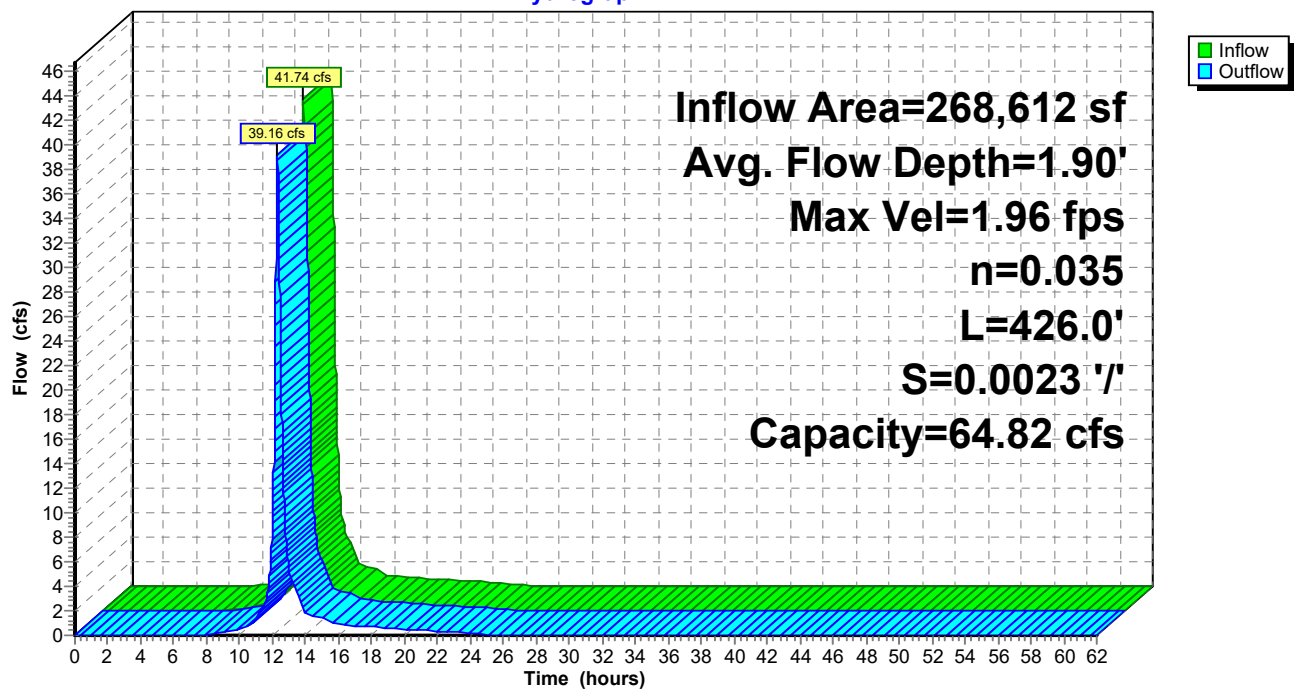
Peak Storage= 8,494 cf @ 12.23 hrs
 Average Depth at Peak Storage= 1.90'
 Bank-Full Depth= 2.30' Flow Area= 29.1 sf, Capacity= 64.82 cfs

0.00' x 2.30' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 25.30'
 Length= 426.0' Slope= 0.0023 '/'
 Inlet Invert= 908.00', Outlet Invert= 907.00'



Reach B9T: B9 Terrace

Hydrograph



Summary for Reach BB1T: BB1 Terrace

Inflow Area = 36,136 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 7.82 cfs @ 12.14 hrs, Volume= 16,366 cf
 Outflow = 7.44 cfs @ 12.19 hrs, Volume= 16,366 cf, Atten= 5%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.40 fps, Min. Travel Time= 1.9 min

Avg. Velocity = 1.10 fps, Avg. Travel Time= 5.9 min

Peak Storage= 860 cf @ 12.16 hrs

Average Depth at Peak Storage= 0.63'

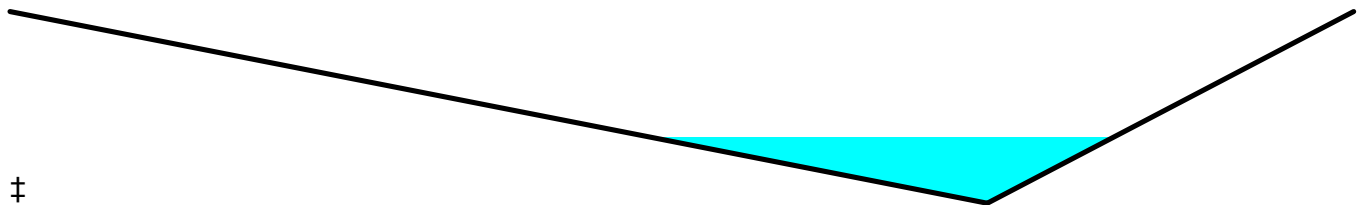
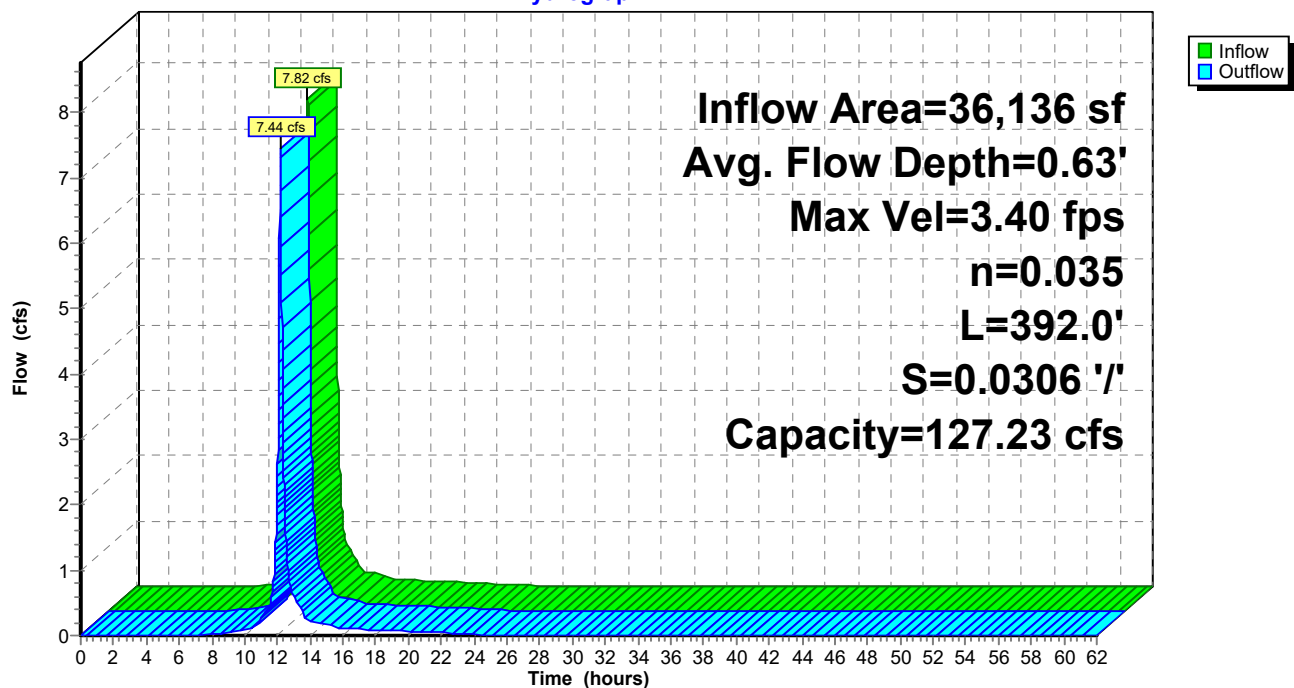
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 127.23 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 392.0' Slope= 0.0306 '/'

Inlet Invert= 950.00', Outlet Invert= 938.00'

**Reach BB1T: BB1 Terrace****Hydrograph**

Summary for Reach BB3T: BB3 Terrace

[62] Hint: Exceeded Reach BBBDS2 OUTLET depth by 4.99' @ 12.19 hrs

Inflow Area = 141,315 sf, 0.00% Impervious, Inflow Depth = 5.29" for 100-yr 24-hr event
 Inflow = 24.01 cfs @ 12.15 hrs, Volume= 62,348 cf
 Outflow = 22.38 cfs @ 12.24 hrs, Volume= 62,348 cf, Atten= 7%, Lag= 5.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 2.73 fps, Min. Travel Time= 3.0 min

Avg. Velocity= 0.82 fps, Avg. Travel Time= 10.0 min

Peak Storage= 4,001 cf @ 12.19 hrs

Average Depth at Peak Storage= 1.22'

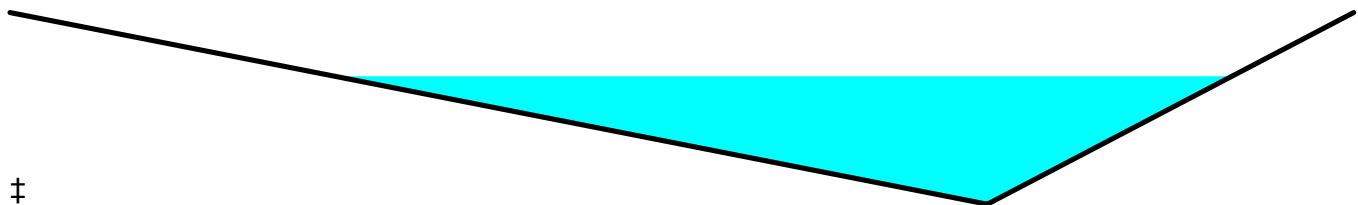
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 65.84 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' / ' Top Width= 20.13'

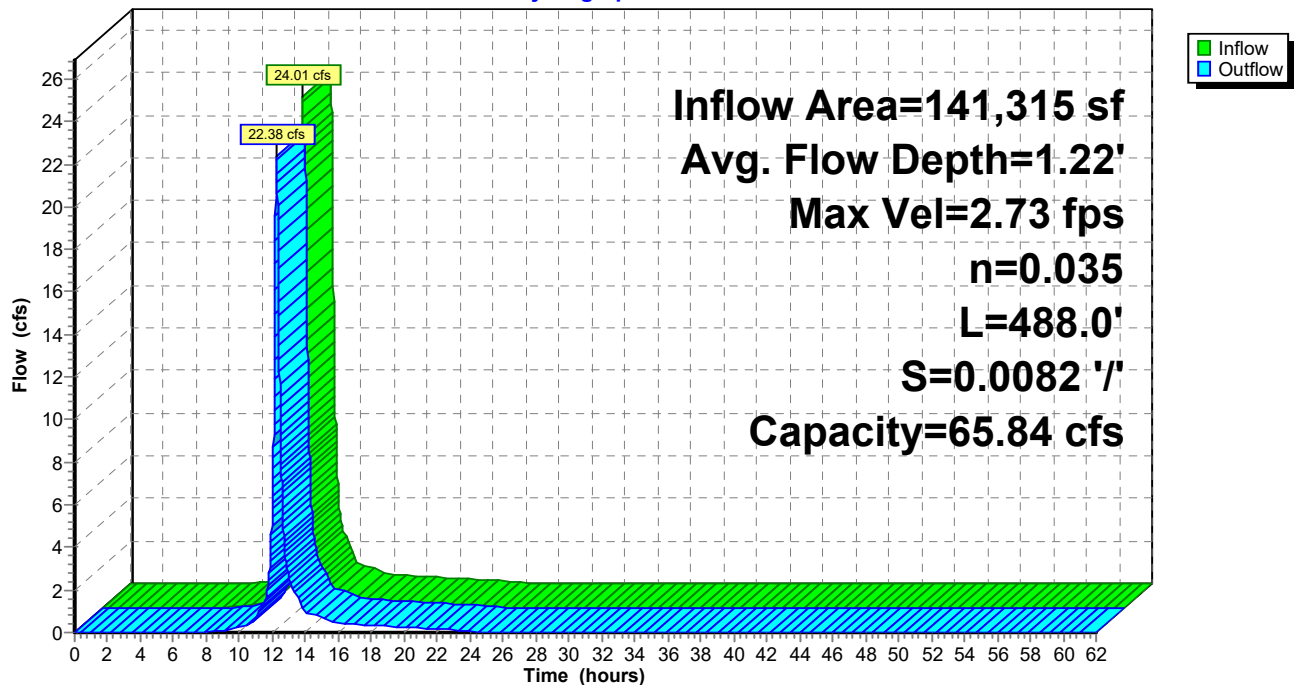
Length= 488.0' Slope= 0.0082 ' / '

Inlet Invert= 908.00', Outlet Invert= 904.00'



Reach BB3T: BB3 Terrace

Hydrograph



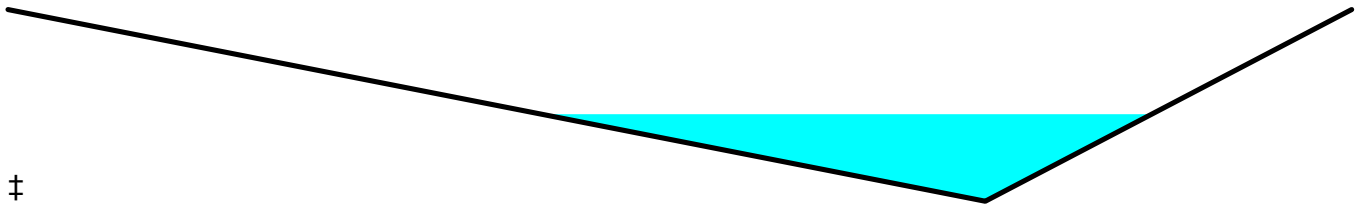
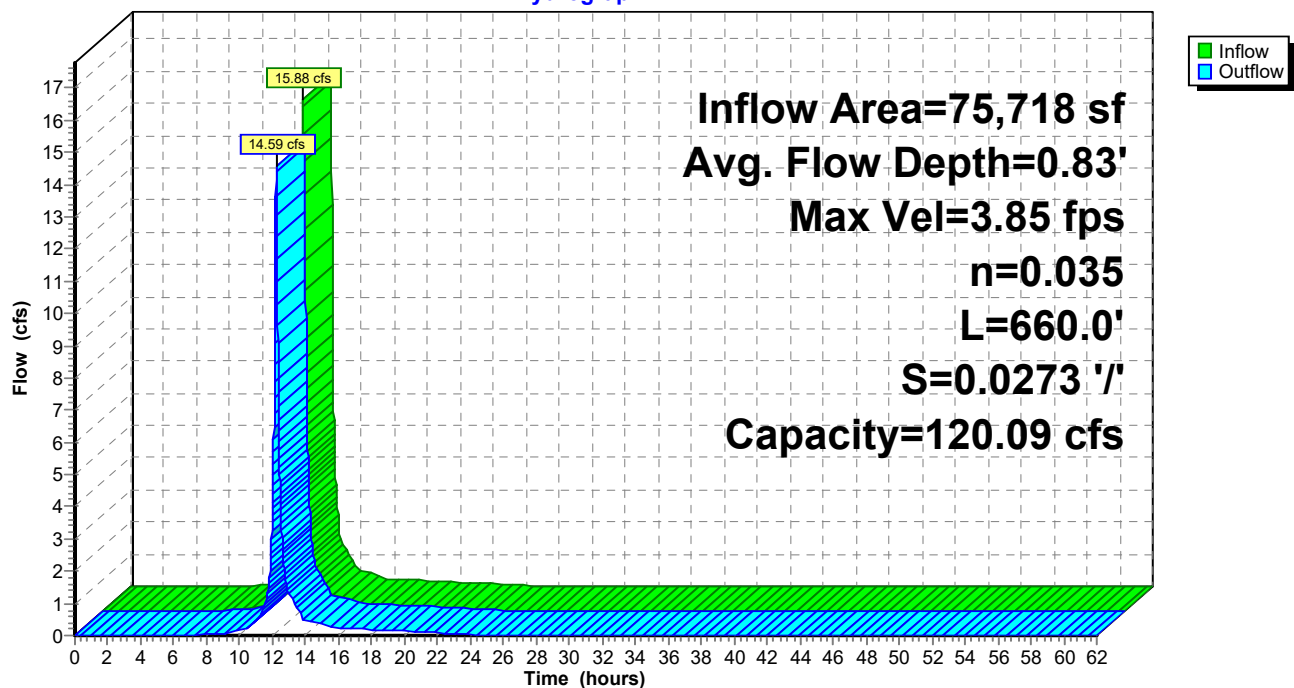
Summary for Reach BBB1T: BBB1 Terrace

Inflow Area = 75,718 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 15.88 cfs @ 12.14 hrs, Volume= 34,292 cf
 Outflow = 14.59 cfs @ 12.22 hrs, Volume= 34,292 cf, Atten= 8%, Lag= 4.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.85 fps, Min. Travel Time= 2.9 min
 Avg. Velocity = 1.20 fps, Avg. Travel Time= 9.1 min

Peak Storage= 2,505 cf @ 12.17 hrs
 Average Depth at Peak Storage= 0.83'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 120.09 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 660.0' Slope= 0.0273 '/'
 Inlet Invert= 968.00', Outlet Invert= 950.00'

**Reach BBB1T: BBB1 Terrace****Hydrograph**

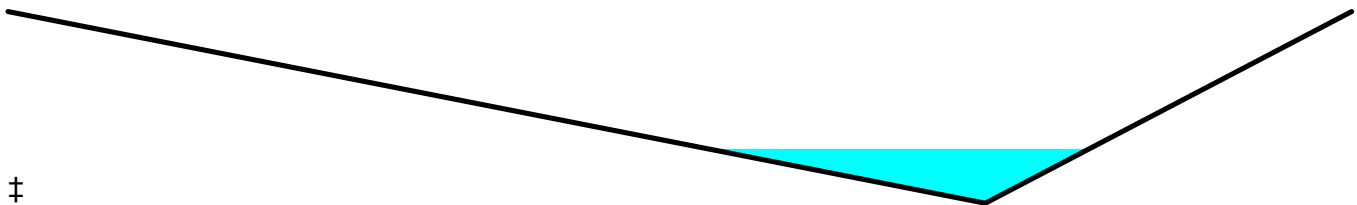
Summary for Reach BBB3T: BBB3 Terrace

Inflow Area = 22,009 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 5.47 cfs @ 12.10 hrs, Volume= 9,968 cf
 Outflow = 5.30 cfs @ 12.14 hrs, Volume= 9,968 cf, Atten= 3%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.57 fps, Min. Travel Time= 1.7 min
 Avg. Velocity = 1.14 fps, Avg. Travel Time= 5.4 min

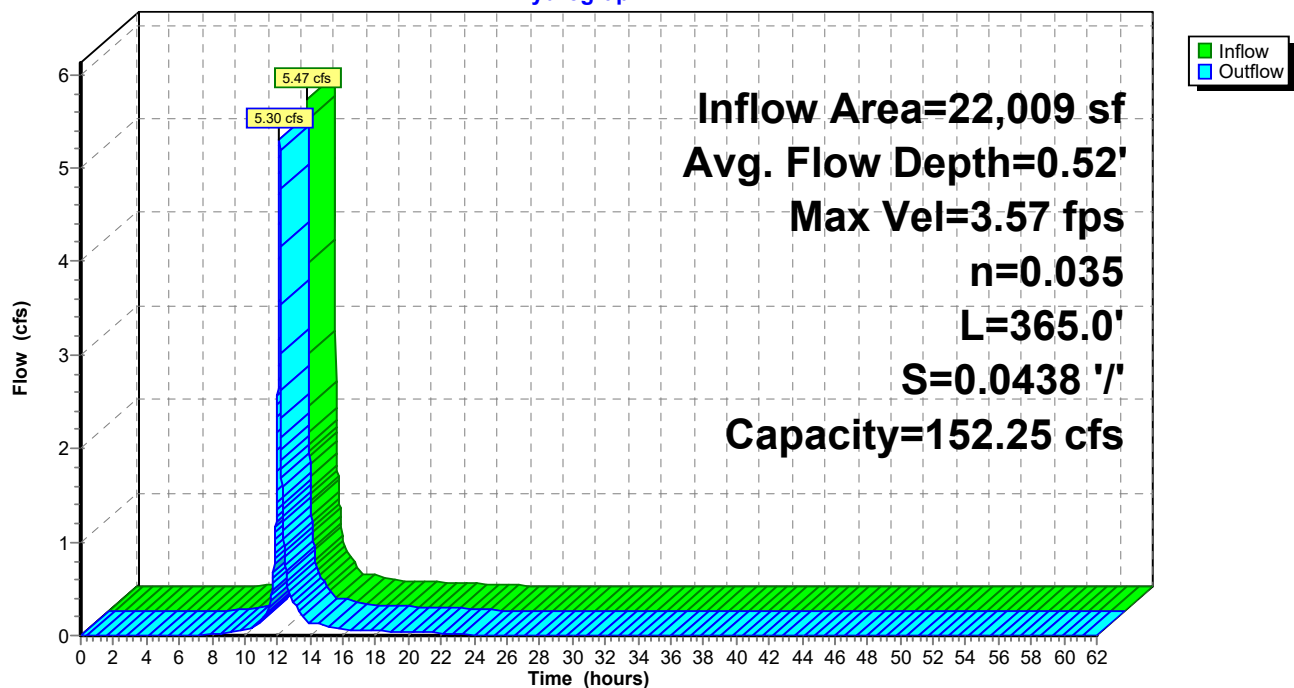
Peak Storage= 542 cf @ 12.11 hrs
 Average Depth at Peak Storage= 0.52'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 152.25 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 365.0' Slope= 0.0438 '/'
 Inlet Invert= 934.00', Outlet Invert= 918.00'



Reach BBB3T: BBB3 Terrace

Hydrograph



Summary for Reach BBBDS1: BBB Downslope 1

[61] Hint: Exceeded Reach BBB1T outlet invert by 0.18' @ 12.22 hrs

Inflow Area = 75,718 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 14.59 cfs @ 12.22 hrs, Volume= 34,292 cf
 Outflow = 14.57 cfs @ 12.22 hrs, Volume= 34,292 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 8.38 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.27 fps, Avg. Travel Time= 0.4 min

Peak Storage= 104 cf @ 12.22 hrs

Average Depth at Peak Storage= 0.18'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 1,011.66 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

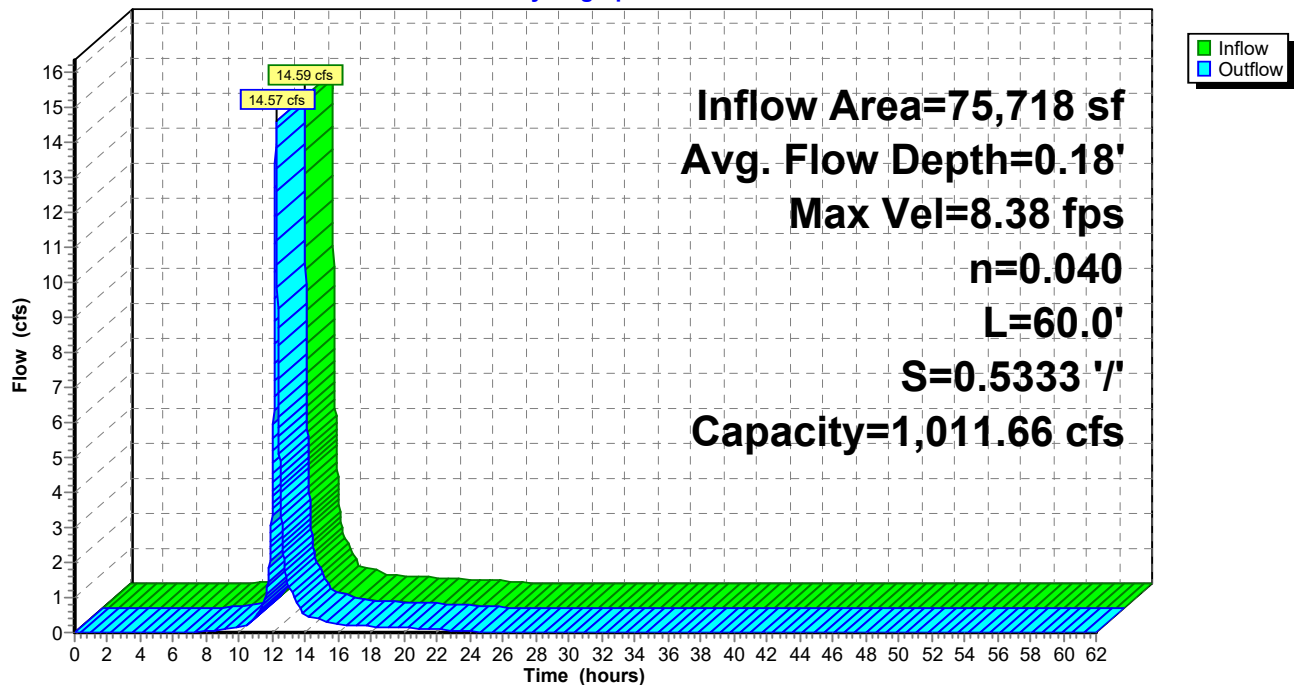
Length= 60.0' Slope= 0.5333 '/'

Inlet Invert= 950.00', Outlet Invert= 918.00'



Reach BBBDS1: BBB Downslope 1

Hydrograph



Summary for Reach BBBDS2: BBB Downslope 2

[61] Hint: Exceeded Reach BBB3T outlet invert by 0.23' @ 12.22 hrs

[62] Hint: Exceeded Reach BBBDS1 OUTLET depth by 0.07' @ 12.14 hrs

Inflow Area = 97,727 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
Inflow = 16.71 cfs @ 12.21 hrs, Volume= 44,260 cf
Outflow = 16.70 cfs @ 12.22 hrs, Volume= 44,260 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 7.43 fps, Min. Travel Time= 0.1 min

Avg. Velocity= 1.87 fps, Avg. Travel Time= 0.4 min

Peak Storage= 101 cf @ 12.22 hrs

Average Depth at Peak Storage= 0.23'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 772.67 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

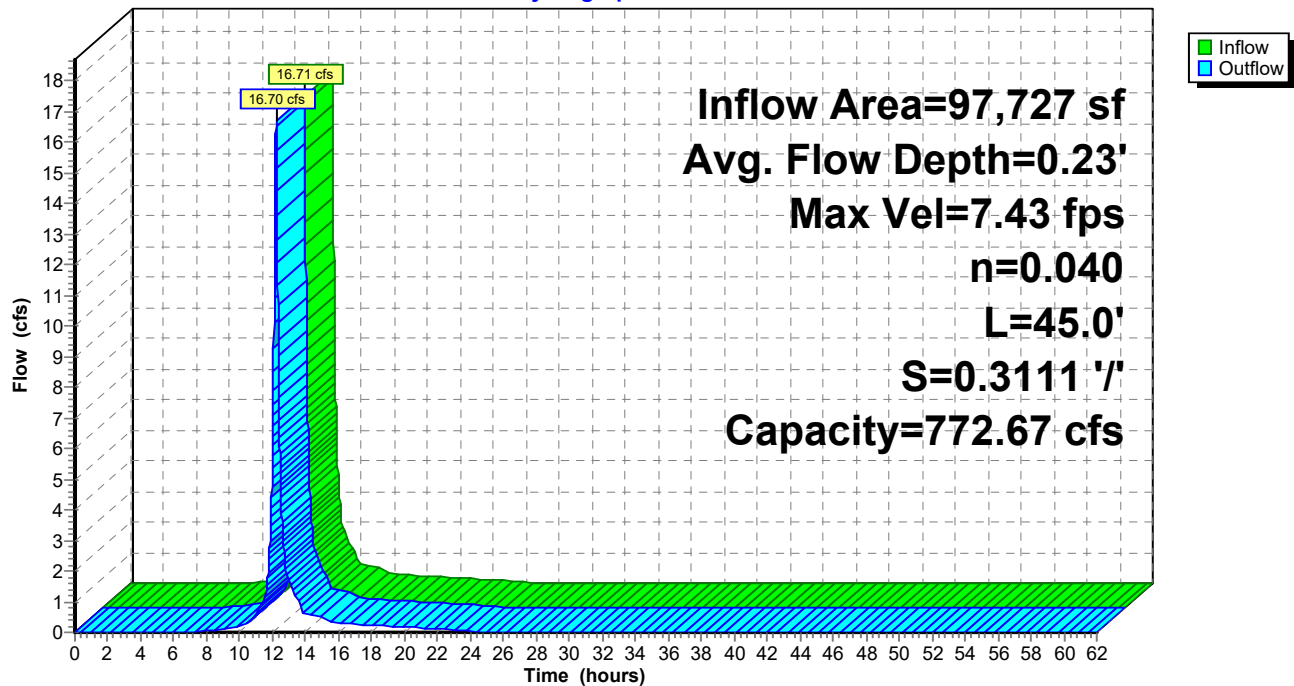
Length= 45.0' Slope= 0.3111 '/'

Inlet Invert= 918.00', Outlet Invert= 904.00'



Reach BBBDS2: BBB Downslope 2

Hydrograph



Summary for Reach BBDS1: BB Downslope 1

[61] Hint: Exceeded Reach BB1T outlet invert by 0.13' @ 12.19 hrs

Inflow Area = 36,136 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 7.44 cfs @ 12.19 hrs, Volume= 16,366 cf
 Outflow = 7.42 cfs @ 12.19 hrs, Volume= 16,366 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 6.31 fps, Min. Travel Time= 0.2 min

Avg. Velocity = 2.04 fps, Avg. Travel Time= 0.5 min

Peak Storage= 73 cf @ 12.19 hrs

Average Depth at Peak Storage= 0.13'

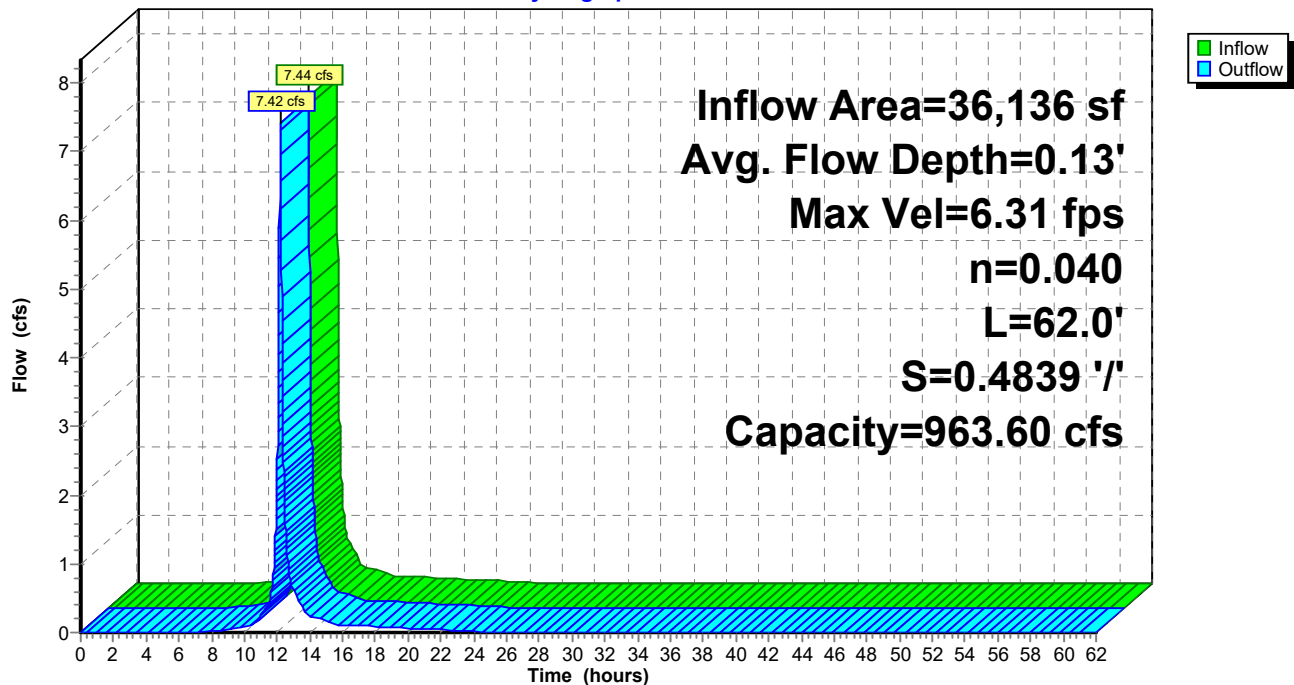
Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 963.60 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

Length= 62.0' Slope= 0.4839 '/'

Inlet Invert= 938.00', Outlet Invert= 908.00'

**Reach BBDS1: BB Downslope 1****Hydrograph**

Summary for Reach BDS1: B Downslope 1

[61] Hint: Exceeded Reach B1T outlet invert by 0.14' @ 12.48 hrs

Inflow Area = 80,368 sf, 0.00% Impervious, Inflow Depth = 4.75" for 100-yr 24-hr event
 Inflow = 7.72 cfs @ 12.48 hrs, Volume= 31,840 cf
 Outflow = 7.72 cfs @ 12.49 hrs, Volume= 31,840 cf, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.94 fps, Min. Travel Time= 0.3 min

Avg. Velocity= 1.92 fps, Avg. Travel Time= 0.9 min

Peak Storage= 130 cf @ 12.48 hrs

Average Depth at Peak Storage= 0.14'

Bank-Full Depth= 1.83' Flow Area= 26.5 sf, Capacity= 719.18 cfs

9.00' x 1.83' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 19.98'

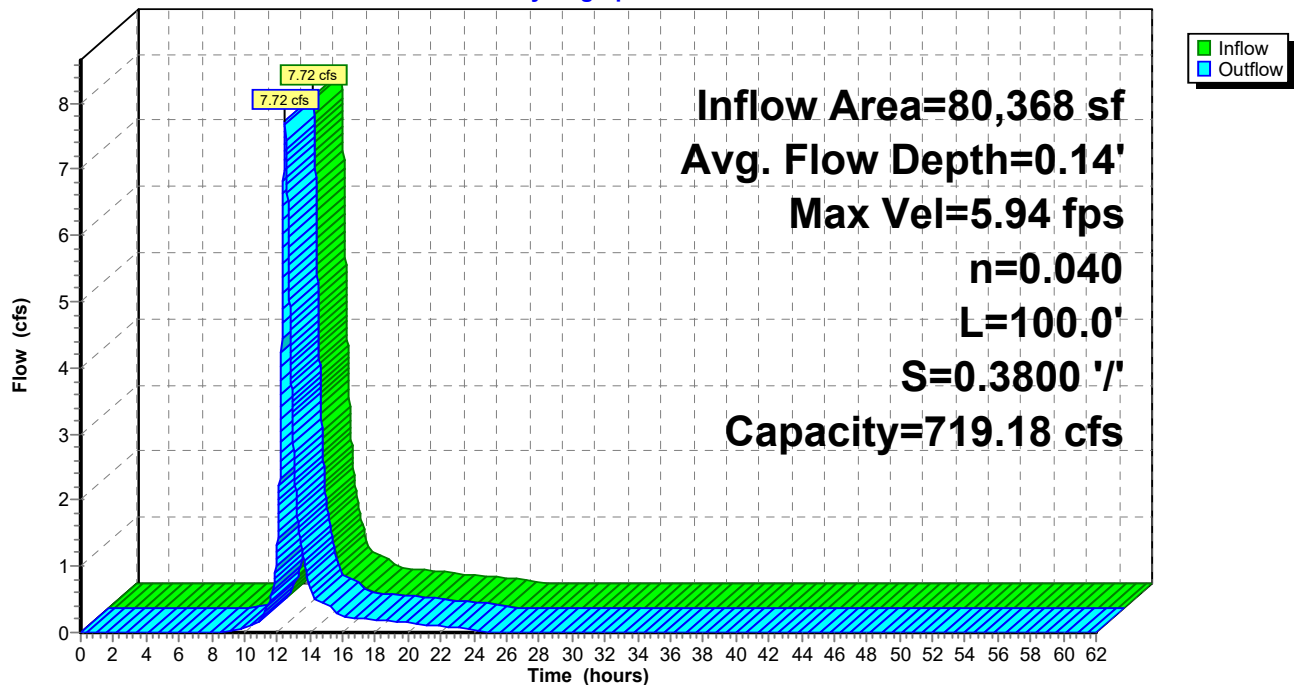
Length= 100.0' Slope= 0.3800 '/'

Inlet Invert= 1,058.00', Outlet Invert= 1,020.00'



Reach BDS1: B Downslope 1

Hydrograph



Summary for Reach BDS2: B Downslope 2

[61] Hint: Exceeded Reach B3T outlet invert by 0.16' @ 12.22 hrs

[62] Hint: Exceeded Reach BDS1 OUTLET depth by 0.08' @ 12.19 hrs

Inflow Area = 126,404 sf, 0.00% Impervious, Inflow Depth = 5.00" for 100-yr 24-hr event
 Inflow = 11.73 cfs @ 12.22 hrs, Volume= 52,690 cf
 Outflow = 11.72 cfs @ 12.22 hrs, Volume= 52,690 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 7.72 fps, Min. Travel Time= 0.2 min

Avg. Velocity = 2.44 fps, Avg. Travel Time= 0.5 min

Peak Storage= 114 cf @ 12.22 hrs

Average Depth at Peak Storage= 0.16'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 1,011.66 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

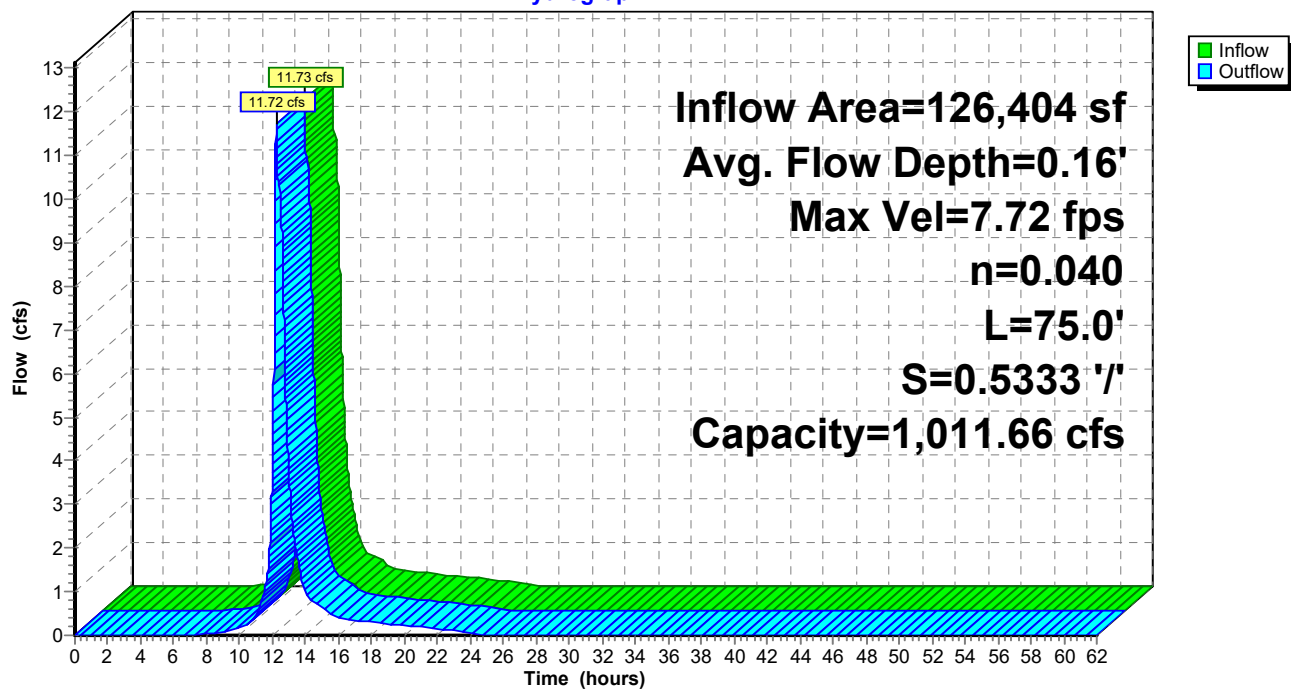
Length= 75.0' Slope= 0.5333 ' '

Inlet Invert= 1,020.00', Outlet Invert= 980.00'



Reach BDS2: B Downslope 2

Hydrograph



Summary for Reach BDS3: B Downslope 3

[61] Hint: Exceeded Reach B5T outlet invert by 0.24' @ 12.13 hrs

[62] Hint: Exceeded Reach BDS2 OUTLET depth by 0.11' @ 12.11 hrs

Inflow Area = 184,658 sf, 0.00% Impervious, Inflow Depth = 5.14" for 100-yr 24-hr event
Inflow = 22.04 cfs @ 12.13 hrs, Volume= 79,073 cf
Outflow = 21.97 cfs @ 12.13 hrs, Volume= 79,073 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 9.40 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.54 fps, Avg. Travel Time= 0.5 min

Peak Storage= 187 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.24'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 954.73 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

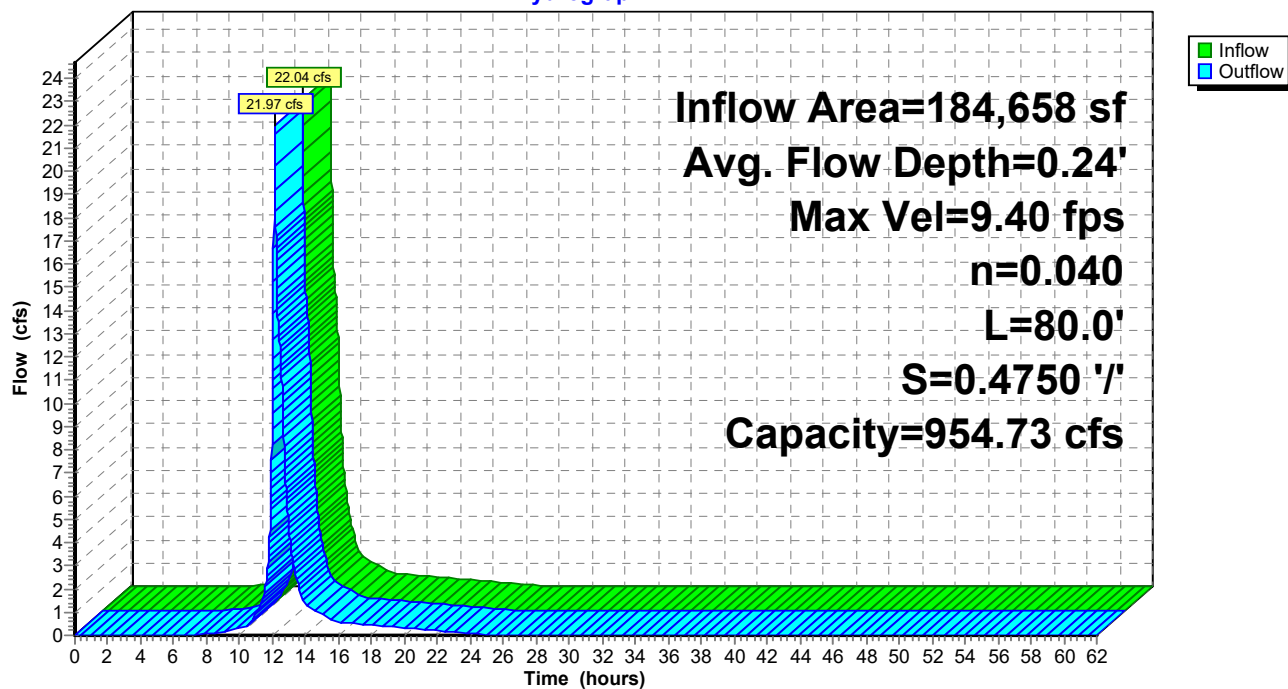
Length= 80.0' Slope= 0.4750 ' '

Inlet Invert= 980.00', Outlet Invert= 942.00'



Reach BDS3: B Downslope 3

Hydrograph



Summary for Reach BDS4: B Downslope 4

[61] Hint: Exceeded Reach B7T outlet invert by 0.37' @ 12.13 hrs

[62] Hint: Exceeded Reach BDS3 OUTLET depth by 0.13' @ 12.12 hrs

Inflow Area = 250,037 sf, 0.00% Impervious, Inflow Depth = 5.22" for 100-yr 24-hr event
Inflow = 37.61 cfs @ 12.13 hrs, Volume= 108,683 cf
Outflow = 37.46 cfs @ 12.13 hrs, Volume= 108,683 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 10.04 fps, Min. Travel Time= 0.2 min

Avg. Velocity = 2.40 fps, Avg. Travel Time= 0.7 min

Peak Storage= 374 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.37'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 783.63 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

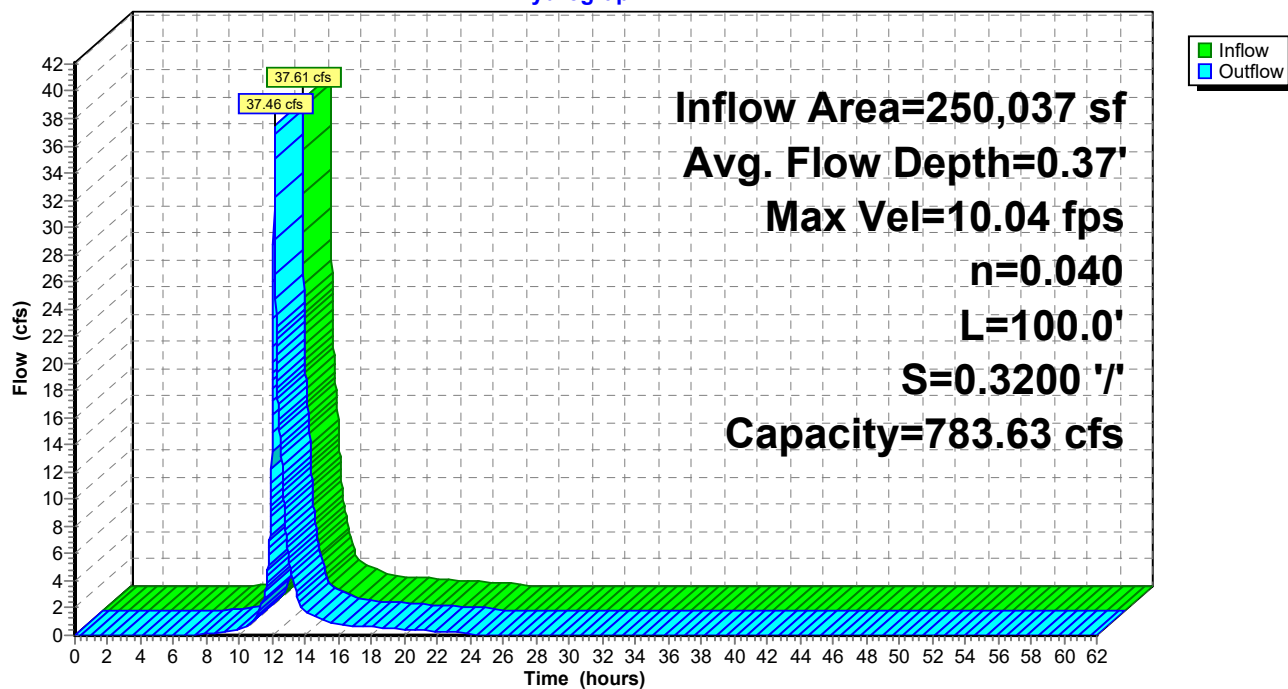
Length= 100.0' Slope= 0.3200 '/'

Inlet Invert= 942.00', Outlet Invert= 910.00'



Reach BDS4: B Downslope 4

Hydrograph



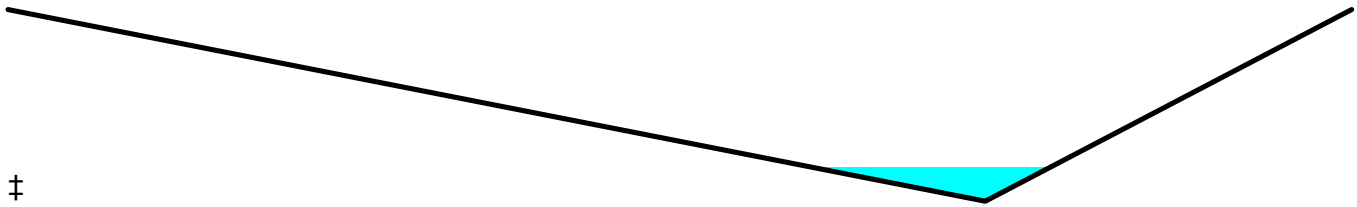
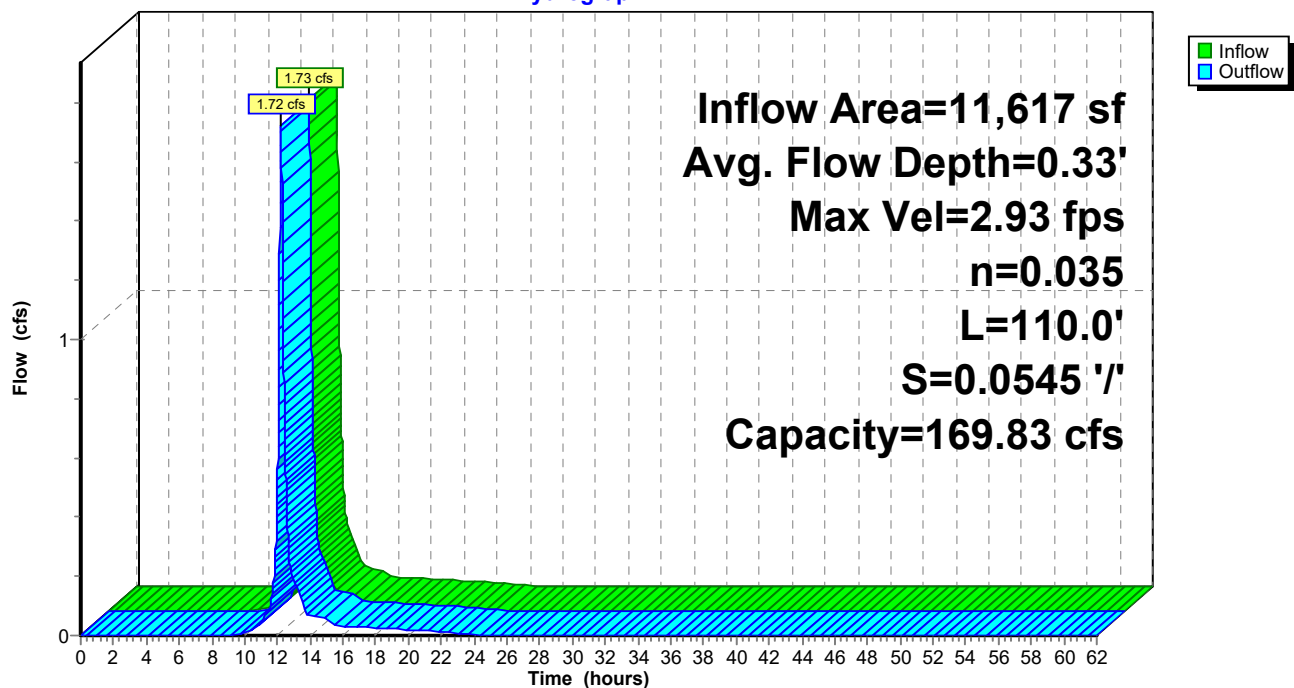
Summary for Reach C0T: C0 Terrace

Inflow Area = 11,617 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
 Inflow = 1.73 cfs @ 12.20 hrs, Volume= 4,386 cf
 Outflow = 1.72 cfs @ 12.22 hrs, Volume= 4,386 cf, Atten= 0%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 2.93 fps, Min. Travel Time= 0.6 min
 Avg. Velocity= 1.08 fps, Avg. Travel Time= 1.7 min

Peak Storage= 65 cf @ 12.21 hrs
 Average Depth at Peak Storage= 0.33'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 169.83 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 110.0' Slope= 0.0545 '/'
 Inlet Invert= 1,096.00', Outlet Invert= 1,090.00'

**Reach C0T: C0 Terrace****Hydrograph**

Summary for Reach C10T: C10 Terrace

[62] Hint: Exceeded Reach CCDS1 OUTLET depth by 0.83' @ 12.13 hrs

Inflow Area = 112,878 sf, 0.00% Impervious, Inflow Depth = 5.27" for 100-yr 24-hr event
 Inflow = 24.80 cfs @ 12.11 hrs, Volume= 49,577 cf
 Outflow = 22.33 cfs @ 12.18 hrs, Volume= 49,577 cf, Atten= 10%, Lag= 4.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.44 fps, Min. Travel Time= 3.0 min

Avg. Velocity= 1.33 fps, Avg. Travel Time= 10.0 min

Peak Storage= 3,999 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.96'

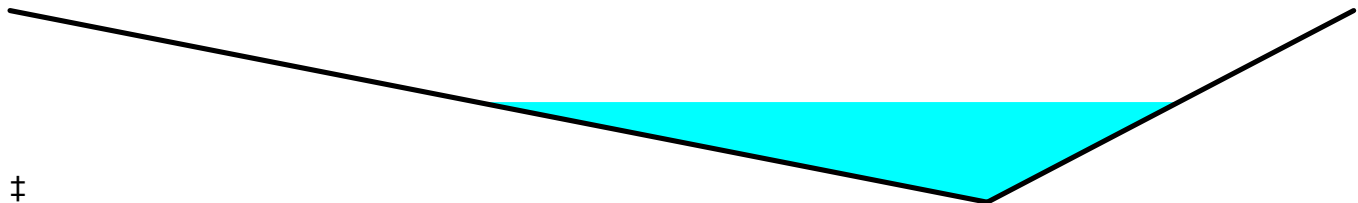
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 126.27 cfs

0.00' x 1.83' deep channel, n= 0.035

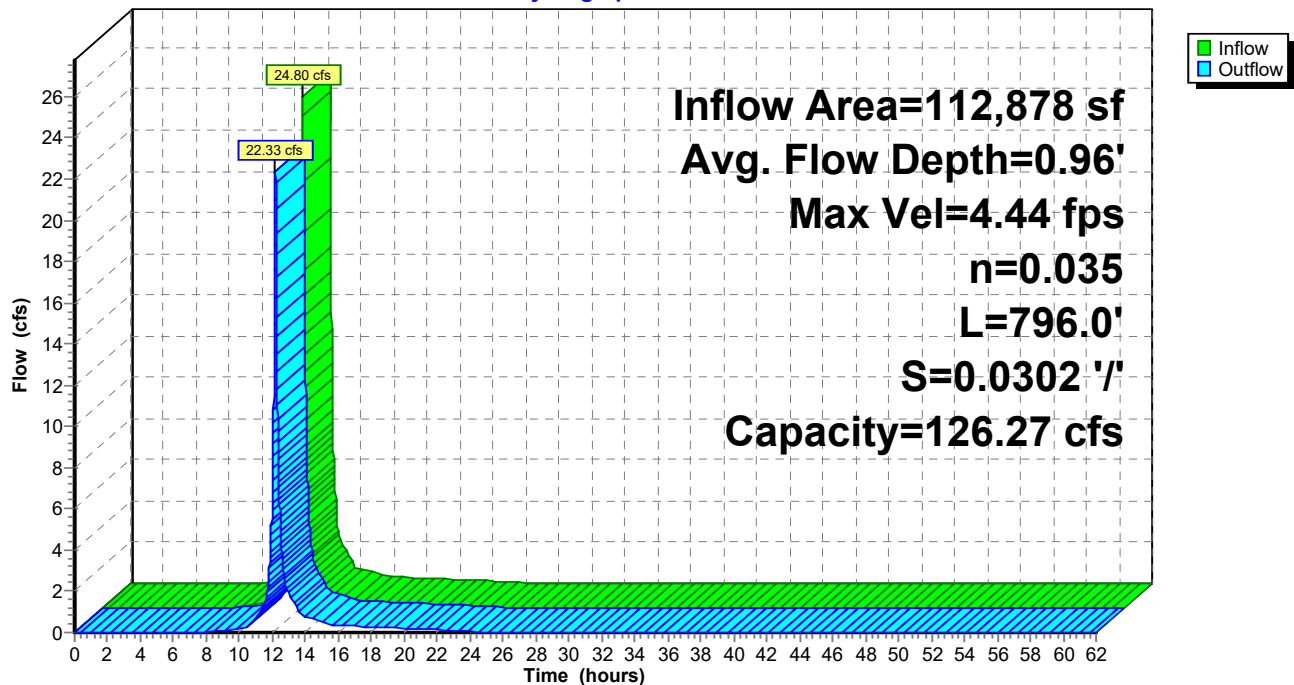
Side Slope Z-value= 8.0 3.0 ' / ' Top Width= 20.13'

Length= 796.0' Slope= 0.0302 ' / '

Inlet Invert= 924.00', Outlet Invert= 900.00'

**Reach C10T: C10 Terrace**

Hydrograph



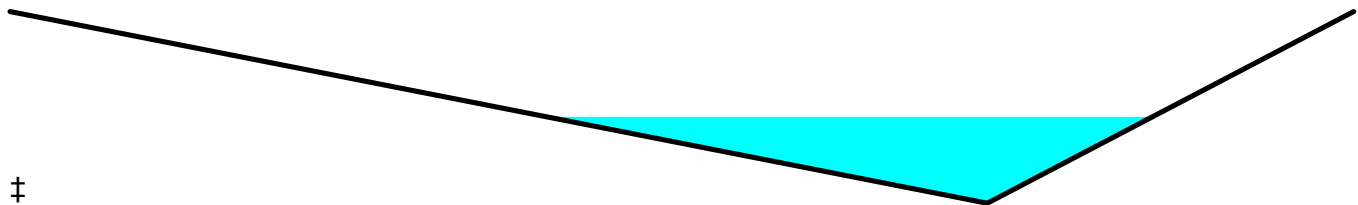
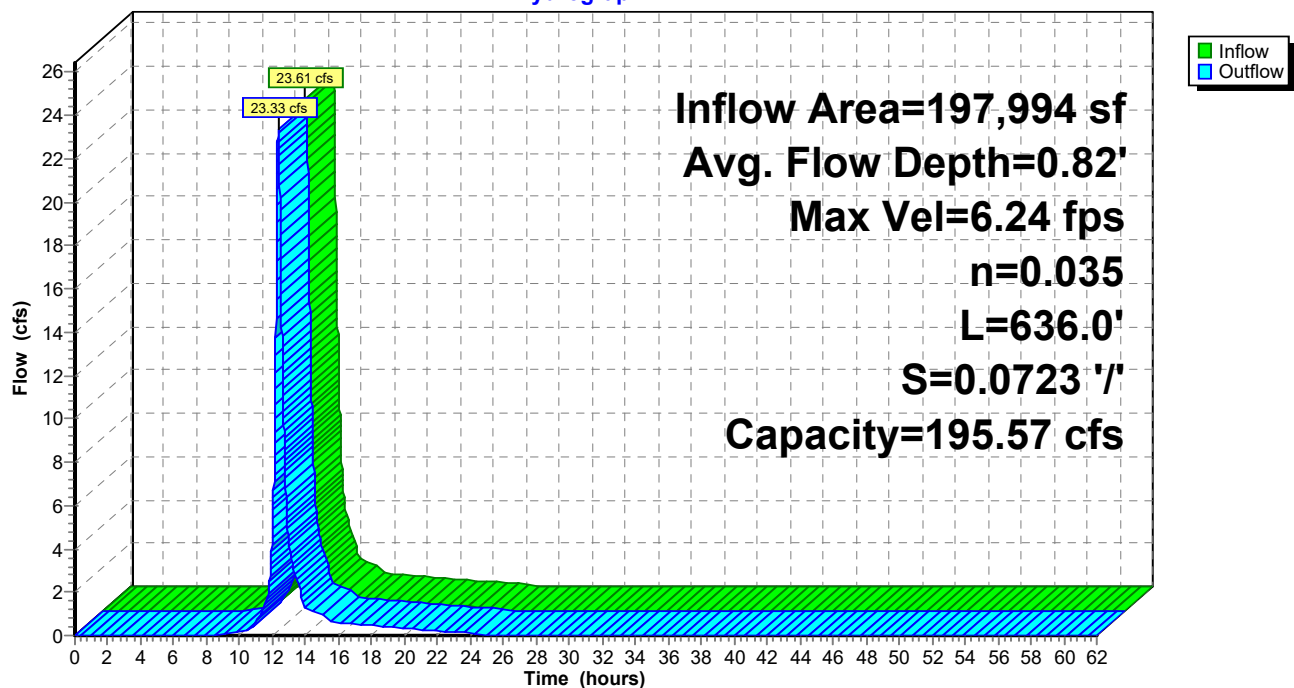
Summary for Reach C1T: C1 Terrace

Inflow Area = 197,994 sf, 0.00% Impervious, Inflow Depth = 4.64" for 100-yr 24-hr event
 Inflow = 23.61 cfs @ 12.29 hrs, Volume= 76,593 cf
 Outflow = 23.33 cfs @ 12.34 hrs, Volume= 76,593 cf, Atten= 1%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 6.24 fps, Min. Travel Time= 1.7 min
 Avg. Velocity = 2.25 fps, Avg. Travel Time= 4.7 min

Peak Storage= 2,378 cf @ 12.32 hrs
 Average Depth at Peak Storage= 0.82'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 195.57 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'
 Length= 636.0' Slope= 0.0723 ' / '
 Inlet Invert= 1,094.00', Outlet Invert= 1,048.00'

**Reach C1T: C1 Terrace****Hydrograph**

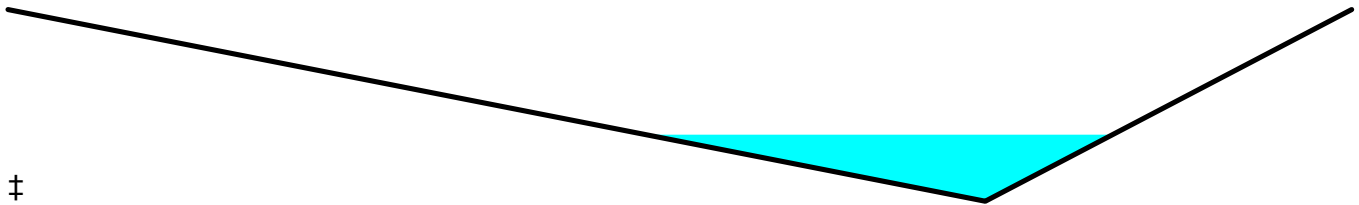
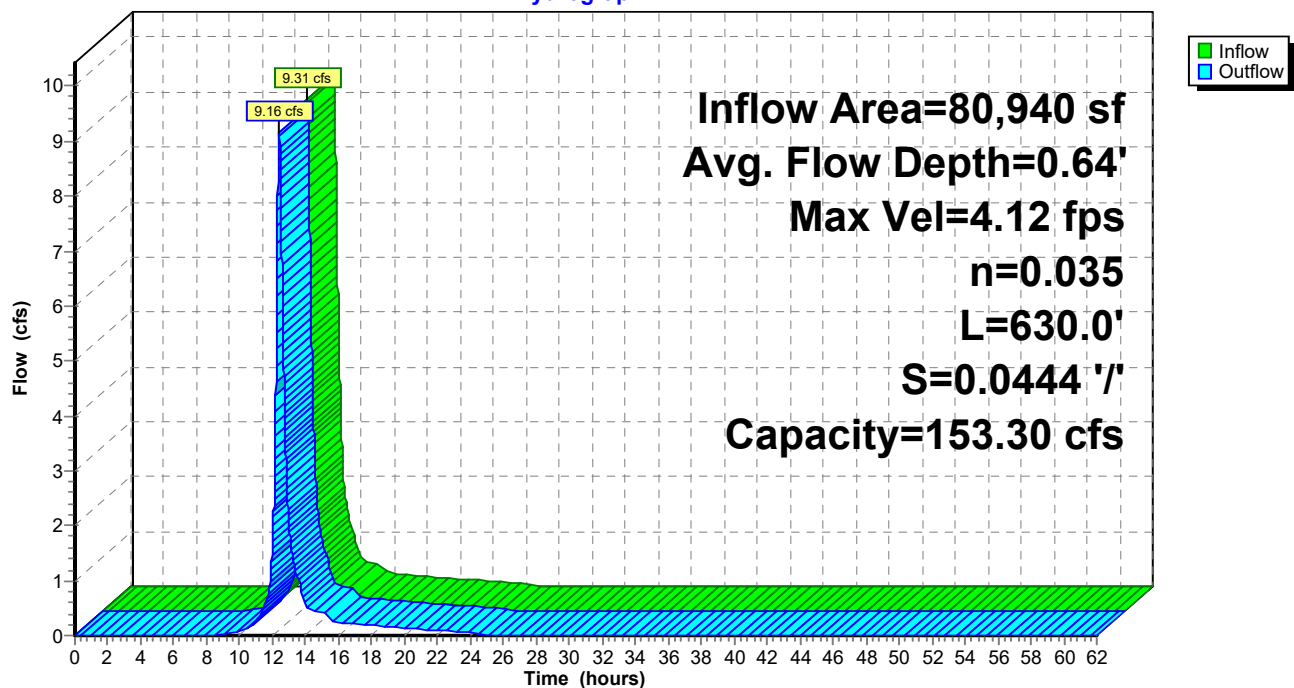
Summary for Reach C2T: C2 Terrace

Inflow Area = 80,940 sf, 0.00% Impervious, Inflow Depth = 4.75" for 100-yr 24-hr event
 Inflow = 9.31 cfs @ 12.32 hrs, Volume= 32,067 cf
 Outflow = 9.16 cfs @ 12.40 hrs, Volume= 32,067 cf, Atten= 2%, Lag= 4.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 4.12 fps, Min. Travel Time= 2.6 min
 Avg. Velocity = 1.49 fps, Avg. Travel Time= 7.0 min

Peak Storage= 1,402 cf @ 12.35 hrs
 Average Depth at Peak Storage= 0.64'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 153.30 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 630.0' Slope= 0.0444 '/'
 Inlet Invert= 1,090.00', Outlet Invert= 1,062.00'

**Reach C2T: C2 Terrace****Hydrograph**

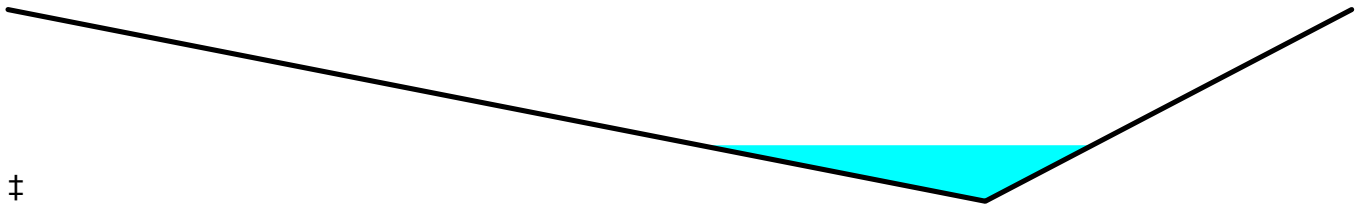
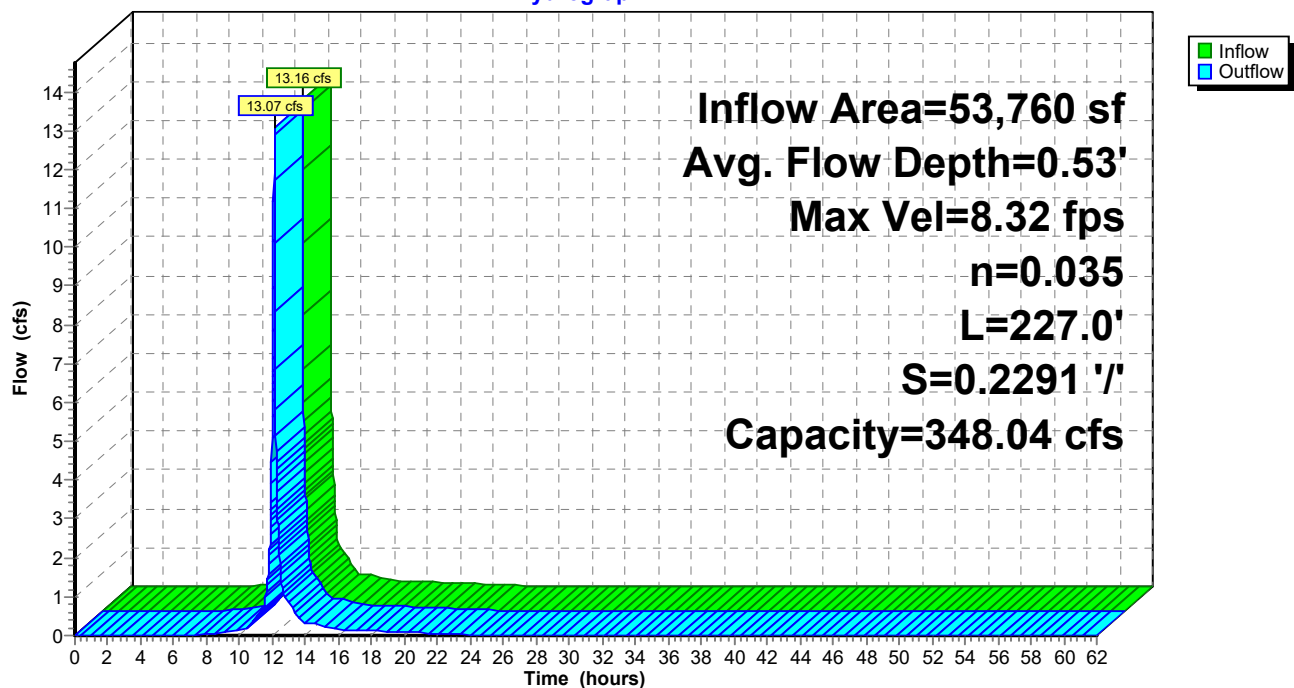
Summary for Reach C3T: C3 Terrace

Inflow Area = 53,760 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 13.16 cfs @ 12.11 hrs, Volume= 24,348 cf
 Outflow = 13.07 cfs @ 12.12 hrs, Volume= 24,348 cf, Atten= 1%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 8.32 fps, Min. Travel Time= 0.5 min
 Avg. Velocity = 2.72 fps, Avg. Travel Time= 1.4 min

Peak Storage= 357 cf @ 12.11 hrs
 Average Depth at Peak Storage= 0.53'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 348.04 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 227.0' Slope= 0.2291 '/'
 Inlet Invert= 1,056.00', Outlet Invert= 1,004.00'

**Reach C3T: C3 Terrace****Hydrograph**

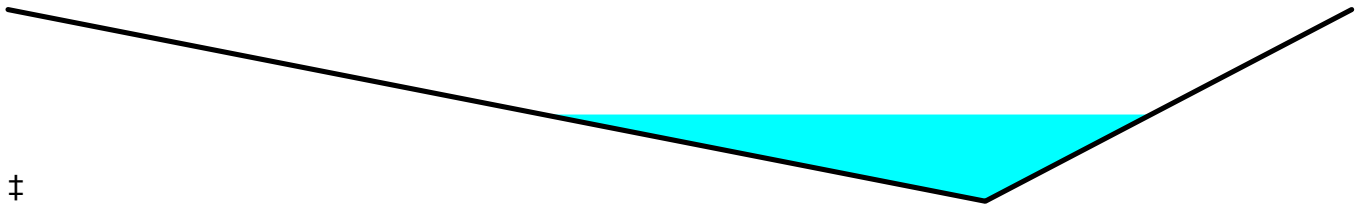
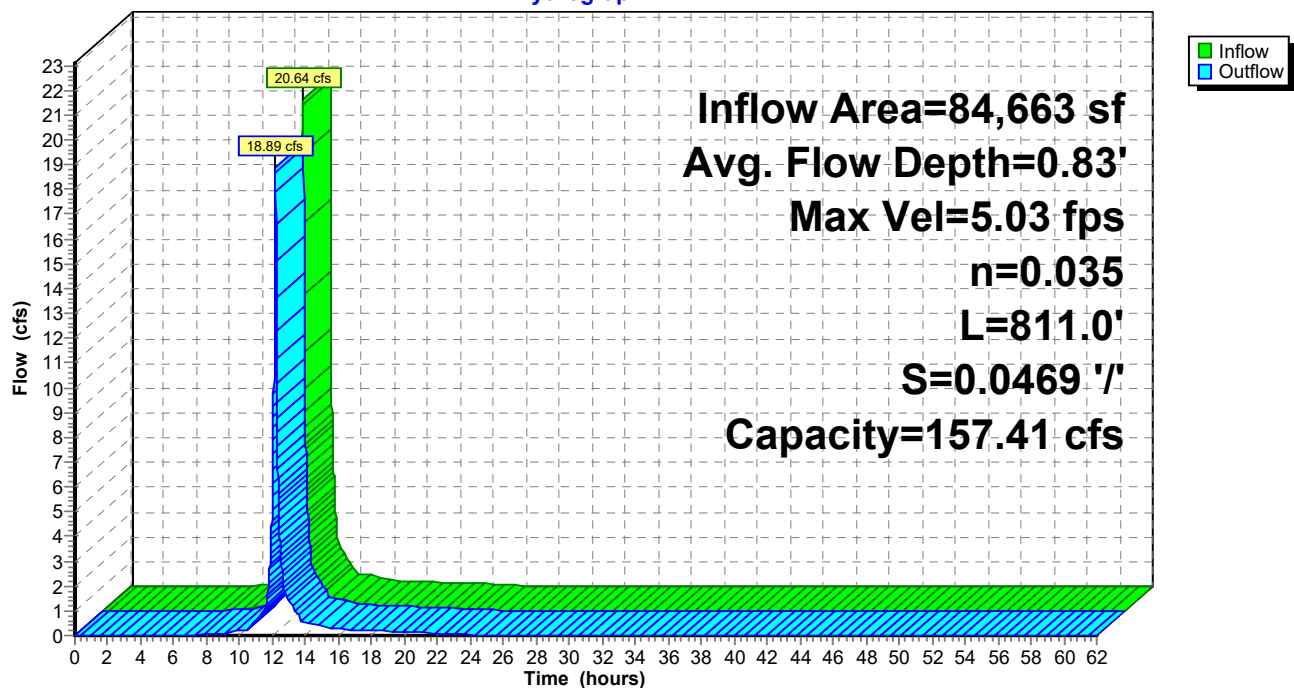
Summary for Reach C4T: C4 Terrace

Inflow Area = 84,663 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 20.64 cfs @ 12.11 hrs, Volume= 38,344 cf
 Outflow = 18.89 cfs @ 12.17 hrs, Volume= 38,344 cf, Atten= 8%, Lag= 3.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 5.03 fps, Min. Travel Time= 2.7 min
 Avg. Velocity = 1.53 fps, Avg. Travel Time= 8.8 min

Peak Storage= 3,056 cf @ 12.13 hrs
 Average Depth at Peak Storage= 0.83'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 157.41 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 811.0' Slope= 0.0469 '/'
 Inlet Invert= 1,058.00', Outlet Invert= 1,020.00'

**Reach C4T: C4 Terrace****Hydrograph**

Summary for Reach C5T: C5 Terrace

Inflow Area = 86,214 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 20.79 cfs @ 12.11 hrs, Volume= 39,046 cf
 Outflow = 17.94 cfs @ 12.20 hrs, Volume= 39,046 cf, Atten= 14%, Lag= 5.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.03 fps, Min. Travel Time= 3.8 min

Avg. Velocity= 1.50 fps, Avg. Travel Time= 12.9 min

Peak Storage= 4,145 cf @ 12.14 hrs

Average Depth at Peak Storage= 0.81'

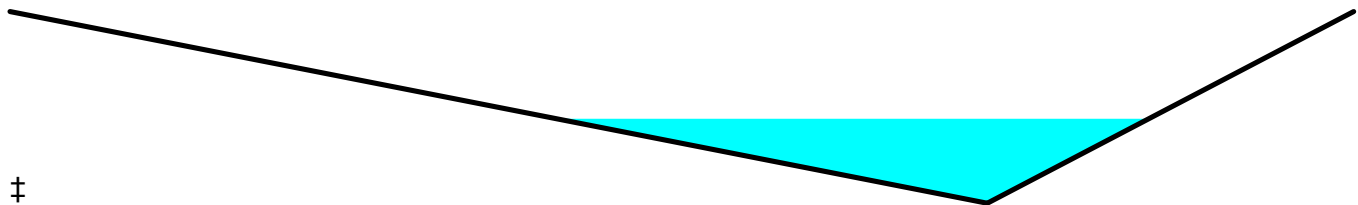
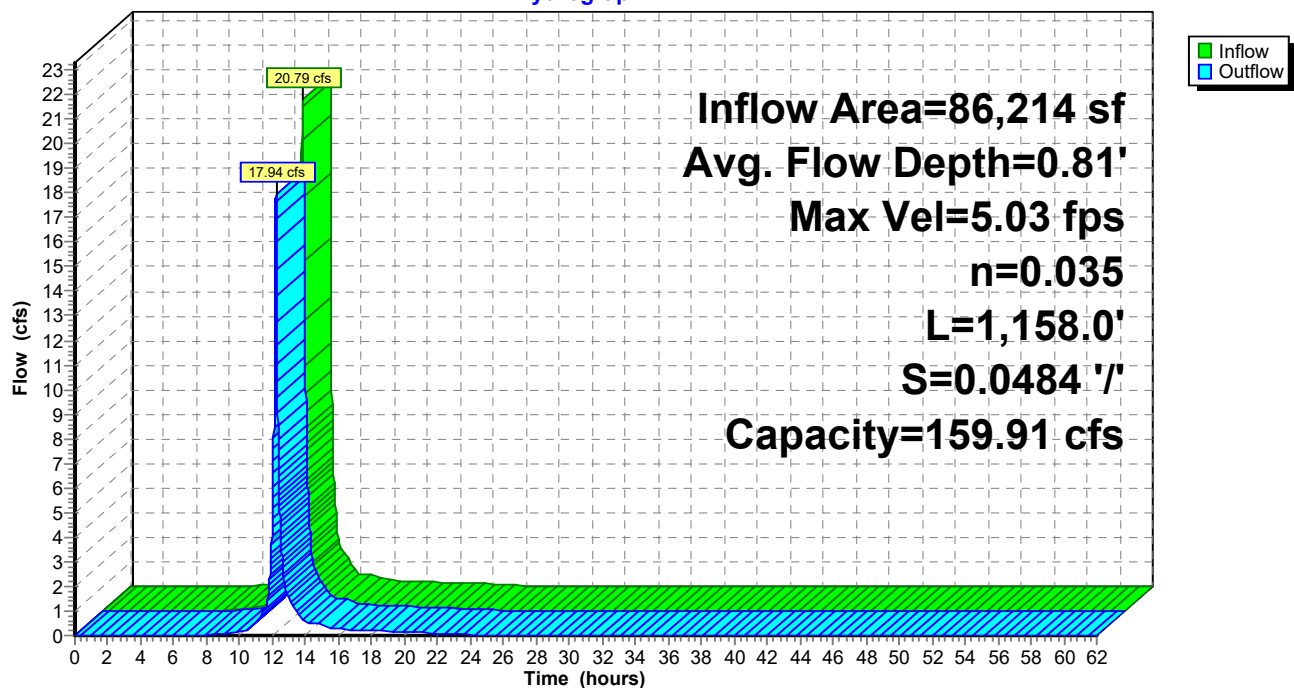
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 159.91 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 1,158.0' Slope= 0.0484 '/'

Inlet Invert= 1,018.00', Outlet Invert= 962.00'

**Reach C5T: C5 Terrace****Hydrograph**

Summary for Reach C6T: C6 Terrace

Inflow Area = 68,040 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 16.00 cfs @ 12.12 hrs, Volume= 30,815 cf
 Outflow = 15.81 cfs @ 12.13 hrs, Volume= 30,815 cf, Atten= 1%, Lag= 1.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 28.98 fps, Min. Travel Time= 0.6 min

Avg. Velocity = 28.98 fps, Avg. Travel Time= 0.6 min

Peak Storage= 545 cf @ 12.12 hrs

Average Depth at Peak Storage= 0.01'

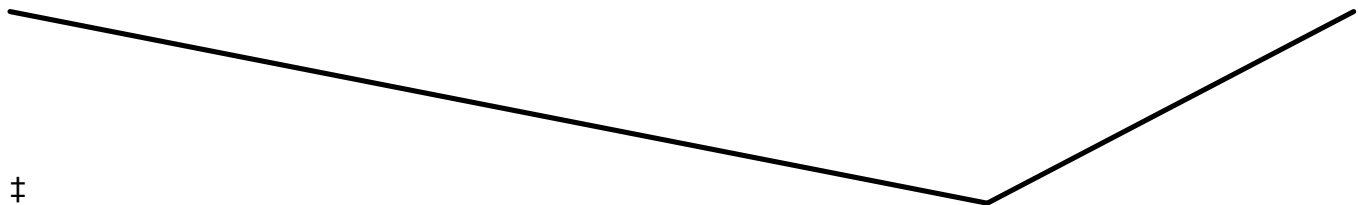
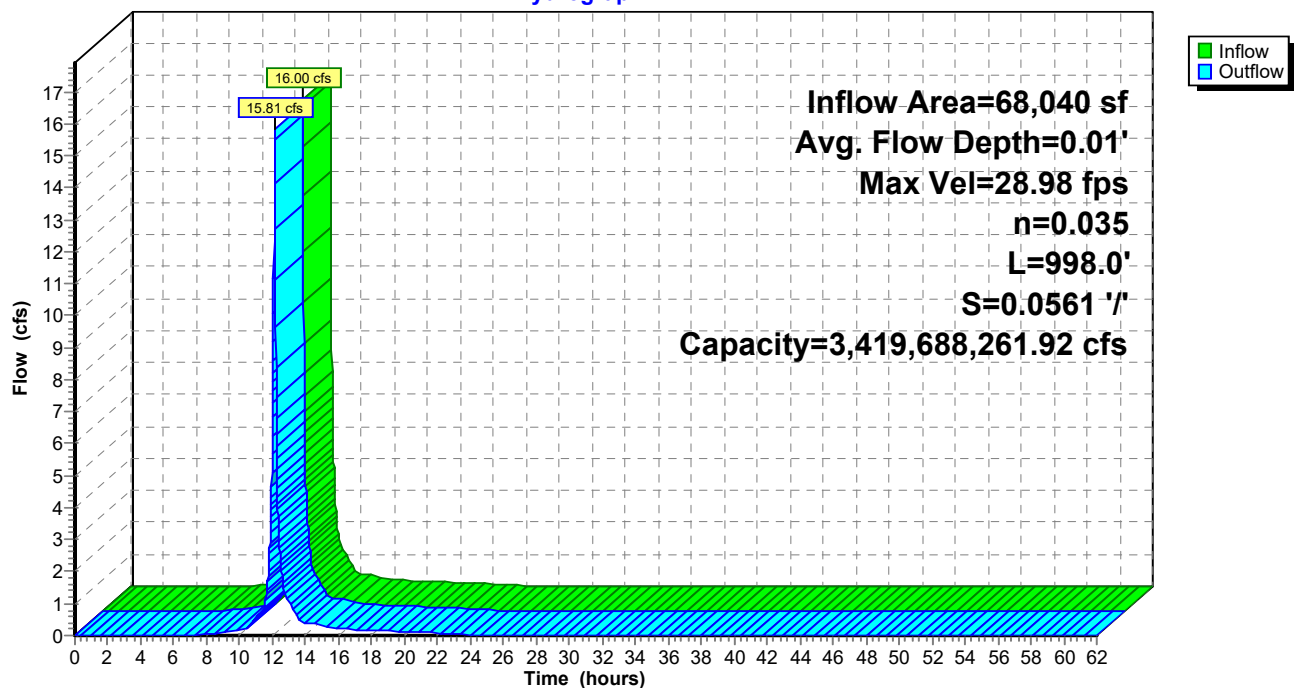
Bank-Full Depth= 998.00' Flow Area= 5,478,022.0 sf, Capacity= 3,419,688,261.92 cfs

0.00' x 998.00' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 10,978.00'

Length= 998.0' Slope= 0.0561 '/'

Inlet Invert= 1,036.00', Outlet Invert= 980.00'

**Reach C6T: C6 Terrace****Hydrograph**

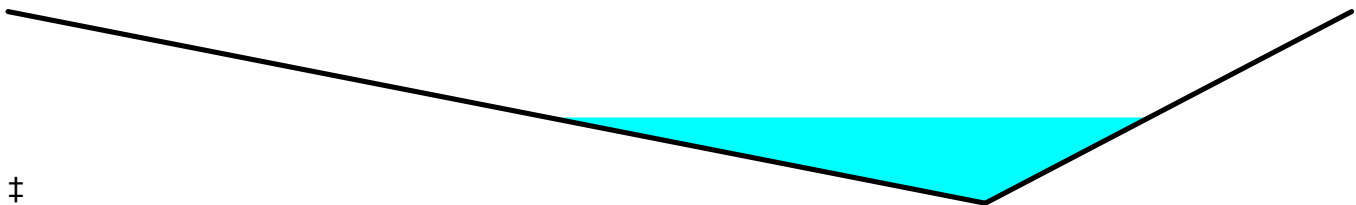
Summary for Reach C7T: C7 Terrace

Inflow Area = 89,993 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 22.12 cfs @ 12.11 hrs, Volume= 40,758 cf
 Outflow = 19.16 cfs @ 12.19 hrs, Volume= 40,758 cf, Atten= 13%, Lag= 5.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 5.21 fps, Min. Travel Time= 3.8 min
 Avg. Velocity = 1.55 fps, Avg. Travel Time= 12.7 min

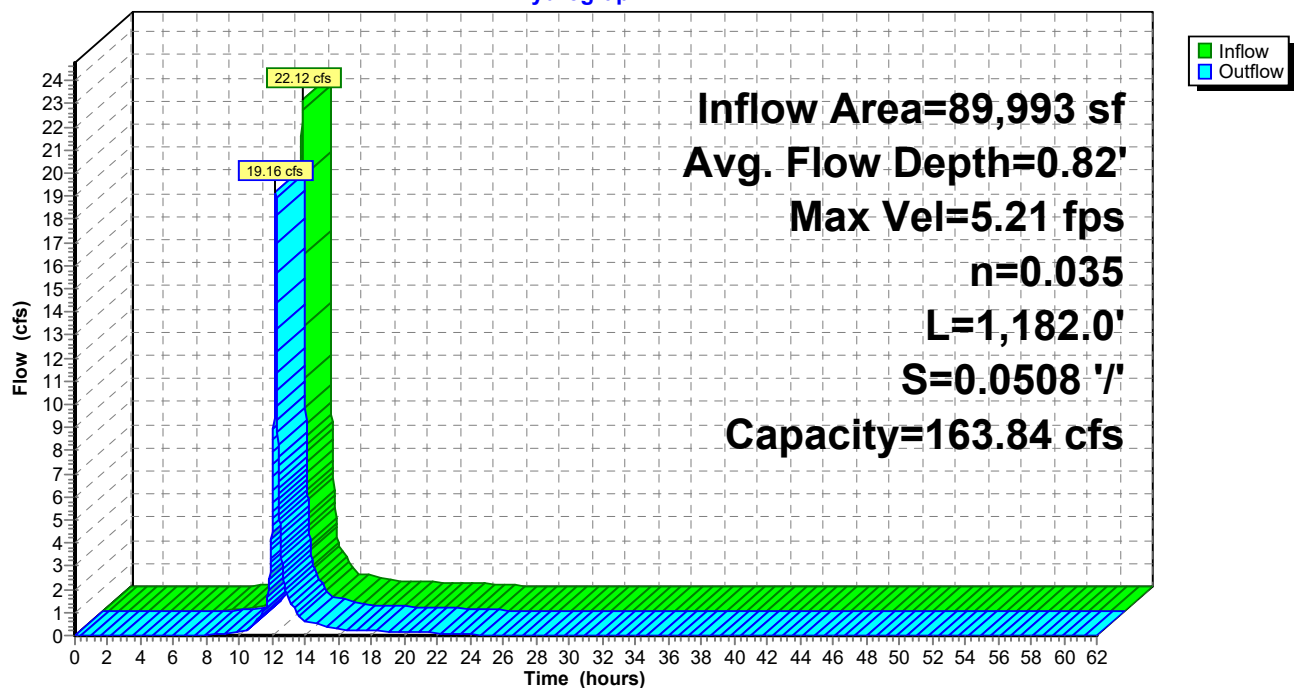
Peak Storage= 4,365 cf @ 12.13 hrs
 Average Depth at Peak Storage= 0.82'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 163.84 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 1,182.0' Slope= 0.0508 '/'
 Inlet Invert= 982.00', Outlet Invert= 922.00'



Reach C7T: C7 Terrace

Hydrograph



Summary for Reach C8T: C8 Terrace

Inflow Area = 79,459 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 19.00 cfs @ 12.11 hrs, Volume= 35,987 cf
 Outflow = 16.43 cfs @ 12.20 hrs, Volume= 35,987 cf, Atten= 14%, Lag= 5.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.19 fps, Min. Travel Time= 3.8 min

Avg. Velocity= 1.57 fps, Avg. Travel Time= 12.6 min

Peak Storage= 3,755 cf @ 12.14 hrs

Average Depth at Peak Storage= 0.76'

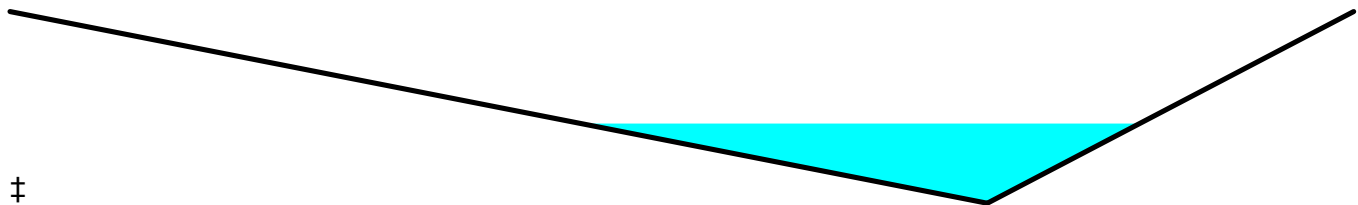
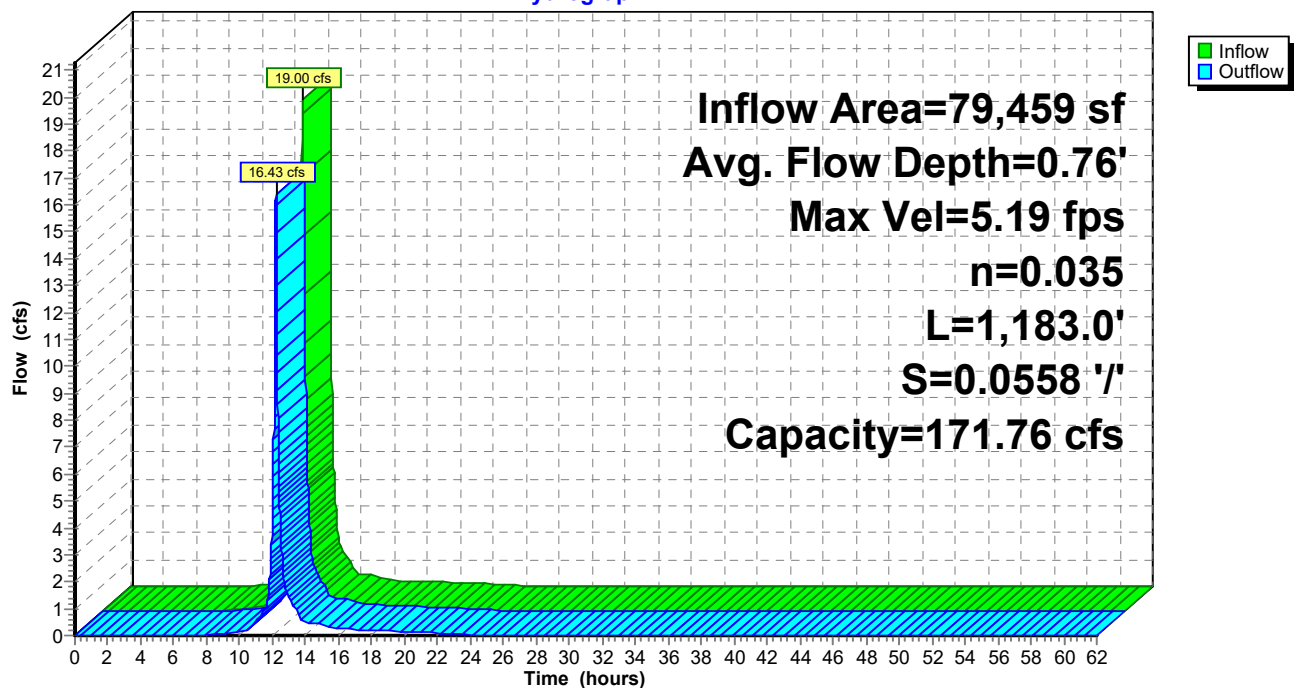
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 171.76 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 1,183.0' Slope= 0.0558 '/'

Inlet Invert= 1,004.00', Outlet Invert= 938.00'

**Reach C8T: C8 Terrace****Hydrograph**

Summary for Reach C9T: C9 Terrace

Inflow Area = 129,406 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 27.01 cfs @ 12.15 hrs, Volume= 58,608 cf
 Outflow = 19.74 cfs @ 12.34 hrs, Volume= 58,608 cf, Atten= 27%, Lag= 11.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 2.59 fps, Min. Travel Time= 8.3 min

Avg. Velocity = 0.67 fps, Avg. Travel Time= 32.2 min

Peak Storage= 9,832 cf @ 12.21 hrs

Average Depth at Peak Storage= 1.18'

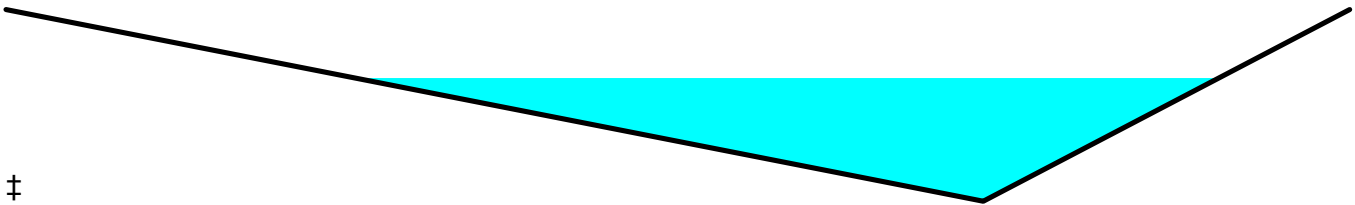
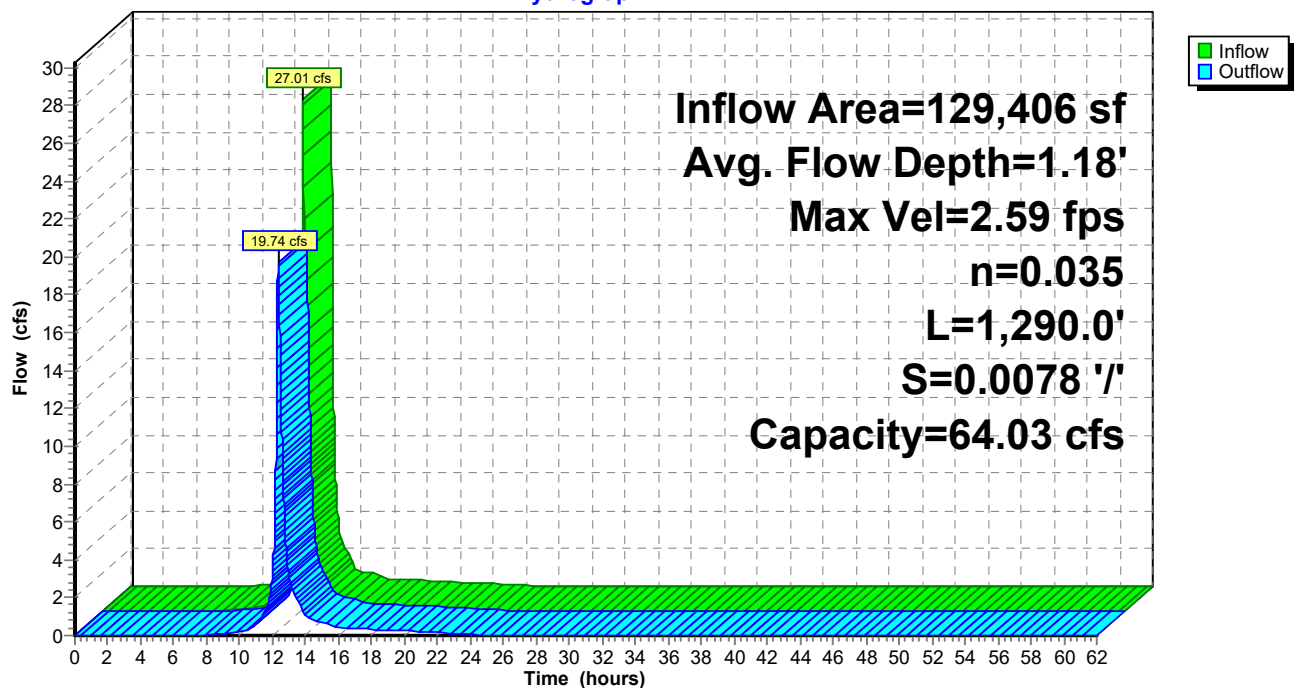
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 64.03 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 1,290.0' Slope= 0.0078 '/'

Inlet Invert= 910.00', Outlet Invert= 900.00'

**Reach C9T: C9 Terrace****Hydrograph**

Summary for Reach CC2T: CC2 Terrace

Inflow Area = 31,665 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
Inflow = 7.68 cfs @ 12.11 hrs, Volume= 14,341 cf
Outflow = 7.23 cfs @ 12.16 hrs, Volume= 14,341 cf, Atten= 6%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.44 fps, Min. Travel Time= 2.1 min

Avg. Velocity = 1.41 fps, Avg. Travel Time= 6.7 min

Peak Storage= 923 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.54'

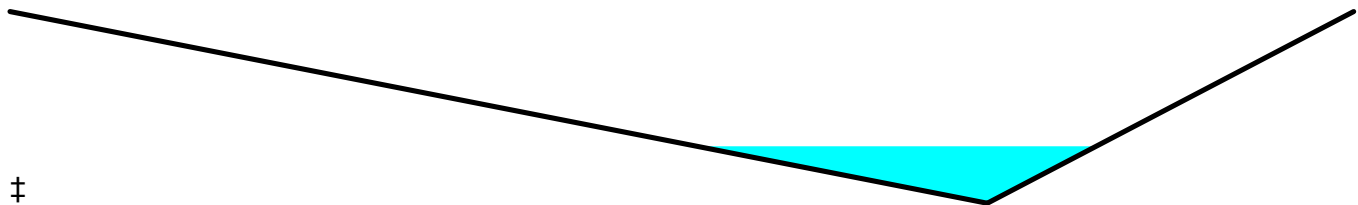
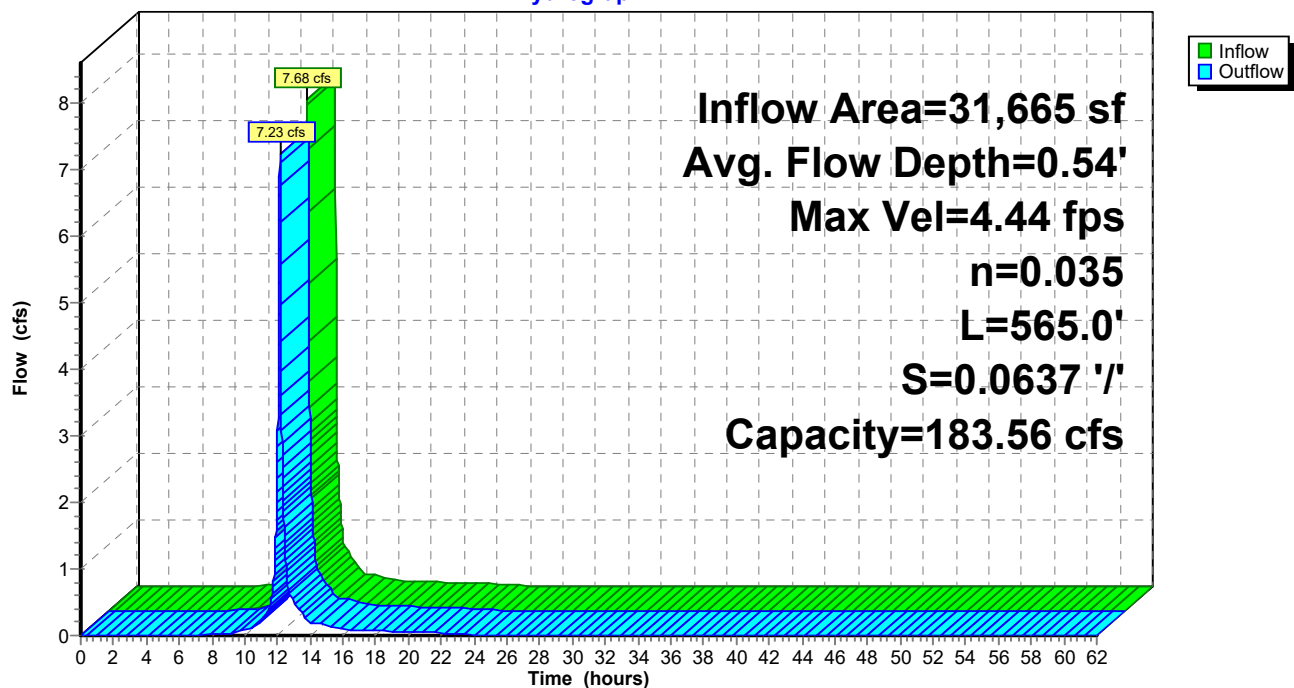
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 183.56 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 565.0' Slope= 0.0637 '/'

Inlet Invert= 980.00', Outlet Invert= 944.00'

**Reach CC2T: CC2 Terrace****Hydrograph**

Summary for Reach CC4T: CC4 Terrace

Inflow Area = 76,564 sf, 0.00% Impervious, Inflow Depth = 5.09" for 100-yr 24-hr event
 Inflow = 15.53 cfs @ 12.14 hrs, Volume= 32,494 cf
 Outflow = 11.23 cfs @ 12.33 hrs, Volume= 32,494 cf, Atten= 28%, Lag= 11.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.17 fps, Min. Travel Time= 8.2 min

Avg. Velocity = 0.90 fps, Avg. Travel Time= 28.9 min

Peak Storage= 5,520 cf @ 12.20 hrs

Average Depth at Peak Storage= 0.80'

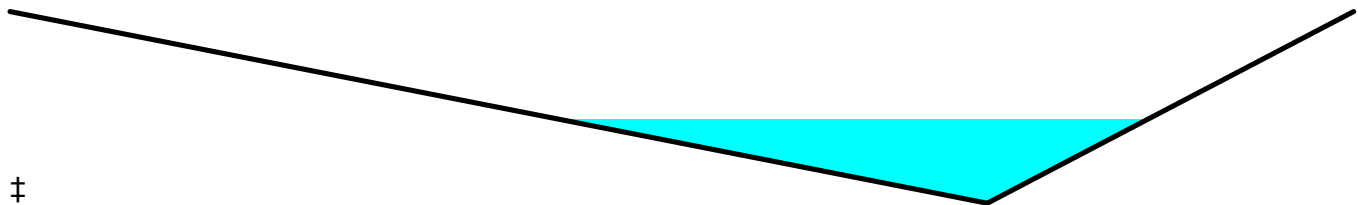
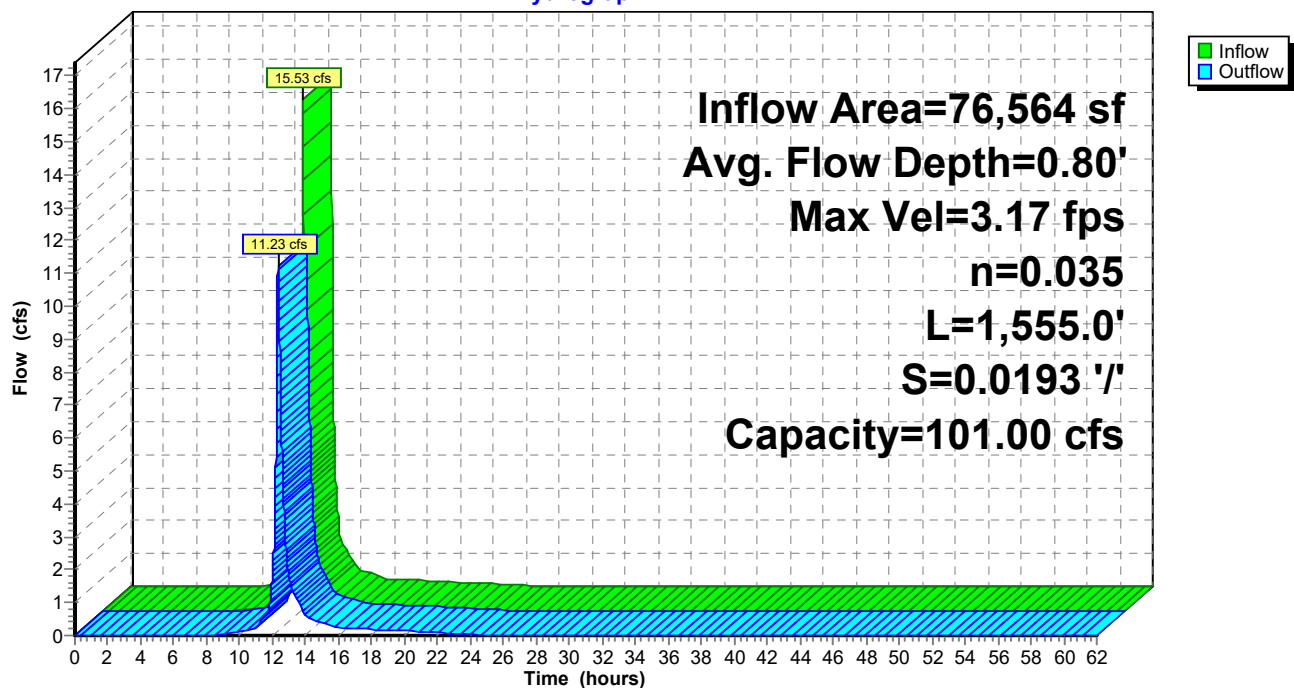
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 101.00 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 1,555.0' Slope= 0.0193 '/'

Inlet Invert= 924.00', Outlet Invert= 894.00'

**Reach CC4T: CC4 Terrace****Hydrograph**

Summary for Reach CCDS1: CC Downslope 1

[61] Hint: Exceeded Reach CC2T outlet invert by 0.13' @ 12.16 hrs

Inflow Area = 31,665 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 7.23 cfs @ 12.16 hrs, Volume= 14,341 cf
 Outflow = 7.19 cfs @ 12.16 hrs, Volume= 14,341 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.78 fps, Min. Travel Time= 0.2 min

Avg. Velocity= 1.80 fps, Avg. Travel Time= 0.6 min

Peak Storage= 86 cf @ 12.16 hrs

Average Depth at Peak Storage= 0.13'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 852.35 cfs

9.00' x 2.00' deep channel, n= 0.035

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

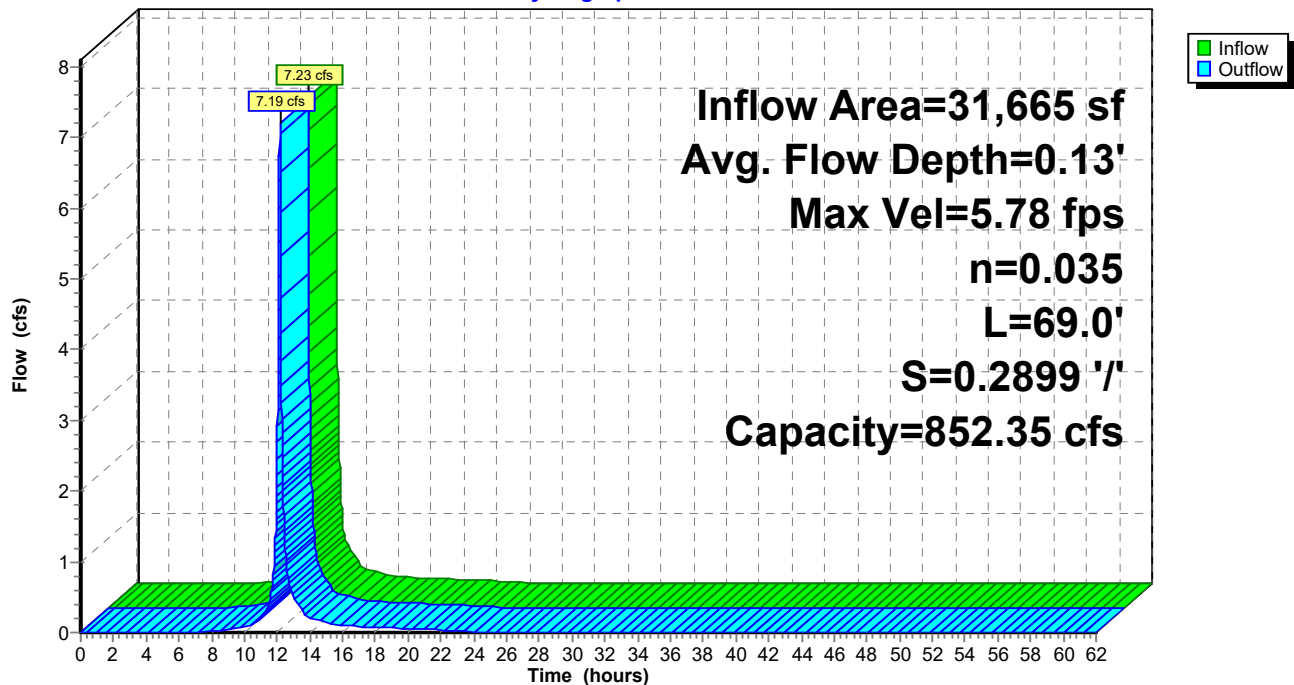
Length= 69.0' Slope= 0.2899 '/'

Inlet Invert= 944.00', Outlet Invert= 924.00'



Reach CCDS1: CC Downslope 1

Hydrograph



Summary for Reach CDS1: C Downslope 1

[61] Hint: Exceeded Reach COT outlet invert by 0.06' @ 12.22 hrs

Inflow Area = 11,617 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
 Inflow = 1.72 cfs @ 12.22 hrs, Volume= 4,386 cf
 Outflow = 1.72 cfs @ 12.23 hrs, Volume= 4,386 cf, Atten= 0%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.30 fps, Min. Travel Time= 0.4 min

Avg. Velocity= 1.68 fps, Avg. Travel Time= 0.8 min

Peak Storage= 40 cf @ 12.22 hrs

Average Depth at Peak Storage= 0.06'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 835.35 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

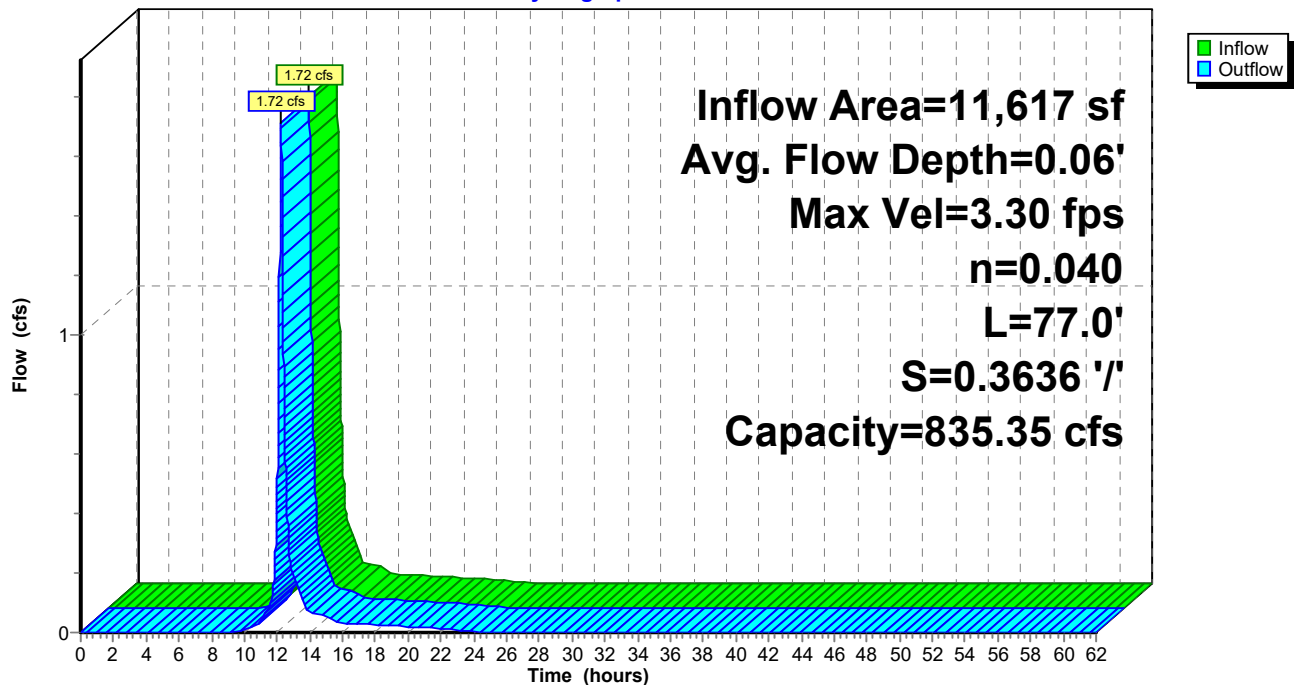
Length= 77.0' Slope= 0.3636 '/'

Inlet Invert= 1,090.00', Outlet Invert= 1,062.00'



Reach CDS1: C Downslope 1

Hydrograph



Summary for Reach CDS2: C Downslope 2

[61] Hint: Exceeded Reach C2T outlet invert by 0.16' @ 12.38 hrs

[62] Hint: Exceeded Reach CDS1 OUTLET depth by 0.13' @ 12.42 hrs

Inflow Area = 92,557 sf, 0.00% Impervious, Inflow Depth = 4.73" for 100-yr 24-hr event
 Inflow = 10.05 cfs @ 12.38 hrs, Volume= 36,453 cf
 Outflow = 10.05 cfs @ 12.39 hrs, Volume= 36,453 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 6.44 fps, Min. Travel Time= 0.1 min

Avg. Velocity= 1.97 fps, Avg. Travel Time= 0.3 min

Peak Storage= 61 cf @ 12.38 hrs

Average Depth at Peak Storage= 0.16'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 829.98 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' Top Width= 21.00'

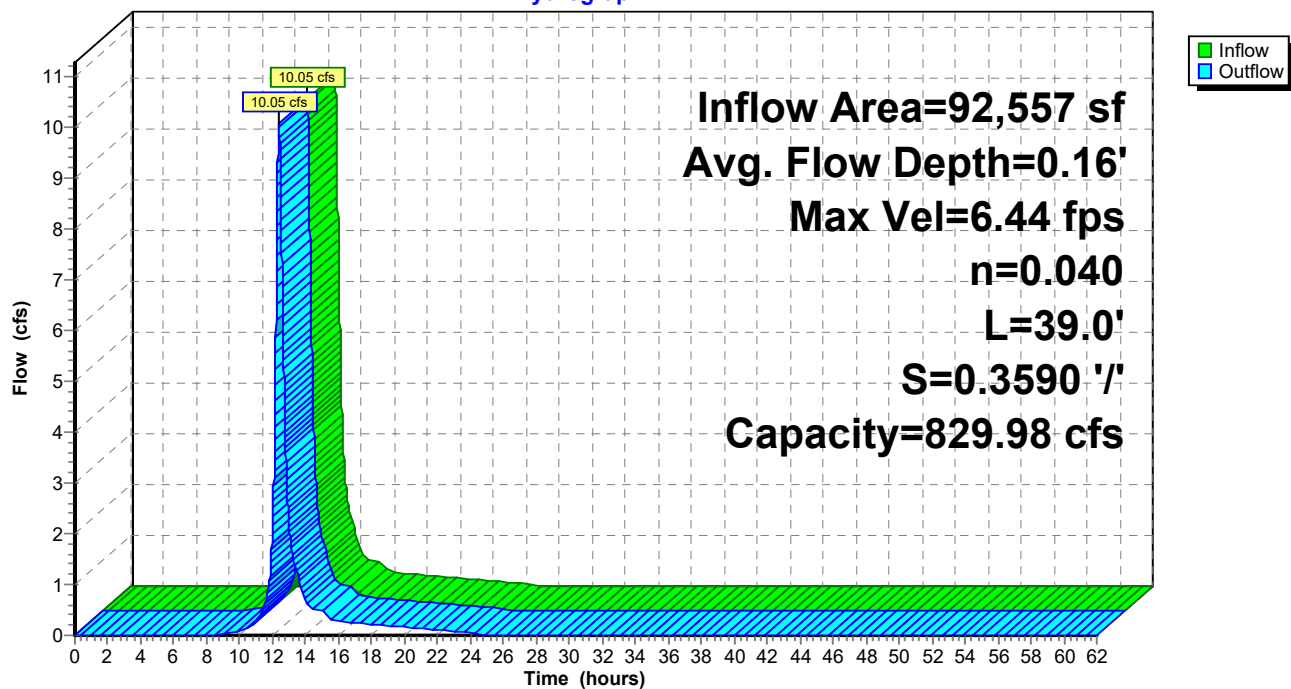
Length= 39.0' Slope= 0.3590 ' /'

Inlet Invert= 1,062.00', Outlet Invert= 1,048.00'



Reach CDS2: C Downslope 2

Hydrograph



Summary for Reach CDS3: C Downslope 3

[61] Hint: Exceeded Reach C1T outlet invert by 0.33' @ 12.36 hrs

[62] Hint: Exceeded Reach CDS2 OUTLET depth by 0.16' @ 12.34 hrs

Inflow Area = 290,551 sf, 0.00% Impervious, Inflow Depth = 4.67" for 100-yr 24-hr event
Inflow = 33.21 cfs @ 12.35 hrs, Volume= 113,046 cf
Outflow = 33.20 cfs @ 12.36 hrs, Volume= 113,046 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 10.23 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.66 fps, Avg. Travel Time= 0.5 min

Peak Storage= 234 cf @ 12.36 hrs

Average Depth at Peak Storage= 0.33'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 863.87 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

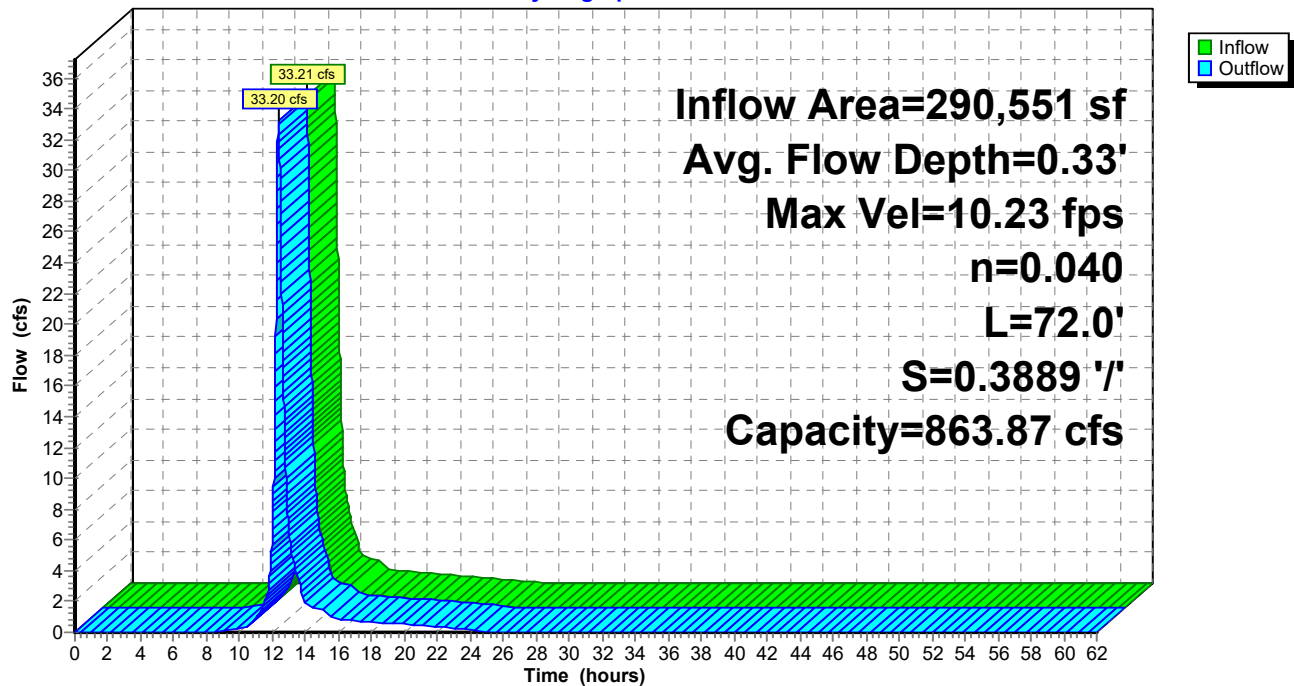
Length= 72.0' Slope= 0.3889 ' '

Inlet Invert= 1,048.00', Outlet Invert= 1,020.00'



Reach CDS3: C Downslope 3

Hydrograph



Summary for Reach CDS4: C Downslope 4

[62] Hint: Exceeded Reach C3T OUTLET depth by 16.10' @ 12.39 hrs

[62] Hint: Exceeded Reach CDS3 OUTLET depth by 0.13' @ 12.11 hrs

Inflow Area = 344,311 sf, 0.00% Impervious, Inflow Depth = 4.79" for 100-yr 24-hr event
Inflow = 35.80 cfs @ 12.35 hrs, Volume= 137,394 cf
Outflow = 35.79 cfs @ 12.35 hrs, Volume= 137,394 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 9.30 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.39 fps, Avg. Travel Time= 0.4 min

Peak Storage= 231 cf @ 12.35 hrs

Average Depth at Peak Storage= 0.38'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 715.35 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

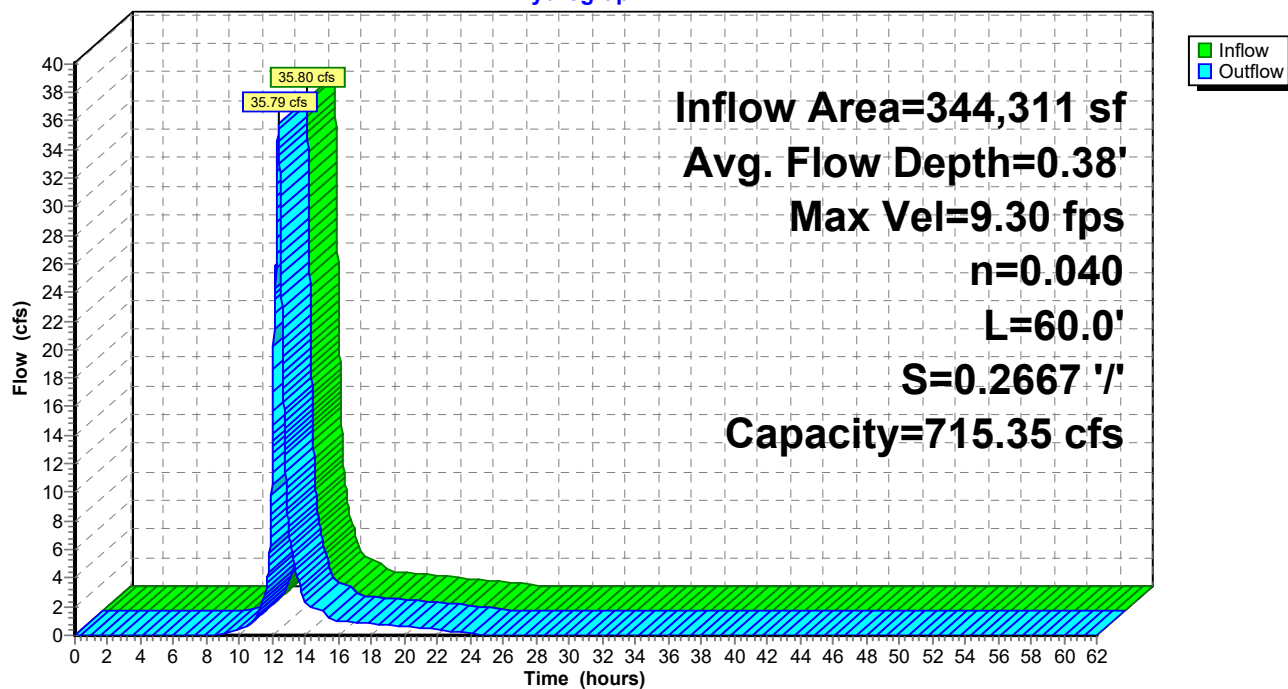
Length= 60.0' Slope= 0.2667 ' '

Inlet Invert= 1,020.00', Outlet Invert= 1,004.00'



Reach CDS4: C Downslope 4

Hydrograph



Summary for Reach CDS5: C Downslope 5

[62] Hint: Exceeded Reach CDS4 OUTLET depth by 0.08' @ 12.17 hrs

Inflow Area = 428,974 sf, 0.00% Impervious, Inflow Depth = 4.92" for 100-yr 24-hr event
 Inflow = 43.21 cfs @ 12.15 hrs, Volume= 175,737 cf
 Outflow = 43.19 cfs @ 12.15 hrs, Volume= 175,737 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 11.04 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.88 fps, Avg. Travel Time= 0.4 min

Peak Storage= 254 cf @ 12.15 hrs

Average Depth at Peak Storage= 0.39'

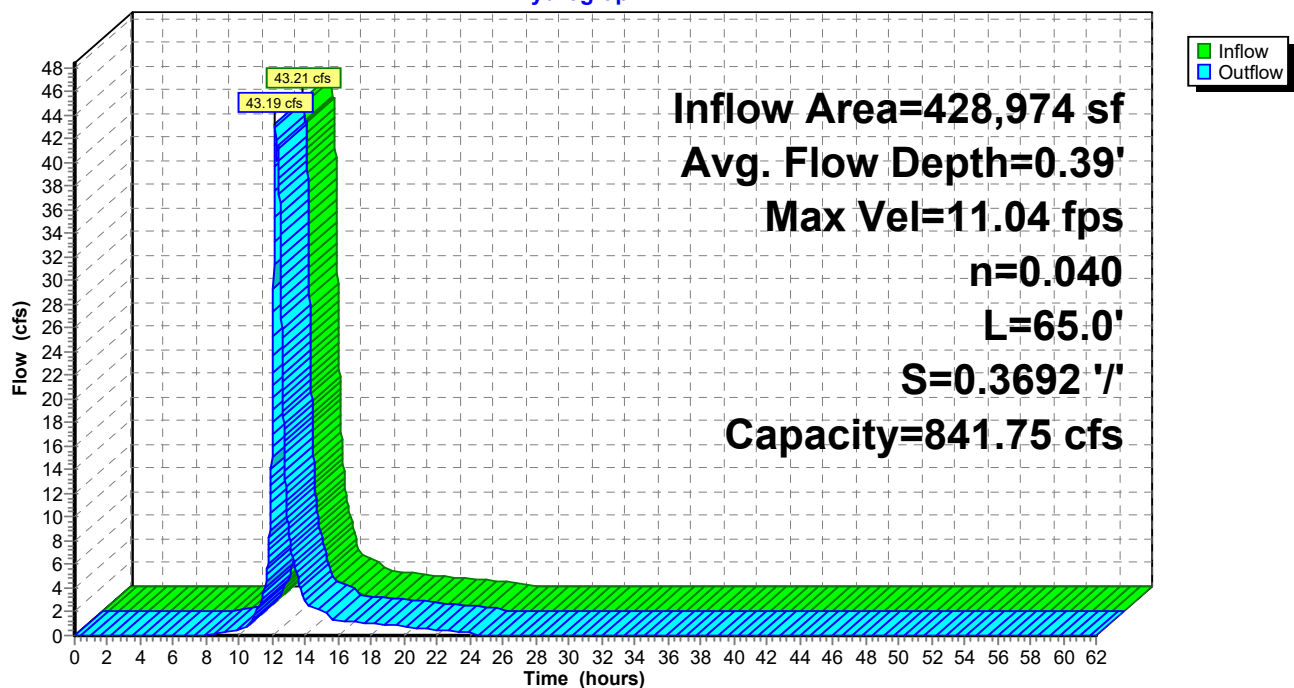
Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 841.75 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

Length= 65.0' Slope= 0.3692 '/'

Inlet Invert= 1,004.00', Outlet Invert= 980.00'

**Reach CDS5: C Downslope 5****Hydrograph**

Summary for Reach CDS6: C Downslope 6

[62] Hint: Exceeded Reach C6T OUTLET depth by 0.48' @ 12.15 hrs

[62] Hint: Exceeded Reach CDS5 OUTLET depth by 0.11' @ 12.14 hrs

Inflow Area = 497,014 sf, 0.00% Impervious, Inflow Depth = 4.99" for 100-yr 24-hr event
Inflow = 58.52 cfs @ 12.14 hrs, Volume= 206,552 cf
Outflow = 58.43 cfs @ 12.15 hrs, Volume= 206,552 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 11.33 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.79 fps, Avg. Travel Time= 0.4 min

Peak Storage= 320 cf @ 12.15 hrs

Average Depth at Peak Storage= 0.49'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 746.41 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

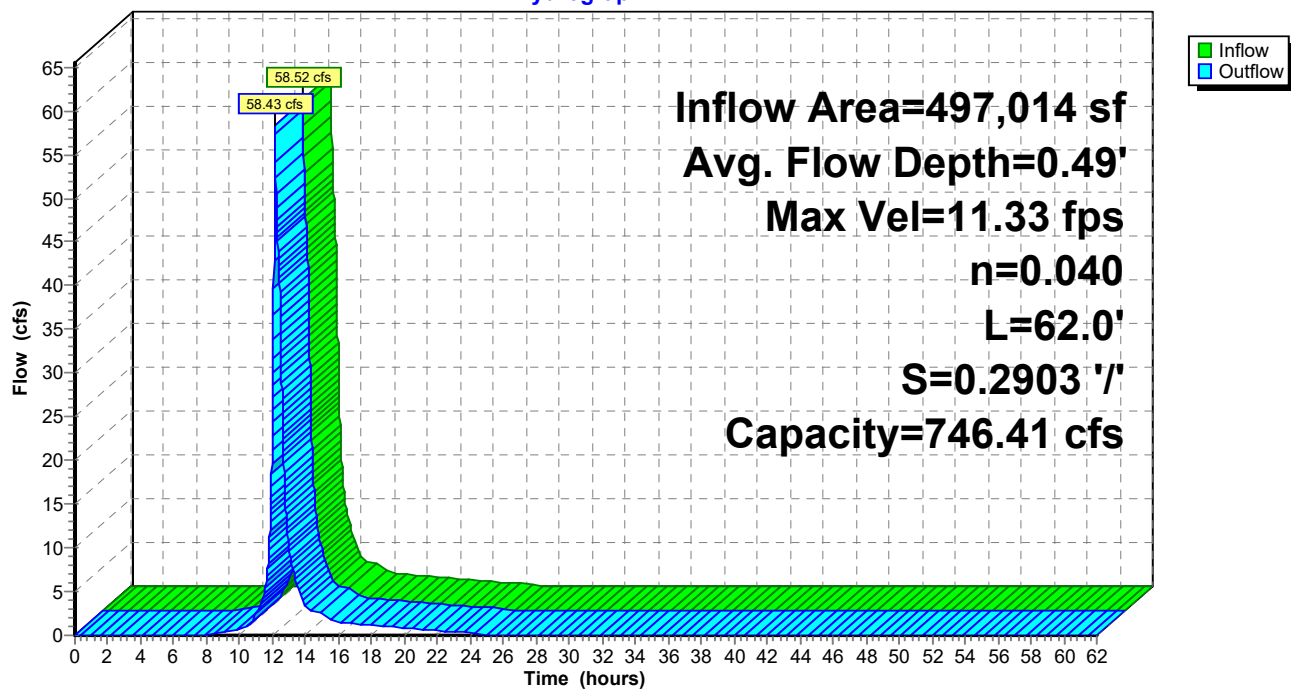
Length= 62.0' Slope= 0.2903 ' '

Inlet Invert= 980.00', Outlet Invert= 962.00'



Reach CDS6: C Downslope 6

Hydrograph



Summary for Reach CDS7: C Downslope 7

[61] Hint: Exceeded Reach C5T outlet invert by 0.52' @ 12.16 hrs

[62] Hint: Exceeded Reach CDS6 OUTLET depth by 0.05' @ 12.21 hrs

Inflow Area = 583,228 sf, 0.00% Impervious, Inflow Depth = 5.05" for 100-yr 24-hr event
Inflow = 73.09 cfs @ 12.16 hrs, Volume= 245,598 cf
Outflow = 73.04 cfs @ 12.16 hrs, Volume= 245,598 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 13.23 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 3.16 fps, Avg. Travel Time= 0.3 min

Peak Storage= 359 cf @ 12.16 hrs

Average Depth at Peak Storage= 0.52'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 841.75 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

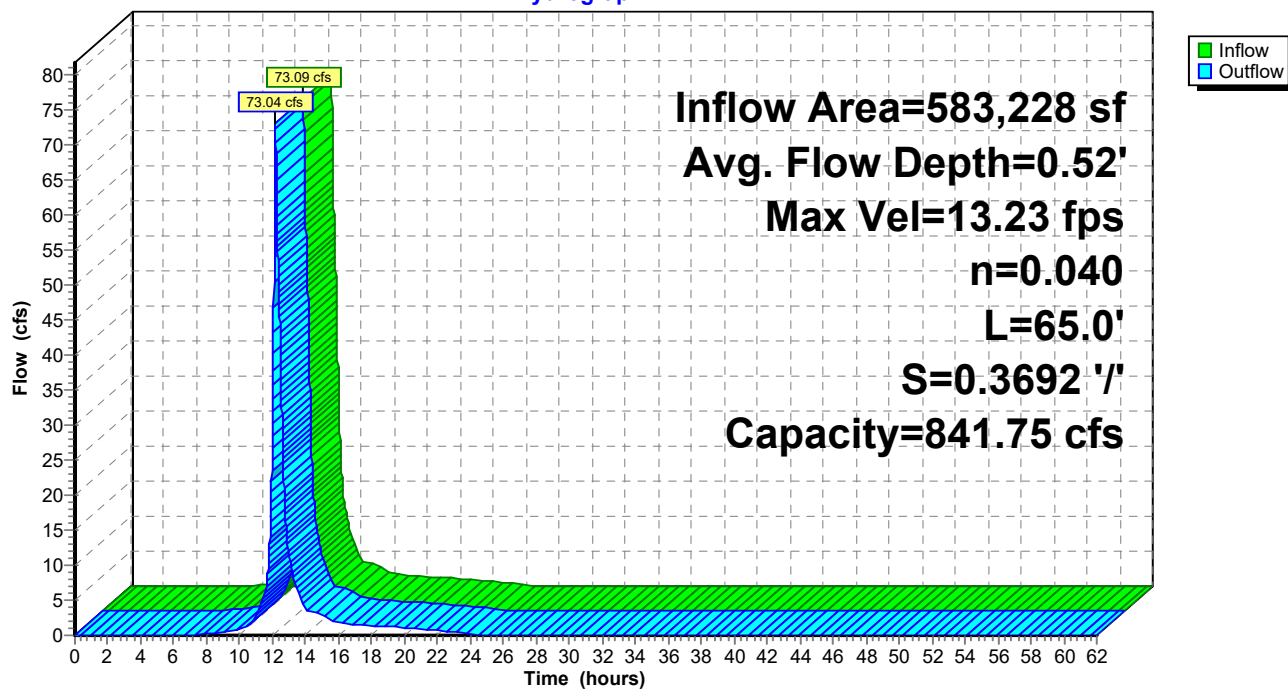
Length= 65.0' Slope= 0.3692 ' '

Inlet Invert= 962.00', Outlet Invert= 938.00'



Reach CDS7: C Downslope 7

Hydrograph



Summary for Reach CDS8: C Downslope 8

[61] Hint: Exceeded Reach C8T outlet invert by 0.57' @ 12.17 hrs

[62] Hint: Exceeded Reach CDS7 OUTLET depth by 0.06' @ 12.21 hrs

Inflow Area = 662,687 sf, 0.00% Impervious, Inflow Depth = 5.10" for 100-yr 24-hr event
 Inflow = 87.44 cfs @ 12.17 hrs, Volume= 281,585 cf
 Outflow = 87.42 cfs @ 12.17 hrs, Volume= 281,585 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 14.32 fps, Min. Travel Time= 0.0 min
 Avg. Velocity = 3.34 fps, Avg. Travel Time= 0.2 min

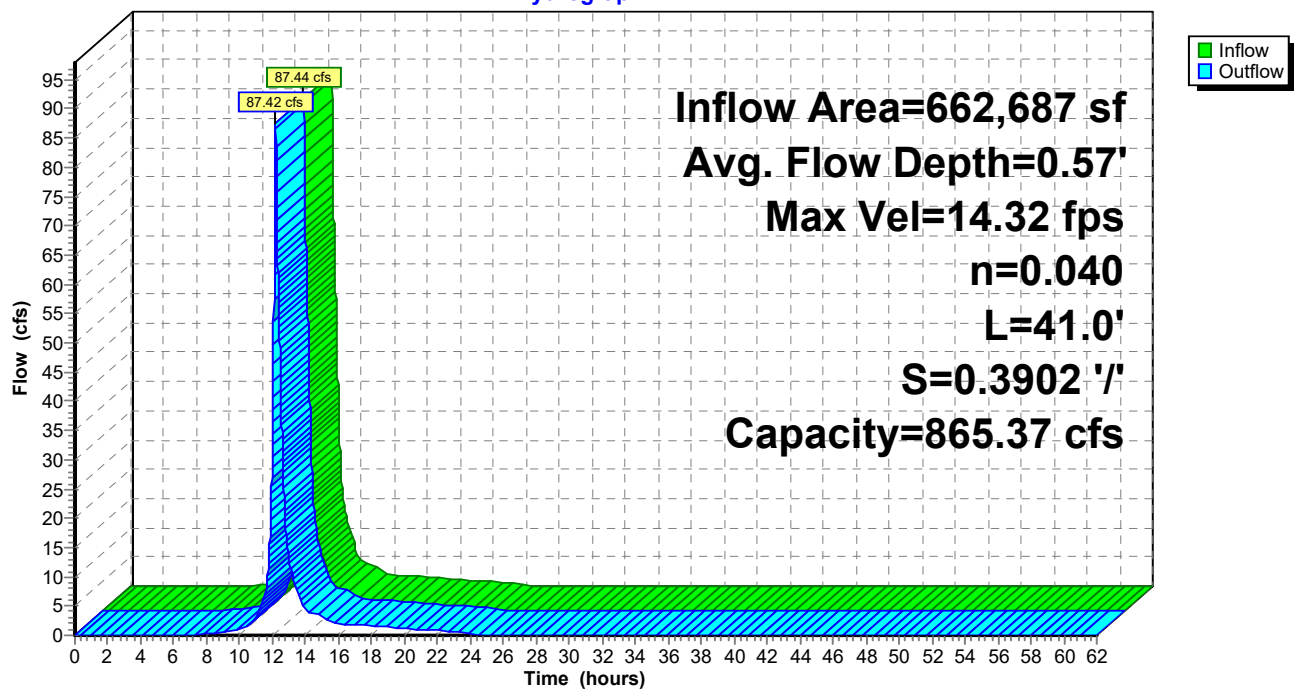
Peak Storage= 250 cf @ 12.17 hrs
 Average Depth at Peak Storage= 0.57'
 Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 865.37 cfs

9.00' x 2.00' deep channel, n= 0.040
 Side Slope Z-value= 3.0 ' ' Top Width= 21.00'
 Length= 41.0' Slope= 0.3902 ' '
 Inlet Invert= 938.00', Outlet Invert= 922.00'



Reach CDS8: C Downslope 8

Hydrograph



Summary for Reach CDS9: C Downslope 9

[62] Hint: Exceeded Reach C7T OUTLET depth by 0.05' @ 12.39 hrs

[62] Hint: Exceeded Reach CDS8 OUTLET depth by 0.16' @ 12.19 hrs

Inflow Area = 752,680 sf, 0.00% Impervious, Inflow Depth = 5.14" for 100-yr 24-hr event
Inflow = 106.12 cfs @ 12.18 hrs, Volume= 322,343 cf
Outflow = 106.05 cfs @ 12.18 hrs, Volume= 322,343 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 13.09 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.96 fps, Avg. Travel Time= 0.5 min

Peak Storage= 721 cf @ 12.18 hrs

Average Depth at Peak Storage= 0.73'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 688.73 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

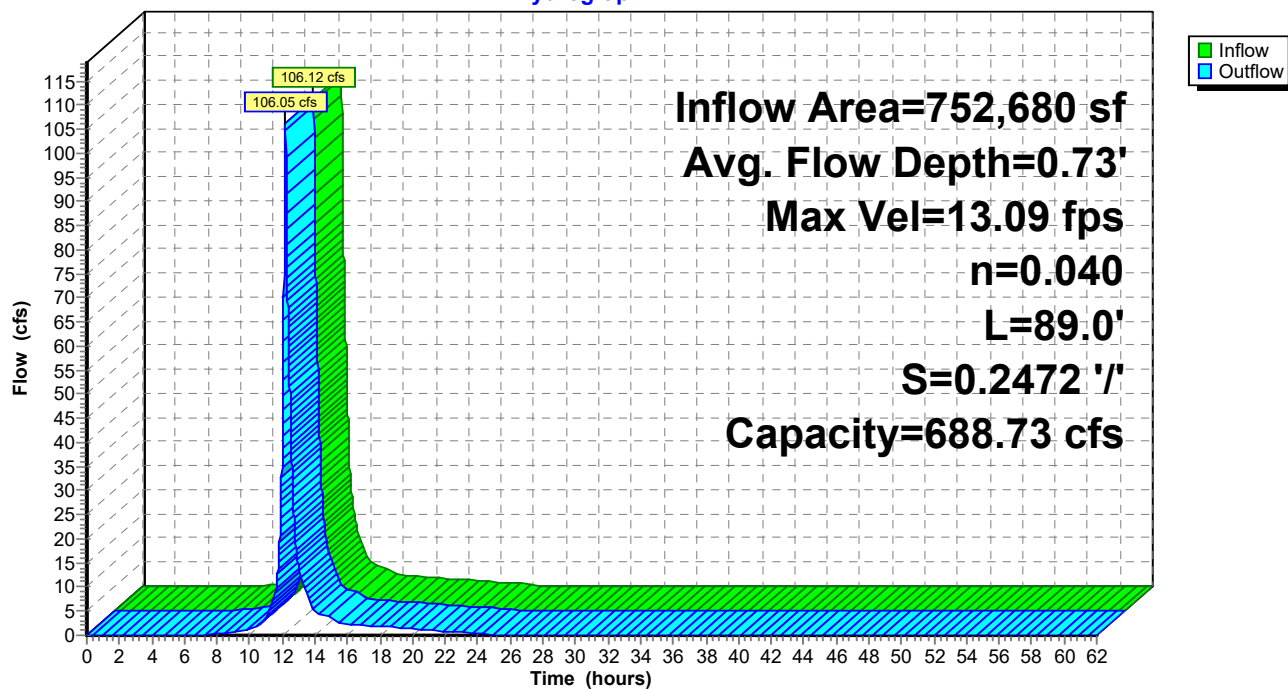
Length= 89.0' Slope= 0.2472 ' '

Inlet Invert= 922.00', Outlet Invert= 900.00'



Reach CDS9: C Downslope 9

Hydrograph



Summary for Reach D10T: D10 Terrace

Inflow Area = 24,411 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 5.63 cfs @ 12.12 hrs, Volume= 11,056 cf
 Outflow = 5.50 cfs @ 12.15 hrs, Volume= 11,056 cf, Atten= 2%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.48 fps, Min. Travel Time= 1.2 min

Avg. Velocity= 1.14 fps, Avg. Travel Time= 3.7 min

Peak Storage= 395 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.54'

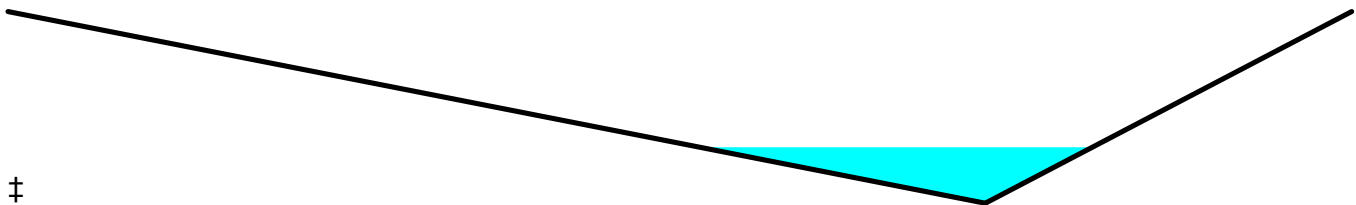
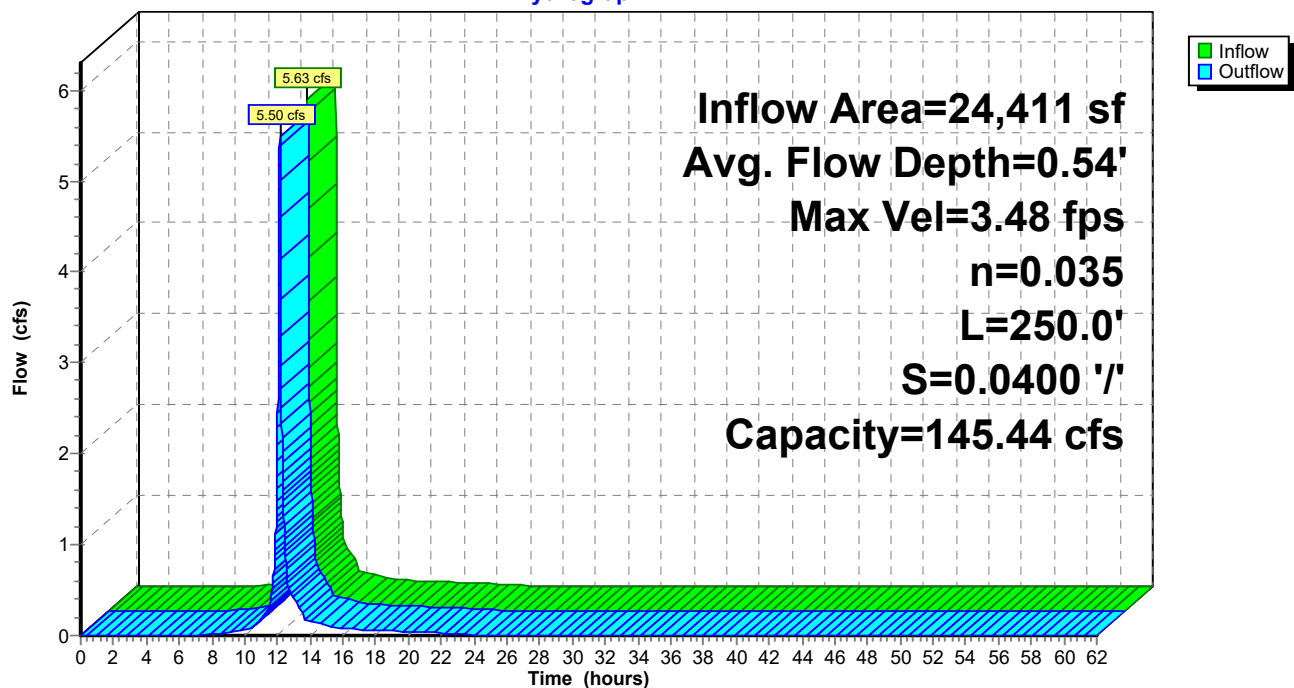
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 145.44 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 250.0' Slope= 0.0400 '/'

Inlet Invert= 932.00', Outlet Invert= 922.00'

**Reach D10T: D10 Terrace****Hydrograph**

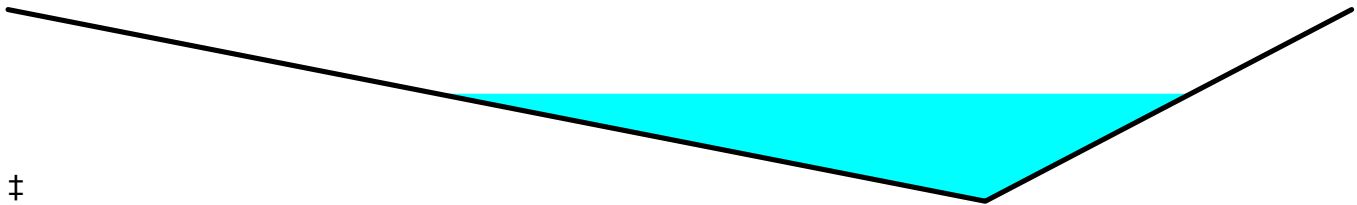
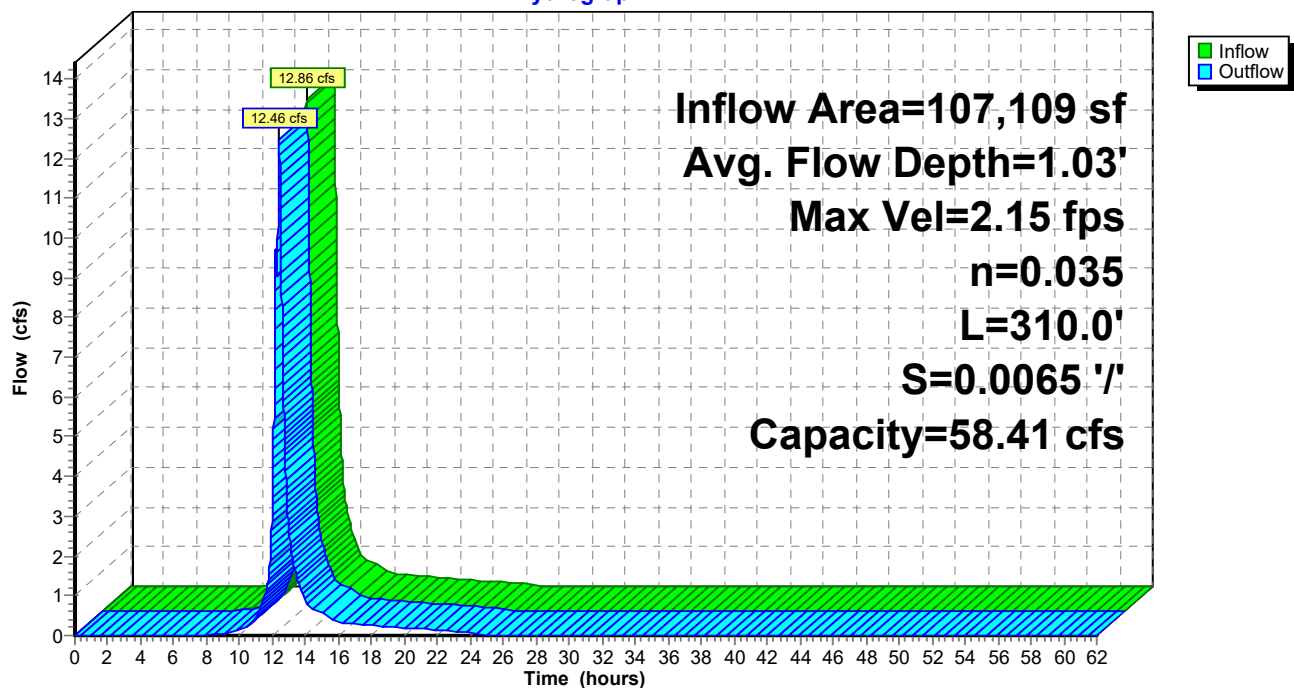
Summary for Reach D11T: D11 Terrace

Inflow Area = 107,109 sf, 0.00% Impervious, Inflow Depth = 5.19" for 100-yr 24-hr event
 Inflow = 12.86 cfs @ 12.33 hrs, Volume= 46,327 cf
 Outflow = 12.46 cfs @ 12.40 hrs, Volume= 46,327 cf, Atten= 3%, Lag= 4.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 2.15 fps, Min. Travel Time= 2.4 min
 Avg. Velocity = 0.61 fps, Avg. Travel Time= 8.5 min

Peak Storage= 1,792 cf @ 12.36 hrs
 Average Depth at Peak Storage= 1.03'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 58.41 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 310.0' Slope= 0.0065 '/'
 Inlet Invert= 890.00', Outlet Invert= 888.00'

**Reach D11T: D11 Terrace****Hydrograph**

Summary for Reach D12T: D12 Terrce

Inflow Area = 16,855 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 4.09 cfs @ 12.11 hrs, Volume= 7,634 cf
 Outflow = 4.04 cfs @ 12.13 hrs, Volume= 7,634 cf, Atten= 1%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.61 fps, Min. Travel Time= 0.8 min

Avg. Velocity = 1.51 fps, Avg. Travel Time= 2.3 min

Peak Storage= 186 cf @ 12.12 hrs

Average Depth at Peak Storage= 0.40'

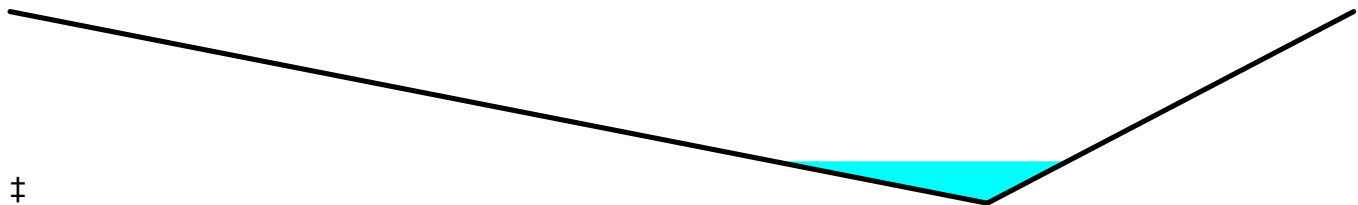
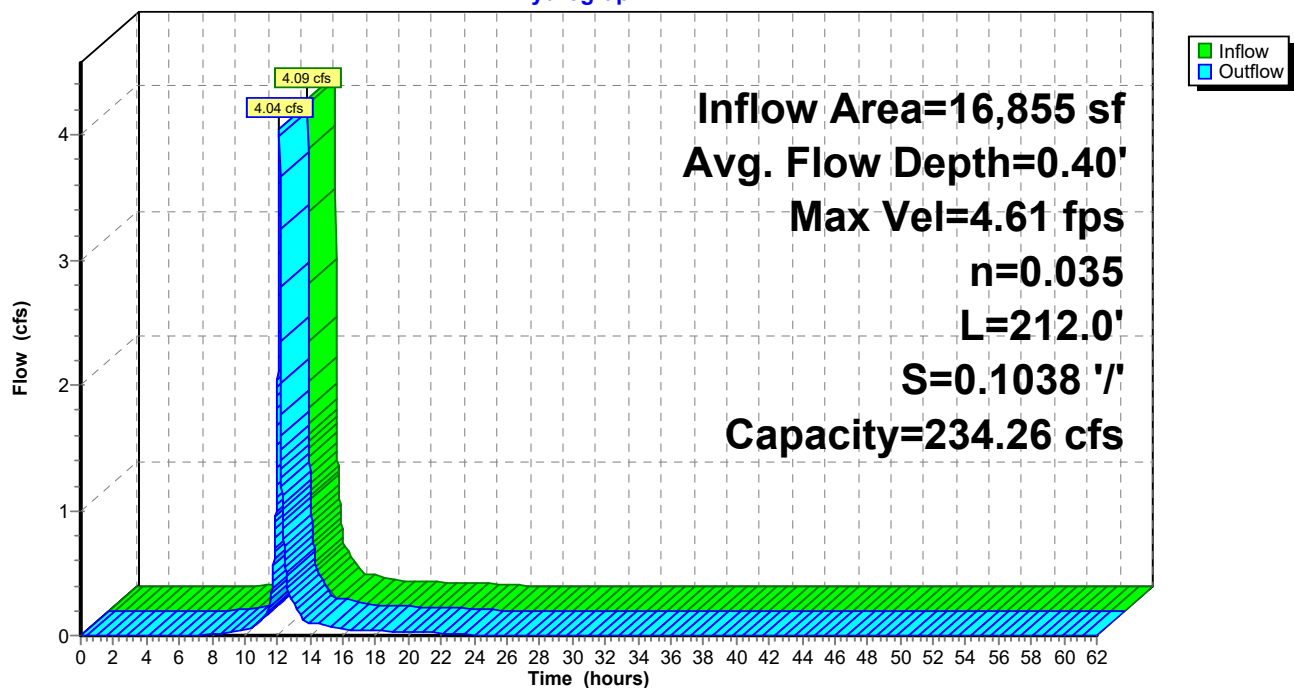
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 234.26 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 212.0' Slope= 0.1038 '/'

Inlet Invert= 910.00', Outlet Invert= 888.00'

**Reach D12T: D12 Terrce****Hydrograph**

Summary for Reach D1T: D1 Terrace

Inflow Area = 10,290 sf, 0.00% Impervious, Inflow Depth = 4.64" for 100-yr 24-hr event
 Inflow = 1.61 cfs @ 12.19 hrs, Volume= 3,981 cf
 Outflow = 1.61 cfs @ 12.21 hrs, Volume= 3,981 cf, Atten= 1%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 2.49 fps, Min. Travel Time= 0.7 min

Avg. Velocity = 0.90 fps, Avg. Travel Time= 2.0 min

Peak Storage= 70 cf @ 12.20 hrs

Average Depth at Peak Storage= 0.34'

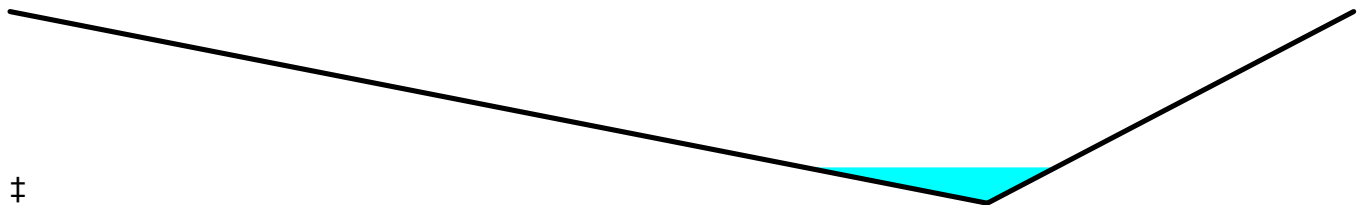
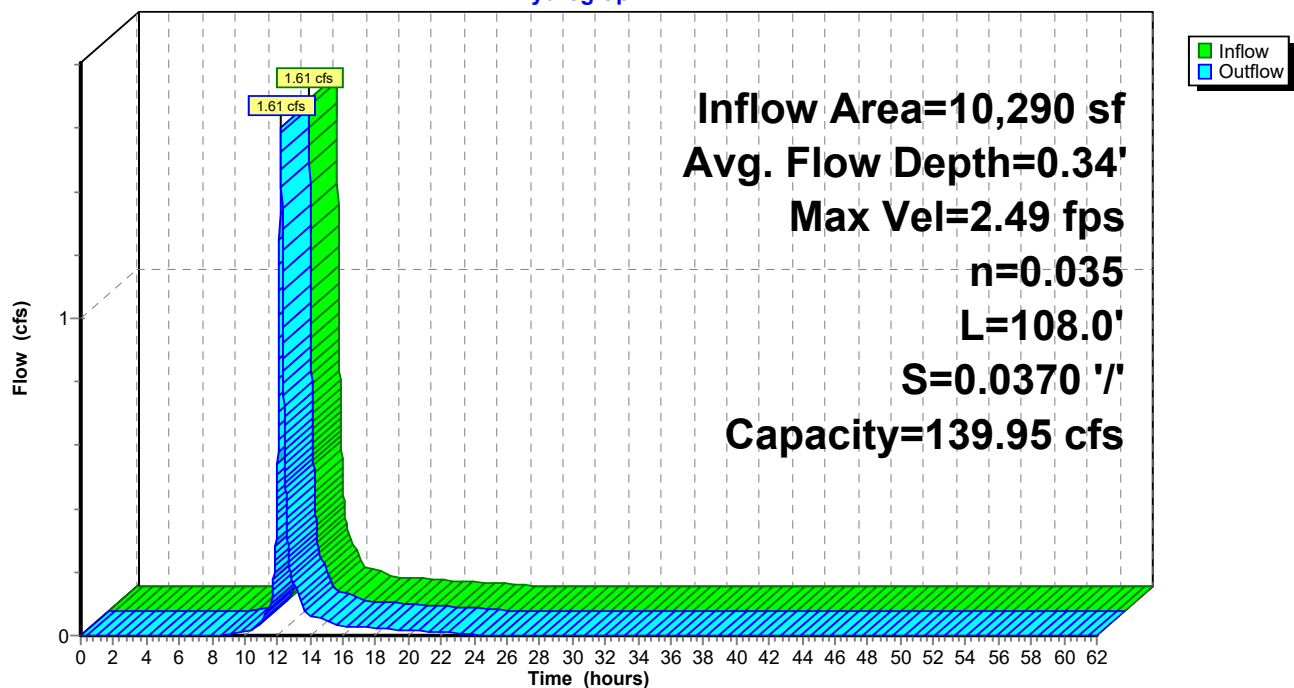
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 139.95 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 108.0' Slope= 0.0370 '/'

Inlet Invert= 1,086.00', Outlet Invert= 1,082.00'

**Reach D1T: D1 Terrace****Hydrograph**

Summary for Reach D2T: D2 Terrace

Inflow Area = 93,952 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
 Inflow = 12.71 cfs @ 12.23 hrs, Volume= 35,471 cf
 Outflow = 12.63 cfs @ 12.26 hrs, Volume= 35,471 cf, Atten= 1%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.95 fps, Min. Travel Time= 1.1 min

Avg. Velocity= 1.00 fps, Avg. Travel Time= 4.4 min

Peak Storage= 851 cf @ 12.24 hrs

Average Depth at Peak Storage= 0.32'

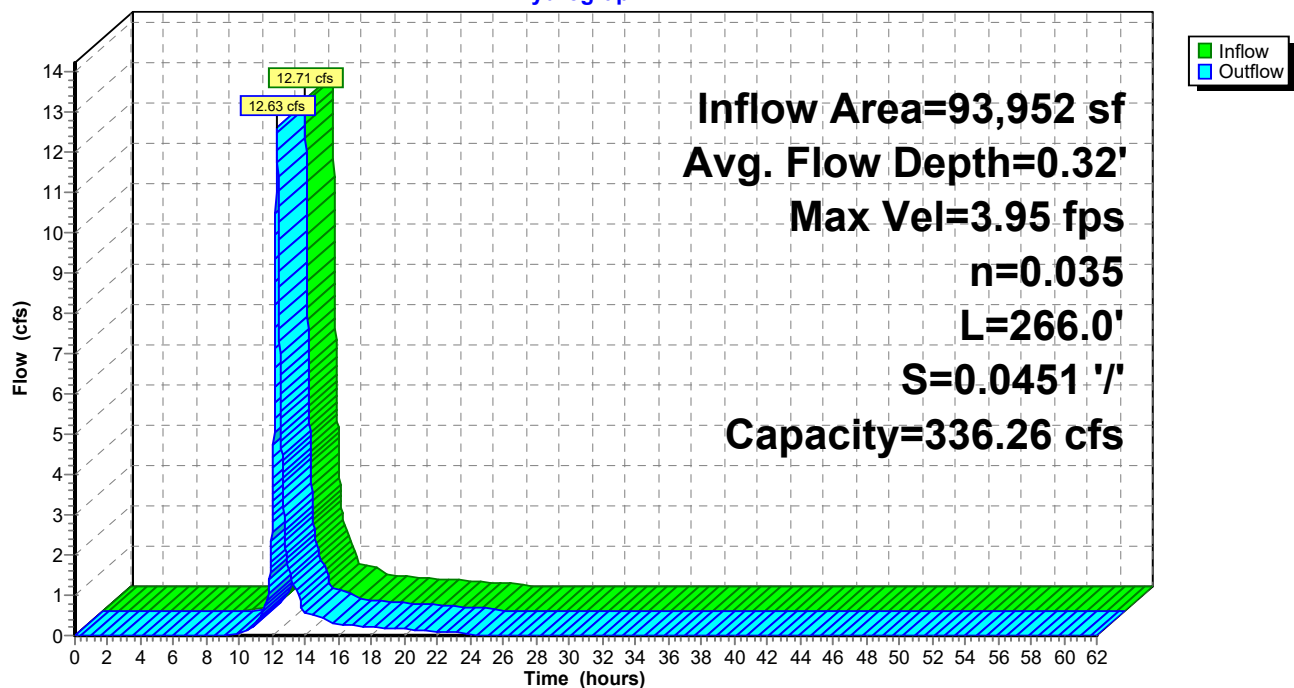
Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 336.26 cfs

9.00' x 2.00' deep channel, n= 0.035

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

Length= 266.0' Slope= 0.0451 '/'

Inlet Invert= 1,094.00', Outlet Invert= 1,082.00'

**Reach D2T: D2 Terrace****Hydrograph**

Summary for Reach D3T: D3 Terrace

Inflow Area = 11,479 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 2.74 cfs @ 12.11 hrs, Volume= 5,199 cf
 Outflow = 2.70 cfs @ 12.14 hrs, Volume= 5,199 cf, Atten= 2%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 2.16 fps, Min. Travel Time= 1.2 min
 Avg. Velocity = 0.67 fps, Avg. Travel Time= 3.7 min

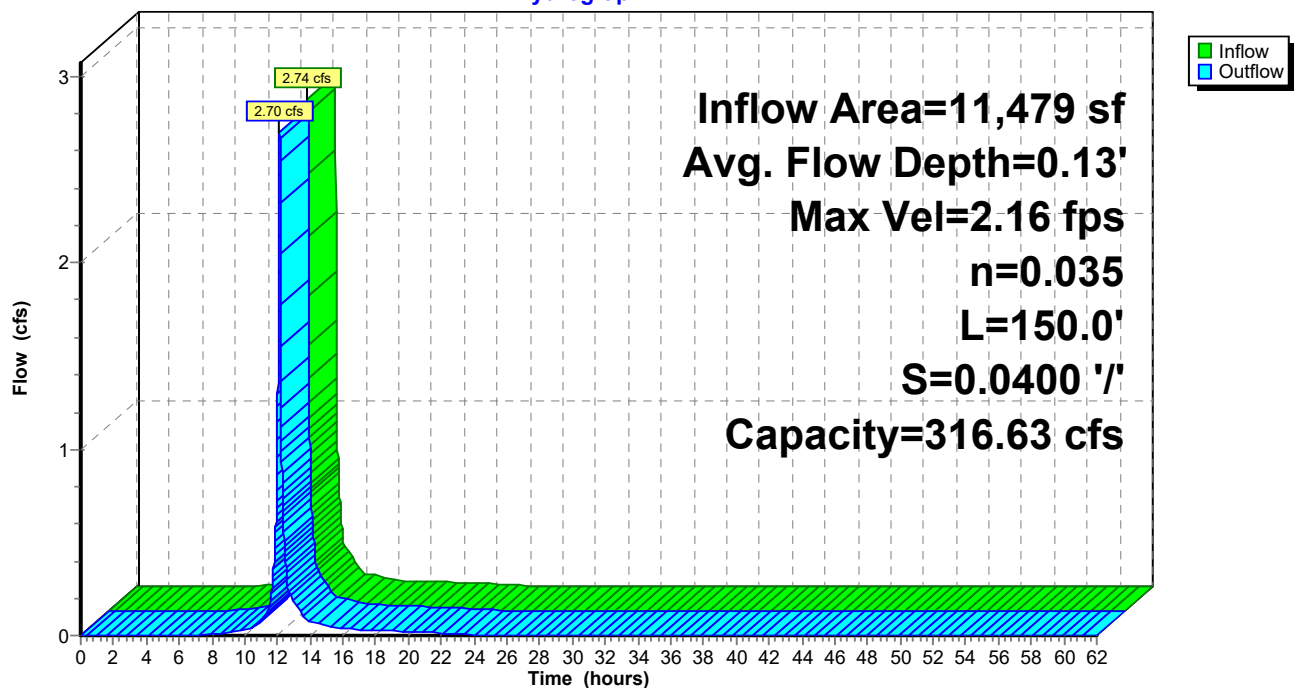
Peak Storage= 188 cf @ 12.12 hrs
 Average Depth at Peak Storage= 0.13'
 Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 316.63 cfs

9.00' x 2.00' deep channel, n= 0.035
 Side Slope Z-value= 3.0 '/' Top Width= 21.00'
 Length= 150.0' Slope= 0.0400 '/'
 Inlet Invert= 1,048.00', Outlet Invert= 1,042.00'



Reach D3T: D3 Terrace

Hydrograph



Summary for Reach D4T: D4 Terrace

Inflow Area = 33,635 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 8.14 cfs @ 12.11 hrs, Volume= 15,233 cf
 Outflow = 7.81 cfs @ 12.15 hrs, Volume= 15,233 cf, Atten= 4%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.09 fps, Min. Travel Time= 1.7 min

Avg. Velocity = 1.31 fps, Avg. Travel Time= 5.2 min

Peak Storage= 786 cf @ 12.12 hrs

Average Depth at Peak Storage= 0.59'

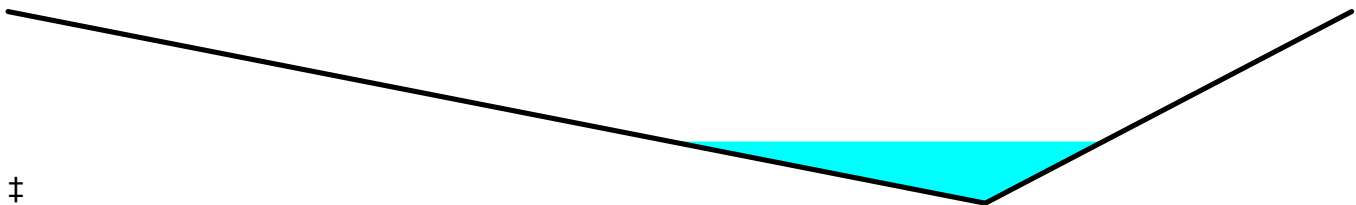
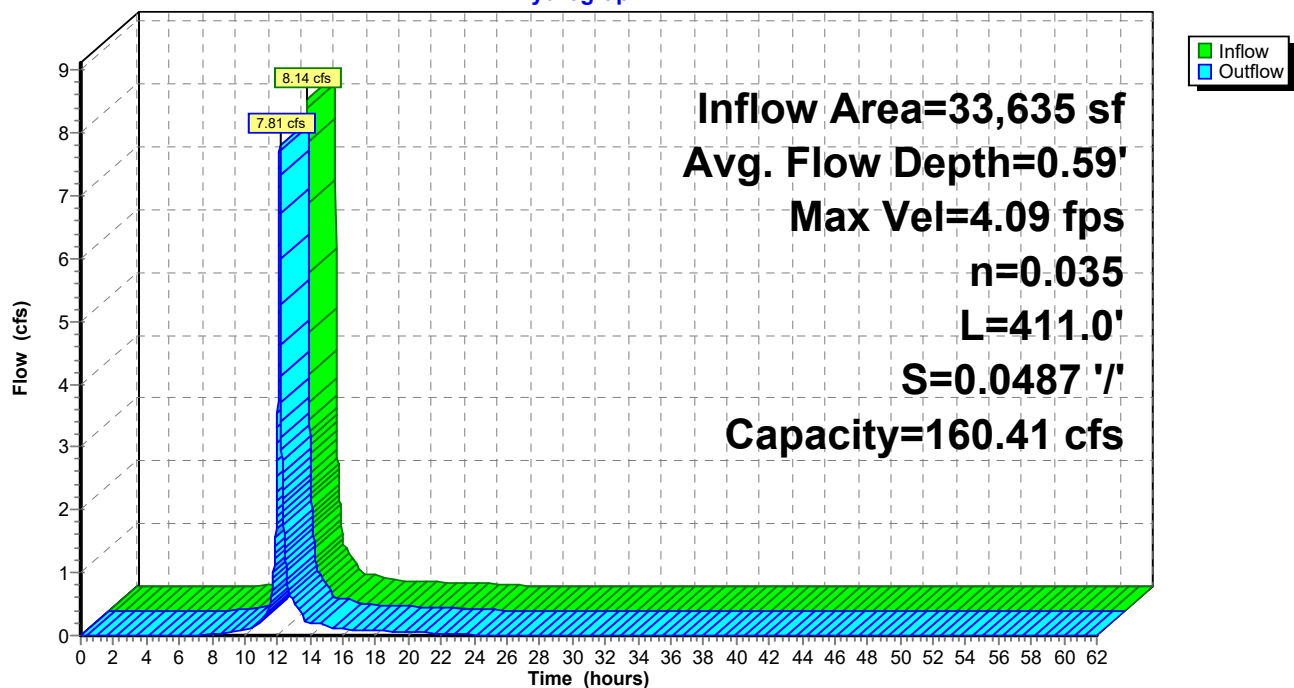
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 160.41 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 411.0' Slope= 0.0487 '/'

Inlet Invert= 1,062.00', Outlet Invert= 1,042.00'

**Reach D4T: D4 Terrace****Hydrograph**

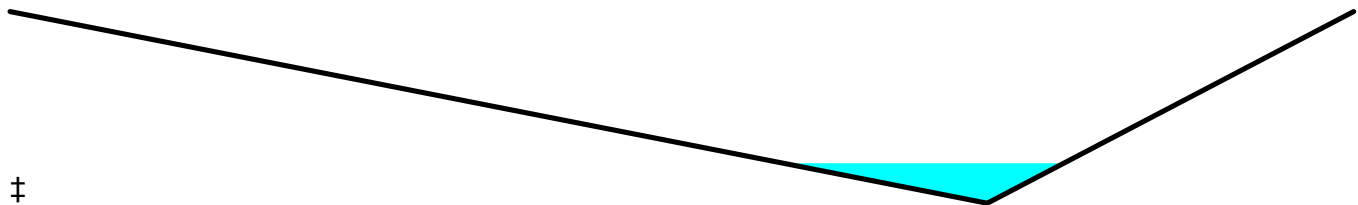
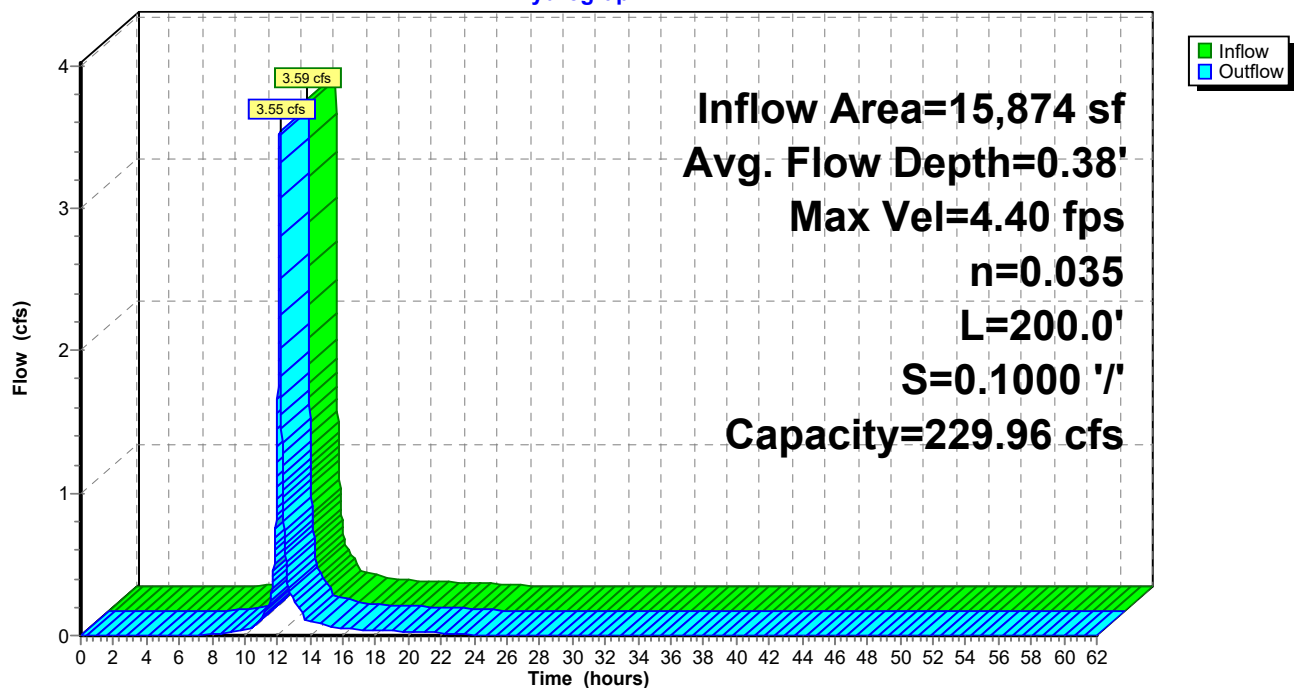
Summary for Reach D5T: D5 Terrace

Inflow Area = 15,874 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
Inflow = 3.59 cfs @ 12.13 hrs, Volume= 7,189 cf
Outflow = 3.55 cfs @ 12.15 hrs, Volume= 7,189 cf, Atten= 1%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.40 fps, Min. Travel Time= 0.8 min
Avg. Velocity= 1.47 fps, Avg. Travel Time= 2.3 min

Peak Storage= 161 cf @ 12.14 hrs
Average Depth at Peak Storage= 0.38'
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 229.96 cfs

0.00' x 1.83' deep channel, n= 0.035
Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
Length= 200.0' Slope= 0.1000 '/'
Inlet Invert= 1,022.00', Outlet Invert= 1,002.00'

**Reach D5T: D5 Terrace****Hydrograph**

Summary for Reach D6T: D6 Terrace

Inflow Area = 33,213 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.07 cfs @ 12.18 hrs, Volume= 15,042 cf
 Outflow = 5.92 cfs @ 12.23 hrs, Volume= 15,042 cf, Atten= 2%, Lag= 2.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.82 fps, Min. Travel Time= 1.6 min

Avg. Velocity= 1.31 fps, Avg. Travel Time= 4.7 min

Peak Storage= 573 cf @ 12.20 hrs

Average Depth at Peak Storage= 0.53'

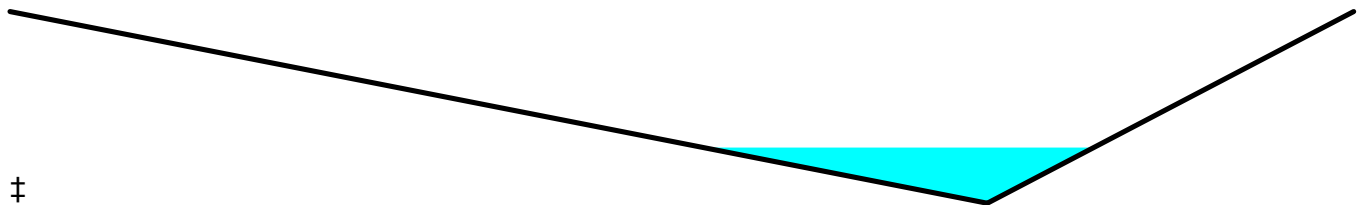
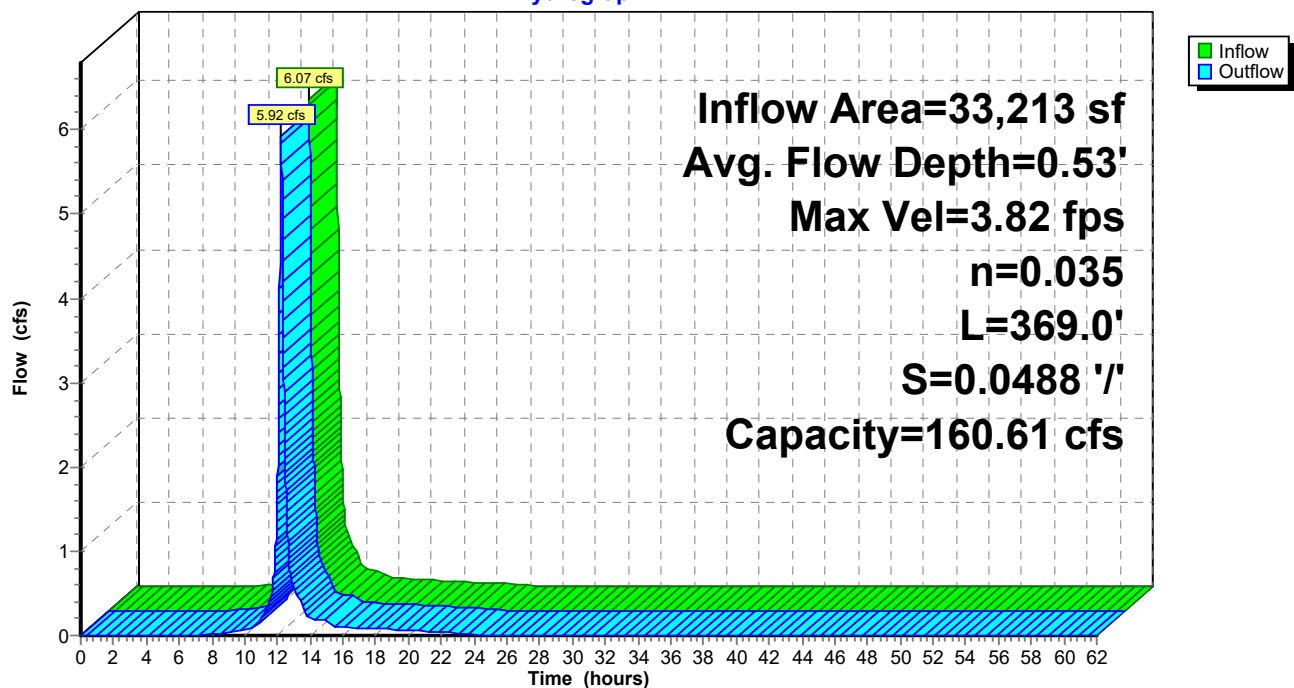
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 160.61 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 369.0' Slope= 0.0488 '/'

Inlet Invert= 1,020.00', Outlet Invert= 1,002.00'

**Reach D6T: D6 Terrace****Hydrograph**

Summary for Reach D7T: D7 Terrace

Inflow Area = 19,733 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 4.70 cfs @ 12.12 hrs, Volume= 8,937 cf
 Outflow = 4.61 cfs @ 12.14 hrs, Volume= 8,937 cf, Atten= 2%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.30 fps, Min. Travel Time= 1.0 min

Avg. Velocity = 1.41 fps, Avg. Travel Time= 3.0 min

Peak Storage= 272 cf @ 12.12 hrs

Average Depth at Peak Storage= 0.44'

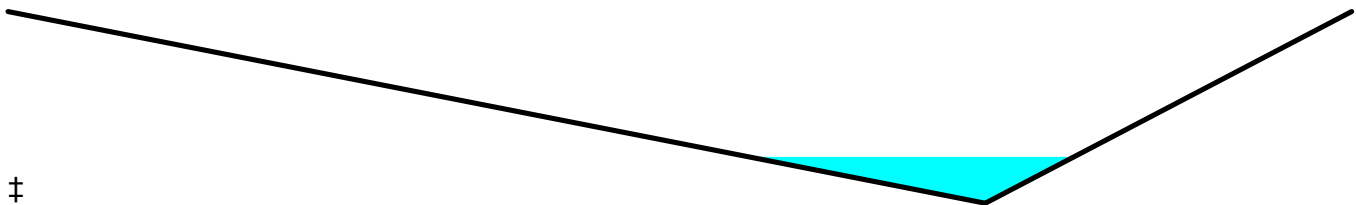
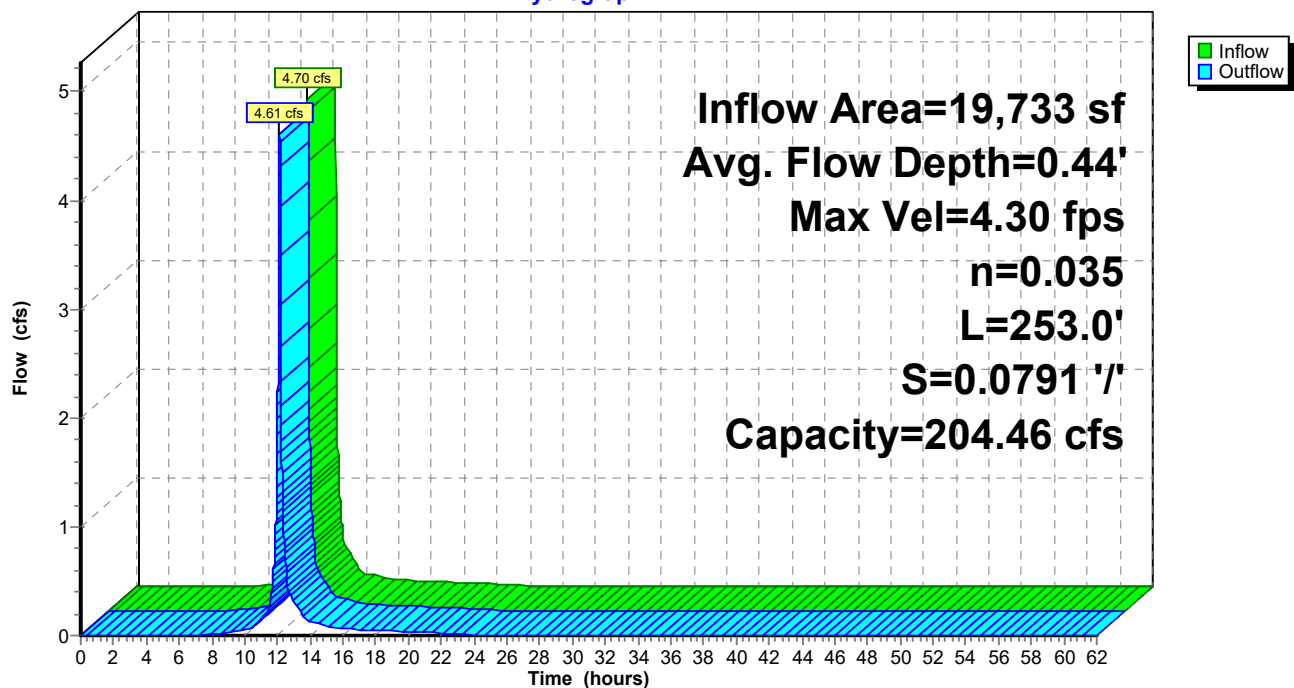
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 204.46 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' / ' Top Width= 20.13'

Length= 253.0' Slope= 0.0791 ' / '

Inlet Invert= 984.00', Outlet Invert= 964.00'

**Reach D7T: D7 Terrace****Hydrograph**

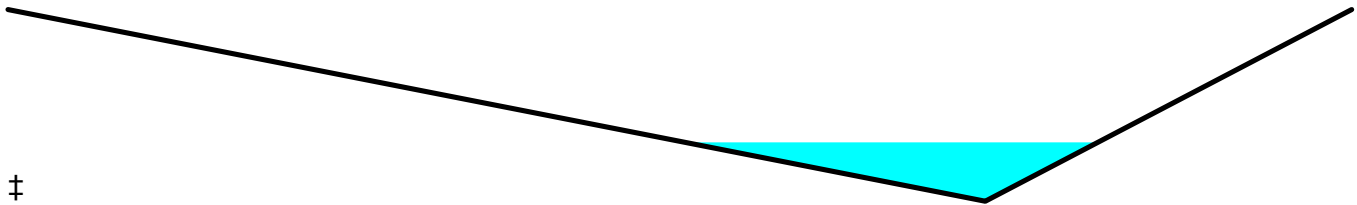
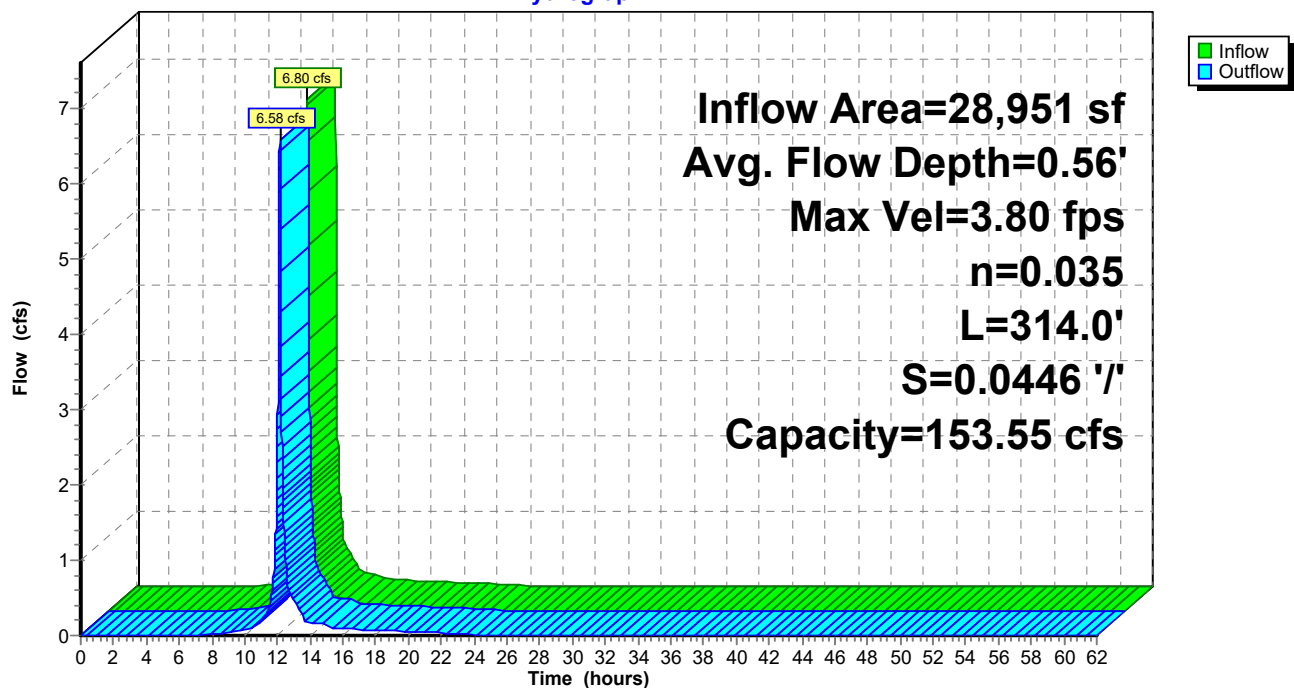
Summary for Reach D8T: D8 Terrace

Inflow Area = 28,951 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.80 cfs @ 12.12 hrs, Volume= 13,112 cf
 Outflow = 6.58 cfs @ 12.15 hrs, Volume= 13,112 cf, Atten= 3%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.80 fps, Min. Travel Time= 1.4 min
 Avg. Velocity = 1.23 fps, Avg. Travel Time= 4.3 min

Peak Storage= 546 cf @ 12.13 hrs
 Average Depth at Peak Storage= 0.56'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 153.55 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 314.0' Slope= 0.0446 '/'
 Inlet Invert= 978.00', Outlet Invert= 964.00'

**Reach D8T: D8 Terrace****Hydrograph**

Summary for Reach D9T: D9 Terrace

Inflow Area = 23,491 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 5.92 cfs @ 12.09 hrs, Volume= 10,639 cf
 Outflow = 5.86 cfs @ 12.10 hrs, Volume= 10,639 cf, Atten= 1%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.65 fps, Min. Travel Time= 1.0 min

Avg. Velocity= 1.49 fps, Avg. Travel Time= 3.2 min

Peak Storage= 367 cf @ 12.09 hrs

Average Depth at Peak Storage= 0.48'

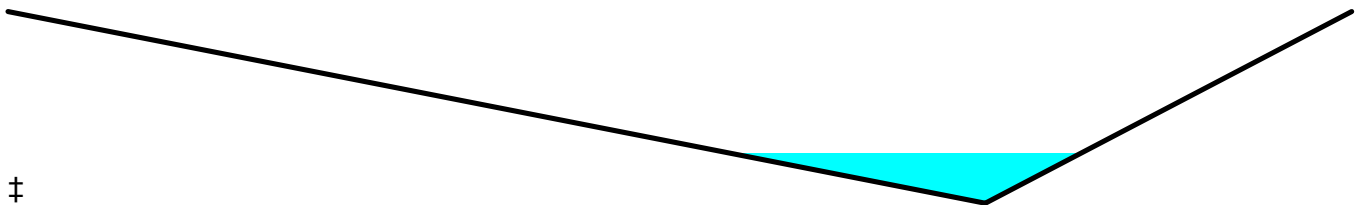
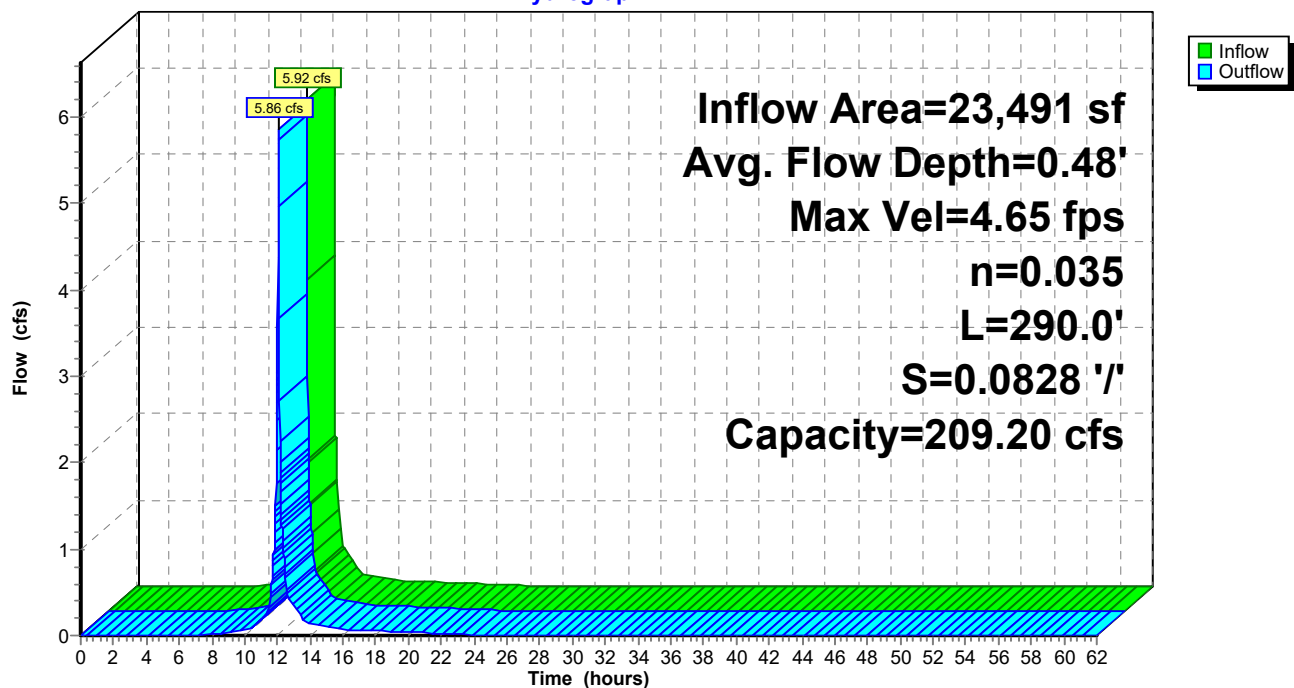
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 209.20 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 290.0' Slope= 0.0828 '/'

Inlet Invert= 946.00', Outlet Invert= 922.00'

**Reach D9T: D9 Terrace****Hydrograph**

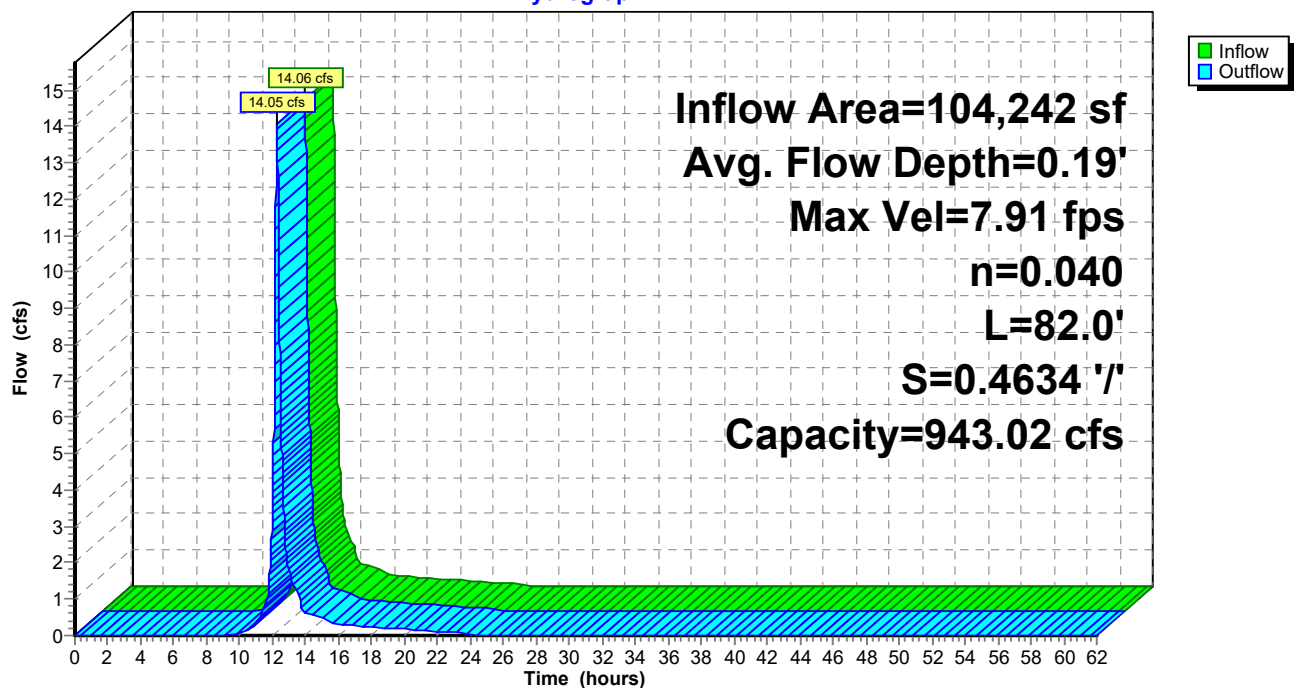
Summary for Reach DDS1: D Downslope 1

Inflow Area = 104,242 sf, 0.00% Impervious, Inflow Depth = 4.54" for 100-yr 24-hr event
 Inflow = 14.06 cfs @ 12.25 hrs, Volume= 39,451 cf
 Outflow = 14.05 cfs @ 12.26 hrs, Volume= 39,451 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 7.91 fps, Min. Travel Time= 0.2 min
 Avg. Velocity = 2.24 fps, Avg. Travel Time= 0.6 min

Peak Storage= 146 cf @ 12.26 hrs
 Average Depth at Peak Storage= 0.19'
 Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 943.02 cfs

9.00' x 2.00' deep channel, n= 0.040
 Side Slope Z-value= 3.0 '/' Top Width= 21.00'
 Length= 82.0' Slope= 0.4634 '/'
 Inlet Invert= 1,080.00', Outlet Invert= 1,042.00'

**Reach DDS1: D Downslope 1****Hydrograph**

Summary for Reach DDS2: D Downslope 2

[62] Hint: Exceeded Reach D3T OUTLET depth by 0.15' @ 12.27 hrs

[61] Hint: Exceeded Reach D4T outlet invert by 0.23' @ 12.17 hrs

[62] Hint: Exceeded Reach DDS1 OUTLET depth by 0.08' @ 12.14 hrs

Inflow Area = 149,356 sf, 0.00% Impervious, Inflow Depth = 4.81" for 100-yr 24-hr event
 Inflow = 20.20 cfs @ 12.17 hrs, Volume= 59,883 cf
 Outflow = 20.17 cfs @ 12.17 hrs, Volume= 59,883 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 9.26 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.44 fps, Avg. Travel Time= 0.5 min

Peak Storage= 174 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.23'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 979.53 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

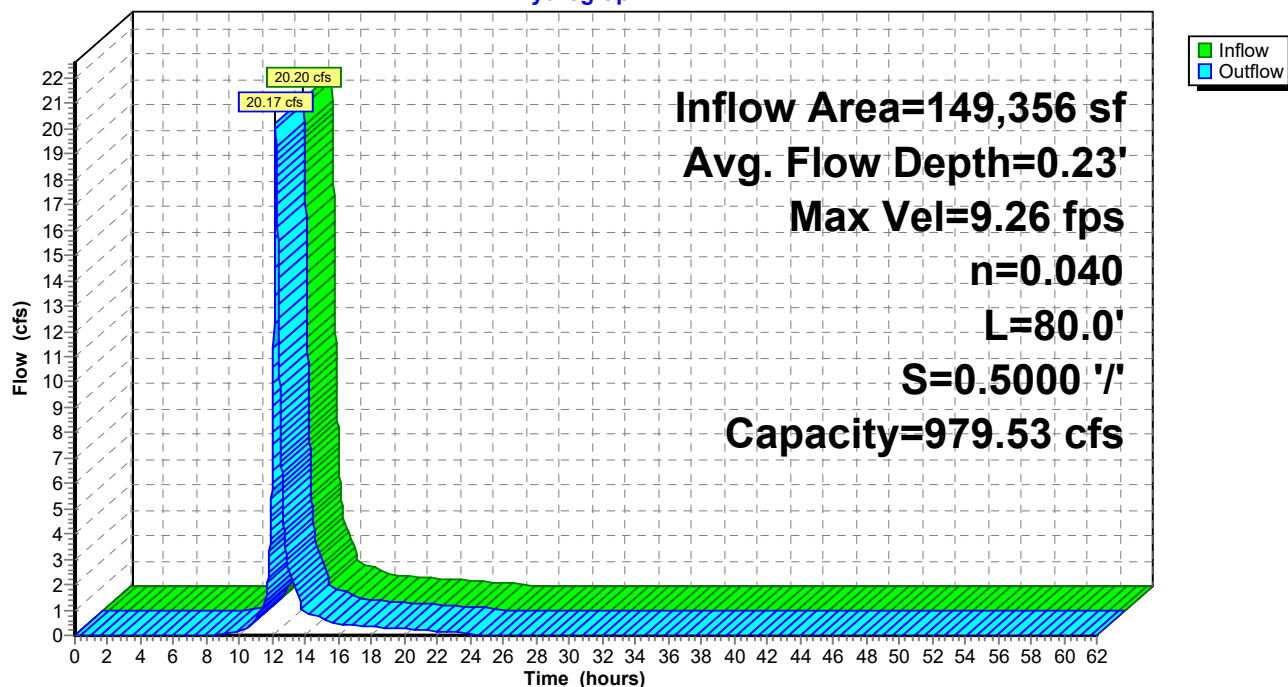
Length= 80.0' Slope= 0.5000 ' '

Inlet Invert= 1,042.00', Outlet Invert= 1,002.00'



Reach DDS2: D Downslope 2

Hydrograph



Summary for Reach DDS3: D Downslope 3

[61] Hint: Exceeded Reach D5T outlet invert by 0.28' @ 12.17 hrs

[61] Hint: Exceeded Reach D6T outlet invert by 0.28' @ 12.17 hrs

[62] Hint: Exceeded Reach DDS2 OUTLET depth by 0.06' @ 12.19 hrs

Inflow Area = 198,443 sf, 0.00% Impervious, Inflow Depth = 4.97" for 100-yr 24-hr event
Inflow = 28.48 cfs @ 12.17 hrs, Volume= 82,115 cf
Outflow = 28.43 cfs @ 12.18 hrs, Volume= 82,115 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 10.24 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.54 fps, Avg. Travel Time= 0.5 min

Peak Storage= 228 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.28'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 943.02 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' Top Width= 21.00'

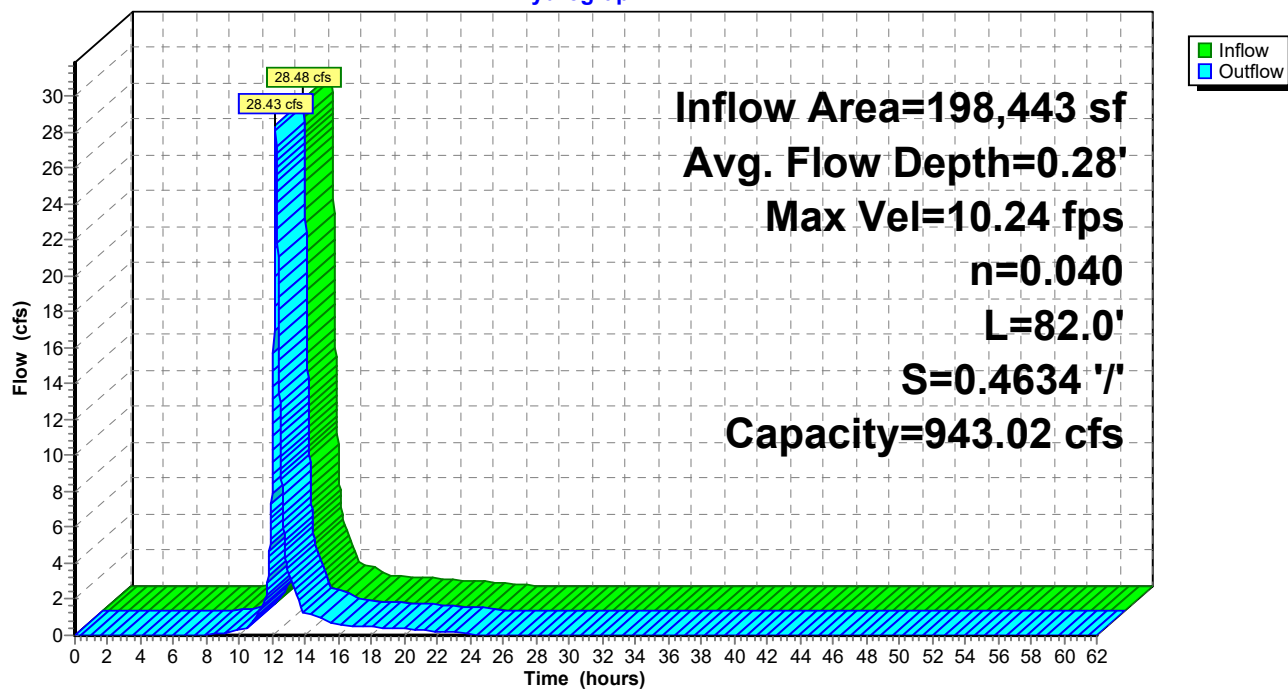
Length= 82.0' Slope= 0.4634 ' /'

Inlet Invert= 1,002.00', Outlet Invert= 964.00'



Reach DDS3: D Downslope 3

Hydrograph



Summary for Reach DDS4: D Downslope 4

[61] Hint: Exceeded Reach D7T outlet invert by 0.33' @ 12.17 hrs

[61] Hint: Exceeded Reach D8T outlet invert by 0.33' @ 12.17 hrs

[62] Hint: Exceeded Reach DDS3 OUTLET depth by 0.05' @ 12.14 hrs

Inflow Area = 247,127 sf, 0.00% Impervious, Inflow Depth = 5.06" for 100-yr 24-hr event
 Inflow = 38.79 cfs @ 12.16 hrs, Volume= 104,163 cf
 Outflow = 38.72 cfs @ 12.17 hrs, Volume= 104,163 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 11.81 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.81 fps, Avg. Travel Time= 0.5 min

Peak Storage= 269 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.33'

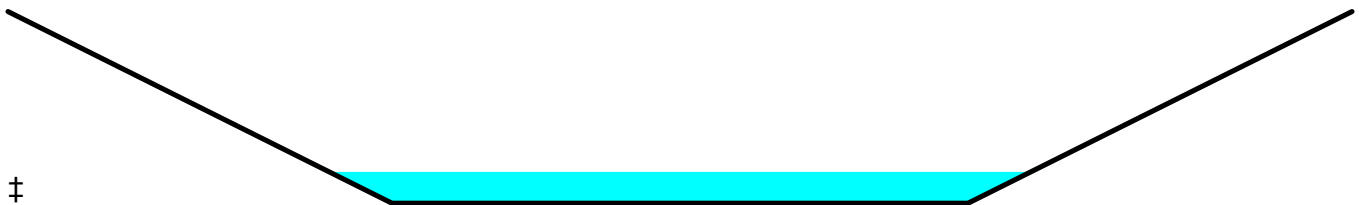
Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 991.41 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

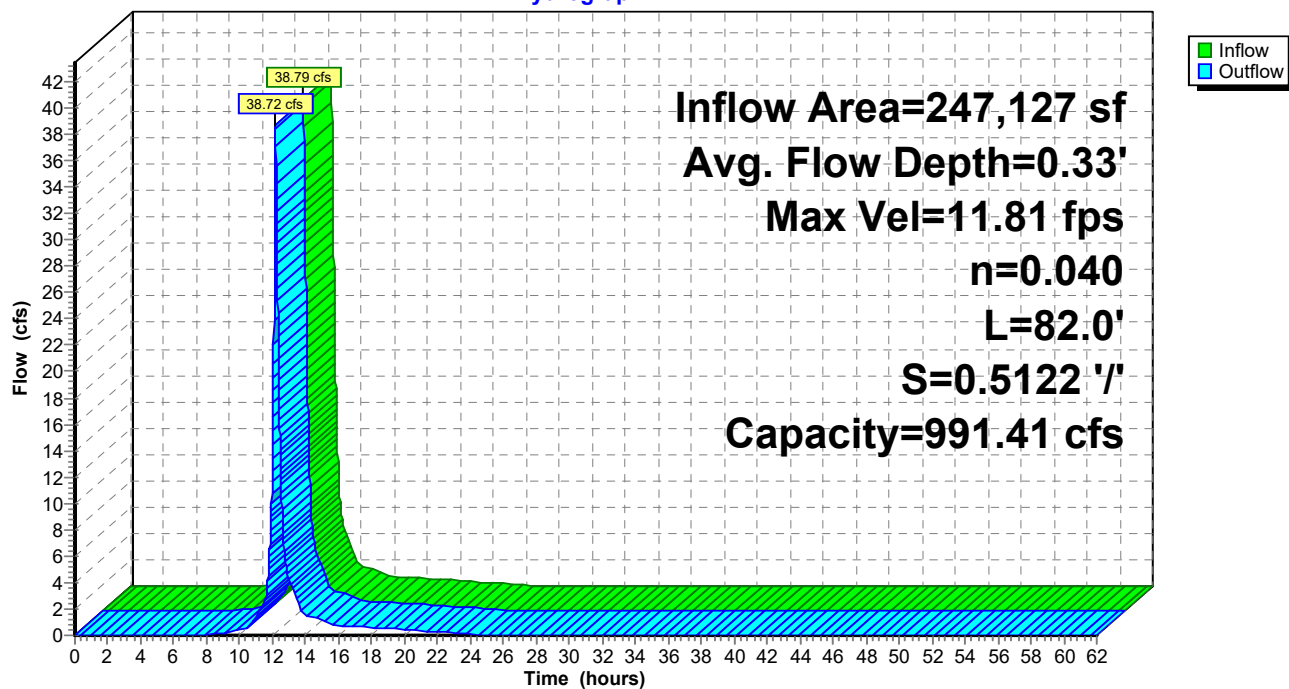
Length= 82.0' Slope= 0.5122 ' '

Inlet Invert= 964.00', Outlet Invert= 922.00'



Reach DDS4: D Downslope 4

Hydrograph



Summary for Reach DDS5: D Downslope 5

[61] Hint: Exceeded Reach D10T outlet invert by 0.38' @ 12.16 hrs

[62] Hint: Exceeded Reach D9T OUTLET depth by 0.07' @ 12.17 hrs

[62] Hint: Exceeded Reach DDS4 OUTLET depth by 0.07' @ 12.11 hrs

Inflow Area = 295,029 sf, 0.00% Impervious, Inflow Depth = 5.12" for 100-yr 24-hr event
 Inflow = 46.08 cfs @ 12.16 hrs, Volume= 125,858 cf
 Outflow = 46.03 cfs @ 12.17 hrs, Volume= 125,858 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 11.91 fps, Min. Travel Time= 0.1 min
 Avg. Velocity = 2.81 fps, Avg. Travel Time= 0.5 min

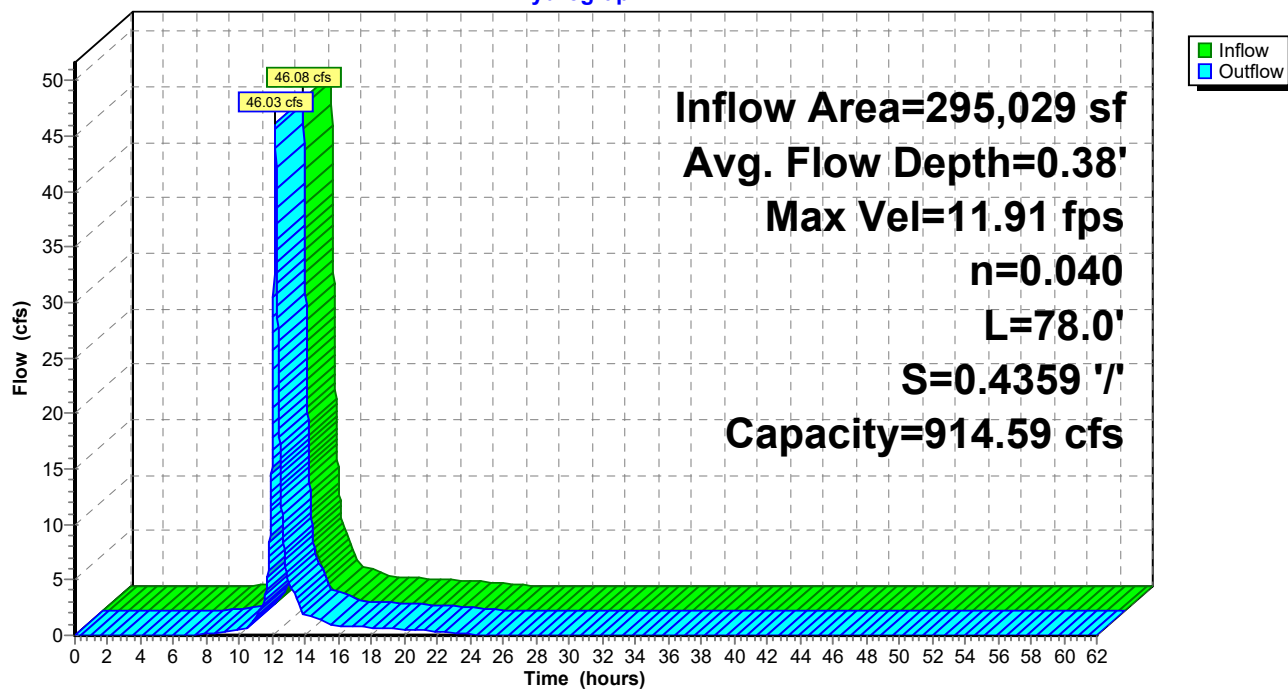
Peak Storage= 301 cf @ 12.16 hrs
 Average Depth at Peak Storage= 0.38'
 Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 914.59 cfs

9.00' x 2.00' deep channel, n= 0.040
 Side Slope Z-value= 3.0 '/' Top Width= 21.00'
 Length= 78.0' Slope= 0.4359 '/'
 Inlet Invert= 922.00', Outlet Invert= 888.00'



Reach DDS5: D Downslope 5

Hydrograph



Summary for Reach DDS6: D Downslope 6

[61] Hint: Exceeded Reach D11T outlet invert by 0.43' @ 12.17 hrs

[62] Hint: Exceeded Reach D12T OUTLET depth by 0.14' @ 12.20 hrs

[62] Hint: Exceeded Reach DDS5 OUTLET depth by 0.08' @ 12.43 hrs

Inflow Area = 418,993 sf, 0.00% Impervious, Inflow Depth = 5.15" for 100-yr 24-hr event
 Inflow = 58.31 cfs @ 12.16 hrs, Volume= 179,819 cf
 Outflow = 58.26 cfs @ 12.17 hrs, Volume= 179,819 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 13.03 fps, Min. Travel Time= 0.1 min
 Avg. Velocity = 2.91 fps, Avg. Travel Time= 0.5 min

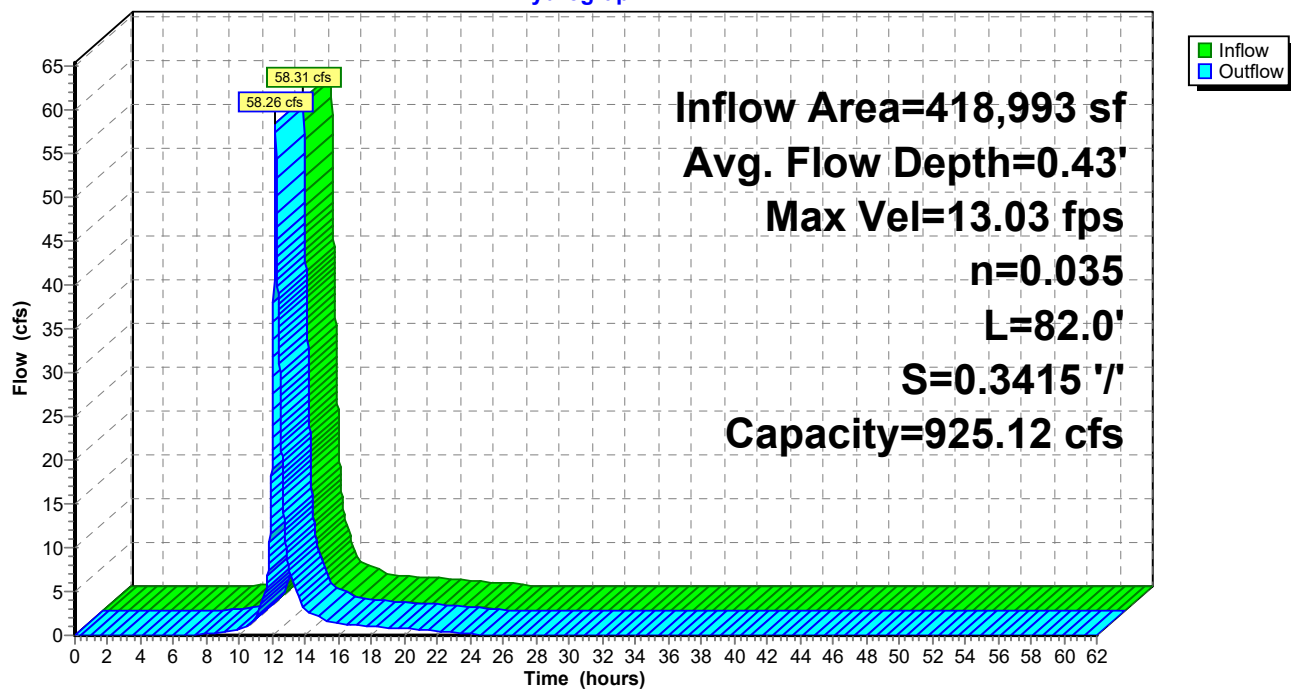
Peak Storage= 367 cf @ 12.17 hrs
 Average Depth at Peak Storage= 0.43'
 Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 925.12 cfs

9.00' x 2.00' deep channel, n= 0.035
 Side Slope Z-value= 3.0 ' ' Top Width= 21.00'
 Length= 82.0' Slope= 0.3415 ' '
 Inlet Invert= 888.00', Outlet Invert= 860.00'



Reach DDS6: D Downslope 6

Hydrograph



Summary for Reach E10T: E10 Terrace

Inflow Area = 76,146 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 15.89 cfs @ 12.15 hrs, Volume= 34,486 cf
 Outflow = 13.83 cfs @ 12.25 hrs, Volume= 34,486 cf, Atten= 13%, Lag= 6.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.45 fps, Min. Travel Time= 4.2 min

Avg. Velocity = 1.37 fps, Avg. Travel Time= 13.5 min

Peak Storage= 3,447 cf @ 12.18 hrs

Average Depth at Peak Storage= 0.75'

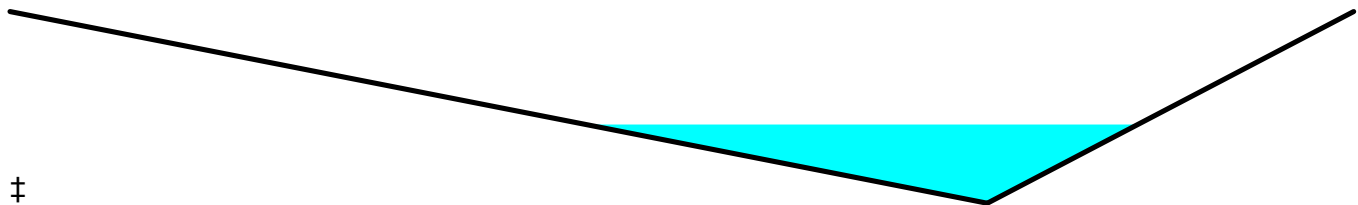
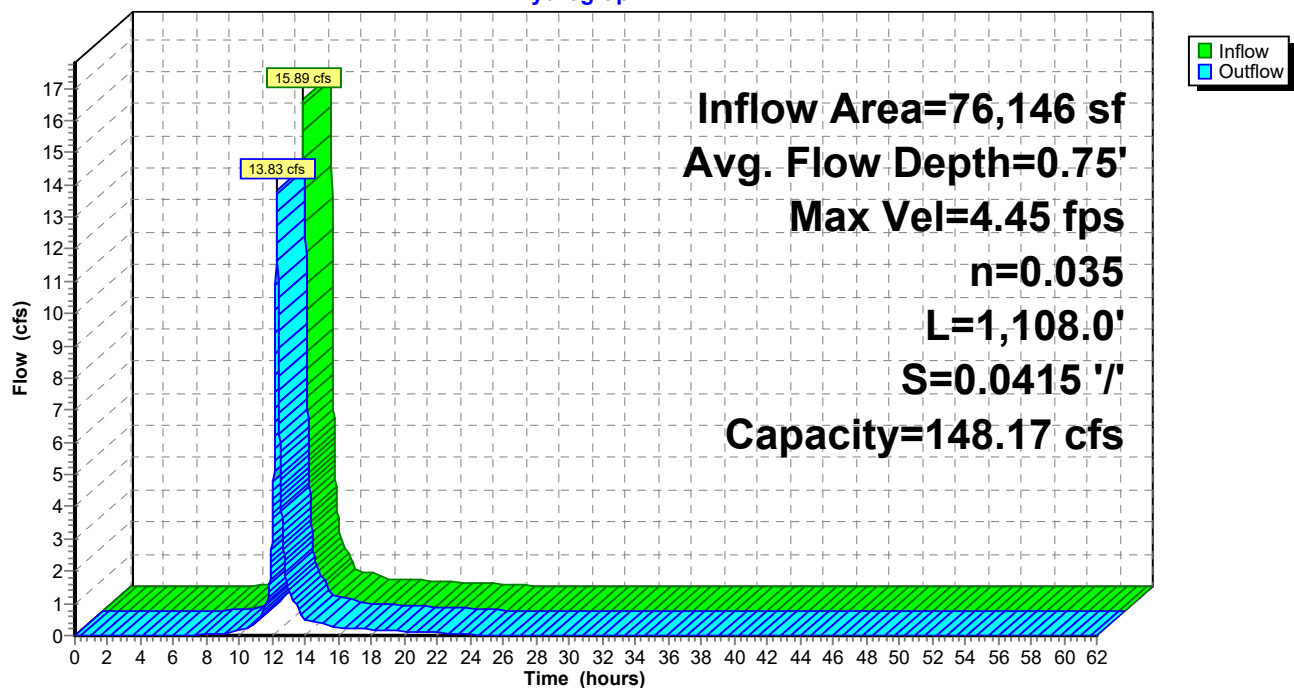
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 148.17 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 1,108.0' Slope= 0.0415 '/'

Inlet Invert= 956.00', Outlet Invert= 910.00'

**Reach E10T: E10 Terrace****Hydrograph**

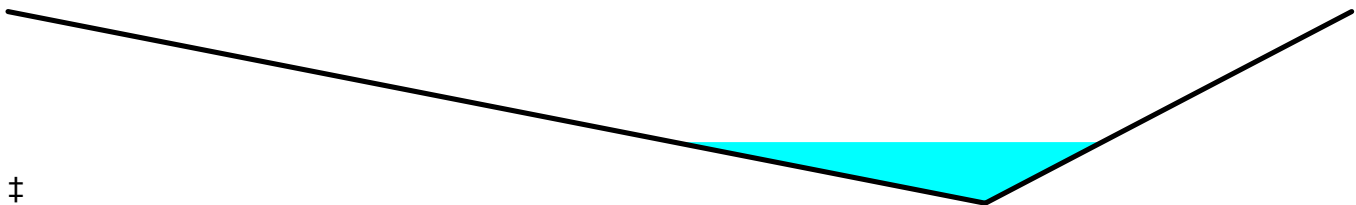
Summary for Reach E11T: E11 Terrace

Inflow Area = 29,213 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.32 cfs @ 12.14 hrs, Volume= 13,230 cf
 Outflow = 6.17 cfs @ 12.17 hrs, Volume= 13,230 cf, Atten= 2%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.31 fps, Min. Travel Time= 1.2 min
 Avg. Velocity= 1.09 fps, Avg. Travel Time= 3.8 min

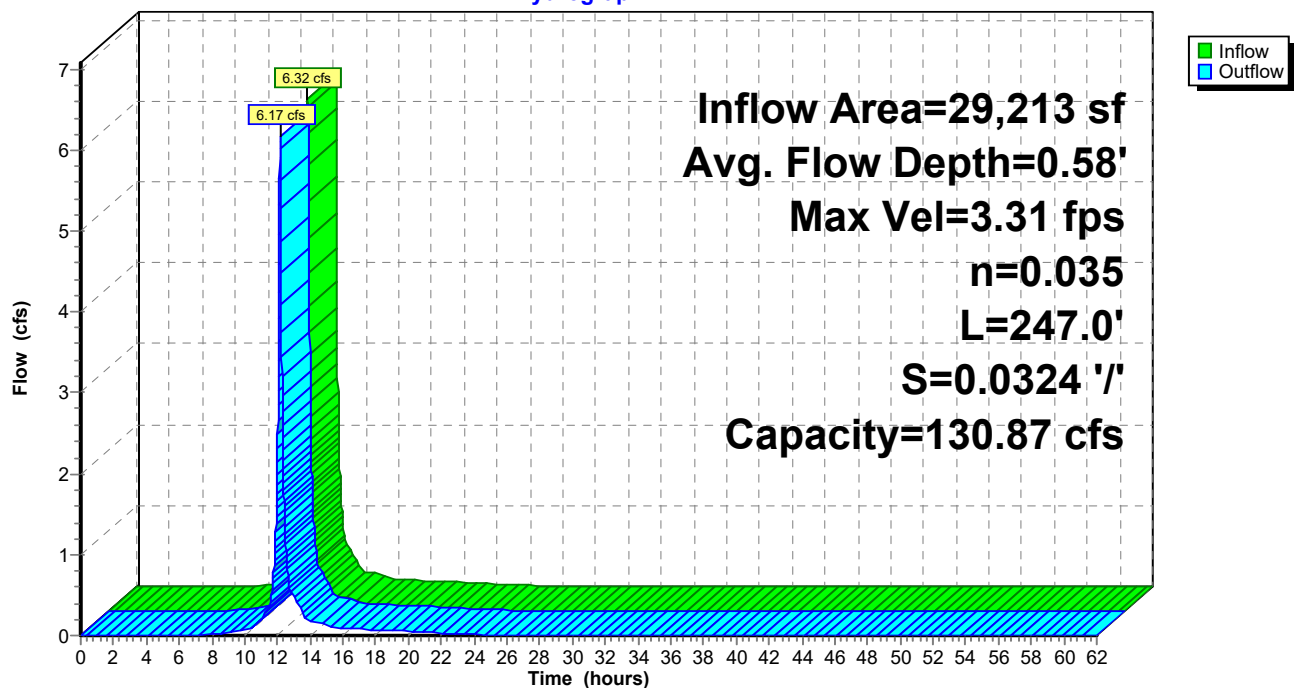
Peak Storage= 461 cf @ 12.15 hrs
 Average Depth at Peak Storage= 0.58'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 130.87 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 247.0' Slope= 0.0324 '/'
 Inlet Invert= 890.00', Outlet Invert= 882.00'



Reach E11T: E11 Terrace

Hydrograph



Summary for Reach E12T: E12 Terrce

Inflow Area = 88,379 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 19.70 cfs @ 12.13 hrs, Volume= 40,027 cf
 Outflow = 16.67 cfs @ 12.24 hrs, Volume= 40,027 cf, Atten= 15%, Lag= 6.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.68 fps, Min. Travel Time= 4.4 min

Avg. Velocity= 1.40 fps, Avg. Travel Time= 14.7 min

Peak Storage= 4,426 cf @ 12.16 hrs

Average Depth at Peak Storage= 0.81'

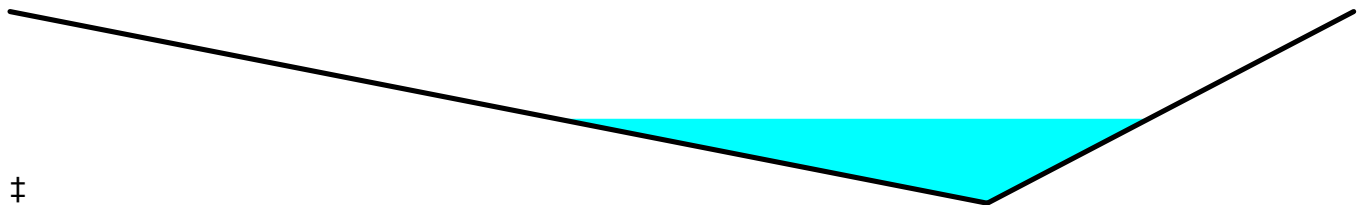
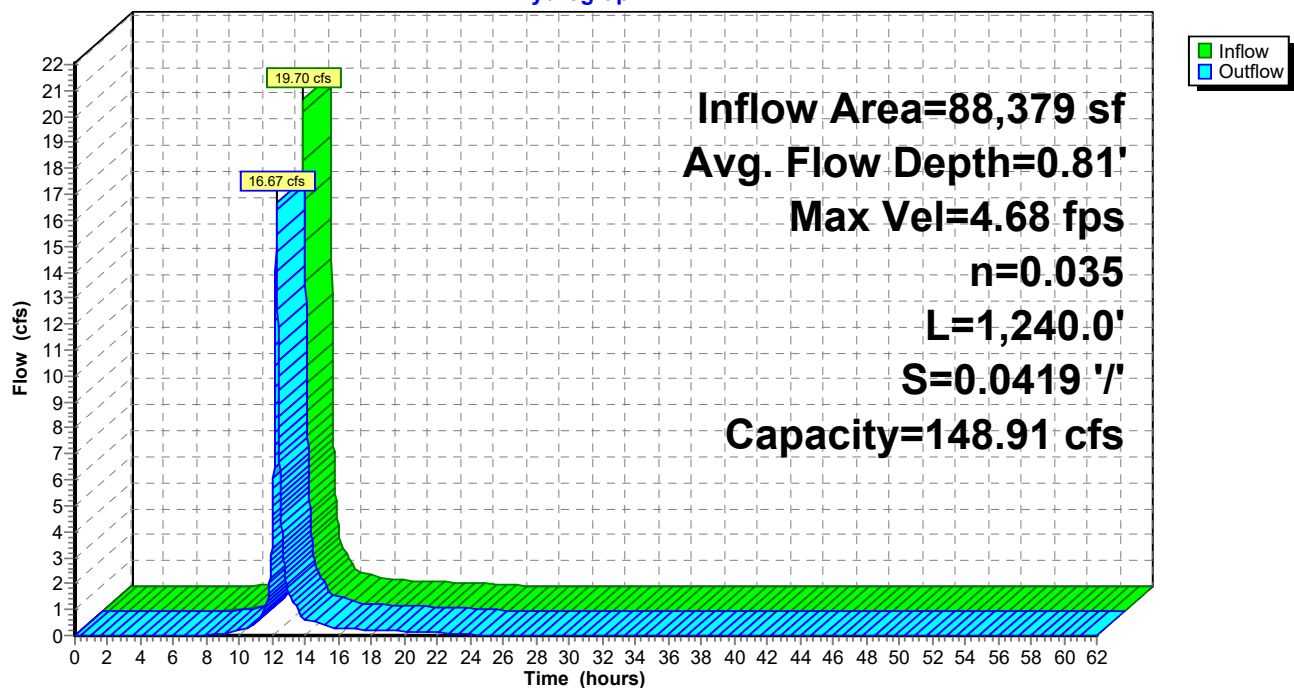
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 148.91 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 1,240.0' Slope= 0.0419 '/'

Inlet Invert= 938.00', Outlet Invert= 886.00'

**Reach E12T: E12 Terrce****Hydrograph**

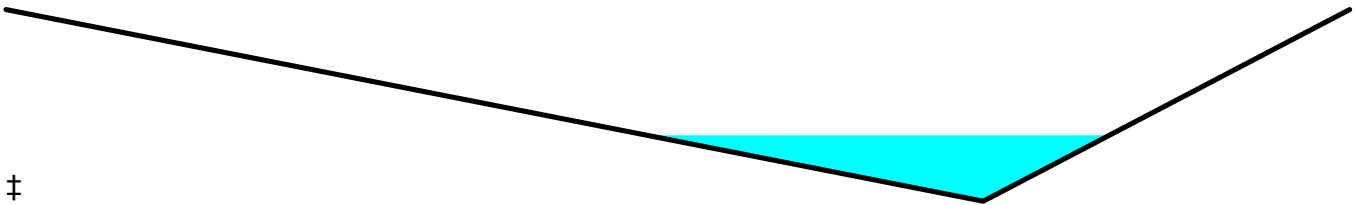
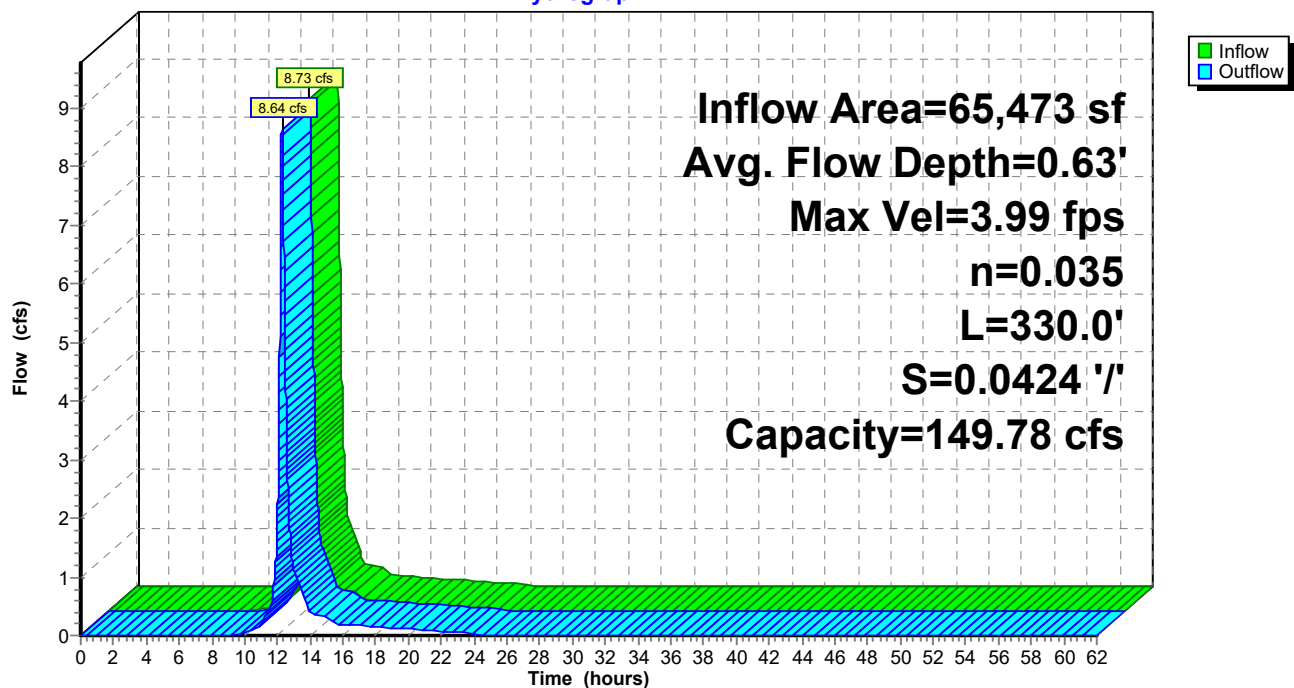
Summary for Reach E1T: E1 Terrace

Inflow Area = 65,473 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
 Inflow = 8.73 cfs @ 12.23 hrs, Volume= 24,719 cf
 Outflow = 8.64 cfs @ 12.28 hrs, Volume= 24,719 cf, Atten= 1%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.99 fps, Min. Travel Time= 1.4 min
 Avg. Velocity = 1.45 fps, Avg. Travel Time= 3.8 min

Peak Storage= 716 cf @ 12.25 hrs
 Average Depth at Peak Storage= 0.63'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 149.78 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 330.0' Slope= 0.0424 '/'
 Inlet Invert= 1,094.00', Outlet Invert= 1,080.00'

**Reach E1T: E1 Terrace****Hydrograph**

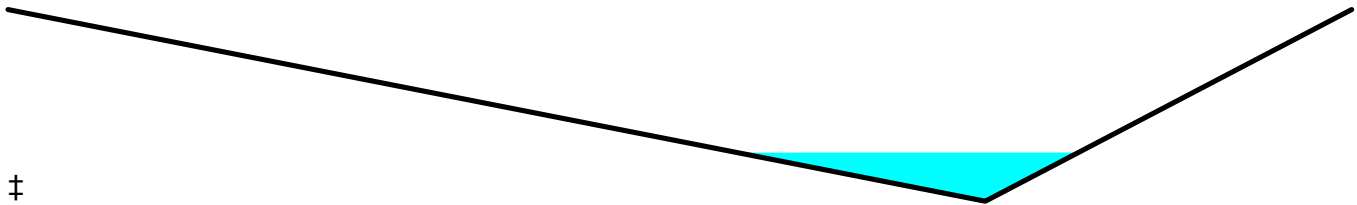
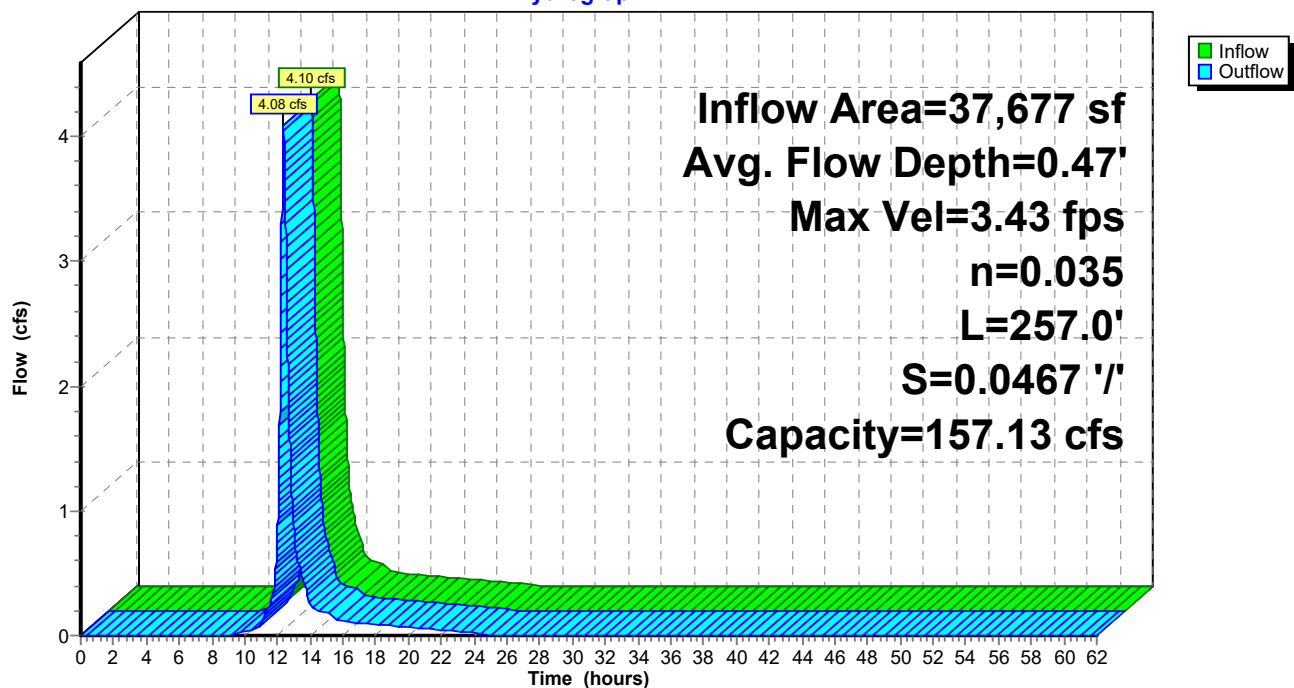
Summary for Reach E2T: E2 Terrace

Inflow Area = 37,677 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
Inflow = 4.10 cfs @ 12.33 hrs, Volume= 14,225 cf
Outflow = 4.08 cfs @ 12.37 hrs, Volume= 14,225 cf, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.43 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.32 fps, Avg. Travel Time= 3.2 min

Peak Storage= 306 cf @ 12.35 hrs
Average Depth at Peak Storage= 0.47'
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 157.13 cfs

0.00' x 1.83' deep channel, n= 0.035
Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
Length= 257.0' Slope= 0.0467 '/'
Inlet Invert= 1,092.00', Outlet Invert= 1,080.00'

**Reach E2T: E2 Terrace****Hydrograph**

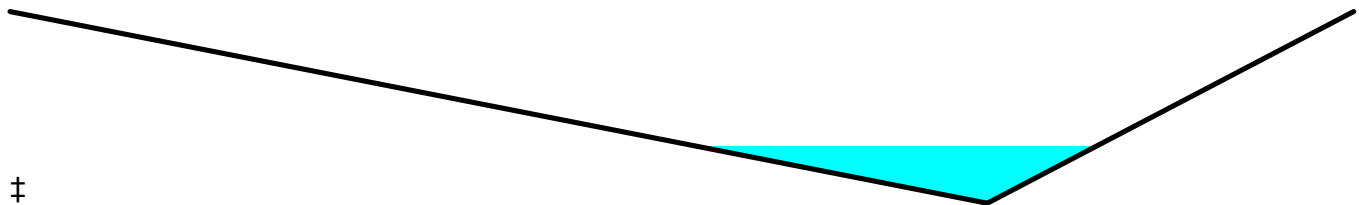
Summary for Reach E3T: E3 Terrace

Inflow Area = 26,387 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.23 cfs @ 12.12 hrs, Volume= 11,951 cf
 Outflow = 5.99 cfs @ 12.15 hrs, Volume= 11,951 cf, Atten= 4%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.64 fps, Min. Travel Time= 1.5 min
 Avg. Velocity = 1.18 fps, Avg. Travel Time= 4.7 min

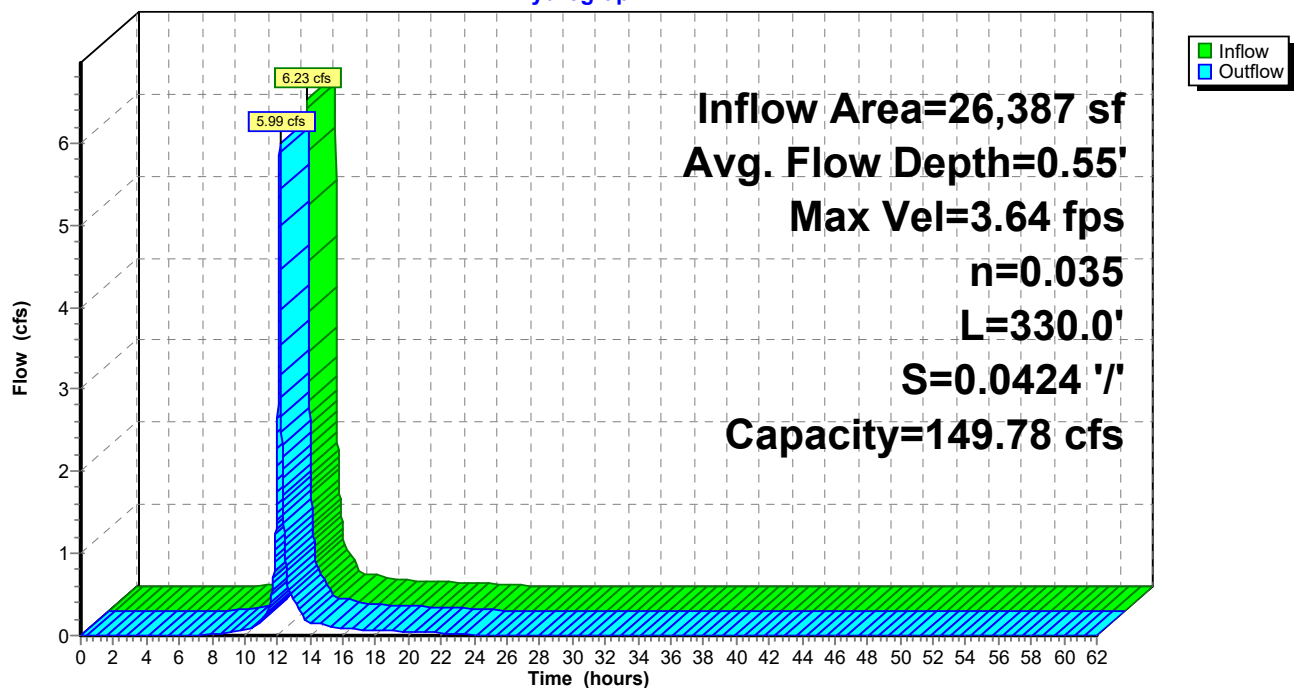
Peak Storage= 545 cf @ 12.13 hrs
 Average Depth at Peak Storage= 0.55'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 149.78 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 330.0' Slope= 0.0424 '/'
 Inlet Invert= 1,054.00', Outlet Invert= 1,040.00'



Reach E3T: E3 Terrace

Hydrograph



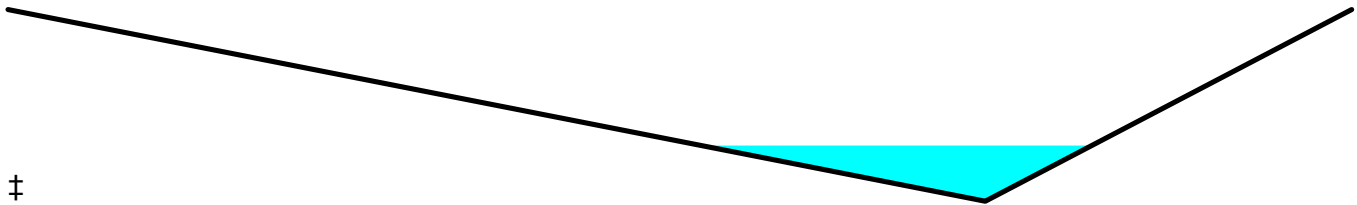
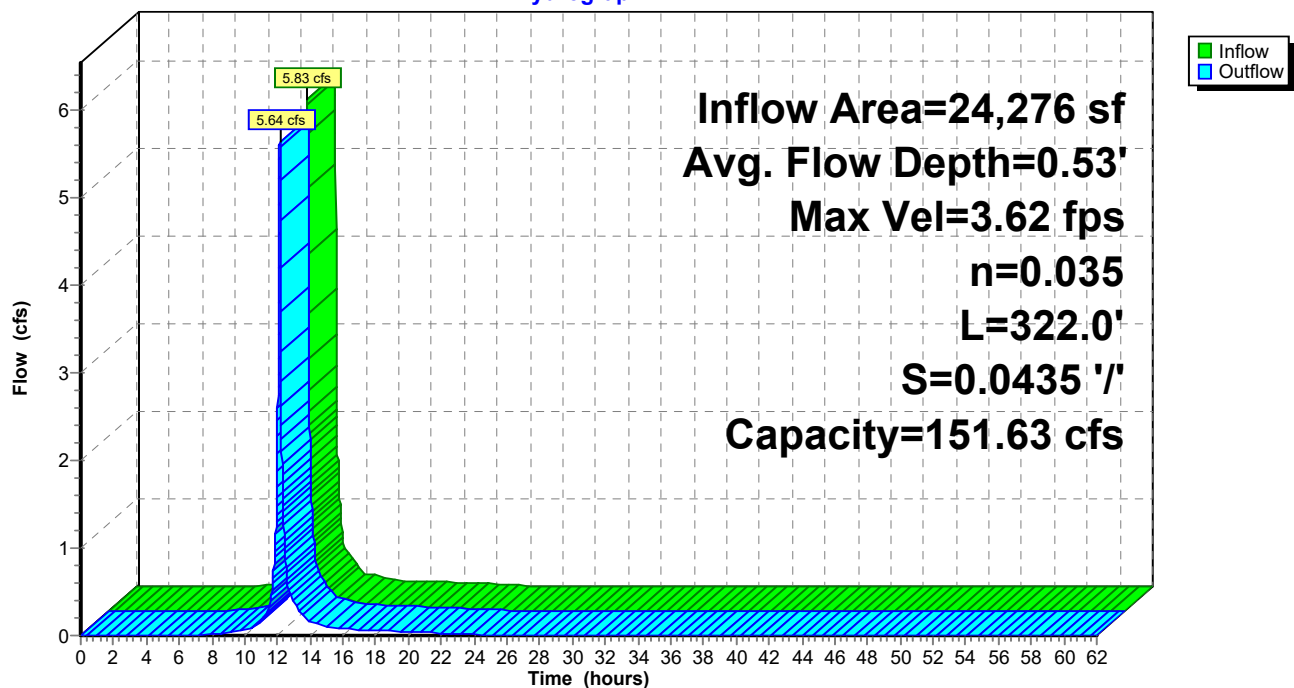
Summary for Reach E4T: E4 Terrace

Inflow Area = 24,276 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 5.83 cfs @ 12.11 hrs, Volume= 10,995 cf
 Outflow = 5.64 cfs @ 12.15 hrs, Volume= 10,995 cf, Atten= 3%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.62 fps, Min. Travel Time= 1.5 min
 Avg. Velocity = 1.16 fps, Avg. Travel Time= 4.6 min

Peak Storage= 503 cf @ 12.12 hrs
 Average Depth at Peak Storage= 0.53'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 151.63 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 322.0' Slope= 0.0435 '/'
 Inlet Invert= 1,054.00', Outlet Invert= 1,040.00'

**Reach E4T: E4 Terrace****Hydrograph**

Summary for Reach E5T: E5 Terrace

Inflow Area = 26,394 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.25 cfs @ 12.12 hrs, Volume= 11,954 cf
 Outflow = 6.02 cfs @ 12.15 hrs, Volume= 11,954 cf, Atten= 4%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 3.79 fps, Min. Travel Time= 1.5 min

Avg. Velocity= 1.23 fps, Avg. Travel Time= 4.6 min

Peak Storage= 540 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.54'

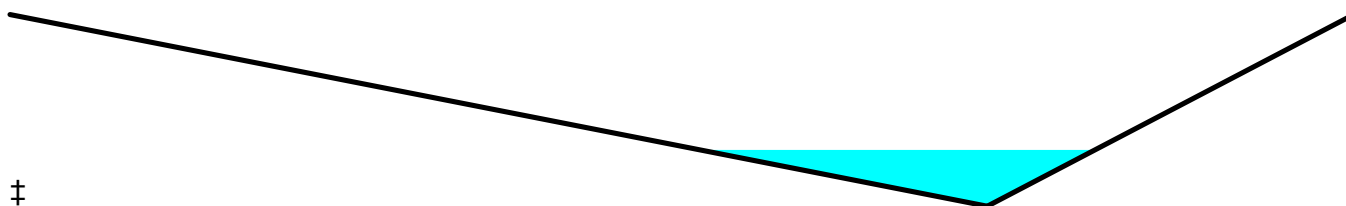
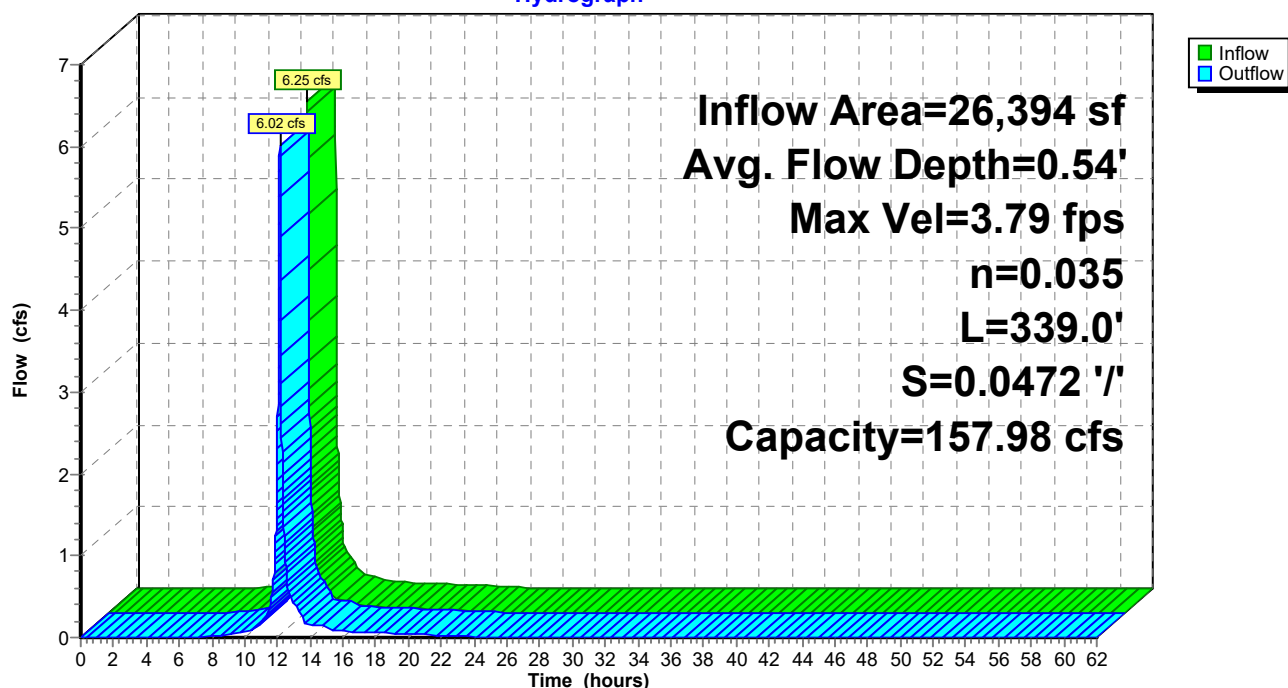
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 157.98 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 339.0' Slope= 0.0472 '/'

Inlet Invert= 1,016.00', Outlet Invert= 1,000.00'

**Reach E5T: E5 Terrace****Hydrograph**

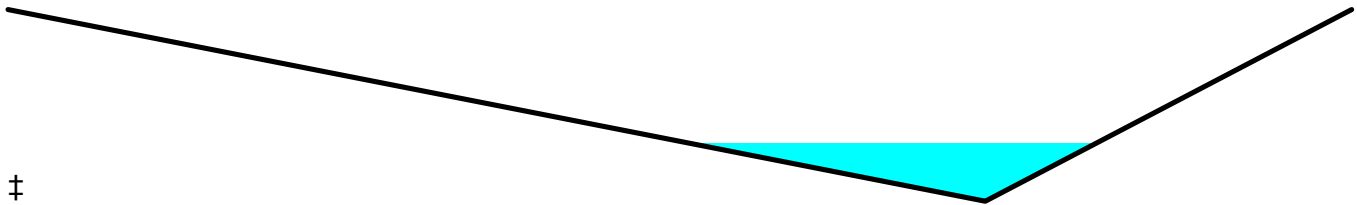
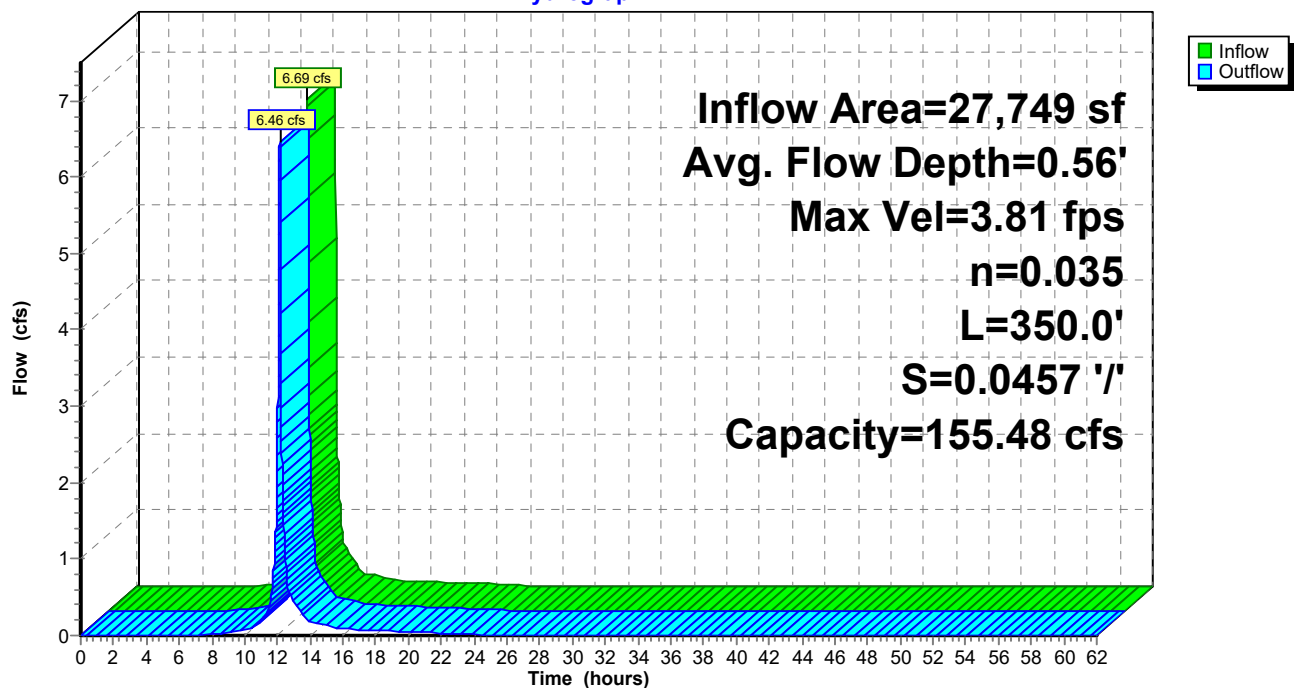
Summary for Reach E6T: E6 Terrace

Inflow Area = 27,749 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 6.69 cfs @ 12.11 hrs, Volume= 12,567 cf
 Outflow = 6.46 cfs @ 12.15 hrs, Volume= 12,567 cf, Atten= 4%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 3.81 fps, Min. Travel Time= 1.5 min
 Avg. Velocity= 1.22 fps, Avg. Travel Time= 4.8 min

Peak Storage= 594 cf @ 12.12 hrs
 Average Depth at Peak Storage= 0.56'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 155.48 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 350.0' Slope= 0.0457 '/'
 Inlet Invert= 1,016.00', Outlet Invert= 1,000.00'

**Reach E6T: E6 Terrace****Hydrograph**

Summary for Reach E7T: E7 Terrace

Inflow Area = 41,042 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 9.22 cfs @ 12.13 hrs, Volume= 18,588 cf
 Outflow = 9.04 cfs @ 12.15 hrs, Volume= 18,588 cf, Atten= 2%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 5.22 fps, Min. Travel Time= 1.0 min

Avg. Velocity = 1.72 fps, Avg. Travel Time= 3.0 min

Peak Storage= 537 cf @ 12.14 hrs

Average Depth at Peak Storage= 0.56'

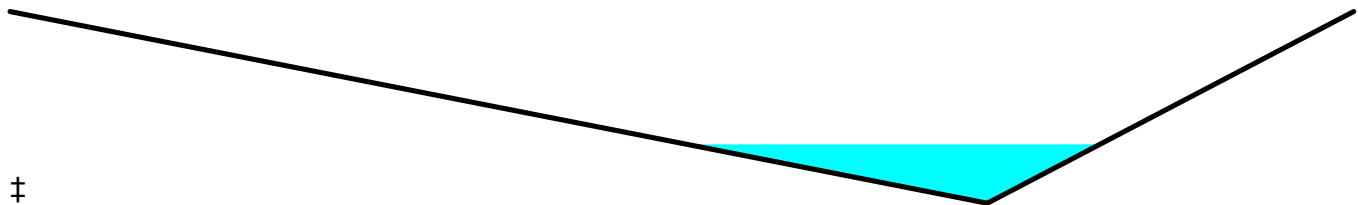
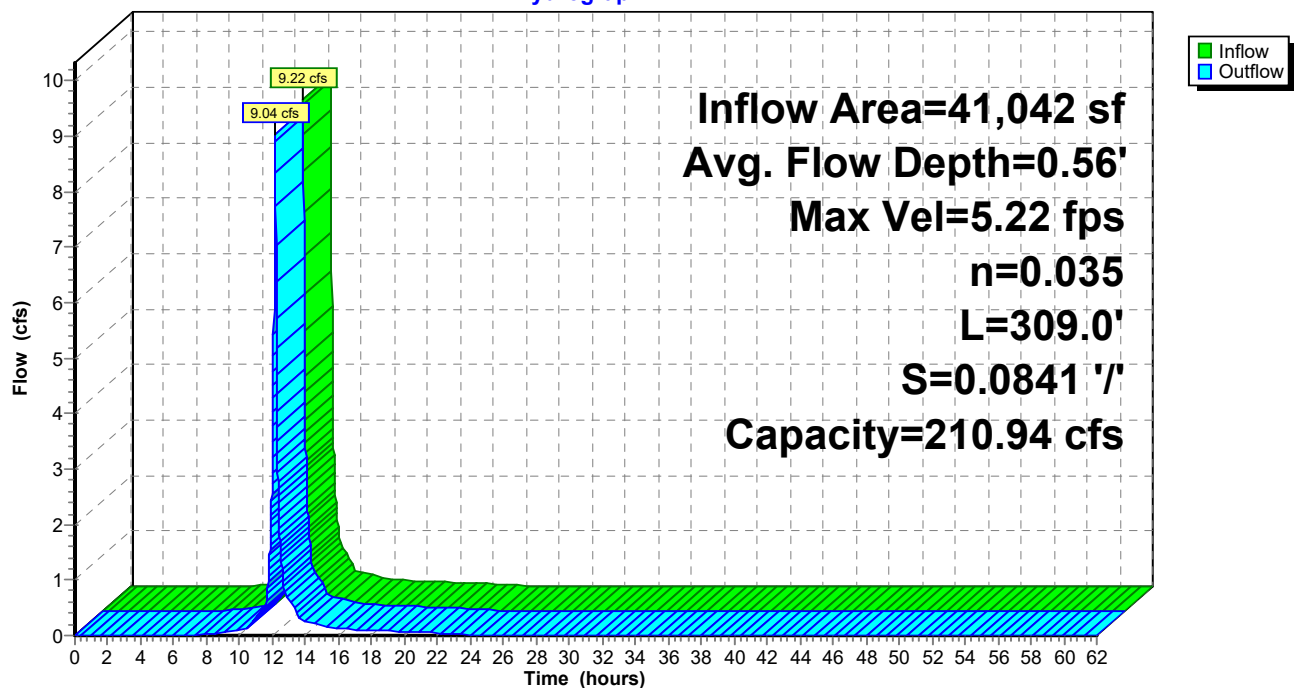
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 210.94 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 ' Top Width= 20.13'

Length= 309.0' Slope= 0.0841 ' /'

Inlet Invert= 962.00', Outlet Invert= 936.00'

**Reach E7T: E7 Terrace****Hydrograph**

Summary for Reach E8T: E8 Terrce

Inflow Area = 60,350 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 12.87 cfs @ 12.14 hrs, Volume= 27,332 cf
 Outflow = 11.42 cfs @ 12.23 hrs, Volume= 27,332 cf, Atten= 11%, Lag= 5.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 4.04 fps, Min. Travel Time= 3.6 min

Avg. Velocity= 1.26 fps, Avg. Travel Time= 11.6 min

Peak Storage= 2,472 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.72'

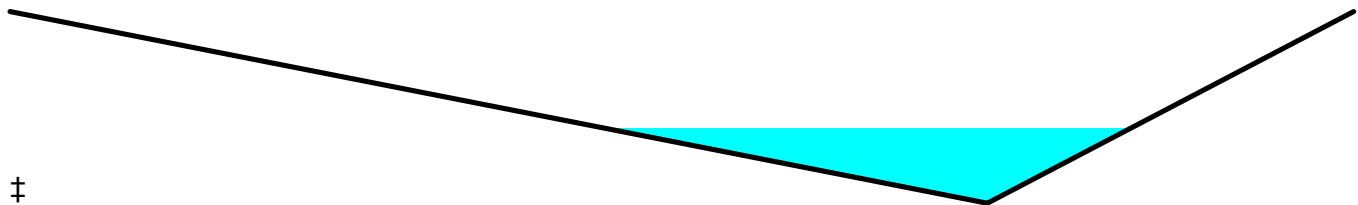
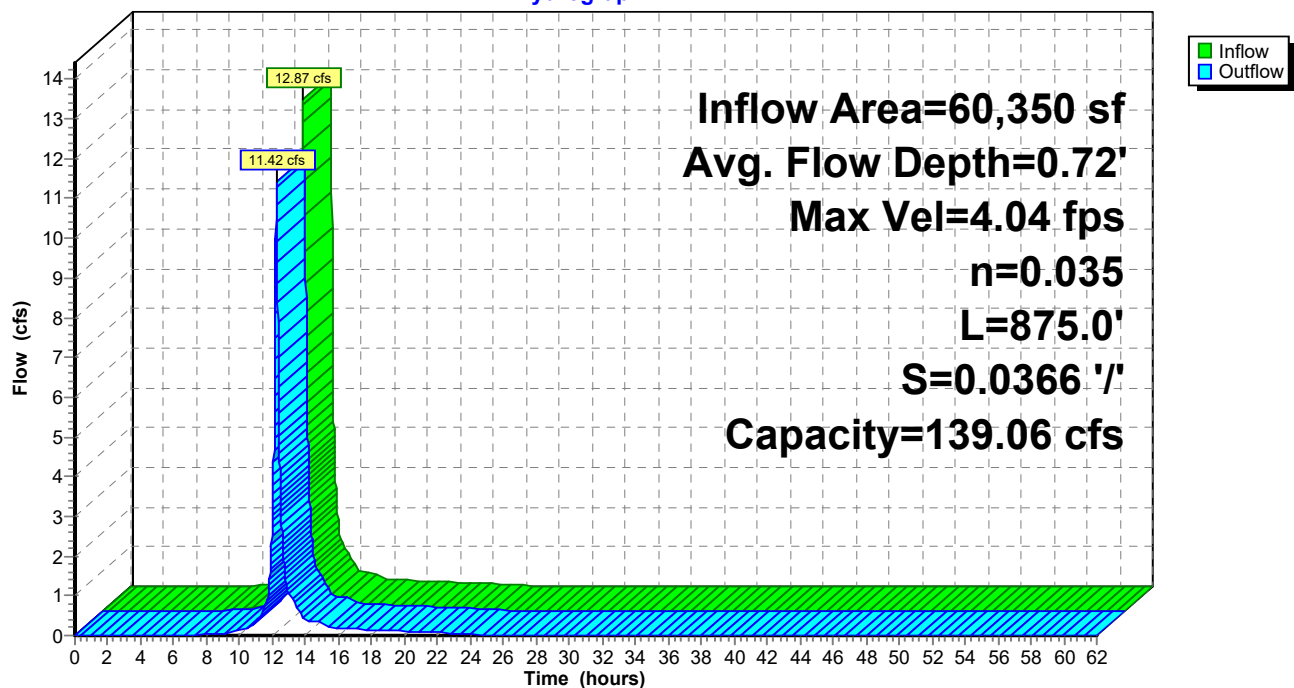
Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 139.06 cfs

0.00' x 1.83' deep channel, n= 0.035

Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'

Length= 875.0' Slope= 0.0366 '/'

Inlet Invert= 982.00', Outlet Invert= 950.00'

**Reach E8T: E8 Terrce****Hydrograph**

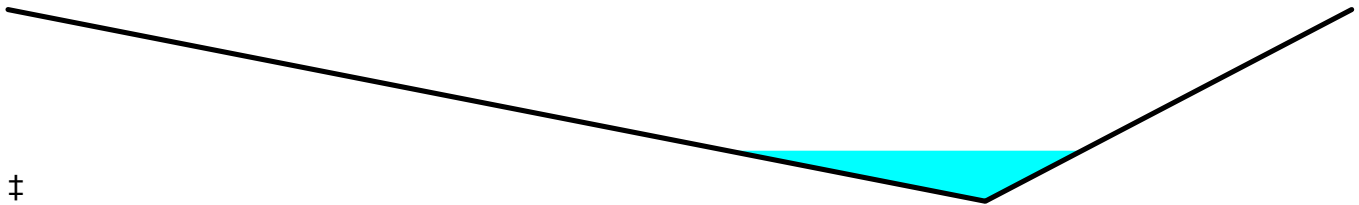
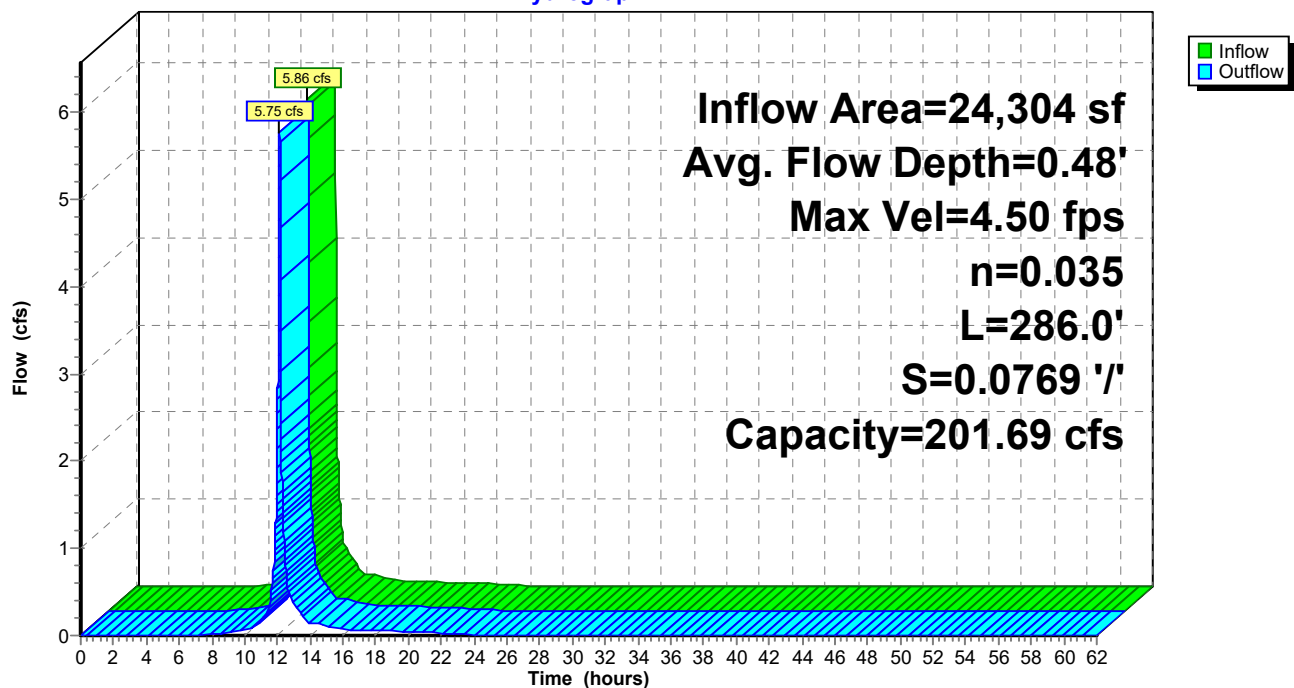
Summary for Reach E9T: E9 Terrace

Inflow Area = 24,304 sf, 0.00% Impervious, Inflow Depth = 5.43" for 100-yr 24-hr event
 Inflow = 5.86 cfs @ 12.11 hrs, Volume= 11,007 cf
 Outflow = 5.75 cfs @ 12.14 hrs, Volume= 11,007 cf, Atten= 2%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 4.50 fps, Min. Travel Time= 1.1 min
 Avg. Velocity= 1.46 fps, Avg. Travel Time= 3.3 min

Peak Storage= 366 cf @ 12.12 hrs
 Average Depth at Peak Storage= 0.48'
 Bank-Full Depth= 1.83' Flow Area= 18.4 sf, Capacity= 201.69 cfs

0.00' x 1.83' deep channel, n= 0.035
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 20.13'
 Length= 286.0' Slope= 0.0769 '/'
 Inlet Invert= 932.00', Outlet Invert= 910.00'

**Reach E9T: E9 Terrace****Hydrograph**

Summary for Reach EDS1: E Downslope 1

[61] Hint: Exceeded Reach E1T outlet invert by 0.17' @ 12.30 hrs

[61] Hint: Exceeded Reach E2T outlet invert by 0.17' @ 12.30 hrs

Inflow Area = 103,150 sf, 0.00% Impervious, Inflow Depth = 4.53" for 100-yr 24-hr event
Inflow = 12.28 cfs @ 12.30 hrs, Volume= 38,943 cf
Outflow = 12.27 cfs @ 12.30 hrs, Volume= 38,943 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 7.67 fps, Min. Travel Time= 0.2 min

Avg. Velocity= 2.30 fps, Avg. Travel Time= 0.6 min

Peak Storage= 130 cf @ 12.30 hrs

Average Depth at Peak Storage= 0.17'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 973.47 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' Top Width= 21.00'

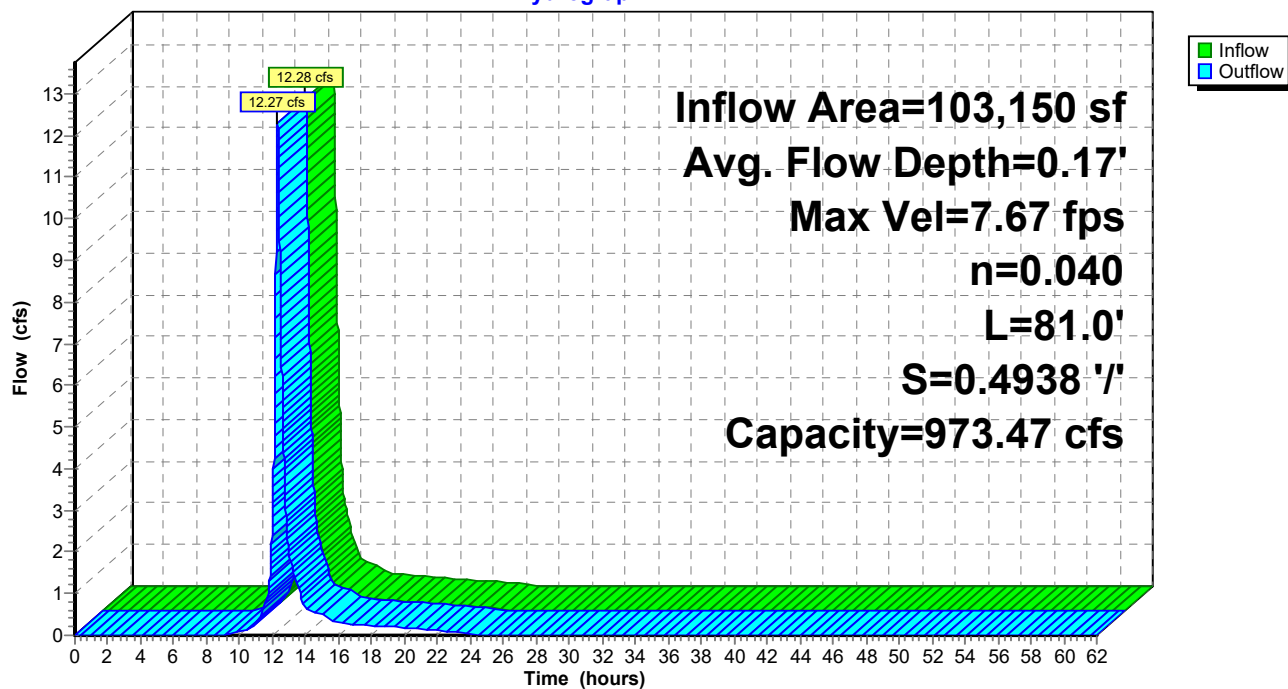
Length= 81.0' Slope= 0.4938 ' '

Inlet Invert= 1,080.00', Outlet Invert= 1,040.00'



Reach EDS1: E Downslope 1

Hydrograph



Summary for Reach EDS2: E Downslope 2

[62] Hint: Exceeded Reach E3T OUTLET depth by 0.19' @ 12.37 hrs

[62] Hint: Exceeded Reach E4T OUTLET depth by 0.21' @ 12.37 hrs

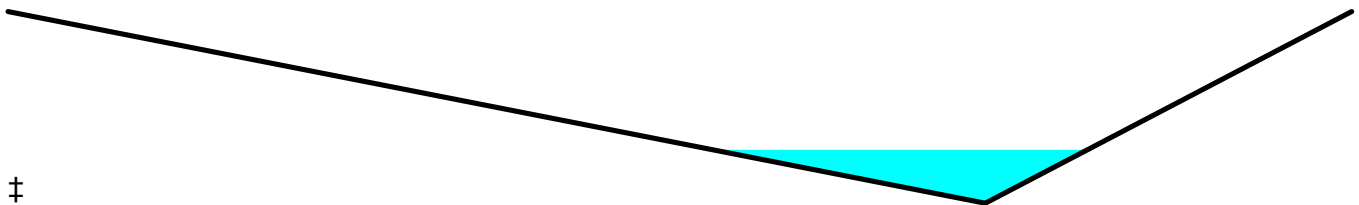
[62] Hint: Exceeded Reach EDS1 OUTLET depth by 0.43' @ 12.15 hrs

Inflow Area = 153,813 sf, 0.00% Impervious, Inflow Depth = 4.83" for 100-yr 24-hr event
 Inflow = 18.67 cfs @ 12.17 hrs, Volume= 61,888 cf
 Outflow = 18.64 cfs @ 12.17 hrs, Volume= 61,888 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Max. Velocity= 10.87 fps, Min. Travel Time= 0.1 min
 Avg. Velocity = 3.91 fps, Avg. Travel Time= 0.4 min

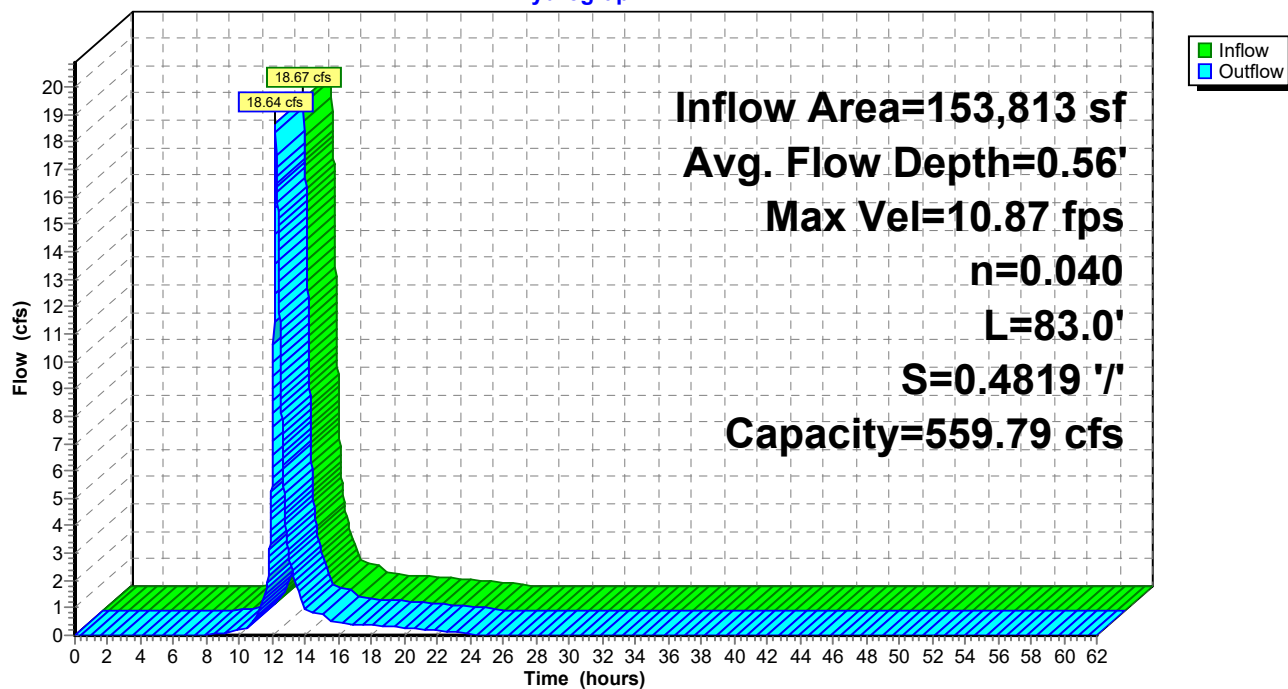
Peak Storage= 142 cf @ 12.17 hrs
 Average Depth at Peak Storage= 0.56'
 Bank-Full Depth= 2.00' Flow Area= 22.0 sf, Capacity= 559.79 cfs

0.00' x 2.00' deep channel, n= 0.040
 Side Slope Z-value= 8.0 3.0 '/' Top Width= 22.00'
 Length= 83.0' Slope= 0.4819 '/'
 Inlet Invert= 1,040.00', Outlet Invert= 1,000.00'



Reach EDS2: E Downslope 2

Hydrograph



Summary for Reach EDS3: E Downslope 3

[62] Hint: Exceeded Reach E5T OUTLET depth by 0.24' @ 12.31 hrs

[62] Hint: Exceeded Reach E6T OUTLET depth by 0.24' @ 12.30 hrs

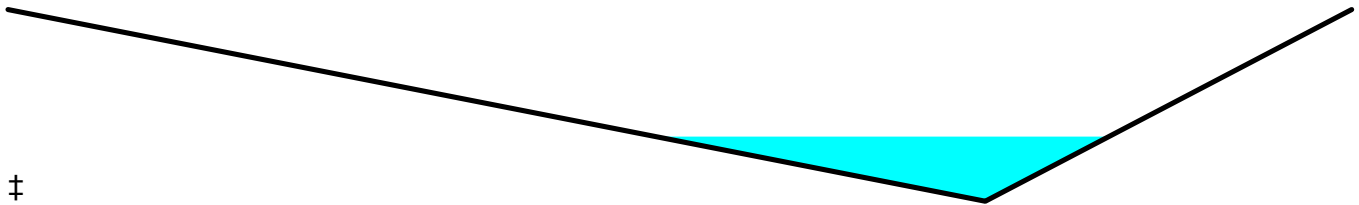
[62] Hint: Exceeded Reach EDS2 OUTLET depth by 0.12' @ 12.15 hrs

Inflow Area = 207,956 sf, 0.00% Impervious, Inflow Depth = 4.99" for 100-yr 24-hr event
Inflow = 30.80 cfs @ 12.16 hrs, Volume= 86,410 cf
Outflow = 30.72 cfs @ 12.16 hrs, Volume= 86,410 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
Max. Velocity= 12.31 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.25 fps, Avg. Travel Time= 0.4 min

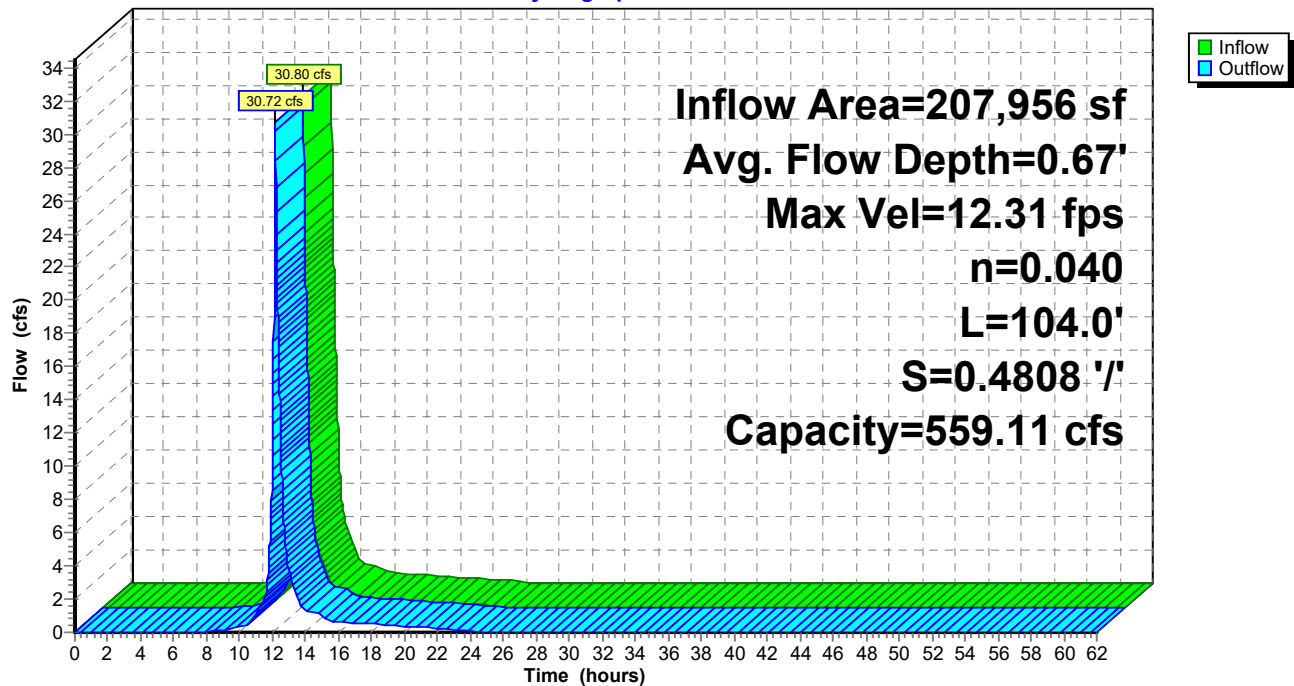
Peak Storage= 260 cf @ 12.16 hrs
Average Depth at Peak Storage= 0.67'
Bank-Full Depth= 2.00' Flow Area= 22.0 sf, Capacity= 559.11 cfs

0.00' x 2.00' deep channel, n= 0.040
Side Slope Z-value= 8.0 3.0 '/' Top Width= 22.00'
Length= 104.0' Slope= 0.4808 '/'
Inlet Invert= 1,000.00', Outlet Invert= 950.00'



Reach EDS3: E Downslope 3

Hydrograph



Summary for Reach EDS4: E Downslope 4

[61] Hint: Exceeded Reach E8T outlet invert by 0.35' @ 12.17 hrs

[61] Hint: Exceeded Reach EDS3 outlet invert by 0.35' @ 12.17 hrs

Inflow Area = 268,306 sf, 0.00% Impervious, Inflow Depth = 5.09" for 100-yr 24-hr event
Inflow = 39.29 cfs @ 12.17 hrs, Volume= 113,742 cf
Outflow = 39.25 cfs @ 12.17 hrs, Volume= 113,742 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 11.18 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.66 fps, Avg. Travel Time= 0.3 min

Peak Storage= 165 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.35'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 903.65 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 ' ' Top Width= 21.00'

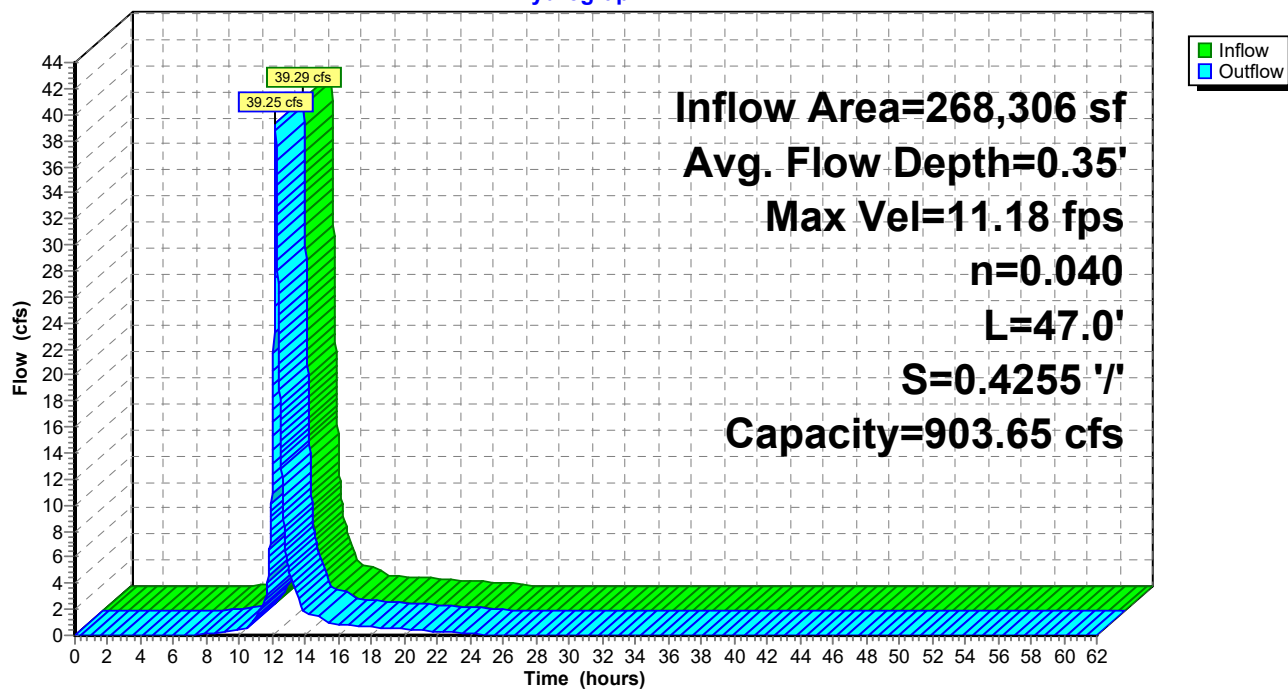
Length= 47.0' Slope= 0.4255 ' '

Inlet Invert= 950.00', Outlet Invert= 930.00'



Reach EDS4: E Downslope 4

Hydrograph



Summary for Reach EDS5: E Downslope 5

[62] Hint: Exceeded Reach EDS4 OUTLET depth by 0.14' @ 12.17 hrs

Inflow Area = 309,348 sf, 0.00% Impervious, Inflow Depth = 5.13" for 100-yr 24-hr event
 Inflow = 47.98 cfs @ 12.17 hrs, Volume= 132,330 cf
 Outflow = 47.87 cfs @ 12.17 hrs, Volume= 132,330 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 9.37 fps, Min. Travel Time= 0.2 min

Avg. Velocity = 2.12 fps, Avg. Travel Time= 0.8 min

Peak Storage= 512 cf @ 12.17 hrs

Average Depth at Peak Storage= 0.49'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 619.51 cfs

9.00' x 2.00' deep channel, n= 0.040

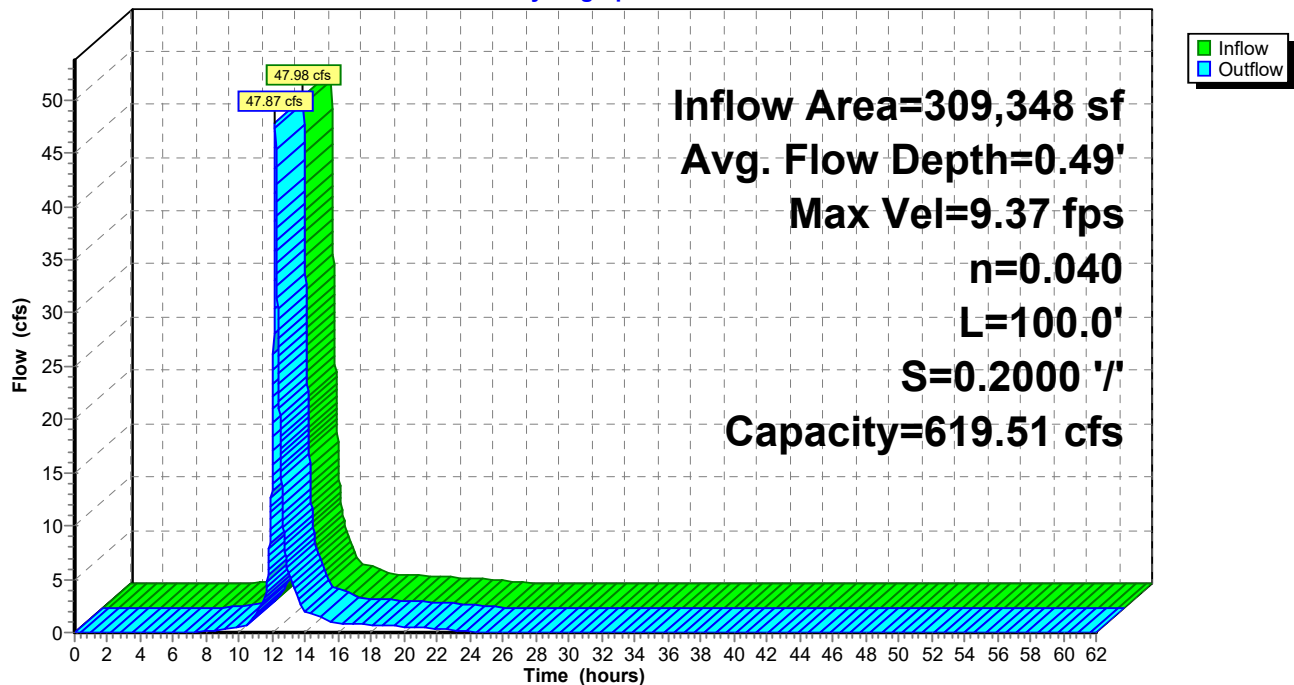
Side Slope Z-value= 3.0 '/' Top Width= 21.00'

Length= 100.0' Slope= 0.2000 '/'

Inlet Invert= 930.00', Outlet Invert= 910.00'

**Reach EDS5: E Downslope 5**

Hydrograph



Summary for Reach EDS6: E Downslope 6

[61] Hint: Exceeded Reach E10T outlet invert by 0.49' @ 12.18 hrs

[62] Hint: Exceeded Reach E9T OUTLET depth by 0.14' @ 12.27 hrs

[62] Hint: Exceeded Reach EDS5 OUTLET depth by 0.03' @ 12.27 hrs

Inflow Area = 409,798 sf, 0.00% Impervious, Inflow Depth = 5.21" for 100-yr 24-hr event
 Inflow = 62.00 cfs @ 12.18 hrs, Volume= 177,823 cf
 Outflow = 61.95 cfs @ 12.18 hrs, Volume= 177,823 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Max. Velocity= 12.10 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.74 fps, Avg. Travel Time= 0.4 min

Peak Storage= 369 cf @ 12.18 hrs

Average Depth at Peak Storage= 0.49'

Bank-Full Depth= 2.00' Flow Area= 30.0 sf, Capacity= 799.79 cfs

9.00' x 2.00' deep channel, n= 0.040

Side Slope Z-value= 3.0 '/' Top Width= 21.00'

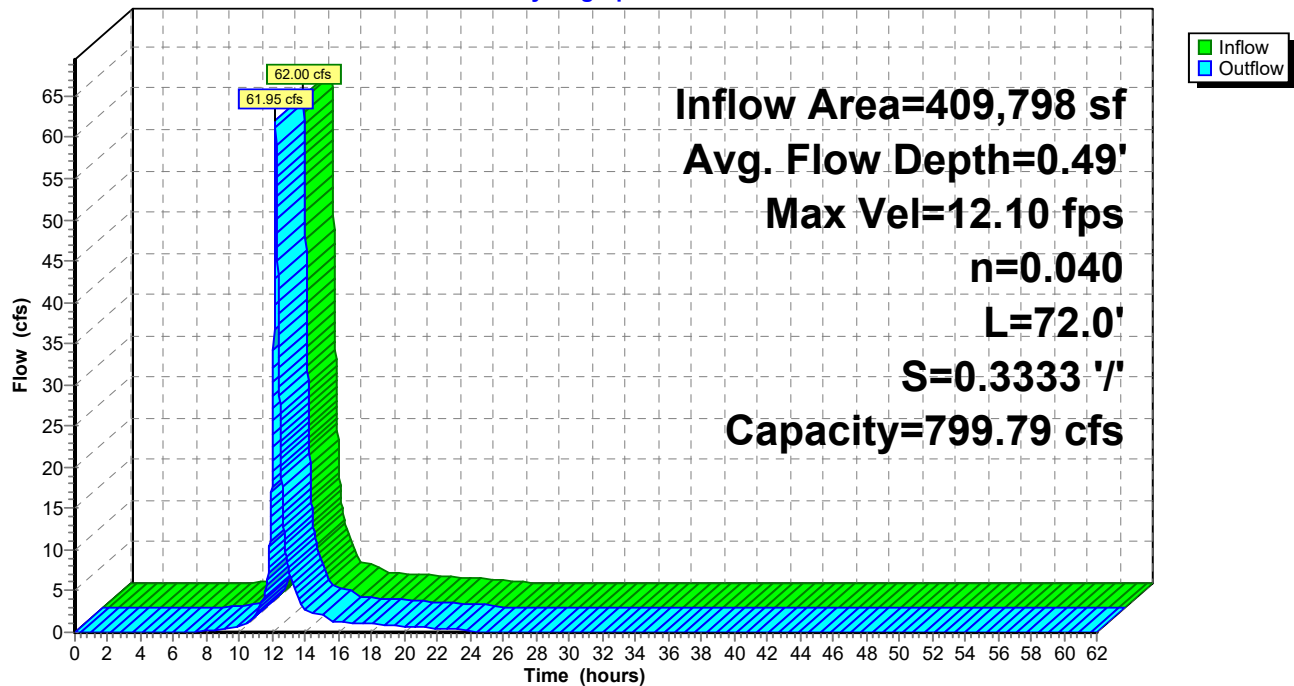
Length= 72.0' Slope= 0.3333 '/'

Inlet Invert= 910.00', Outlet Invert= 886.00'



Reach EDS6: E Downslope 6

Hydrograph



Summary for Pond 1P: Existing West Pond (infiltration)

Inflow Area = 530,705 sf, 0.00% Impervious, Inflow Depth = 5.26" for 100-yr 24-hr event
 Inflow = 81.61 cfs @ 12.19 hrs, Volume= 232,582 cf
 Outflow = 1.29 cfs @ 17.88 hrs, Volume= 200,898 cf, Atten= 98%, Lag= 341.6 min
 Discarded = 1.29 cfs @ 17.88 hrs, Volume= 200,898 cf

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs / 2
 Peak Elev= 847.07' @ 17.88 hrs Surf.Area= 69,574 sf Storage= 184,178 cf

Plug-Flow detention time= 1,301.1 min calculated for 200,865 cf (86% of inflow)
 Center-of-Mass det. time= 1,250.1 min (2,045.2 - 795.1)

Volume	Invert	Avail.Storage	Storage Description
#1	843.00'	1,565,998 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

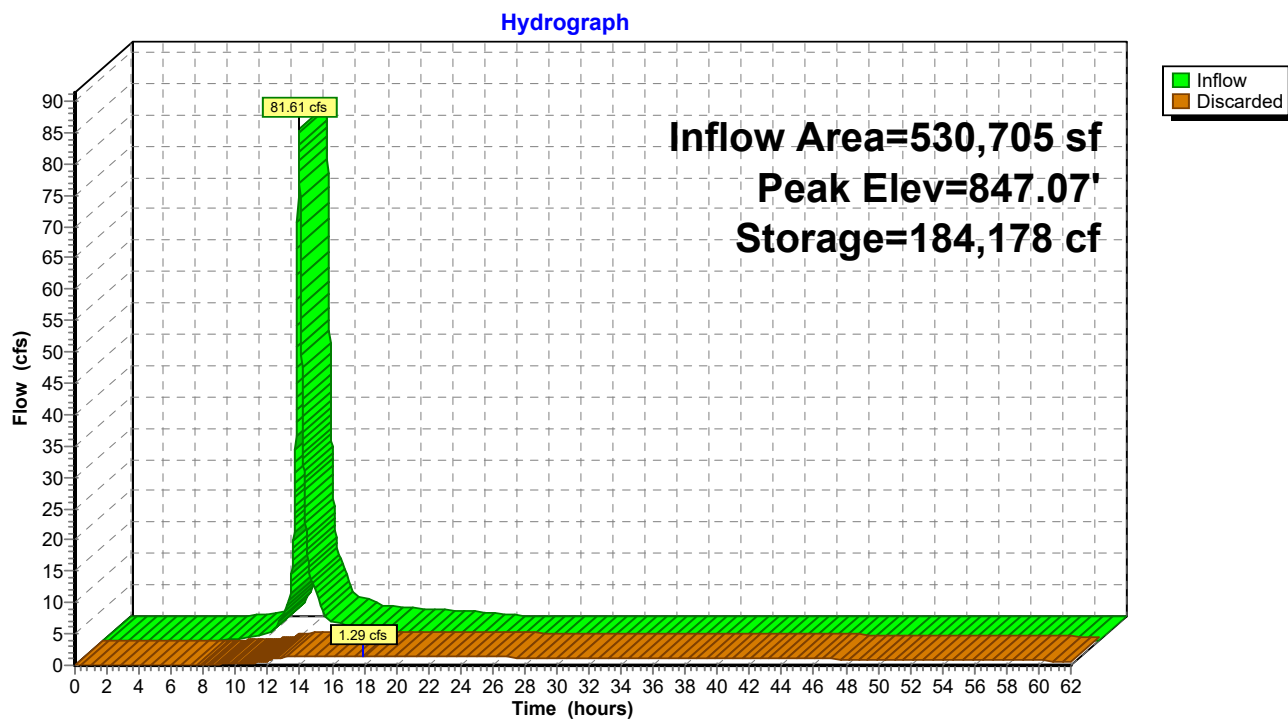
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
843.00	7,708	0	0
844.00	30,410	19,059	19,059
845.00	45,796	38,103	57,162
846.00	64,648	55,222	112,384
847.00	69,110	66,879	179,263
848.00	75,650	72,380	251,643
849.00	81,456	78,553	330,196
850.00	87,020	84,238	414,434
851.00	92,934	89,977	504,411
852.00	99,015	95,975	600,386
853.00	105,834	102,425	702,810
854.00	117,429	111,632	814,442
855.00	130,852	124,141	938,582
856.00	144,383	137,618	1,076,200
857.00	157,201	150,792	1,226,992
858.00	169,560	163,381	1,390,372
859.00	181,692	175,626	1,565,998

Device	Routing	Invert	Outlet Devices
#1	Discarded	843.00'	0.800 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 0.00'

Discarded OutFlow Max=1.29 cfs @ 17.88 hrs HW=847.07' (Free Discharge)

↑ **1=Exfiltration** (Controls 1.29 cfs)

Pond 1P: Existing West Pond (infiltration)



Summary for Pond 2P: 96" RCP

Inflow Area = 530,705 sf, 0.00% Impervious, Inflow Depth = 5.26" for 100-yr 24-hr event
 Inflow = 81.61 cfs @ 12.19 hrs, Volume= 232,582 cf
 Outflow = 81.61 cfs @ 12.19 hrs, Volume= 232,582 cf, Atten= 0%, Lag= 0.0 min
 Primary = 81.61 cfs @ 12.19 hrs, Volume= 232,582 cf

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Peak Elev= 859.27' @ 12.19 hrs

Flood Elev= 882.00'

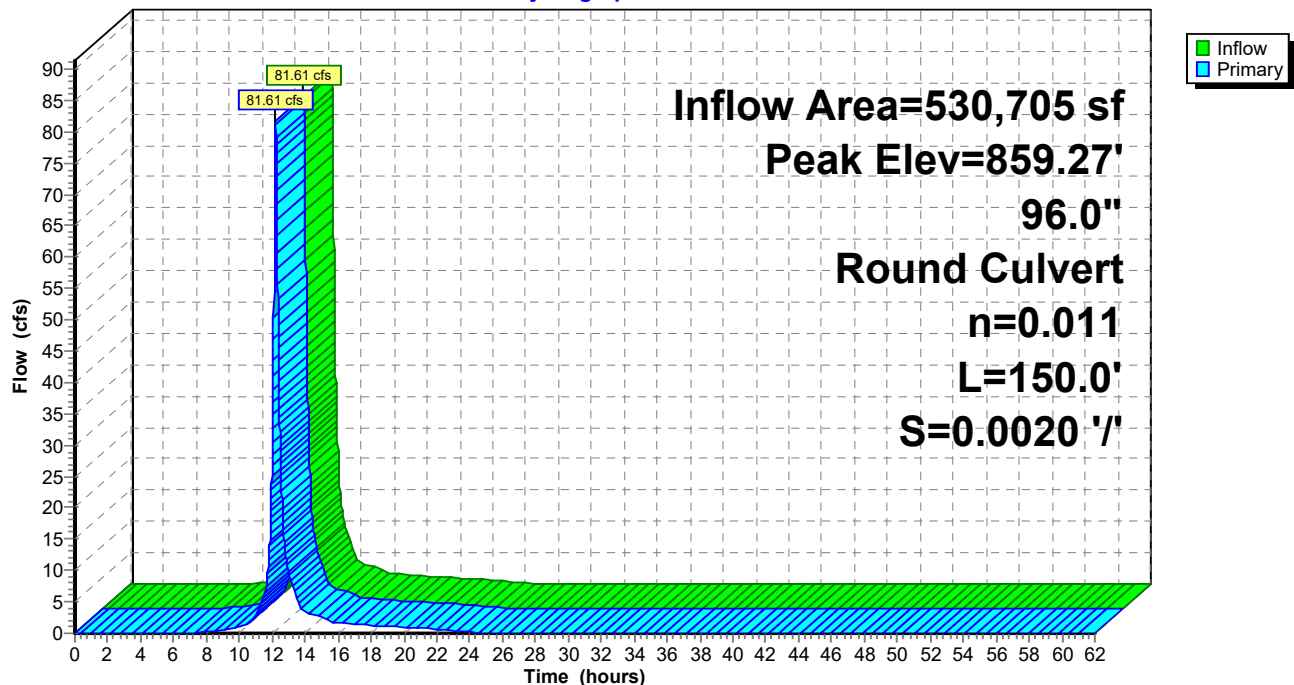
Device	Routing	Invert	Outlet Devices
#1	Primary	856.00'	96.0" Round Culvert L= 150.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 856.00' / 855.70' S= 0.0020 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 50.27 sf

Primary OutFlow Max=81.51 cfs @ 12.19 hrs HW=859.27' (Free Discharge)

↑1=Culvert (Barrel Controls 81.51 cfs @ 6.25 fps)

Pond 2P: 96" RCP

Hydrograph



Summary for Pond 3P: Existing Northwest Sedimentation Pond

[62] Hint: Exceeded Reach DDS6 OUTLET depth by 3.15' @ 61.30 hrs

Inflow Area = 418,993 sf, 0.00% Impervious, Inflow Depth = 5.15" for 100-yr 24-hr event
 Inflow = 58.26 cfs @ 12.17 hrs, Volume= 179,819 cf
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Peak Elev= 863.15' @ 61.30 hrs Surf.Area= 46,883 sf Storage= 179,795 cf

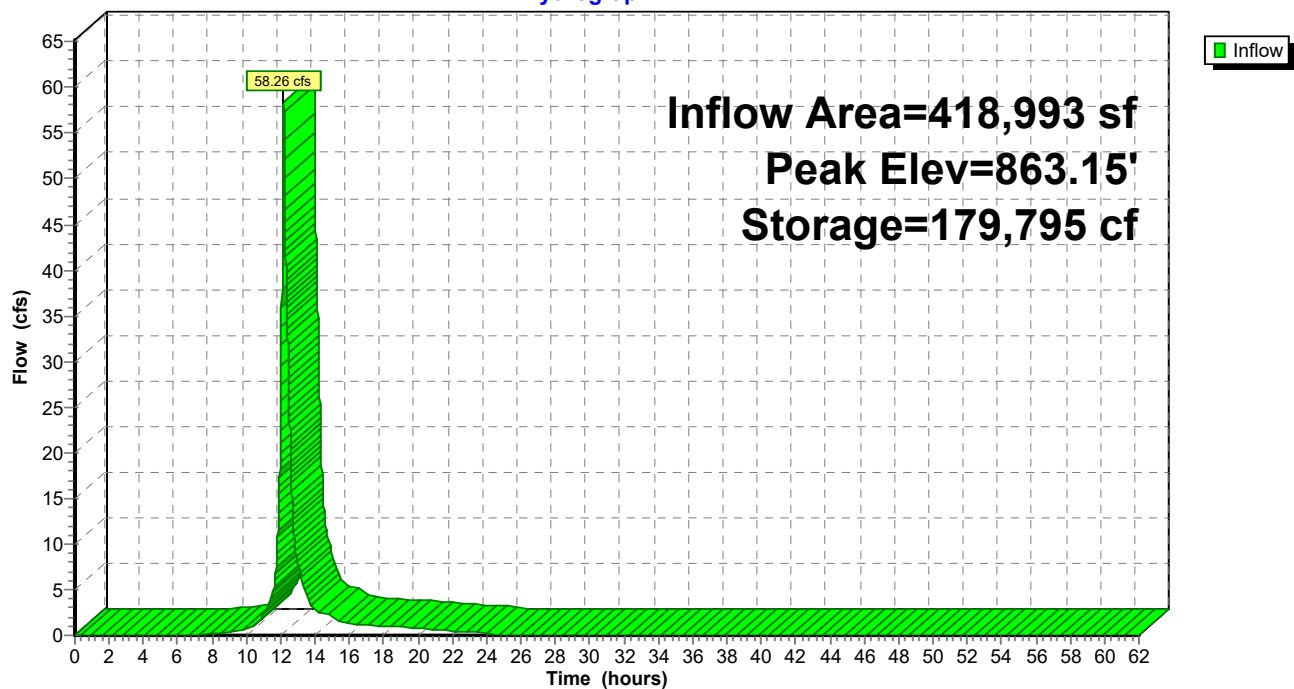
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
 Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	858.00'	1,100,759 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
858.00	25,547	0	0
860.00	32,527	58,074	58,074
862.00	39,433	71,960	130,034
864.00	52,356	91,789	221,823
866.00	58,389	110,745	332,568
868.00	64,929	123,318	455,886
870.00	72,080	137,009	592,895
872.00	79,010	151,090	743,985
874.00	89,732	168,742	912,727
876.00	98,300	188,032	1,100,759

Pond 3P: Existing Northwest Sedimentation Pond

Hydrograph



Summary for Pond 4P: Existing Northeast Sedimentation Pond

Inflow Area = 994,964 sf, 0.00% Impervious, Inflow Depth = 5.19" for 100-yr 24-hr event
 Inflow = 136.89 cfs @ 12.19 hrs, Volume= 430,527 cf
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Peak Elev= 886.64' @ 61.98 hrs Surf.Area= 107,164 sf Storage= 430,519 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

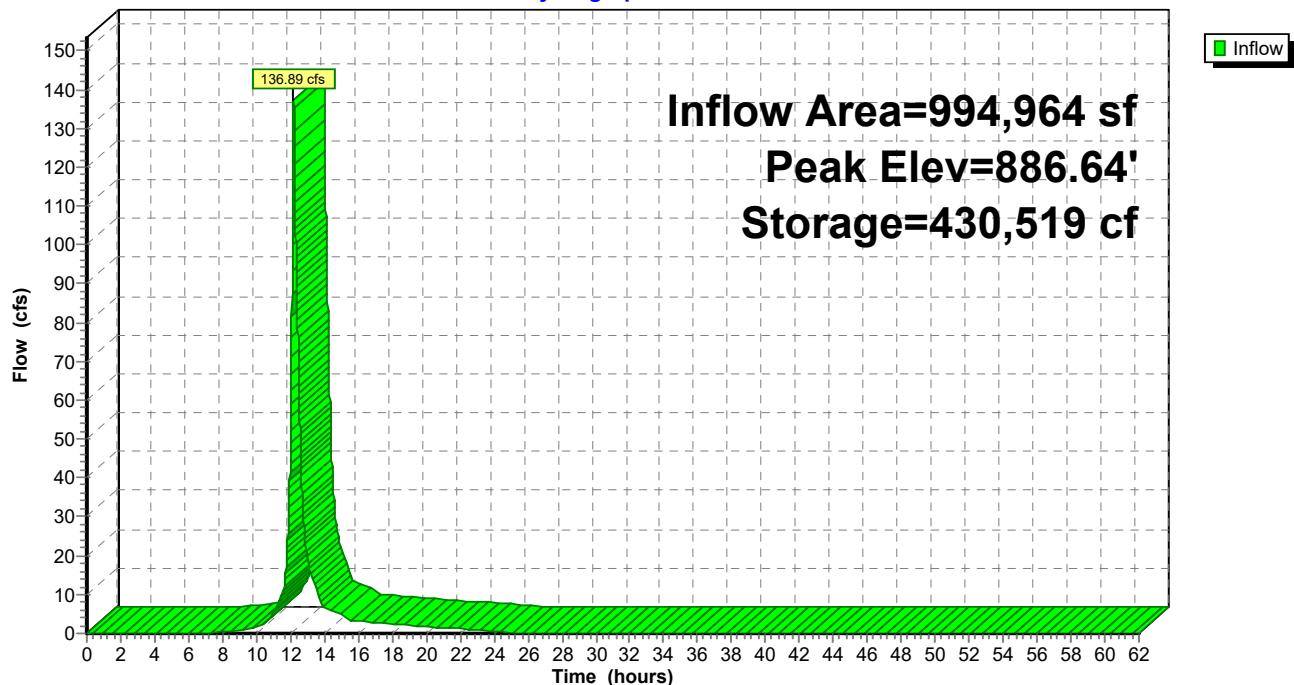
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	882.00'	1,101,680 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
882.00	79,845	0	0
884.00	90,522	170,367	170,367
886.00	102,795	193,317	363,684
888.00	116,521	219,316	583,000
890.00	129,005	245,526	828,526
892.00	144,149	273,154	1,101,680

Pond 4P: Existing Northeast Sedimentation Pond

Hydrograph



Summary for Pond 5P: Existing ponding area

Inflow Area = 518,649 sf, 0.00% Impervious, Inflow Depth = 5.29" for 100-yr 24-hr event
 Inflow = 58.42 cfs @ 12.26 hrs, Volume= 228,683 cf
 Outflow = 58.40 cfs @ 12.26 hrs, Volume= 228,683 cf, Atten= 0%, Lag= 0.3 min
 Primary = 58.40 cfs @ 12.26 hrs, Volume= 228,683 cf

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Peak Elev= 896.89' @ 12.26 hrs Surf.Area= 806 sf Storage= 961 cf

Plug-Flow detention time= 0.3 min calculated for 228,646 cf (100% of inflow)
 Center-of-Mass det. time= 0.3 min (799.3 - 799.1)

Volume	Invert	Avail.Storage	Storage Description
#1	895.40'	7,837 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
895.40	500	97.0	0	0	500
901.57	2,250	418.0	7,837	7,837	13,751

Device	Routing	Invert	Outlet Devices
#1	Primary	895.39'	36.0" Round RCP_Round 36" L= 135.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 895.39' / 888.64' S= 0.0500 ' S= 0.0500 ' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 7.07 sf
#2	Primary	895.00'	36.0" Round RCP_Round 36" X 2.00 L= 135.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 895.00' / 888.25' S= 0.0500 ' S= 0.0500 ' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 7.07 sf

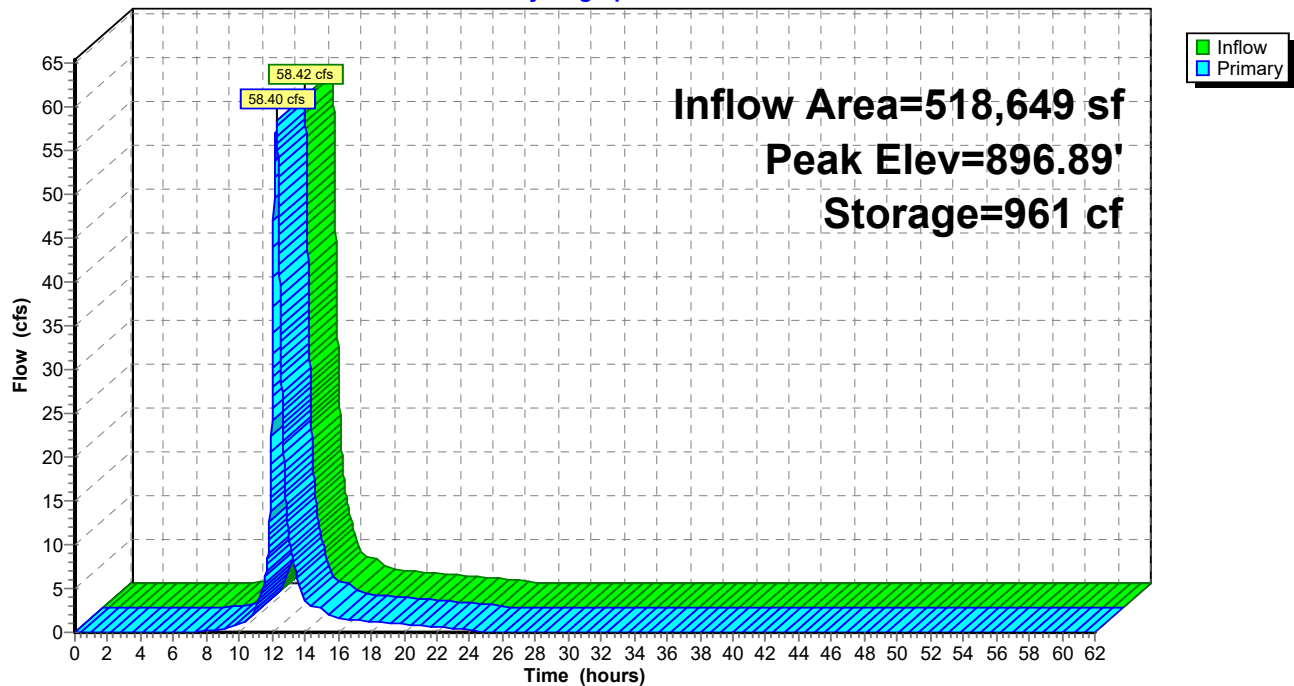
Primary OutFlow Max=58.39 cfs @ 12.26 hrs HW=896.89' (Free Discharge)

1=RCP_Round 36" (Inlet Controls 14.66 cfs @ 4.16 fps)

2=RCP_Round 36" (Inlet Controls 43.73 cfs @ 4.67 fps)

Pond 5P: Existing ponding area

Hydrograph



Summary for Pond 6P: Existing East Sedimentation Pond

[79] Warning: Submerged Pond 5P Primary device # 1 OUTLET by 1.67'

[79] Warning: Submerged Pond 5P Primary device # 2 OUTLET by 2.06'

Inflow Area = 518,649 sf, 0.00% Impervious, Inflow Depth = 5.29" for 100-yr 24-hr event
 Inflow = 58.40 cfs @ 12.26 hrs, Volume= 228,683 cf
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Peak Elev= 890.31' @ 50.92 hrs Surf.Area= 114,960 sf Storage= 228,677 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

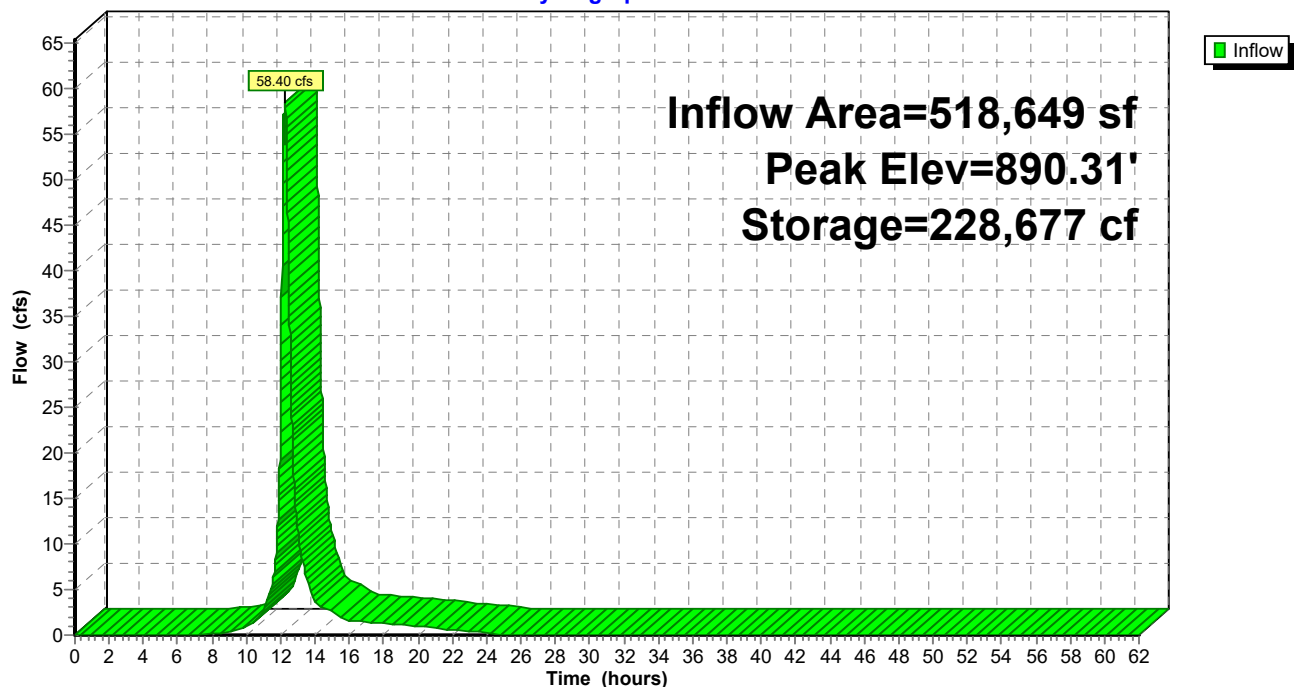
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	888.00'	1,080,782 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
888.00	83,528	0	0
890.00	110,405	193,933	193,933
892.00	139,953	250,358	444,291
894.00	159,007	298,960	743,251
896.00	178,524	337,531	1,080,782

Pond 6P: Existing East Sedimentation Pond

Hydrograph



Summary for Pond 7P: Diversion Structure with 60" RCP

Inflow Area = 530,705 sf, 0.00% Impervious, Inflow Depth = 5.26" for 100-yr 24-hr event
 Inflow = 81.62 cfs @ 12.19 hrs, Volume= 232,582 cf
 Outflow = 81.61 cfs @ 12.19 hrs, Volume= 232,582 cf, Atten= 0%, Lag= 0.1 min
 Primary = 81.61 cfs @ 12.19 hrs, Volume= 232,582 cf

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs
 Peak Elev= 872.67' @ 12.19 hrs Surf.Area= 401 sf Storage= 873 cf
 Flood Elev= 882.00' Surf.Area= 401 sf Storage= 3,613 cf

Plug-Flow detention time= 0.2 min calculated for 232,544 cf (100% of inflow)
 Center-of-Mass det. time= 0.2 min (795.1 - 794.8)

Volume	Invert	Avail.Storage	Storage Description
#1	870.00'	3,613 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
870.00	15	0	0
870.50	200	54	54
871.00	401	150	204
871.50	401	201	405
872.50	401	401	806
873.50	401	401	1,207
874.50	401	401	1,608
875.50	401	401	2,009
876.50	401	401	2,410
877.50	401	401	2,811
878.50	401	401	3,212
879.50	401	401	3,613

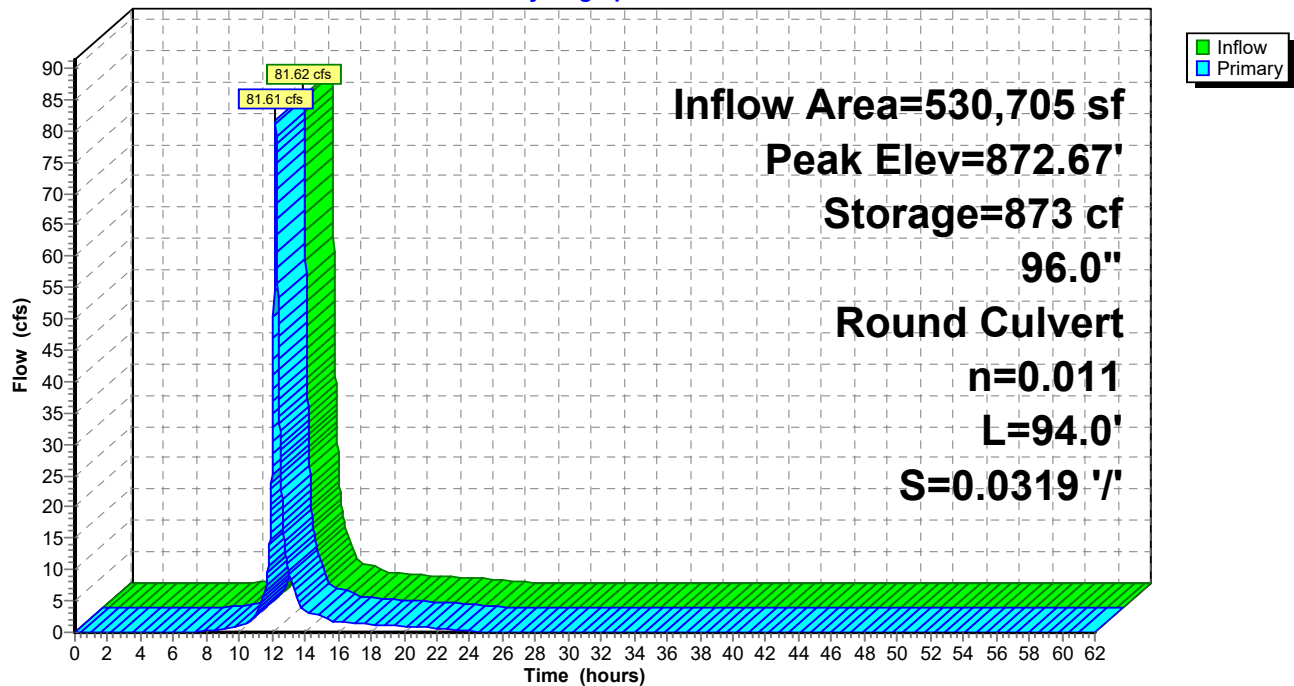
Device	Routing	Invert	Outlet Devices
#1	Primary	870.00'	96.0" Round Culvert L= 94.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 870.00' / 867.00' S= 0.0319 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 50.27 sf

Primary OutFlow Max=81.58 cfs @ 12.19 hrs HW=872.67' (Free Discharge)

↑ **1=Culvert** (Inlet Controls 81.58 cfs @ 5.56 fps)

Pond 7P: Diversion Structure with 60" RCP

Hydrograph



Summary for Pond 8P: Existing Southwest Pond (infiltration)

Inflow Area = 435,908 sf, 0.00% Impervious, Inflow Depth = 5.25" for 100-yr 24-hr event
 Inflow = 62.78 cfs @ 12.17 hrs, Volume= 190,608 cf
 Outflow = 0.84 cfs @ 19.58 hrs, Volume= 144,012 cf, Atten= 99%, Lag= 444.5 min
 Discarded = 0.84 cfs @ 19.58 hrs, Volume= 144,012 cf
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs / 2
 Peak Elev= 841.01' @ 19.58 hrs Surf.Area= 44,928 sf Storage= 153,565 cf

Plug-Flow detention time= 1,372.3 min calculated for 144,012 cf (76% of inflow)
 Center-of-Mass det. time= 1,305.5 min (2,102.5 - 797.0)

Volume	Invert	Avail.Storage	Storage Description
#1	837.00'	250,081 cf	Custom Stage Data (Prismatic) Listed below (Recalc) x 1.1

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
837.00	28,968	0	0
838.00	31,837	30,403	30,403
839.00	34,768	33,303	63,705
840.00	37,762	36,265	99,970
841.00	40,817	39,290	139,260
842.00	43,950	42,384	181,643
843.00	47,456	45,703	227,346

Device	Routing	Invert	Outlet Devices
#1	Discarded	837.00'	0.800 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 0.00'
#2	Primary	842.90'	8.0' long x 10.0' breadth emergency overflow Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

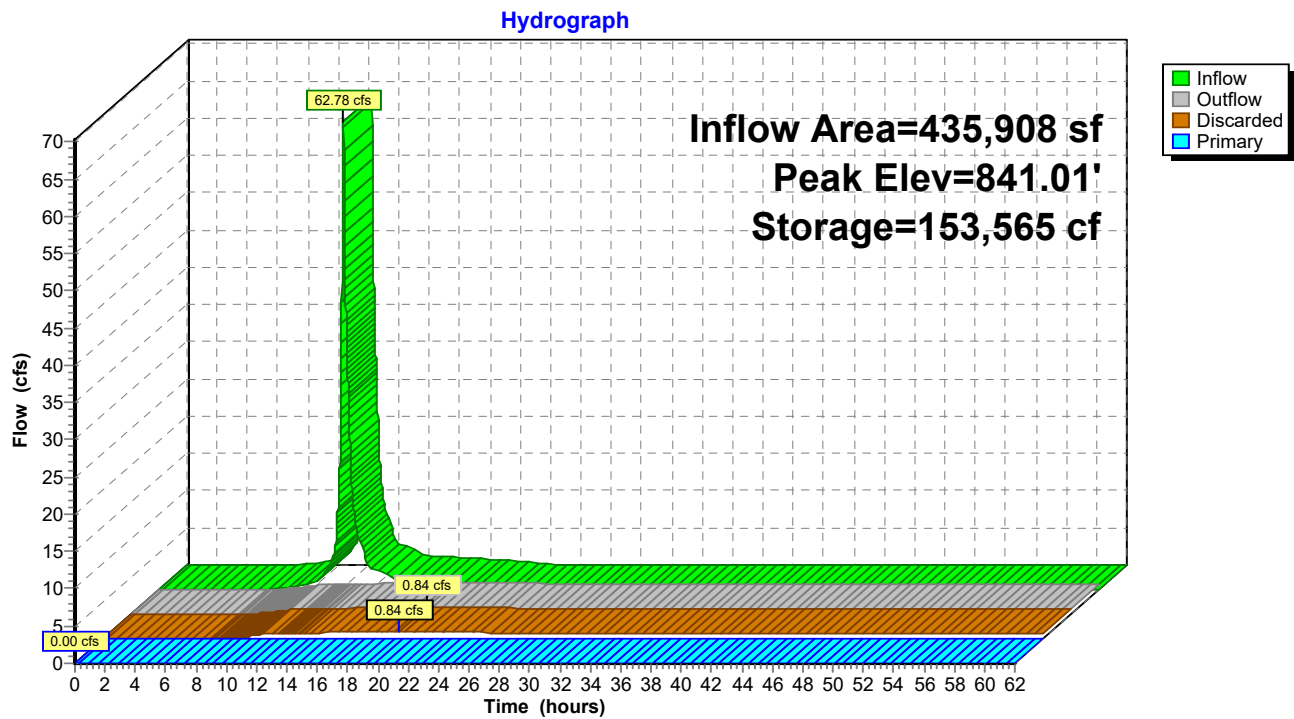
Discarded OutFlow Max=0.84 cfs @ 19.58 hrs HW=841.01' (Free Discharge)

↑ **1=Exfiltration** (Controls 0.84 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=837.00' (Free Discharge)

↑ **2=emergency overflow** (Controls 0.00 cfs)

Pond 8P: Existing Southwest Pond (infiltration)



Summary for Pond 9P: 48" RCP

[57] Hint: Peaked at 867.39' (Flood elevation advised)

[62] Hint: Exceeded Reach A10T OUTLET depth by 6.58' @ 12.18 hrs

[62] Hint: Exceeded Reach ADS5 OUTLET depth by 6.92' @ 12.17 hrs

Inflow Area = 435,908 sf, 0.00% Impervious, Inflow Depth = 5.25" for 100-yr 24-hr event
 Inflow = 62.78 cfs @ 12.17 hrs, Volume= 190,608 cf
 Outflow = 62.78 cfs @ 12.17 hrs, Volume= 190,608 cf, Atten= 0%, Lag= 0.0 min
 Primary = 62.78 cfs @ 12.17 hrs, Volume= 190,608 cf

Routing by Stor-Ind method, Time Span= 0.00-62.00 hrs, dt= 0.01 hrs

Peak Elev= 867.39' @ 12.17 hrs

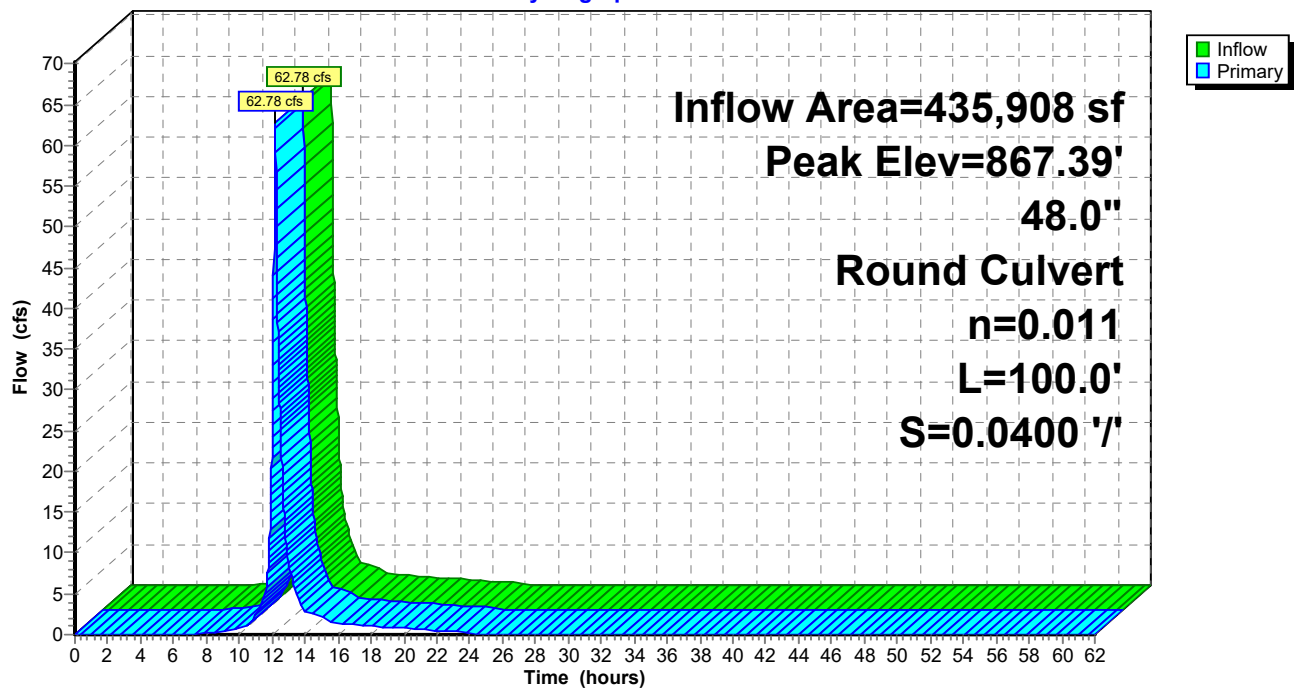
Device	Routing	Invert	Outlet Devices
#1	Primary	864.00'	48.0" Round Culvert L= 100.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 864.00' / 860.00' S= 0.0400 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 12.57 sf

Primary OutFlow Max=62.76 cfs @ 12.17 hrs HW=867.39' (Free Discharge)

↑1=Culvert (Inlet Controls 62.76 cfs @ 5.53 fps)

Pond 9P: 48" RCP

Hydrograph



APPENDIX D

Geotechnical Evaluation





Stantec Consulting Services Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359

To: Tom Shustarich, PE
From: Paul T. Eickenberg, PE
Date: March 29, 2022
Subject: Pine Bend Landfill | Vertical Expansion Geotechnical Evaluation
Project #: 227704791

1.0 Purpose of Technical Memorandum

The purpose of this technical memorandum is to provide an understanding of the overall (or global) stability and the veneer stability of the vertical expansion at Pine Bend Landfill. With respect to the veneer analyses, the following cover system is considered:

- 6-inches of topsoil;
- 18-inches of cover soil;
- Geocomposite (defined as a geonet with a geotextile heat bonded to both sides)
- Textured 40-mil LLDPE geomembrane;
- 6-inches intermediate (buffer) cover soil;
- Waste materials.

The geosynthetic drainage system may consist of a drain liner with an overlying geotextile or a geonet geocomposite (as defined above). The exact materials have not been included herein as manufacturers are subject to change and new products may be developed for consideration.

The veneer stability analysis was completed (shown herein) to evaluate the currently permitted final cover profile design. Interface friction values were assigned based on properties found in literature. If alternate products are used for the geosynthetic drainage system option (i.e. drain liner and geotextile), applicable interface friction values will be reviewed at the time of construction and compared to the completed assessment to confirm stability.

2.0 Methodology

The overall stability analyses were calculated using Slope/W, a two-dimensional limit-equilibrium slope stability program created by GeoSlope International. A limit-equilibrium method calculates the driving and resisting forces and/or moments acting on a soil mass and compares them to calculate the slope factor of safety. As a result, a factor of safety of less than 1.0 suggests that the slope is on the verge of failing due to the driving forces being greater than the resisting forces. On the other hand, a factor of safety greater than 1.0 suggests that the slope is stable because the resisting forces are greater than the driving forces.

Even though a factor of safety (FS) equal to 1.0 suggests that the slope is theoretically stable, the geotechnical engineering community typically prefers minimum factor of safety values ranging from 1.3 to 1.5 for long-term conditions and 1.0 to 1.2 for short-term conditions to account for unanticipated loading or

material nonuniformities. As the completed analyses consider a long-term situation, a minimum factor of safety of 1.5 is considered.

3.0 Material Properties

The assumed shear strength and interface parameters for the cover slope stability analyses are provided in Table 2. These parameters are consistent with those provided in the Wenck (August 27, 2015) "Pine Bend Landfill Phase 6 Expansion Geotechnical Evaluation" stability memo.

Table 2. Shear Strength Parameters used in the Global Stability Analyses

Material	Unit Weight	Cohesion	Friction Angle
Cap Liner	1 pcf	0 psf	8 degrees
Existing Waste	65 pcf	0 psf	35 degrees
Proposed Waste	65 pcf	0 psf	35 degrees
Native Material	110 pcf	0 pcf	35 degrees

Table 2. Shear strength parameters used for the veneer cap liner stability analyses

Material	Unit Weight	Cohesion	Friction Angle
Layer 1. Topsoil	100 pcf	--	--
<i>Interface Properties between Layer 1 and Layer 2 – Peak, Figure 1</i>	--	<i>50 psf</i>	<i>20 degrees</i>
<i>Interface Properties between Layer 1 and Layer 2 – Large Displacement, Figure 2</i>	--	<i>25 psf</i>	<i>20 degrees</i>
Layer 2. Cover Soil	105 pcf	--	--
<i>Interface Properties between Layer 2 and Layer 3 – Peak, Figure 1</i>	--	<i>50 psf</i>	<i>25 degrees</i>
<i>Interface Properties between Layer 2 and Layer 3 – Large Displacement, Figure 2</i>	--	<i>50 psf</i>	<i>23 degrees</i>
Layer 3. Geocomposite	--	--	--
<i>Interface Properties between Layer 3 and Layer 4 – Peak, Figure 1</i>	--	<i>50 psf</i>	<i>19 degrees</i>

Material	Unit Weight	Cohesion	Friction Angle
<i>Interface Properties between Layer 3 and Layer 4 – Large Displacement, Figure 2</i>	--	59 psf	13.4 degrees
Layer 4. Textured 40-mil LLDPE Geomembrane	--	--	--
<i>Interface Properties between Layer 4 and Layer 5 – Peak, Figure 1</i>	--	50 psf	25 degrees
<i>Interface Properties between Layer 4 and Layer 5 – Large Displacement, Figure 2</i>	--	50 psf	22 degrees
Layer 5. Intermediate Cover	110 pcf	--	--
<i>Interface Properties between Layer 5 and Layer 6 – Peak, Figure 1</i>	--	50 psf	20 degrees
<i>Interface Properties between Layer 5 and Layer 6 – Large Displacement, Figure 2</i>	--	25 psf	20 degrees
Layer 6. Waste	--	--	--

4.0 Results of Stability Analyses

The results of these global limit-equilibrium slope stability analyses are provided below. Both cases indicate that the design factor of safety is greater than the required value of 1.5.

- Case 1: Overall System: FS = 1.81 (see Figure 1)
- Case 2: Lower Liner: FS = 1.91 (see Figure 2)

Pine Bend Landfill | Vertical Expansion Geotechnical Evaluation

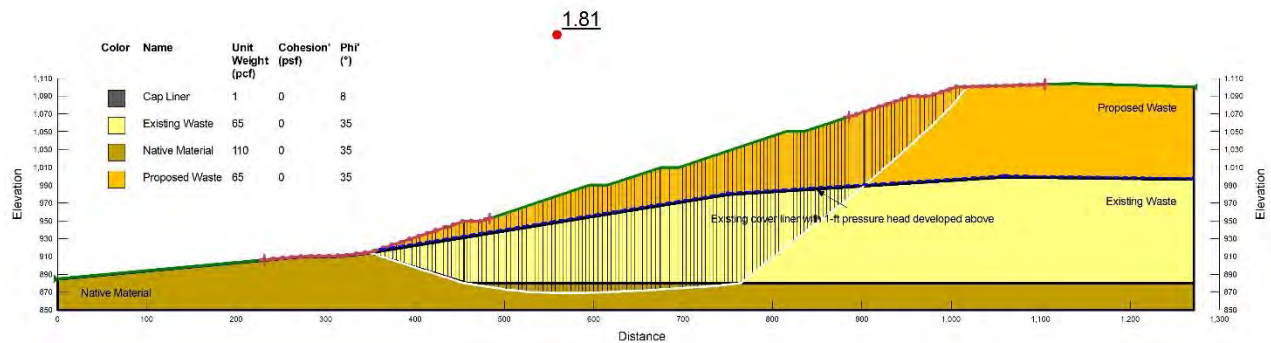


Figure 1. Overall System

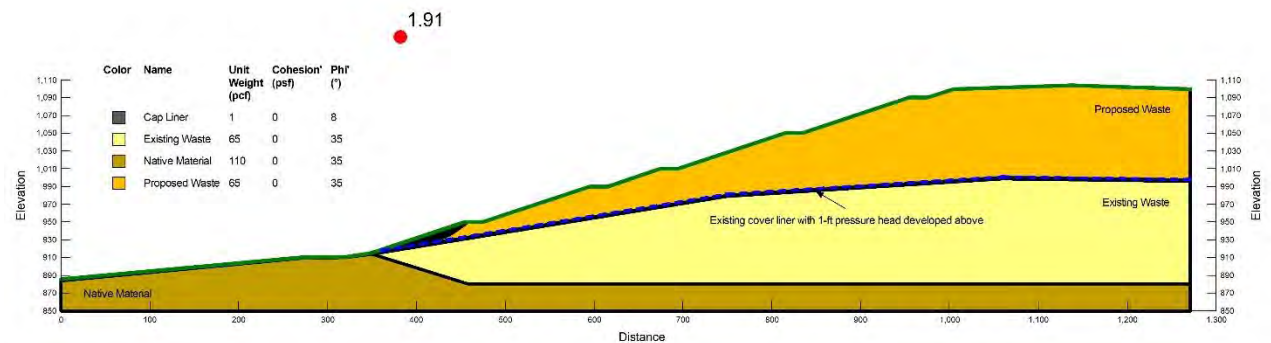


Figure 2. Liner

The requirements and results of the slope stability analyses for the design case is provided in Table 2 below. Also shown below are results for peak and large-displacement conditions associated with the geomaterial interfaces. The calculations for each of these conditions is provided as an attachment to this memo.

Table 2. Results for the veneer cap analyses.

Case ID and Condition	Required FS	Calculated FS
Dry Conditions by Koerner (1994) Method		
Peak	1.50	2.22
Large Displacement	1.25	1.84
Dry Conditions by Koerner and Soong (1998) Method		
Peak	1.50	2.22

Case ID and Condition	Required FS	Calculated FS
Large Displacement	1.25	1.84
75% soil saturation running parallel to the surface		
Peak	1.20	1.48
Large Displacement	1.10	1.32
Loading by CAT D6 dozer running perpendicular (up slope) by Impact method		
Peak	1.20	2.02
Large Displacement	1.10	1.70
Loading by CAT D6 dozer running perpendicular (up slope) by Koerner and Soong (1998) Method		
Peak	1.20	2.10
Large Displacement	1.10	1.78

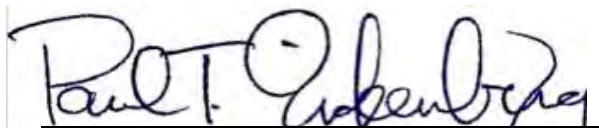
As shown in Table 2, the factor of safety of the cap slope meets the required factor of safety values.

5.0 Summary and Conclusion

The calculated factors of safety are all greater than the required values. Therefore, the system discussed herein is applicable for this situation.

Regards,

STANTEC CONSULTING SERVICES INC.


Paul T. Eickenberg MSCE, MSLE, PE
Associate, Senior Geo-Structural Engineer
Phone: (612) 248-6099
paul.eickenberg@stantec.com

**Pine Bend Landfill
2022 Major Permit Mod Modification**

Deflection Determination - Method 1

Pipe Evaluated: 6" HDPE SDR 11
MSW Cell Leachate Collection Pipe

References: "Modulus of Soil Reaction Values for Pipeline Design",
J Jeyapalan and R Watkins

Solution: **1. Determine Vertical Stress**

Material	Density (pcf)	Depth (ft)	Load (psf)
Final Cover Soils	130	1.5	195
Drainage Layer	120	1	120
Waste and Cover	65	160	10400
Drainage Layer	120	1	120
Intermediate Filter	120	1	120
Coarse Aggregate	130	1.5	195
Total Load =			11150 psf
Total Vertical Load (P) =			77.4 psi

2. Determine Dynamic Stress (DL) on Pipe

Assume Caterpillar D4 dozer or equivalent is placing materials.

From Caterpillar performance handbook ground pressure of D4
580 psf x 1.3 dynamic factor = 754 psf

DL = dynamic pressure (psf) / 144 psi/psf = 5.2 psi
--

3. Determine Total Vertical Stress on Solid Pipe (TP)

Total Vertical Stress (TP) = Static Stress + Dynamic Stress = 82.7 psi
--

4. Determine Strain in Aggregate Envelope using Hookes Law

Hookes Law
Stress / Strain = Elastic Modulus

Therefore the elastic strain in the soil/pipe system is equal to the stress applied to the aggregate envelope divided by E'

Determine Soil Reaction Modulus

Assume bedding is coarse aggregate (USCS Classification GP or GW) compacted to 90% of standard proctor density.

Adjustment is 25 psi at 85% compaction and 100 psi at 100% compaction.

Adjust E' by 50 psi for every foot of additional soil cover above 5'.

Initial E' for 5' of soil cover =	1000 psi
Adjust E' above 5' =	8050 psi
Total E' =	9050 psi

**Pine Bend Landfill
2022 Major Permit Mod Modification**

Deflection Determination - Method 1

Pipe Evaluated: 6" HDPE SDR 11
MSW Cell Leachate Collection Pipe

Assume FS = 2.0, then E' = 4525

Therefore the strain in the soil/pipe system is equal to $TP/E' \times 100\% = 1.83\%$

5. Determine Safety Factor Against Wall Crushing

Determination of stress in pipe S_a

$$S_a = (SDR-1) \times TP / 2$$

S_a = Stress in Pipe

SDR = Standard Dimension Ratio = 11

$S_a = 413 \text{ psi}$

Allowable $S_a = 1500 \text{ psi}$, where 1500 psi is the compressive yield strength

$$FS = 1500/S_a$$

$FS = 3.6 > 2.0 \text{ O.K.}$
--

6. Determine Safety Factor Against Wall Buckling

$$P_c = 5.65[(B' E_p E_s I)/D_m^3]^{1/2}$$

P_c = Critical collapse pressure (psi)

B' = Dimensionless Vertical Stress Factor

$$B' = 1/(1+4e^{(-.065H)})$$

H = Height of Soil Cover above Pipe = 166 Ft

$$B' = 1.000$$

E_p = Modulus of Elasticity = 28,200 psi

E_s = Modulus of soil reaction = 3800 psi

OD = 6 inch SDR 11 = 6.625

D_m = mean diameter = OD - t = 6.023 in

I = Moment of Inertia = $t^3/12$ = 0.0182 in³

t = wall thickness = 0.602 in

$P_c = 533 \text{ psi}$

$$FS = P_c/TP$$

$FS = 6.5 > 2.0 \text{ O.K.}$
--

OPERATIONS AND MAINTENANCE PLAN



OPERATIONS AND MAINTENANCE PLAN

MPCA Permit #SW-45

Pine Bend Landfill

June 2, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359

Project Number:
227704791

Table of Contents

1	INTRODUCTION.....	1
2	EMERGENCY PREPAREDNESS AND PREVENTION	2
2.1	General	2
2.2	Emergency Response Facilities	3
2.3	On-Site Communications.....	3
2.4	Fire Control Equipment.....	3
2.5	Equipment Testing.....	3
2.6	Arrangements with Local Authorities	3
2.7	Emergency Action Plan	3
2.8	Emergency Procedures	4
2.8.1	Physical Injury	4
2.8.2	Fire or Explosion.....	4
3	FACILITY OPERATIONS	5
3.1	General	5
3.2	Site Access and Traffic Control	5
3.3	Waste Acceptance.....	5
3.4	Access to Fill Area	6
3.4.1	Citizen Drop-Off Area	6
3.4.2	Active Areas	6
3.4.3	Closed Area.....	6
3.5	Waste Placement Techniques.....	7
3.6	Leachate Storage and Removal	7
3.7	Equipment	7
3.8	Cover Procedures.....	8
3.9	Shutdown Procedures	8
3.10	Surface Water Control	9
3.11	Wet Weather Conditions.....	9
3.12	Litter Control	9
3.13	Cold Weather Operations	10
3.14	Dust Control.....	10
3.15	Vector Control.....	10
3.16	Fire Protection	10
3.17	Noise Control.....	10
3.18	Pump Inspection.....	10
3.19	Worker Safety	10
3.20	Security	11
3.21	Personnel Training	11
3.22	Maintenance Plan.....	11
3.22.1	General Site Maintenance	11
3.22.2	Equipment	11
3.22.3	Equipment Maintenance.....	12
3.22.4	Drainage Control Feature Maintenance	12
3.22.5	Road Maintenance	13
3.22.6	Leachate Management System Maintenance	13
3.22.7	Landfill Gas Management System Maintenance.....	13
3.22.8	Landfill Dual Extraction System Maintenance	13
4	MONITORING AND INSPECTION REQUIREMENTS	15
4.1	Gas Monitoring Plan	15



4.2	Environmental Monitoring System.....	15
4.3	Site Inspection	15
4.4	Operating Record	16
4.5	Annual Report.....	17

LIST OF APPENDICES

- Appendix A: Leachate Management Plan
- Appendix B: Gas Management and Monitoring Plan
- Appendix C: Landfill Inspection Checklist



1 Introduction

This Operation and Maintenance Manual presents specific information regarding the operations of the facility and maintenance of the facility equipment, structures, and mechanical systems. This manual addresses requirements of the Minnesota Pollution Control Agency Rules, including Part 7001.3300 Items D, G, and P, and Part 7001.3475 Items F and G.

Operational information specific to industrial solid waste management is included in the 2009 Special Waste Management Plan prepared for this facility. Non-hazardous industrial wastes are disposed of in lined MSW cells. Certain industrial waste requires special handling. The site operators must review those procedures as part of their training. As part of the material acceptance protocol, Dakota County reviews the applications for waste acceptance concurrently with Pine Bend Landfill (PBL)

The objective of the Operations and Maintenance Plan is to establish guidelines for use by facility personnel in the daily operations, as well as inspection and maintenance procedures.

The Closure, Post-Closure, Contingency Action Plan should be referred to for information on the closure and post-closure procedures and range of possible emergencies or non-compliances that could occur, and the procedures to be followed in case of these events.

The Design Report and plans should be referred to for more detail on the design of facility features. The Leachate Management Plan for this site should be referred to for more detail on the current leachate management procedures followed at the site and is provided in Appendix A.



2 Emergency Preparedness and Prevention

2.1 General

The objective of an emergency response is to limit the effect on human health and the environment in the event of a calamity, such as fire and/or explosion or personal injury. All staff are trained in first aid, and many in cardiopulmonary resuscitation. First aid kits are available at several locations at the site. Emergency eye-wash stations are also available at several locations at the site.

The Pine Bend Landfill (PBL) provides an ongoing training in safety and emergency preparedness. In 2021, the following topics were included as part of the PBL mandatory safety training program:

Eye/Face Protection	Powered Industrial Trucks
Load Inspection	Back Injuries
Housekeeping	High-Vis Clothing
Towing Safety	Hand Power Tool Safety
Emergency Preparedness	Machine Guarding
Spill Response	Safe Backing
Grinding Adjustments	SPCC
SWPPP	Heat Disorders
Pre-/Post-Trip Inspections	PPE
Electrical Safety	Confined Spaces
Lock-Out, Tag-Out	Overhead Door Safety
Landfill Hazards	Substance Abuse
Respirator Training	Hazard Communication
Safe Welding – Hot Work	Seat Belt Policy
Accident/Injury Reporting	Slips, Trips, and Falls
Blood borne Pathogens	

Similar training topics have been and are currently being completed in 2022.



2.2 Emergency Response Facilities

Personnel are instructed to notify both the facility office and the proper facilities in the case of emergency. The telephone numbers are as follows:

Ambulance:	911	Hospital Name:	Regina Hospital Hastings, MN
		Hospital Phone:	(651) 480-4100
Fire:	911		
Police:	911	City of Inver Grove Heights Police Dept.:	(651) 450-2525

2.3 On-Site Communications

All equipment regularly used for waste and cover material handling are equipped with two-way radios. Telephones are available at the service building and at the office.

2.4 Fire Control Equipment

Fire extinguishers are located on all large earth moving and waste handling equipment. They are also available in the shop and office. They are checked annually by the vendor. Testing verification is maintained with the facility records. The landfill has a water truck, normally used for dust control, that can be used for fires. It can draw water from a water supply tank or a surface water source.

2.5 Equipment Testing

As mentioned, fire extinguishers are checked annually, by the vendor. Communications equipment is kept in working order as a part of regular maintenance activities at the site.

2.6 Arrangements with Local Authorities

The facility is located within the corporate boundaries of the City of Inver Grove Heights. Therefore, the City is obligated to provide fire control and police services.

2.7 Emergency Action Plan

An "Emergency Action Plan" is prepared and maintained at the facility. The manual provides information to be used in case of an emergency, including:

1. A list of names and telephone numbers for emergency services (fire, police, ambulance, etc.).
2. A list of equipment available for emergency control, communication, alarms, earth moving, and other relevant equipment.
3. A description of procedures to be followed from discovery of an emergency situation until it is corrected on the contingency action plan is activated. Notification, control, and cleanup measures will be included.
4. A description of prior arrangements with local authorities.



2.8 Emergency Procedures

The primary emergencies, that could occur, are physical injury, or fire and/or explosion. Each emergency is addressed below. After completion of an emergency action, the plan is evaluated to determine adequacy. Changes to the plan are made as appropriate.

2.8.1 PHYSICAL INJURY

The recommended sequence of events in dealing with a medical emergency is as follows:

- Discovery of injury;
- Emergency first aid at the site;
- Notification of authorities (911) if necessary, based on severity of the injury;
- Notification of Pine Bend Landfill Operations Manager, if not present on-site, via mobile phone (612)300-8610; and
- Written report of accident and circumstances.

2.8.2 FIRE OR EXPLOSION

The recommended sequence of events in dealing with a fire and/or explosion is as follows:

- Discovery of event;
- Account for all site personnel. If medical emergency is associated with the event, see above;
- Notification of the Fire Department (911);
- Notification of Pine Bend Landfill Operations Manager, if not present on-site, via mobile phone (612)300-8610;
- Extinguish fire or mitigate hazard;
- Notification of MPCA personnel within 48 hours of the event (651) 296-6300;
- Written report of event and corrective efforts; and
- Submittal of report to the MPCA Commissioner within two weeks of event.

Any liquids that result from extinguishing a fire are contained by constructing soil berms as appropriate from on-site stockpiles. All liquids that are collected during emergency actions are tested and treated, if necessary, prior to discharge



3 Facility Operations

3.1 General

Normal operating hours for the facility are from 5:00 a.m. to 5:00 p.m. Monday through Friday, with waste received from 6:00 a.m. to 4:00 p.m. Saturday operations may occur during the same weekly hours listed above, but Saturday operations are not a regular occurrence. It should be noted that the landfill may be opened on Sunday should a solid waste processing facility request service on Sunday. The hours for receipt on Sunday shall be 7:00 a.m. to 2:00 p.m. with placement of daily cover until 4:00 p.m. A certified operator is on-site during the normal operating hours and during extended hours when waste is being delivered.

A bound copy of this manual along with the latest site evaluation report as amended and approved and a complete set of plans will be kept in the operations office at the landfill for reference. A certified operator will be present to observe proper operation and monitoring of the facility.

3.2 Site Access and Traffic Control

Site access is controlled by a fence surrounding the entire property with a 40-foot sliding and locking gate at the site entrance on 117th Street. There is also a site exit and construction access off of 117th Street that is controlled by a 20-foot swinging gate, as well as a gate on the west end which leads to the gas plant. Traffic is routed to the various disposal areas with appropriate signs. The site access roads are 16 to 20 feet wide to accommodate two way traffic. They are maintained year-round by landfill staff. It is important to note that PBL has a citizens drop-off area near the site entrance, which keeps private citizens who are delivering waste separate from commercial waste collection vehicles.

3.3 Waste Acceptance

Waste is the building material for developing the facility. The waste must be identified to allow proper handling and development of the fill areas. A process exists to ensure that only acceptable waste is delivered to the site. The first step in this process is the proper education of individuals and the waste haulers and their clients, the generators. The second step is a preliminary inspection of the waste at the gate and a determination of the waste type. The third step is the final inspection of the waste as it is deposited at the working face.

Waste accepted at the site includes: commercial, municipal, industrial, demolition/construction, and residential wastes. These wastes are generated by businesses and the general population and are acceptable under normal operating conditions.

The following wastes which are discovered in any volume are rejected from the facility;

- Asbestos
- Liquids of any sort;
- Sewage sludge, septic tank pumping, sewage sludge compost
- Infectious wastes;
- Paints or oils;
- Other substances that are deemed unacceptable by the MPCA or by the City and County.



Operations and Maintenance Plan

3 Facility Operations

Industrial waste disposal occurs in accordance with the Special Waste Management Plan (SWMP) for the facility. The SWMP defines steps which a potential industrial client must take to determine the suitability of their waste for disposal at the facility. This determination includes identifying any special handling needs to ensure worker safety at the facility. The SWMP is updated as needed to include all authorized industrial wastes and any special handling procedures. Operating personnel will familiarize with all SWMP updates. A copy of the SWMP is kept in the office and can be provided upon request.

The hauler/generator completes all necessary waste characterization and paperwork, including a PBL Special Waste Application form, as required in the SWMP. This information is submitted to PBL and Dakota County concurrently. Dakota County reviews the waste characterization for conformance with Ordinance 110 and PBL reviews for conformance with the SWMP in conjunction with one another. If approved, a PBL Special Waste Code is designated for the special waste. The generator is notified of the waste code number. The hauler presents the non-hazardous special waste manifest completed by the generator and containing the waste code when delivering industrial waste to the facility.

Waste screening at the site is the responsibility of the scale attendant, laboratory technician, and operators. Vehicles carrying unacceptable waste are refused admittance to the facility. Haulers have their loads inspected by the operators as they are deposited at the working face. If the operators encounter unacceptable wastes at the working face, the hauler or individual is stopped and required to remove the waste. If the hauler or individual cannot be identified or cannot respond in a timely fashion, the unacceptable wastes are pushed away from the working face and isolated until it can be properly removed. Steps are initiated to dispose of the wastes in an appropriate manner. The hauler and MPCA are notified by the facility of the occurrence in all cases.

3.4 Access to Fill Area

3.4.1 CITIZEN DROP-OFF AREA

The facility has a permitted citizen drop-off area designed to allow for a safer means for individual citizens to drop off waste, keeping them out of the working face and away from the larger haul truck traffic. The drop-off area is located just to the east of the main gate and consists of three 40 cubic yard roll-off containers which are emptied on a daily basis. MSW, demolition debris and miscellaneous bulky items may be disposed in these containers.

3.4.2 ACTIVE AREAS

Vehicles with waste enter the main facility entrance from 117th Street and proceed to the scale house where they are weighed and recorded. The attendant directs the vehicle to proceed along the existing gravel access road to the active MSW cell. Signs are posted along the road to assist the vehicle.

Temporary gravel access roads are provided within the disposal area as needed. Traffic routing is accomplished by the use of signs. All access roads are maintained to allow year-round access.

3.4.3 CLOSED AREA

Access over closed areas, for example to monitoring wells, is provided. All-terrain-vehicles, pickup trucks, and low-ground-pressure tracked equipment can readily be driven over the final cover without damage to the underlying FML. This is reasonable since, during final cover and base liner construction, this type of equipment is typically driven on the drainage layer. The only damage expected is to the vegetative layer or shallow rutting of the topsoils, which would be promptly repaired.



In the event that larger equipment is needed for larger repairs or modifications, temporary access roads would be constructed. The low frequency of such an event makes this an appropriate approach. The surface water swales will not serve as access roads for larger equipment due to stability concerns.

3.5 Waste Placement Techniques

All acceptable waste is incorporated into the working face. The working face consists of a level area where vehicles unload the waste and an inclined area where the waste is pushed by the operating equipment. The working face is kept as narrow as possible to allow for greater management of waste placement. Such management helps prevent blowing litter, leads to greater compaction efficiency due to more travel in one area, minimizes daily cover and offers easier inspection of incoming loads. The width of the working face can vary in response to the anticipated waste volumes. The width of the typical working face averages approximately 100 feet.

All waste is unloaded at the working face and pushed into position. The waste is deposited in continuous lifts from the toe to the top of the slope. The waste is placed and compacted in two-foot lifts. This is completed until a 15 to 20 foot height is reached in the working face. The sloped portion of the working face is maintained at a 3 percent to 33 percent incline to allow for maximum compaction efficiency. The length of the sloped working face ranges from 100 to 200 feet. The operators determine the slope of the working face based on the daily waste volumes. Compaction of the MSW is accomplished with three to five passes of the waste compactor.

When a new cell is opened, special techniques are used to construct the first waste lift. The first lift is constructed to minimum thickness required by MPCA rules using waste free of elongated objects and demolition debris. The waste is unloaded at the top of the lift and pushed downslope. No equipment or trucks will travel directly on the sand drainage layer. The first waste lift is capped with intermediate cover capable of supporting future operations and minimizing infiltration of surface water.

Non-hazardous industrial solid waste is placed for disposal in the same location, and using the same procedure, as MSW.

It is important to note that the proposed vertical expansion (Phase 7) will be developed in phases. Operational items will be considered when determining the size of each working area or phase. Surface water diversion during the filling in these areas will be crucial to reduce the amount of surface water that may contact the waste to reduce the amount of leachate generated.

3.6 Leachate Storage and Removal

Further details of the leachate management system are provided in the Leachate Management Plan presented in Appendix A.

3.7 Equipment

The following equipment is available on-site and is adequate for daily landfill operations.

- Two 836H landfill compactors
- 836K landfill compactor
- D-8T dozer
- D-6T dozer
- D-6R dozer
- Two 740B Haul Trucks
- Motor Grader



Operations and Maintenance Plan

3 Facility Operations

- Wheel loader 930
- Skid Steer
- Farm Tractor with mower deck
- Water truck

This equipment list may change at any time depending upon available technology and the requirements of the site. All equipment is maintained on a routine basis. Equipment maintenance records are kept on-site at the landfill.

3.8 Cover Procedures

During operations, two types of cover layers are utilized: daily and intermediate. Application of suitable cover soils can result in reduced litter, odors, and vermin; minimize fire potential; enable better access to the working face; increase safety to operators and haulers; reduce infiltration of rainfall; and promote the growth of vegetation.

The intermediate cover functions to reduce the quantity of moisture entering the waste. Any fill area not scheduled to receive wastes for 30 days receives a 12-inch layer of intermediate cover consisting of compacted soils. Also, as each cell reaches its final design height, intermediate cover soils will be placed. The intermediate cover soils are sloped a minimum of 2 percent away from the working face to promote drainage. Temporary berms are constructed at the edge of the covered areas, as needed, to limit run-on to the working face. These berms are 2 feet high and constructed of lower-permeability site soils. Any seeps observed in the intermediate cover system are corrected.

Soil cover material is obtained from on-site borrow sources and the material is stored in stockpiles near the working face. Alternative daily cover materials will be used as approved by the Dakota County. It should be noted that PBL is requesting to stockpile and store approved alternative daily cover materials on top of the Phase 5 area. Additionally, an AutoTarper may be used as alternative daily cover.

When a cell is completed to the final elevations described in the Engineering Plans, the slopes are graded to a minimum of 3 percent and a maximum of 33 percent, and are covered with intermediate cover. Construction of the final cover occurs on a periodic basis as areas of the facility reach final elevations. In areas where prolonged periods (greater than 180 days) occur prior to constructing the cover, an intermediate cover will be installed.

The final cover system design consists of a 40-mil linear low density polyethylene liner, a geonet, 18-inch general fill rooting zone, and a 6-inch topsoil layer.

3.9 Shutdown Procedures

Inclement weather of several types can cause problems in the operations of the facility. These conditions include heavy rain or snow falls, high winds, etc. Operations may be altered to mitigate weather effects as outlined above, however, at times the facility will close. The facility operations are reviewed if there are sustained winds, if daily cover is not available, or if access to the working face is not safe. Each commercial hauler is given a number to call in the event extreme weather conditions warrant facility closure. The general public is notified at the gate and informed about the duration of the weather-related closure.

In the event inclement weather conditions occur during operational hours, the operators attempt to place available cover over the working face. The operators assist the vehicles on site or already at the working face. Waste loads are held at the gate until weather conditions improve.



3.10 Surface Water Control

A Storm Water Pollution Prevention Plan (SWPPP) was updated for PBL in March 2020 to meet the requirements of the MPCA Multi-sector General Permit for Industrial Activities. Some specific surface water control procedures for PBL are detailed in the following section.

With the implementation of the area fill method, the above grade development of the waste fill minimizes the potential for run-on by surface water from adjacent areas. A series of temporary ditches and culverts are constructed as shown in the site drawings to divert surface water away from the toe of the waste deposit.

As the waste deposit reaches planned elevations, intermediate cover is constructed, resulting in the creation of surface water run-off. The surface water on the cap is routed by piping within the swales, constructed on the cap which led to energy breaks, ditches, culverts, and ultimately sedimentation ponds.

Water collected in the perimeter ditch system is routed to the sedimentation basin located on the site. The sedimentation basin is meant to improve the water quality of the run-off leaving the site. Samples of the water in the sedimentation basin is collected periodically for analysis.

During various phases of operation, a series of sediment control measures may be installed near the outlets of the drainage structures to prevent the migration of sediments from the site. These measures may include staked silt fences and hay bales. Long-term use of these measures will not be required when vegetation is established in the ditches.

3.11 Wet Weather Conditions

Temporary berms and ditches are provided to divert surface water from the working faces and areas where vehicular traffic will occur. Temporary access roads to the working face will be maintained with a gravel surface to keep them passable. The site manager has the option to stop operations if weather conditions make normal operation impossible.

3.12 Litter Control

Unloading of demolition debris and new construction debris, as well as MSW, shall be confined to as small an area as practical, and surrounded with appropriate facilities to confine wind-blown material within the area. At the end of each 48-hour period, all debris from the landfill shall be picked up on and off the landfill property.

During periods of windy weather, the operators employ an appropriate variety of tactics to prevent littering. These tactics are described as follows:

- Maintain disposal area in well-screened areas;
- Place the waste at the lowest level of the fill area possible;
- Apply liberal quantities of cover soil as the cell is constructed;
- Refuse to accept waste highly susceptible to becoming windblown; and
- Police the site fences and tree lines and return all litter to the working face.

In certain extreme conditions, operations will cease. The decision for operations to cease is made at the discretion of the facility manager.



3.13 Cold Weather Operations

During extremely cold weather, operations will be moved to low areas not exposed to the wind. No liquids or sludge's are accepted at the site, therefore, no special waste handling measures are required.

A stockpile of cover material is maintained. Frozen soil is removed so unfrozen soil can be spread as necessary. Winter operations require snow removal on service, access, and temporary roads at the site. Snow removal is also required on the working face of the cell to avoid waste placement on top of snow. Landfill equipment is utilized, as required, to provide snow removal operations. Placement and compaction of the waste is performed in a timely manner to avoid freezing of unloaded material. Snow which has come in contact with waste is stored in the lined area.

3.14 Dust Control

Dust will be controlled by watering the access roads if necessary and by prompt revegetation of filled cells.

3.15 Vector Control

Vector control is achieved through the use of daily, intermediate, and final cover. Highly putrescible wastes are covered immediately upon placement at the working face. PBL also has a contract with a pest control company to provide inspection of the site on a monthly basis.

3.16 Fire Protection

Fire protection will be in accordance with the Facility's Fire Protection Plan. Fire extinguishers are maintained throughout the facility. In addition, some pieces of equipment used to operate the landfill contain on-board fire extinguishers. Fire protection is provided by the City of Inver Grove Heights Fire Department. No open burning is conducted on this site.

3.17 Noise Control

Noise control is handled on-site by limiting hours of operation and by providing acceptable muffler systems on the vehicle traffic.

3.18 Pump Inspection

Pumps are repaired or replaced on an as-needed basis. Malfunction is detected by the various warning lights. Manufacturer's operation and maintenance recommendations are followed for routine maintenance and trouble-shooting.

3.19 Worker Safety

Manholes and leachate storage tanks are confined spaces which require a confined space entry permit outlining precautionary steps that must be taken prior to entry. Pumps and controls can be removed from the leachate storage tanks at the surface for routine maintenance .

When leachate handling structures are opened, a combined oxygen, combustible gas (methane) and hydrogen sulfide meter is used to determine if conditions on the surface are safe. If not, workers are instructed to move away until conditions are safe. Only personnel trained in the use of, and equipped with, supplied air should enter these structures.



Operations and Maintenance Plan

3 Facility Operations

Landfill operators are trained in equipment safety and waste handling and are MPCA certified operators. Additional safety training is coordinated by PBL and is ongoing as detailed in Section 2.1.

3.20 Security

Operating hours are posted at the site entrance. This entrance is closed and locked during non-operating hours, or at any other time that the site operations building is not staffed.

3.21 Personnel Training

As of March of 2022, the facility has three (3) MPCA-certified operators, allowing one certified operator to be present at the facility during all hours of site operation. New site personnel who will be charged with operating responsibilities generally receive formal training within the first six months of employment. All employee-training records are maintained at the facility office. Facility operators are encouraged to update their training on a biannual basis, or as necessary, to maintain MPCA certification.

The facility strives to maintain a safe work environment for the employees and customers. The Pine Bend Landfill has a mandatory safety and/or training program. The emergency procedures at the site have been described and detailed in Section 2.1 of this report.

The meetings are held on a monthly basis, or more often, to review and update current operating procedures.

3.22 Maintenance Plan

3.22.1 GENERAL SITE MAINTENANCE

The site will be maintained to provide a safe operating environment. The perimeter fencing and entrance gate will be maintained to provide security for the facility and discourage unauthorized access. The operator will lock the gates at the end of each working day and maintain the security systems on the facility buildings. The facility will adhere to MPCA guidelines regarding litter suppression and removal.

3.22.2 EQUIPMENT

Facility equipment, which was previously itemized, includes a landfill compactor to handle waste at the working face, dozers to assist in waste movement and placing operational cover from the stockpiles onto the waste, off-road vehicles to carry cover soils from the borrow areas to the stockpiles, and equipment to maintain site roads.

The filling of all fuel tanks for the equipment is monitored. Unattended filling of equipment or fuel tank is not allowed. In the event of a discharge during fueling, the following steps are taken:

- Contain spill to as small an area as possible using on-site equipment to create soil berms.
- Recover as much product as possible using pumps, sorbent material or other materials. Remove any soil that has been visibly contaminated by the product.
- Notify the MPCA of the spill.



3.22.3 EQUIPMENT MAINTENANCE

Facility equipment is adequately maintained to ensure safe operation and the ability to handle the waste as they are received. Each piece of equipment has its own maintenance schedule, depending on its level of usage. General maintenance operations are performed at the site. In-depth maintenance and repair is performed in the facility equipment building. Maintenance manuals for all equipment at the site are kept in a file in the equipment building.

A daily maintenance program includes: removing waste from radiators and checking for worn cooling system hoses and fan belts, checking hydraulic systems for worn hoses and fluid leaks, checking for fuel leaks, worn tracks or tires, etc.

Prior to operating the equipment at the beginning of each day, all water, hydraulic fluid, oil, and fuel levels are checked. An inspection of the area around the equipment is made to ensure the area is clear. The backup warning system is checked before leaving the startup area.

While equipment is operating, the machine is checked periodically for hanging or attached debris. The fuel and hydraulic systems are checked for leaks. Waste is handled in a manner, which protects the operator, as well as those at the working face.

At shutdown, the engine is allowed to cool evenly prior to shutting off. A 3-to-5 minute idle period is typical. All blades and other moveable parts are lowered to the ground, and the brakes and transmission locks set.

Records are kept of all maintenance work performed on the facility equipment. These records are kept with the equipment manuals in the maintenance building.

3.22.4 DRAINAGE CONTROL FEATURE MAINTENANCE

Routine maintenance of drainage control structures are initiated in response to general inspections or inspections prompted by a heavy rain. The drainage control features present include the sedimentation basins, culverts, ditches, berms, and catch basin inlet structures on the surface water benches.

Drainage berms are inspected to ensure that they are not breached or excessively eroded at their toe. Corrective measures include reconstruction of the berm or regrading at the berm toe or erosion cuts in the ditches. These areas are regraded to the design profile of the ditch and seeded for vegetation re-establishment as required to maintain efficient flow and operation. If erosion problems persist, the operator uses hay bales, silt fences, erosion control matting, or sod to abate the problem. Siltation in the ditches is removed and used in regrading projects or in facility operations. All catch basin inlets must be manually cleared of debris on a regular basis.

The sedimentation basins require periodic maintenance to remove sediments which have accumulated. The accumulated depth is monitored and sediments removed by pan scraper and/or tracked dozer. A dragline or backhoe may be necessary if the moisture conditions warrant. The sediment is used in the facility operations as intermittent cover. Inlet and outlet structures are inspected for scour of riprap materials. If problems exist, appropriate correction measures are implemented.

Culverts are inspected for erosion damage at inlet and outfall structures. Eroded areas are regraded. Any debris accumulated near the inlet is removed to the active working area.



3.22.5 ROAD MAINTENANCE

A two-lane all-weather access road is maintained to the operating area on a continual basis. The gravel course is supplemented and graded out to eliminate rutting as needed. Ramps within the fill area are constructed with MSW and have grades limited to 15 percent. Access roads to the working face within the facility are maintained at a 15 percent maximum grade, allowing vehicles to reach the working face under their own power. The roads periodically change alignment or are extended as the filling progresses. Dust is controlled by addition of water to the access roads at the discretion of the facility.

3.22.6 LEACHATE MANAGEMENT SYSTEM MAINTENANCE

Sediments are cleaned from the leachate collection and transmission pipes on an annual basis. The cleaning is accomplished by high-pressure jetting equipment or other mechanical means. Access to the pipes is available through the cleanout structures at various points in the piping system. Enclosed space entry is not necessary to accomplish the cleaning.

The leachate sump pumps and pumps in the lift station and storage tanks receive preventative maintenance on a schedule called out in the operating manuals. Repairs to the pump control panels are made on an as-needed basis.

3.22.7 LANDFILL GAS MANAGEMENT SYSTEM MAINTENANCE

The condition of the landfill gas management system is monitored during the monthly well field monitoring activities. The blowers and flares are maintained according to the manufacturer's recommendation. Repairs to the wellheads are made on an as-needed basis. Blockages in the gas transmission header or condensate lines are investigated and repaired as needed.

3.22.8 LANDFILL DUAL EXTRACTION SYSTEM MAINTENANCE

The leachate extraction system at the was installed in 2002 to collect leachate from the unlined portion of the fill area. Fifty (50) existing gas extraction wells were reconfigured to allow for dual use for landfill gas and leachate recovery. Currently, 9 (nine) extraction wells are equipped with leachate extraction pumps and are operating as dual leachate extraction wells. The number of dual extraction wells is down to nine due to wells being taken off-line for Phase 5 and 6 landfill construction. PBL is currently researching the option for a pneumatic system using 2-inch HDPE air lines and 3-inch HDPE leachate forcemains. The dual-extraction system will be redesigned and pumps will be installed in wells when practical.

Field technicians regularly (typically weekly) monitor the dual extraction system, which includes the function of the leachate pumps, the condensate sumps, leachate storage tanks, collecting data, etc.

The "2021 Annual Report for the Phases 1 and 2 Dual Extraction System" which was submitted to the MPCA, Dakota County, and the city of Inver Grove Heights should be reviewed for more detailed information and data.

An evaluation of the current system shows a continued reduction in leachate levels on the liner system from 2002 to the present. Extraction volumes on average have increased in the over the last three years. Volume of leachate removed via the dual extraction system over the last ten years is as follows:

2012: 187,000 gal
2013: 537,498 gal
2014: 367,620 gal
2015: 217,998 gal



Operations and Maintenance Plan
3 Facility Operations

2016: 179,520 gal
2017: 183,612 gal
2018: 198,594 gal
2019: 556,710 gal
2020: 639,804 gal
2021: 396,660 gal



4 Monitoring and Inspection Requirements

4.1 Gas Monitoring Plan

Landfill gas is currently and will continue to be monitored according to the facility's permit. A Gas Management Plan was prepared and is included in Appendix C. Monthly readings are taken at 219 gas monitoring points by Opal Fuels, LLC. The readings are stored in an online data base.

4.2 Environmental Monitoring System

A groundwater monitoring program has been prepared that establishes a monitoring well network, sampling schedule, and data evaluation procedures to meet the objectives of routine groundwater monitoring and corrective action monitoring at PBL. Routine groundwater monitoring is required as part of PBL's operating permit (SW-45) and has been ongoing at the facility for over 40 years. The purpose of routine groundwater monitoring is to facilitate the detection of releases to groundwater from the landfill. Corrective action monitoring is required to evaluate the progress of remedial actions in re-establishing groundwater quality conditions in conformance with MPCA groundwater performance standards at the compliance boundary. The groundwater corrective action monitoring plan will be followed until compliance is achieved. When groundwater quality conditions are in compliance, the routine groundwater monitoring plan will be implemented. The groundwater monitoring program is described in detail in the facility's Sampling and Analysis Plan (SAP). The SAP is intended to fulfill the requirements of the Minnesota Rules Chapter 7035.

4.3 Site Inspection

Inspections of the facility by MPCA personnel are conducted on a random basis for regulatory compliance. Reports of the MPCA inspections are maintained at the office and the MPCA regional and St. Paul offices. The facility manager or certified operator is notified and present during all inspections. Dakota County conducts inspections of the landfill on a twice monthly basis.

The facility has developed a self-inspection program whereby the MPCA certified operator inspects the waste disposal area on a daily basis. The site is also inspected by a MPCA certified operator on a monthly basis as well to thoroughly complete a more detailed facility inspection. A copy of the daily and monthly inspection logs are included in Appendix D. Additional inspections are conducted and documented in response to events, such as heavy precipitation, to ensure protection of public health and the environment. A checklist is used to identify facility features that are observed in order to detect malfunctions, deteriorations and/or discharges. An inspection logbook will be kept at the office. A brief description of certain inspection procedures follows.

The active area is checked for length and slope of the working face, placement of daily cover, locations of berms to divert surface water flow from adjacent areas, location and condition of litter fences, and the condition of the access roads and working area immediately adjacent to the working face. The groundwater and landfill gas monitoring wells are inspected for properly furnished locks and any vandalism is noted for repair.

The leachate management system is checked by activating the discharge pump in each cell or phase and verifying the flow of leachate to the storage tanks. During this discharge process, the flow of leachate from the cell is verified by inspection at the manhole. The pipes and/or manhole are cleaned and rechecked if free flow is not noted. The head of leachate on the liner is determined by measurements taken by a pressure transducer within the leachate pump.



Operations and Maintenance Plan

The pumps in the lift station and leachate storage tanks are checked to verify satisfactory operation. The high/low level floats in the lift stations and storage tanks are checked for proper operation. The drain of the leachate lead-out pad is checked for blockage.

The closed and general working areas of the facility are inspected. The closed areas are checked for settlement of the cover; erosion of the intermediate and final cover on slopes or along drainage control berms and ditches; unchecked vegetative growth that might damage the cap or block the drainageways; or stressed vegetative growth which might indicate gas migration. The gas flare, leachate pumps, and storage basins are reviewed. The sedimentation basin is checked to determine if cleaning is required, as are the drainageways and culverts leading to the basin.

Safety equipment, including fire extinguishers and first aid kits are checked for their condition and presence on the heavy equipment at the working face and at the various structures of the facility.

The following systems are inspected formally, during operations, in accordance with the schedule below:

System	Schedule
1. Active Area	Daily
2. Leachate Management	Daily
3. Final Cover	Daily and after major storm events
4. Surface Water Control	Daily and after major storm events
5. Landfill Gas Management	Daily
6. Dual Extraction system	Weekly
7. Environmental Monitoring System	Daily
8. General Site	Daily and after major storm events

These inspections will occur for currently active areas and previously closed areas on the facility. The results of each inspection will be recorded on the forms attached as Appendix C. These forms are maintained in a log book and summaries included in the annual report. The facility also does inspections on all tanks stored at the site. Those forms are also included in Appendix C.

4.4 Operating Record

PBL maintains a written operating record. The record contains the following information:

1. The amount, type and date of waste received.
2. The management techniques used.
3. Summary reports and details of events requiring contingency action.
4. Records and results of inspections by the City of Inver Grove Heights and Dakota County, including hazardous waste inspections.
5. Monitoring, testing, and analytical data.
6. The volume and frequency of leachate removal.
7. Expenditures relating to closure, post-closure care, and contingency action.



The operating record will be maintained for minimum of 5 years following closure.

4.5 Annual Report

PBL submits an annual report to the commissioner by March 1st on activities for the previous calendar year. The report includes:

1. The permit number, name, and address of the facility.
2. The year covered by the report.
3. The quantity and type of waste handled at the facility.
4. The remaining capacity for storage of waste at the facility based on the amount of waste received and the original site capacity approved.
5. The most recent closure cost estimate and the most recent contingency action plans.
6. An assessment of the adequacy of the closure and contingency action plans.
7. Personnel training information.
8. A summary of the operators inspections of the facilities.
9. The signature of the owner or operator, certifying the accuracy of the report.
10. Annual water, gas monitoring, and dual extraction system reports.
11. The fill area must be surveyed annually before November 1st by a land surveyor registered in Minnesota. An updated existing conditions plan must be submitted with the annual report required in Part 7035.2585. The plan must show the elevations of completed fill areas, areas partially filled, and all design features that changed in elevation due to facility operations or settlement. The remaining fill capacity must be calculated and shown on the plan.



APPENDIX A

Leachate Management Plan



LEACHATE MANAGEMENT PLAN

MPCA Permit #SW-45

Pine Bend Landfill

June 2, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359
Phone: 763-479-4200

Project Number:
227704791

Table of Contents

1	INTRODUCTION.....	1
1.1	General	1
1.2	Design of Leachate Collection System.....	1
1.2.1	Collection Pipes	1
1.2.2	Leachate Storage Sump.....	2
1.2.3	Leachate Head Build-Up	2
1.2.4	Sideslope Risers.....	2
1.2.5	Leachate Sump Leak Detection	2
1.2.6	Leachate Lift Station and Forcemain.....	3
2	LEACHATE QUALITY	4
3	LEACHATE MANAGEMENT OPTIONS	5
3.1	Leachate Generation	5
3.2	Selected Leachate Management Options	5
4	MONITORING PROCEDURES	6
4.1	Leachate Collection System	6
4.1.1	Leachate Sampling.....	6
4.1.2	Analysis	6
4.2	Leachate Sump Leak Detection System	6
4.2.1	Leak Detection Schedule	6
4.2.2	Liquid Identification.....	6
4.2.3	Reporting	6
4.3	Quality Control.....	6
4.3.1	Introduction	6
4.3.2	Sample Collection and Laboratory Analysis.....	7



1 Introduction

1.1 General

This document is the Leachate Management Plan for the Pine Bend Landfill (PBL) (MPCA Permit SW-45). The Leachate Management Plan (LMP) outlines an operations protocol for the safe management of the leachate generated at the landfill. In addition to the disposal procedures, this plan discusses the leachate sampling requirements and disposal options.

Additional information about the leachate management system is contained in the Design Report, which discusses details of the leachate collection system and leachate generation rates. A summary of the leachate collection system design is given below. The Operations and Maintenance Plan, and Closure, Post-Closure, Contingency Action Plan and financial assurance documents also give supplementary information about the leachate management system as it pertains to the intent of each report.

The current method of management is to collect and convey leachate from the collection sumps into a leachate storage tank. From the storage tanks, tanker trucks transport the leachate to the Metropolitan Council of Environmental Services (MCES) wastewater treatment plant in St. Paul. This proposed vertical expansion (Phase 7) does not change the manner in which leachate is collected since waste will be placed over cells with existing geosynthetic liner systems.

1.2 Design of Leachate Collection System

The existing leachate collection system at the site was constructed to collect and convey leachate over a liner system to collection sumps located within the phases. The sumps incorporate sideslope risers to eliminate penetration of the composite liner system. The leachate is then pumped to one of two leachate storage tanks. Two above ground steel tanks, which are 80,000 and 101,000 gallon in capacity, are located in the southern portion of the site near the main office. Condensate from the active gas system is also routed to the two tanks. See the Plan Drawings for exact tank locations.

1.2.1 COLLECTION PIPES

The leachate collection pipes for the site are 6-inch diameter, perforated, Standard Dimension Ratio (SDR)-11, HDPE pipe. Locations and inverts of collection pipes are shown on the Plan Drawings.

Access to the leachate collection pipes are provided by cleanout risers, which extend up the side slopes to allow easy access. Existing cleanouts that are filled over by the current vertical expansion of the 3:1 slopes are to be extended up through the waste mass as shown on the Plan Drawing. Cleaning of the collection pipes is conducted as required in the Operations and Maintenance Plan.

A 6-inch diameter HDPE pipe at 1.0 percent slope has a hydraulic capacity of 273 gallons per minute. The pipe in this design is not sized for flow capacity, but to provide sufficient strength and to allow for use of standard sewer pipe cleaning and maintenance equipment. The peak flow expected in any leachate pipe was calculated using the HELP model leachate generation rates, in the active condition, at less than 1 gallon per minute.



Leachate Management Plan

1 Introduction

The collection pipes are placed in trenches. Coarse aggregate and an intermediate filter aggregate are used as a filtering media and also used over the pipes to protect them from loadings from landfill equipment and the waste mass.

Special care was taken to properly align the pipes according to the invert elevations and locations. The perforations are oriented to be on bottom.

A layer of coarse aggregate 3 inches thick was placed in the trench and the pipe was placed and aligned. The remaining coarse aggregate was placed after the pipe was fully installed. The intermediate filter aggregate was then placed over the coarse aggregate to provide a filter media. This filter media helps stop migration of particles that might otherwise clog the collection pipe. The granular drainage layer material was then graded over the trench.

1.2.2 LEACHATE STORAGE SUMP

Leachate collection pipes convey leachate to one of two storage sumps at both ends of the Phase 5 landfill development and the sumps designed and permitted within Phase 6. The sump area and manhole serve as a wet well for the side slope. The sump consists of a 6-foot deep depression in the liner system and was filled with coarse aggregate. Leachate in the landfill that flows to the sump area is then pumped via a sideslope riser system to the leachate storage tank. are constructed of HDPE manholes which house a temporary sump and pumps to facilitate leachate transfer until the ultimate development is completed to the south.

1.2.3 LEACHATE HEAD BUILD-UP

Calculation of the estimated leachate head build-up in the granular drainage layer over the liner indicates an average leachate head build-up of approximately 2.8 inches for the open condition and approximately 0.1 inches for the closed condition. Leachate head is monitored continuously at the riser in accordance with the operations and maintenance plan.

1.2.4 SIDESLOPE RISERS

Two side-slope leachate risers were placed in the leachate storage sump for Phase 5F, running for 5 feet along the base of the sump and up the side-slope to a riser vault. They consist of 18-inch, SDR-11, HDPE pipe. This provides a redundant leachate extraction system in case the first riser is compromised. The Phase 7 vertical expansion will not utilize sideslip risers.

1.2.5 LEACHATE SUMP LEAK DETECTION

With regards to a leak detection system (lysimeter) installed beneath the low point of the Phase 6 fill area, MPCA Solid Waste Rules part 7035.2815, subp. 9 states:

A. The owner or operator must install the detection system at the lowest elevation of the fill area and throughout the fill area, as necessary, to monitor leachate build-up and for use as a part of the collection system. The detection system must be capable of monitoring leachate build-up in the fill area and consist of collection lysimeters and standpipes capable of monitoring, detecting, and collecting leachate movement through the liner. The detection system must consist of materials compatible with the leachate. The commissioner may approve a detection system without collection lysimeters or standpipes provided the owner or operator shows either to be unnecessary based on the liner system, subsurface soil conditions, ground and surface water flow patterns, depth to ground water, and the amount



Leachate Management Plan

1 Introduction

of leachate generated. The detection system must be designed and constructed to monitor the effectiveness of the leachate storage area.

The Phase 6 development includes an enhanced liner system in the sump areas (60 mil, GCL, 2 feet of clay), PBL is proposing to commit to liner leak location testing following each phase of liner system construction in lieu of lysimeters. Historically, PBL sees little to no liquid and no detection of leachate indicator parameters in their current lysimeters. PBL is committing to providing enhanced design and construction activities for this overfill development; above and beyond what has been performed in the past for their liner system that is showing no indication of loss of integrity. PBL is aware that the MPCA has approved the elimination of lysimeters in other composite lined facilities.

1.2.6 LEACHATE LIFT STATION AND FORCEMAIN

Leachate collected in the sump area is pumped via a side slope riser system to one of the two leachate storage tanks. At the top of the riser, the 3-inch forcemain is encased in a 6-inch HDPE protective pipe to convey the leachate to the existing storage tanks. A control manhole is located to the west of the storage tanks to control which of the two tanks leachate is directed to. See Plan Drawings for more detail.



2 Leachate Quality

PBL collects samples of the leachate from the facility's existing leachate collection tanks. A complete description of the leachate environmental monitoring system and the results from the analyses of quarterly samples are detailed in the Facility's Annual Reports.



3 Leachate Management Options

3.1 Leachate Generation

The potential quantity of leachate generation at the Pine Bend Landfill, in the past, has been estimated using the Hydrologic Evaluation of Landfill Performance model. However, the HELP model has been found to generally provide a low estimate. Because of this, the actual leachate generation volumes from the facility from 2017 through 2021 are provided below.

2017	6,642,340	gallons
2018	9,670,009	gallons
2019	7,610,212	gallons
2020	5,148,812	gallons
2021	9,188,290	gallons

The projected leachate generation rates are not expected to increase much due to the vertical expansion in the Phase 5 and 6 area. It is reasonable to estimate that the leachate generation will be between 8 and 9 million gallons per year in upcoming years.

3.2 Selected Leachate Management Options

PBL is proposing to continue to haul leachate to the MCES WWTP in St. Paul for treatment and as presented within and as previously approved will be capable of leachate recirculation operations. Please refer to the Leachate Recirculation Plan provided as the last section to the Application for Permit Renewal.



4 Monitoring Procedures

4.1 Leachate Collection System

4.1.1 LEACHATE SAMPLING

Leachate samples are collected in accordance with presently approved and permitted procedures. PBL conducts leachate sampling twice per year and collect samples from either leachate collection tank. The analytes tested are in accordance with Minnesota Rule 7035.2815, Subp. 14, C, Table 1 and Table 2. Monthly samples are also collected in accordance with the MCES Industrial Discharge permit for the site.

4.1.2 ANALYSIS

Samples are analyzed by Eurofins or contracted out to another qualified laboratory as necessary.

4.2 Leachate Sump Leak Detection System

4.2.1 LEAK DETECTION SCHEDULE

The leachate sump leak detection (lysimeter) riser is checked quarterly during site operations. After the site closes, it will be checked quarterly, as well as by the leachate tanker truck operator when he is on-site. If liquid is found in the standpipe, it will be sampled and analyzed to quarterly determine if it is leachate, groundwater or a mixture of the two.

4.2.2 LIQUID IDENTIFICATION

Liquid found in the lysimeter standpipe are sampled using a bailer and analyzed for the leachate indicator parameters.

If the liquid is identified as groundwater, the lysimeter are pumped dry (to the environment) and no further action is required.

If the liquid is identified as leachate, the Contingency Action Plan is implemented.

4.2.3 REPORTING

If liquid is identified in the standpipe, documentation is included in the annual report which is submitted to the MPCA each March 1.

4.3 Quality Control

4.3.1 INTRODUCTION

Quality Assurance and Quality Control (QA/QC) procedures are designed to assure the accuracy of data generated from the environmental monitoring programs (including leachate and sedimentation basin sampling). Error can be introduced in the process of sample collection or laboratory analysis.



4.3.2 SAMPLE COLLECTION AND LABORATORY ANALYSIS

Leachate samples are collected in accordance with presently approved and permitted procedures. PBL conducts leachate sampling twice per year and collect samples from either leachate collection tank. The analytes tested are in accordance with Minnesota Rule 7035.2815, Subp. 14, C, Table1 and Table 2.



APPENDIX B

Gas Management and Monitoring Plan



**GAS MANAGEMENT AND MONITORING
PLAN**

MPCA Permit #SW-45
Pine Bend Landfill

June 2, 2022

Prepared for:
BFI Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359
Phone: 763-479-4200

Project Number:
227704791

Table of Contents

1	INTRODUCTION.....	1
1.1	Purpose	1
1.2	Background	1
2	GAS SYSTEM DESIGN.....	2
2.1	Extraction Wells	2
2.2	Gas Piping System	2
2.3	Condensate	2
2.4	Methane Monitoring Probes	3
3	GAS MONITORING.....	4
3.1	Methane Monitoring Probes	4
3.2	Continuous Gas Monitors	4
3.3	Gas System Maintenance	4

LIST OF APPENDICES

APPENDIX A Continuous Gas Monitor Log Sheet



1 Introduction

1.1 Purpose

The Pine Bend Landfill (PBL) is a mixed Municipal Solid Waste (MSW) landfill, located in Inver Grove Heights, Minnesota, which has been in operation since 1971 under Minnesota Pollution Control Agency (MPCA) Solid Waste Permit SW-45. PBL is ultimately responsible for all operations at the landfill, including the active gas management system. It should be noted that through a site lease agreement, Opal Fuels, LLC (Opal Fuels) operates the gas to energy plant located at the site. The purpose of this report is to update the Gas Management and Monitoring Plan for Pine Bend Landfill.

1.2 Background

The EPA and MPCA require that landfill gas (LFG) generated at MSW landfills be controlled. This control requirement is to achieve two objectives. First, the methane component of LFG is combustible in the concentration range of 5 to 15 percent by volume in air. Five percent is considered the lower explosive limit or LEL and 15 percent is considered the upper explosive limit or UEL. Consequently, migration and concentration of methane into enclosed spaces could result in an explosive atmosphere. Therefore, Minnesota Rule 7035.2815 Supb. 11 requires that the concentration of any explosive gas not exceed the LEL at the property boundary or 25 percent of the LEL in or around facility structures. PBL has an MPCA-approved gas collection and monitoring system to address concerns with migration of combustible gas.

The second objective in controlling LFG is for maintenance of air quality standards. In March of 1996, the EPA approved air emissions regulations for large new and existing MSW landfills. These are the New Source Performance Standards and Emission Guidelines (NSPS). Under these regulations, affected facilities that emit more than 50 megagrams per year (Mg/yr) of non-methane organic compounds (NMOC) must install controls. The installed controls must be capable of reducing the NMOC in the collected LFG by at least 98 percent by weight. PBL has been proactive in the installation of landfill gas control equipment.

PBL employs a comprehensive monitoring program for early detection of landfill gas (LFG) in on-site structures and at adjacent properties, as well as gas collection and a landfill gas to energy plant. Minnesota Rule 7035.2815 Subp. 11 also requires that occupied buildings and structures located at the facility are continuously monitored using electronic monitoring devices. These devices allow for detection of concentrations of LFG well below the concentrations at which the gas reaches an explosive range. Landfill gas migration from the landfill is monitored with permanent landfill gas monitoring probes around the perimeter of the facility.

The gas management system for the Pine Bend Landfill is shown on the Plan Drawings, which are attached to the Application for Permit Renewal. The Plan Drawings detail the following:

- Gas extraction well locations,
- Gas monitoring probe locations,
- Continuous electronic monitoring device locations,
- Gas system piping, sumps, etc.



2 Gas System Design

2.1 Extraction Wells

Currently, there are 190 existing gas extraction wells at the site. As the site expanded into Phases 5 and 6, some of these wells were extended while proposed new gas extraction wells will need to be installed as shown on the Drawings. For the proposed vertical expansion, new gas extraction wells will be installed as shown on the Plan Drawings. Construction and installation of new wells will be in accordance with the MPCA approved design and PBL design standards.

2.2 Gas Piping System

Gas from the existing wells will continue to be extracted through existing or temporarily installed laterals, subheaders, and header piping until final grades are reached. At that time, new laterals may be installed from the existing wells to new subheaders that will drain to the existing header as shown on the Drawings. Gas collection piping from newly installed wells for Phase 5 and 6 were connected to a new header system that continues around the west side of the landfill with subheader extensions to provide several gas collection loops across the entire facility. All piping within the waste is installed at a minimum grade of 3 percent to allow for proper drainage of condensate liquids into low point collection sumps and eliminating any flow disturbances which may affect the performance of the overall extraction system. High points in the piping may utilize butterfly valves for partial isolation of the extraction system for use in maintenance and operations activities. Valves may also be provided at each wellhead and at the header/subheader junctions to provide maximum operational flexibility.

2.3 Condensate

Condensate generated as a result of the landfill gas extraction system is conveyed in the subheader and header piping to low points in the system where an inverted tee will allow for the liquids to gravity flow into a sump structure. Valving is installed to isolate the sumps from the header for maintenance purposes. A submersible pump removes all liquids collected from the condensate sumps and pumps them into the forcemain piping for subsequent discharge into the leachate storage facility.

Condensate collected in the new header along the western slope of the landfill will flow to the existing leachate manhole at the southwest corner of the landfill. Another sump is located near the leachate loadout facility on the south side of the landfill.

Condensate that currently flows to existing sumps that will be abandoned due to overfilling will be re-routed to the temporary header that will drain to condensate sumps at the north and south sides of the landfill. Condensate from these wells will eventually be collected in the new sump areas since the temporary header will be abandoned and the gas from the existing wells will be collected in the new installed header and sub headers.

Condensate drains will also be utilized at the PBL to drain condensate from lines which may become inaccessible from the Phase 5 expansion and proposed vertical expansion. These drains will be located at the localized low points in the gas collection lines. The drains will deposit the liquids into coarse aggregate trenches where it will ultimately drain to the leachate underdrain system and be pumped out with the leachate generated within the waste mass. Details for the condensate drains can be seen in the Drawings.



2.4 Methane Monitoring Probes

There are currently thirty-nine (39) existing methane monitoring probes located around the perimeter of the landfill. The probes are installed at varying depths in order to detect off-site gas migration.

PBL employs a comprehensive monitoring program for early detection of landfill gas (LFG) in on-site structures and at adjacent properties, as well as gas collection and a landfill gas to energy plant. Minnesota Rule 7035.2815 Subp.11 also requires that occupied buildings and structures located at the facility are continuously monitored using electronic monitoring devices. These devices allow for detection of concentrations of LFG well below the concentrations at which the gas reaches an explosive range. Landfill gas migration from the landfill is monitored with permanent landfill gas monitoring probes around the perimeter of the facility. Per MPCA requirements, all facility gas probes are monitored. Probe readings are acquired using a GEM 2000 monitoring device and are performed by Opal Fuels, the gas developer for the landfill.



3 Gas Monitoring

3.1 Methane Monitoring Probes

Again, there are currently thirty-nine (39) methane monitoring probes located around the perimeter of the Pine Bend Landfill (See Figure 1). The probes are monitored quarterly by Opal Fuels using a portable methane gas meter (Landtech GEM 2000). The methane component of landfill gas (LFG) is combustible in the concentration range of five to 15 percent by volume in air. Five percent is considered the lower explosive limit or LEL and 15 percent is considered the upper explosive limit or UEL. Consequently, migration and concentration of methane into enclosed spaces could result in an explosive atmosphere. Therefore, Minnesota Rule 7035.2815 Supb. 11 requires that the concentration of any explosive gas not exceed the LEL at the property boundary or 25 percent of the LEL in or around facility structures. Methane readings are collected on a quarterly basis unless a positive gas reading is recorded, in which case, monthly readings are taken until two consecutive passing monthly readings are recorded. Along with methane concentrations, barometric pressure, weather conditions, date, time, and technician performing the monitoring are also recorded. Opal Fuels submits the probe readings to the PBL Environmental Manager for inclusion in PBL's Annual Report.

The detection of methane above 25 percent of the LEL at any of these points will trigger an adjustment of flow rate in the landfill gas extraction wells associated with the area in question.

3.2 Continuous Gas Monitors

Three (3) continuous gas monitors are in-place within buildings at the Pine Bend Landfill (See Figure 1 for locations). These monitors are checked daily by PBL staff and the readings are recorded on a Log Sheet. The Log Sheet is presented in Appendix A.

The continuous monitors are Gasmax meters manufactured by GDS Corporation. These are fixed-point monitors designed to provide continuous monitoring of hazardous gases (i.e., methane). The monitored values are displayed on a digital readout. An operation and maintenance manual for the Gasmax is kept on-site and provides the following information:

- Safety information
- Installation and start-up procedures
- Calibration procedures
- Alarm operations

The Gasmax is calibrated at least every ninety (90) days using a known target gas. If methane is detected above acceptable limits (25 percent of LEL) at any of these points, the facility shall be evacuated and ventilated and the source of gas investigated. The Landfill Manager should be notified immediately.

3.3 Gas System Maintenance

The condition of the landfill gas management system is monitored during the periodic site inspections by both PBL and Opal Fuels. The blowers and flares are maintained according to the manufacturer's recommendation. Repairs to the wellheads are made on an as-needed basis. Blockages in the gas transmission header or condensate lines are investigated and repaired as needed.



APPENDIX A

Continuous Gas Monitor Log Sheets



METHANE METER READING LOG

[illegible]

APPENDIX C

Landfill Inspection Checklists



Facility Inspection Report- Post Collection Division

Site:	Division #:	Inspector:	Date:
--------------	--------------------	-------------------	--------------

A.	Exterior/ Yard/ Scale		
Ref	Item	Evaluation	Comment
A1	General appearance of Grounds/ landscape?		☐
A2	Designated smoking area outside?		☐
A3	Building exterior appearance		☐
A4	When working in the yard, Is a positive "Lockout/Tagout" system provided to render machines, trucks, and equipment inoperable while repairs or adjustments are being made? Are locks individually keyed and under the exclusive control of the employee (29 CFR 1910.147)		☐
A5	Equipment kept in secure area? Keys removed when parked?		☐
A6	Equipment equipped with working fire suppression systems as required?		☐
A7	Fences, Gates and locks in good condition?		☐
A8	Are all Permit Required Postings posted at Gate?		☐
A9	Are 24 hour emergency numbers posted at gate?		☐
A10	Perimeter of property has no evidence of discharge of pollutants?		☐
A11	Is "No Trespassing" signage posted along fence?		☐
A12	Required Sign: " Caution- Always leave at least 10 feet between vehicles"		☐
A13	Required sign: " Notice- Only the Driver may exit the truck cab at the active tipping area"		☐
A14	Required sign: "Warning- Proper personal protective equipment must be worn at all times; (high visibility clothing, hard hats) "		☐
A15	Manhole and other confined spaces clearly marked?(1910.146c)		☐
A16	Parking area and Entrance/ Exits are well lighted?		☐
A17	Paved surfaces free of potholes, debris and other trip slip and fall hazards?		☐
A18	Walkways and Steps in good repair?(1910.137)		☐
A19	Are step risers on stairs uniform from top to bottom?(1910.124)		☐
A20	Are steps on stairs and stairways designed to provided with a surface that renders them slip resistant?(1910.24f)		☐
A21	All barriers and bollards painted yellow?		☐
A22	Fuel Island Dispensers Hoses and Nozzles in good repair? (1910.106, NFPA #30, Local Fire Codes)		☐
A23	Fuel Island- No Smoking and Shut off Engine signs(1910.106, NFPA #30, Local Fire Codes)		☐
A24	Fuel Island- Emergency Shut off clearly marked?(1910.106, NFPA #30, Local Fire Codes) Pumps shut off and/or locked when facility closed?		☐
A25	Fuel Island- Adequate barrier protection?(1910.106, NFPA #30, Local Fire Codes)		☐
A26	Fuel Island- Adequate number of Fire Ext? Charged/ tagged/ inspected?		☐
A27	Fuel Island- Spill Kit dry and well marked?-(1910.106, NFPA #30, Local Fire Codes)		☐
A28	Fuel Truck- Dispensers Hoses and Nozzles in good repair? (1910.106, NFPA #30, Local Fire Codes)?		☐
A29	Fuel Truck- No leaks or signs of deterioration of tank integrity(1910.106, NFPA #30, Local Fire Codes)		☐

A30	Radiation Monitors and Scales calibrated?		☐
A31	Working Video Surveillance System with correct camera placement and operational recording system		☐
A32	Working odor control system		☐

B. Office/Dispatch/ Employee/ Storage/and Facility Areas			
Ref	Item	Evaluation	Comment
B1	Are portable fire extinguishers kept at their designated places at all times (accessible, mounted, charged, pinned and sealed)? Is each extinguisher marked with a sign and do each sign have a corresponding extinguisher? Are annual and monthly inspections documented on the tag? Is there an adequate number of extinguishers for the prevailing fire hazards Are extinguishers free from obstructions to access?(1910.157)		☐
B2	Are first aid kits available and maintained? Any items expired? No Oral Meds?(1910.151)		☐
B3	Are interior lights adequate and all in working order? Do emergency lights work when tested?		☐
B4	Is clear working space in front of an electrical panel maintained at no less than 36"? (1910.303)		☐
B5	Are all live parts of electrical equipment operating at 50 volts or more guarded against accidental contact? Are outlet boxes in good condition? No exposed wiring. Are GFCI outlets used in wet or damp areas?		☐
B6	Are Panel box doors and individual electrical circuit breakers (and fuel pump switches) legibly identified(1910.303)		☐
B7	Are electric cords, extension cords, and trouble lights of approved 3-wire ground type and in good condition? Is there any temporary wiring that should be permanent?(1910.305)		☐
B8	Is a Large Format, laminated, copy of the latest Safety Alert posted at the time clock or other appropriate Operations Point? Are previous Safety Alerts taken down and kept in a 3 Ring binder for training(Corporate Safety Standard)		☐
B9	Company required postings ?(Policy G- 102) ➤ Commitment to Drug and Alcohol Free Workplace, ➤ Sexual Harassment Policy, ➤ Americans with Disabilities Act Policy, ➤ Reaffirmation of Equal Employment Opportunity, ➤ Benefits Point of Contact name and number, ➤ AWARE line toll free number and reporting procedures flow chart, ➤ Code of Business Conduct and Ethics. ➤ First Aid Responders and CPR trained employees names		☐
B10	Federal Required Posting ➤ Federal 5 in 1 Poster, ➤ OSHA "It's the Law" Poster, ➤ OSHA 300a Summary from Feb 1 to April 30, ➤ Evacuation Map,(1910.38) ➤ Emergency Contact Numbers, ➤ Employee Polygraph Protection Act, ➤ Fair labor Standards Act, ➤ Family and Medical Leave Act, , ➤ Beck Notice for Union Locations, ➤ <i>Equal Employment Opportunity</i> ➤ <i>Uniform Services Employment Act,</i> ➤ <i>Invitation to Self Identify,</i> ➤ <i>Notice of viewing Affirmative Action Plans)-</i> ➤ Notes: Items in <i>italics</i> must be viewable by job applicants Some of the above requirements may be covered by the 5 in 1 Poster		☐

Ref	Item	Evaluation	Comment
B11	State and Local Required Posting ➤ State OSHA, ➤ Workers Compensation Poster ➤ State Wage and Hour(minimum wage)		☐
B12	Is the injury record (OSHA 300 log) maintained up to date with copies at satellite facilities(1904.7)		☐
B13	Is Clinic name, address, and phone number posted for after hour use?		☐
B14	Are the site emergency exit plans posted throughout the facility?(1910.38)		☐
B15	Records present and complete: ➤ ,Fleet Inspection Log, ➤ OSHA 200/300 log, ➤ Employee Observation Log, ➤ Subcontractor/ critical Vendor log, ➤ Safety Meeting/ training, ➤ Hazard communication ➤ SARA Title II, ➤ Volatile Organic compounds(VOC's), ➤ Facility Permits, ➤ PPE/Hazard Assessments, ➤ SPCC/ SWPPP Plans, ➤ Accident and Injury Data, ➤ Facility Inspections, ➤ Cab Inspections, ➤ Safety Alerts and Safety Alert Standards, ➤ DOT Record able Accident Logs,		☐
B16	Are aisleways and passageways kept clean and in good repair and are there no obstructions across aisleways that could create a hazard?		☐
B17	Are floor openings and platforms or workstations 48" or higher guarded by a cover, a guardrail, or equivalent on all side?		☐
B18	Are changes of direction or elevations readily identifiable? (painted yellow)		☐
B19	Are step risers on stairs uniform from top to bottom? Are steps on stairs and stairways designed to provided with a surface that renders them slip resistant?		☐
B20	Are "No Smoking" signs posted throughout the facility if required by State and Local Law? Designated smoking area outside?		☐
B21	Are automatic Sprinkler fusible links clean, unpainted and undamaged? Is the minimum vertical clearance between automatic sprinklers and material below them at least 18 inches (36 inches for bales)?		☐
B22	Is the Sprinkler header marked with a tag indicating inspection and service in the last 12 months.(1910.159) Is the Sprinkler or other Fire detection system operational and connected to a Central Station Alarm system?(AW Fire Detection Standard)		☐
B23	Are Stairs adequately lighted, treads and risers uniform from top to bottom, have appropriate Handrails and slip resistant surfaces(1910.24)		☐
B24	Are Exits marked with appropriate signage? (1910.36) Are Emergency Exit doors functioning and not locked from the inside. Are interior doors leading to areas that could be mistaken for an exit, marked "Not an Exit"(1910.37)		☐
B25	Are toilets and washing facilities clean and sanitary with warm water and soap, and means of hand drying?(AW Safety Standard- Housekeeping)(190.141)		☐
B26	Are an adequate number of waste disposal containers provided Are they covered and emptied daily? (AW Safety Standard- Housekeeping)(1910.141)		☐

B27	Are lunch rooms, and break rooms kept clean?		☐
B28	Is ventilation system functioning adequately		☐

C.	Maintenance Area		
C1	Personal Protective Equipment/ First Aid		
Ref	Item	Evaluation	Comment
C1.1	Are protective eye and face equipment worn where required and are safety glasses worn over corrective lenses or do corrective lenses conform to ANSI Z-87.1-1968)(1910.133)		☐
C1.2	Is there a supply of loaner safety glasses located at all entrance points to the shop (Corporate Standard) Are Safety Glass cleaning stations located in the shop? ?(Eye and Face Protection – Safety Glasses		☐
C1.3	Are caution signs present at entrance points and at machines generating eye and face hazards, which state; “ Caution Eye Protection Required”?(Corporate Standard)		☐
C1.5	Is a safe passage area clearly marked by a painted yellow line?		☐
C1.6	Are employees who are exposed to the hazards created by welding, cutting or brazing operations protected by appropriate personal protective equipment?		☐
C1.7	Is there a supply of vests available in the truck and container shop for use by mechanics and welders while outside the shop area?		☐
C1.8	Are suitable gloves, hearing protection, and protective clothing available to be worn as necessary?		☐
C1.9	Are appropriate safety glasses face shields, etc. used while using hand tools or abrasive wheels or equipment which might produce flying materials or be subject to breakage?		☐
C1.10	Are respirators; clean, properly stored, and respirator program in effect?		☐
C1.11	Is there a clean, accessible, functioning eyewash station in any area where hazardous or corrosive materials are used.(1910.151)		☐
C1.12	If emergency showers are present- are they clean, operable and accessible?		☐
C1.13	Are first aid kits available and maintained? Any items expired? No Oral Meds?		☐
C2	Shop-Fire Protection		
C2.1	Are portable fire extinguishers kept at their designated places at all times (accessible, mounted, charged, pinned and sealed)? Is each extinguisher marked with a sign and does each sign have a corresponding extinguisher? Are annual and monthly inspections documented on the tag? Are there an adequate number of extinguishers for the prevailing fire hazards? Are extinguishers free from obstructions to access?(1910.157)		☐
C2.2	Have all Fire Extinguishers been inspected and serviced with the past 12 months by a licensed Fire Protection Company?		☐
C2.4	Are Reels and cabinets for hose systems in good working order, conspicuously identified accessible and used only as fire equipment?		☐
C2.5	No Smoking Signs posted in; Fuel Area, Battery Charging Area, Paint Booths and Storage?		☐
C2.6	Test Emergency Lighting Equipment to ensure proper working order		☐
C3	Shop- Electrical/ Lighting		
C3.1	Are interior lights adequate and all in working order?		☐
C3.2	Is clear working space in front of an electrical panel maintained at no less than 36”?		☐
C3.5	Are all live parts of electrical equipment operating at 50 volts or more guarded against accidental contact?		☐
C3.6	Are Panel box doors and individual electrical circuit breakers (and fuel pump switches) legibly identified		☐
C3.8	Are electric cords, extension cords, and trouble lights are of approved 3-wire ground type and in good condition?		☐

C3.9	Are overhead doors and controls in good working order?		☐
Ref	Item	Evaluation	Comment
C3.10	Are outlet boxes in good condition? Are all outlets grounded? Are GFCI outlets used in wet or damp areas?		☐
C3.11	Is a positive "Lockout/Tagout" system provided to render machines, trucks, and equipment inoperable while repairs or adjustments are being made? Are locks individually keyed and under the exclusive control of the employee. Is there a means of identifying the individual who placed the lock(tag) (29 CFR 1910.147)		☐
C3.12	Is the Hazard Communication Program complete and are the Material Safety Data Sheets present and available? Is the Chemical Inventory present and complete?		☐
C4	Shop-Walking and Working Surfaces		
C4.1	Are floor openings and platforms or workstations 48" or higher guarded by a cover, a guardrail, or equivalent on all side?(1910.23)		☐
C4.2	Are grates or covers over floor openings such as floor drains, secured?(1910.23a8)		☐
C4.3	Are step risers on stairs uniform from top to bottom?(1910.124) Are steps on stairs and stairways designed to provided with a surface that renders them slip resistant?(1910.24f)		☐
C4.5	Are aisles and passageways kept clear and marked as appropriate?(1910.22)		☐
C4.6	Are wet surfaces cleaned up or covered with non-slip materials?1910.22a)		☐
C4.7	Are changes of direction or elevations readily identifiable? (painted yellow)		☐
C4.8	Are aisles and walkways protected from potential hazards of adjacent work areas? Are aisles and passageways kept clean and in good repair and are there no obstructions across aisles that could create a hazard?(1910.22a)(1910.176a)		☐
C4.9	Are floor loading capacity limits posted for 2nd floor storage?(1910.22d)		☐
C4.10	Is the exit pathway clearly marked by signs from all points within the working area?(1910.36b) Are doors which could be mistaken for an exit identified with signs which read, "Not an Exit"		☐
C4.11	Where mechanical handling equipment is used, are there sufficient safe clearances allowed for aisles, at loading docks, through doorways and wherever a turn or passage must be made?		☐
C4.13	Does the storage of material not create a hazard - stacked, blocked, interlocked and limited in height to ensure they are stable and secured against sliding or collapse?(1910.76b)		☐
C4.14	Are unused portions of service pits and pits not actually in use either covered or protected by guardrails or equivalent? Do all PM pits have a 4" toe board? Are PM pits equipped with explosion proof wiring and lighting(1910.22c)(1910.307)		☐
C4.15	Manhole and other confined spaces clearly marked?(1910.146c)		☐
C4.16	Are storage areas kept free from accumulation of materials that constitute hazards from tripping, fire, explosion or harborage of pests?(1910.176c)		☐
C4.17	Is there a fall protection system available to employees working on top of trucks		☐
C5	Shop-Ladders		
C5.1	Are portable ladders in good condition with slip proof feet and no cracks, paint or splinters on the rungs?(1910.24, 1910.26)		☐
C5.2	Are fixed metal ladders painted or treated to resist corrosion and rusting?		☐
C5.3	Is the fixed ladder's clearance distance at least 36 inches between the nearest permanent object and the centerline of the rungs?		☐
C6	Shop-Cranes, Hoists and Slings:		
C6.1	Are all bolts or rivets properly secured?		☐
C6.2	Is there a documented Inspection program with Annual certifications and monthly inspections in file(1910.179j&m)		☐
C6.3	Is the load rating clearly marked on each side of the crane(1910.179b)		☐

C7	Shop-Flammables-Liquid Storage		
Ref	Item	Evaluation	Comment
C7.1	Spray booths have explosive proof wires, adequate ventilation, no smoking signage, and an operational fire suppression system? Filters are regularly checked and changed?		☐
C7.2	Are only approved metal storage cans used for flammable liquids, including gasoline? Are all containers marked as to contents?(1910.106d)		☐
C7.3	Are flammable and combustible liquids (fuels, solvents, paints, etc.) stored in a UL/FM approved flammable storage cabinet?(1910.106d)		☐
C7.4	Parts washer is in good working order, with fusible link attached and no obstructions for lid closure? Protective Gloves and Eye protection available?		☐
C7.7	Are drums of petroleum products kept in secondary containment		☐
C7.8	Are spills cleaned up in the liquid storage areas?		☐
C7.9	Are closable containers provided for soiled rag disposal?		☐
C7.10	Is pressure washer in good working order? (hoses, vent and fuel lines)		☐
C7.11	No smoking signs, adequate ventilation, eye and face protection and no spark or flame sources in battery charging/ storage areas?		☐
C7.12	Is MSDS book available to employees, complete and updated(1910.1200)		☐
C8	Shop- Compressors		
Ref	Item	Evaluation	Comment
C8.1	Do all compressors prominently display a sign stating "Caution- this machine starts automatically"		☐
C8.2	Are compressors equipped with pressure relief valves, pressure gauge, and spring-loaded safety valves, a totally enclosed belt drive system, and are air filters installed and maintained on the compressor intake?		☐
C9	Shop-Welding Equipment		
C9.1	Are welder cables, clamps and guards in good condition and are torch hoses, regulators and valves equipped with anti-flash back valves?		☐
C9.2	Are "Hot Work Permits" used when welding is conducted outside of designated areas, Is the designated welding area at least 35 feet from combustible materials, spray painting, etc.? (1910.253)		☐
C10	Shop-Compressed Gas Cylinders:		
C10.1	Are all stored cylinders effectively secured to prevent tipping? Are Cylinder valve protector in place unless in use(1910.253b)		☐
C10.2	Are cylinders legibly marked and labeled to clearly identify the gas contained?(1910.253b)		☐
C10.3	Are oxygen and acetylene (or other fuel) tanks stored separated by 20' or with a 5' high 1 half hour fire resistant wall between oxygen and fuels?		☐
C10.4	Are cylinders stored in areas which are protected from heat and flame, located at least 25 feet from electrical equipment and people and at least 20 feet from flammable liquids or combustible materials?(1910.253b)		☐
C11	Shop-Machine Guarding:		
C11.1	Is tire repair equipment in good working order?		☐
C11.2	Are Chop Saws equipped with a retracting blade guard and functioning spring return? Do they have proper feet to prevent movement while in use		☐
C11.3	Are power machines, shears, grinders, saws, drill presses, etc. properly anchored maintained and guarded? (1910.212a)		☐
C11.4	Do fixed grinders have side guards that cover the spindle, nut, and flange and 75% of the wheel diameter, a tool rest adjusted to within 1/8" and a tongue guard adjusted to within 1/4" of wheel?(1910.215a)		☐
C11.5	Before new abrasive wheels are mounted, are they visually inspected and ring tested?(1910.215d)		☐
C11.6	Is the appropriate eye protection caution sign, and full face shield located at Grinder?		☐
C11.7	Have all hazards from points of operation, ingoing nip points, rotating parts,		☐

	flying chips, sparks, moving chains, gears, pulleys and belts, including fan blades (within 7 feet of the floor) been guarded?		
C12	Shop-Tools and Jacks		
Ref	Item	Evaluation	Comment
C12.1	Are all tools and equipment (both company and employee-owned) in good condition and used with the correct handle, shield, guard, or attachment, recommended by the manufacturer?		☐
C12.2	Are hand tools such as chisels, punches, wrenches, etc. which are worn, bent or mushroomed during use,, reconditioned or replaced as necessary?		☐
C12.3	Are appropriate handles used on files and similar tools?		☐
C12.6	Are all cord-connected, electrically-operated tools and equipment effectively grounded or of the approved double insulated type?		☐
C12.7	Are pneumatic and hydraulic hoses on power-operated tools free of deterioration or damage?		☐
C12.8	Are all jacks and jack stands in good condition, with OEM pin and labeled with load capacity(1910.244)		☐

D.	Heavy Equipment/Forklift/ Industrial Truck		
Ref	Item	Evaluation	Comment
D1	Are all nameplates and markings in place and legible on powered industrial trucks?		☐
D2	Are industrial trucks kept in a clean condition, free of lint, excess oil and grease?		☐
D3	Is directional lighting provided on each industrial truck		☐
D4	Does equipment have a warning horn, or other device which can be clearly heard above the normal noise in the areas where operated?		☐
D5	Does equipment have a reverse signal alarm audible above the surrounding noise level?		☐
D6	Are the brakes on equipment capable of bringing the vehicle to a complete and safe stop when fully loaded and does the parking brake effectively prevent the equipment from moving when unattended?		☐
D7	Does the Equipment have a working seatbelt and working strobe?		☐
D8	Is Equipment driven by trained and authorized personnel only?(1910.178)		☐
D9	Is an examination of equipment made at least daily and after each shift and is a Vehicle Condition Report completed?(1910.178q)		☐
D10	Is equipment left in an off position when unattended or when the operator is more than 25 feet from the vehicle?(1910.178m)		☐
D11	Is the rated capacity of the industrial truck clearly posted within the view of the Operator?		☐
D12	Do all forklifts have a mounted, inspected and pinned fire extinguisher?		☐
D13	Is the overhead guard clear of obstruction, enabling the operator to view raised loads?(1910.178e)		☐
D14	Does the Operator have a grease gun and are regular grease requirements being met?		☐
D15	Are radiators cleaned daily or as required?		☐
D16	Do tracked machines have a clean carriage?		☐
D17	Are Compactor wheel teeth worn?		☐
D18	Are bucket cutting edges and teeth worn?		☐
D19	Are there signs of equipment abuse or damage?		☐
D20	Do all equipment requiring cameras have them installed and operational?		☐
D21	Does all equipment have a functioning beacon?		☐
D22	Are all required fire suppression systems in place and operational?		☐

	Working Face/Tipping Floor/ Sort Line		
Ref	Item	Evaluation	Comment
F1	Are trucks kept at least 10 feet apart?		☐

**CLOSURE, POST-CLOSURE,
CONTINGENCY ACTION PLAN AND
FINANCIAL ASSURANCE PLAN**



**CLOSURE, POST-CLOSURE,
CONTINGENCY ACTION PLAN**

MPCA Permit #SW-45
Pine Bend Landfill

June 2, 2022

Prepared for:
BFI Waste Systems of North America, LLC
Pine Bend Landfill
2495 East 117th Street
Inver Grove Heights, MN 55077

Prepared by:
Stantec Consulting Services Inc.
1800 Pioneer Creek Center
PO Box 249
Maple Plain, MN 55359
Phone 763-479-4200

Project Number:
227704791

Table of Contents

1	INTRODUCTION.....	1
2	CLOSURE PLAN.....	2
2.1	General	2
2.2	Notification Of Cell Closure	2
2.3	Notification Of Final Cell Closure	2
2.4	Closure Schedule	2
2.5	Closure Procedures.....	2
2.6	Certification Of Phase/Final Closure	3
2.7	Deed Notation.....	3
2.8	Amendment Of Closure Plan.....	3
2.9	Closure Cost Estimate.....	4
3	POST-CLOSURE PLAN.....	5
3.1	General	5
3.2	Inspection And Maintenance	5
3.3	Environmental Monitoring.....	5
3.3.1	Water Quality	5
3.3.2	Leachate	6
3.3.3	Leak Detection.....	6
3.4	Surface Water Runoff Control Facilities	6
3.5	Land Surface	6
3.6	Leachate System Management.....	6
3.7	Landfill Gas Management	6
3.8	Reporting	7
3.9	Ultimate Land Use	7
3.10	Amendment Of Post-Closure Plan	7
3.11	Post-Closure Care Cost Estimate	7
4	CONTINGENCY ACTION PLAN	8
4.1	General	8
4.2	Potential Contingencies.....	8
4.2.1	Event-Triggered Contingencies.....	9
4.2.2	Inspection-Triggered Contingencies.....	9
4.2.3	Monitoring-Triggered Contingencies	9
4.3	Corrective Actions	9
4.3.1	Emergency Actions.....	9
4.3.2	Follow-up to Emergency Actions.....	10
4.3.3	Events Not Requiring Emergency Action	10
4.3.4	Action Levels	11
4.3.5	Equipment Availability	12
4.3.6	Amendment of Contingency Plan.....	12
4.3.7	Estimated Costs for Contingency Actions	12
5	FINANCIAL ASSURANCE	13



LIST OF TABLES

1	Final Cover Cost Estimate Breakdown
2	Post-Closure Care Cost Estimate: Annual Cost Summary
2A	Post-Closure Care Cost Estimate: Facility Inspection Costs
2B	Post-Closure Care Cost Estimate: Routine Maintenance
2C	Post-Closure Care Cost Estimate: Leachate System Management Costs
2D	Post-Closure Care Cost: Landfill Gas Management System Costs
2E	Post-Closure Care Cost Estimate: Monitoring Costs
2F	Post-Closure Care Cost Estimate: Administrative and Reporting Services Costs
3	Event-Triggered Contingencies
4	Inspection-Triggered Contingencies
5	Monitoring-Triggered Contingencies
6	Contingency Action Cost Estimate
7	Post – Closure Calculation



1 Introduction

This Report consists of a Closure Plan, Post-Closure Plan, and Contingency Action Plan for the Pine Bend Landfill (PBL) in Inver Grove Heights. This report complies with the Minnesota Pollution Control Agency (MPCA) requirements for closure (Minnesota Solid Waste Rules, Part 7035.2625), post-closure (Parts 7035.2645 and 7035.2655), and contingency action (Part 7035.2615). The objective of the Closure, Post-Closure, and Contingency Action Plans is to establish procedures to be followed during each of the activities. Cost estimates for the closure, post-closure care, and contingency action in accordance with Part 7035.2685 are also included for financial assurance calculation purposes. The cost estimates have been updated in accordance with MPCA requests during the permitting process requirements for the proposed vertical expansion and acknowledge the closure of the site using final cover slopes of 3:1.



2 Closure Plan

2.1 General

Closure of filled areas is the responsibility of BFI. Closure activities described below will take place sequentially as areas of the site are brought to final grades. Minnesota Rules for Municipal Solid Waste Part 7035.2625 are used as a guide to determine closure requirements.

Contact after closure is: BFI Waste Systems of North America, LLC
Aaron Janusz, Environmental Manager
Phone: (651) 434-9843

A copy of the approved closure plan and all revisions to the plan will be kept at the facility until closure is completed and certified.

2.2 Notification Of Cell Closure

The MPCA will be notified of impending phase closure at least two weeks prior to initiation of closure activities.

2.3 Notification Of Final Cell Closure

Final closure will begin within 30 days after receiving the last shipment of waste. Final closure will be preceded by the following:

- a. The MPCA Commissioner will be notified 90 days before closure activities begin.
- b. A closure notice will be posted 60 days prior to closing. Date of closure and alternate disposal sites will be indicated.
- c. A notice of closure will be published in a local newspaper 30 days prior to closure. A copy will be sent to the MPCA Commissioner.

2.4 Closure Schedule

The closure schedule is dependent on the waste flows and construction of landfill cells, or portions thereof, will be closed once filled to final elevation. The Phase 7 vertical expansion will be developed from the north end to the south end in an orderly fashion. PBL will close areas of the landfill as they reach final grade.

2.5 Closure Procedures

Closure of each phase will be initiated upon reaching final grade according to the closure requirement in the permit. The surface will be brought to final grade and benched according to the design plans. Appropriate buffer layers to bring surface to final grade will be placed during site operations. A summary of closure procedures is as follows:

- a. Install minimum 40-mil synthetic flexible membrane liner.
- b. Install geonet drainage layer according to the design plans.
- c. Grading and placement of 18 inches of soil fill.



Closure, Post-closure, Contingency Action Plan

2 Closure Plan

- d. Placement of 6 inches of vegetation supporting topsoil.
- e. Seed and mulch the final covered area.

Landfill gas management features will be installed prior to placement of final cover according to the Landfill Gas Management Plan.

Any changes in the design will be incorporated into a re-evaluation of closure costs and the related financial assurance calculations at the time of final cover construction.

All stored material, tires, appliances, etc. will be hauled to a permitted facility. On-site structures which will require removal upon closure will be evaluated as the site approaches final closure.

All temporary and final cap materials will comply with the requirements of all applicable rules for cap materials.

2.6 Certification Of Phase/Final Closure

Upon completion of activities for final closure of any phase, a closure documentation report, signed by the owner and a professional engineer registered in the State of Minnesota, stating that the cell has been closed in accordance with approved plans and specifications will be submitted to the MPCA as required by the MPCA Solid Waste Rules Part 7035.2610.

Testing of the various components of the cap will be conducted and documented in accordance with the Construction Quality Assurance Plan in effect at the time of final closure and in accordance with all applicable rules. The closure and construction documentation will be submitted to the MPCA no later than 60 days following completion of final closure. The documentation will contain record drawings, testing data, description of the construction process and photographs of the major aspects of the construction phase.

In addition, a description of what the facility was used for, waste types, a survey plat of the site certified by a land surveyor registered in Minnesota, and a copy of record drawings will be submitted to the Dakota County Recorder and the MPCA, upon final closure.

2.7 Deed Notation

Dakota County will record a notation on the deed to the property, or on some other instrument normally examined during a title search. The notation will, in perpetuity, notify any potential purchasers of the property of the types and quantities of waste received and the depth to which they were disposed, and any special conditions or limitations for use of the site. The notation will include record drawings for the facility. A copy of the notation carrying the County Recorder's seal will be included with the final closure certification.

2.8 Amendment Of Closure Plan

A modified closure plan will be prepared and submitted to the MPCA for approval within 60 days of any change or event that affects the closure plan. This applies to any change in the operating plan or facility design affecting closure procedures. In the case of this facility, the closure plan will be updated at the time of re-permitting to incorporate any changes in operations, design or scheduling of closure.



2.9 Closure Cost Estimate

MPCA Rules Part 7035.2685 requires that a cost estimate be prepared for closure of the largest area that may require closure. As of October of 2020, the open area consisted of:

- 69.4 acres of MSW landfill are currently at final elevation without final cover.

These open areas were used for calculating closure costs. Table 1 provides the detailed closure costs for the areas. The cost estimates are made using 2022 prices from similar type construction projects. The attached Figure 1 details the outline of the existing areas to be closed.

Closure cost estimates will be updated by March 1 of each year to adjust for inflation, areas previously closed, and changes in design, closure plans, or site conditions which require changes in the cost estimates.



3 Post-Closure Plan

3.1 General

The owner of the facility and any successor in interest will be responsible for the post-closure care of the site. Minnesota Rules Parts 7035.2645 and 7035.2655 for Solid Waste Facilities are used as a guide to determine post-closure requirements. The post-closure period begins after final closure certification and continues for a period of at least 30 years in accordance with the U.S. Environmental Protection Agency Subtitle D regulations. A summary of the post-closure care program is provided in the following text.

3.2 Inspection And Maintenance

Three times a year (spring, summer, and fall) routine inspection of the site will occur. These inspections will include observations for cap integrity, erosion of the final cap and vegetation quality; evaluation of settlement and surface water drainage; inspection of the leachate collection system, inspection of the landfill gas extraction system, and inspection of monitoring systems and site security features.

If a site inspection reveals any problems with leachate collection systems, landfill gas extraction system, monitoring systems, security or the final cap systems, appropriate corrective measures will be taken as outlined in the "Contingency Action Plan". If erosion occurs, additional soil will be placed and compacted and measures taken to prevent further occurrence of the problem. If there are any areas where the cover vegetation is poorly established or stressed, reseeding and/or growth and development measures will be instituted and an adequate vegetative cover established. In addition, routine maintenance such as mowing to prevent tree growth and maintaining drainageway flow capacity will be performed. Any equipment found to need repair or maintenance will be properly repaired and maintained. This includes, but is not limited to, security fencing, landfill gas extraction equipment, monitoring equipment, leachate collection systems, and surface water control structures.

Other inspection and maintenance practices are defined below for specific facility features.

3.3 Environmental Monitoring

Routine water monitoring will be conducted during the post-closure period in accordance with the facility permit or an approved Closure Order issued by the MPCA at the time of facility closure. The current Site Specific Sampling Protocol is referenced for the lists of analytical parameters and current sampling locations were used to develop the proposed EMS for the post-closure monitoring of groundwater, surface water, and leachate.

3.3.1 WATER QUALITY

Groundwater and surface water will be monitored according to the Phase IV Water Quality Monitoring Workplan on file for this site.



3.3.2 LEACHATE

Leachate will be monitored in accordance with procedures detailed in the Leachate Management Plan.

3.3.3 LEAK DETECTION

The facility lysimeters will be monitored three times per year to coincide with water quality monitoring.

3.4 Surface Water Runoff Control Facilities

The benches, drainage ditches, swales, surface water piping catch basins, and ponds will be inspected three times annually for need of maintenance. Maintenance associated with sediment accumulations or erosion problems will be performed as needed within five working days of the date of the inspection, weather permitting.

3.5 Land Surface

The landfill surface will be inspected three times annually and after major storm events for erosion and settlement. Land surface repairs will be performed as needed. Supplemental cover soil will be placed when needed due to erosion and settlement. Seeding, fertilizing, and mulching of bare soil will be provided where required. All surface repair will be performed within five working days of the inspection, when appropriate, and weather permitting.

Any and all areas that have been seeded, fertilized and mulched will be inspected periodically to check for erosion to make sure that sustained vegetative growth has been established and continues to survive. All erosion ruts or gullies and general settlement areas of the completed landfill area will be refilled with suitable earth, graded and reseeded accordingly within five working days, as appropriate.

Inspections will occur on scheduled occasions and as needed due to severe weather including peak rainfalls and periods of drought.

3.6 Leachate System Management

The leachate handling systems collect leachate and transfer it to one of two leachate storage tanks. The leachate collection system pipes will be cleaned annually. The HELP model shows that after final closure, leachate generation approaches zero. This is due to the extremely efficient performance of the FML/geonet combination. Therefore, an alternative method for estimating post-closure leachate generation will be used. As described in the Design Report and Leachate Management Plan, leachate generation in the open condition is expected to be at approximately 8 to 9 million gallons per year. This is expected to continue until final closure, when average annual leachate production for the facility during post-closure is estimated to be 50,000 to 100,000 gallons. This includes landfill gas condensate.

3.7 Landfill Gas Management

The existing gas management system will be kept operational and replacement and maintenance procedures will be performed as required. Annual emissions testing will be performed as required by the Air Quality Permit.

Landfill gas readings at the active gas well system will take place as needed but is to keep the well field in good operating condition. A portable methane gas meter will be used to measure the gas concentrations



Closure, Post-closure, Contingency Action Plan

3 Post-Closure Plan

at designated monitoring probes on a quarterly basis. The detection of methane above 25 percent of the LEL at any of these points will trigger an adjustment of flow rate in the landfill gas wells associated with the area in question. The methane monitoring probes around the site will be monitored on a quarterly basis unless a detection is noted, in which case monthly readings will take place until two consecutive clean readings are achieved.

3.8 Reporting

A report describing the inspection, conditions observed, corrective actions, maintenance activities and monitoring activities and results will be prepared and transmitted to the MPCA annually.

3.9 Ultimate Land Use

PBL will control uses of the site so there will not be disturbance to the final cap system, liner, leachate collection system, landfill gas management system, or monitoring system unless approval is obtained from the MPCA.

3.10 Amendment Of Post-Closure Plan

A modified post-closure plan will be prepared and submitted to the MPCA for approval within 60 days of any change or event that affects the post-closure plan. This applies to, but is not limited to, any change in the monitoring system or procedures. The post-closure plan will be amended whenever the permit is renewed.

3.11 Post-Closure Care Cost Estimate

Table 2 provides a summary of annual post-closure care costs which are detailed in Tables 2A through 2F. The long-term care cost projection for 20 years based on the annual post-closure costs will be used for financial assurance calculations.



4 Contingency Action Plan

4.1 General

This section of the report presents the Contingency Action Plan for the PBL, prepared in accordance with Part 7035.2615 of the MPCA Solid Waste Rules.

The purpose of this plan is to:

- Identify occurrences at the landfill such as natural disasters, vandalism, accidents or failure of constructed design features that could lead to release of solid waste or leachate and endanger human health and the environment.
- Establish the sequence and timing of response actions that would minimize hazards to human health and the environment.
- Identify equipment needed to remediate each occurrence.
- Identify any possible prior arrangements to be made with contractors in order to assure timely and effective response action.
- Estimate the costs associated with these response actions.

Part 2 identifies potential occurrences for this landfill which are addressed in this contingency action plan.

Part 3 describes contingent corrective action procedures, including the sequence and timetable, to be followed in case any of the events identified in Part 2 take place.

Part 4 presents action levels for groundwater, surface water and air quality, whichever are included in the monitoring program.

Part 5 discusses equipment availability.

Part 6 presents estimated costs for the identified contingency actions.

A copy of this plan will be kept at the landfill at all times for reference by on-site and operations personnel and regulatory inspection personnel.

Each contingency set forth in this plan has a number of possible solutions and no contingency plan can directly address all circumstances encountered. Therefore, the Minnesota Pollution Control Agency (MPCA) will be promptly notified of all incidents and regular discussions will be held on proposed actions and response status.

4.2 Potential Contingencies

Certain events that may occur at the landfill could lead to the release of waste or leachate into the environment. These events could be the result of natural disasters, accidents, vandalism or failure of constructed design features. The contingencies identified in this plan have been divided into three categories as follows:



4.2.1 EVENT-TRIGGERED CONTINGENCIES

Event-triggered contingencies may include severe rainfall, flood, leachate spill, grass fire, or other sudden, unanticipated events. Table 3 lists potential event-triggered contingencies and strategies to deal with them.

4.2.2 INSPECTION-TRIGGERED CONTINGENCIES

Inspection-triggered contingencies may include signs of distress in the landfill cap (such as stressed vegetation), cap erosion, leachate head buildup on the liner beneath the waste, surface drainage problems and other findings associated with routine wear and aging of the facility and noticed during routine inspections. Table 4 lists potential inspection-triggered contingencies.

4.2.3 MONITORING-TRIGGERED CONTINGENCIES

Monitoring-triggered contingencies may include contamination of groundwater beyond action levels, leachate detected in the leak detection systems, detection of methane at gas monitoring points, and other findings discovered as a result of routine facility monitoring. Table 5 lists potential monitoring triggered contingencies.

Each of the above-referenced tables lists contingencies which may be triggered by events, inspections or monitoring; the possible result, effect, or cause of the contingency; and actions to be taken to evaluate and respond to the contingency.

4.3 Corrective Actions

4.3.1 EMERGENCY ACTIONS

Many of the event-triggered contingencies such as natural disasters, vandalism, fire, embankment failure or leachate spill may require an emergency response. Such responses typically need to be implemented immediately and may involve equipment and personnel beyond those routinely involved with facility operation. These additional resources could include city fire and police departments and additional contractor equipment and personnel. The following paragraphs and Table 5 summarizes the general emergency actions which may be necessary in response to each identified event-triggered contingency.

4.3.1.1 General

In the event of emergencies at the site, PBL personnel must be contacted. The following is the key contact for site operation and design:

Operations Manager:
Chris Parker
Phone: (612)300-8610

4.3.1.2 Severe Rainfall

As soon as weather permits, inspect the site to determine any damage to the vegetation, berms, cap, surface water controls, and monitoring systems. Place temporary erosion controls such as hay bales, soil fill or mulch to minimize further erosion. Place sand bags or riprap to stabilize facility features. Place sandbags and temporary piping to make surface water controls temporarily functional. Sediment may require removal from berms, swales, and outlets.



Closure, Post-closure, Contingency Action Plan

4 Contingency Action Plan

4.3.1.3 Flood

The PBL is not within the flood plain.

4.3.1.4 Leachate Spill

Immediately retrieve any free liquid by pumping it into holding tanks, tank trucks or steel drums. Apply materials to absorb unpumpable liquid. Immediately contact the MPCA at (651) 296-8100.

4.3.1.5 Grass Fire

Contact the Inver Grove Heights Fire Department for assistance. Clear all access roads of equipment to facilitate emergency vehicle access. Attempt to extinguish fire using water, fire extinguisher or soil.

4.3.1.6 Vandalism

For acts of vandalism that create hazards to human health and the environment, appropriate temporary repairs should be performed as soon as possible to make the damaged system temporarily functional.

Within two weeks after an emergency, a written report describing the emergency and the procedures followed to minimize potential hazards will be submitted to the MPCA.

4.3.2 FOLLOW-UP TO EMERGENCY ACTIONS

As soon as possible following the occurrence and emergency response to an event requiring emergency actions, a detailed inspection of the affected areas will be performed. The site operation team will conduct the inspection. The purpose of the inspection will be to assess the degree and extent of damage, if any, to the final cap, surface water controls, landfill gas management system, leachate collection system, monitoring systems, access roads, fencing, etc. The extent of any damage will be described in detailed inspection notes and photographed.

Following the inspection, a brief report will be prepared by PBL's technical staff describing the effects of damage, if any, on the intended purposes of the engineering features of the facility. The report will also identify repair procedures that generally will restore the features to their pre-damage condition. The inspection report and repair schedule will be submitted to the MPCA.

4.3.3 EVENTS NOT REQUIRING EMERGENCY ACTION

Inspection-triggered and monitoring-triggered contingencies such as small cracks in embankments or the cap, a gradual embankment or cap movement trend, leachate seeps, minor erosion, leachate head buildup, detects in leachate leak detection devices, surface drainage problems and water quality violations generally will not require an emergency response. These contingencies may require interim response actions, continued or enhanced monitoring, assessment of the extent of the problem, and evaluation of the design prior to implementation of final repairs or remedial actions. Action for inspection- and monitoring-triggered contingencies are summarized in Tables 4 and 5, respectively.

4.3.3.1 Water Quality

The following discussion describes the general procedures to follow for actions related to water quality problems. The procedure is divided into two steps. The first is verification of the problem. The second is the response to employ if the first step is indicative of a problem. Each problem has a number of possible solutions and no contingency plan of action can directly address all circumstances encountered. Therefore, this plan is conceptual and flexible, to be used as a preliminary guide by all those associated



Closure, Post-closure, Contingency Action Plan

4 Contingency Action Plan

with the project. The initial steps identified here will help define the plan of action to be followed for specific contingency occurrences.

- If a water quality action level defined by the current permitting document is exceeded, notify the MPCA in writing.
- Check all sampling, sample handling and analytical procedures to verify that proper techniques were used.
- Determine the potential implications of the elevated parameters, by examining background and historical data, reviewing regional and time variations in water quality and determining if all monitoring points are showing elevated levels or if the occurrence is localized.
- If necessary, resample to verify results.
- If similar results are found from resampling, evaluate the results for potential impact to human health and the environment.
- Based on the significance of the results, determine if immediate action is needed or if continued or expanded monitoring is sufficient. Expanded monitoring may include increasing the frequency of sampling.
- Meet with the MPCA staff to determine the need to implement assessment monitoring to comply with requirements for MSW sites.
- Determine, if possible, the source of the problem.

During the time period covering the above actions, routine water monitoring will also continue according to the regular schedule.

Once the above evaluation is complete and the conclusion is reached that a problem is occurring, the next step is to determine the nature and extent of that problem. This may be done by continuing to monitor the existing monitoring points or by installing additional monitoring points. The information gathered during this period of investigation will be submitted to the MPCA in a report.

The result will then be used to complete a feasibility study that will determine the remedial action needed, if any, to correct the problem. Examples of remedial actions which might be selected individually or in combination are:

- Continuing the monitoring of groundwater and surface water and, if necessary, expanding the monitoring system.
- Repairing the final cap or surface drainage features these have been identified as the cause of the problems.
- Repairing the leachate collection system if this has been identified as the cause of the problem.
- Installation of a groundwater extraction system and/or groundwater flow barrier.
- Installation or modification of landfill gas extraction wells.

4.3.4 ACTION LEVELS

Action levels to define the water quality criteria that are to be met at the landfill are defined in the site permit.

In the event of action level exceedances, the MPCA will be notified by Pine Bend staff and a contingency plan of action will be discussed and implemented as necessary.



4.3.5 EQUIPMENT AVAILABILITY

Pine Bend Landfill maintains several pieces of equipment at the site for operations. These could be utilized for emergency actions at the landfill. A partial list of available equipment (as of March 2022) is:

- 2-836H landfill compactors
- 836K landfill compactor
- D-8T dozer
- D-6T dozer
- D-6R dozer
- 2-740B haul trucks
- Motor Grader
- Wheel loader 930
- Skid Steer
- Farm tractor with mower deck
- Water truck

In addition, equipment is available on very short notice from a variety of local sources.

4.3.6 AMENDMENT OF CONTINGENCY PLAN

A modified contingency plan will be prepared and submitted to the MPCA whenever the facility permit is amended; whenever the design, construction, operation or maintenance of the facility change; or when a release at or failure of the facility occurs which indicates revised procedures or costs are necessary. The Financial Assurance will be revised whenever amendment of the contingency plan affects that calculation.

4.3.7 ESTIMATED COSTS FOR CONTINGENCY ACTIONS

Cost estimates for contingency actions are presented in Table 6. The actions included in the contingency plan cost estimates are considered to be occurrences above and beyond the routine maintenance performed during site operation and post-closure care. The cost estimates include the capital expenditure required to implement the contingency action, and where appropriate, the annual operation and maintenance costs of the contingency action. Operating and maintenance costs for subsequent years are included for the estimated period of operating time of the contingency action. Cost estimates for contingency actions will be revised by February 1 of each year during the operating life of the facility to account for inflation needed changes such as those which would be addressed in an amended plan.



5 Financial Assurance

Financial assurance for site closure, post-closure care, and contingency action is provided by establishment of a Financial Guarantee Bond (Letter of Credit). The value of the performance bond on December 31, 2021 was \$11,979,440

The cost estimates provided within this submittal will be utilized to provide financial assurance for the facility in the future and are summarized below. The cost estimates below are for the year 2022 used to determine monthly payments from the 2021 annual report. Once this plan is approved, BFI will obtain an updated surety bond. The value of the surety bond will be based on the following costs:

Closure	\$4,838,876.00
Post-Closure	\$9,098,860.00
Contingency Action	<u>\$1,166,117.00</u>
Total of:	\$15,105,854.00



TABLES

- 1 Final Cover Cost Estimate Breakdown**
- 2 Post-Closure Care Cost Estimate: Annual Cost Summary**
 - 2A Post-Closure Care Cost Estimate: Facility Inspection Costs**
 - 2B Post-Closure Care Cost Estimate: Routine Maintenance**
 - 2C Post-Closure Care Cost Estimate: Leachate System Management Costs**
 - 2D Post-Closure Care Cost: Landfill Gas Management System Costs**
 - 2E Post-Closure Care Cost Estimate: Monitoring Costs**
 - 2F Post-Closure Care Cost Estimate: Administrative and Reporting Services Costs**
- 3 Event-Triggered Contingencies**
- 4 Inspection-Triggered Contingencies**
- 5 Monitoring-Triggered Contingencies**
- 6 Contingency Action Cost Estimate**
- 7 Post – Closure Calculation**



Table 1
Closure Cost Estimate
Pine Bend Landfill, SW-45

Item	Description	Depth (ft)	Quantity	Unit	Unit Cost		Cost
Construction Costs							
1	Final Closure Construction ⁽¹⁾		32.6	AC			
2	Mobilization and Demobilization		1	LS	\$	54,500.00	\$ 54,500.00
3	Temporary Construction Facilities and Utilities		1	LS	\$	5,020.00	\$ 5,020.00
4	Buffer Soils	0.5	26,297	CY	\$	6.00	\$ 157,784.00
5	40 mil LLDPE Liner		1,420,056	SF	\$	0.70	\$ 994,000.00
6	Geocomposite (double sided)		1,420,056	SF	\$	1.13	\$ 1,604,663.28
7	Drain Piping / Stormwater Management Features		10,000	LF	\$	10.00	\$ 100,000.00
8	Cover Soils	1.5	78,892	CY	\$	6.00	\$ 473,352.00
9	Topsoil	0.5	26,297	CY	\$	20.00	\$ 525,946.67
10	Erosion Control (Erosion Mat, Seed, Fertilize and Mulch)		33	AC	\$	2,500.00	\$ 81,500.00
11	Gas Collection System Infrastructure		1	LS	\$	200,000.00	\$ 200,000.00
Engineering and Certification Costs							
12	Drawings, Specifications, CQA Plan, Bid Process		1	LS	\$	60,000.00	\$ 60,000.00
13	Construction Observation, Testing, and Surveying		1	LS	\$	170,000.00	\$ 170,000.00
14	Documentation Report		1	LS	\$	15,000.00	\$ 15,000.00
15	Contingency (5% of total Closure Construction Costs)		1	LS	\$	209,838.30	\$ 209,838.30
TOTAL COST							\$ 4,651,604.24
COST PER ACRE							\$ 142,687.25

Comments:

1. Assuming approximately 70 Acres will be closed at the time of final closure
2. Updated 2022 construction bid costs

Table 2
Post-Closure Care Cost Estimate
Annual Cost Summary
Pine Bend Landfill, SW-45

Item	Description	Extension⁽¹⁾
1	Facility Inspection Costs	\$ 5,500.00
2	Routine Maintenance and Repair Costs	\$ 71,750.00
3	Leachate System Management Costs	\$ 64,400.00
4	Landfill Gas Management Costs	\$ 63,200.00
5	Monitoring Costs	\$ 79,800.00
6	Administrative and Reporting Services Costs	\$ 8,300.00
TOTAL (Annual)		\$ 292,950.00

Comments:

(1)Refer to Tables 2A to 2F for an itemized breakdown of annual costs.

Table 2A
Post-Closure Care Cost Estimate
Facility Inspection Costs
Pine Bend Landfill, SW-45

Item	Description	Quantity	Unit	Unit Cost	Extension ⁽¹⁾
1	Landfill Supervisor	80	AC	\$ 55.00	\$ 4,400.00
2	Mobilization and Demobilization	32	LS	\$ 33.00	\$ 1,100.00
TOTAL (Annual)					\$ 5,500.00

Comments:

(1)Extensions are rounded to the nearest \$100. Updated 2022 costs.

Table 2B
Post-Closure Care Cost Estimate
Routine Maintenance
Pine Bend Landfill, SW-45

Item	Description	Quantity	Unit	Unit Cost	Extension ⁽¹⁾
1	Mowing (assume 1x/yr) ⁽²⁾	180	HR	\$ 150.00	\$ 27,000.00
2	Fertilizing (assume 1x/yr)	8	AC	\$ 220.00	\$ 1,750.00
3	Cover Revegetation (assume 1x/yr) ⁽³⁾	4	AC	\$ 2,100.00	\$ 8,400.00
4	Security and Building Repairs	1	LS	\$ 2,200.00	\$ 2,200.00
5	Surface Water Management and Maintenance	1	LS	\$ 14,000.00	\$ 14,000.00
6	Access Road Maintenance	1	LS	\$ 2,500.00	\$ 2,500.00
7	Rodent Control	20	HR	\$ 45.00	\$ 900.00
8	Erosion Repair (assume 1x/yr) ⁽⁴⁾	2	AC	\$ 7,500.00	\$ 15,000.00
TOTAL (Annual)					\$ 71,750.00

Comments:

(1) Extensions are rounded to the nearest \$100.

(2) Mowing: 180 acres at 1 hour/acre, once per year. Includes all closed areas on landfill.

(3) Cover revegetation: 4 acres per event. Includes all closed areas on landfill. Assume 2% of landfill cover.

(4) Assume 1% of landfill cover.

Table 2C
Post-Closure Care Cost Estimate
Leachate System Management Costs
Pine Bend Landfill, SW-45

Item	Description	Quantity	Unit	Unit Cost	Extension ⁽¹⁾
1	Collection System Cleaning (once per year)	6,000	LF	\$ 0.66	\$ 3,960.00
2	Leachate Management ⁽²⁾	900,000	Gal	\$ 0.06	\$ 54,000.00
Leachate Monitoring					
3	Monthly Sample Collection	12	Samples	\$ 110.00	\$ 1,300.00
4	Monthly Analysis	12	Samples	\$ 60.00	\$ 700.00
5	Quarterly Analysis	4	Samples	\$ 990.00	\$ 4,000.00
6	Annual Analysis	1	Samples	\$ 440.00	\$ 400.00
TOTAL (Annual)					\$64,360

Comments:

(1)Extensions are rounded to the nearest \$100.

(2)Assumes hauling and treatment at MCES

Table 2D
Post-Closure Care Cost Estimate
Landfill Gas Management System Costs
Pine Bend Landfill, SW-45

Item	Description	Quantity	Unit	Unit Cost	Extension ⁽¹⁾
1	Blower and Flare Replacements	1	LS	\$ 11,050.00	\$ 11,050.00
2	Flare and Generator Maintenance	1	LS	\$ 1,330.00	\$ 1,330.00
	System Operation				
3	Electrical Requirements	1	LS	\$ 19,560.00	\$ 19,600.00
4	Management (on-site personnel for inspection and operations management)	500	Hr.	\$ 33.00	\$ 16,500.00
5	Collection System Replacement (one well 100-foot deep and wellhead every two years)	0.5	LS	\$ 12,380.00	\$ 6,200.00
6	Emissions Testing	1	LS	\$ 3,870.00	\$ 3,900.00
7	Reporting	1	LS	\$ 4,640.00	\$ 4,600.00
TOTAL (Annual)					\$ 63,180.00

Comments:

(1) Extensions are rounded to the nearest \$100.

Table 2E
Post-Closure Care Cost Estimate
Monitoring Costs
Pine Bend Landfill, SW-45

Item	Description	Quantity	Unit	Unit Cost	Extension ⁽¹⁾
1	Water Sample Collection (17 monitoring wells assumed) ⁽²⁾	1	LS	\$ 5,800.00	\$ 5,800.00
2	Lab Analysis ⁽²⁾	1	LS	\$ 3,900.00	\$ 3,900.00
3	Surface Water (5 points 3X/Year)	15	Samples	\$ 280.00	\$ 4,200.00
4	System Maintenance	16	Hr.	\$ 55.00	\$ 900.00
5	Bio attenuation O&M	1	LS	\$ 55,300.00	\$ 55,300.00
6	Monitoring Well Replacement (3 wells every 10 years)	0.3	Well	\$ 4,420.00	\$ 1,300.00
7	Gas Monitoring	1	LS	\$ 3,320.00	\$ 3,300.00
8	Reporting	1	LS	\$ 5,080.00	\$ 5,100.00
TOTAL (Annual)					\$ 79,800.00

Comments:

(1)Extensions are rounded to the nearest \$100.

(2)Based on actual 2021 costs??

Table 2F
Post-Closure Care Cost Estimate
Administrative and Reporting Services Costs
Pine Bend Landfill, SW-45

Item	Description	Quantity	Unit	Unit Cost	Extension ⁽¹⁾	
1	PBL/Third Party Project Management	1	LS	\$ 8,290.00	\$	8,300.00
TOTAL (Annual)					\$	8,300.00

Comments:

(1)Extensions are rounded to the nearest \$100. Updated 2022 costs.

TABLE 3
Event-Triggered Contingencies
Pine Bend Landfill

Event-Triggered Contingency	Result	Action
1. Severe Rainfall	Threatened Embankment Stability	Report; immediately assess damage visually; within five days place sand bags, soil fill or riprap to temporarily stabilize embankment; check for cracking and differential movement; evaluate condition and design and prepare permanent repair procedures report; implement recommendations.
	Erosion	Report; within five days place temporary erosion controls, such as hay bales, erosion control mats, silt fences, or mulch; assess damage; make permanent repairs.
	Damaged Surface Water Control	Report; within five days place sandbags, soil fill, and/or temporary piping to make surface water controls temporarily functional; remove sediments from outlets; evaluate and make permanent repairs.
2 Leachate Spill	Damaged Vegetation	Report; assess damage; if necessary, within five days place temporary erosion controls; evaluate cause; revegetate.
	Surface Water or Groundwater Contamination	Report; immediately contain and collect retrievable leachate and absorb remaining leachate; monitor; evaluate impact; determine and implement appropriate follow-up actions.
	Soil Contamination	Report; within five days collect saturated soil for disposal in lined cell; collect soil samples below excavation; evaluate impact; determine and implement appropriate follow-up actions.
3. Grass Fire	Damaged Vegetation	Report; contact City of Inver Grove Heights Fire Department if necessary to extinguish fire; clear access roads for equipment access; immediately place soil over fire or use water to extinguish fire; place temporary erosion controls; revegetate.
4. Subsurface Fire	Waste Burning	Notify the City of Inver Grove Heights Fire Department. Reduce extraction rate from gas wells and cover area with impermeable soils.
5. Explosion		Report; contact City of Inver Grove Heights Fire Department; if necessary to extinguish fire, evaluate damage, determine and implement appropriate follow-up action.
6. Vandalism	Damage to Facility Features	Report; within ten days assess impact; based on impact, repair damage; assess site security.

TABLE 4
Inspection-Triggered Contingencies
Pine Bend Landfill

Inspection-Triggered Contingency	Result	Action
1. Leachate Head Buildup	Increased Groundwater Contamination Potential	Extract and dispose or treat leachate; monitor; evaluate cause of leachate head buildup; if necessary, increase leachate hauling frequency.
2. Erosion or Degradation of Cap	Increased Leachate Generation, Potential Surface Water Contamination	Report; immediately assess damage; within two weeks place temporary erosion controls; evaluate cause and design; make permanent repairs.
3. Clogged Surface Water Controls	Erosion	Report; within five days place temporary erosion controls; remove cause of clogs; assess damage; repair erosion; evaluate design and make any needed changes; clean pipes, ditches, and sedimentation ponds, as needed.
4. Leachate Conveyance System Failure	Potential Groundwater Contamination	Monitor; evaluate impact; evaluate cause, repair or replace failing component, such as lift pump, or pipe joint; Monitor. If failure is under a significant amount of waste, final cover the area in question.

TABLE 5
Monitoring-Triggered Contingencies
Pine Bend Landfill

Monitoring-Triggered Contingency		Result	Action
1.	Exceedance of Groundwater Standard	Groundwater Contamination	Notify MPCA; check sampling, handling techniques; resample; evaluate impact; complete feasibility study and determine remedial action; prepare report within 30 days; implement remedial action.
2.	Exceedance of Surface Water Standard (in sedimentation basins)	Surface Water Contamination	Notify MPCA; check sampling, handling techniques; resample; evaluate impact; complete feasibility study and determine remedial action; prepare report within 30 days; implement remedial action.
3.	Exceedance of Allowable Levels for Leachate Discharge to Treatment Plant	Unacceptable Impacts at MCES Treatment Plant	Monitor; report; evaluate cause of exceedance; design permanent pretreatment actions or choose alternative disposal method, choose alternative and write report; implement recommendations
4.	Leachate Detected in Leachate Leak Detection System	Increased Groundwater Contamination Potential	Report; within five days extract and dispose or treat leachate; monitor; evaluate quantity and rate of leakage; evaluate potential impacts on groundwater; if necessary, evaluate cause and determine potential remedial actions; implement remedial action.
5.	Detection of methane concentrations above acceptable limits at gas monitoring points	Potential explosive conditions	If exceedance is near any enclosed structures, evacuate and ventilate structure, investigate whether methane is entering structure, propose response to protect structure if needed; report; adjust flow rate at applicable extraction wells; continue monitoring. For continued exceedances at compliance boundary, PBL will prepare an evaluation report including evaluation of existing probes where exceedances are occurring for determination if they were placed in waste; evaluate the gas flows at the adjacent gas extraction wells and determine if they are efficiently extracting landfill gas; evaluate the need to install additional or replacement monitoring probes or gas extraction wells; evaluate the need for additional blower/flare capabilities. Prepare report within 60 days: implement remedial action.

Table 6
Contingency Action Cost Estimate
Pine Bend Landfill

Description	Quantity	Unit	Unit Cost	Cost ⁽¹⁾
<u>Event Triggered Contingency</u>				
1. Severe Rainfall (Erosion/Embankment Repair)				
Cover Fill	7,300	CY	\$ 8.00	\$ 58,400.00
Clean Surface Water Controls	1	LS	\$ 38,700.00	\$ 38,700.00
Revegetation	3	acres	\$ 2,200.00	\$ 6,600.00
2. Leachate or Fuel Spill (1,000 gallons, 100 cy soil)				
Problem Assessment and Engineering	1	LS	\$ 2,200.00	\$ 2,200.00
Mobilization	1	LS	\$ 2,800.00	\$ 2,800.00
Liquid Recovery	6	HR	\$ 280.00	\$ 1,700.00
Disposal	2	truckload	\$ 83.00	\$ 200.00
Contaminated Soil Excavation	100	CY	\$ 17.00	\$ 1,700.00
Clean Soil Fill	100	CY	\$ 6.00	\$ 600.00
Revegetation (assume 1 acre)	1	acres	\$ 2,210.00	\$ 2,200.00
3. Grass Fire				
Extinguish Fire	8	HR	\$ 660.00	\$ 5,300.00
Revegetation	2	acres	\$ 2,210.00	\$ 4,400.00
Gas Well Repair	2	well heads	\$ 1,660.00	\$ 3,300.00
4. Subsurface Fire				
Firefighting	1	LS	\$ 276,300.00	\$ 276,300.00
5. Explosion				
Extinguish Fire	6	HR	\$ 660.00	\$ 4,000.00
Problem Assessment and Engineering	1	LS	\$ 2,200.00	\$ 2,200.00
Repair LFG components	1	LS	\$ 11,100.00	\$ 11,100.00
6. Vandalism				
Miscellaneous Repairs	1	LS	\$ 2,800.00	\$ 2,800.00
<u>Inspection-Triggered Contingency</u>				
1. Leachate Head Buildup				
Problem Assessment and Engineering	1	LS	\$ 1,700.00	\$ 1,700.00
High pressure flushing	2,000	LF	\$ 4.00	\$ 8,000.00
2. Erosion, Settlement, or Degradation of Cap				
Problem Assessment and Engineering	1	LS	\$ 5,500.00	\$ 5,500.00
Temporary erosion controls	1	LS	\$ 2,200.00	\$ 2,200.00
Repair cap	1	LS	\$ 110,500.00	\$ 110,500.00
3. Clogged Surface Water Controls				
Problem Assessment and Engineering	1	LS	\$ 1,110.00	\$ 1,100.00
Clean Surface Water Controls/Sedimentation Pond	1,000	CY	\$ 3.00	\$ 3,000.00
4. Leachate Collection System Repair (3)				
A. Cleaning of Collection and Conveyance Pipe	6,000	LF	\$ 4.00	\$ 24,000.00
B. Replace Collapsed Pipe	200	LF	\$ 17.00	\$ 3,400.00
C. Excavate and Replace Waste	9,000	CY	\$ 17.00	\$ 153,000.00
D. If damage is deep, install final cover	1	LS	\$ 497,300.00	\$ 497,300.00
<u>Monitoring-Triggered Contingency</u>				
1. Exceedance of GW Standard				
Work Plan	1	LS	\$ 6,100.00	\$ 6,100.00
Sample Collection and Analysis	33	EA	\$ 660.00	\$ 21,800.00
Evaluation and Report	1	LS	\$ 18,800.00	\$ 18,800.00
Installation of additional wells	3	EA	\$ 7,180.00	\$ 21,500.00
2. Groundwater Containment/Extraction System				
Install Additional Wells with pumps	4	EA	\$ 16,600.00	\$ 66,400.00
Lift station, piping, appurtenances	1	LS	\$ 66,300.00	\$ 66,300.00
Electrical power	500	LF	\$ 14.00	\$ 7,000.00
Systems design and specs	1	LS	\$ 11,100.00	\$ 11,100.00
3. Groundwater Treatment				
On-site treatment facility	1	LS	\$ 221,000.00	\$ 221,000.00
4. Groundwater Extraction/Containment Operating costs				
Water disposal (on-site treatment)	50,000	1,000 gal	\$ 3.00	\$ 150,000.00
Electrical cost	15	YR	\$ 550.00	\$ 8,300.00
Pump maintenance	15	YR	\$ 550.00	\$ 8,300.00
Monitoring	90	event	\$ 1,100.00	\$ 99,000.00

5. Surface Water Assessment Monitoring						
Sample Collection and Analysis	8	locations	\$	550.00	\$	4,400.00
Sample analysis	8	samples	\$	1,100.00	\$	8,800.00
QC samples	2	samples	\$	880.00	\$	1,800.00
Reporting	2	LS	\$	550.00	\$	1,100.00
6. Additional Flare for when Gas Recovery System is Down						
Mobilization of portable flare	1	LS	\$	11,100.00	\$	11,100.00
Operating costs	12	Months	\$	3,090.00	\$	37,100.00
7. Methane Migration Analysis and Containment						
Evaluation fieldwork and reporting	1	LS	\$	8,800.00	\$	8,800.00
Install additional gas monitoring probes	6	EA	\$	1,330.00	\$	8,000.00
Install additional gas extraction wells	3	EA	\$	11,100.00	\$	33,300.00
TOTAL						\$1,873,800.00
EXPECTED VALUE (60% OF TOTAL)					\$	1,124,300.00

Comments:

1. Extensions are rounded to the nearest \$100.
2. Based on PBL experience
3. Use higher of A+B+C or D

Payment rate estimate table

Solid Waste Permit Program

Doc Type: Permitting Annual Report
w-sw7-26 (Revised 10/27/21)

Submit with 2021 Annual Report

Facility name **Pine Bend Landfill**
SW# **45**

2021 approved closure cost estimate	\$ 461,605.53
2021 approved annual postclosure care cost estimate	\$ 292,938.57
2021 approved contingency action cost estimate	\$ 1,120,986.46
Account balance on December 31, 2021	\$ -
Value of guarantee on December 31, 2021	\$ 11,979,440.16
(Letter of Credit or Surety Bond)	
Operating life in months (maximum 120)	54

Projected costs over post-closure care period

2022 Annual postclosure care cost estimate	\$ 304,732.28
Inflation factor = 4.026%	
Discount rate = 0.25%	

Year	Inflated annual cost	Inflated and discounted annual cost
2022	\$304,732	\$304,732
2023	\$317,001	\$316,210
2024	\$329,763	\$328,121
2025	\$343,040	\$340,480
2026	\$356,850	\$353,304
2027	\$371,217	\$366,611
2028	\$386,162	\$380,420
2029	\$401,709	\$394,749
2030	\$417,882	\$409,618
2031	\$434,706	\$425,046
2032	\$452,207	\$441,056
2033	\$470,413	\$457,669
2034	\$489,352	\$474,907
2035	\$509,053	\$492,795
2036	\$529,548	\$511,356
2037	\$550,867	\$530,617
2038	\$573,045	\$550,603
2039	\$596,116	\$571,342
2040	\$620,116	\$592,862
2041	\$645,081	\$615,193
Totals	\$9,098,861	\$8,857,692
	(Current value - not discounted)	(Current value - discounted)

Basis for this years payments

2022 Closure cost estimate	Current value	Present value*
2022 Postclosure care cost estimate	\$480,189.77	\$474,824.57
2022 Contingency action cost estimate	\$9,098,860.85	\$8,857,691.65
	\$1,166,117.37	n/a
Total	\$10,745,168.00	\$10,498,633.60

* Present value is only for Trust Funds and Dedicated Trust Funds

Account balance on December 31, 2020	\$0.00
Value of guarantee on December 31, 2020	\$11,979,440.16
Operating life in months (never greater than 120 months) =	54

Your monthly payment if not discounting =	\$198,985
Your monthly payment if discounted =	\$194,419





Stantec Consulting Services Inc.
1800 Pioneer Creek Center
Maple Plain MN 55359-9000

September 15, 2022

Project/File: 227704791

Solid Waste Permit Document Coordinator

Minneapolis Pollution Control Agency
520 Lafayette Road North
St. Paul, Mn 55155-4194

Dear Solid Waste Permit Document Coordinator,

Reference: Pine Bend Landfill, Addendum submittal to the June 3, 2022 SW-45 Application for Permit Major Modification

On behalf of BFI Waste Systems of North America, LLC and the Pine Bend Landfill (PBL), please find enclosed an Addendum to the Application for Permit Major Modification SW-45, which was submitted on June 3, 2022 and was determined to be incomplete by the MPCA solid waste engineer to the Minnesota Pollution Control Agency (MPCA) as detailed in a July 6, 2022 letter to PBL. This submittal also includes the previously submitted MPCA Permit Application Forms for the Request for Major Modification Application of Permit SW-45. The MPCA Application Forms have been updated to reflect that this Application is for "Resubmittal of an Incomplete Application Originals submitted on June 3, 2002".

The addendum information is being submitted in both hard copy and electronic format. Copies of the original Request for Major Modification Application and EAW are not included with this submittal.

If you have any questions or comments, or require additional information, please contact us at 763-479-4226 or Ethan at 763-479-5187. Thank you for your assistance on this project.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Thomas Shustarich PE
Sr. Associate/Project Manager
Phone: (763) 479-4226
thomas.shustarich@stantec.com

Ethan Ketelsen PE
Project Engineer
Phone: (763) 479-5187
ethan.ketelsen@stantec.com

Reference: Pine Bend Landfill, SW-45 Application for Permit Major Modification

c: Mr. Aaron Janusz, Pine Bend Landfill
Mr. Tyler Kraft, Pine Bend Landfill
Ms. Ally Sutherland, City of Inver Grove Heights
Mr. Dave Magnuson, Dakota County
Mr. Abdi Hassan, MPCA
Ms. Beth Gawrys, MPCA
Mr. Dan Card, MPCA
Mr. Peder Sandhei, MPCA

Attachments: 1) Updated MPCA Application Forms
2) Addendum Letter

ATTACHMENT 1

MPCA Application Forms

Permit application for issuance, reissuance, or major modification

Solid Waste Permit Program

Doc Type: Permit Application

Print or type application: Before submitting, make a photocopy for your records. The Minnesota Pollution Control Agency (MPCA) will review the application for completeness and provide an official response to the permittees within 30 business days of receipt of the application.

MPCA Use Only	
AI number:	
Activity ID:	

Permit application assembly: To expedite the processing and review of your application, **put this form at the beginning** of your submittal package. Please place all checklists directly behind this application form in order by the number found on the bottom left hand corner of each checklist. **Do not place forms and checklist in an appendix** as this makes it difficult and time consuming for staff to locate them.

Completeness instructions: Without properly completed forms, an application cannot be processed and will be determined to be incomplete. All sections of this form must be completed. If portions do not apply to this facility, please indicate so with "n/a".

The completed form is to be returned to: **Solid Waste Permit Document Coordinator**
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Submittal: You must submit one (1) paper copy **and** one (1) electronic copy (i.e., disc or thumb drive) of your application.

Application is for (check appropriately): ☐ New permit ☐ Permit reissuance ☐ Major modification

☒ Resubmittal of 'Incomplete' application originally submitted on: 06/03/2022

Note: Different forms are available for Minor Modifications or Change in Ownership/Operation. (Found on the MPCA's Solid Waste Permitting website at <https://www.pca.state.mn.us/waste/solid-waste-permitting>.) (mm/dd/yyyy)

Facility name and address

Facility name: Pine Bend Landfill

Address: 2495 East 117th Street

City: Inver Grove Heights State: MN Zip: 55077

MPCA Region (check one): ☐ Brainerd ☐ Detroit Lakes ☐ Duluth ☐ Marshall ☒ Metro ☐ Rochester

Applications for metro facilities must include information to demonstrate the proposed facility is in accordance with the metropolitan policy plan (Minn. Stat. 473.823).

Is there an existing solid waste permit for the facility? ☒ Yes ☐ No

If yes, what is the permit number: PBR _____ or SW 45

Permit expiration date (mm/dd/yyyy): 07/30/2025

Checklists required (Please check all that are included with this application.)

All applicable checklists must be completed and submitted with this application. The MPCA will not process an application that does not include all of the required checklists. All checklists can be found on the MPCA's website at <https://www.pca.state.mn.us/waste/solid-waste-permitting>.

All solid waste facilities

☒ [Solid Waste Facility Application Checklist](#)

☒ [Metro permit review application checklist \(w-sw7-44\)](#)
(Required for metro facilities only)

Activity specific checklist

☒ [MSW Landfill Application Checklist](#)

☐ [SSOM Compost Facility Application Checklist](#)

☐ [MSW Combustor Ash Landfill Application Checklist](#)

☐ [Checklist for a Site Suitability Workplan for a Source-Separated Compost Facility](#)

☐ [Demolition Debris Landfill Application Checklist](#)

☐ [Refuse-Derived Fuel Processing Facilities Application Checklist](#)

☐ [Industrial Solid Waste Landfill Application Checklist](#)

☐ [Solid Waste Transfer Station Application Checklist](#)

☐ [Solid Waste Compost Facility Application Checklist](#)

I. Facility information

A. Legal description of property (acreage includes the entire area of the facility)

255 Acres $\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$ Section 33 T 27 N R 22 W
Township name: _____ MN Legislative District: _____
County: Dakota
Latitude: 44 Deg 46 Min 59 Sec North
Longitude: 93 Deg 3 Min 15 Sec West

B. General information

1. Directions to the facility (physical location) [Minn. R. 7001.3300, item A]:
Approximately 4,000 feet West of Highway 52 on north side of 117th Street
2. Current land use [Minn. R. 7001.3300, item N]:
MSW Landfill
3. Current zoning designation of the site and the surrounding areas within a quarter mile radius [Minn. R. 7001.3300, item N]:
Industrial site surrounded by mostly industrial usage and some agriculture to the west
4. Describe the key topographic features at and around the facility [Minn. R. 7001.0050, item F]:
See Section C below.
5. a) Has either an Environmental Assessment Worksheet (EAW) or Environmental Impact Statement (EIS) been completed in the past? [Minn. R. 7001.0050, item G] ☒ Yes ☐ No
If yes, please provide date of completion:
An EAW was prepared as part of the previous major modification (3:1 slopes vertical expansion) and submitted in the spring of 2016, the document was published in June of 2016.
b) Does this application require a new Environmental Assessment Worksheet (EAW) [Minn. R. 4410.4300] or Environmental Impact Statement (EIS) [Minn. R. 4410.4400]? ☒ Yes ☐ No
Explain:
Minnesota Environmental Review Rules, Section 4410, 4300, Subp. 17, state that an EAW is mandatory for the expansion of a mixed municipal solid waste project by at least 10 percent but less than 25 percent of the previous disposal capacity for 100,000 cubic yards or more of waste fill per year.
6. a) Have variances been approved in the past for this facility? ☐ Yes ☒ No
If yes, please list and provide approval dates and documentation:
b) Are there new variances requested in this application in accordance with Minn. R. 7000.7000? ☐ Yes ☒ No
If yes, list/explain (this should include the applicable rule citation for the requested variance(s)):
7. Is this facility in an environmental justice area? Please use the link below to identify ☐ Yes ☒ No
<http://mpca.maps.arcgis.com/apps/MapSeries/index.html?appid=f5bf57c8dac24404b7f8ef1717f57d00>
If yes, which areas apply?
☐ At least 40% of people reported income less than 185% of the federal poverty level
☐ 50% or more people of color
☐ Federally recognized tribal areas
8. a) Has Certificate of Need (CON) been granted in the past for this facility? ☒ Yes ☐ No
If yes, please list and provide approval dates and amounts issued:
2,398,746 tons approved on Decemebr 15, 2021.

b) Is additional CON requested in this application in accordance with Minn. Stat. 115A.917
Metropolitan Policy Plan?

☐ Yes ☒ No

C. Identify the following features within a one mile radius of the site

Feature	Name of feature	Distance	Units
Current and former water supply or monitoring wells	See attached CWI		
Airports (Minn. R. 7035.2815, subp 2(C))	N/A		
Lakes or ponds (Minn. R. 7035.2555, subp 2(A))	N/A		
Rivers, streams or springs (Minn. R. 7035.2555, subp 2(A))	Mississippi River	5,000 feet from NE corner of site	
Wetlands (Minn. R. 7035.2555, subp 2(B))	Various wetlands located on west 100 acre property	Adjacent	
Floodplains (Minn. R. 7035.2555, subp 1)	N/A		
Karst features (sinkholes, caves) (Minn. R. 7035.2815, subp 2(1); Minn. R. 7035.2825, subp 2(A))	N/A		
Parks or wildlife refuges	N/A		
Present or proposed access and major haul roads, and their weight restrictions	Highway 52	3,000 feet East of Site	
Easements or right-of-way	N/A		
Recreational areas	N/A		
Historical or archeological areas	N/A		

II. Waste activity information

A. Waste Activities that occur at the facility (complete a row for each waste activity area and each waste type)

[illegible]

B. Land disposal (complete a row for each separate waste disposal area, closed and active areas)

[illegible]

III. Operational information

- A. The facility will have capacity to receive 400 vehicles per day and expects to receive an average of 150 vehicles per day.** List the vehicle types (i.e., packer trucks, roll-off boxes, private citizen vehicles) using the facility including those that transport special wastes, such as tires or white goods.

Vehicle type	Vehicle capacity	Waste type transported
Transfer Trailer	80 to 100 CY	MSW
Packer Trucks	25 to 35 CY	MSW, Industrial
Private Citizen Vehicles	Varies	MSW
Side dumps, Roll-offs	10 to 15 CY	Contaminated soils

- B. Describe the equipment to be located and used on site at the facility, or the availability and arrangement for use of equipment kept off-site, managing the waste:**

836G and 836H Landfill Compactor, D8-T Dozer, Motor Grader, Wheel Loader 930, skid steer, 2 farm tractors with mower decks, water truck and other equipment as necessary

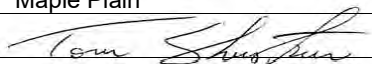
IV. Solid waste annual report contact

Print name: Aaron Janusz Title: Environmental Manager
Email: ajanusz@republicservices.com Phone: 651-434-9843
Organization: BFI Waste System of North America, LLC
Address: 2495 E 117th Street
City: Inver Grove Heights State: MN Zip: 55077

V. Signature and certification

A. Engineer (Consultant)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Print name: Thomas J. Shustarich License number: 21210
Title: Project Manager State licensed: MN
Email: thomas.shustarich@stantec.com Phone: (763) 479-4226
Organization: Stantec
Address: 1800 Pioneer Creek Center
City: Maple Plain State: MN Zip: 55359
Signature:  Date (mm/dd/yyyy): 6/1/2022

B. Permittees

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

I further certify that the construction and operation of the above described facility will be in accordance with the plans, specifications, reports and related communications accepted by the MPCA and on file in its office; and in accordance with conditions imposed in the permit issued by the MPCA.

I certify that the facility is consistent with local solid waste management plans. I am aware an MPCA permit must be obtained before construction or operation of the facility may begin and all local permits, licenses or other government approval must be obtained before an MPCA permit can be issued.

I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

Landowner

Print name: Tyler Kraft Title: General Manager
Email: tkraft2@republicservices.com Phone: 651-403-2200
Organization: BFI Waste Systems of North America, LLC
Address: 11380 Courthouse Blvd
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Tyler Kraft* Date (mm/dd/yyyy): 06/02/2022

Activity owner (Applicant)

Print name: Tyler Kraft Title: General Manager
Email: tkraft2@republicservices.com Phone: 651-403-2200
Organization: BFI Waste Systems of North America, LLC
Address: 11380 Courthouse Blvd
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Tyler Kraft* Date (mm/dd/yyyy): 06/02/2022

Operator*

Print name: Ross Ziegenhagen Certification No: _____
Title: Operations Supervisor Expiration date: _____
Email: rzeiegenhagen@republicservices.com Phone: 651-308-1064
Organization: BFI Waste Systems of North America, LLC
Address: 2495 E 117th Street
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Ros Ziegenhagen* Date (mm/dd/yyyy): 06/02/2022

***Provide the same information for other certified operators.**

Aaron Janusz
Type II Operator
Cert # 53794014
Expires 11/15/2022

Drake Vocovich
Type II Operator
Cert # 77732252
Expires 3/4/2025

VI. Local acknowledgment

This section is primarily meant to notify the county and local authorities of the applicant's intent so that all county and local ordinances and plans can be met. It is intended to validate that counties and local authorities were properly notified of this permit application for construction and operation. Signature by the county or local authority is not meant to imply approval.

A. County acknowledgment/permission (to be completed by County Solid Waste Administrator or County Zoning Administrator)

Print name: Dave Magnuson Title: Waste Regulations Supervisor
Email: dave.magnuson@co.dakota.mn.us Phone: 952-891-7551
Organization: Dakota County
Address: 14955 Galaxie Avenue
City: Apple Valley State: MN Zip: 55124
Signature: *Dave Magnuson* Date (mm/dd/yyyy): 06/02/2022

B. Local acknowledgment/permission (to be completed by local building or zoning office)

Print name: Ally Sutherland Title: Environmental Specialist
Email: asutherland@ighmn.gov Phone: 651-604-8511
Organization: City of Inver Grove Heights
Address: 8150 Barbara Avenue
City: Inver Grove Heights State: MN Zip: 55077
Signature: _____ Date (mm/dd/yyyy): _____

In lieu of completion of this part of the application, the applicant may submit documentation that the applicant has sent appropriate notification to the county and local authorities. Documentation must consist of copies of letters sent to the county and local authorities via certified mail, return receipt requested and copies of the signed return receipt.

C. Local approvals

Have all local licenses/approvals been acquired? ☐ Yes ☒ No

If yes, please list all approvals, include issuances and expiration dates (include a copy of each approval)

If no, please explain:

The Pine Bend Landfill is currently permitted and licensed, and in good standing with the City of Inver Grove Heights and Dakota County. Pine Bend will be working with the City and County to ensure that all permits and licenses are updated.

D. Solid waste transfer facilities and source-separated organic material (SSOM) compost facilities

The applicant for a transfer facility or SSOM compost facility must attach copies of all required municipal licenses/approvals, unless the applicant is a municipality. The MPCA will not process an application without these approvals. See Minn. R. 7001.3400, item C, or 7001.3375 item L for more details. If no municipal approvals are required the owner or operator must sign the statement below stating that no municipal approvals are required.

I certify, no municipal approvals are required:

Print name: _____ Title: _____
Signature: _____ Date (mm/dd/yyyy): _____

E. Land disposal facilities

The MPCA may not issue a permit for a new disposal area or an expansion of an existing disposal area prior to local units of government granting approval. All local approval will need to be obtained prior to issuance of the MPCA solid waste permit for disposal activities. See Minn. Stat. § 116.07, subd. 4j, item d(1) for more details.

VI. Local acknowledgment

This section is primarily meant to notify the county and local authorities of the applicant's intent so that all county and local ordinances and plans can be met. It is intended to validate that counties and local authorities were properly notified of this permit application for construction and operation. Signature by the county or local authority is not meant to imply approval.

A. County acknowledgment/permission (to be completed by County Solid Waste Administrator or County Zoning Administrator)

Print name: Dave Magnuson Title: Waste Regulations Supervisor
Email: dave.magnuson@co.dakota.mn.us Phone: 952-891-7551
Organization: Dakota County
Address: 14955 Galaxie Avenue
City: Apple Valley State: MN Zip: 55124
Signature: _____ Date (mm/dd/yyyy): _____

B. Local acknowledgment/permission (to be completed by local building or zoning office)

Print name: Ally Sutherland Title: Environmental Specialist
Email: asutherland@ighmn.gov Phone: 651-604-8511
Organization: City of Inver Grove Heights
Address: 8150 Barbara Avenue
City: Inver Grove Heights State: MN Zip: 55077
Signature: *Ally Sutherland* Date (mm/dd/yyyy): 06/02/2022

In lieu of completion of this part of the application, the applicant may submit documentation that the applicant has sent appropriate notification to the county and local authorities. Documentation must consist of copies of letters sent to the county and local authorities via certified mail, return receipt requested and copies of the signed return receipt.

C. Local approvals

Have all local licenses/approvals been acquired? ☐ Yes ☒ No

If yes, please list all approvals, include issuances and expiration dates (include a copy of each approval)

If no, please explain:

The Pine Bend Landfill is currently permitted and licensed, and in good standing with the City of Inver Grove Heights and Dakota County. Pine Bend will be working with the City and County to ensure that all permits and licenses are updated.

D. Solid waste transfer facilities and source-separated organic material (SSOM) compost facilities

The applicant for a transfer facility or SSOM compost facility must attach copies of all required municipal licenses/approvals, unless the applicant is a municipality. The MPCA will not process an application without these approvals. See Minn. R. 7001.3400, item C, or 7001.3375 item L for more details. If no municipal approvals are required the owner or operator must sign the statement below stating that no municipal approvals are required.

I certify, no municipal approvals are required:

Print name: _____ Title: _____
Signature: _____ Date (mm/dd/yyyy): _____

E. Land disposal facilities

The MPCA may not issue a permit for a new disposal area or an expansion of an existing disposal area prior to local units of government granting approval. All local approval will need to be obtained prior to issuance of the MPCA solid waste permit for disposal activities. See Minn. Stat. § 116.07, subd. 4j, item d(1) for more details.

ATTACHMENT 2

Addendum Letter



Stantec Consulting Services Inc.
1800 Pioneer Creek Center
Maple Plain MN 55359-9000

September 15, 2022

Project/File: 227704791

Mr. Abdi Hassan

Engineer

Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155

Dear Mr. Hassan,

Reference: Addendum to the Request for Major Modification of Permit SW-45

This addendum letter submittal is in response to your July 6, 2022 incomplete determination letter following your review of the Major Modification Application submitted on June 3, 2022 for the Pine Bend Landfill (PBL), SW-45. The following information was requested as part of the resubmitted and revised application by the MPCA:

1. *The facility was issued CON on December 15, 2021 for the facility to continue to utilize existing permitted capacity. Tat space is expected to last the landfill for a period of approximately seven years. MPCA will open the nest metro CON process before metro area landfills are close to reaching their permitted capacities. However, the Pine Bend facility application cannot be considered complete under MPCA rules without having CON in place. Since the facility has not received CON for the applied expansion yet, the facility must wait to apply for expansion until after the next CON cycle which is expected to be in about 4-5 years depending on fill rates.*
2. *The MPCA Environmental Review Unit (ERU) has determined that the EAW submittal sent in by Pine Bend is incomplete due to the incomplete solid waste permit application and therefore ERU cannot process the EAW until a complete EAW (with complete solid waste permit application) is submitted.*

With regards to the above request for additional information, several meetings and conversations between PBL and MPCA management and staff have taken place per the MPCA request, PBL is providing an updated analysis of Airspace consumption versus CON consumption, which is included as an Attachment to this addendum. In support of that analysis, an Isopach Map detailing the remaining airspace at the Pine Bend Landfill as of May 2022 is also attached.

Reference: Addendum to the Request for Major Modification of Permit SW-45

It is PBL's understanding that this Addendum and attached information addresses the MPCA's request for additional information and the MPCA review of the request for Major Modification Application for SW-45 and the Environmental Assessment Worksheet may move forward.

Sincerely,

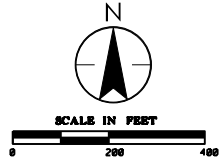
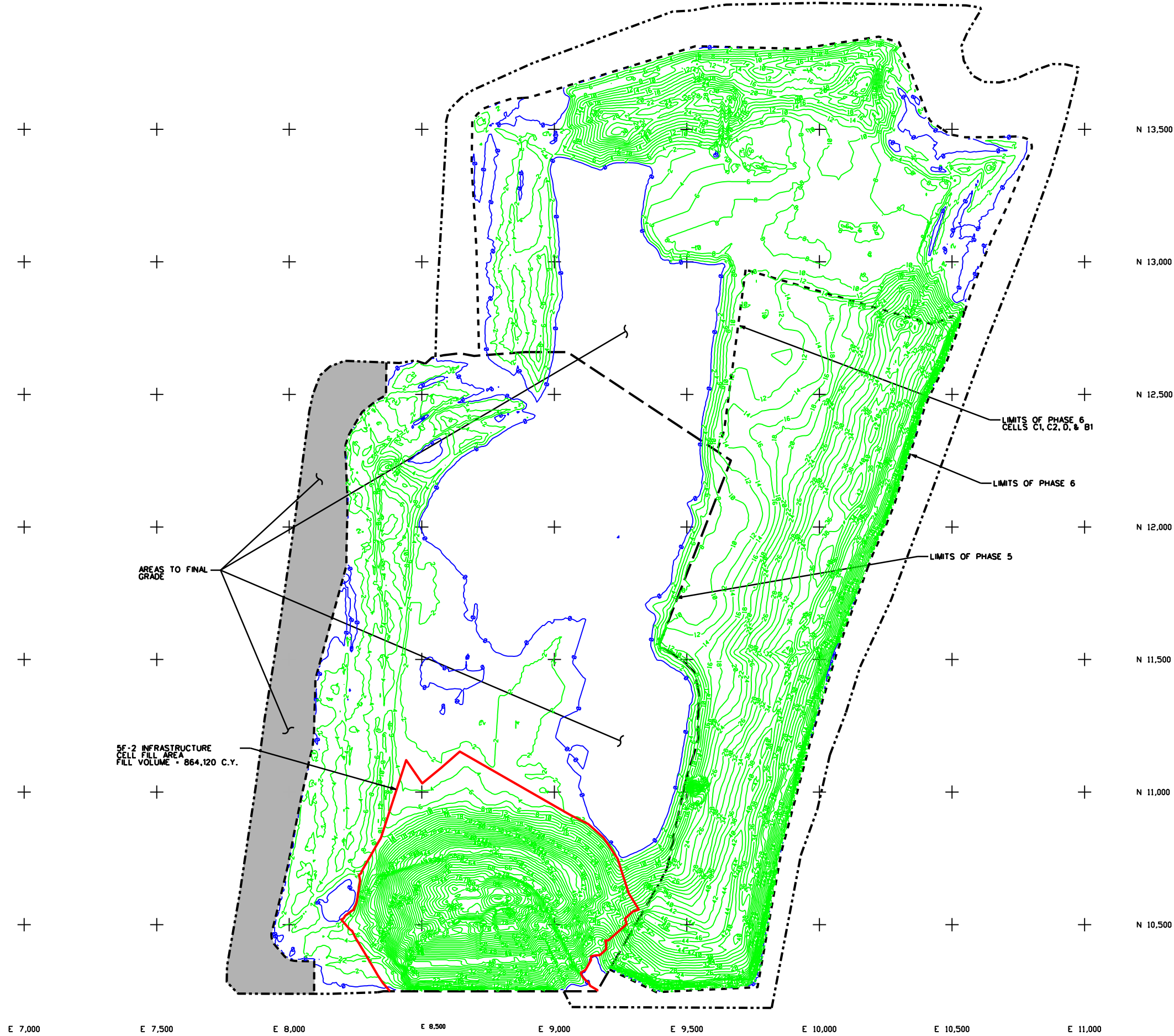
STANTEC CONSULTING SERVICES INC.

A handwritten signature in black ink that reads "Tom Shustarich". The signature is fluid and cursive, with the first name "Tom" and last name "Shustarich" clearly distinguishable.

Thomas Shustarich PE
Sr. Associate/Project Manager
Phone: (763) 479-4226
thomas.shustarich@stantec.com

Attachments: Isopach Map
PBL Airspace Consumption vs CON Consumption

U:\227704899\caddling\may 23 2022\remaining waste isopach.dgn
By: jfifield 10:50



- LEGEND
- 920 CONTOURS
 - LIMITS OF PHASE 4 FINAL COVER
 - PHASE 5 LIMITS OF WASTE
 - PHASE 6 LIMITS OF WASTE
 - 4 FILL CONTOUR
 - 0 EVEN CONTOUR

NOTE:
CONTOURS SHOWN REPRESENT
ISOPACH BETWEEN 05/23/22
TOPOGRAPHY WITH PHASE 6
AND 5F-2 FULLY CONSTRUCTED AND
TOP OF WASTE GRADES

FILL VOLUME = 2,902,555 C.Y.
AREA TO FINAL GRADE = 69.4 ACRES



Client/Project
BH WASTE SYSTEMS OF NORTH AMERICA, LLC
PINE BEND LANDFILL

INVER GROVE HEIGHTS, MINNESOTA
Isopach Map of Remaining Airspace Using Maximum Grades

Project Number: 227704899	may 23 2022 remaining waste isopach.dgn
JWT	2022.08.24
Drawing No. 1	
Revision	Sheet
0	1 of 1

Issued	By	YJW/JDD
	App'd	
	Check'd	
	Reviewed	
	Approved	

**Pine Bend Landfill
Airspace Consumption vs CON Consumption
9/6/2022**

Airspace Analysis

Remaining Permitted Airspace May 2022 (cy)	2,902,555	Stantec analysis of survey
Density (lb/cy)	1,350	Current density
Annual Tonnage (tons/yr)	480,000	2022 Actuals + Forecast
Annual Airspace Estimate (cy/yr)	711,111	
Years Airspace Remaining from May 2022	4.1	July 2026
Cell 5F-2 (Infrastructure Cell) Airspace (cy)	864,120	
Remaining Permitted Airspace Less 5F-2 (cy)	2,038,435	
Years Airspace Remaining Less 5F-2 from May 2022	2.9	April 2025

CON Analysis (Metro + Out-State)

Metro CON at Start of 2022 (tons)	2,398,746	Initial amount granted
Wright County (tons)	-	36,800 tons x 7 years
Tri-County (tons)	-	50,00 tons x 7 years
Total CON at Start of 2022 (tons)	2,398,746	
CON Consumed through May 2022 (tons)	161,238	Landfill Tonnage Reports
CON Remaining May 2022 (tons)	2,237,508	
Estimated Annual CON Consumption (tons/yr)	400,000	All MN MSW
Years CON Remaining from May 2022	5.6	January 2028