# ENGINEERING REPORT

## Part 360 Series Permit Renewal/Modification Application

### LOCKWOOD ASH DISPOSAL SITE

**Prepared on behalf of:**


**Lockwood Hills LLC**
590 Plant Road
P.O. Box 187
Dresden, New York 14441


**Prepared by:**


DAIGLER ENGINEERING, P.C.
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Grand Island, New York 14072-2131


**August 2020**

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Lockwood Hills LLC

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# 1 INTRODUCTION

The Lockwood Ash Disposal Site (Landfill or Lockwood) is located off State Route 14, near the Village of Dresden in the Town of Torrey, Yates County, New York. Coal combustion byproducts (CCBPs) including fly ash, bottom ash, water/wastewater sludge and mill rejects were previously disposed at the Landfill. The Landfill is identified on the map in Figure 1-1.

The Landfill is owned and operated by Lockwood Hills LLC (Lockwood Hills). The operation of the Landfill is carried out in accordance with the requirements of 6 NYCRR Part 360 Solid Waste Management Facility Permit No. 8-5736-00005-00003-0. Stormwater and leachate discharge from the Landfill are managed in accordance with the requirements of State Pollutant Discharge Elimination System (SPDES) Permit No. NY-0107069.

This Engineering Report is intended to meet the requirements of NYCCR Part 360 Section 363-4.3. Table 1-1 lists the Part 363 Engineering Report requirements and the corresponding section the requirement is addressed.

## Table 1-1: NYCCR Part 363 Engineering Report Requirements

| NYCCR Part 360 Section 363-4.3 | | |
|---|---|---|
| **Engineering Report Requirements** | | |
| | | |
| **Requirement** | **Description** | **Report Location** |
| **363-4.3 (a) Site Description and Analysis** | | |
| 363-4.3(a)(1) | Description of Type and Amount of Waste | Section 2.1 |
| 363-4.3(a)(2) | Description of Machinery and Equipment | Facility Manual (Section 4) |
| **363-4.3(a)(3) Description of Materials and Construction Methods** | | |
| 363-4.3(a)(3)(i) | Monitoring Wells | CQA Plan (Section 5.8) |
| 363-4.3(a)(3)(ii) | Landfill Gas Management System | NA (Section 6.1) |
| 363-4.3(a)(3)(iii) | Leachate Conveyance, Storage, Treatment, and Disposal System | Section 5 |
| 363-4.3(a)(3)(iv) | The Cover System | Section 6-1 |
| 363-4.3(a)(3)(v) | Liner and Leachate Collection and Removal System | Section 4 and 5 |
| 363-4.3(a)(4) | Description of Post Construction Care Measures | Facility Manual (Section 3) |
| 363-4.3(a)(5) | Description of Landfill Gas Management System | NA (Section 6.1) |
| 363-4.3(b) | Liner Subbase Settlement Analysis | Section 8 |
| 363-4.3(c) | Structural Integrity and overall slope stability Analysis | Section 6.2 and 9 |
| 363-4.3(d) | Seismic Stability Analysis | Section 9-4 |
| **363-4.3(e) Description and Analysis of Leachate Collection and Removal System** | | |
| 363-4.3(e)(1) | Evaluation of Leachate Generation Data | Section 5.8 |
| 363-4.3(e)(2)(i) | Evaluation of the Design to Withstand Stresses | Section 5.6 |
| 363-4.3(e)(2)(ii) | Description of Allowance for Effective Monitoring | Section 5.5 |
| 363-4.3(e)(2)(iii) | Description of Allowance for Access to Maintenance | Section 5.5 |
| 363-4.3(e)(3) | Maximum Daily Volume of Leachate, Leachate Head, Leakage Rate | Section 5.9 and 5.10 |
| 363-4.3(f) | Stormwater/run-off Conveyance System | Section 7 |
| 363-4.3(g) | Mined Land Use Plan | NA |
| 363-4.3(h) | Facility Closure and Post-Closure Plan | Facility Manual (Section 17.1) |


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# SITE LOCATION

ENGINEERING REPORT

| LOCKWOOD HILLS LLC | | | FIGURE 1-1 |
|---|---|---|---|
| TOWN OF TORREY | YATES COUNTY | NEW YORK | |
| August 2020 | SCALE: NOT TO SCALE | REVISION # 0 | |

Q:\Lockwood Hills LLC\31-1518 Consent Order Eng Report 2.1\acad\Figure 1-1 Site Location ENG REPORT.dwg 4/29/2020 4:52 PM

# 2 FACILITY BACKGROUND

Lockwood started accepting Coal Combustion Residual (CCR) waste in approximately 1979. The currently permitted extent of the Facility is 44.2 acres, of which, 29.8 acres have been constructed to date. The current Facility consists of a soil-lined Original Ash Disposal Site (OADS) and two of four permitted stages of a geomembrane-lined expansion. Stage I includes a section of overfill liner above the wastes placed in the OADS. Stage II extends the baseliner to the south. The remainder of the overfill liner and the baseliner for Stages III and IV are permitted, but not yet constructed.

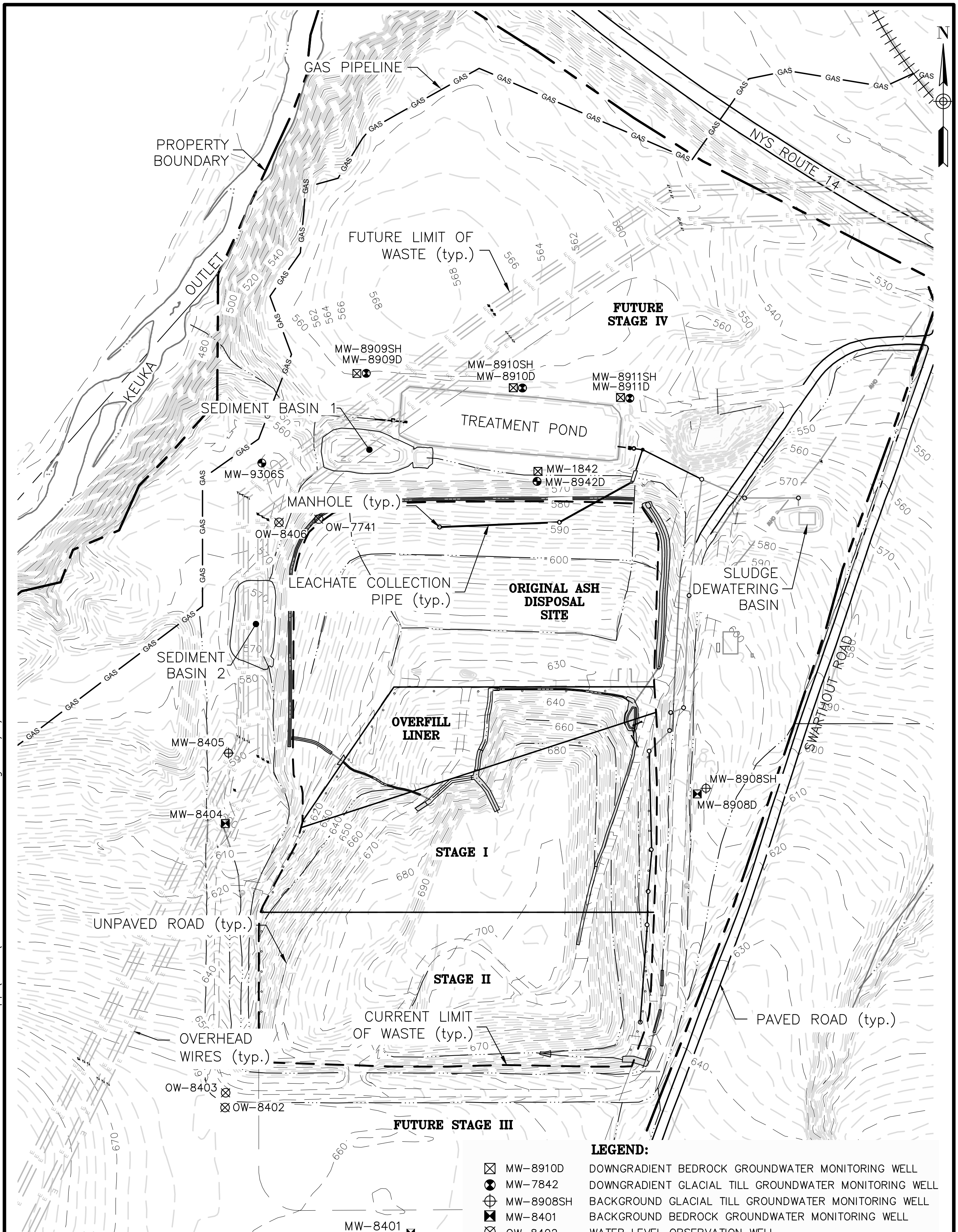
The OADS is closed with final cover and the majority of Stage I and Stage II are covered with intermediate cover defined by the Facility's Cover Material Management Plan (Section 6.3 of the Facility Manual, Daigler Engineering PC, May 2020) as six to nine inches of clayey/silty soils, sandy soils or gravelly soils, or other NYSDEC approved materials, overlain by three to four inches of soil suitable to sustain vegetative growth.

The current extent of the Facility is shown on PD-1 Existing Conditions. A 100-foot Grid Map showing existing topography, final grade elevation, baseliner subgrade and subsurface soil layer and groundwater elevations is provided on Permit Drawing PD-3. The Final Grading Plan for the Landfill is shown on Permit Drawing PD-6. The site layout is also shown on Figure 2-1.

## 2.1 ACCEPTED WASTE

The Landfill is approved for the disposal of fly ash, bottom ash, pulverized mill rejects, and wastewater treatment plant sludge from the Greenidge Power Generating Station (Greenidge Station). The Landfill is also permitted to accept waste from various other facilities, including former AES power plants, Garlock, Inc., and Eastman Kodak. The primary waste stream disposed of in the Landfill is anticipated to be sludge from the Greenidge Station wastewater treatment plant and fly ash and bottom ash from Greenidge Station associated with the up to 19% biomass Greenidge Station is authorized to co-fire with natural gas. It is estimated that the biomass co-firing would produce 6,500 tons per year of fly ash. The dewatered solids from the Greenidge wastewater treatment plant are also regularly disposed of at Lockwood at a rate of 12 tons per year. Additionally, permitted wastes from routine maintenance or other activities have the potential to be disposed of in the landfill.

The approved design capacity for the Landfill is 1,729 tons per day. Approximately 2,136,000 cubic yards of waste have been disposed within the Landfill. The maximum in-place density of the waste is approximately 1.3 tons/cubic yard. The total quantity of waste to be placed within the fully permitted Landfill is approximately 5,065,700 cubic yards.




# SITE LAYOUT

ENGINEERING REPORT

LOCKWOOD HILLS LLC

| | | | |
|---|---|---|---|
| TOWN OF TORREY | YATES COUNTY | NEW YORK | FIGURE 2-1 |
| August 2020 | SCALE: NOT TO SCALE | REVISION # 0 | |

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# 3 SITE HYDROGEOLOGY

The units comprising the geology of the Site include glacial till on the surface underlain by the Geneseo Formation Shale, the Tully Formation Limestone and the Moscow Formation Shale. At the southern end of the Landfill, all four units exist. At the southern limit of the Original Ash Disposal Site (OADS), both the Geneseo and Tully formations have been completely eroded away. A layer of weathered rock and till, between approximately 12 and 15 feet thick, covers the northern terminus of these two units. At the north end of the Site, the till layer thickness is approximately 40 feet thick and overlies the Moscow Formation Shale. The top of bedrock contours constructed from a 100-foot grid are shown on Permit Drawing PD-2 along with the extent of Geneseo and Tully formations. The top of bedrock and glacial till are also shown in cross sectional view on Permit Drawing PD-7.

### 3.1.1 Glacial Till

The glacial till is characterized as dense, non-plastic silt, sand and gravel. The unit increases in thickness northward and downslope, in the direction of the Keuka Lake Outlet northwest of the Site. The upper 10 to 15 feet of the till is poorly stratified with occasional thin, discontinuous sand lenses. Except for locations near the center of the Site where bedrock outcropping was noted, the till unit is continuous and overlies the bedrock units.

### 3.1.2 Bedrock Formations

The Geneseo Formation Shale is dark gray to black, fissile and highly weathered with thin, "poker chip" fractures. Monitoring well 8401 and observation well 8403 are fully screened in this Formation. Monitoring well 8908SH, which is mostly screened in the glacial till, also extends into the top of the Geneseo Formation Shale. The top of the Formation follows the contours of the ground surface sloping downward to the north. There appears to be a ridge in the rock along the western edge of the landfill. The bottom of this unit is in horizontal contact with the Tully Formation.

The Tully Formation Limestone is described as a dark gray fossiliferous rock, fair to good quality with horizontal to subhorizontal relatively tight fractures. The Tully Formation appears to have a uniform thickness of approximately 10 feet and is horizontally oriented where it exists on the Site.

Monitoring Wells 8404, 8908D, and abandoned well 8922 are shown to have been screened partially within this unit.

The Moscow Formation Shale is a black shale containing abundant crinoidal, coral and shelly fossils usually occurring in well preserved horizontal beds. The shale also contains pyritic veins, inclusions and fossil replacements. Bedding planes in the Moscow Formation are nearly horizontal, but rock obtained from coring had a strongly developed, high angle (60 to 70 degrees) fracture set. Monitoring wells 8406, 8909D, 8910D, 8911D and 8942D and observation well 8407 are screened in this unit. Monitoring wells 8404, 8908D and 8922 (abandoned) are screened across the interface of the Moscow Formation and the Tully Formation. The location of the monitoring wells discussed in this section are shown on Figure 2-1 and the Top of Bedrock Permit Drawing PD-2.

### 3.1.3 Groundwater

Two water bearing units have previously been identified at Lockwood; including a water table in the unconsolidated glacial till unit; and groundwater in the fractures of the underlying consolidated bedrock units. The seasonal high glacial till and bedrock groundwater head levels and the direction of groundwater flow are shown on Permit Drawing PD-3.

Physical site characteristics, soil, and bedrock properties, help establish the groundwater flow patterns at Lockwood. For example, the original ground surface at the site and the immediately surrounding areas slope down to the north between about one to six percent, promoting some lateral groundwater flow to the north in the overburden. The Keuka Outlet presents a deep cut through the till and bedrock units, with a water surface elevation in the range of 470 to 460 feet above MSL, lower than the well screen intervals for any of the site monitoring wells, tending to promote lateral groundwater drainage in both the overburden and bedrock along the western margin of the site. Seneca Lake's western shore is approximately 4,000 feet northeast of the Landfill with a surface water elevation of approximately 445 feet MSL; and together with the Keuka Outlet, constitutes the likely groundwater discharge area for groundwater found below the Landfill.

# 4 LANDFILL BASELINER SYSTEM

Existing baseliner systems have been constructed in the OADS, Stage I, and Stage II of the Landfill. An overfill liner on the OADS and Stage III and Stage IV baseliners are to be constructed in the future per the Landfill Fill Progression Plan shown on Permit Drawing PD-10. The following section describes the in-place baseliner systems and those to be constructed during future development.

## 4.1 ORIGINAL ASH DISPOSAL SITE

The OADS was constructed in two phases, the first in 1979 and the second in 1981. The OADS containment liner system is constructed above a series of groundwater drain trenches and consists of a two-foot thick compacted soil barrier and overlying two-foot thick layer of bottom ash, which acts as the leachate drainage layer. A network of leachate collection pipes is installed in the drainage layer. The OADS is closed and has a soil based final cover system. The top of the OADS soil liner and the leachate collection pipe network is shown on PD-5.

## 4.2 STAGE I AND II

Stage I was constructed in 1989 and 1990, including a basal area double liner and underlying groundwater drainage trenches above natural soil deposits, and a single geomembrane overfill liner atop the wastes in the southern portion of the OADS. Stage II was completed in 1992, and consisted of a basal area double liner. The basal liner in Stage I and Stage II consists of the following components in ascending order:

- A two-foot thick compacted soil liner;
- A secondary leachate collection and removal system composed of a four-inch thick sand layer, with embedded band drains and a six-inch diameter PVC header;
- A geotextile cushion layer;
- A 50-mil polyvinyl chloride (PVC) geomembrane liner;
- A geotextile cushion layer; and
- A two-foot thick drainage layer with an embedded leachate collection pipe network.

The geomembrane overfill liner atop the OADS (Stage I Overfill) consists of the following components, in ascending order:

- A geotextile cushion layer;
- A 50-mil PVC geomembrane liner;
- A geotextile cushion layer; and
- A one-foot thick drainage layer including a leachate collection pipe network.

The Stage I (including overfill) and Stage II top of subgrade elevations and the leachate collection pipe network are shown on Permit Drawing PD-5.

## 4.3 OADS Overfill (Future)

The next planned phase of landfill construction, Phase 1b as shown on PD-10, includes an approximate 10.5-acre extension of the Stage I overfill liner to be constructed above the northern soil covered slope of the OADS once Stage I/II achieves its interim capacity. This overfill liner will be a double composite liner system consistent with the Stage III and Stage IV Baseliner System described in Section 4.4 below. The conceptual OADS Overfill liner subgrade is shown on PD-5.

## 4.4 Stage III and Stage IV Baseliner System

Stage III is to be constructed during Phase 2 of the fill progression plan and Stage IV is to be constructed during Phase 4 of the fill progression plan as shown on PD-10. The conceptual Baseliner subgrade and leachate collection pipe layout is shown on PD-5. The Stage III and Stage IV Baseliner System shall consist of the following in ascending order:

- A porewater geocomposite where necessary above the subgrade;
- A two-foot thick compacted secondary soil liner;
- A 60-mil secondary textured HDPE geomembrane liner;
- A secondary geocomposite;
- A one-foot thick secondary leachate drainage layer with a minimum hydraulic conductivity of 0.1 cm/s including a leachate collection pipe network;

- A Geosynthetic Clay liner;
- A 60-mil primary textured HDPE geomembrane liner;
- A 16-oz non-woven cushion geotextile;
- A one-foot thick primary leachate drainage layer with a minimum hydraulic conductivity of 1.0 cm/s including a primary leachate collection pipe network; and
- A one-foot thick primary leachate drainage layer with a minimum hydraulic conductivity of 0.1 cm/s.

The baseliner system details are included on Permit Drawing PD-8, and the material specifications are included in the accompanying CQA/CQC Plan (Daigler Engineering, PC, May 2020). Where the vertical separation between the base of the constructed liner system and the top of the Bedrock is less than ten feet, the limit of excavation will be extended a minimum of ten feet below the base of the constructed liner system. This over excavation will then be backfilled with structural fill to the grades for the bottom of the liner system. A porewater collection system including a geocomposite porewater drain will be installed in all areas where the subgrade lies five feet or less above the seasonal high glacial till groundwater elevation.

# 5 LEACHATE MANAGEMENT SYSTEM

Leachate is liquid, primarily derived from the infiltration of precipitation into the wastes, that is contained and collected by the Landfill's basal liner systems. Currently, leachate management at the Landfill focuses on the conveyance of collected leachate to the Treatment Pond where influent is treated to promote aeration, metals precipitation, and sedimentation of suspended solids as treatment and subsequent discharge through the SPDES Outfall 01A to the Keuka Outlet.

Each Stage of the Landfill includes a network of perforated PVC lateral collection pipes that convey leachate flow to a PVC header pipe (see PD-5). The header pipe in turn conveys leachate to the Treatment Pond for treatment and discharge. The entire system is gravity driven.

## 5.1 ORIGINAL ASH DISPOSAL SITE

The OADS leachate collection pipes consist of eight-inch diameter perforated PVC leachate collection pipes that direct leachate towards the center of the cell to a 12-inch PVC header pipe. The OADS header pipe conveys the leachate to the north and east before transitioning back to an eight-inch diameter SCH 80 PVC in MH OADS-3 and joining leachate from the other Stages in MH Common-1 just upstream of the meter pit and Treatment Pond. The OADS does not have a secondary leachate collection system.

## 5.2 STAGE I AND STAGE II

The Stage I and II primary leachate collection pipes consist of six-inch diameter perforated PVC leachate collection pipe spaced at approximately 50 feet apart that run from west to east through the cell. The collection pipes are sloped at approximately one percent. A 21-inch PVC solid wall header pipe runs along the entire length of the eastern perimeter of the landfill. Stage II primary leachate collection pipe empty directly into the 21-inch header. Most of the Stage I primary leachate collection pipe drain to a six-inch solid wall PVC header pipe oriented parallel to the 21-header. The six-inch header connects to the 21-inch header with a six-inch wye just upstream from MH I/II-1. The two northern most laterals of the Stage I baseliner drain into the 21-inch header pipe through MH I/II-1 and MH I/II-2. The header pipe then directs the fluid north along the eastern perimeter of the landfill at approximately a two percent slope.

A secondary leachate collection system, or leak detection system, is in place beneath the baseliner in Stages I and II. The leak detection system consists of a six-inch wide strip of geocomposite drainage material (band drains) embedded within the sand bedding underneath the liner system and running directly underneath every primary leachate collection pipe. The band drains direct liquid collected in the system to a six-inch perforated leak detection system header which drains from south to north along the eastern side of the landfill, parallel to the 21-inch and six-inch primary headers. The perforated header transitions to a solid wall header before penetrating the soil liner and connecting into the 21-inch header through MH I/II-3.

The Stage I overfill liner leachate collection pipes consist of six-inch diameter perforated PVC leachate collection pipe spaced at approximately 50 feet apart that run from northwest to southeast down the slope. The collection pipes drain to a six-inch PVC header pipe at the toe of slope which drains to the east into the 21-inch PVC header pipe at MH I/II-3. The Stage I overfill does not have a secondary leachate collection system.

## 5.3 OADS OVERFILL

The proposed OADS Overfill primary leachate collection pipes consist of eight-inch diameter slotted SCH 80 PVC collection pips spaced at approximately 50 feet apart. The collection pipes are sloped at 1% or greater and run from the southwest to northeast, and southeast to northwest to two eight-inch, slotted SCH 80 PVC primary header pipes, respectively. The header pipes drain to a sump in the northwest, and a sump in the southeast portion of the OADS Overfill, respectively. From each sump a solid wall SCH 80 PVC drain penetrates the double composite liner and connects to the OADS leachate collection system at MH OADS-3.

The OADS Overfill will have a secondary leachate collection system installed within the secondary drainage layer between the primary and secondary geomembranes. The secondary collection pipe network will be vertically aligned with the primary collection pipe network and consist of six-inch, slotted SCH 80 PVC pipe. The secondary leachate collection pipes will drain to a six-inch, slotted SCH 80 PVC header pipe which will connect to the leachate conveyance system at a point downstream to maintain drainage by gravity.

## 5.4 STAGE III AND STAGE IV

The proposed Stage III and IV primary leachate collection pipes consist of eight-inch diameter slotted SCH 80 PVC collection pipes spaced at approximately 50 feet apart. In Stage III, the pipes run on an angle from northwest to southeast at an approximate one percent slope to an eight-inch, slotted SCH 80 PVC primary header pipe which drains to the east and then north eventually connecting to the end of the existing 21-inch header pipe along the eastern perimeter of the landfill. In Stage IV, the primary leachate collection pipes run from west to east at an approximate one percent slope to an eight-inch, slotted SCH 80 PVC primary header pipe which drains to the south and will enter the leachate conveyance system via a new manhole along the eastern perimeter of the landfill.

Both Stage III and Stage IV will have a secondary leachate collection system installed within the secondary drainage layer between the primary and secondary geomembranes. The secondary collection pipe network will be vertically aligned with the primary collection pipe network and consist of six-inch, slotted SCH 80 PVC pipe. The secondary leachate collection pipes will drain to a six-inch, slotted SCH 80 PVC header pipe which will connect to the leachate conveyance system at a point downstream to maintain drainage by gravity.

## 5.5 MONITORING AND MAINTENANCE

The leachate collection system piping is equipped with cleanout risers extending above the ground surface and consisting of near vertical PVC pipe connected to the lateral collection pipe. These cleanouts allow for periodic cleaning (annually at a minimum) of the lateral collection pipe to help ensure they are free and clear of any obstructions that may reduce liner system efficiency. Leachate flow in the system can be visually monitored through manholes along the 21-inch header pipe along the eastern perimeter of the landfill, and via a flow meter discussed in Section 5.7 of this report.

The secondary leachate collection and removal system is used to monitor the performance of the primary geomembrane liner. The flow rate is measured in the field and used to compute a secondary leakage rate by dividing by the total acreage of the respective double composite liner system. The computed leakage rates are compared to the maximum allowable leakage rate of 20 gallons per acre per day.

## 5.6 LEACHATE COLLECTION PIPE INTEGRITY

The radial compressive stress, deflection, and buckling forces on the leachate collection pipes was evaluated for the most critical existing and proposed areas of the Landfill. The critical areas include the OADS and Stage IV, which have the highest loading overtop of the existing and proposed pipe, respectively. The calculations demonstrate that the existing and proposed pipe can accommodate the design loads associated with the overlying liner system, waste, and cover soil according to the Final Grading Plan without compromising their integrity. The calculations are included in Attachment 5.

## 5.7 TREATMENT POND

The combined primary and secondary leachate from the landfill is routed through a flow meter and then a cascade aerator before discharging to the Treatment Pond. The flow meter consists of a large 60-degree V-trapezoidal flume positioned within the meter pit in-line with the leachate sewer pipe with an Open Channel Flow Monitor, comprised of an ultrasonic level sensor mounted above the flume and display monitor powered by a solar panel unit. The cascade aerator consists of a four-foot by four-foot square concrete structure with formed-in-place steps and V-notched weirs. The cascade aerator increases the dissolved oxygen concentration of the leachate to promote the oxidation of ferrous iron to iron hydroxide precipitate. The Treatment Pond itself provides adequate detention time for the precipitation of iron hydroxide and settlement of suspended solids in the leachate.

The Treatment Pond includes a containment liner system consisting of the following in ascending order:

- Prepared subgrade.
- 60-mil textured HDPE geomembrane.
- 16 oz, non-woven, cushion geotextile; and
- One-foot minimum thickness of Type II stone ballast.

A temporary Leachate Storage and Transfer Area (LSTA) is located to the east of the Treatment Pond for contingency use. The LSTA also includes a containment liner system with a porewater drainage system.

Treated water from the Treatment Pond is discharged to the Keuka Outlet through Outfall 01A, pursuant to SPDES Permit No. NY-0107069, as a controlled release, batch discharge via an approximate 600-foot long open channel. The Keuka Outlet discharges to Seneca Lake approximately 1.2 miles downstream of the discharge point.

As shown on the Fill Progression Plan on Permit Drawing PD-10, future development of the Landfill will result in leachate being routed to a relocated Treatment Pond to the east of the Landfill. It is anticipated that the relocated Treatment Pond will be similar in design to the Treatment Pond and sized based on updated leachate generation calculations at that time. Discharge from the relocated Treatment Pond will continue to discharge to the Kueka Outlet approximately 800 feet downstream from its current location via a discharge pipe that will run parallel to NYS Route 14, just inside the property boundary.

## 5.8 LEACHATE GENERATION RATES

The fill progression plan shown on PD-10 provides a phased liner construction and waste placement strategy that intends to control and limit leachate generation. Leachate minimization practices will be implemented during operation of the Landfill by placement of exposed geomembrane and intermediate cover during the active filling stages, final cover on completed back slopes where installation will not be impeded by construction or the working face operation, and final cover placed during the closure period. The exposed geomembrane and final cover systems are described in Section 6 of this Report.

Five distinct leachate generation rates that characterize the typical stages of land disposal operations were used to estimate leachate quantities, as shown on Table 5-1. The landfilling leachate generation rate is 644 gpad and consists of the average leachate flow rate from Stages I and II prior to May 2011, when active landfilling was occurring in Stages I and II, and the entire area was under no more than daily cover. The OADS was already closed and under a soil-based final cover system. The intermediate cover leachate generation rate consists of the average leachate generation rate from the leachate flow meter measurements collected between July 1st, 2016 and November 30, 2017, as reported in the Leachate Monitoring and Analysis Report, Daigler Engineering, Jan 2018. The leachate generation rate after exposed geomembrane and final cover placement was calculated using a method described in Giroud, et al (1997), see Attachment 5.

**TABLE 5-1: LEACHATE GENERATION RATES**

| Landfill Operation Condition | GPAD | Method to determine flow rate |
|---|---|---|
| Landfilling | 644 | Historic measured average flow |
| Open Cell-25-year Storm | 113,000 | Calculated peak flow |
| Open Cell-500-year Storm | 185,000 | Calculated peak flow |
| Intermediate Cover | 470 | Average Measured Flow |
| Exposed Geomembrane | 30 | Calculated migration through the cover system assuming fair contact, four 2.0 mm-diameter defects per acre in the geomembrane, and a maximum head of six inches which may become trapped behind a wrinkle |
| Final Cover | 10 | Calculated migration through the cover system assuming good contact, two 2.0 mm-diameter defects per acre in the geomembrane, and saturation of the full 12-inches of the barrier protection layer |

The land disposal stage that results in the highest leachate generation rate is an open landfill cell before waste placement occurs. A 500-year, 24-hour storm occurring while a newly constructed baseliner system was not covered with waste was assumed to be the worst-case scenario. This storm condition relates to 6.80 inches of precipitation falling over 24 hours. Temporary stormwater diversion will be afforded by the strategic placement of geomembrane diversion flaps. The geomembrane flaps were assumed to divert run on such that no more than a one-acre area of a baseliner not covered with waste would drain to the leachate management system. The resulting leachate generation rate was calculated at 185,000 gallons per acre per day (gpad). A 25-year, 24-hour storm was also analyzed with a storm condition of 4.16 inches of precipitation, and the resulting leachate generation rate was calculated at 113,000 gpad. These calculations are provided in Attachment 5.

A number of scenarios were evaluated to determine the probable range in leachate generation rates over the life of the facility. The scenarios were created by using a combination of open cell, initial landfilling, active landfilling, and exposed geomembrane and final cover areas, in a manner consistent with the fill progression plan on PD-10. The leachate generation rate was determined over a seven-day period. The associated leachate generation calculations for each phase are included in Attachment 5. Based on this evaluation, the maximum leachate generation would be produced if a 500-year storm occurs while there is open liner during Phase 4, with a leachate generation of 263,351 gallons over seven days.

## 5.9 LEACHATE COLLECTION AND REMOVAL SYSTEM CAPACITY

The primary leachate collection pipe flow capacity was compared to the maximum seven-day leachate generation scenario to evaluate the consistency of the design with paragraph 363-6.11(a)(1) which requires the primary collection pipe network be capable of draining peak flow attributed to a 24-hour-25-year storm within 7 days or less, at a minimum. The calculations in Attachment 5 show that the slotted eight-inch diameter SCH 80 PVC pipe provides sufficient conveyance of the peak flow with a capacity (pipe flowing half full) of 0.72 cubic feet per second compared to the worst-case design flowrate of 0.06 cubic feet per second for an open-liner, 500-year storm condition for the OADS Overfill. The 21-inch diameter leachate collection main header flow capacity and the eight-inch diameter sewer pipe that conveys leachate from MH I/II/S-1 to the Treatment Pond was also checked against the worst-case leachate generation rate of an open-liner, 500-year storm condition during Phase IV. The calculations in Attachment 5 support that the existing header pipes will be a sufficient size to convey the additional leachate from the fully developed landfill with a capacity (pipe flowing half full) of 26.3 cubic feet per second and 0.51 cubic feet per second, respectively, compared to the design flow rate of 0.05 cubic feet per second.

Steady state leachate head above the primary geomembrane liner was estimated for the maximum leachate generation scenario using the method presented by J.P. Giroud, J.G. Zornberg, and A. Zhao in The Hydraulic Design of Geosynthetic and Granular Liquid Collection Layer (2000). The maximum leachate head was calculated at 0.18 inches for Stage III, 0.16inches for Stage IV, and 0.08 inches in the OADS Overfill, well below the allowable one foot specified in subparagraph 363-6.6(a)(3). The head calculation spreadsheets are included in Attachment 5.

## 5.10 COMPOSITE LINER SYSTEM EFFICIENCY

Liner system efficiency is defined as the ratio of the liner system leakage rate to the leachate generation rate (impingement rate). The efficiency calculation considers an assumed number and size of defects in the geomembrane liner, static leachate head, permeability of the collection system, thickness and permeability of the soil liner and the quality of contact between the geomembrane and the soil liner. The primary liner system leakage rate to the secondary system was conservatively computed to be 5.93 gpad assuming four 0.01-meter diameter defects per acre with the maximum allowable one foot of head. Thus, volume of leachate that may infiltrate through the primary liner will not exceed the allowable primary liner leakage rate of 20 gpad in accordance with provisions of paragraph 363-7.1(f)(7). The resulting efficiency was calculated at 99.86% compared to the impingement rate computed for Stage III, which has the highest computed head level. Liner leakage and efficiency calculations are provided in Attachment 5.

Leakage through the secondary liner system in areas below the piezometric surface (intragradient) is inward toward the secondary leachate collection system and is a function of the differential hydrostatic pressure acting on the base of the liner system. Leakage through the secondary liner system in areas above the piezometric surface (extragradient) is outward and is a function of leachate head. The secondary liner system leakage rate, that is, the leakage rate for the double composite liner system, was conservatively computed to be 0.1027 gpad for extragradient conditions, an efficiency of 99.9897%, assuming the required design impingement rate of 1,000 gallons per acre per day. Liner leakage and efficiency calculations are provided in Attachment 5.

# 6 COVER SYSTEMS

## 6.1 GENERAL

The OADS portion of the Landfill has been closed. The remainder of the Landfill is under intermediate cover in general accordance with the Layup Plan prepared by Daigler Engineering, PC and submitted to the NYSDEC in May 2011. Final cover and exposed geomembrane placement on the Landfill will occur as shown on the Fill Progression Plan on PD-10. The proposed final cover system is based on the prescribed final cover system required in paragraph 363-6.17 of the Part 360 regulations.

The final cover system components shall consist of the following in ascending order:

- 6-inch thick minimum prepared subgrade soil layer after stripping existing intermediate soil cover;
- GCL for slopes less than 25%;
- Nominal 40-mil textured Linear Low-Density Polyethylene (LLDPE) geomembrane liner;
- Geocomposite infiltration drainage layer;
- 12-inch thick (minimum) barrier protection soil layer; and
- 6-inch thick (minimum) vegetated topsoil layer with sustainable cool-season vegetation.

The exposed geomembrane final cover system components shall consist of the following in ascending order:

- 6-inch thick minimum prepared subgrade soil layer after stripping existing intermediate soil cover;
- GCL for slopes less than 25% (optional);
- Reinforced Textured LLDPE geomembrane liner; and
- Anchoring system.

Due to the composition of the waste contained in the Landfill, gas production is expected to be negligible which is why neither a gas venting layer, nor gas vents are included in the closure plan.

A gas generation study is underway to support this assumption and the results of the Study will be provided under separate cover once a NYSDEC-approved soil gas sampling protocol can be completed. The cover system details are included on Permit Drawing PD-8 and the material specifications are included in the accompanying CQA/CQC Plan.

## 6.2 FINAL COVER VENEER STABILITY ANALYSIS

### 6.2.1 Long-Term Stability

The long-term stability of the final cover system slope was analyzed using an industry standard reference: *Analysis and Design of Veneer Cover Soils* by Robert M. Koerner, and Te-Yang Soong (1998 Sixth International Conference on Geosynthetics). Using that procedure, the minimum required interface shear strength parameters for long-term conditions were established. A Factor of Safety (FS) of 1.50 is the minimum acceptable for long-term static conditions and peak shear strength.

The final cover system materials are not expected to have any significant adhesion strength, ordinarily assumed to be the interface shear strength at zero normal load. A conservative representation of the interface shear strength is the lowest secant friction angle measured during interface shear laboratory testing. Based on the analysis, the minimum required interface shear strength for a FS of 1.50 is described by a friction angle of 26.4 degrees. This interface shear strength can be provided by the available manufactured geosynthetic products. The analysis is included in Attachment 2.

### 6.2.2 Short-Term Stability

Short-term stability considers the influence of construction equipment live load stresses expectable during construction. A FS of 1.25 is the minimum acceptable for short-term static conditions and peak shear strength. Peter J. Carey’s paper entitled *Strength Requirements for Final Cover Materials* (2011) was used to define the minimum required interface shear strength parameters for short-term conditions. This analysis considers the tractive force of a bulldozer pushing soil up a slope overtop of geosynthetic material interface. Based on that analysis, the minimum required interface shear strength for a FS of 1.25 is described by a secant friction angle of 27.2 degrees. The analysis is included in Attachment 2.

# 7 STORMWATER MANAGEMENT SYSTEM

## 7.1 GENERAL

A conceptual stormwater collection system is shown on the Conceptual Final Cover and Drainage Plan on Permit Drawing PD-6. The stormwater collection system consists of side slope swales which intercept and route runoff from the landfill slopes to a single down chute and perimeter channels, which discharge to sediment basins. Calculations and supporting documentation outlining the final stormwater management system design are presented in Attachment 1. A description of the design basis and summary of the output is presented hereon.

## 7.2 STORMWATER RUNOFF ANALYSIS

### 7.2.1 Hydraflow Computer Model

The stormwater runoff analysis was completed using *Hydraflow Hydrographs Extension for AutoCAD Civil 3D 2020* (Hydraflow), a computer program for modeling hydrology and hydraulics for specified site conditions.

The Soil Conservation Service (SCS) Method and *Technical Release 55: Urban Hydrology for Small Watersheds (TR-55)* were used to calculate the discharge quantities, among other characteristics, for subcatchments tributary to stormwater management features located within the closure area. Input variables in Hydraflow for the *SCS Runoff hydrograph* type include the watershed acreage, curve numbers, the storm distribution (Type II), and time of concentration. Hydraflow contains a built-in TR-55 worksheet that computes time of concentration by adding the travel times (velocity) of sheet flow, shallow concentrated flow and open channel flow. In general, sheet flow is defined as flow over plane surfaces in the upper reaches of the drainage area, whereas shallow concentrated flow is best described as the surface between sheet flow and open channel flow. Hydraflow computes the average shallow concentrated flow velocity based on the watercourse slope and surface type, either paved or unpaved. When shallow concentrated flow enters a well-defined watercourse, Hydraflow computes the average velocity for the channel flow assuming the channel is bank full.

In addition to the *SCS Runoff hydrograph*, there are four other hydrograph types used in Hydraflow; combine, diversion, reach, and reservoir. The combine tool joins multiple hydrographs at the same location, while the diversion tool separates two hydrographs, assigning a known flow to the diverted hydrographs. A reach refers to the routing of the storm through a long and well-defined channel which is expected to have an impact on the attenuation of the hydrograph.

### 7.2.2 Watershed Delineation

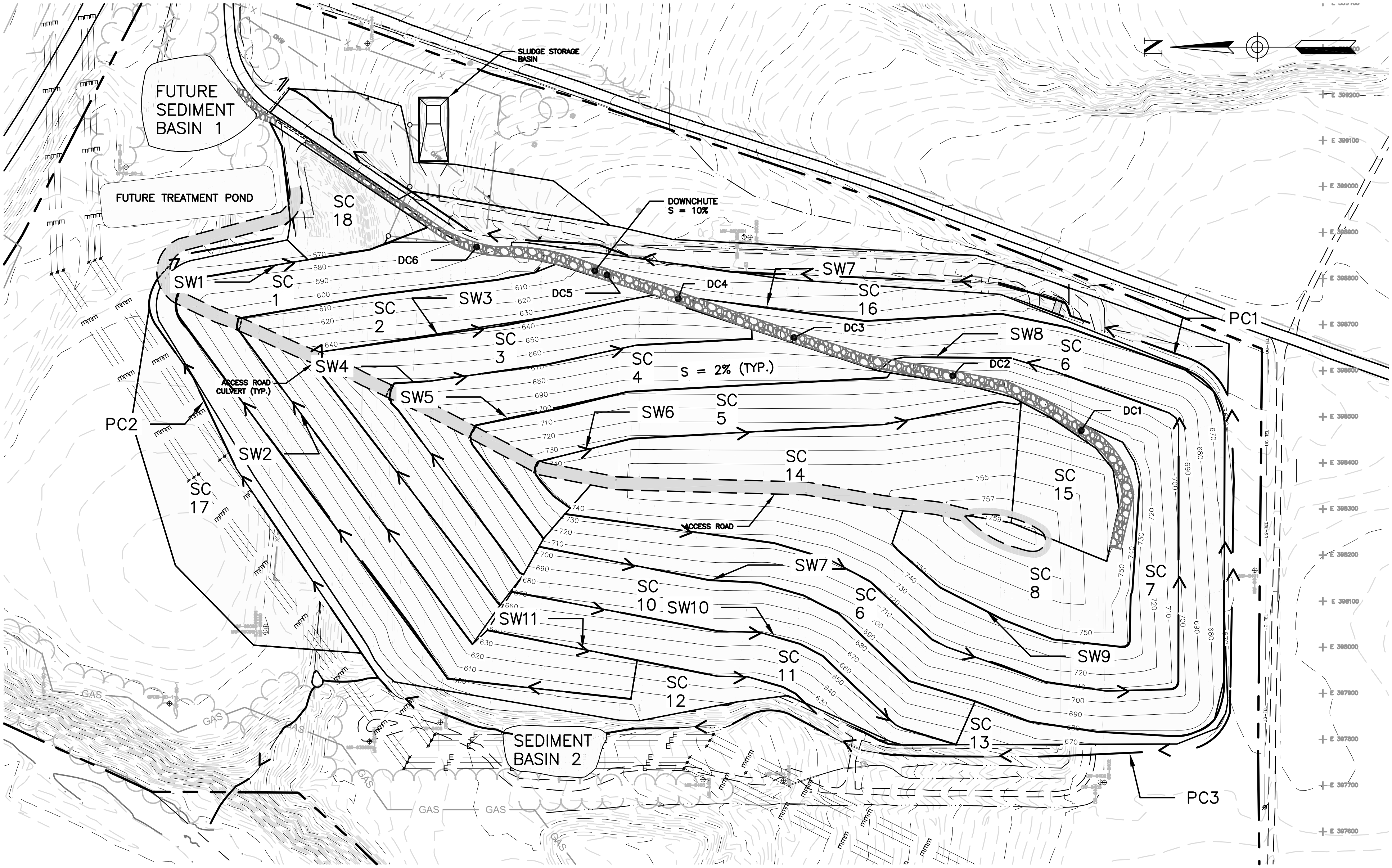
The Landfill's conceptual final grading plan was delineated into subcatchment (SC) areas as detailed in Figure 7-1. As such, the runoff from each subcatchment area was computed, added, and/or reach routed to areas and features of interest.

### 7.2.3 Land Use, Hydrologic Soil Groups and Runoff

Table 2-2a, 2-2b, and 2-2c of TR-55 were utilized to determine appropriate curve numbers based on the hydrogeologic soil conditions and expected cover types for each subcatchment as depicted on Figure 7-1. To determine the TR-55 curve numbers for each subcatchment, the cover/land use and hydrologic soil groups (HSGs) were delineated. In general, the cover type across the final cover area is best described as "meadow-continuous grass, protected from grazing and generally mowed for hay", as defined by Table 2-2c of TR-55.

HSGs were delineated based on the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey.

Due to the similarity of the cover/land use and hydrologic soil groups, the curve number used for each subcatchment area associated with the final cover was 79.

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**DAIGLER ENGINEERING, P.C.**
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| LOCKWOOD HILLS LLC | | WATERSHED DELINEATION | | | FIGURE 7-1 |
|---|---|---|---|---|---|
| SCALE: 1" = 300' | REVISION # 0 | ENGINEERING REPORT | | | |
| August 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

### 7.2.4 Design Storms

Hydraflow requires the input of the amount of rainfall (in inches) for all requisite storm event frequencies for a specified location.

The Precipitation Frequency Data Server (PFDS) provided by the National Oceanic and Atmospheric Administration's (NOAA) Weather Service was developed to deliver Atlas 14 precipitation frequency estimates. The location of the site was identified on the PFDS as shown in Attachment 1 and the amount of rainfall was subsequently determined for the 24-hour storm events for the 100-year, and 500-year recurrence intervals. A summary of the storm events and the corresponding depths of precipitation are provided in Table 7-1 below.

**TABLE 7-1: STORM EVENT FREQUENCIES AND RAINFALL AMOUNTS**

| Storm Event Frequency | Rainfall (inches) |
|---|---|
| 100-year, 24-hour | 5.24 |
| 500-year, 24-hour | 6.80 |

### 7.2.5 Manning's Roughness Coefficient Values

Manning's roughness coefficient values (Manning's n) were estimated for the watershed based on published values. Sheet flow estimates are from TR-55 while all other values are based on the Oregon Department of Transportation Hydraulics Manual, which is found to be a comprehensive compilation of Manning's n values from multiple sources, and the ADS Water Management Drainage Handbook. Table 7-2 illustrates the assumptions made regarding Manning's n values.

**TABLE 7-2: MANNING'S ROUGHNESS COEFFICIENT VALUES**

| Manning's Roughness Coefficient Description | Site Specific Description | Manning's Roughness Coefficient Value(Reference Footnote) | |
|---|---|---|---|
| *Sheet Flow*<br>Smooth Surfaces, Bare Soil | Gravel/Paved Access Roads | 0.011(1) | |
| *Sheet Flow*<br>Grasses, Short Grass Prairie | Graded Slopes with Vegetation | 0.15(1) | |
| *Channel Flow*<br>Depth of Flow 6 inches to 2 feet<br>Riprap Lined | Proposed Riprap Lined Channel | 0.070(2) | |
| *Channel Flow*<br>Earth Straight Uniform, with Short Grass, Few Weeds | Grass Lined Channels | 0.027(3) | |
| *Channel Flow*<br>Vmax SC250 Turf Reinforcement Mat | Erosion Control Blanket Lined Channels | Flow Depth < 0.5 ft: | 0.040(4) |
| | | Flow Depth 0.5-2.0 ft: | 0.040-0.012 |
| | | Flow Depth > 2 ft: | 0.011 |

(1) Technical Release 55 Urban Hydrology for Small Watersheds

(2) "Manning's "n" for Riprap Lined Channels Based on Flow Depth" included in the Stormwater Separation Plan Eng Report, June 2016

(3) Oregon Department of Transportation Hydraulic Manual

(4) Rollmax Rolled Erosion Control Specification Sheet - Vmax SC250 Turf Reinforcement Mat

### 7.2.6 Time of Concentration

The time of concentration values were calculated based on the flow paths from the most hydraulically distant point of the subcatchment area and TR-55 requirements. Sheet flow, shallow concentrated flow, and channel flow were estimated based on the land slope, Manning's n values, and flow path lengths. The maximum length of overland flow used in the time of concentration calculations was limited to no more than 100 feet as recommended by NRCS.

### 7.2.7 Hydrology Calculations

Attachment 1 contains the stormwater runoff analysis results produced by Hydraflow; including a return period recap which summarizes the peak outflows from all subcatchment areas for each storm event.

## 7.3 DESIGN AND EVALUATION

In accordance with current subdivision 363-4.3f, the final cover stormwater management system was designed to manage a 100-year, 24-hour storm from the landfill site without sustaining damage.  An evaluation of the performance of the stormwater/run-off conveyance system during a 500-year storm event is provided as well.

### 7.3.1 Conveyances

Sideswales, perimeter channels, and roadside ditches were sized using Hydraflow Express Extension for AutoCAD Civil 3D, 2020 (Hydraflow Extension) in concert with peak flowrates determined from the stormwater runoff analysis detailed in Section 7.2.

All subcatchment areas and conveyance features within the watershed tributary to the final closure area were included in the evaluation presented herein to determine their influence on the hydrology of the downgradient features

#### 7.3.1.1 Side swales

Side swales (SWs) will be constructed along the side slope of the Landfill above the barrier protection layer (i.e., tack-on side swales) to convey runoff from final cover areas to the proposed down chute and perimeter channels.  All side swales slope at two percent and are triangular in shape.  They will be constructed with 3H:1V and 2H:1V side slopes and a depth of 2.0 feet as detailed on Permit Drawing PD-9.  The side swales were spaced at approximately 100 feet parallel to each other.

Hydraflow Extensions was used to confirm the side swale geometry provides adequate hydraulic capacity to convey the estimated peak discharge from the 100-year, 24-hour storm event with a minimum of 0.5 foot of freeboard, and contain the 500-year, 24-hour storm event without over topping adjacent side slopes.  A Hydraflow Express report for SW 7, the longest side swale with the largest catchment area and highest modeled peak flow and, therefore, the worst-case side swale, is provided in Attachment 1 detailing the estimated flowrate, velocity, and freeboard as summarized in Table 7-.

**TABLE 7-3: SUMMARY OF SIDE SWALE EVALUATION FOR SW 7**

| Side swale I.D. | 100-Year Storm Event | | | 500-Year Storm Event | | |
|---|---|---|---|---|---|---|
| | Q ($ft^3/s$) | V (ft/s) | FB (ft) | Q ($ft^3/s$) | V (ft/s) | FB (ft) |
| **SW 7** | 32.4 | 6.0 | 0.5 | 44.2 | 6.5 | 0.4 |

Notes:
Q=Flowrate, V=Velocity, FB=Freeboard

Erosion protection for the vegetated side swales was dictated by flow velocities. Table 4.10 of the 2016 New York State Standards and Specifications for Erosion and Sediment Control (2016 Blue Book) was used to specify a permissible velocity. Given that the maximum velocity was below seven ft/s, smooth bromegrass is an acceptable grass type.

#### 7.3.1.2 Down chute

One down chute will convey stormwater from the Landfill side swales to future Sediment Basin 1. Placed on each side of the down chute, the side swales deposit their flow at various points. The down chute is trapezoid in shape, 15 feet wide, two feet deep, and has a slope of ten percent.

Hydraflow Express was used to confirm that the proposed down chute would provide adequate hydraulic capacity to convey the 100-year, 24-hour storm event with a free board of 0.5 feet, and contain the 500-year, 24-hour storm event without over topping. The results of the evaluation are shown on Table 7-4. A Hydraflow Express report is provided in Attachment 1.

**TABLE 7-4: DOWN CHUTE EVALUATION**

| 100-Year Storm Event | | | 500-Year Storm Event | | |
|---|---|---|---|---|---|
| Q ($ft^3/s$) | V (ft/s) | FB (ft) | Q ($ft^3/s$) | V (ft/s) | FB (ft) |
| 159 | 6.9 | 0.73 | 220 | 7.7 | 0.48 |

Notes:
Q=Flowrate, V=Velocity, FB=Freeboard

Erosion protection for the roadside swales was dictated by flow velocities. Table 4.10 of the 2016 New York State Standards and Specifications for Erosion and Sediment Control (2016 Blue Book) was used to specify a permissible velocity. Given that the maximum velocity was below 8.5 ft/s, Light Type II stone fill was acceptable at a thickness of 18 inches.

#### 7.3.1.3 Perimeter and Future Sediment Basin Channels

Perimeter Channels (PCs) convey stormwater outside the limit of waste to designated sediment basins. These channels receive flows predominantly from perimeter access road run off and landfill side slopes. Three perimeter channels are proposed to convey runoff to future Sediment Basin 1 and existing Sediment Basin 2. The proposed dimensions are detailed in Table 7-5.

**TABLE 7-5: PROPOSED PERIMETER CHANNEL DIMENSIONS**

| Perimeter Channel | Minimum Depth (ft) | Bottom Width (ft) | Side slopes (H:V) | Longitudinal Slope (%) |
|---|---|---|---|---|
| **PC1** | 2 | 5 | 2:1 | 3.7 |
| **PC2** | 2 | 5 | 2:1 | 0.4 |
| **PC3** | 2 | 5 | 2:1 | 6.0 |

Hydraflow was used to estimate the flowrates for each with reports included in Attachment 1. Hydraflow Express was used to confirm that the proposed perimeter channels would provide adequate hydraulic capacity to convey the 100-year, 24-hour storm event with a minimum of 0.5 foot of freeboard, and contain the 500-year, 24-hour storm event without over topping adjacent access roads and surrounding areas. A summary of the results from this evaluation is provided in Table 7-6. A Hydraflow Express report for the worst-case perimeter channel, PC3, is provided in Attachment 1.

**TABLE 7-6: SUMMARY OF PERIMETER CHANNEL EVALUATION**

| Perimeter Channel | 100-Year Storm Event | | | 500-Year Storm Event | | |
|---|---|---|---|---|---|---|
| | Q ($ft^3/s$) | V (ft/s) | FB (ft) | Q ($ft^3/s$) | V (ft/s) | FB (ft) |
| **PC3** | 24.7 | 4.0 | 1.1 | 34.3 | 4.4 | 0.9 |

Notes:
Q=Flowrate, V=Velocity, FB=Freeboard

PC3 conveys stormwater directly to Sediment Basin 2. PCs 1 and 2 convey stormwater to future Sediment Basin 1 from the south and north ends of the Landfill, respectively and flow to the future Sediment Basin 1 inlet channel. Erosion protection in the perimeter channels consists of grass vegetation. The stormwater from the down chute is also conveyed to future Sediment Basin 1 by the future Sediment Basin 1 inlet channel. A summary of the future Sediment Basin 1 channel dimensions and the hydraulic evaluation is provided in Tables 7-7 and 7-8, respectively. Erosion protection in the future Sediment Basin 1 inlet channel consists of Light Type II stone fill.

**TABLE 7-7: FUTURE SEDIMENT BASIN 1 CHANNEL DIMENSIONS**

| Sed. Basin 1 Channel | Minimum Depth (ft) | Bottom Width (ft) | Side slopes (H:V) | Longitudinal Slope (%) |
|---|---|---|---|---|
| **SBC 1** | 3.5 | 5 | 2:1 | 6.0 |

**TABLE 7-8: FUTURE SEDIMENT BASIN 1 CHANNEL EVALUATION**

| Sed. Basin 1 Channel | 100-Year Storm Event | | | 500-Year Storm Event | | |
|---|---|---|---|---|---|---|
| | Q ($ft^3/s$) | V (ft/s) | FB (ft) | Q ($ft^3/s$) | V (ft/s) | FB (ft) |
| **SBC 1** | 179 | 7.0 | 1.0 | 248 | 7.6 | 0.5 |

Notes:
Q=Flowrate, V=Velocity, FB=Freeboard

### 7.3.2 Sediment Basins

The final design of future Sediment Basin 1 and Sediment Basin 2 shall be determined prior to the future construction based on the applicable New York State guidance at that time.

# 8 SUBGRADE SETTLEMENT ANALYSIS

A settlement analysis was performed to calculate the settlement of the subbase and the leachate collection and removal system for critical areas of the Landfill. The analysis evaluates the baseliner and leachate collection and removal system's integrity and performance considering the final grading plan.

## 8.1 ANALYSIS

The soil layer analyzed for settlement was the glacial till layer directly beneath the baseliner subgrade, and above the top of bedrock. The amount of settlement is dictated by the thickness, density, and compression characteristics of the glacial till layer, and the thickness and density of the soil layers placed above it. The most critical areas of the landfill include the OADS and Stage IV which have the thickest layers of waste and glacial till, respectively. Therefore, these areas were analyzed for settlement.

A conservative approach was taken when selecting the settlement analysis input parameters. Profile views of the subgrade were selected across areas that would experience the highest loading from the conceptual final grading plan. Settlement was analyzed at points along profiles within the OADS and Stage IV. The thickness of the subsurface soil layers and waste differed along each profile, producing variable settlement. The settlement was plotted in profile view for each point allowing the impacts of the differential settlement to be evaluated.

Unit weights were assumed as shown in Table 8-1.

**TABLE 8-1: UNIT WEIGHTS**

| Material | Unit Weight (pcf) |
|---|---|
| Soil Liner, Topsoil and Barrier Protection Layers | 130 |
| Fly Ash Waste | 96.3 |
| Stone and Sand Drainage Layers | 100 |
| Glacial Till | 77.6 |

The unit weight of glacial till was assumed at 140 pcf but due to most of that material layer being beneath the water table, the buoyancy value of 77.6 pcf was used. The buoyancy value was calculated by subtracting the unit weight of water (62.4 pcf) from the assumed value of 140 pcf. Thicknesses for each layer were measured using the cross-section views that are shown in Attachment 3. The glacial till layer was divided into sublayers to calculate the settlement when the thickness was greater than 6.5 feet. The settlement for each sublayer were then added together find the total primary and secondary consolidation settlement.

### 8.1.1 Primary Consolidation Settlement

Primary consolidation is the change in volume of a fine-grained soil caused by the expulsion of water from the voids and the transfer of load from the excess porewater pressure to the soil particles. When calculating the primary consolidated settlement, it was assumed that the glacial till was overconsolidated. The equation listed below was used to calculate the primary settlement for an overconsolidated fine grained soil layer.

$$P_{pc} = \left(\frac{H_O}{1 + e_o}\right) C_r \log \frac{\sigma_{fin}}{\sigma_{zo}}$$

$H_O$ = Thickness of Glacial Till (ft)

$e_o$= Void Ratio

$C_r$ = Recompression Index

$\sigma_{fin}$ = Final Vertical Stress (psf)

$\sigma_{zo}$= Effective Stress at mid-depth of Glacial Till (psf)

Per Ladd, 1973 (Estimating Settlement of Structures on Cohesive Soils), the recompression index is 10-20% of the compression index. The glacial till is classified as a non-plastic silt, sand, and gravel. Compression index values for similar non-plastic soil types were researched. A compression index value of 0.16 reported by Kaufmann and Shermann (1964) for a non-plastic silt was selected to approximate the behavior the of the glacial till layer. The recompression index was calculated as 15 percent of the compression index value resulting in 0.024 (Ladd, 1973). The void ratio was calculated by using a water content of 14.5 percent (site moisture content test result) and a specific gravity of 2.7. A copy of the calculation is included in Attachment 3.

### 8.1.2 Secondary Consolidation Settlement

Secondary consolidation is the change in volume of a fine-grained soil caused by the adjustment of the internal structure after primary consolidation has been completed. The secondary consolidation settlement was calculated to account for a period of 30 years after the estimated closure date of the facility. The following equation was used to calculate the secondary settlement under a constant vertical effective stress.

$$P_{sc} = \frac{H_{os}}{(1 + e_s)} C_\alpha \log \frac{t}{t_p}$$

$H_{os}$= Thickness of Subgrade before Secondary Consolidation (ft)

$e_s$= Initial Void Ratio

$C_\alpha$= Secondary Compression Index

$t_p$= Starting Time of Period (years)

$t$= Ending Time of Period (years)

The secondary compression index was calculated by taking the midpoint of 0.015 to 0.03 of the compression index (Bowles, 1996). The calculations are included in Attachment 3.

## 8.2 RESULTS

Included in Attachment 3 are the summarized tables listing the settlements at multiple points in the OADS and Stage IV as well as graphs depicting the settlements of the subgrade and leachate collection system. At no point did the total settlement exceed 1.0 foot, therefore, a settlement monitoring plan is not required per paragraph 363-4.3(b) of the Part 360 regulations. The settlement also did not affect the integrity and performance of the leachate management system by maintaining a positive slope.

# 9 SLOPE STABILITY EVALUATION

## 9.1 GENERAL

A stability analysis was performed for the Landfill in accordance with Subpart 363-4.3(c). The analysis is presented in Attachment 4 along with the cross-sectional views. The purpose of the analysis is to demonstrate that the landfill can meet or exceed the factors of safety established in Subpart 363-4.3(c)(3).

## 9.2 ANALYSIS

The parameters used for the slope stability analysis are provided in Table 9-1.

**TABLE 9-1: DESIGN PARAMETERS FOR SLOPE STABILITY**

| Material | Unit Weight (pcf) | Secant Friction Angle | Cohesion (psf) |
|---|---|---|---|
| Fly Ash | 89 | 33° | 0 |
| Baseliner System (Interface) | 120 | 18° for slopes < 5%, 15° for slopes > 5% | 0 |
| Structural Fill | 130 | 35° | 0 |
| Glacial Till | 140 | 34° | 0 |
| Shale Bedrock | 145 | 35° | 0 |

The soil parameters were chosen based on typical values. The entire fly ash thickness was conservatively assumed to consist of the lowest shear strength fly ash material disposed within the landfill. The baseliner system values are based on currently available products and believed to be a conservative representation of the in-place baseliner system in the Stage I Overfill liner, and the Stage I and Stage II baseliner systems. The existing PVC geomembrane and non-woven geotextile interface is expected to have a higher interface shear strength than the assumed baseliner interface shear strength. When a potential failure surface passed through the liner system at an angle greater than 10° to the plane of the liner, a shear strength described by a secant friction angle of 26° was used to reflect the liner strength being that of the compacted soil components rather than the interface of the geosynthetic materials.

The analysis was completed using Slide2 as part of the rocscience software package. Seven different cross-sectional views were generated and imported into the Slide2 program for evaluation. The cross-section locations are shown on Figure 9-1 in Attachment 4. The water table was assigned to be equal to the subgrade elevation. A surcharge load of 6,000 pounds per square foot (psf) was placed over top of the access routes accounting for a Caterpillar 740 dump truck traveling on it. The load was placed by adding a distributed load across 2 feet, approximating the tire locations.

Circular and block failure surfaces were analyzed for each cross section. The program analyzes all the failure surfaces until the failure surface with the lowest factor of safety is located to a minimum depth of five feet. Several different methods were evaluated, including Bishop Simplified Method, Janbu Simplified Method, Spencer's Method, and GLE/Morgenstern-Price Method. The results from the method that resulted in the lowest factor of safety is shown. All the results shown are from the Janbu Simplified Method.

## 9.3 RESULTS

The results for each cross-section are shown in Attachment 4. As shown by the analysis, factors of safety of 1.5 or greater can be achieved using onsite soils and currently available geosynthetic and other construction materials; accordingly, the proposed landfill configuration is considered stable.

## 9.4 Seismic Stability Analysis

A seismic hazard zone is an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material expressed as a percentage of the earth's gravitational pull (g) will exceed 0.10g in 250 years. Based on a 2018 National Seismic Hazard Model map from the United States Geological Survey (USGS), the Lockwood Hills site is located in an area where the two percent chance in 50 years peak horizontal acceleration exceedance is less than 0.10g, which is also less than ten percent over 250 years. Therefore, the Lockwood Hills site is not in a seismic hazard zone and does not require a seismic stability analysis. The USGS probability maps are included in Attachment 6.

# 10 NOISE ASSESSMENT

## 10.1 REQUIREMENTS

According to subdivision 360.19(j), the owner or operator of a solid waste management facility must ensure that noise (other than occurring during the construction of the facility) resulting from equipment or operations at the facility does not exceed the following energy equivalent sound levels beyond the property line owned or controlled by the owner or operator of the facility at locations authorized for residential purposes:

**TABLE 10-1: ALLOWABLE $L_{EQ}$ SOUND LEVELS**

| Character of Community within a one-mile radius of facility | $L_{eq}$ Energy Equivalent Sound Levels | |
|---|---|---|
| | **7am - 10pm** | **10pm - 7am** |
| Rural | 57 decibels (A) | 47 decibels (A) |
| Suburban | 62 decibels (A) | 52 decibels (A) |
| Urban | 67 decibels (A) | 57 decibels (A) |

The $L_{eq}$ is the equivalent steady-state sound level which contains the same acoustic energy as the time-varying sound level during a one-hour period.

## 10.2 COMMUNITY CHARACTER

The 44.2-acre Site is situated in a rural environment comprised of agricultural fields and residential property. There are not any residential structures directly beside the property limits. Due to these factors, the site lies within a rural setting.

## 10.3 NOISE MODEL

The facility is permitted to operate between 6:00 am and 6:00pm. Operating conditions were assumed to include a bulldozer, compactor, and two waste trucks.

A noise level modeling tool provided by MAS Environmental at www.noisetools.net was employed to estimate the noise levels at the property limits for comparison to those limits presented in subdivision 360.19(j). The software predicts source noise levels considering distance attenuation, and ground effect in accordance with ISO9613-2, as well as air absorption in accordance with ISO9613-1. Modeled noise sources include the following:

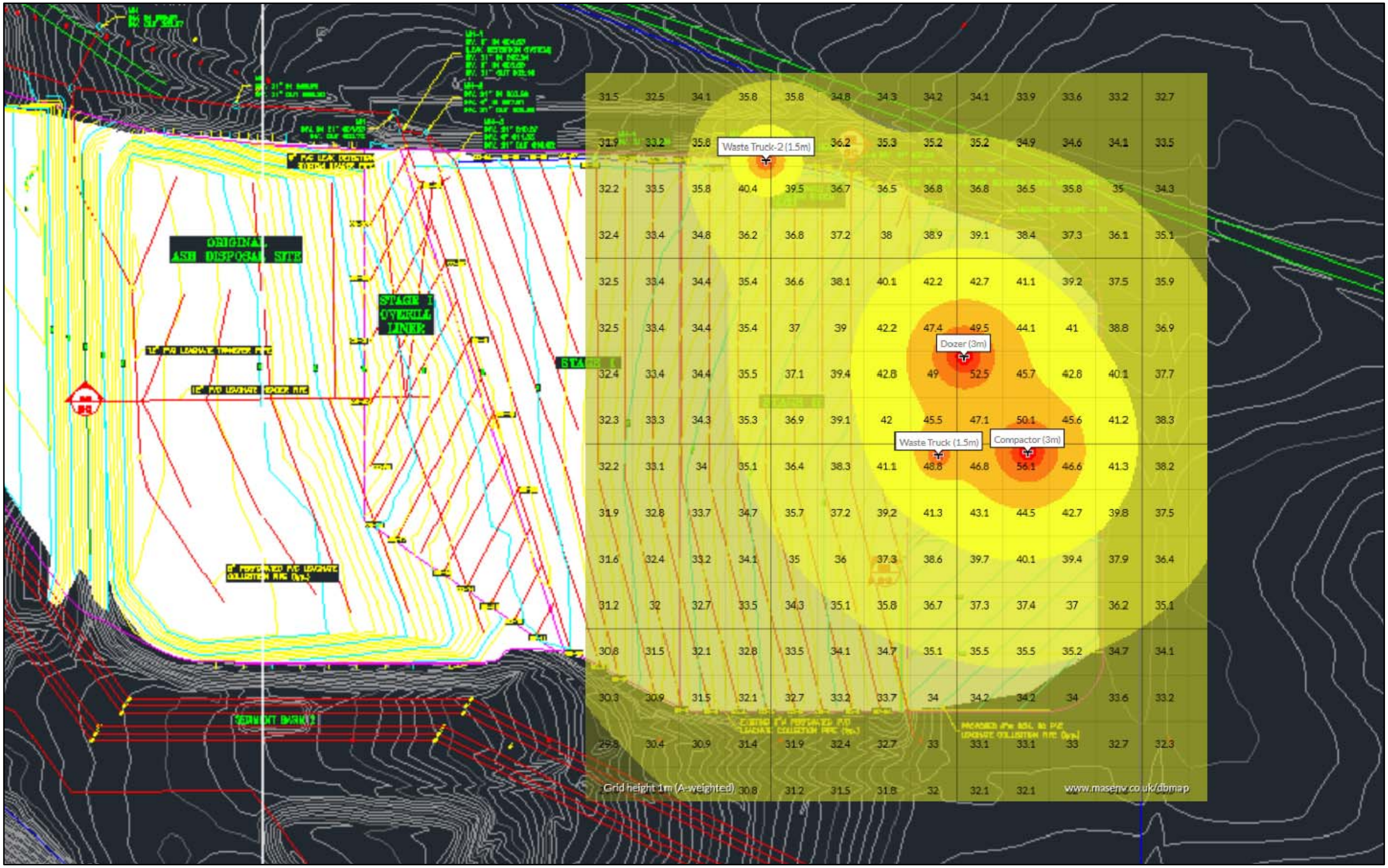
**TABLE 10-2:EQUIPMENT SOUND PRESSURE LEVELS**

| Equipment | Sound Level at 50 feet dB(A) |
|---|---|
| Bulldozer | 85 |
| Compactor | 80 |
| Waste Truck | 76 |

The model allows for noise sources to be placed as points on a grid, that can be transferred to the Site Plan depicting the location of the equipment. The sound levels assigned to those points are in accordance with Table 10-2. It was assumed that all pieces of proposed equipment would be operating simultaneously during Phase 3 when landfilling is closest to the property boundary to develop a conservative estimate of sound pressure levels at the property boundary.

The predicted noise levels across the Site are presented on Figure 10-1, illustrating the highest sound pressure level of approximately 41 dB(A) on the south side of the Site.

Q:\Lockwood Hills LLC\31-1619 Consent Order 2019\Part 360 Permit Modification Application\CQA\figure 10-1.dwg 4/29/2020 11:52 AM





DAIGLER ENGINEERING, P.C.
CIVIL & GEO-ENVIRONMENTAL ENGINEERING
2620 GRAND ISLAND BLVD. GRAND ISLAND, NEW YORK 14072
(716) 773-6872 (716) 773-6873 FAX


| LOCKWOOD HILLS LLC | | PREDICTED SOUND PRESSURE LEVELS<br>ENGINEERING REPORT | | | FIGURE 10-1 |
|---|---|---|---|---|---|
| SCALE: NOT TO SCALE | REVISION # 0 | | | | |
| August 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

## 10.4 CONCLUSION

Based on the modeling tool, the greatest predicted noise level is at the closest property line and is 41 dB(A), below the daytime rural noise standard of 57 dB(A) and the nighttime rural noise standard of 47 dB(A) as summarized in Table 10-1.

Noise impacts will be minimized by site features and vegetation. Sound generated at the Facility will be consistent with sound generated in the surrounding area.

Since operations at the Lockwood Ash Disposal site satisfy the operational noise provision specified in subdivision 360.19(j), a Noise Monitoring and Control Plan is not required.

# ATTACHMENT 1

# Stormwater Management System Calculations

- **Precipitation Frequency Data Server by National Oceanic and Atmospheric Administration Weather Service**
- **Hydraflow Hydrograph Reports**
- **Hydraflow Express Reports**

# Precipitation Frequency Data Server by National Oceanic and Atmospheric Administration Weather Service

**NOAA Atlas 14, Volume 10, Version 3**
**Location name: Town of Torrey, New York, USA***
**Latitude: 42.677°, Longitude: -76.9633°**
**Elevation: 506.95 ft****
* source: ESRI Maps
** source: USGS

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.283 (0.221-0.355) | 0.346 (0.270-0.434) | 0.448 (0.349-0.563) | 0.533 (0.411-0.674) | 0.650 (0.487-0.858) | 0.738 (0.542-0.991) | 0.831 (0.594-1.16) | 0.939 (0.633-1.33) | 1.10 (0.712-1.60) | 1.23 (0.780-1.83) |
| 10-min | 0.401 (0.314-0.503) | 0.490 (0.383-0.615) | 0.635 (0.494-0.800) | 0.756 (0.584-0.956) | 0.922 (0.691-1.22) | 1.05 (0.769-1.41) | 1.18 (0.842-1.64) | 1.33 (0.895-1.88) | 1.56 (1.01-2.27) | 1.75 (1.11-2.59) |
| 15-min | 0.472 (0.369-0.592) | 0.577 (0.450-0.724) | 0.748 (0.581-0.941) | 0.889 (0.687-1.12) | 1.08 (0.812-1.43) | 1.23 (0.904-1.66) | 1.39 (0.990-1.93) | 1.57 (1.05-2.21) | 1.83 (1.19-2.67) | 2.06 (1.30-3.05) |
| 30-min | 0.637 (0.498-0.799) | 0.778 (0.607-0.976) | 1.01 (0.784-1.27) | 1.20 (0.927-1.52) | 1.46 (1.10-1.93) | 1.66 (1.22-2.23) | 1.87 (1.33-2.60) | 2.11 (1.42-2.98) | 2.47 (1.60-3.59) | 2.77 (1.75-4.10) |
| 60-min | 0.802 (0.626-1.00) | 0.979 (0.764-1.23) | 1.27 (0.986-1.60) | 1.51 (1.17-1.91) | 1.84 (1.38-2.42) | 2.09 (1.53-2.81) | 2.35 (1.68-3.27) | 2.65 (1.79-3.75) | 3.10 (2.01-4.52) | 3.48 (2.20-5.16) |
| 2-hr | 0.995 (0.781-1.24) | 1.20 (0.942-1.50) | 1.54 (1.20-1.92) | 1.82 (1.41-2.28) | 2.20 (1.67-2.90) | 2.48 (1.85-3.35) | 2.80 (2.03-3.93) | 3.20 (2.16-4.48) | 3.83 (2.49-5.54) | 4.39 (2.79-6.46) |
| 3-hr | 1.12 (0.884-1.39) | 1.35 (1.06-1.67) | 1.71 (1.35-2.13) | 2.02 (1.58-2.53) | 2.44 (1.85-3.20) | 2.74 (2.05-3.69) | 3.09 (2.26-4.34) | 3.54 (2.39-4.94) | 4.28 (2.78-6.16) | 4.94 (3.14-7.22) |
| 6-hr | 1.37 (1.09-1.69) | 1.63 (1.29-2.02) | 2.07 (1.63-2.56) | 2.42 (1.90-3.01) | 2.92 (2.23-3.80) | 3.28 (2.46-4.37) | 3.68 (2.70-5.12) | 4.21 (2.86-5.83) | 5.06 (3.31-7.23) | 5.83 (3.72-8.45) |
| 12-hr | 1.66 (1.32-2.03) | 1.97 (1.57-2.42) | 2.49 (1.98-3.06) | 2.92 (2.30-3.60) | 3.51 (2.69-4.52) | 3.95 (2.96-5.19) | 4.42 (3.23-6.03) | 5.00 (3.42-6.86) | 5.88 (3.86-8.32) | 6.64 (4.26-9.56) |
| 24-hr | 1.96 (1.57-2.38) | 2.34 (1.87-2.84) | 2.95 (2.35-3.60) | 3.46 (2.74-4.24) | 4.16 (3.19-5.30) | 4.68 (3.52-6.08) | 5.24 (3.82-7.03) | 5.88 (4.04-8.00) | 6.80 (4.49-9.54) | 7.57 (4.87-10.8) |
| 2-day | 2.27 (1.83-2.74) | 2.71 (2.18-3.27) | 3.42 (2.74-4.14) | 4.01 (3.20-4.88) | 4.82 (3.71-6.09) | 5.43 (4.09-6.99) | 6.07 (4.44-8.07) | 6.80 (4.69-9.19) | 7.87 (5.21-10.9) | 8.76 (5.66-12.4) |
| 3-day | 2.50 (2.02-3.00) | 2.97 (2.40-3.57) | 3.73 (3.00-4.50) | 4.36 (3.49-5.29) | 5.23 (4.05-6.59) | 5.89 (4.46-7.55) | 6.58 (4.83-8.72) | 7.37 (5.10-9.91) | 8.53 (5.66-11.8) | 9.49 (6.14-13.3) |
| 4-day | 2.69 (2.18-3.23) | 3.18 (2.58-3.82) | 3.98 (3.21-4.79) | 4.64 (3.72-5.61) | 5.55 (4.31-6.97) | 6.24 (4.73-7.97) | 6.96 (5.12-9.19) | 7.79 (5.40-10.4) | 9.00 (5.98-12.4) | 10.00 (6.48-14.0) |
| 7-day | 3.19 (2.60-3.81) | 3.72 (3.03-4.44) | 4.59 (3.72-5.49) | 5.30 (4.28-6.38) | 6.29 (4.90-7.84) | 7.04 (5.36-8.93) | 7.82 (5.76-10.2) | 8.70 (6.05-11.6) | 9.99 (6.66-13.7) | 11.0 (7.18-15.4) |
| 10-day | 3.67 (3.00-4.36) | 4.23 (3.45-5.03) | 5.14 (4.18-6.13) | 5.90 (4.77-7.07) | 6.95 (5.42-8.62) | 7.74 (5.90-9.76) | 8.56 (6.32-11.1) | 9.48 (6.61-12.6) | 10.8 (7.22-14.7) | 11.9 (7.74-16.5) |
| 20-day | 5.13 (4.22-6.05) | 5.77 (4.74-6.81) | 6.81 (5.58-8.07) | 7.68 (6.25-9.14) | 8.88 (6.96-10.9) | 9.79 (7.49-12.2) | 10.7 (7.91-13.7) | 11.7 (8.22-15.4) | 13.1 (8.79-17.7) | 14.2 (9.26-19.5) |
| 30-day | 6.36 (5.25-7.48) | 7.06 (5.82-8.30) | 8.19 (6.73-9.66) | 9.14 (7.46-10.8) | 10.4 (8.20-12.7) | 11.4 (8.77-14.2) | 12.4 (9.18-15.8) | 13.5 (9.48-17.6) | 14.8 (10.00-19.9) | 15.9 (10.4-21.7) |
| 45-day | 7.91 (6.55-9.26) | 8.66 (7.17-10.2) | 9.90 (8.16-11.6) | 10.9 (8.94-12.9) | 12.3 (9.72-14.9) | 13.4 (10.3-16.5) | 14.5 (10.7-18.2) | 15.5 (11.0-20.2) | 16.9 (11.4-22.5) | 17.8 (11.7-24.3) |
| 60-day | 9.22 (7.65-10.8) | 10.0 (8.30-11.7) | 11.3 (9.34-13.2) | 12.4 (10.2-14.6) | 13.9 (11.0-16.7) | 15.0 (11.6-18.4) | 16.2 (11.9-20.2) | 17.2 (12.2-22.2) | 18.5 (12.5-24.6) | 19.4 (12.7-26.2) |

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

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

Please refer to NOAA Atlas 14 document for more information.

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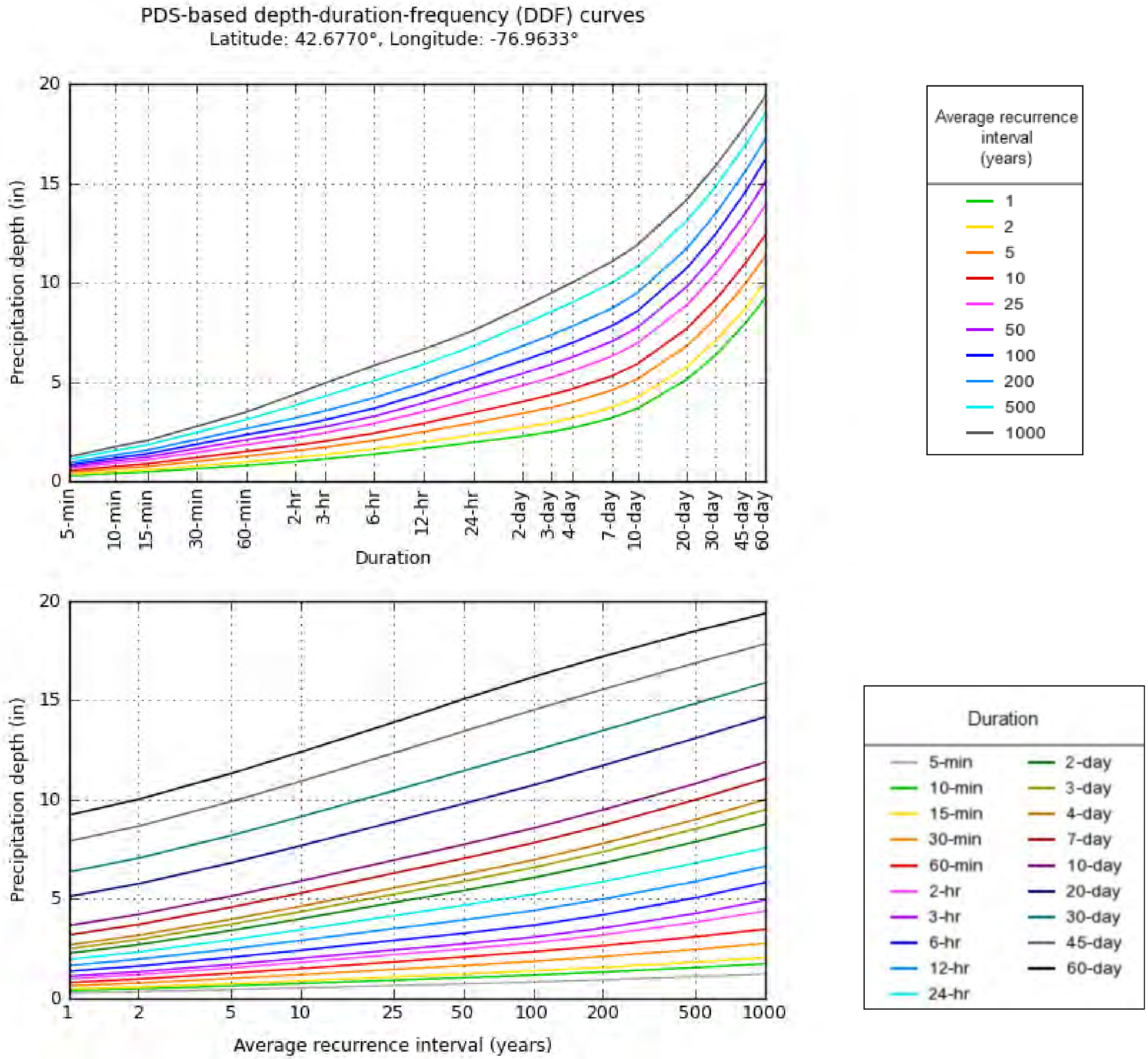
## PF graphical




NOAA Atlas 14, Volume 10, Version 3 Created (GMT): Thu Feb 20 17:48:32 2020

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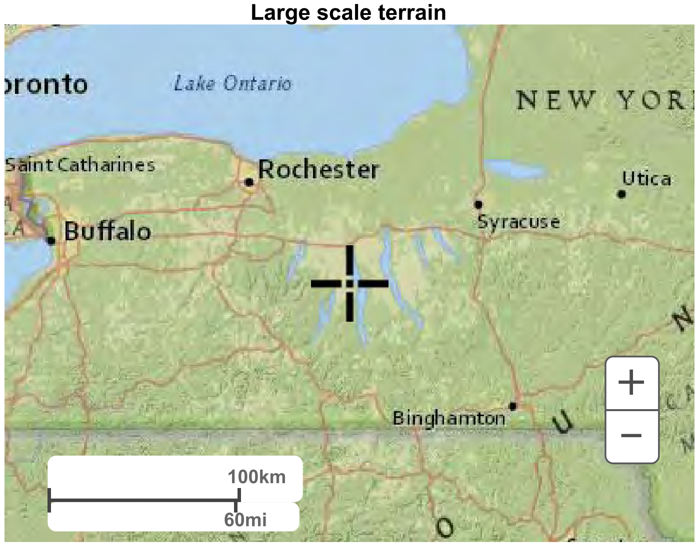
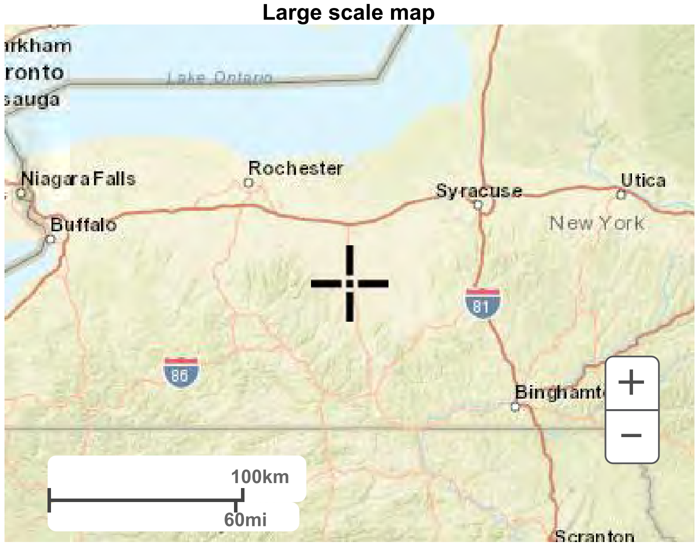
## Maps & aerials

**Small scale terrain**

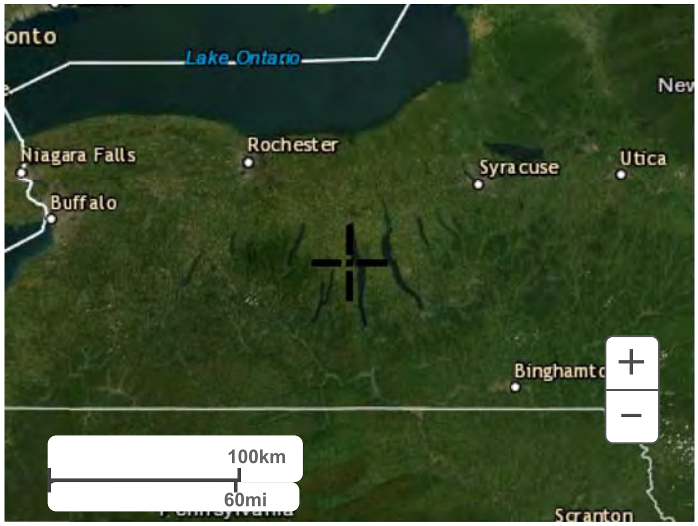

**Large scale terrain**




**Large scale map**




**Large scale aerial**

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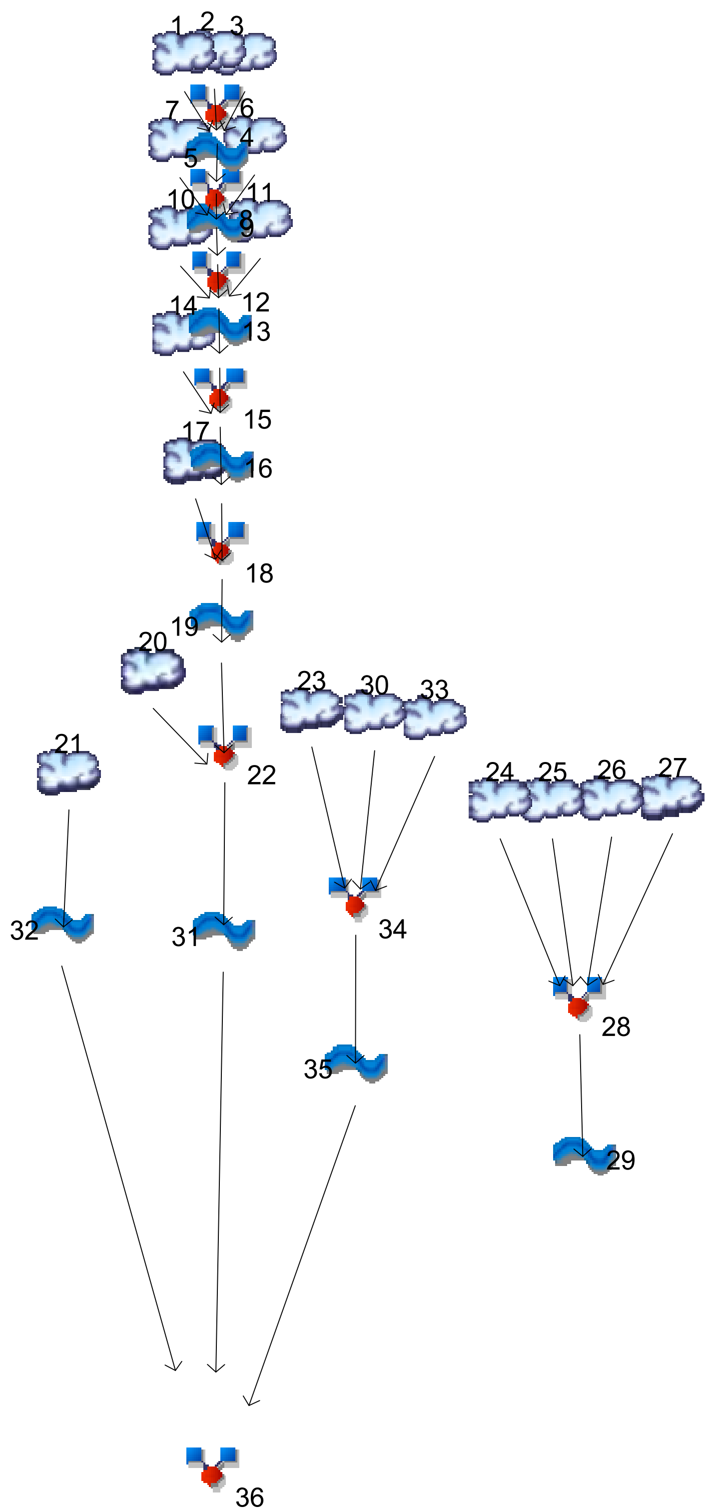
US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

# Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020




| | |
|---|---|
| Project: Hydrograph_Rev2.gpw | Tuesday, 08 / 4 / 2020 |

# Hydraflow Hydrograph Reports

# 100-Year Storm

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| Hyd. No. | Hydrograph type (origin) | Peak flow (cfs) | Time interval (min) | Time to Peak (min) | Hyd. volume (cuft) | Inflow hyd(s) | Maximum elevation (ft) | Total strge used (cuft) | Hydrograph Description |
|---|---|---|---|---|---|---|---|---|---|
| 1 | SCS Runoff | 15.94 | 2 | 720 | 41,419 | ------ | ------ | ------ | SC14 TO SW6 |
| 2 | SCS Runoff | 6.166 | 2 | 718 | 14,175 | ------ | ------ | ------ | SC15 TO DC |
| 3 | SCS Runoff | 11.72 | 2 | 720 | 30,455 | ------ | ------ | ------ | SC8 TO SW9 |
| 4 | Combine | 33.74 | 2 | 720 | 86,049 | 1, 2, 3 | ------ | ------ | DC1 |
| 5 | Reach | 33.13 | 2 | 722 | 86,049 | 4 | ------ | ------ | DC1 TO SC5 |
| 6 | SCS Runoff | 14.39 | 2 | 718 | 33,076 | ------ | ------ | ------ | SC5 TO SW5 |
| 7 | SCS Runoff | 28.26 | 2 | 718 | 64,971 | ------ | ------ | ------ | SC7 TO SW8 |
| 8 | Combine | 72.82 | 2 | 720 | 184,095 | 5, 6, 7 | ------ | ------ | DC2 |
| 9 | Reach | 73.02 | 2 | 722 | 184,095 | 8 | ------ | ------ | DC2 TO SC4 |
| 10 | SCS Runoff | 14.90 | 2 | 718 | 34,257 | ------ | ------ | ------ | SC4 TO SW4 |
| 11 | SCS Runoff | 32.35 | 2 | 720 | 84,056 | ------ | ------ | ------ | SC6 TO SW7 |
| 12 | Combine | 117.52 | 2 | 722 | 302,408 | 9, 10, 11 | ------ | ------ | DC3 |
| 13 | Reach | 118.21 | 2 | 722 | 302,408 | 12 | ------ | ------ | DC3 TO SC3 |
| 14 | SCS Runoff | 15.42 | 2 | 718 | 35,438 | ------ | ------ | ------ | SC3 TO SW3 |
| 15 | Combine | 131.31 | 2 | 722 | 337,847 | 13, 14 | ------ | ------ | DC4 |
| 16 | Reach | 132.72 | 2 | 724 | 337,846 | 15 | ------ | ------ | DC4 TO SC2 |
| 17 | SCS Runoff | 16.96 | 2 | 718 | 38,982 | ------ | ------ | ------ | SC2 TO SW2 |
| 18 | Combine | 143.80 | 2 | 724 | 376,828 | 16, 17 | ------ | ------ | DC5 |
| 19 | Reach | 144.54 | 2 | 724 | 376,828 | 18 | ------ | ------ | DC5 TO SW1 |
| 20 | SCS Runoff | 22.61 | 2 | 718 | 51,976 | ------ | ------ | ------ | SC1 TO SW1 |
| 21 | SCS Runoff | 22.81 | 2 | 722 | 64,037 | ------ | ------ | ------ | SC16 TO PC1 |
| 22 | Combine | 159.32 | 2 | 724 | 428,804 | 19, 20, | ------ | ------ | DC6 |
| 23 | SCS Runoff | 8.428 | 2 | 726 | 29,098 | ------ | ------ | ------ | SC12 TO PC2 |
| 24 | SCS Runoff | 13.05 | 2 | 716 | 26,579 | ------ | ------ | ------ | SC10 TO SW10 |
| 25 | SCS Runoff | 2.718 | 2 | 716 | 5,537 | ------ | ------ | ------ | SC13 TO PC3 |
| 26 | SCS Runoff | 10.33 | 2 | 716 | 21,042 | ------ | ------ | ------ | SC11 TO SW11 |
| 27 | SCS Runoff | 3.261 | 2 | 716 | 6,645 | ------ | ------ | ------ | SC12 TO PC3 |
| 28 | Combine | 29.35 | 2 | 716 | 59,802 | 24, 25, 26, 27 | ------ | ------ | SC10+11+12+13 |
| 29 | Reach | 24.66 | 2 | 720 | 59,800 | 28 | ------ | ------ | PC3 |
| 30 | SCS Runoff | 8.367 | 2 | 728 | 30,697 | ------ | ------ | ------ | SC17 to PC2 |
| 31 | Reach | 153.31 | 2 | 728 | 428,803 | 22 | ------ | ------ | DC6 to end of Channel |
| 32 | Reach | 15.77 | 2 | 730 | 64,030 | 21 | ------ | ------ | PC1 |
| 33 | SCS Runoff | 5.289 | 2 | 716 | 10,748 | ------ | ------ | ------ | SC18 TO PC2 |
| 34 | Combine | 17.48 | 2 | 726 | 70,543 | 23, 30, 33 | ------ | ------ | PC2 |

| Hydrograph_Rev2.gpw | Return Period: 100 Year | Tuesday, 08 / 4 / 2020 |
|---|---|---|

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| Hyd. No. | Hydrograph type (origin) | Peak flow (cfs) | Time interval (min) | Time to Peak (min) | Hyd. volume (cuft) | Inflow hyd(s) | Maximum elevation (ft) | Total strge used (cuft) | Hydrograph Description |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Reach | 12.74 | 2 | 738 | 70,532 | 34 | ------ | ------ | PC2 |
| 36 | Combine | 179.43 | 2 | 728 | 563,366 | 31, 32, 35 | ------ | ------ | FLOW TO SED BASIN 1 |

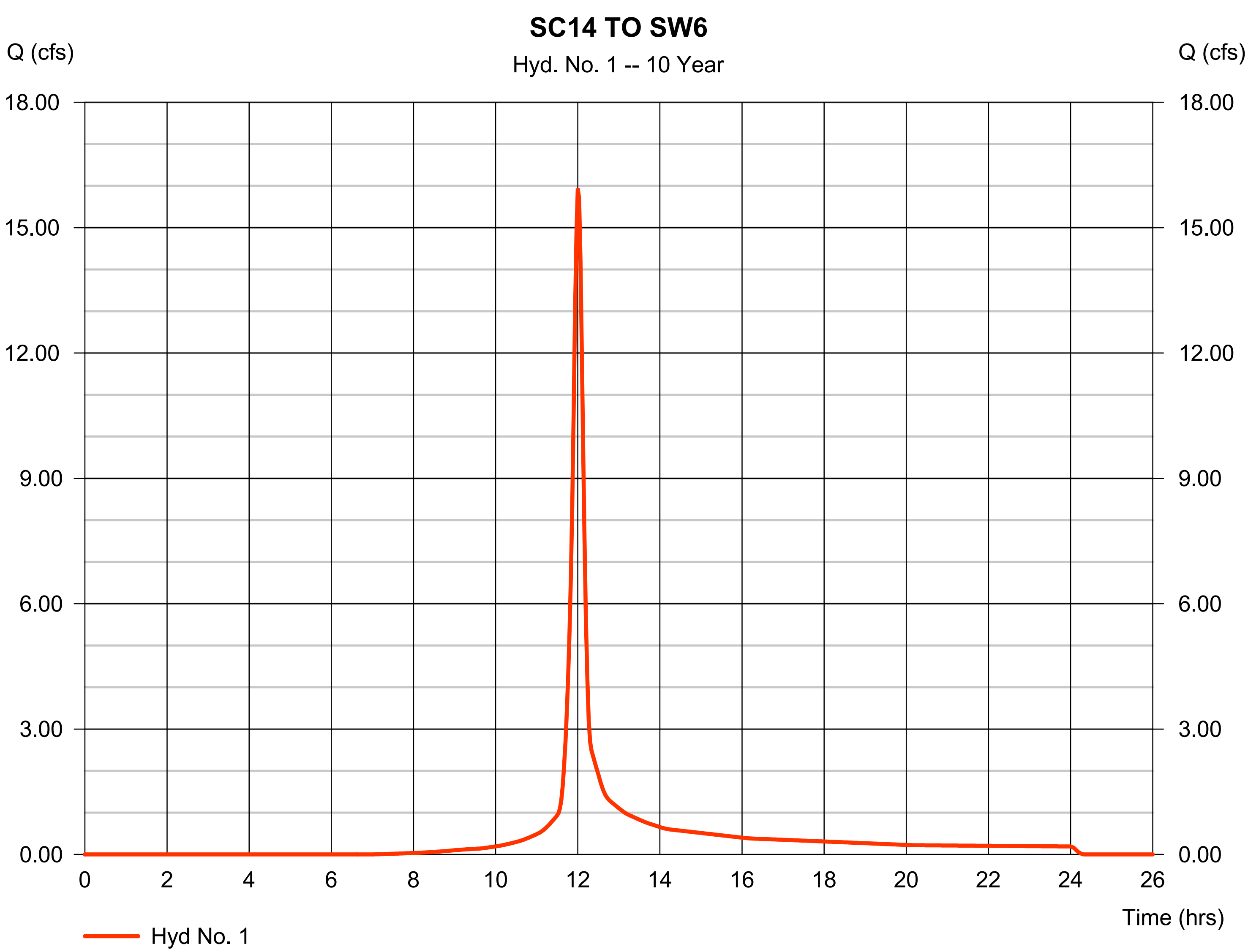
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 1

SC14 TO SW6

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 15.94 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 41,419 cuft |
| Drainage area | = 3.400 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 11.80 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 1

SC14 TO SW6

| Description | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | |
| Manning's n-value | = 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = 4.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 8.96** | **+** | **0.00** | **+** | **0.00** | **=** | **8.96** |
| **Shallow Concentrated Flow** | | | | | | | |
| Flow length (ft) | = 103.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = 4.00 | | 0.00 | | 0.00 | | |
| Surface description | = Unpaved | | Paved | | Paved | | |
| Average velocity (ft/s) | =3.23 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 0.53** | **+** | **0.00** | **+** | **0.00** | **=** | **0.53** |
| **Channel Flow** | | | | | | | |
| X sectional flow area (sqft) | = 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | 0.00 | | 0.00 | | |
| Flow length (ft) | ({0})1010.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **= 2.27** | **+** | **0.00** | **+** | **0.00** | **=** | **2.27** |

**Total Travel Time, Tc .............................................................................. 11.80 min**

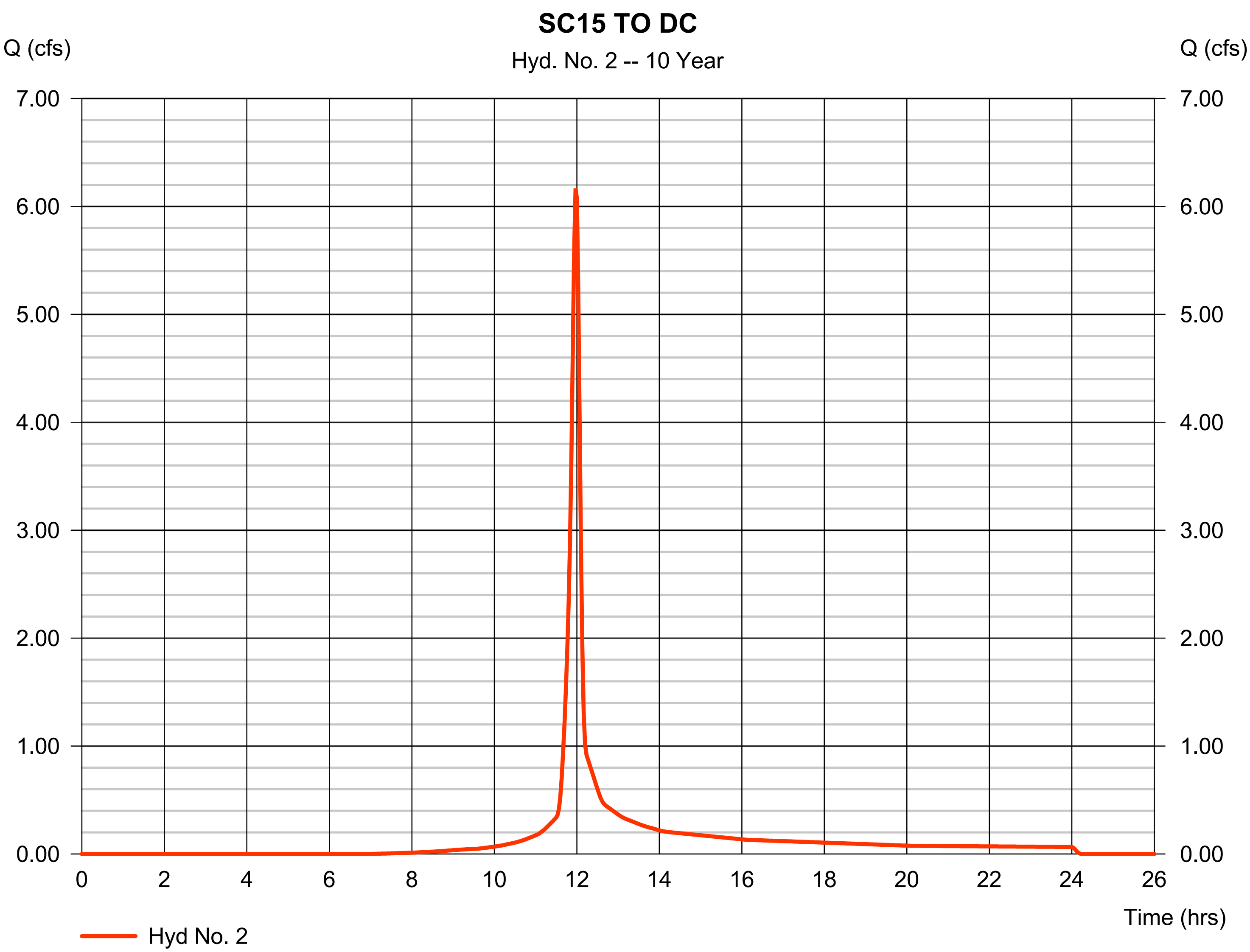
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 2

SC15 TO DC

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 6.166 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 14,175 cuft |
| Drainage area | = 1.200 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 9.30 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 2

SC15 TO DC

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 4.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **8.96** | **+** | **0.00** | **+** | **0.00** | **=** | **8.96** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 58.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 4.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Unpaved | | Paved | | Paved | | |
| Average velocity (ft/s) | =3.23 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.30** | **+** | **0.00** | **+** | **0.00** | **=** | **0.30** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 10.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.070 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =6.39 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})0.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |

**Total Travel Time, Tc ..........................................................................** **9.30 min**

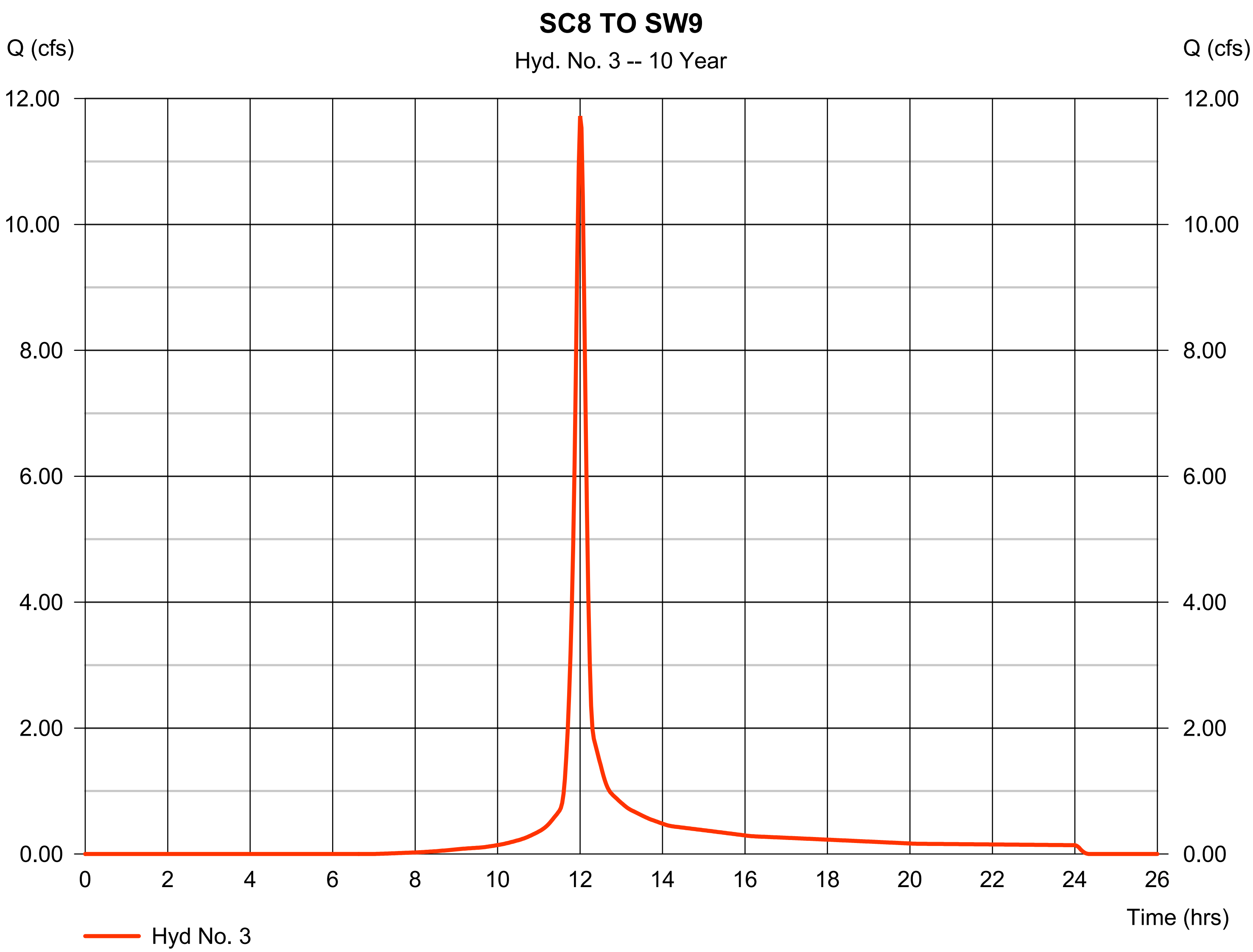
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 3

SC8 TO SW9

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 11.72 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 30,455 cuft |
| Drainage area | = 2.500 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 11.50 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 3

SC8 TO SW9

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 4.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **8.96** | **+** | **0.00** | **+** | **0.00** | **=** | **8.96** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 95.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 4.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Unpaved | | Paved | | Paved | | |
| Average velocity (ft/s) | =3.23 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.49** | **+** | **0.00** | **+** | **0.00** | **=** | **0.49** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})903.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **2.03** | **+** | **0.00** | **+** | **0.00** | **=** | **2.03** |

**Total Travel Time, Tc ........................................................................ 11.50 min**

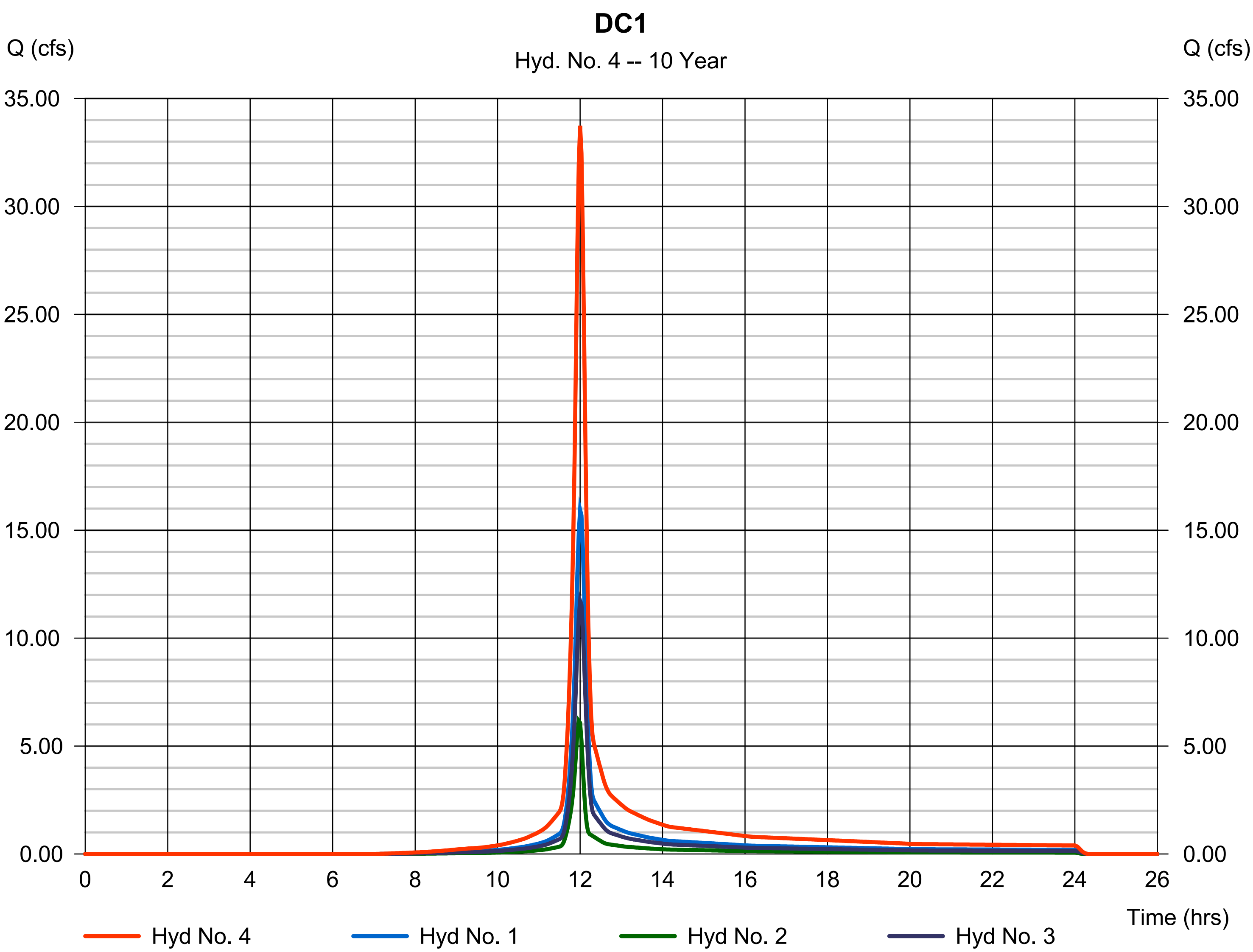
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 4

DC1

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 33.74 cfs |
| Storm frequency | = 100 yrs = | Time to peak | = 12.00 hrs |
| Time interval | 2 min = 1, | Hyd. volume | = 86,049 cuft |
| Inflow hyds. | 2, 3 | Contrib. drain. area | = 7.100 ac |



# Hydrograph Report

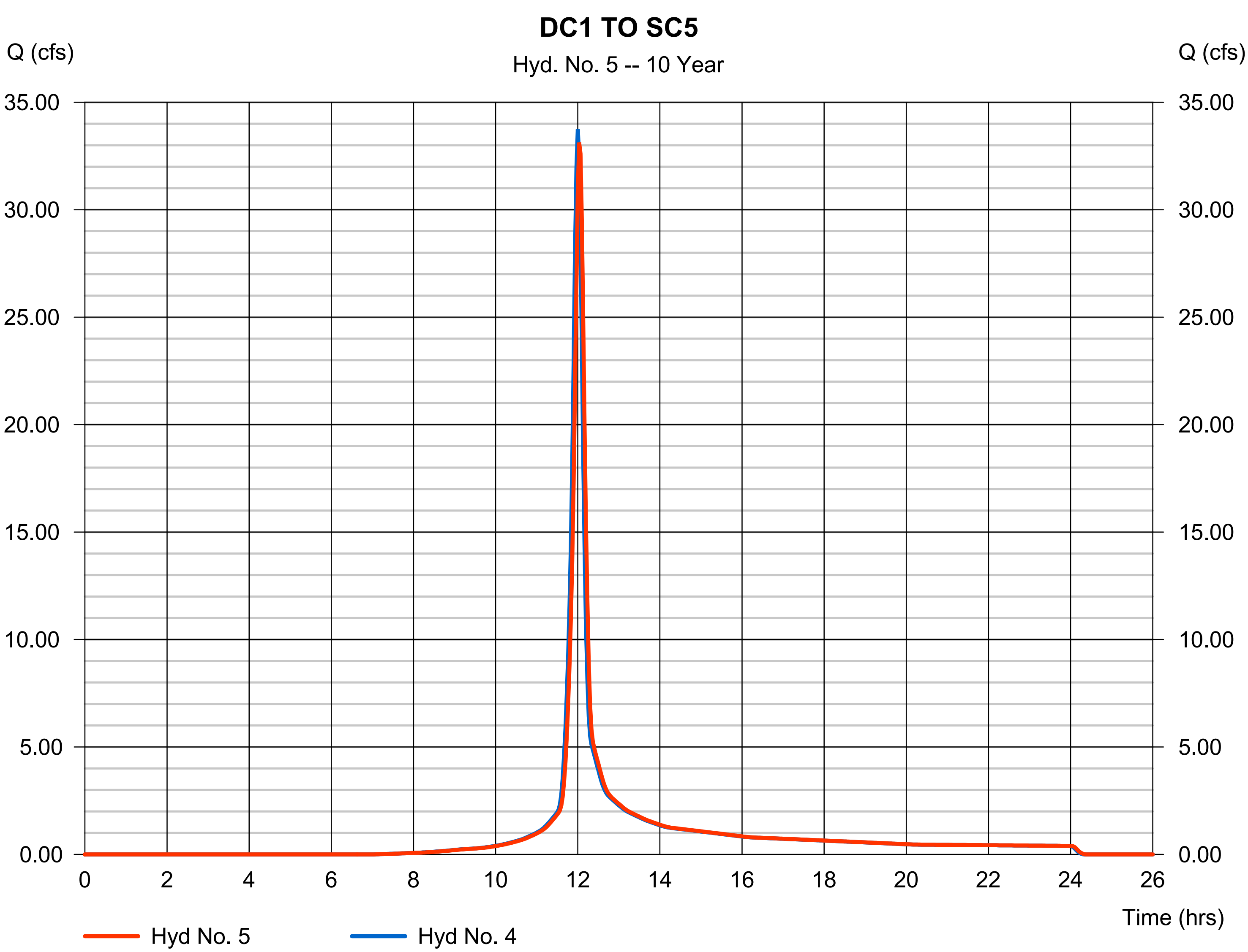
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 5

DC1 TO SC5

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 33.13 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.03 hrs |
| Time interval | = 2 min | Hyd. volume | = 86,049 cuft |
| Inflow hyd. No. | = 4 - DC1 | Section type | = Trapezoidal |
| Reach length | = 450.0 ft | Channel slope | = 10.0 % |
| Manning's n | = 0.070 | Bottom width | = 15.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 3.33 ft/s | Routing coeff. | = 0.7918 |

Modified Att-Kin routing method used.



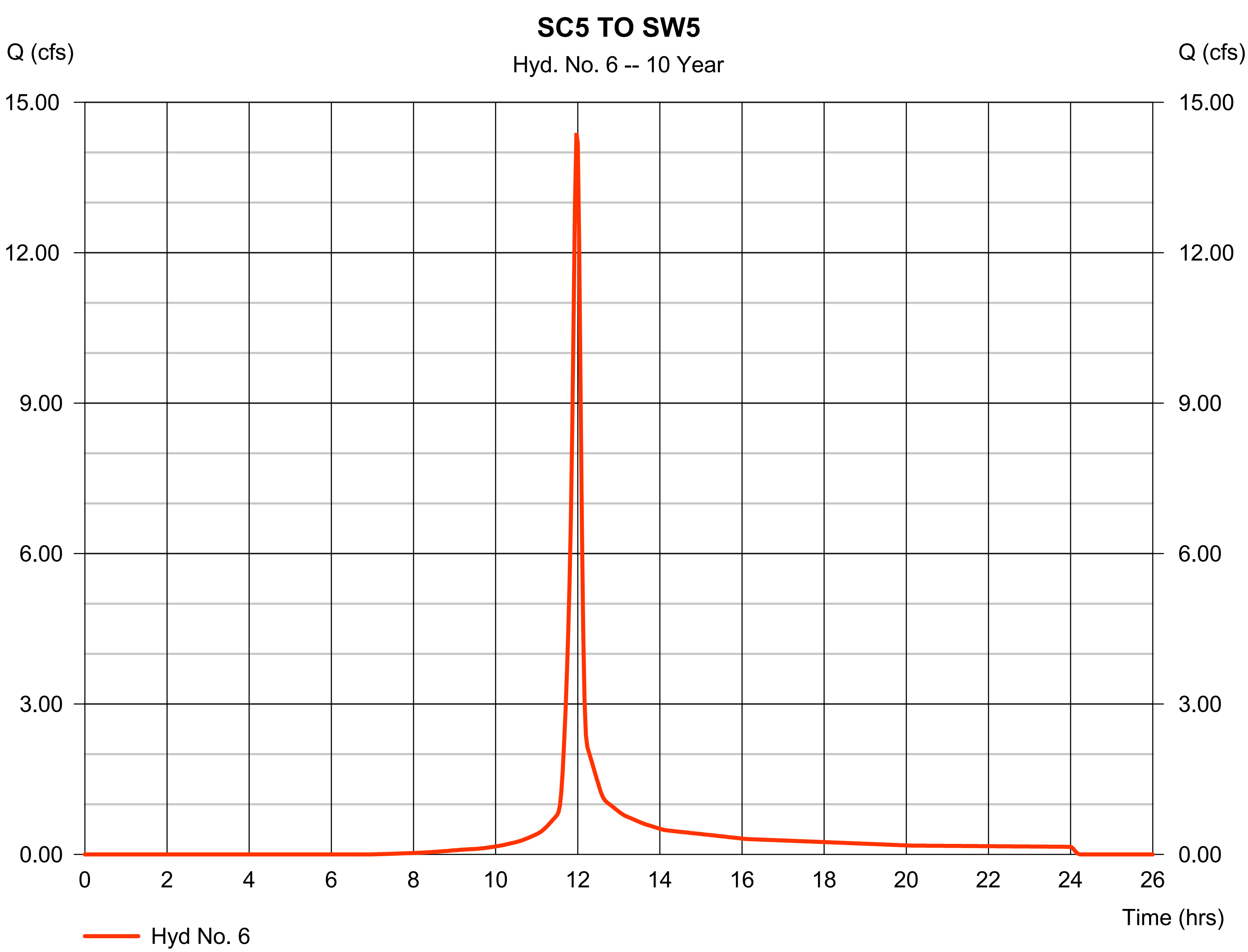
# Hydrograph Report



## Hyd. No. 6

SC5 TO SW5

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 14.39 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 33,076 cuft |
| Drainage area | = 2.800 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.60 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 6

SC5 TO SW5

| Description | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | |
| Manning's n-value | = 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | |
| Flow length (ft) | = 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | |
| X sectional flow area (sqft) | = 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | |
| | | | 0.00 | | | | |
| | | | | | 0.00 | | |
| Flow length (ft) | ({0})1216.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **= 2.73** | **+** | **0.00** | **+** | **0.00** | **=** | **2.73** |

**Total Travel Time, Tc ..........................................................................** **6.60 min**

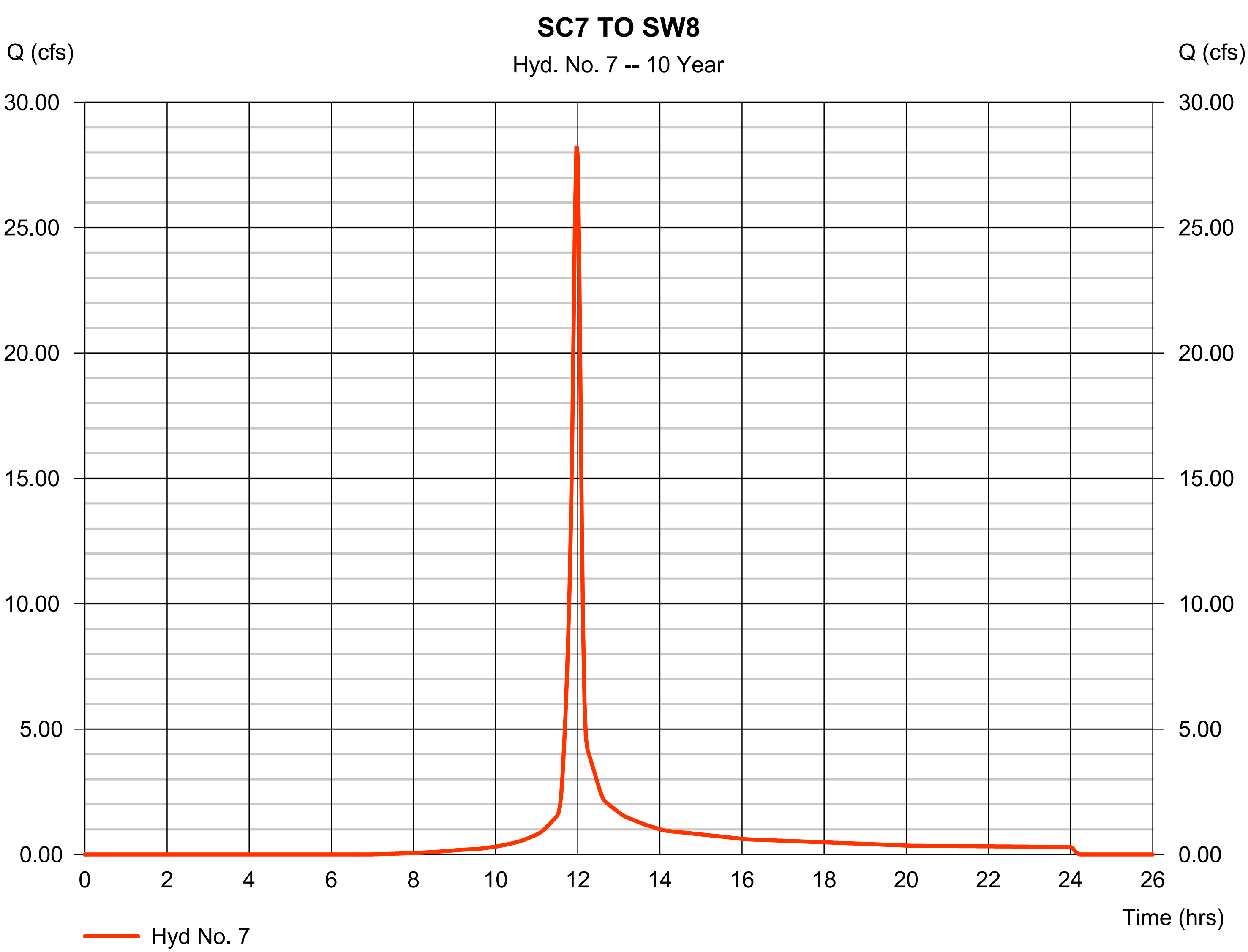
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 7

SC7 TO SW8

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 28.26 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 64,971 cuft |
| Drainage area | = 5.500 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 9.80 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 7

SC7 TO SW8

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})2645.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **5.95** | **+** | **0.00** | **+** | **0.00** | **=** | **5.95** |

**Total Travel Time, Tc ..........................................................................** **9.80 min**

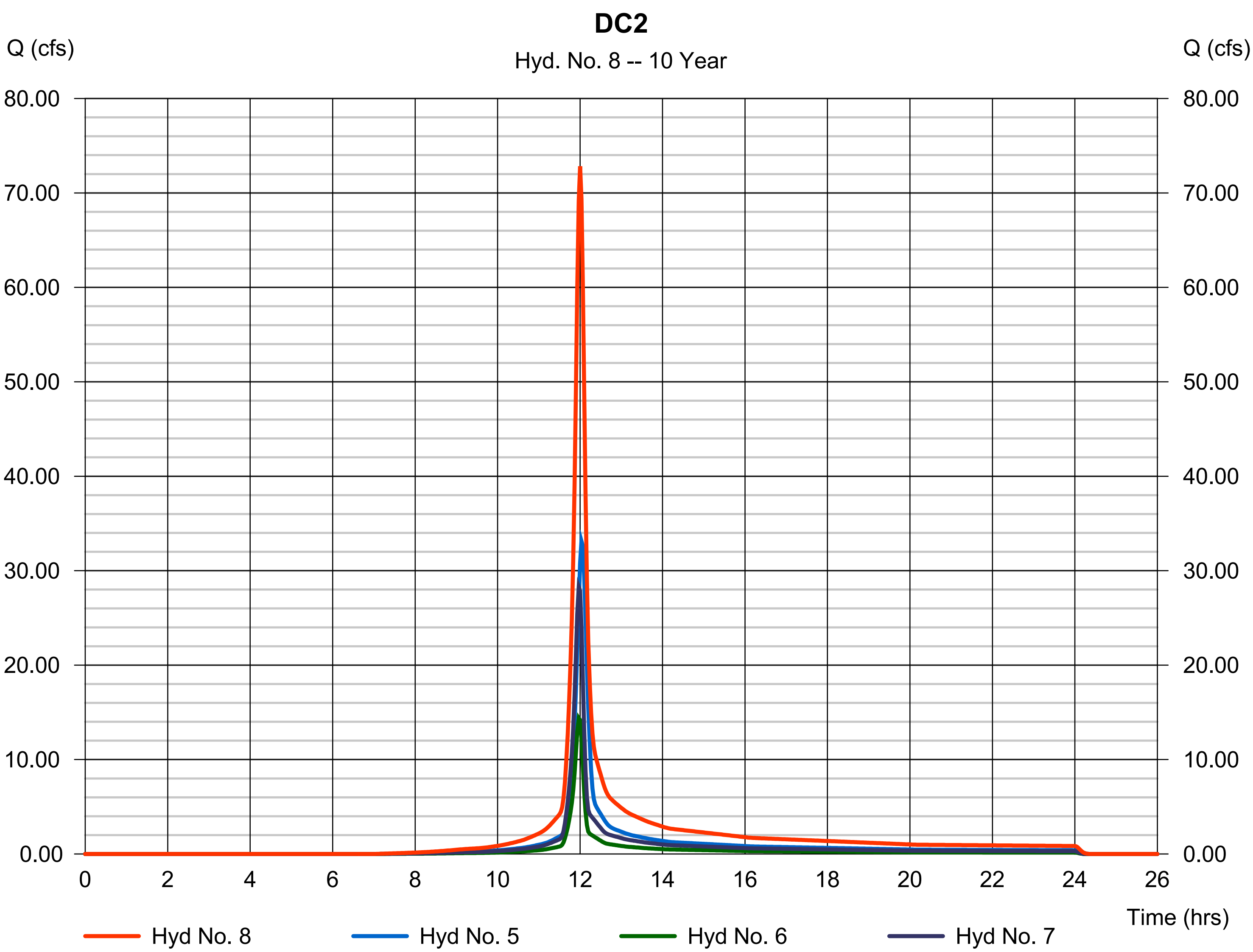
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 8

DC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 72.82 cfs |
| Storm frequency | = 100 yrs = | Time to peak | = 12.00 hrs |
| Time interval | 2 min = 5, | Hyd. volume | = 184,095 cuft |
| Inflow hyds. | 6, 7 | Contrib. drain. area | = 8.300 ac |



# Hydrograph Report

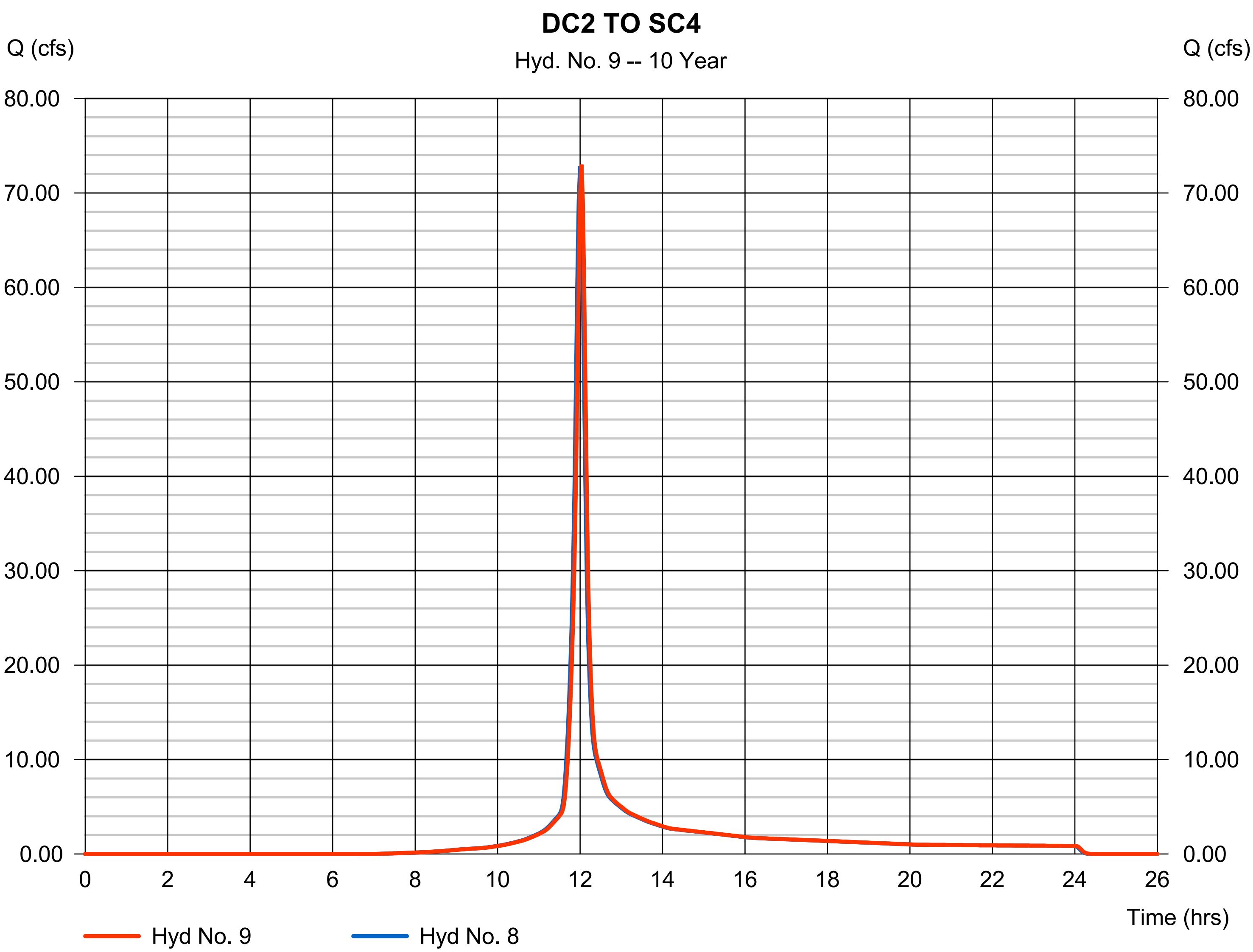
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 9

DC2 TO SC4

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 73.02 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.03 hrs |
| Time interval | = 2 min | Hyd. volume | = 184,095 cuft |
| Inflow hyd. No. | = 8 - DC2 | Section type | = Trapezoidal |
| Reach length | = 333.0 ft | Channel slope | = 10.0 % |
| Manning's n | = 0.070 | Bottom width | = 15.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 4.27 ft/s | Routing coeff. | = 1.0633 |

Modified Att-Kin routing method used.



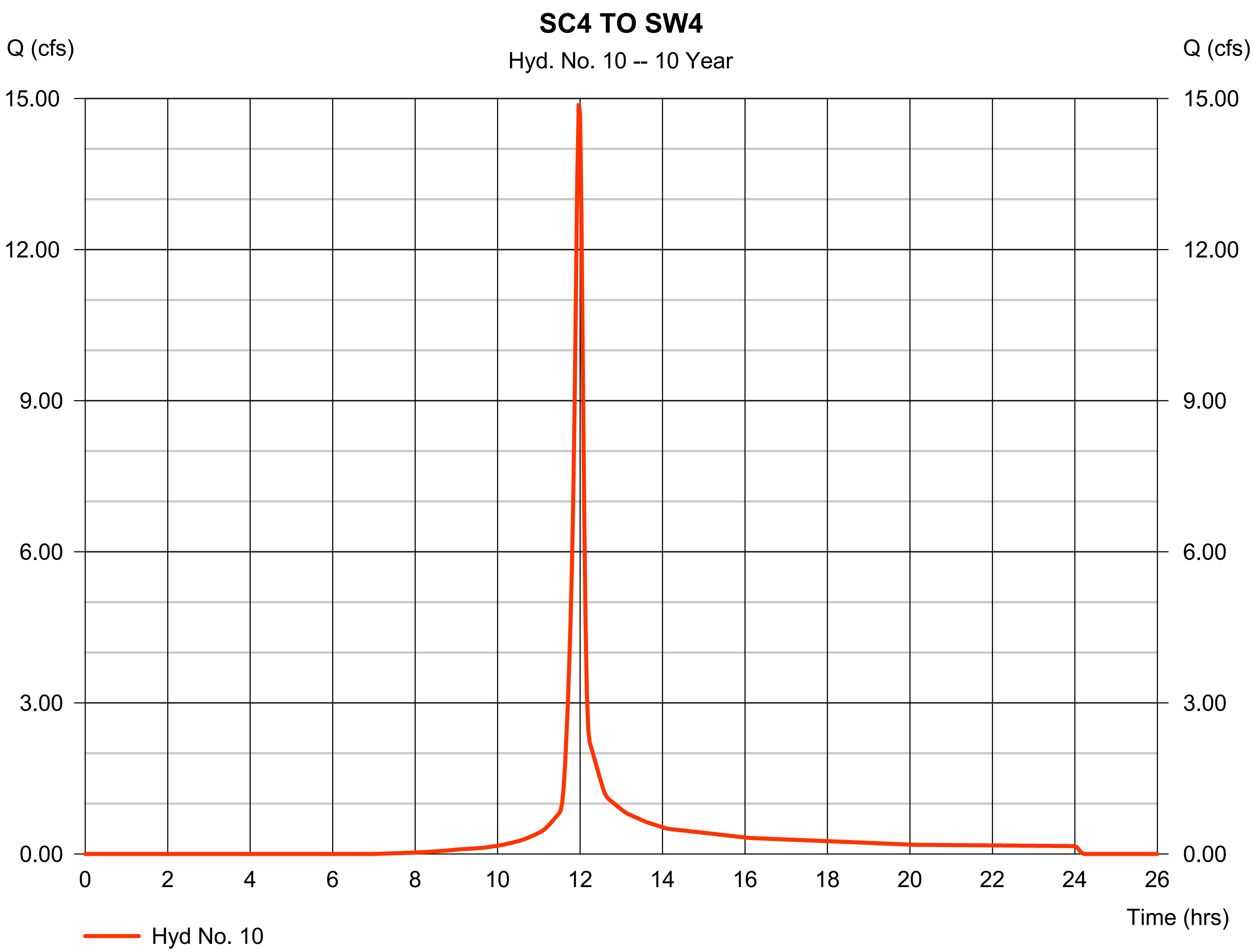
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 10

SC4 TO SW4

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 14.90 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 34,257 cuft |
| Drainage area | = 2.900 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.80 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 10

SC4 TO SW4

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})1302.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **2.93** | **+** | **0.00** | **+** | **0.00** | **=** | **2.93** |

**Total Travel Time, Tc .......................................................................... 6.80 min**

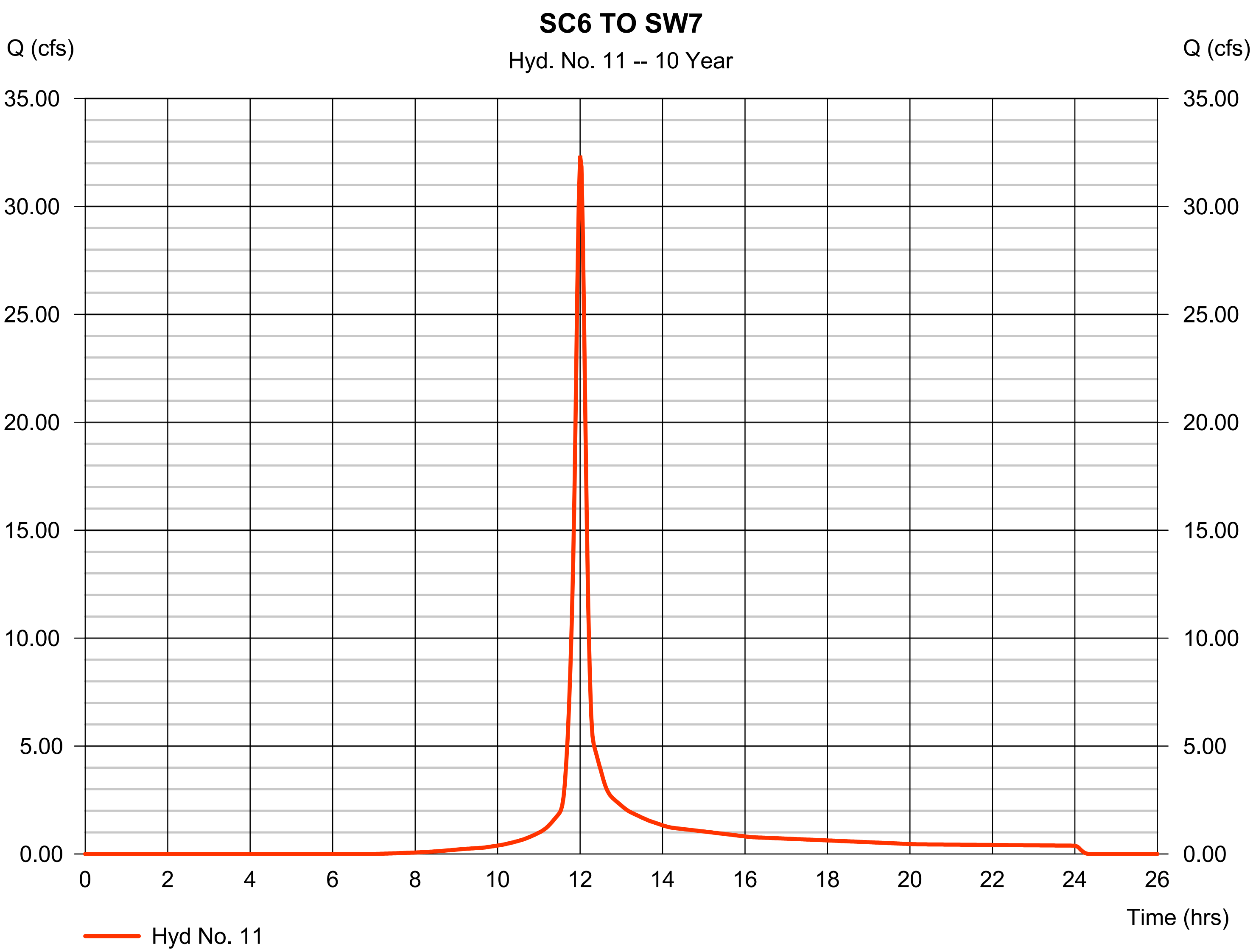
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 11

SC6 TO SW7

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 32.35 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 84,056 cuft |
| Drainage area | = 6.900 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 11.60 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 11

SC6 TO SW7

| Description | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | |
| Manning's n-value | = 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | |
| Flow length (ft) | = 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | |
| X sectional flow area (sqft) | = 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | |
| | | | 0.00 | | | | |
| | | | | | 0.00 | | |
| Flow length (ft) | ({0})3460.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **= 7.78** | **+** | **0.00** | **+** | **0.00** | **=** | **7.78** |

**Total Travel Time, Tc .......................................................................... 11.60 min**

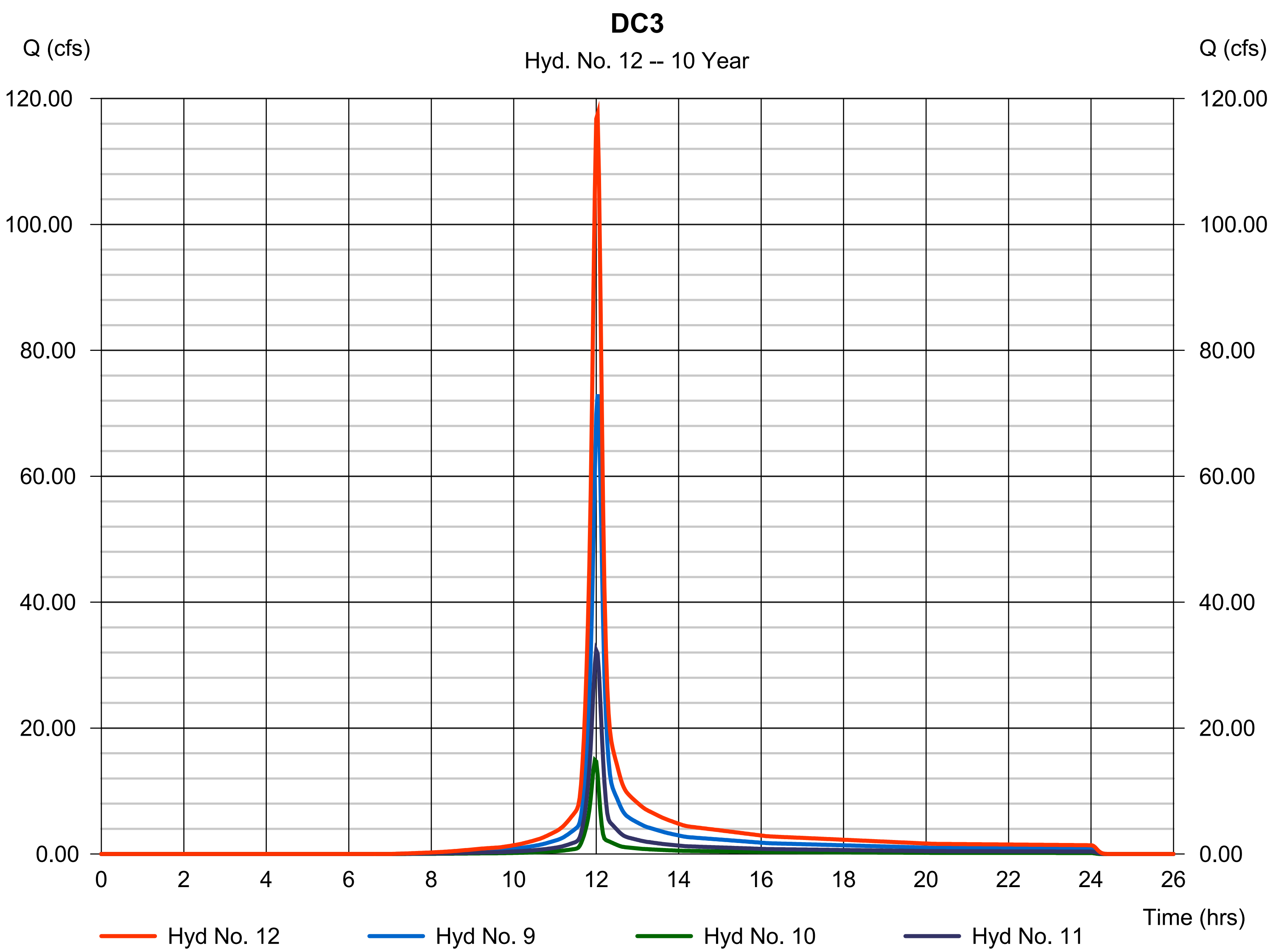
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 12

DC3

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 117.52 cfs |
| Storm frequency | = 100 yrs = | Time to peak | = 12.03 hrs |
| Time interval | 2 min = 9, | Hyd. volume | = 302,408 cuft |
| Inflow hyds. | 10, 11 | Contrib. drain. area | = 9.800 ac |



# Hydrograph Report

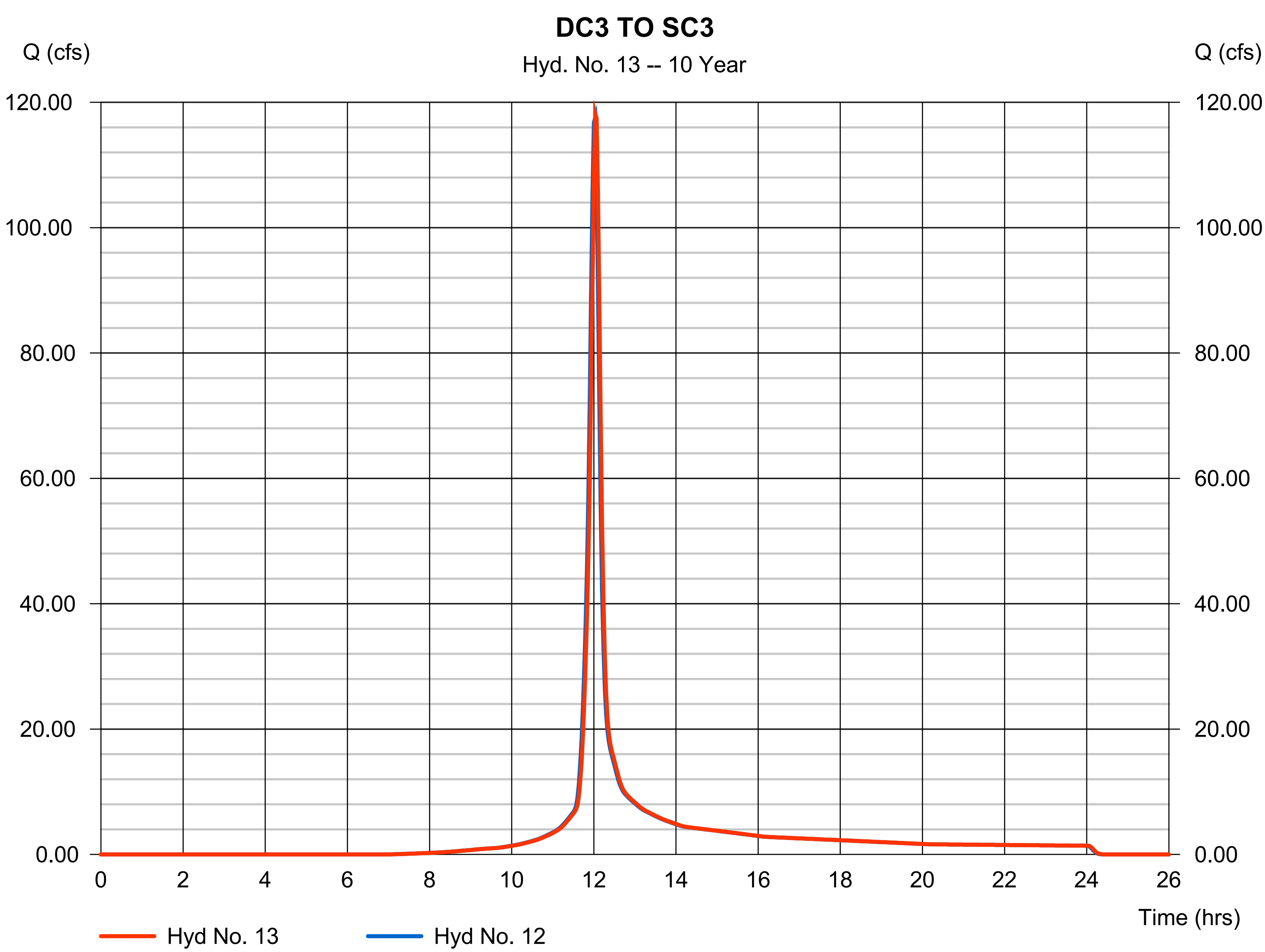
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 13

DC3 TO SC3

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 118.21 cfs |
| Storm frequency | 100 yrs = 2 | Time to peak | = 12.03 hrs |
| Time interval | min = 12 - | Hyd. volume | = 302,408 cuft |
| Inflow hyd. No. | DC3 = | Section type | = Trapezoidal |
| Reach length | 315.0 ft = | Channel slope | = 10.0 % |
| Manning's n | 0.070 = | Bottom width | = 15.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 4.98 ft/s | Routing coeff. | = 1.1668 |

Modified Att-Kin routing method used.



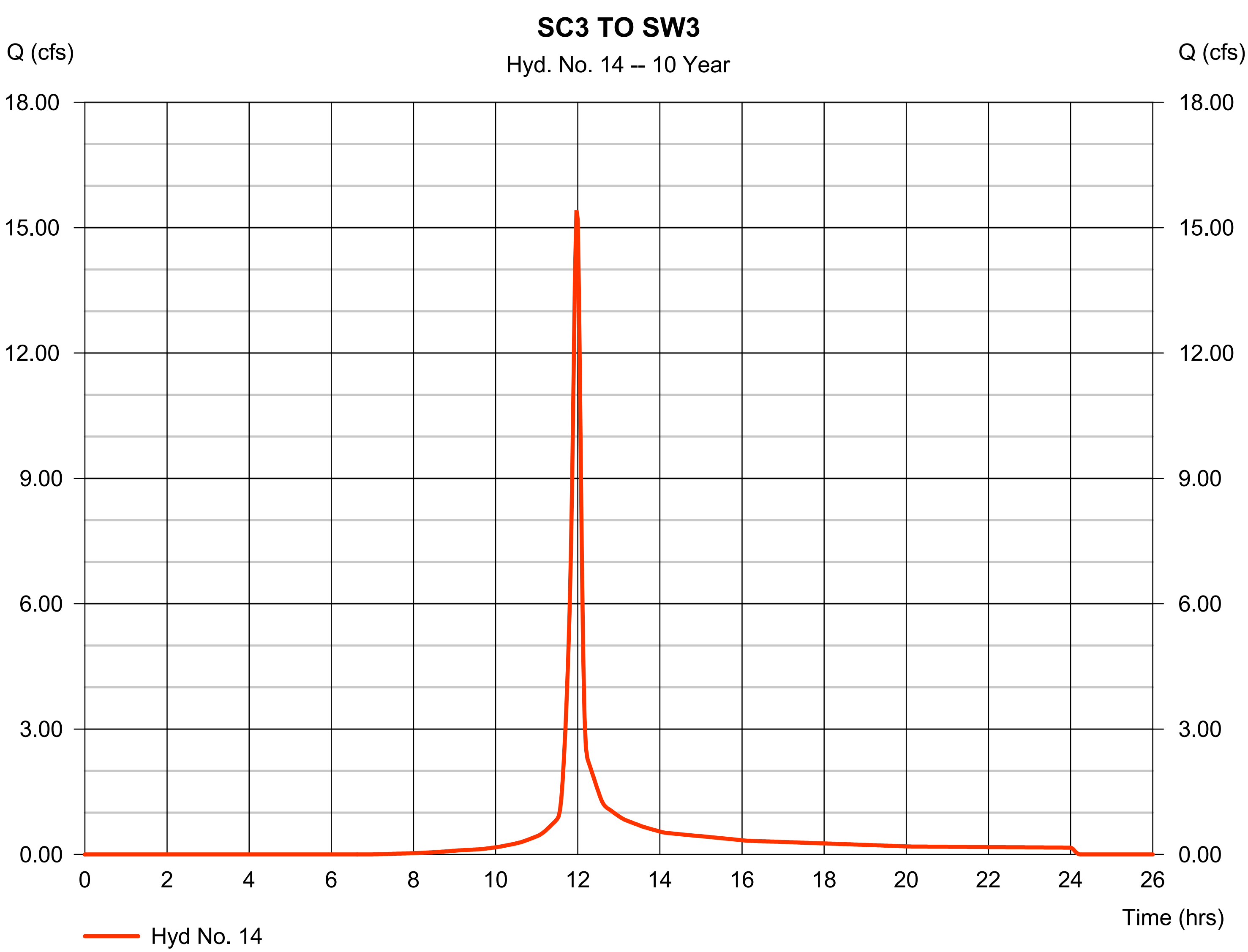
# Hydrograph Report



## Hyd. No. 14

SC3 TO SW3

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 15.42 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 35,438 cuft |
| Drainage area | = 3.000 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.90 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 14

SC3 TO SW3

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})1373.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **3.09** | **+** | **0.00** | **+** | **0.00** | **=** | **3.09** |

**Total Travel Time, Tc ..........................................................................** **6.90 min**

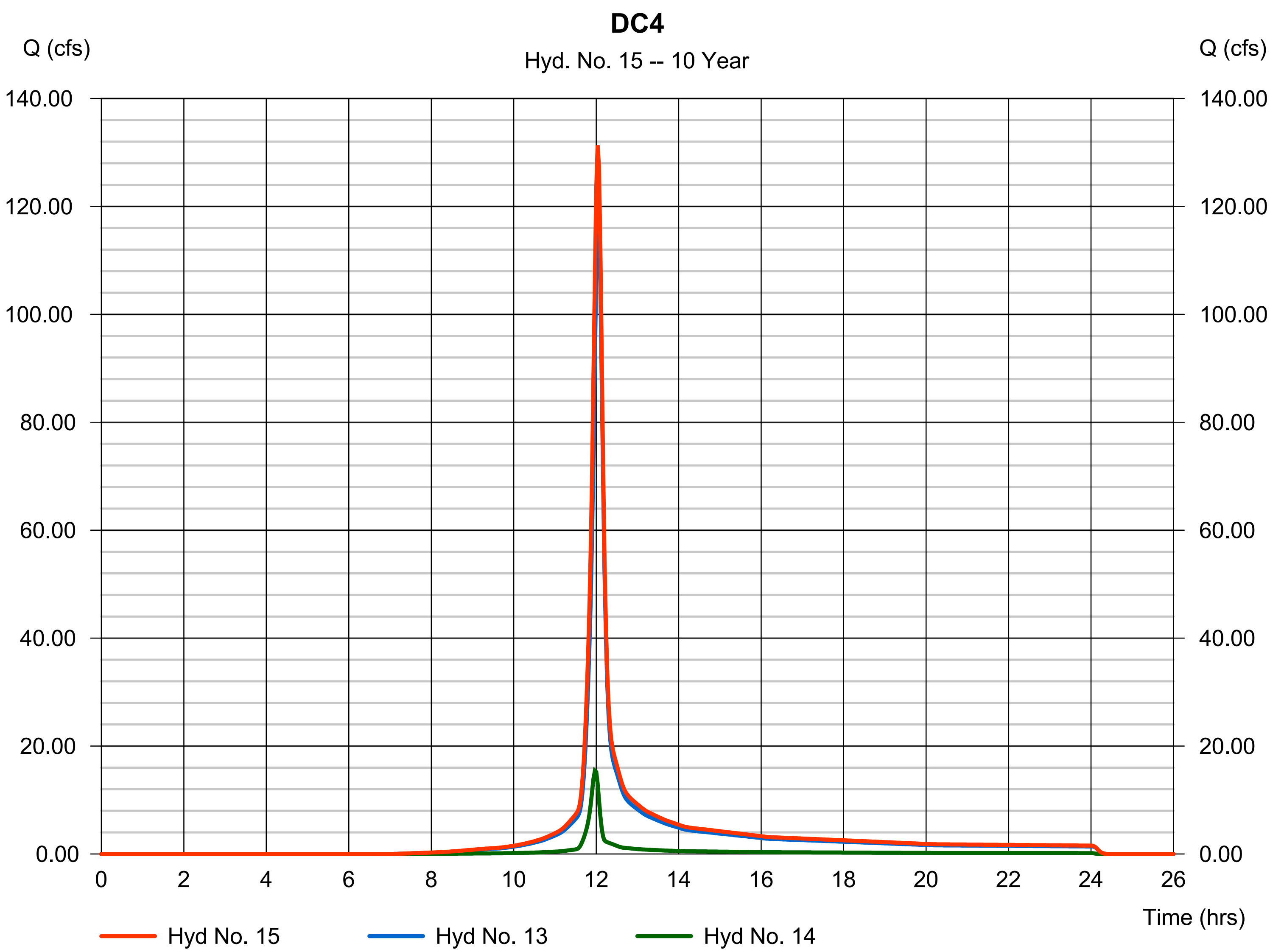
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 15

DC4

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 131.31 cfs |
| Storm frequency | = 100 yrs = | Time to peak | = 12.03 hrs |
| Time interval | 2 min = 13, | Hyd. volume | = 337,847 cuft |
| Inflow hyds. | 14 | Contrib. drain. area | = 3.000 ac |



# Hydrograph Report

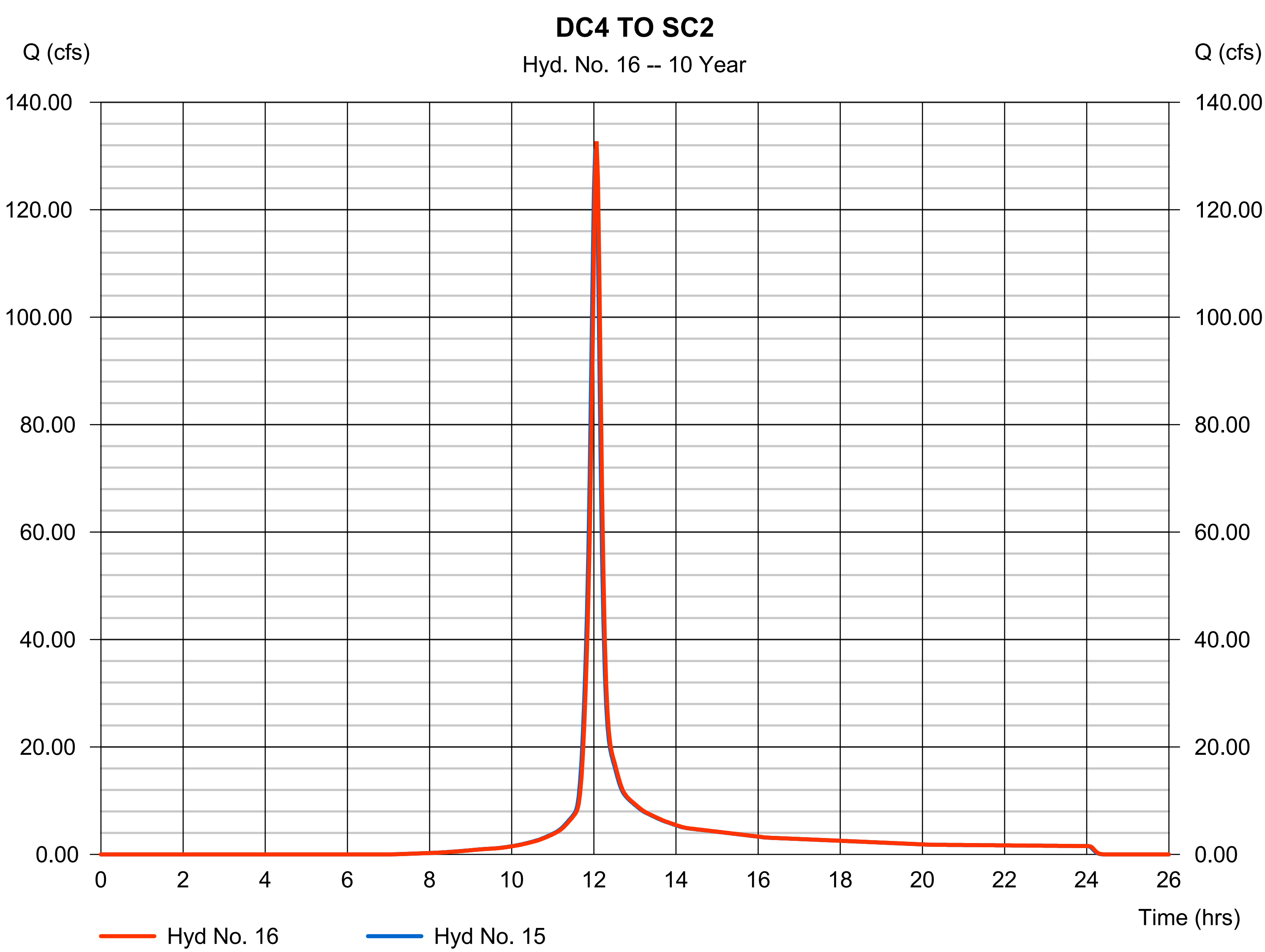
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 16

DC4 TO SC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 132.72 cfs |
| Storm frequency | 100 yrs = 2 | Time to peak | = 12.07 hrs |
| Time interval | min = 15 - | Hyd. volume | = 337,846 cuft |
| Inflow hyd. No. | DC4 = | Section type | = Trapezoidal |
| Reach length | 232.0 ft = | Channel slope | = 10.0 % |
| Manning's n | 0.070 = | Bottom width | = 15.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 5.16 ft/s | Routing coeff. | = 1.3267 |

Modified Att-Kin routing method used.



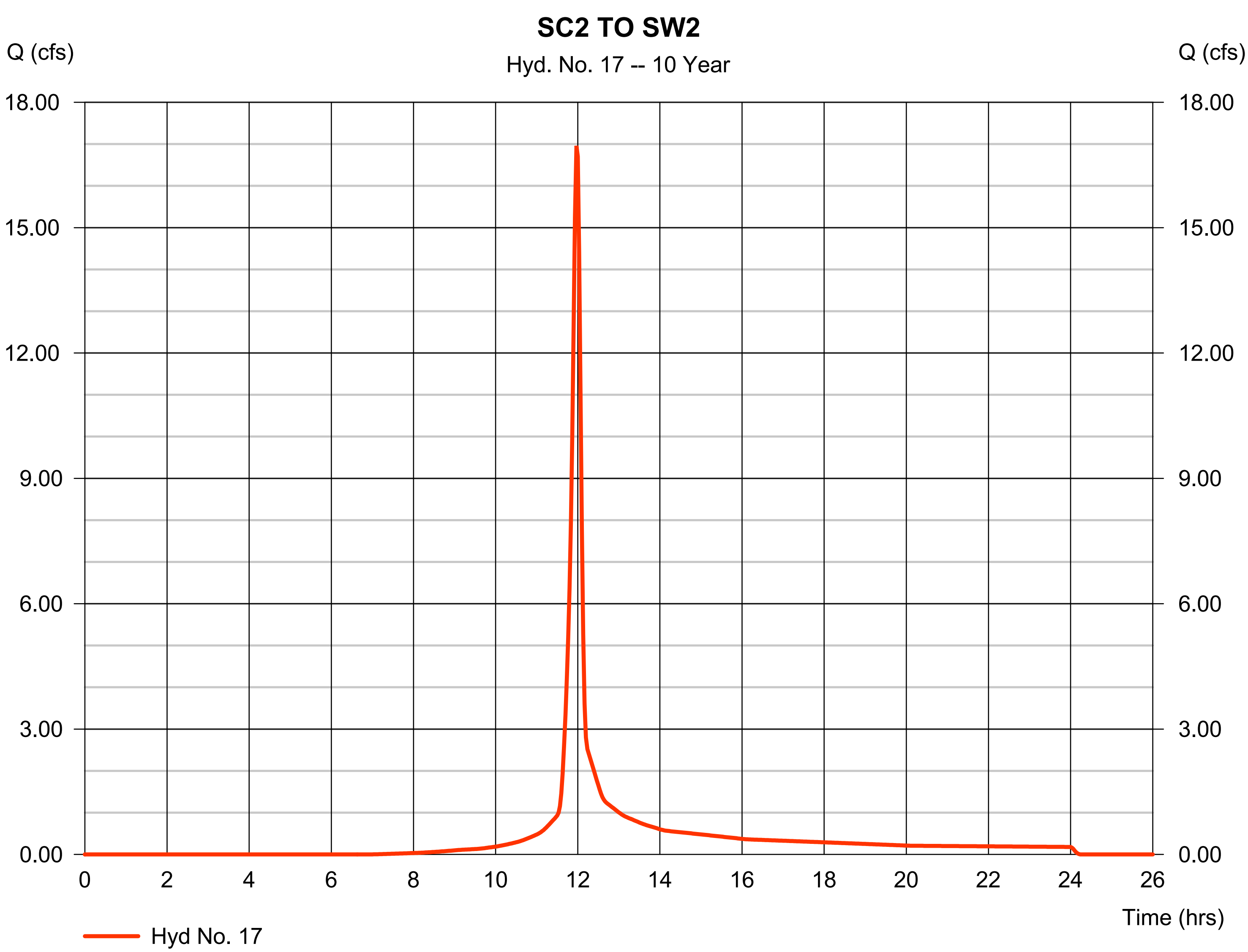
# Hydrograph Report



## Hyd. No. 17

SC2 TO SW2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 16.96 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 38,982 cuft |
| Drainage area | = 3.300 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 7.30 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 17

SC2 TO SW2

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})1543.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **3.47** | **+** | **0.00** | **+** | **0.00** | **=** | **3.47** |

**Total Travel Time, Tc ..........................................................................** **7.30 min**

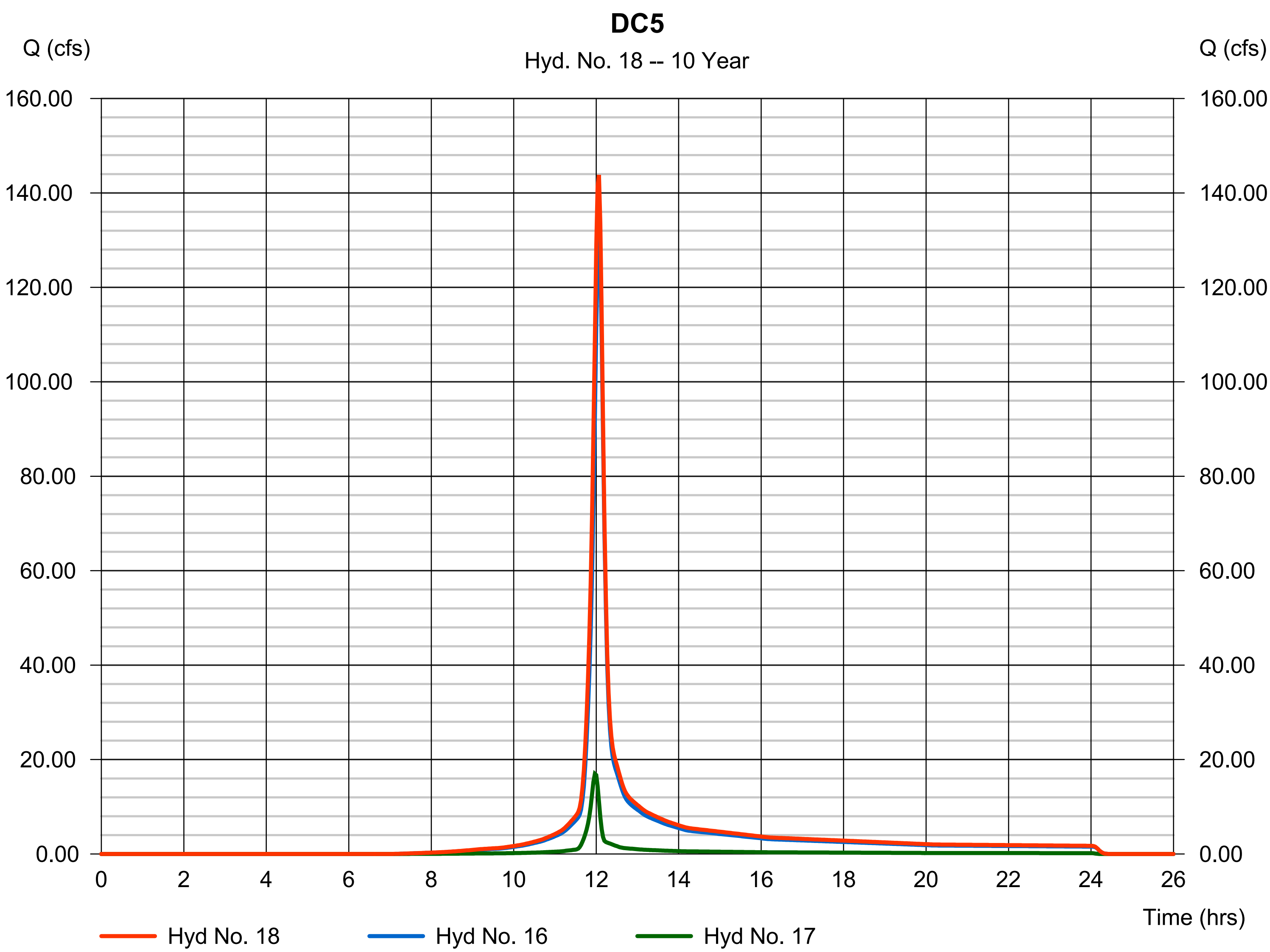
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 18

DC5

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 143.80 cfs |
| Storm frequency | = 100 yrs = | Time to peak | = 12.07 hrs |
| Time interval | 2 min = 16, | Hyd. volume | = 376,828 cuft |
| Inflow hyds. | 17 | Contrib. drain. area | = 3.300 ac |



# Hydrograph Report

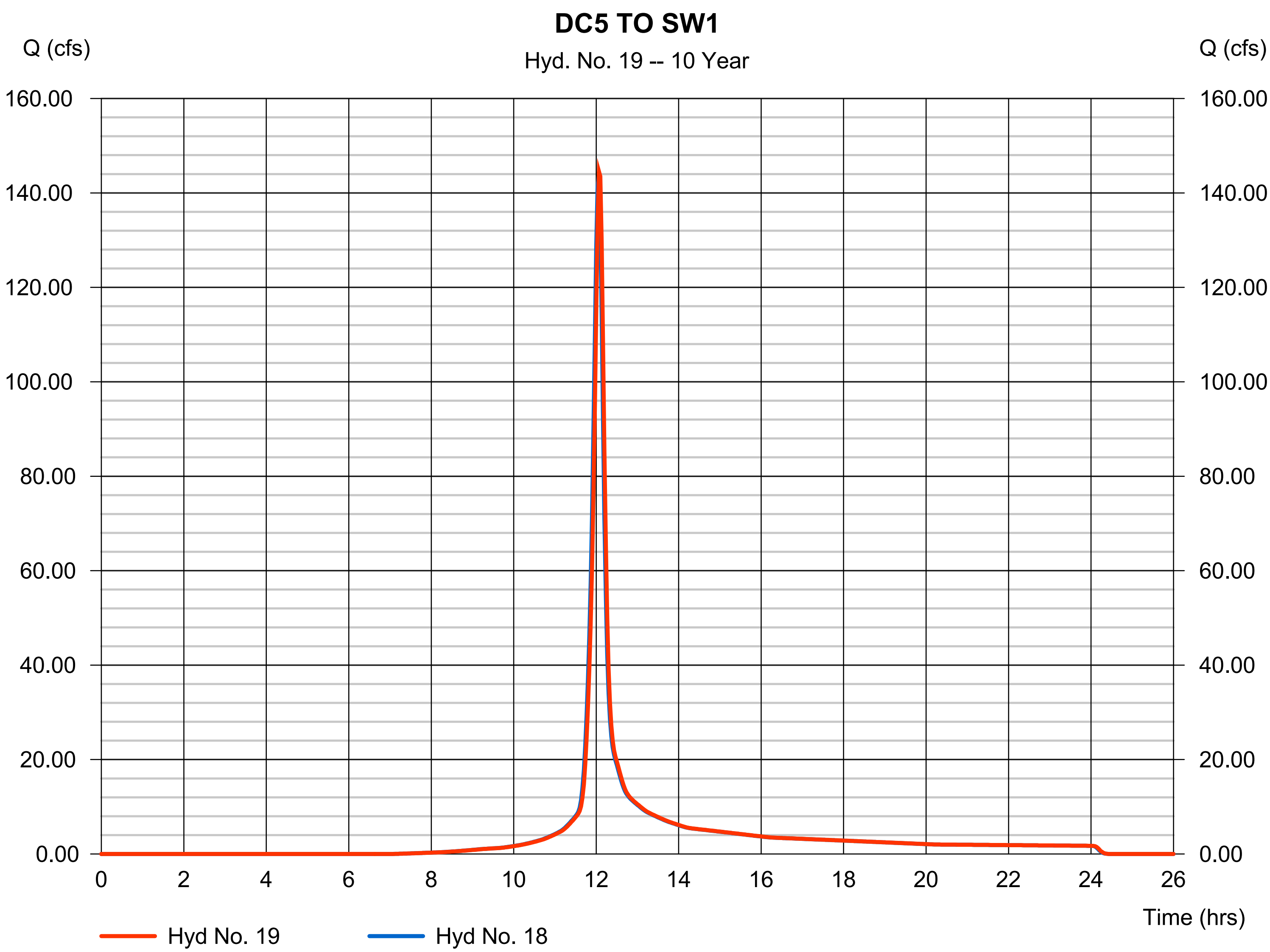
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 19

DC5 TO SW1

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 144.54 cfs |
| Storm frequency | 100 yrs = 2 | Time to peak | = 12.07 hrs |
| Time interval | min = 18 - | Hyd. volume | = 376,828 cuft |
| Inflow hyd. No. | DC5 = | Section type | = Trapezoidal |
| Reach length | 200.0 ft = | Channel slope | = 10.0 % |
| Manning's n | 0.070 = | Bottom width | = 15.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 5.32 ft/s | Routing coeff. | = 1.4037 |

Modified Att-Kin routing method used.



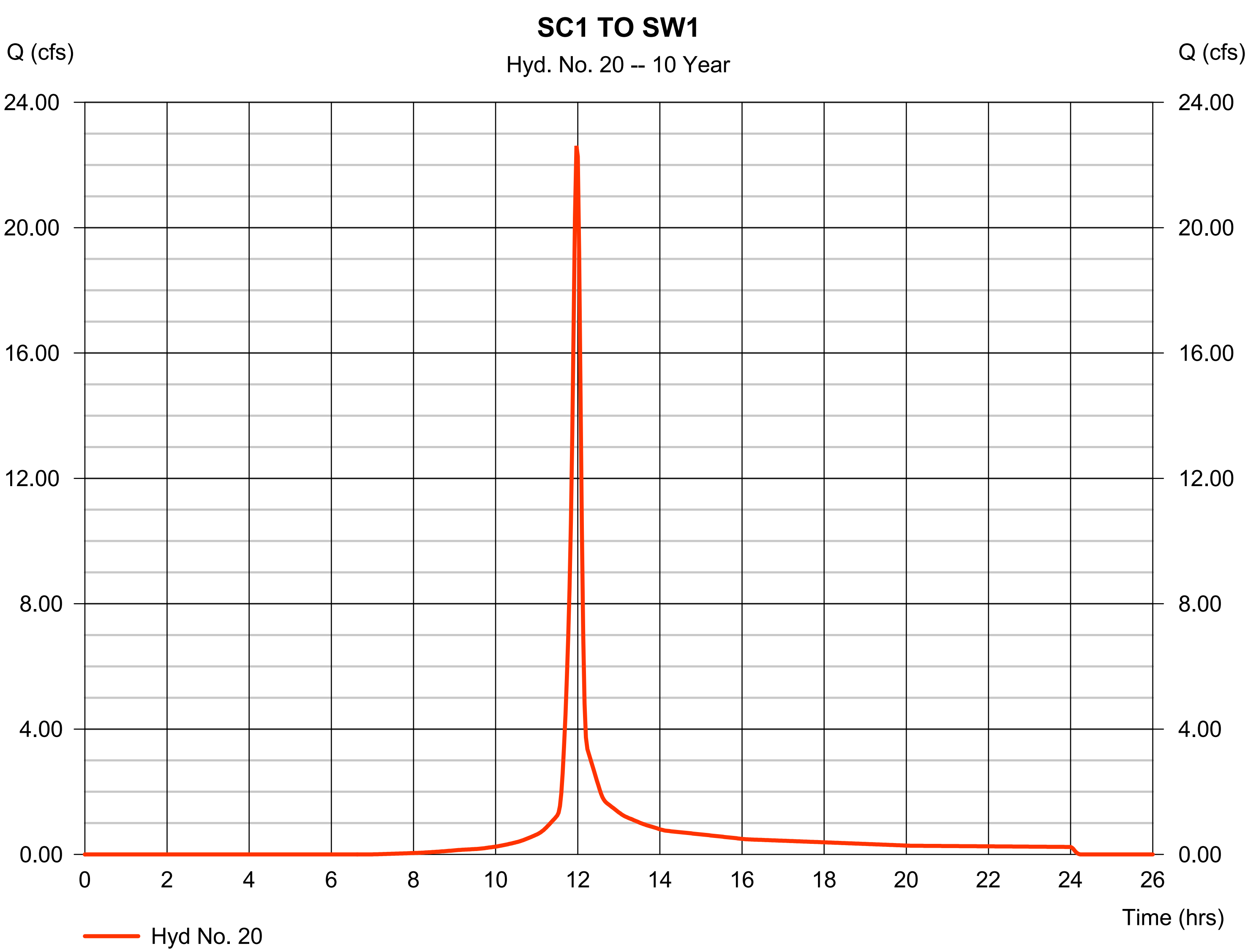
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 20

SC1 TO SW1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 22.61 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 51,976 cuft |
| Drainage area | = 4.400 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 8.00 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 20

SC1 TO SW1

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})1865.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **4.19** | **+** | **0.00** | **+** | **0.00** | **=** | **4.19** |

**Total Travel Time, Tc ..........................................................................** **8.00 min**

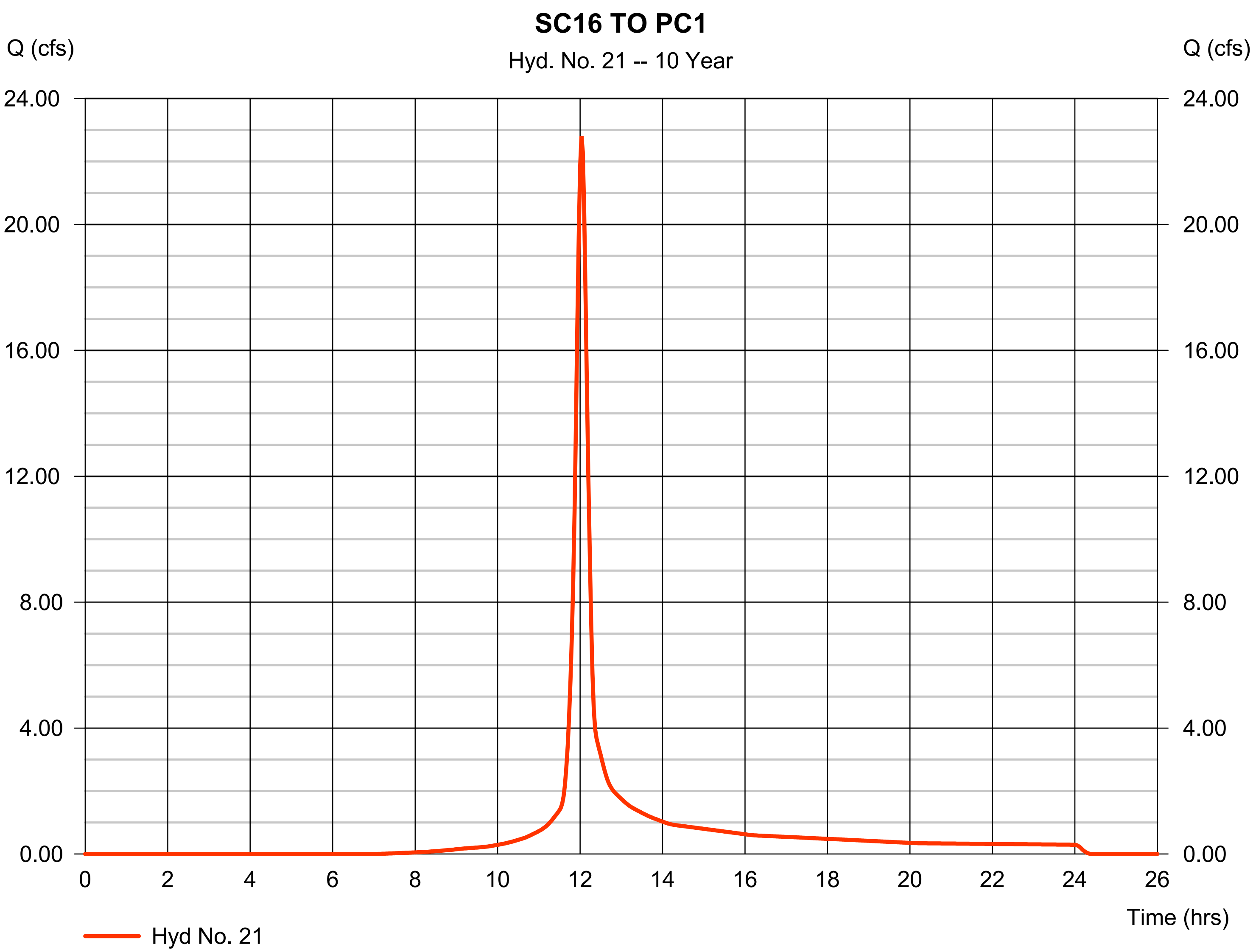
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 21

SC16 TO PC1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 22.81 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.03 hrs |
| Time interval | = 2 min | Hyd. volume | = 64,037 cuft |
| Drainage area | = 5.560 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 14.20 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 21

SC16 TO PC1

| Description | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | |
| Manning's n-value | = 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | |
| Flow length (ft) | = 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | |
| X sectional flow area (sqft) | = 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = 3.70 | | 0.00 | | 0.00 | | |
| Manning's n-value | = 0.070 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =3.89 | | 0.00 | | 0.00 | | |
| Flow length (ft) | ({0})2417.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **= 10.36** | **+** | **0.00** | **+** | **0.00** | **=** | **10.36** |

**Total Travel Time, Tc .............................................................................. 14.20 min**

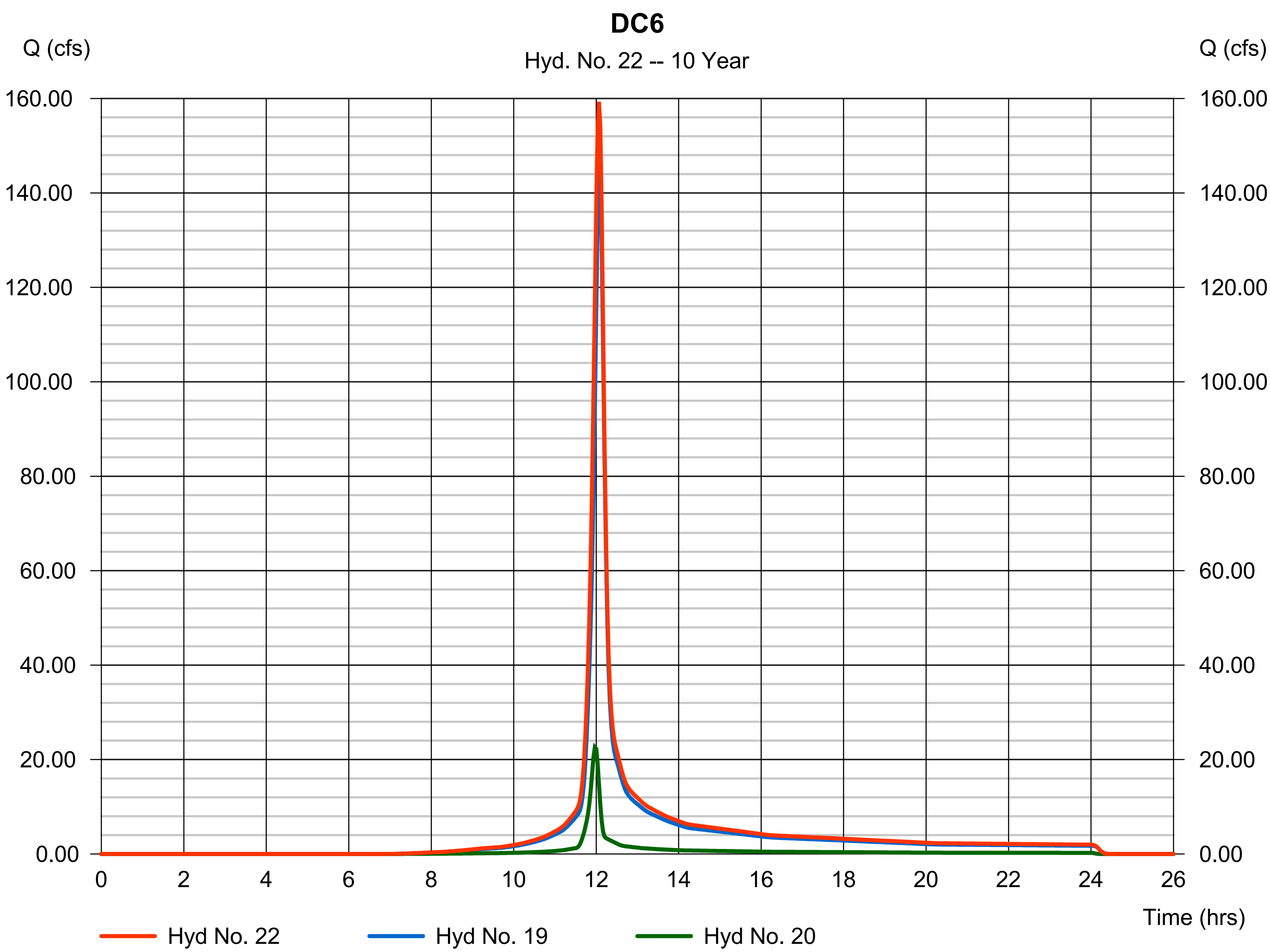
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 22

DC6

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 159.32 cfs |
| Storm frequency | = 100 yrs = | Time to peak | = 12.07 hrs |
| Time interval | 2 min = 19, | Hyd. volume | = 428,804 cuft |
| Inflow hyds. | 20 | Contrib. drain. area | = 4.400 ac |



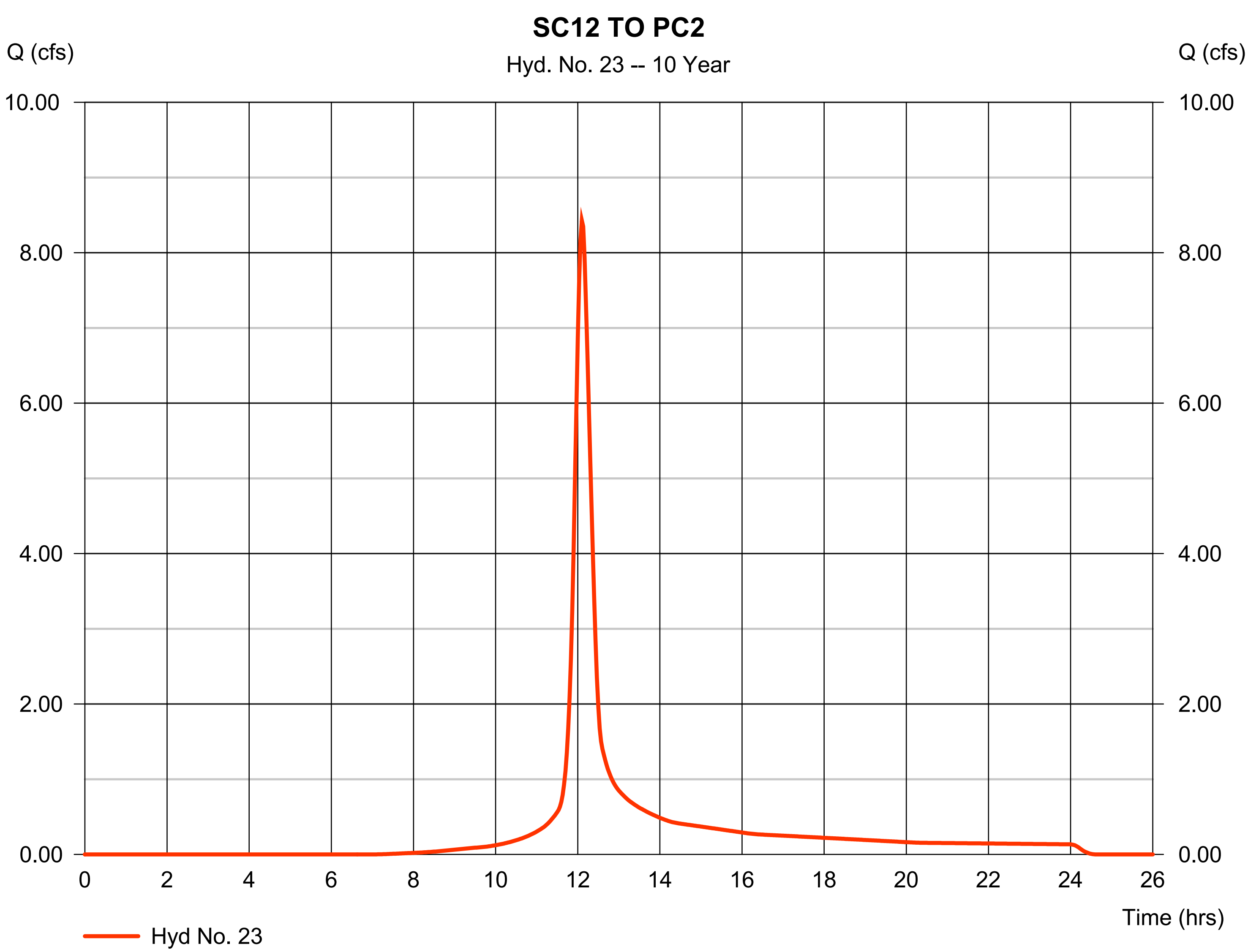
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 23

SC12 TO PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 8.428 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.10 hrs |
| Time interval | = 2 min | Hyd. volume | = 29,098 cuft |
| Drainage area | = 2.420 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 21.40 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 23

SC12 TO PC2

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | = | 0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 0.40 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.070 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | = | 1.28 | | 0.00 | | 0.00 | | |
| Flow length (ft) | | ({0})1350.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **17.60** | **+** | **0.00** | **+** | **0.00** | **=** | **17.60** |

**Total Travel Time, Tc ........................................................................ 21.40 min**

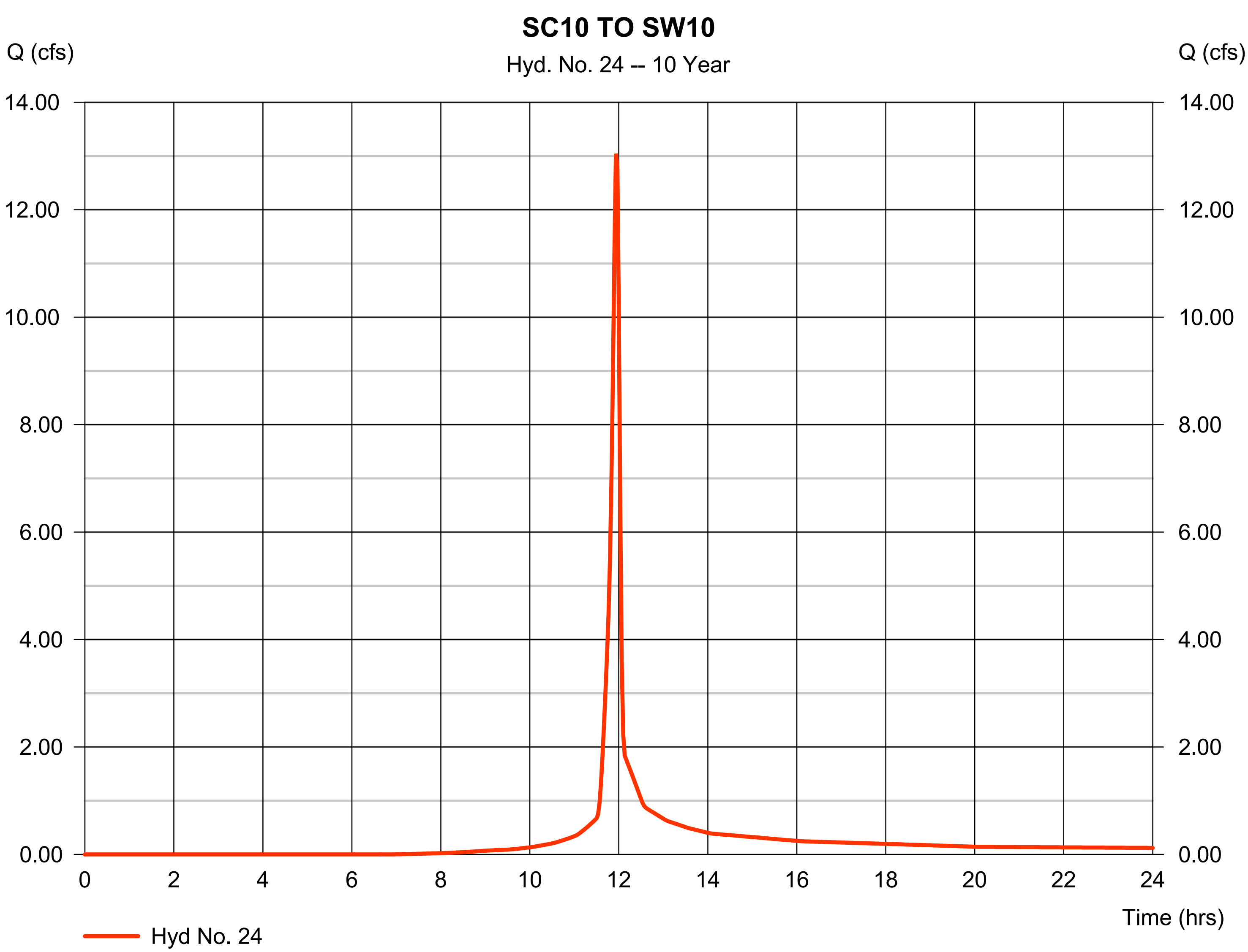
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 24

SC10 TO SW10

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 13.05 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 26,579 cuft |
| Drainage area | = 2.400 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.20 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 24

SC10 TO SW10

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Unpaved | | Paved | | Paved | | |
| Average velocity (ft/s) | = | 0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | = | 7.41 | | 0.00 | | 0.00 | | |
| Flow length (ft) | ({0}) | 1048.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **2.36** | **+** | **0.00** | **+** | **0.00** | **=** | **2.36** |

**Total Travel Time, Tc .......................................................................... 6.20 min**

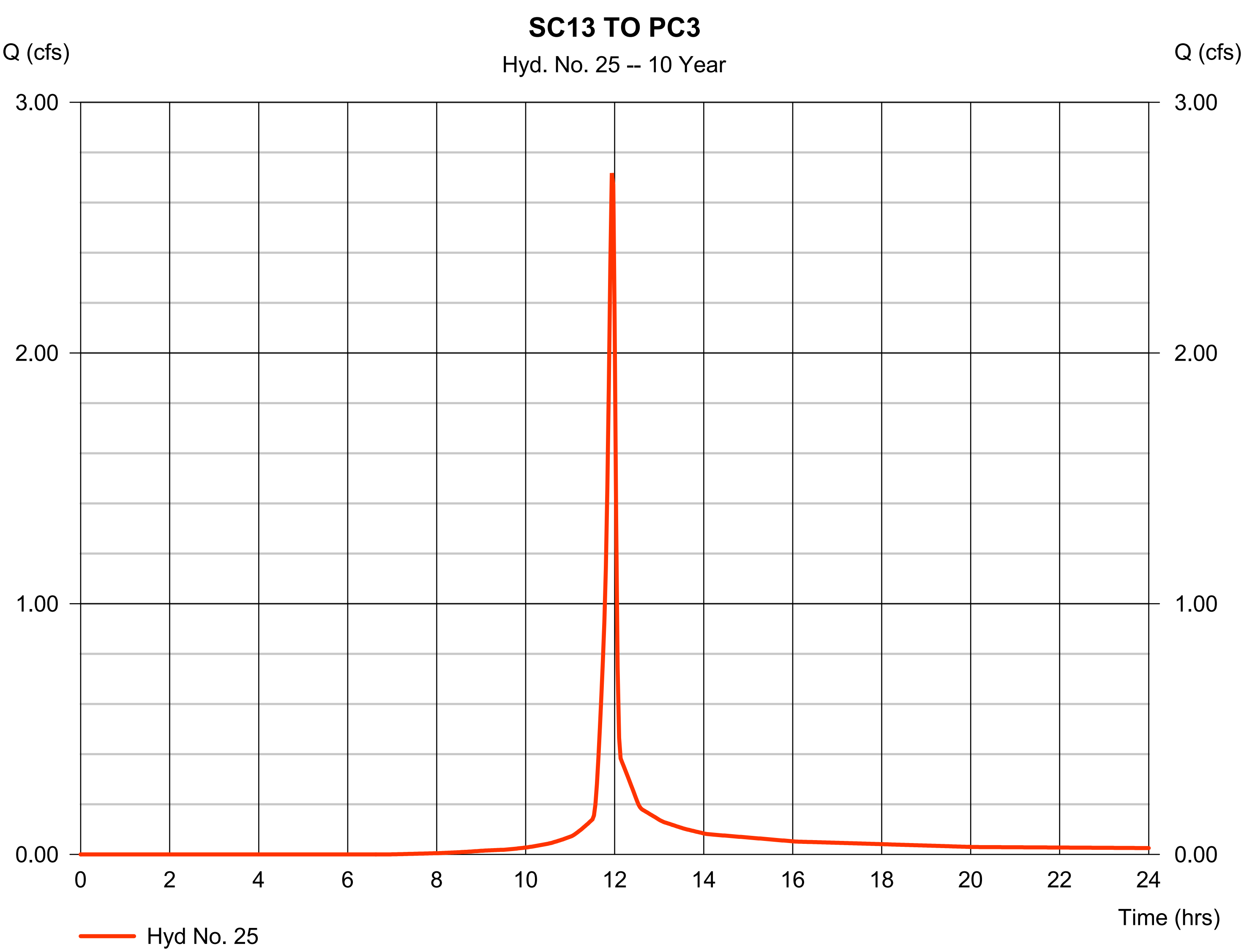
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 25

SC13 TO PC3

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 2.718 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 5,537 cuft |
| Drainage area | = 0.500 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 3.90 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 25

SC13 TO PC3

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 6.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.070 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =4.95 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})0.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |

**Total Travel Time, Tc .......................................................................... 3.90 min**

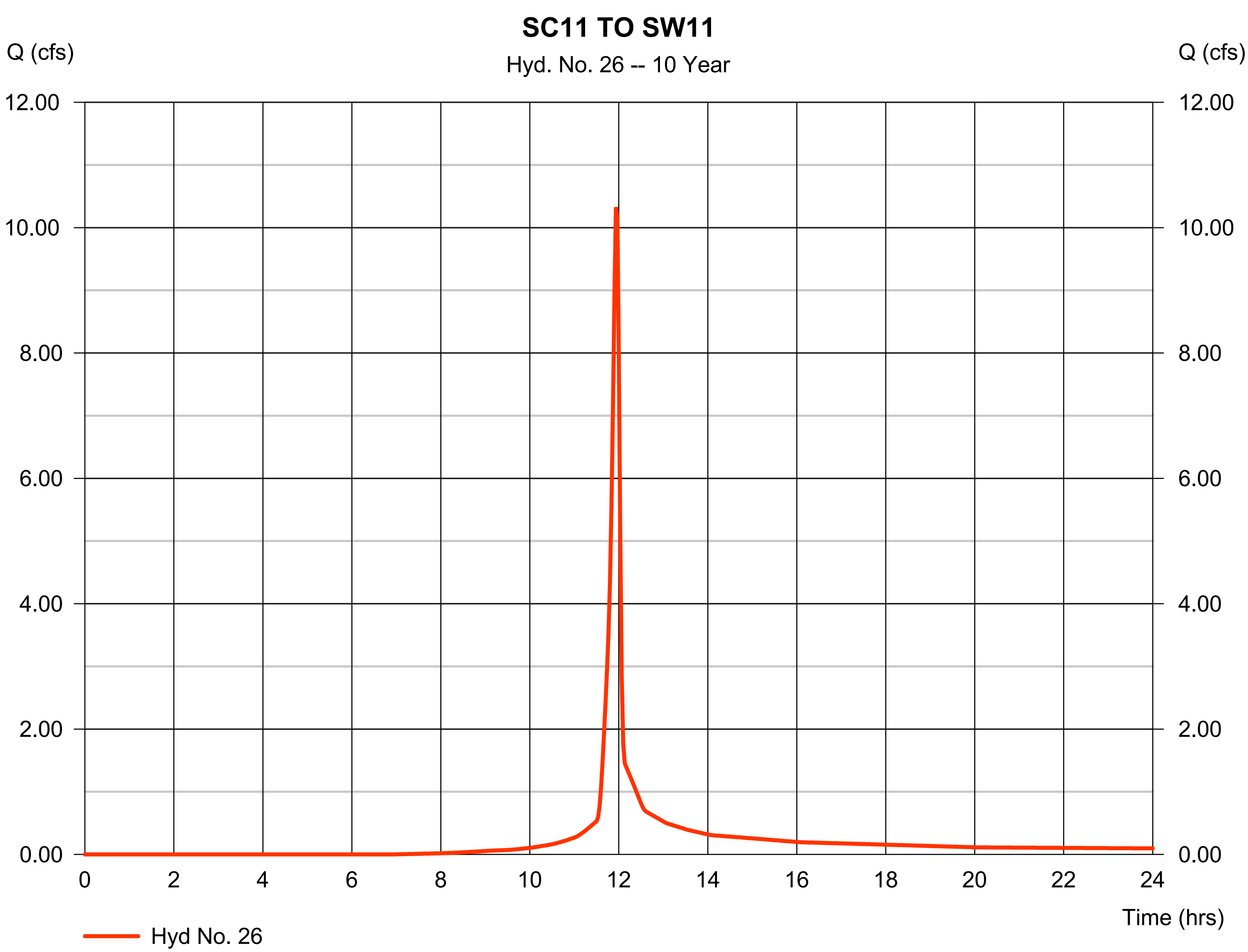
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 26

SC11 TO SW11

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 10.33 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 21,042 cuft |
| Drainage area | = 1.900 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 5.50 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 26

SC11 TO SW11

| Description | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | |
| Manning's n-value | = 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | |
| Flow length (ft) | = 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | |
| X sectional flow area (sqft) | = 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = 2.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = 0.027 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =7.41 | | 0.00 | | 0.00 | | |
| Flow length (ft) | ({0})747.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **= 1.68** | **+** | **0.00** | **+** | **0.00** | **=** | **1.68** |

**Total Travel Time, Tc ..........................................................................** **5.50 min**

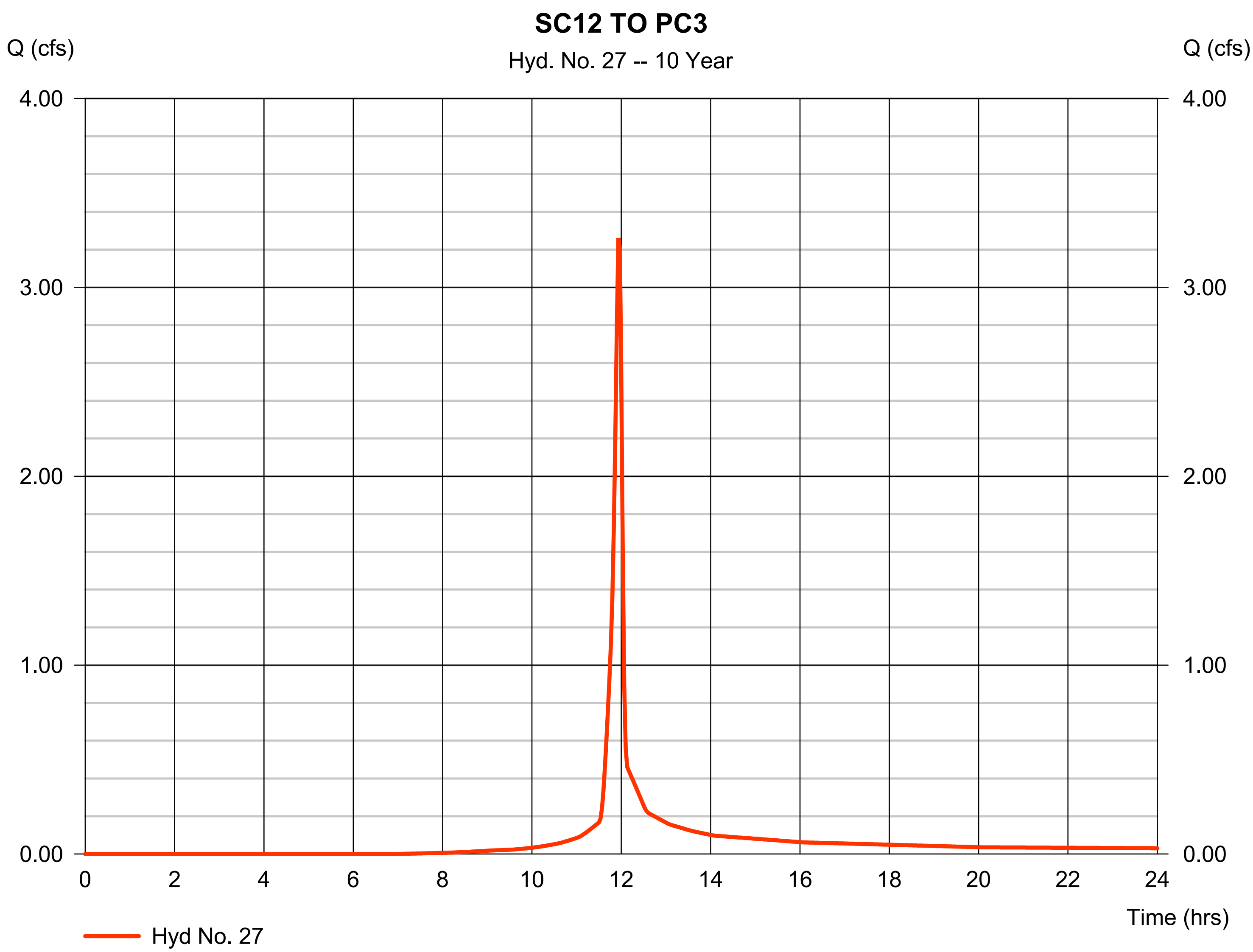
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 27

SC12 TO PC3

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 3.261 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 6,645 cuft |
| Drainage area | = 0.600 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 3.90 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 27

SC12 TO PC3

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 33.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **3.85** | **+** | **0.00** | **+** | **0.00** | **=** | **3.85** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | =0.00 | | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 6.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.070 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =4.95 | | | | | | | |
| | | | | 0.00 | | | | |
| | | | | | | 0.00 | | |
| Flow length (ft) | ({0})0.0 | | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |

**Total Travel Time, Tc ..........................................................................** **3.90 min**

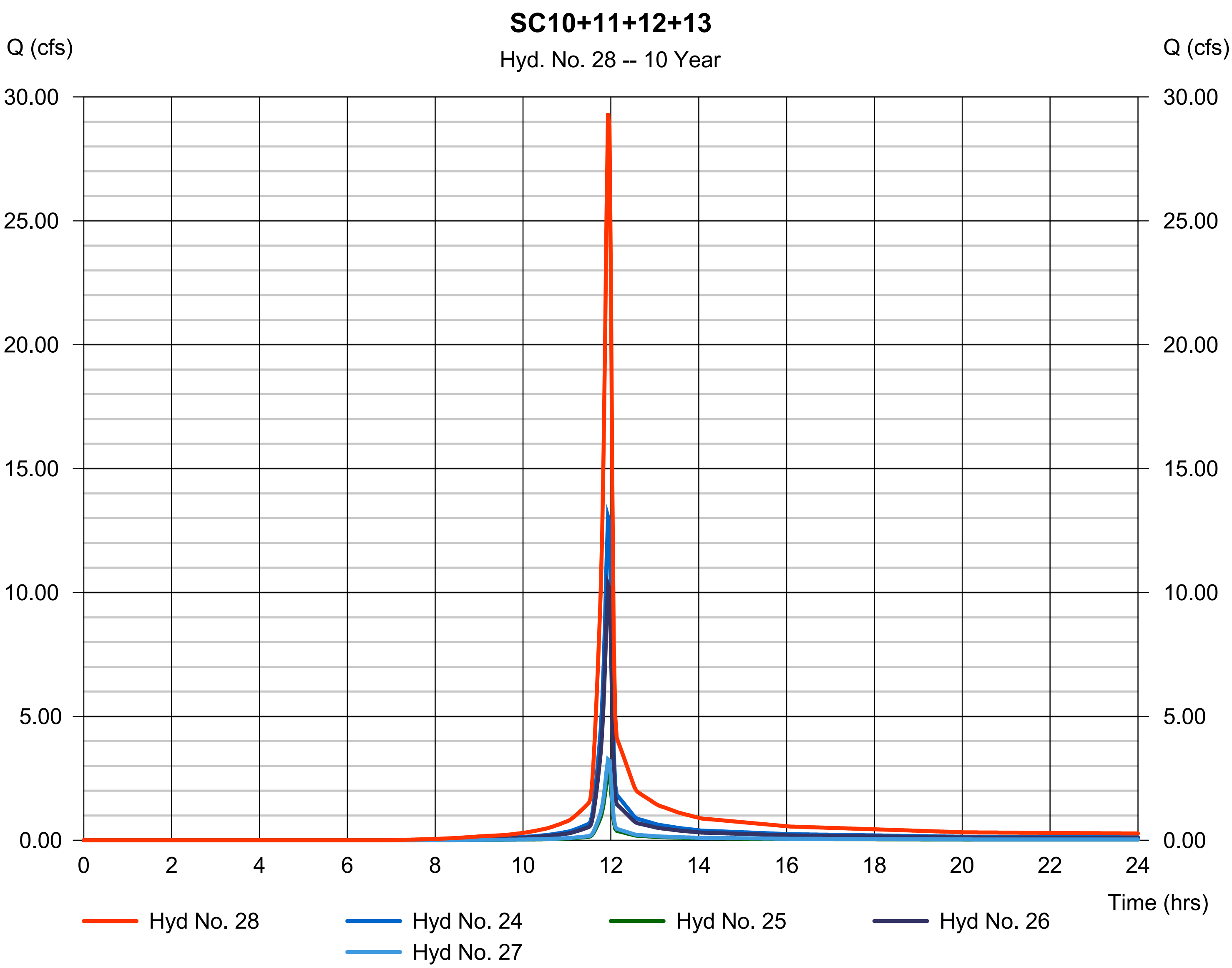
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 28

SC10+11+12+13

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 29.35 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 59,802 cuft |
| Inflow hyds. | = 24, 25, 26, 27 | Contrib. drain. area | = 5.400 ac |



# Hydrograph Report

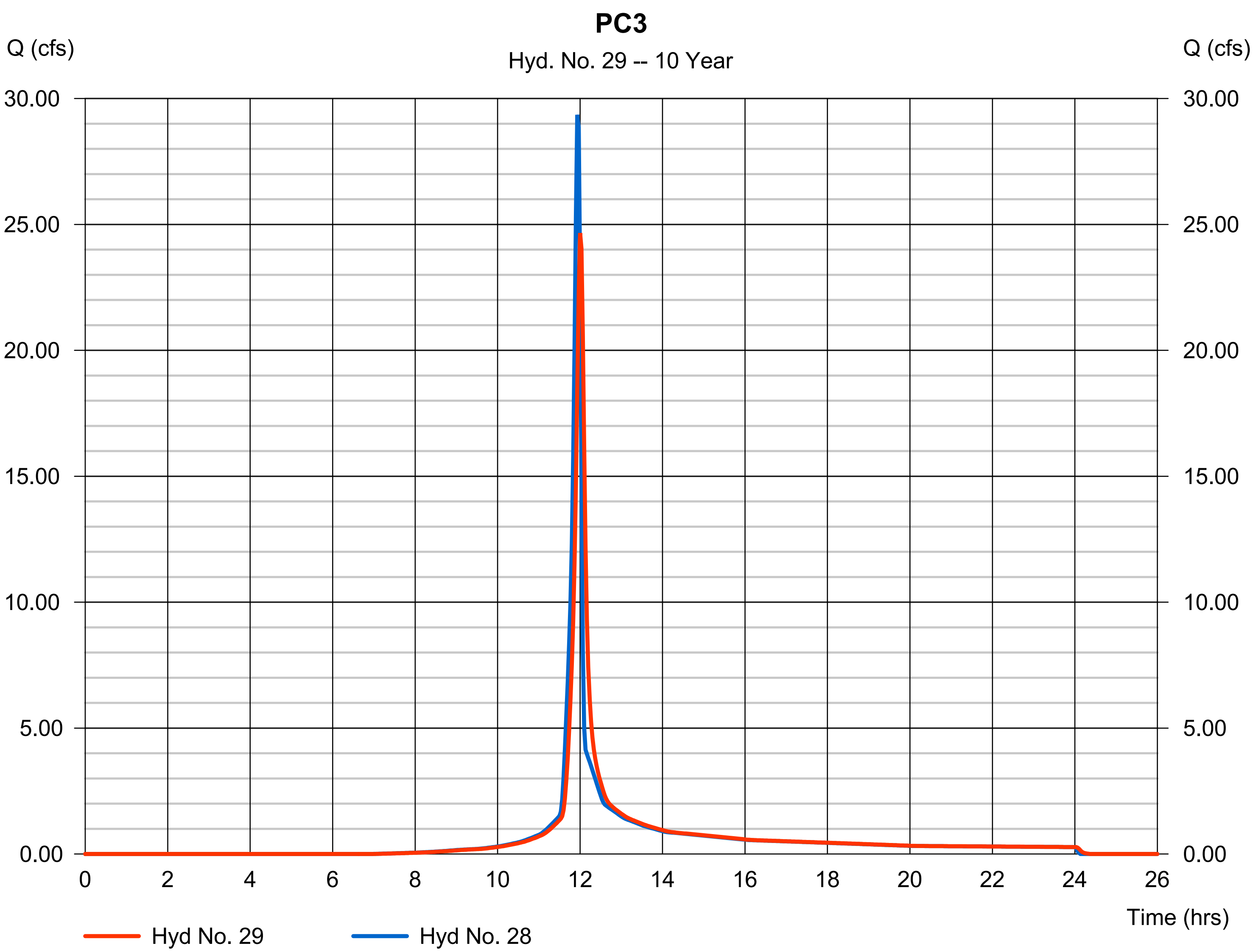
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 29

PC3

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 24.66 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 59,800 cuft |
| Inflow hyd. No. | = 28 - SC10+11+12+13 | Section type | = Trapezoidal |
| Reach length | = 1343.0 ft | Channel slope | = 6.0 % |
| Manning's n | = 0.070 | Bottom width | = 5.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 1.8 ft |
| Rating curve x | = 1.782 | Rating curve m | = 1.339 |
| Ave. velocity | = 3.62 ft/s | Routing coeff. | = 0.3562 |

Modified Att-Kin routing method used.



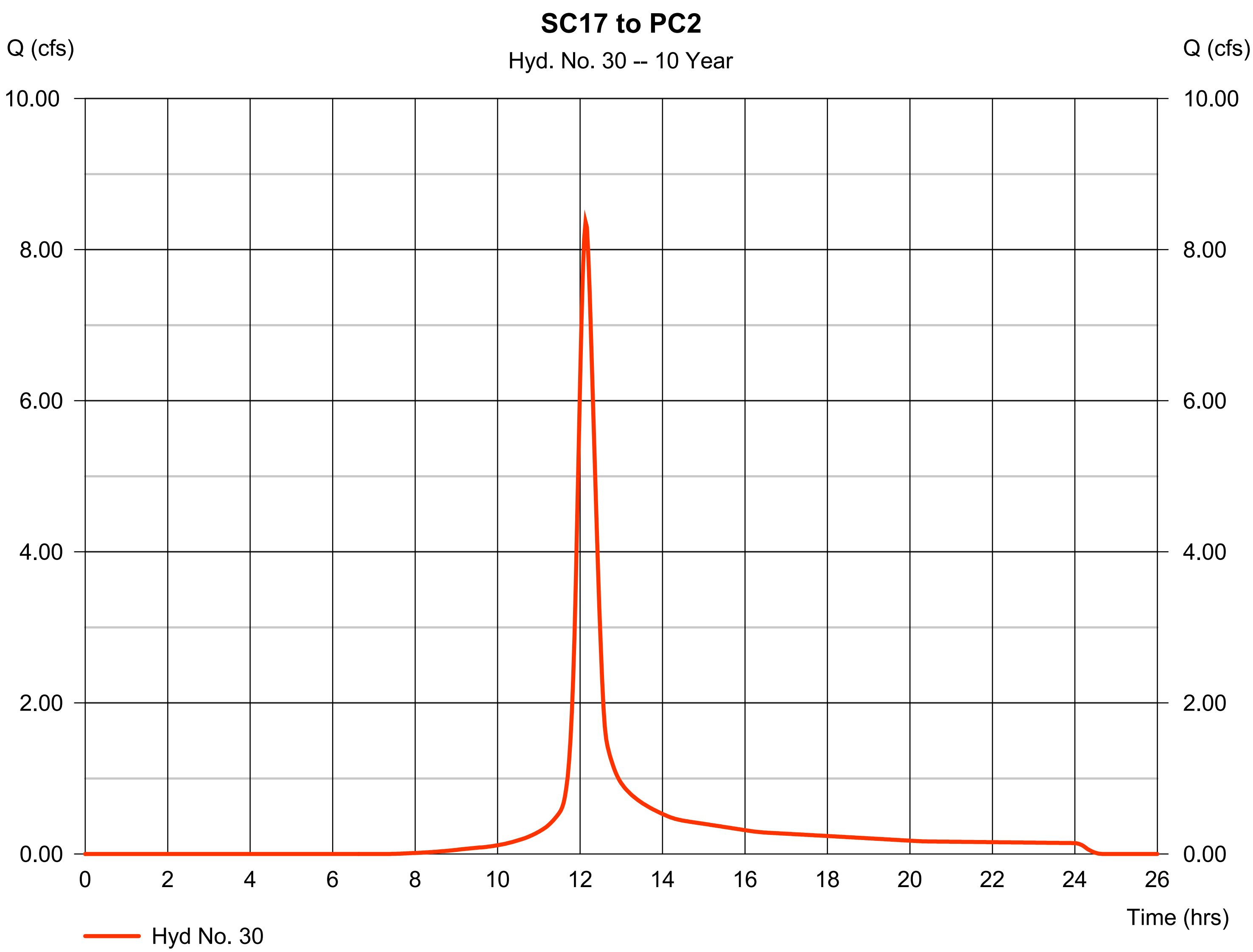
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 30

SC17 to PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 8.367 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.13 hrs |
| Time interval | = 2 min | Hyd. volume | = 30,697 cuft |
| Drainage area | = 2.720 ac | Curve number | = 78 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 24.30 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 30

SC17 to PC2

| Description | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | |
| Manning's n-value | = 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = 10.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 6.21** | **+** | **0.00** | **+** | **0.00** | **=** | **6.21** |
| **Shallow Concentrated Flow** | | | | | | | |
| Flow length (ft) | = 140.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = 10.00 | | 0.00 | | 0.00 | | |
| Surface description | = Unpaved | | Paved | | Paved | | |
| Average velocity (ft/s) | =5.10 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **= 0.46** | **+** | **0.00** | **+** | **0.00** | **=** | **0.46** |
| **Channel Flow** | | | | | | | |
| X sectional flow area (sqft) | = 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = 10.80 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = 0.40 | | 0.00 | | 0.00 | | |
| Manning's n-value | = 0.070 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | =1.28 | | 0.00 | | 0.00 | | |
| Flow length (ft) | ({0})1350.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **= 17.60** | **+** | **0.00** | **+** | **0.00** | **=** | **17.60** |

**Total Travel Time, Tc .............................................................................. 24.30 min**

# Hydrograph Report

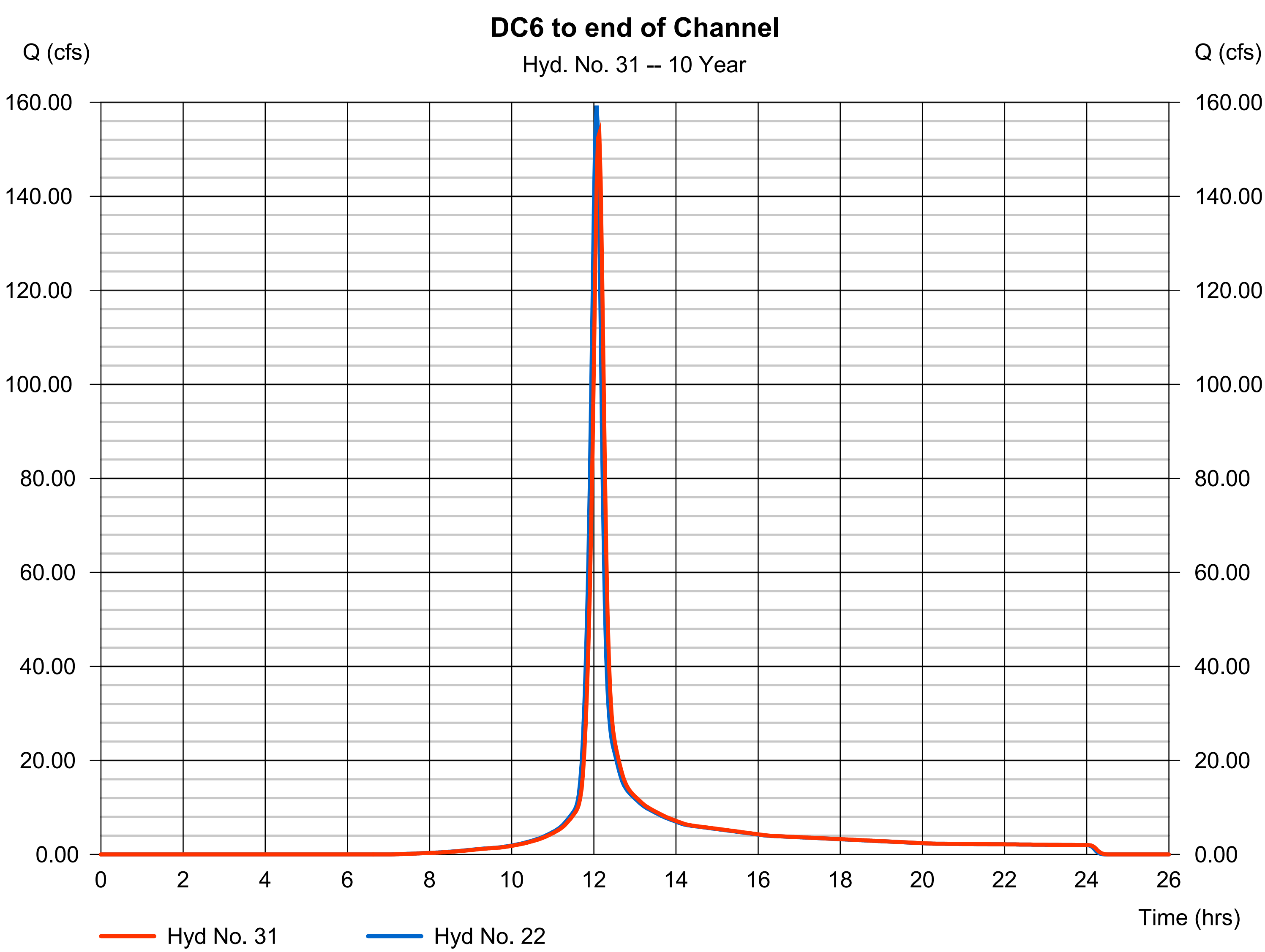
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 31

DC6 to end of Channel

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 153.31 cfs |
| Storm frequency | 100 yrs = 2 | Time to peak | = 12.13 hrs |
| Time interval | min = 22 - | Hyd. volume | = 428,803 cuft |
| Inflow hyd. No. | DC6 = | Section type | = Trapezoidal |
| Reach length | 700.0 ft = | Channel slope | = 2.0 % |
| Manning's n | 0.070 = | Bottom width | = 5.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.029 | Rating curve m | = 1.346 |
| Ave. velocity | = 3.76 ft/s | Routing coeff. | = 0.6047 |

Modified Att-Kin routing method used.



# Hydrograph Report

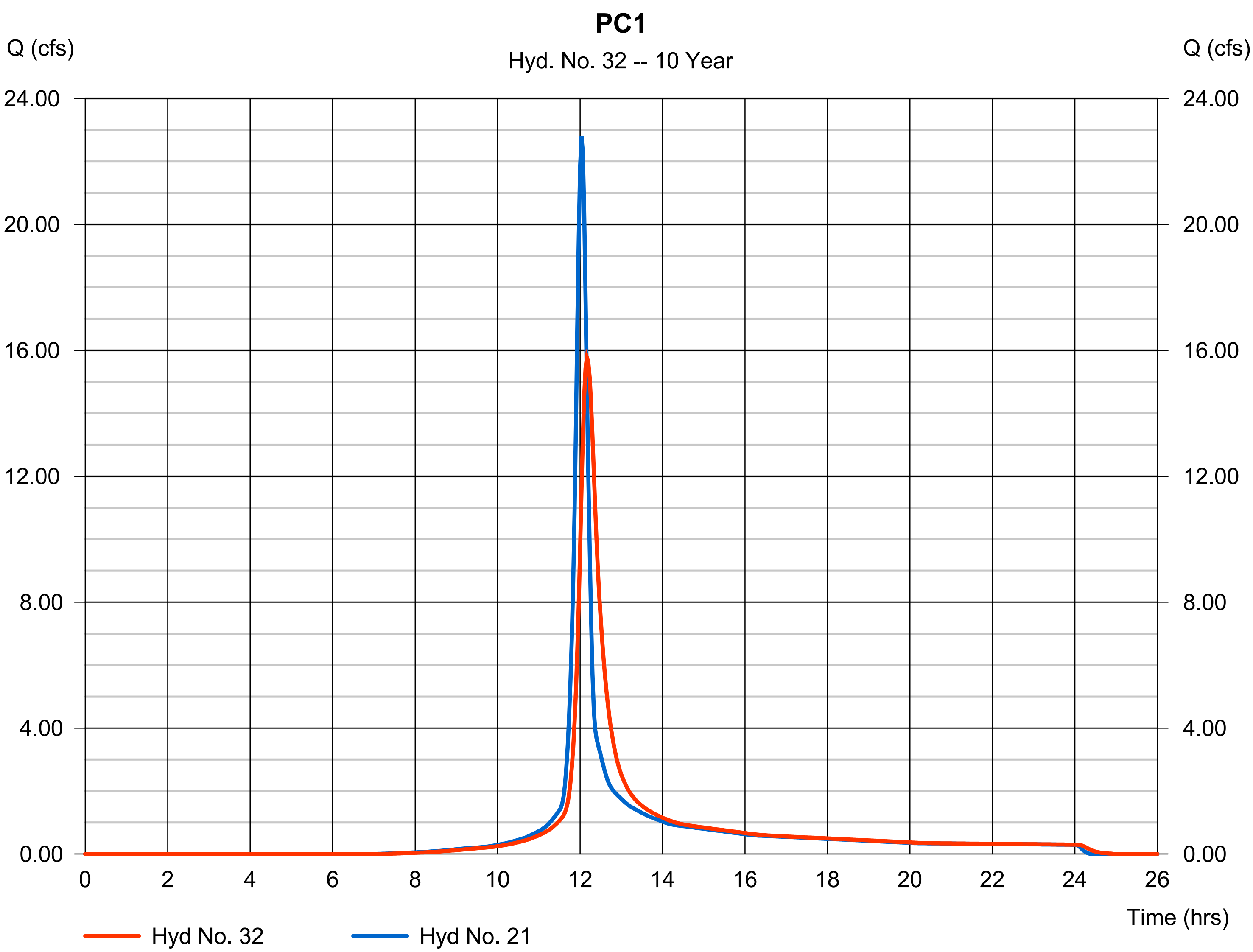


## Hyd. No. 32

PC1

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 15.77 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.17 hrs |
| Time interval | = 2 min | Hyd. volume | = 64,030 cuft |
| Inflow hyd. No. | = 21 - SC16 TO PC1 | Section type | = Trapezoidal |
| Reach length | = 2870.0 ft | Channel slope | = 3.7 % |
| Manning's n | = 0.070 | Bottom width | = 5.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.400 | Rating curve m | = 1.346 |
| Ave. velocity | = 2.87 ft/s | Routing coeff. | = 0.1492 |

Modified Att-Kin routing method used.



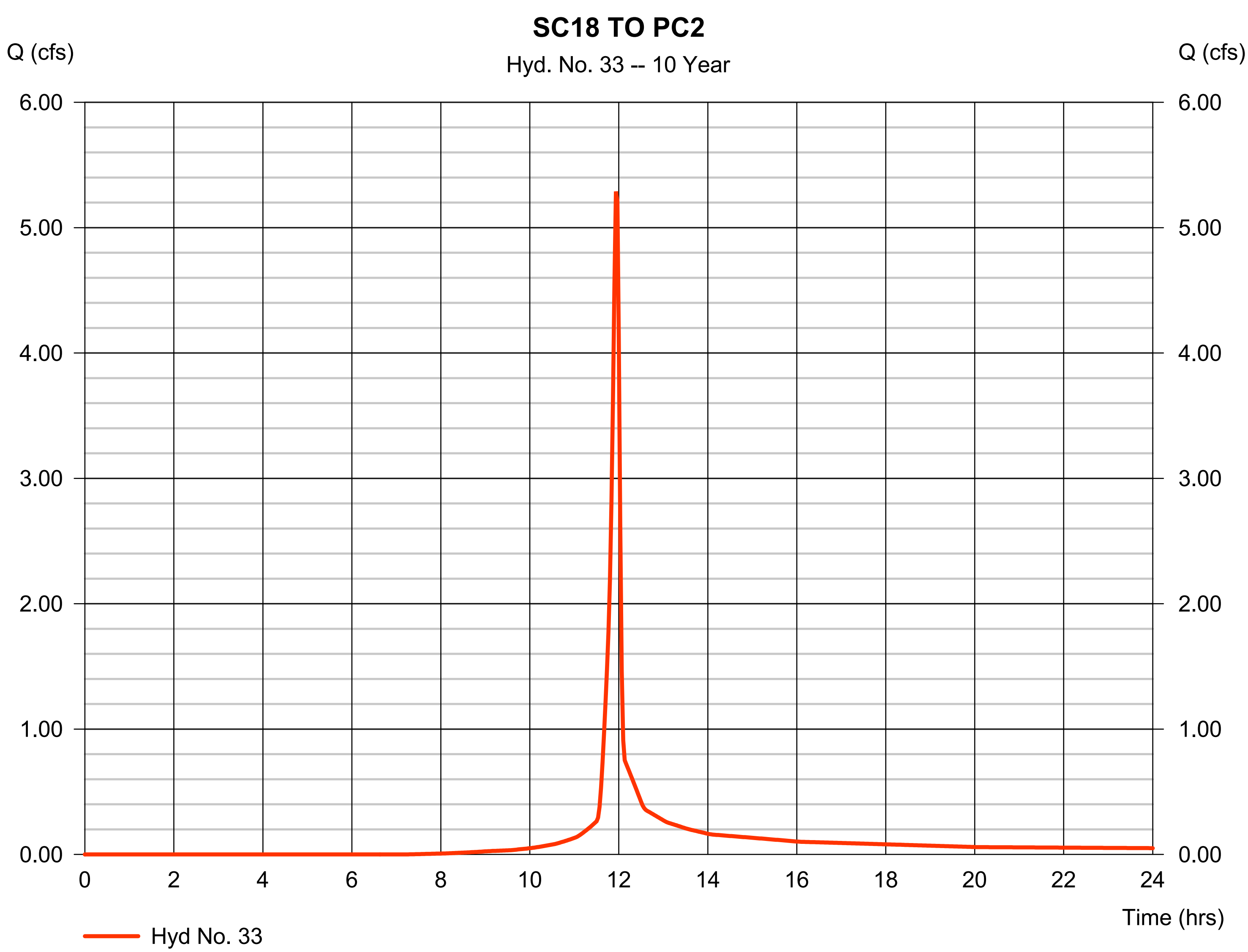
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 33

SC18 TO PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 5.289 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 10,748 cuft |
| Drainage area | = 1.000 ac | Curve number | = 78 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 5.80 min |
| Total precip. | = 5.52 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# TR55 Tc Worksheet



## Hyd. No. 33

SC18 TO PC2

| Description | | A | | B | | C | | Totals |
|---|---|---|---|---|---|---|---|---|
| **Sheet Flow** | | | | | | | | |
| Manning's n-value | = | 0.150 | | 0.011 | | 0.011 | | |
| Flow length (ft) | = | 100.0 | | 0.0 | | 0.0 | | |
| Two-year 24-hr precip. (in) | = | 2.20 | | 0.00 | | 0.00 | | |
| Land slope (%) | = | 12.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **5.77** | **+** | **0.00** | **+** | **0.00** | **=** | **5.77** |
| **Shallow Concentrated Flow** | | | | | | | | |
| Flow length (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Watercourse slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Surface description | = | Paved | | Paved | | Paved | | |
| Average velocity (ft/s) | = | 0.00 | | 0.00 | | 0.00 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |
| **Channel Flow** | | | | | | | | |
| X sectional flow area (sqft) | = | 10.00 | | 0.00 | | 0.00 | | |
| Wetted perimeter (ft) | = | 0.00 | | 0.00 | | 0.00 | | |
| Channel slope (%) | = | 0.00 | | 0.00 | | 0.00 | | |
| Manning's n-value | = | 0.015 | | 0.015 | | 0.015 | | |
| Velocity (ft/s) | = | 0.00 | | 0.00 | | 0.00 | | |
| Flow length (ft) | | ({0})0.0 | | 0.0 | | 0.0 | | |
| **Travel Time (min)** | **=** | **0.00** | **+** | **0.00** | **+** | **0.00** | **=** | **0.00** |

**Total Travel Time, Tc .............................................................................. 5.80 min**

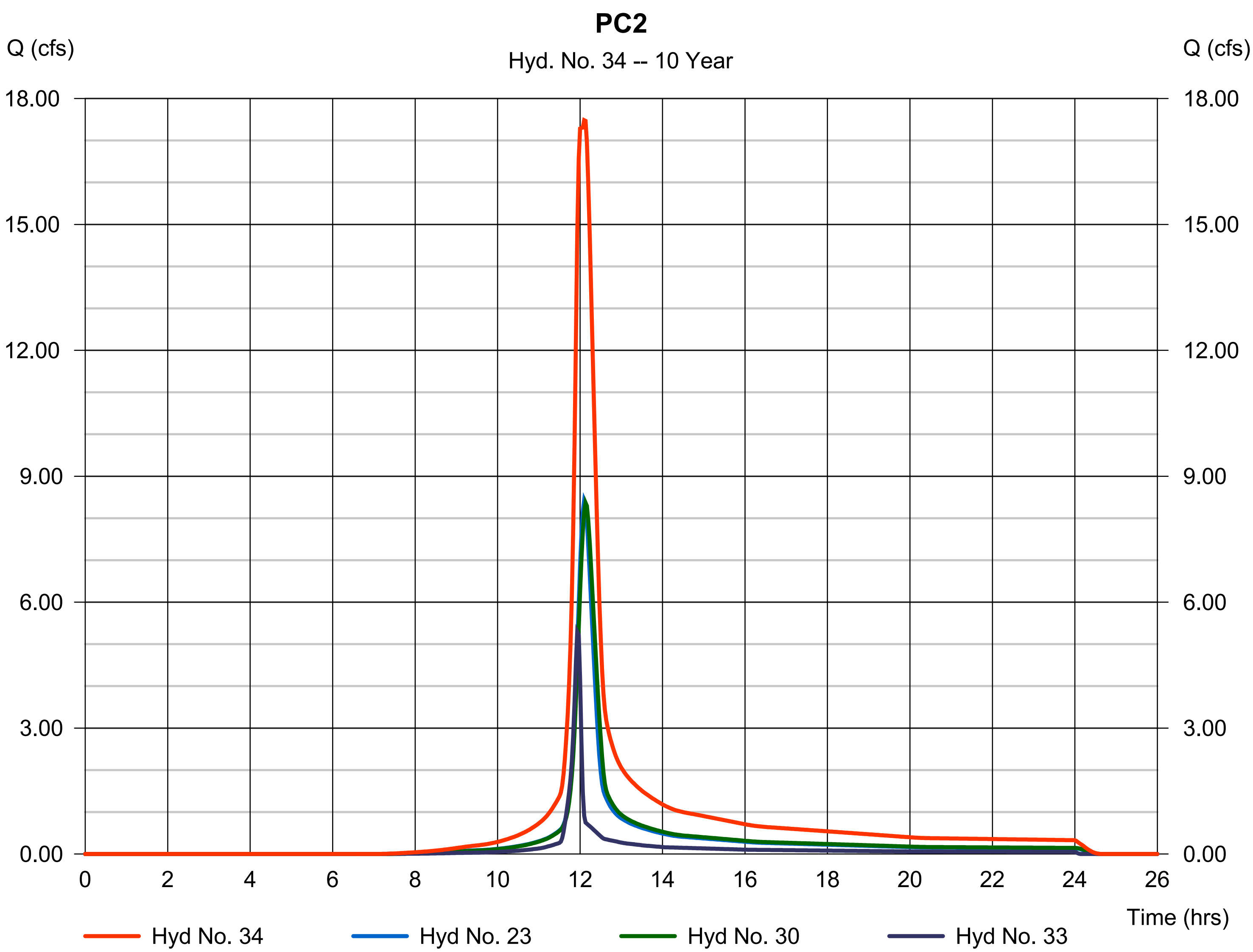
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 34

PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 17.48 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.10 hrs |
| Time interval | = 2 min | Hyd. volume | = 70,543 cuft |
| Inflow hyds. | = 23, 30, 33 | Contrib. drain. area | = 6.140 ac |



# Hydrograph Report

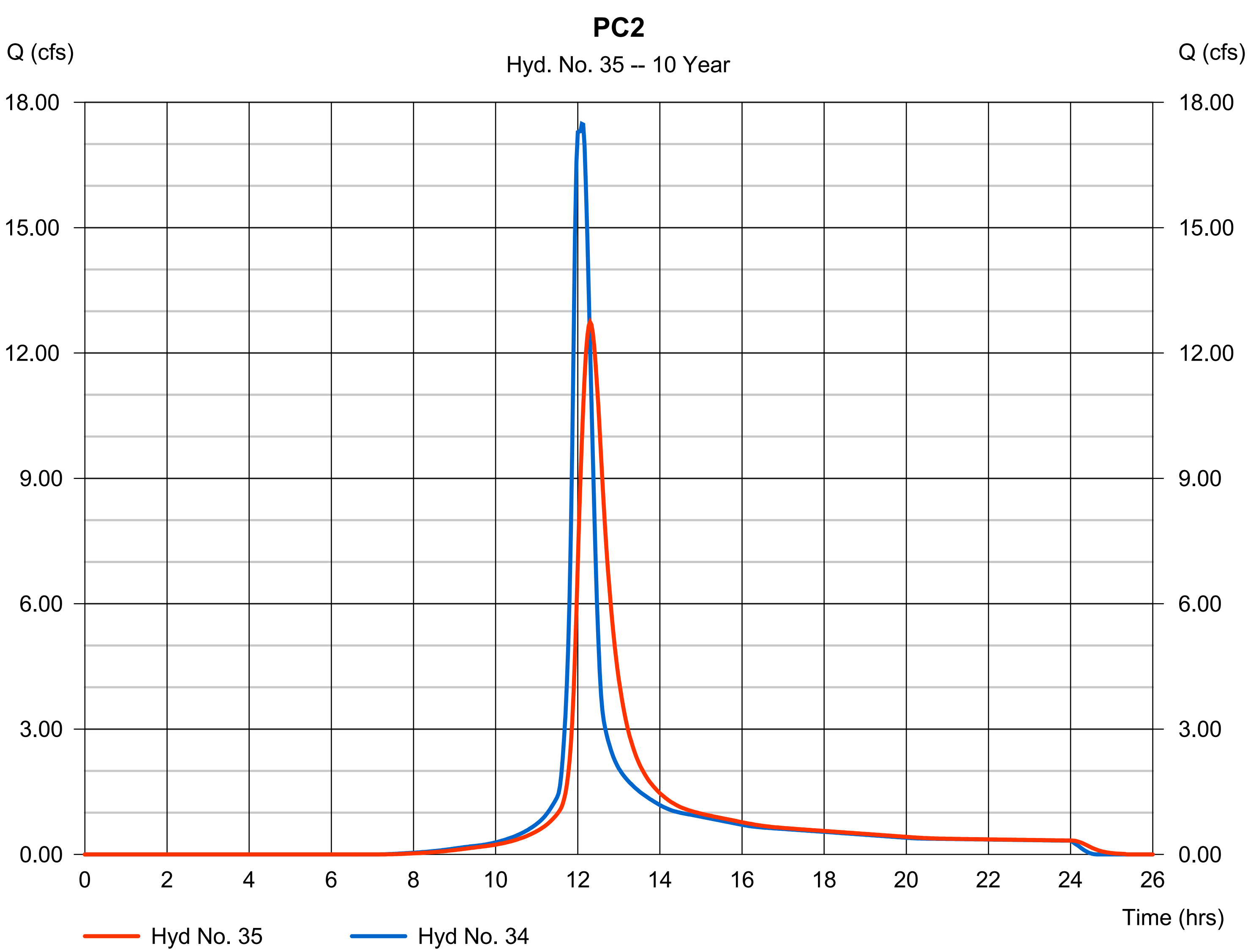
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 35

PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 12.74 cfs |
| Storm frequency | 100 yrs = 2 | Time to peak | = 12.30 hrs |
| Time interval | min = 34 - | Hyd. volume | = 70,532 cuft |
| Inflow hyd. No. | PC2 = | Section type | = Trapezoidal |
| Reach length | 1700.0 ft = | Channel slope | = 0.4 % |
| Manning's n | 0.070 = | Bottom width | = 5.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 0.460 | Rating curve m | = 1.346 |
| Ave. velocity | = 1.17 ft/s | Routing coeff. | = 0.1054 |

Modified Att-Kin routing method used.



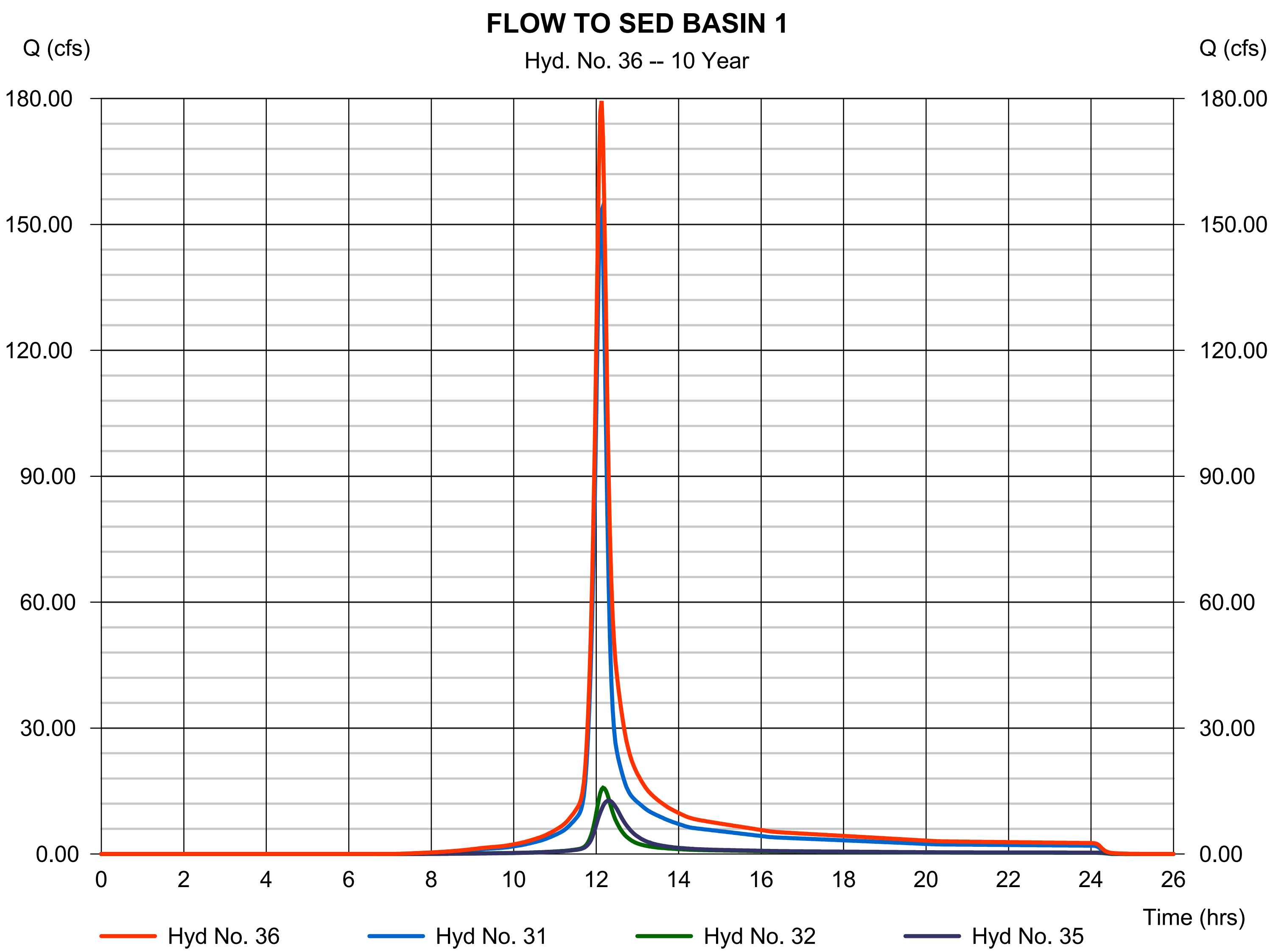
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 36

FLOW TO SED BASIN 1

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 179.43 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.13 hrs |
| Time interval | = 2 min | Hyd. volume | = 563,366 cuft |
| Inflow hyds. | = 31, 32, 35 | Contrib. drain. area | = 0.000 ac |



# 500-Year Storm

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| Hyd. No. | Hydrograph type (origin) | Peak flow (cfs) | Time interval (min) | Time to Peak (min) | Hyd. volume (cuft) | Inflow hyd(s) | Maximum elevation (ft) | Total strge used (cuft) | Hydrograph Description |
|---|---|---|---|---|---|---|---|---|---|
| 1 | SCS Runoff | 21.76 | 2 | 720 | 56,952 | ------ | ------ | ------ | SC14 TO SW6 |
| 2 | SCS Runoff | 8.399 | 2 | 718 | 19,492 | ------ | ------ | ------ | SC15 TO DC |
| 3 | SCS Runoff | 16.00 | 2 | 720 | 41,877 | ------ | ------ | ------ | SC8 TO SW9 |
| 4 | Combine | 45.98 | 2 | 720 | 118,321 | 1, 2, 3 | ------ | ------ | DC1 |
| 5 | Reach | 45.46 | 2 | 722 | 118,320 | 4 | ------ | ------ | DC1 TO SC5 |
| 6 | SCS Runoff | 19.60 | 2 | 718 | 45,481 | ------ | ------ | ------ | SC5 TO SW5 |
| 7 | SCS Runoff | 38.49 | 2 | 718 | 89,337 | ------ | ------ | ------ | SC7 TO SW8 |
| 8 | Combine | 99.62 | 2 | 720 | 253,138 | 5, 6, 7 | ------ | ------ | DC2 |
| 9 | Reach | 99.98 | 2 | 722 | 253,138 | 8 | ------ | ------ | DC2 TO SC4 |
| 10 | SCS Runoff | 20.30 | 2 | 718 | 47,105 | ------ | ------ | ------ | SC4 TO SW4 |
| 11 | SCS Runoff | 44.16 | 2 | 720 | 115,580 | ------ | ------ | ------ | SC6 TO SW7 |
| 12 | Combine | 160.51 | 2 | 720 | 415,823 | 9, 10, 11 | ------ | ------ | DC3 |
| 13 | Reach | 162.71 | 2 | 722 | 415,823 | 12 | ------ | ------ | DC3 TO SC3 |
| 14 | SCS Runoff | 21.00 | 2 | 718 | 48,729 | ------ | ------ | ------ | SC3 TO SW3 |
| 15 | Combine | 180.37 | 2 | 722 | 464,553 | 13, 14 | ------ | ------ | DC4 |
| 16 | Reach | 181.93 | 2 | 724 | 464,552 | 15 | ------ | ------ | DC4 TO SC2 |
| 17 | SCS Runoff | 23.10 | 2 | 718 | 53,602 | ------ | ------ | ------ | SC2 TO SW2 |
| 18 | Combine | 196.82 | 2 | 724 | 518,154 | 16, 17 | ------ | ------ | DC5 |
| 19 | Reach | 199.61 | 2 | 724 | 518,154 | 18 | ------ | ------ | DC5 TO SW1 |
| 20 | SCS Runoff | 30.80 | 2 | 718 | 71,470 | ------ | ------ | ------ | SC1 TO SW1 |
| 21 | SCS Runoff | 31.15 | 2 | 722 | 88,054 | ------ | ------ | ------ | SC16 TO PC1 |
| 22 | Combine | 219.46 | 2 | 724 | 589,624 | 19, 20, | ------ | ------ | DC6 |
| 23 | SCS Runoff | 11.55 | 2 | 726 | 40,010 | ------ | ------ | ------ | SC12 TO PC2 |
| 24 | SCS Runoff | 17.73 | 2 | 716 | 36,547 | ------ | ------ | ------ | SC10 TO SW10 |
| 25 | SCS Runoff | 3.693 | 2 | 716 | 7,614 | ------ | ------ | ------ | SC13 TO PC3 |
| 26 | SCS Runoff | 14.03 | 2 | 716 | 28,933 | ------ | ------ | ------ | SC11 TO SW11 |
| 27 | SCS Runoff | 4.432 | 2 | 716 | 9,137 | ------ | ------ | ------ | SC12 TO PC3 |
| 28 | Combine | 39.89 | 2 | 716 | 82,231 | 24, 25, 26, 27 | ------ | ------ | SC10+11+12+13 |
| 29 | Reach | 34.26 | 2 | 720 | 82,229 | 28 | ------ | ------ | PC3 |
| 30 | SCS Runoff | 11.55 | 2 | 728 | 42,436 | ------ | ------ | ------ | SC17 to PC2 |
| 31 | Reach | 212.41 | 2 | 726 | 589,624 | 22 | ------ | ------ | DC6 to end of Channel |
| 32 | Reach | 22.29 | 2 | 730 | 88,047 | 21 | ------ | ------ | PC1 |
| 33 | SCS Runoff | 7.232 | 2 | 716 | 14,858 | ------ | ------ | ------ | SC18 TO PC2 |
| 34 | Combine | 24.05 | 2 | 726 | 97,304 | 23, 30, 33 | ------ | ------ | PC2 |

| Hydrograph_Rev2.gpw | Return Period: 500 Year | Tuesday, 08 / 4 / 2020 |
|---|---|---|

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| Hyd. No. | Hydrograph type (origin) | Peak flow (cfs) | Time interval (min) | Time to Peak (min) | Hyd. volume (cuft) | Inflow hyd(s) | Maximum elevation (ft) | Total strge used (cuft) | Hydrograph Description |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Reach | 18.08 | 2 | 738 | 97,294 | 34 | ------ | ------ | PC2 |
| 36 | Combine | 248.11 | 2 | 728 | 774,964 | 31, 32, 35 | ------ | ------ | FLOW TO SED BASIN 1 |

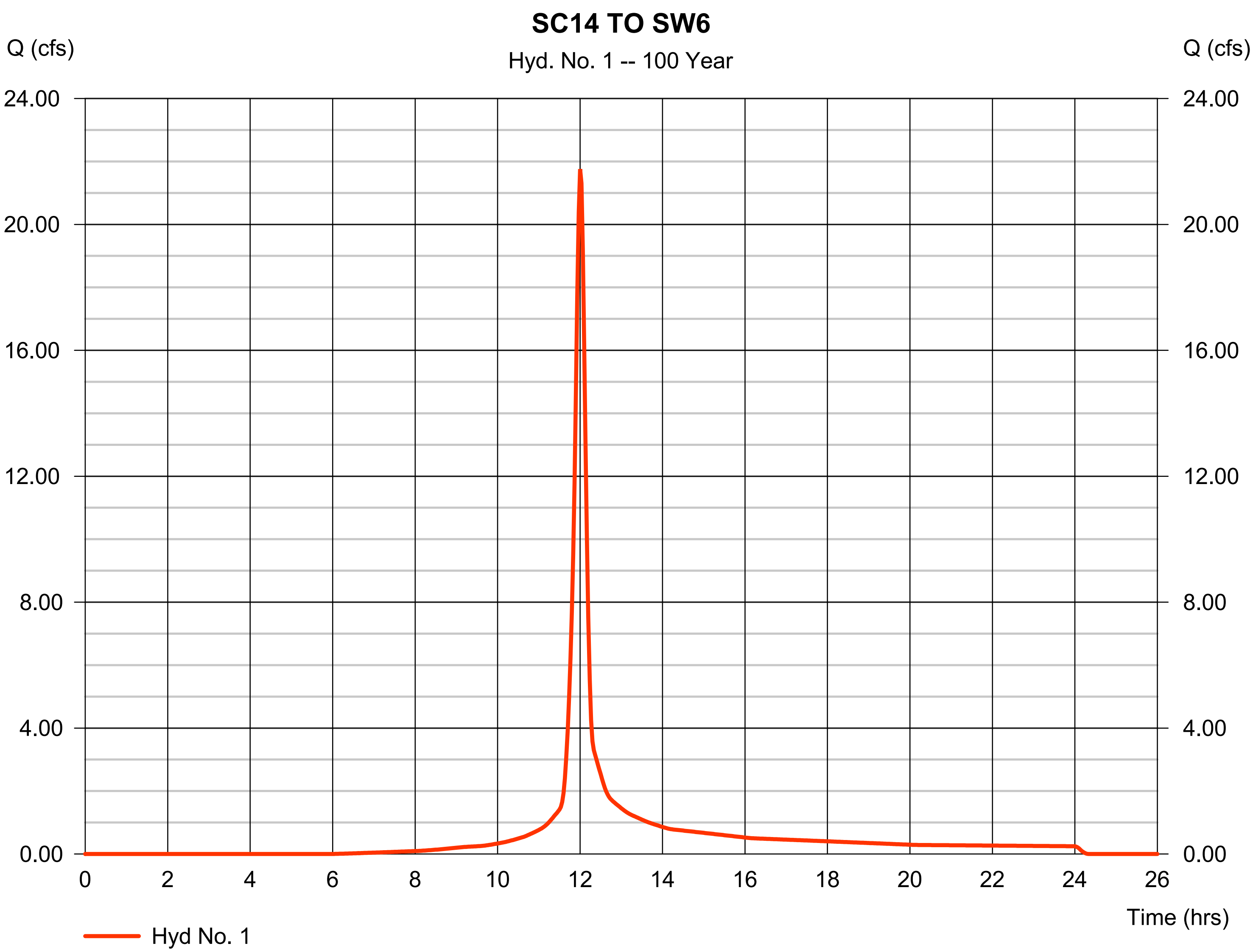
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 1

SC14 TO SW6

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 21.76 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 56,952 cuft |
| Drainage area | = 3.400 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 11.80 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



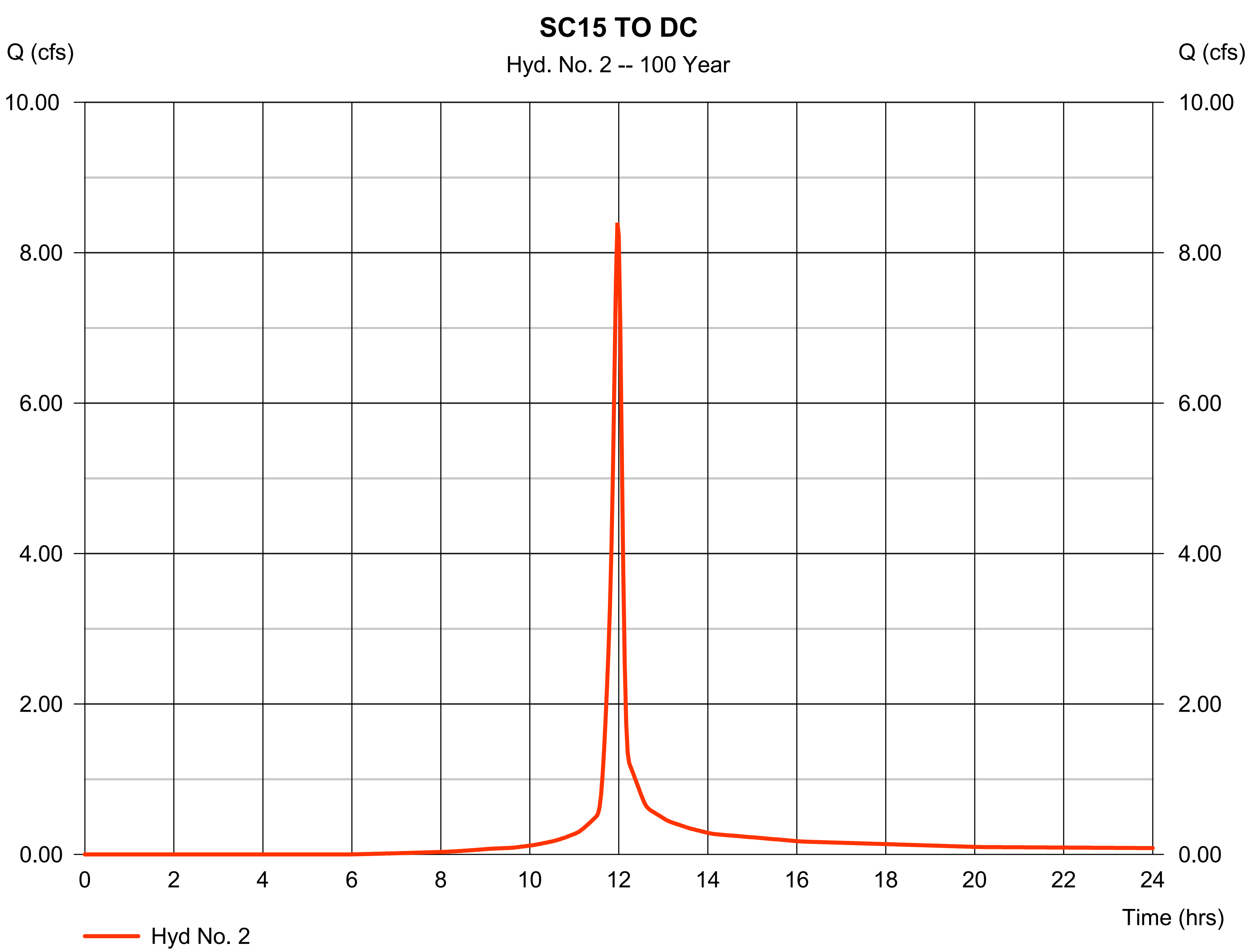
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 2

SC15 TO DC

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 8.399 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 19,492 cuft |
| Drainage area | = 1.200 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 9.30 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



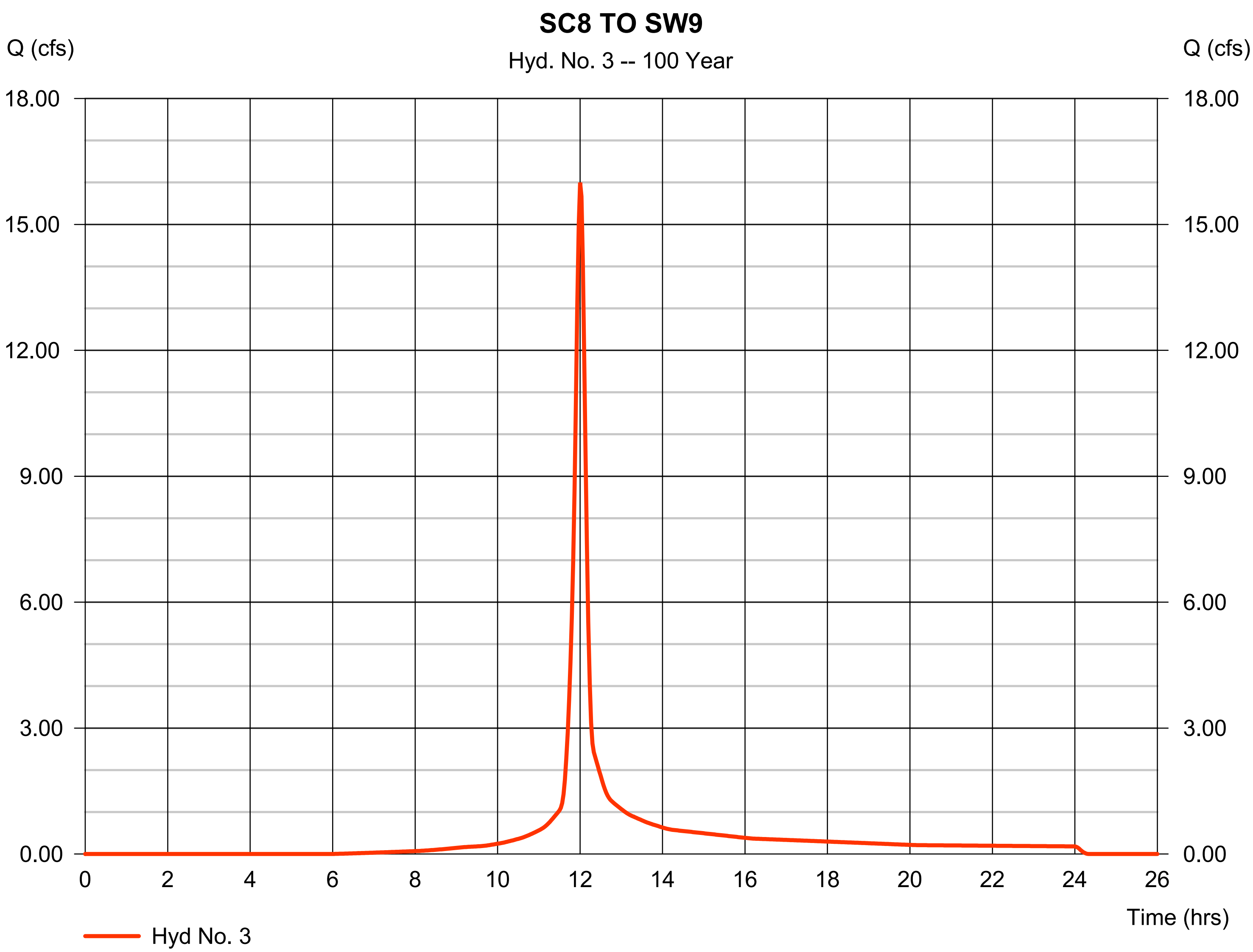
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 3

SC8 TO SW9

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 16.00 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 41,877 cuft |
| Drainage area | = 2.500 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 11.50 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



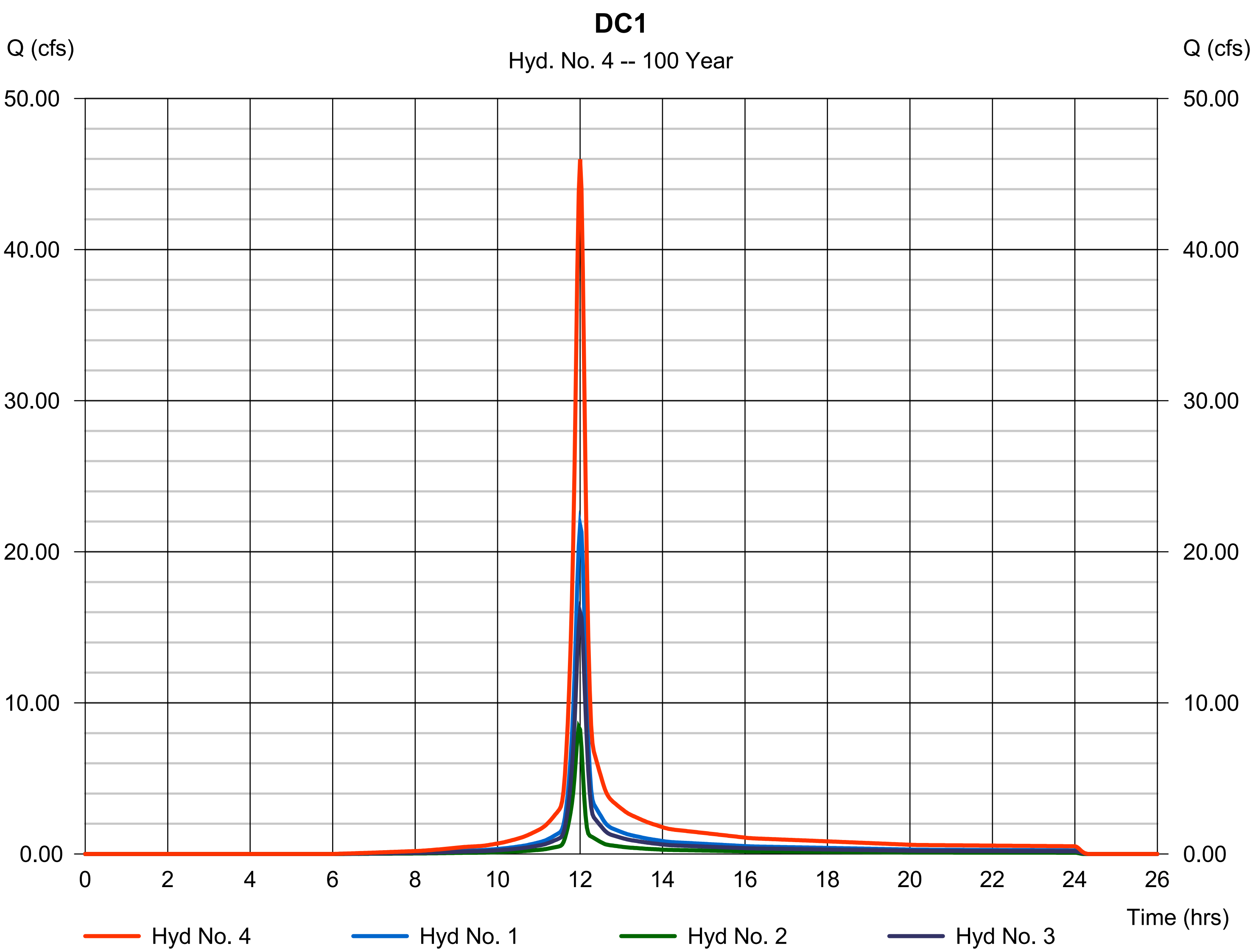
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 4

DC1

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 45.98 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.00 hrs |
| Time interval | 2 min = 1, | Hyd. volume | = 118,321 cuft |
| Inflow hyds. | 2, 3 | Contrib. drain. area | = 7.100 ac |



# Hydrograph Report

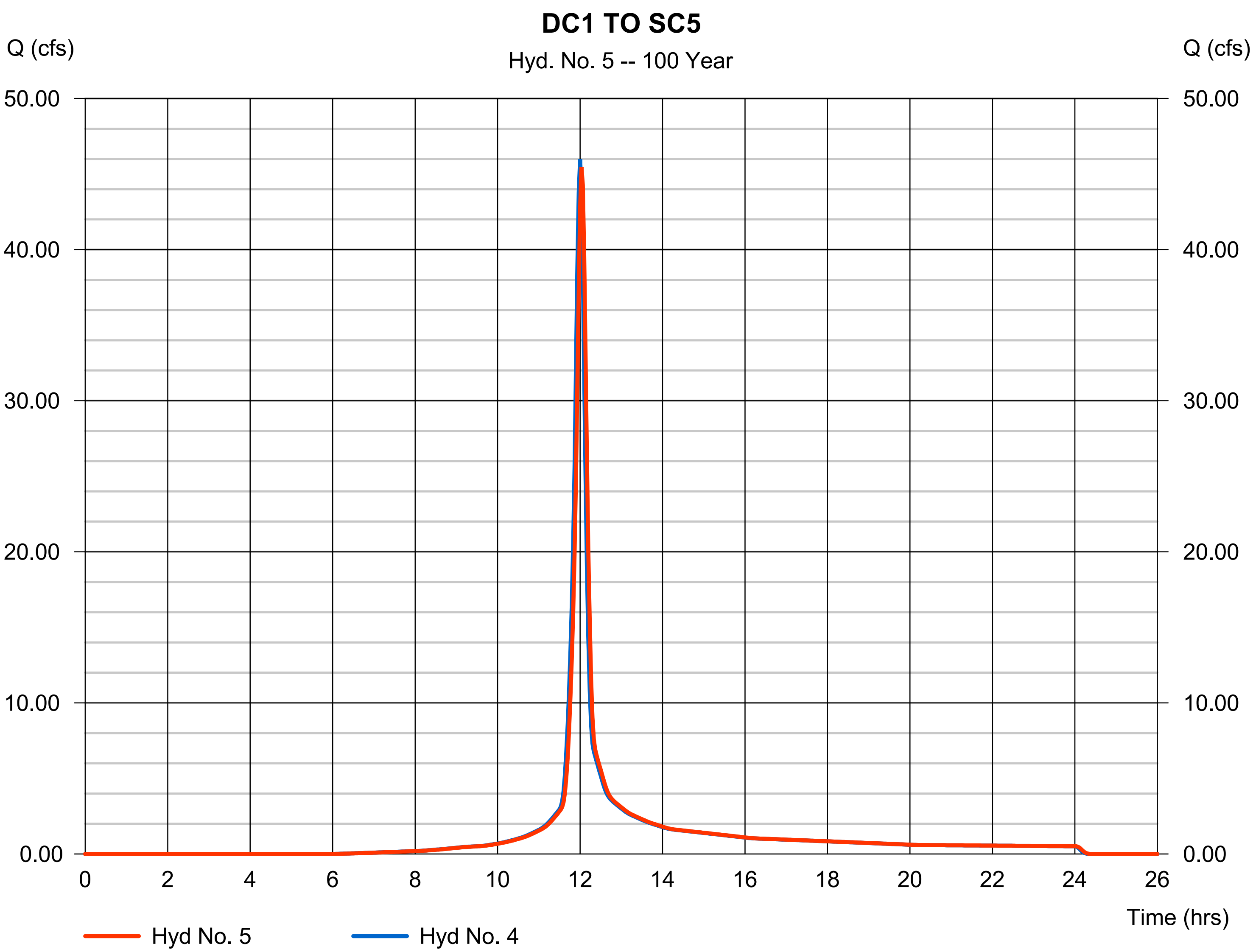
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 5

DC1 TO SC5

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 45.46 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.03 hrs |
| Time interval | = 2 min | Hyd. volume | = 118,320 cuft |
| Inflow hyd. No. | = 4 - DC1 | Section type | = Trapezoidal |
| Reach length | = 450.0 ft | Channel slope | = 10.0 % |
| Manning's n | = 0.070 | Bottom width | = 15.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 3.68 ft/s | Routing coeff. | = 0.8401 |

Modified Att-Kin routing method used.



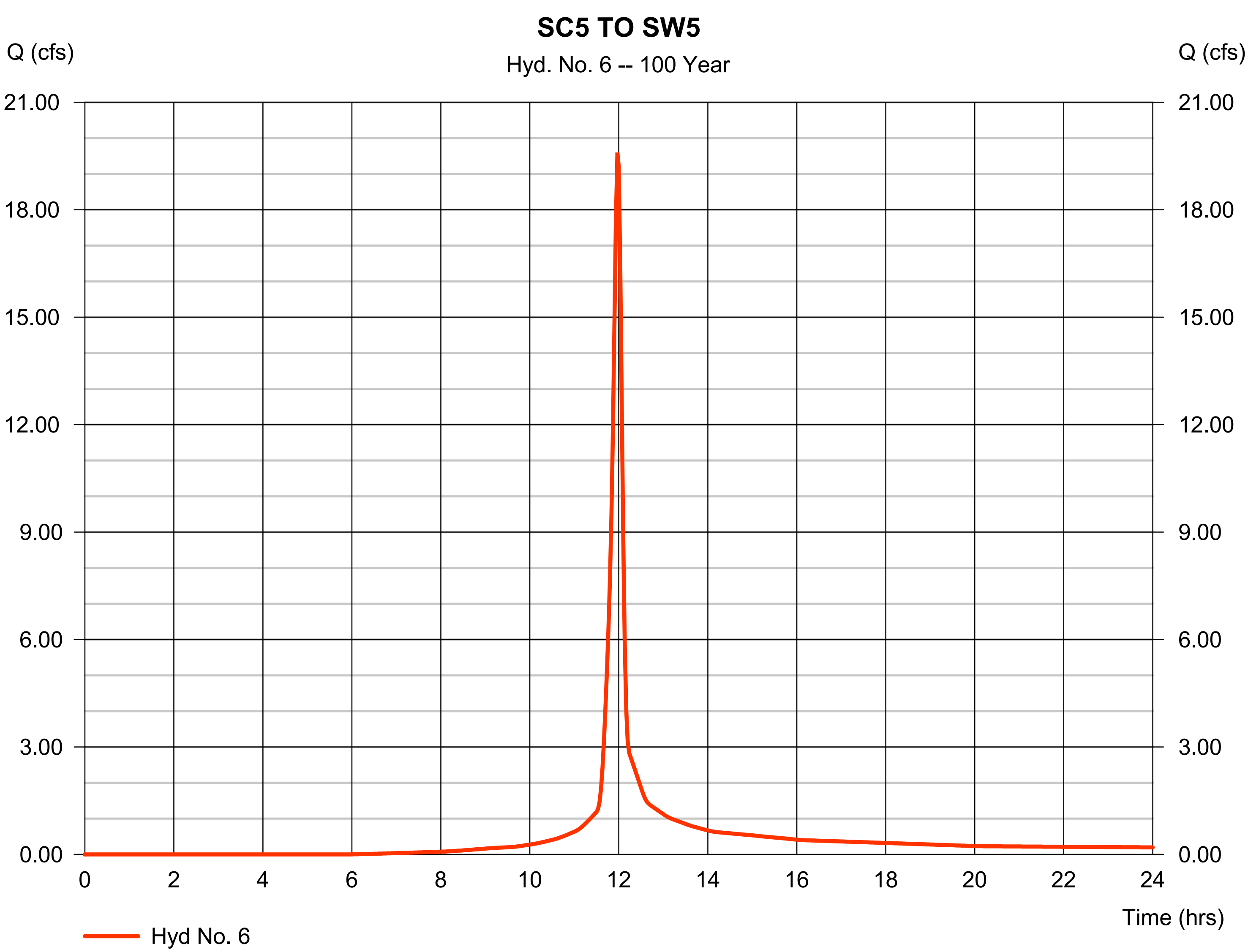
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 6

SC5 TO SW5

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 19.60 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 45,481 cuft |
| Drainage area | = 2.800 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.60 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



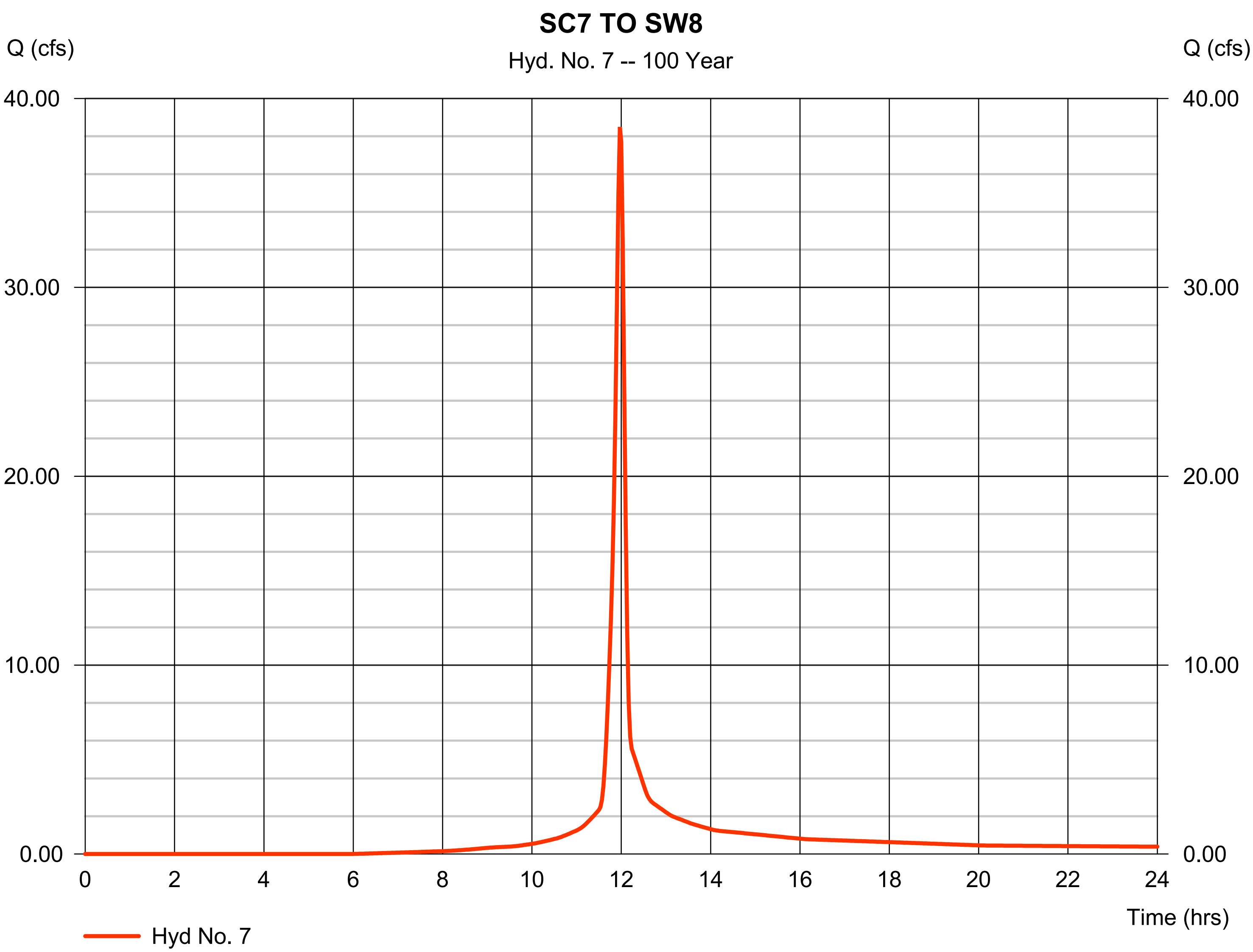
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 7

SC7 TO SW8

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 38.49 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 89,337 cuft |
| Drainage area | = 5.500 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 9.80 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



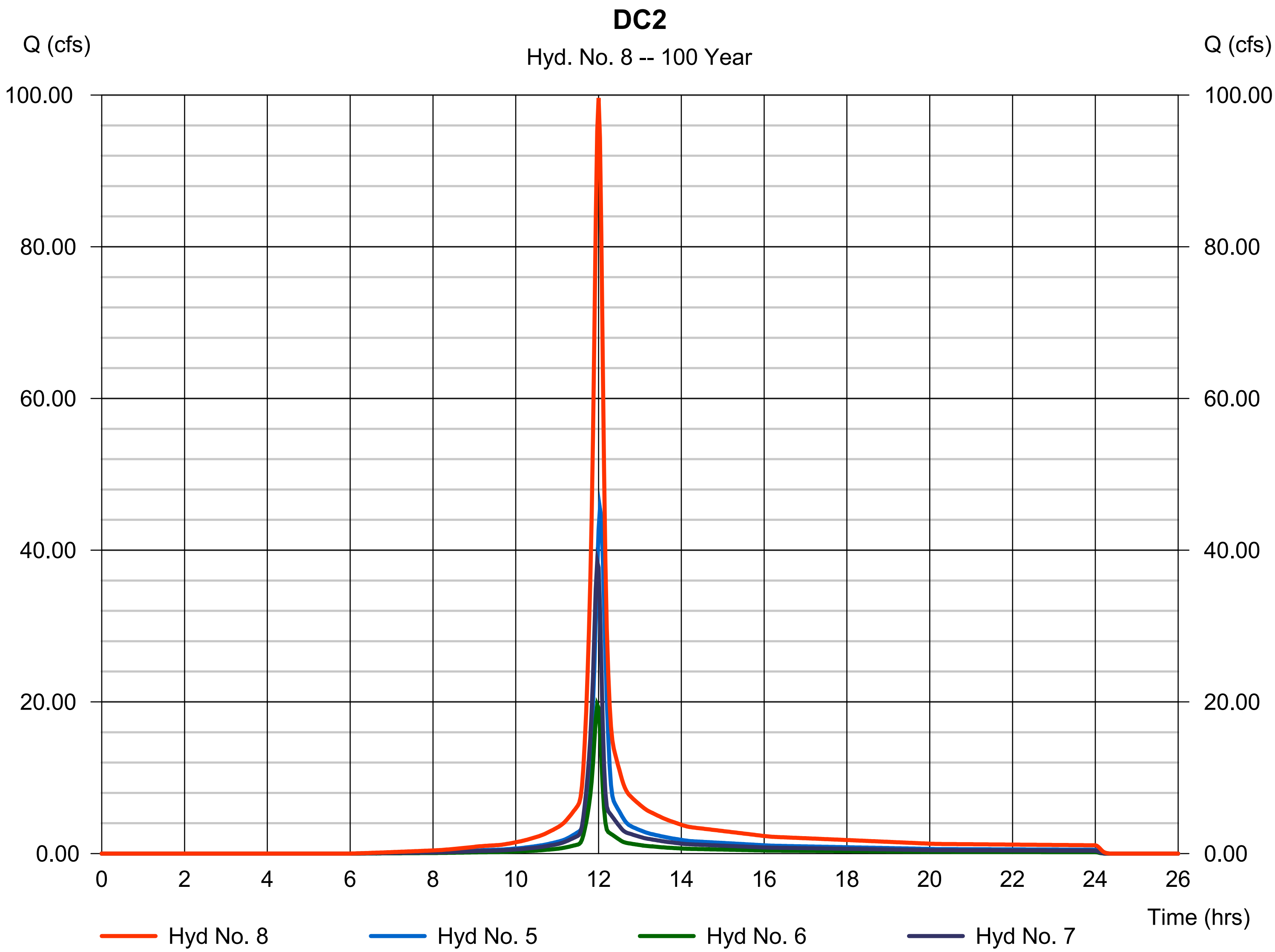
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 8

DC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 99.62 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.00 hrs |
| Time interval | 2 min = 5, | Hyd. volume | = 253,138 cuft |
| Inflow hyds. | 6, 7 | Contrib. drain. area | = 8.300 ac |



# Hydrograph Report

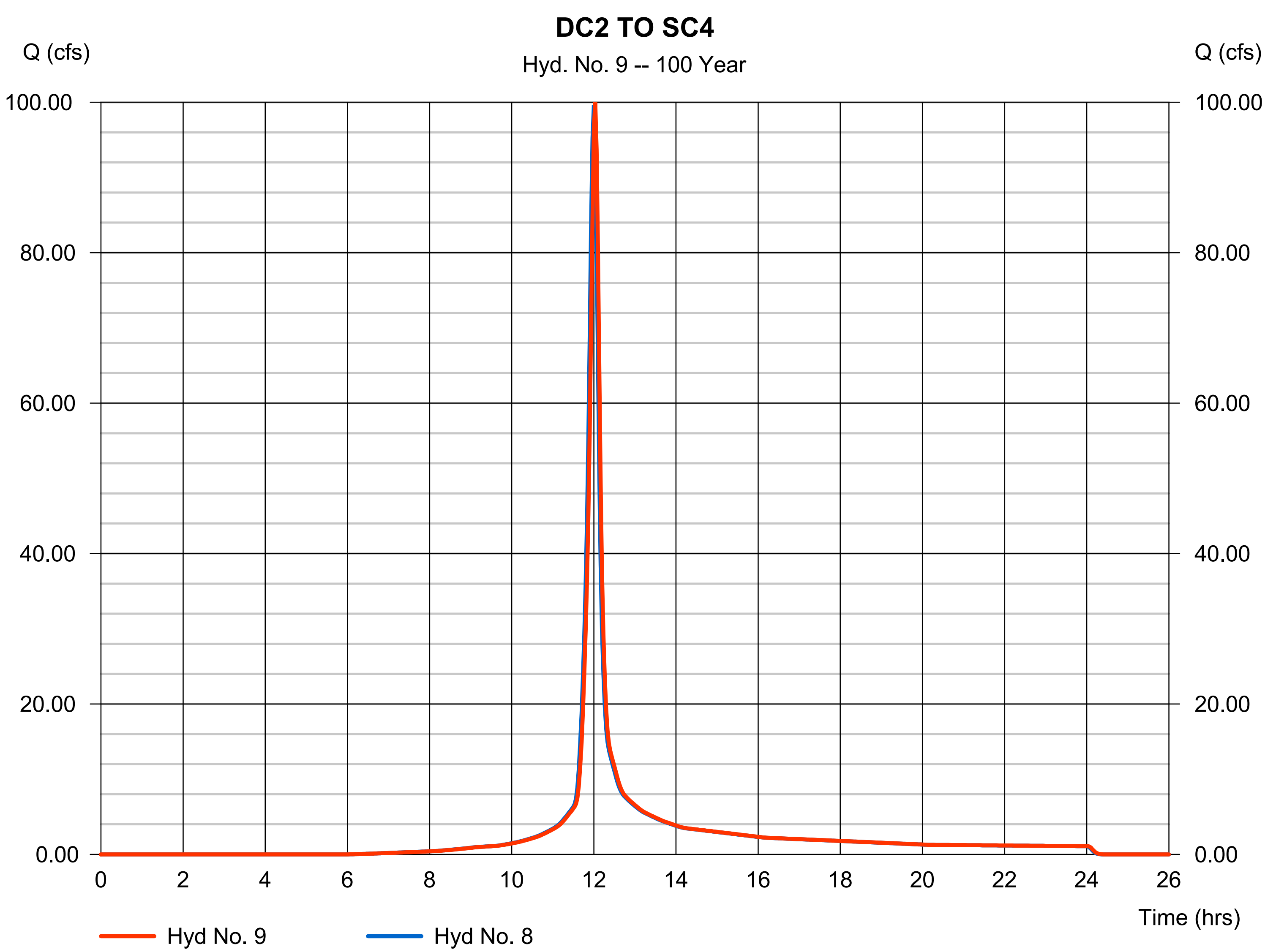
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 9

DC2 TO SC4

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 99.98 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.03 hrs |
| Time interval | = 2 min | Hyd. volume | = 253,138 cuft |
| Inflow hyd. No. | = 8 - DC2 | Section type | = Trapezoidal |
| Reach length | = 333.0 ft | Channel slope | = 10.0 % |
| Manning's n | = 0.070 | Bottom width | = 15.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 4.72 ft/s | Routing coeff. | = 1.1134 |

Modified Att-Kin routing method used.



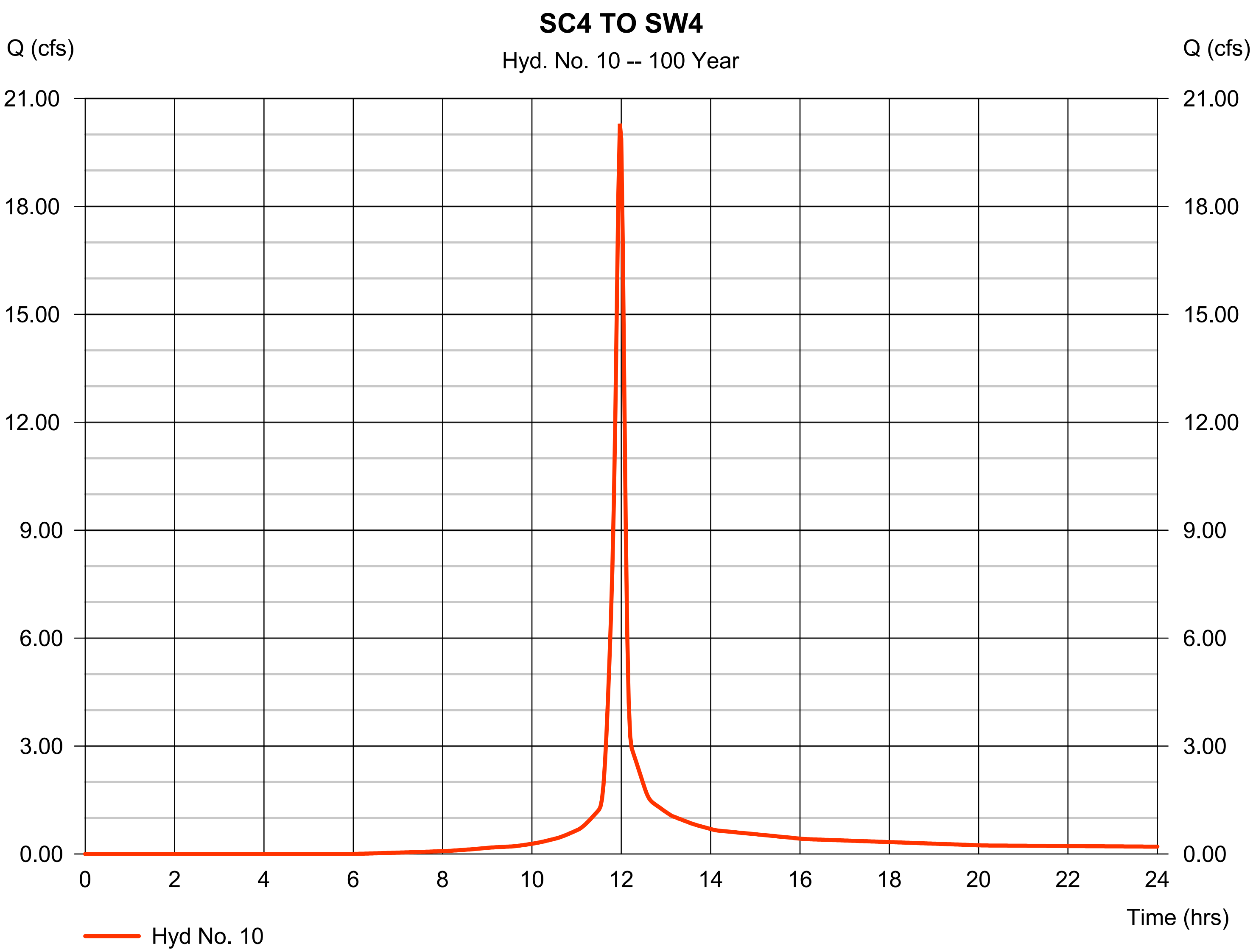
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 10

SC4 TO SW4

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 20.30 cfs |
| Storm frequency | = 1500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 47,105 cuft |
| Drainage area | = 2.900 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.80 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



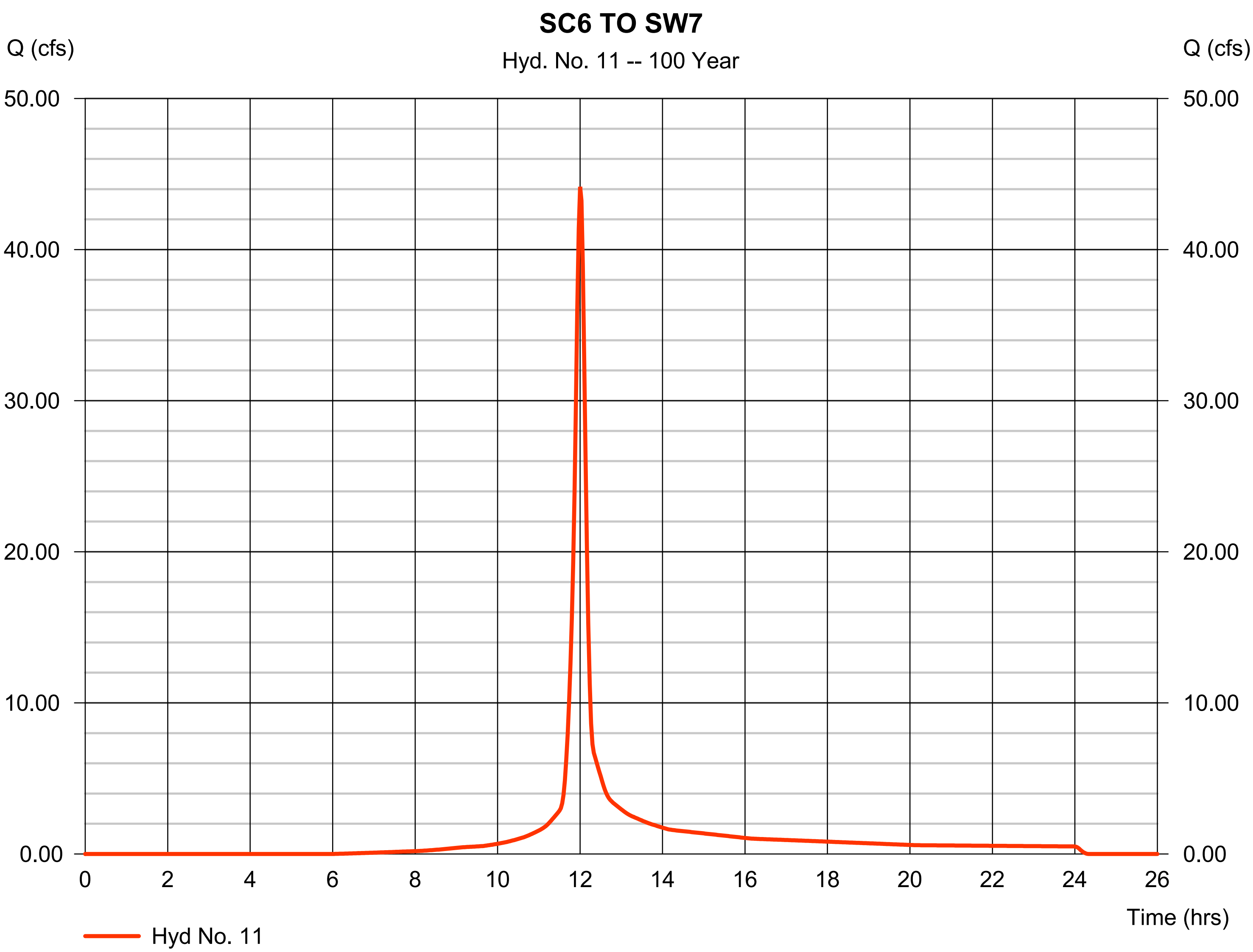
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 11

SC6 TO SW7

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 44.16 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 115,580 cuft |
| Drainage area | = 6.900 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 11.60 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



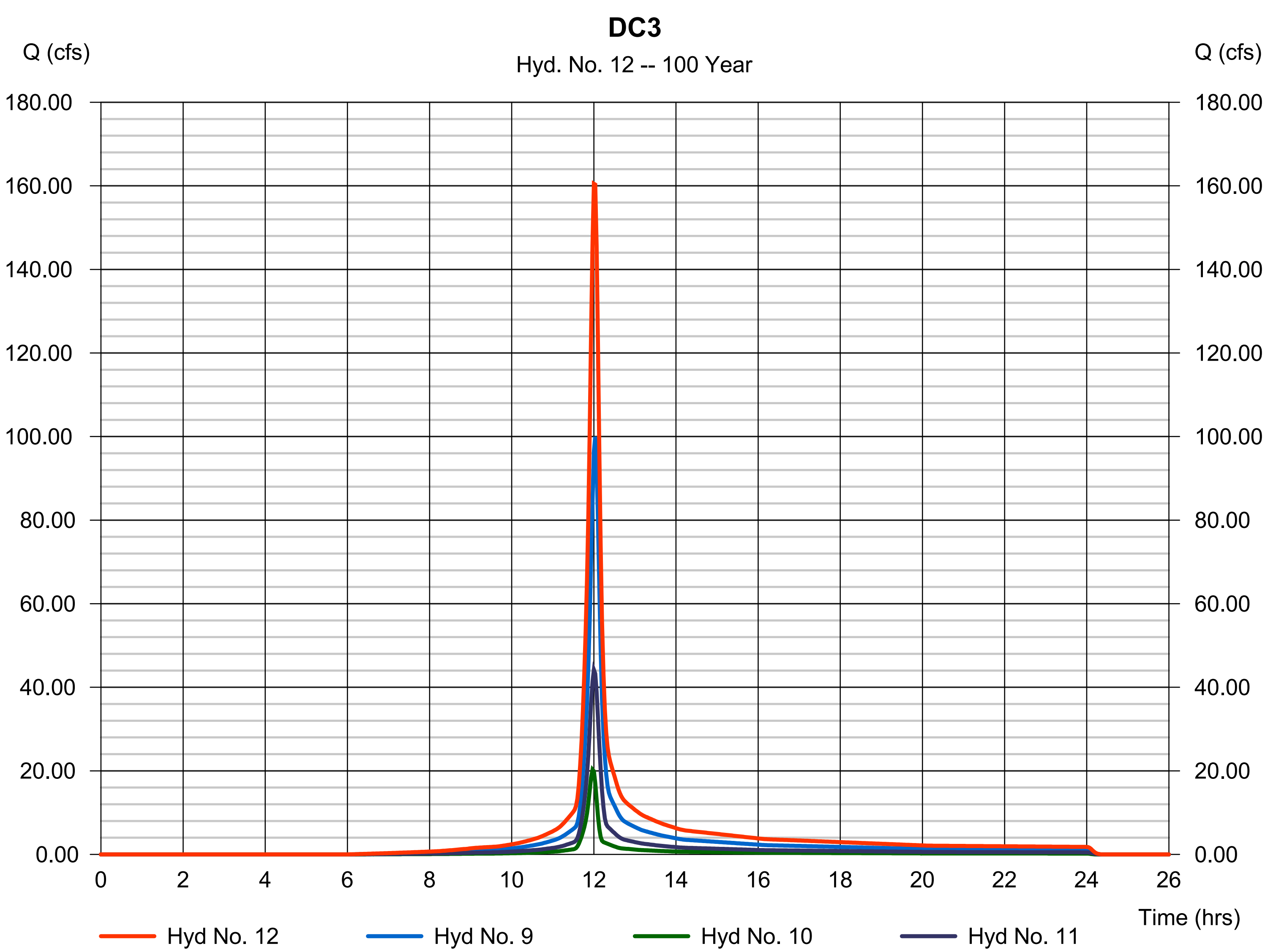
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 12

DC3

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 160.51 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.00 hrs |
| Time interval | 2 min = 9, | Hyd. volume | = 415,823 cuft |
| Inflow hyds. | 10, 11 | Contrib. drain. area | = 9.800 ac |



# Hydrograph Report

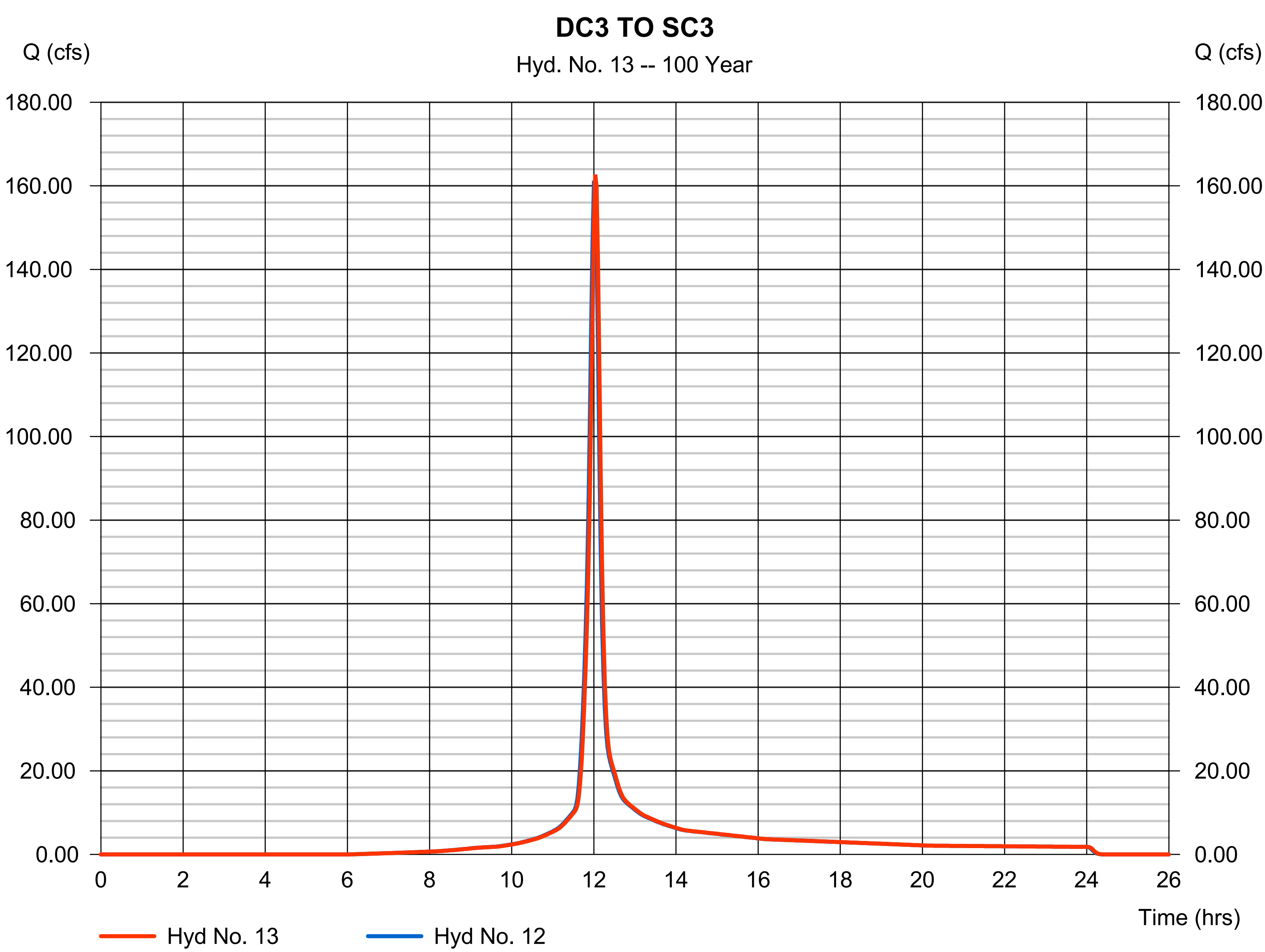
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 13

DC3 TO SC3

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 162.71 cfs |
| Storm frequency | 500 yrs = 2 | Time to peak | = 12.03 hrs |
| Time interval | min = 12 - | Hyd. volume | = 415,823 cuft |
| Inflow hyd. No. | DC3 = | Section type | = Trapezoidal |
| Reach length | 315.0 ft = | Channel slope | = 10.0 % |
| Manning's n | 0.070 = | Bottom width | = 15.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 5.51 ft/s | Routing coeff. | = 1.2152 |

Modified Att-Kin routing method used.



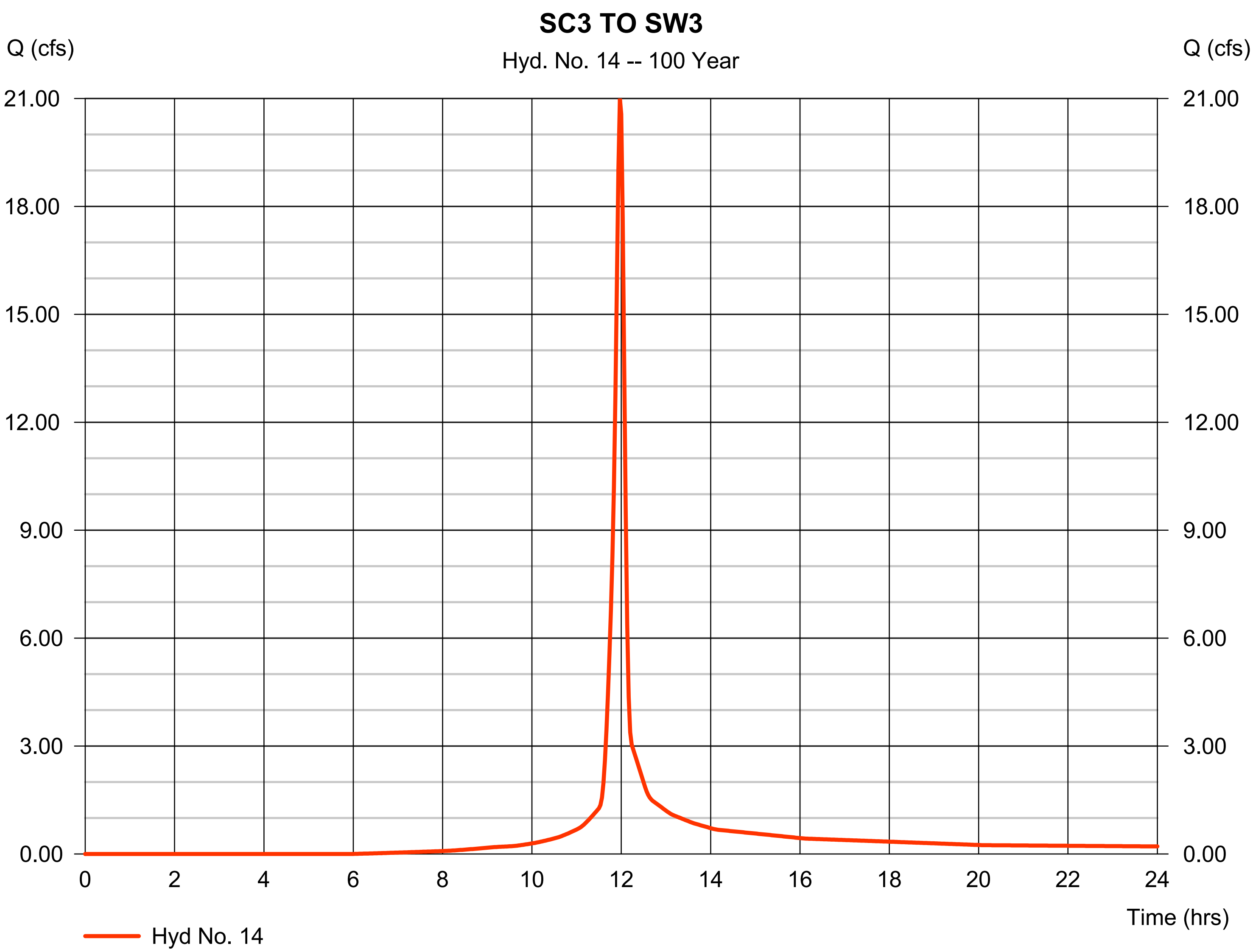
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 14

SC3 TO SW3

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 21.00 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 48,729 cuft |
| Drainage area | = 3.000 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.90 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



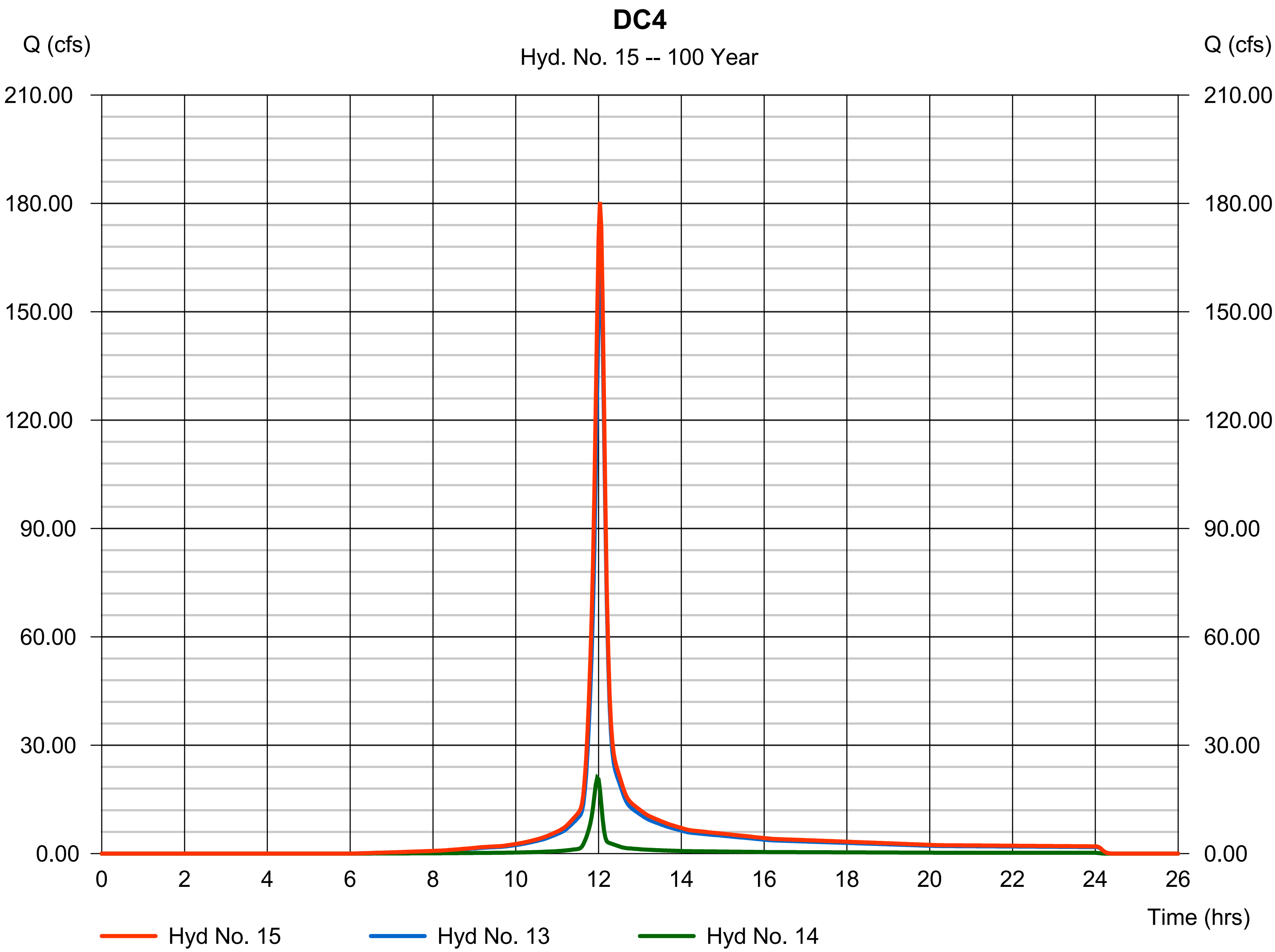
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 15

DC4

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 180.37 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.03 hrs |
| Time interval | 2 min = 13, | Hyd. volume | = 464,553 cuft |
| Inflow hyds. | 14 | Contrib. drain. area | = 3.000 ac |



# Hydrograph Report

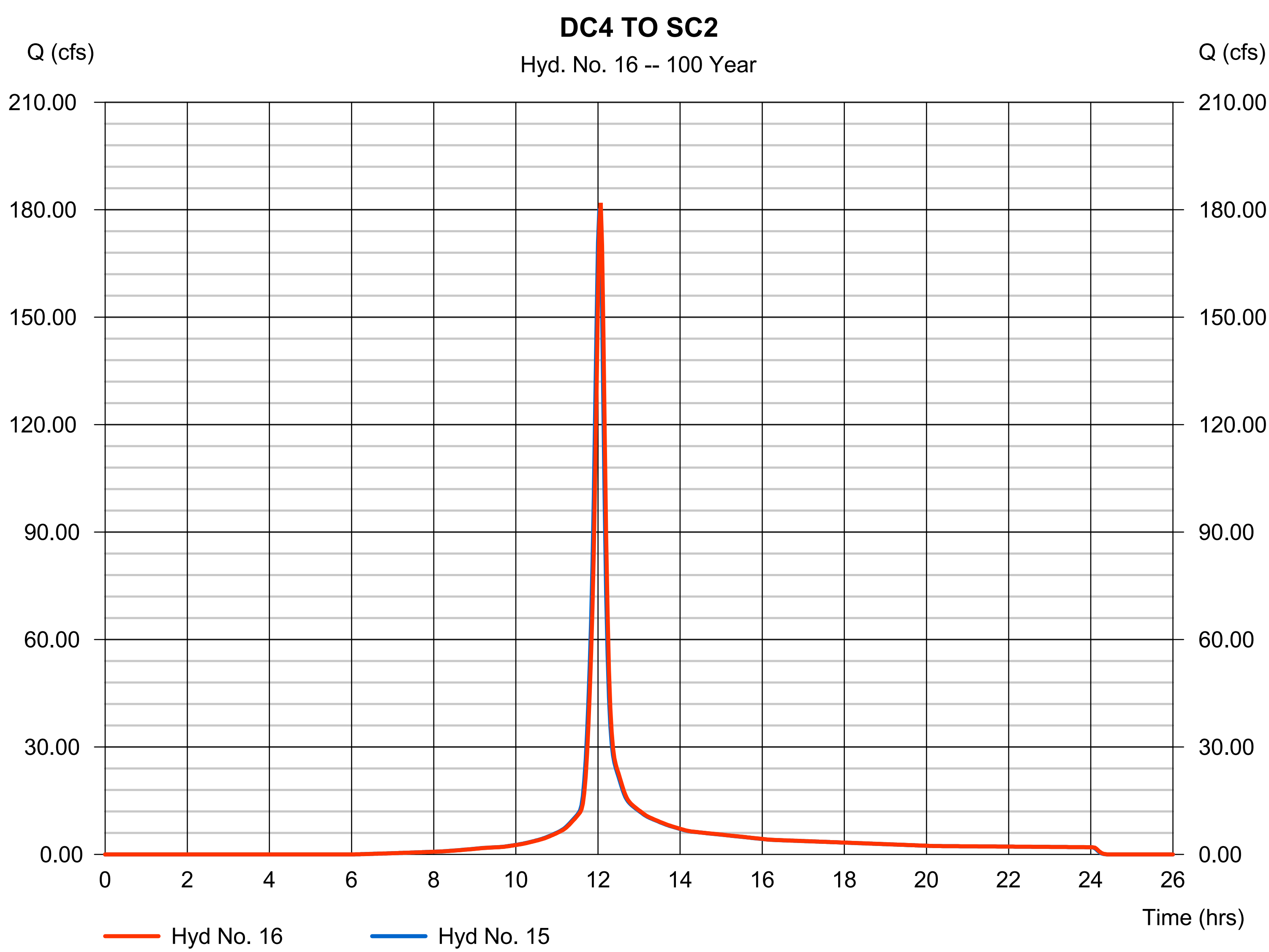
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 16

DC4 TO SC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 181.93 cfs |
| Storm frequency | 500 yrs = 2 | Time to peak | = 12.07 hrs |
| Time interval | min = 15 - | Hyd. volume | = 464,552 cuft |
| Inflow hyd. No. | DC4 = | Section type | = Trapezoidal |
| Reach length | 232.0 ft = | Channel slope | = 10.0 % |
| Manning's n | 0.070 = | Bottom width | = 15.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 5.72 ft/s | Routing coeff. | = 1.3716 |

Modified Att-Kin routing method used.



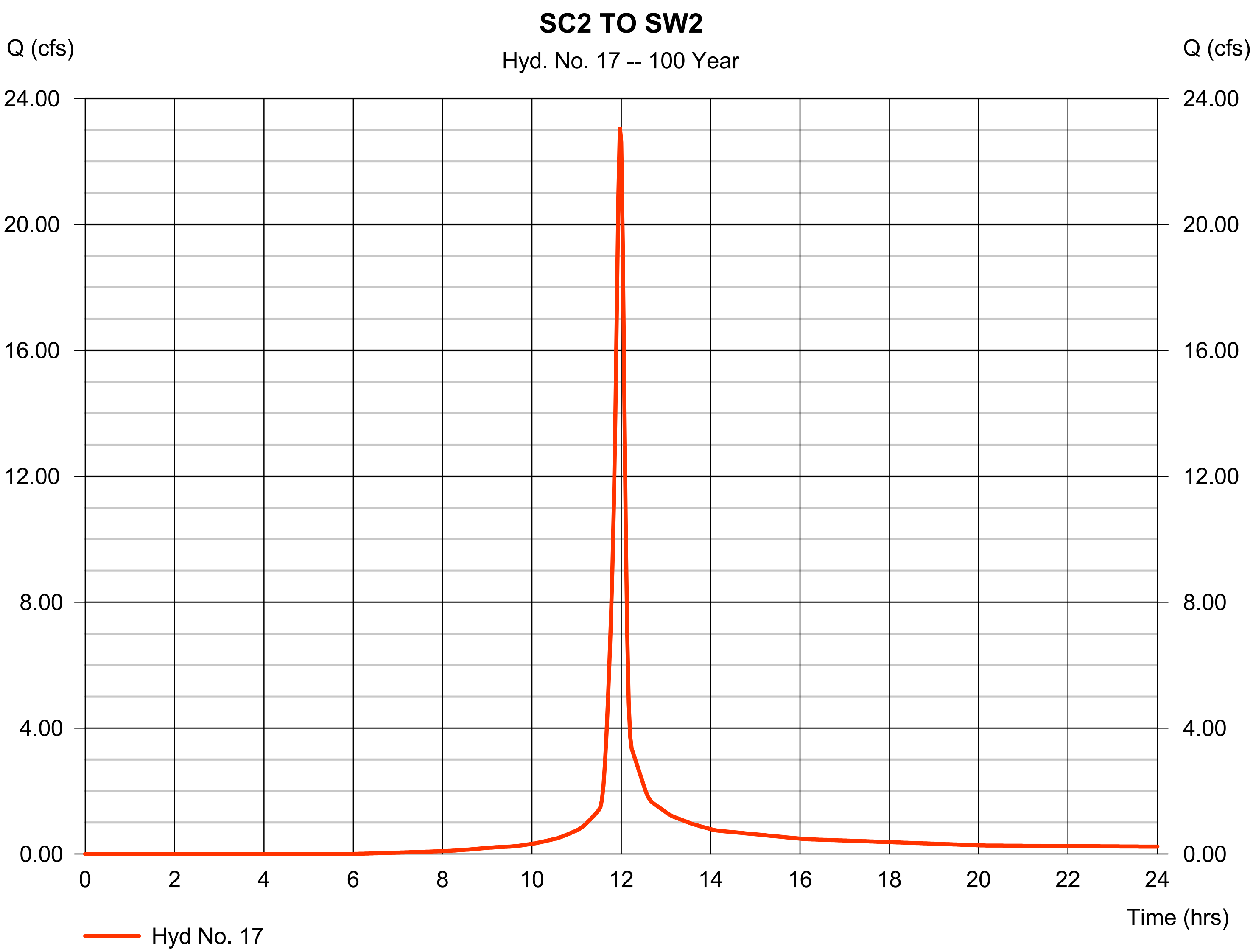
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 17

SC2 TO SW2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 23.10 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 53,602 cuft |
| Drainage area | = 3.300 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 7.30 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



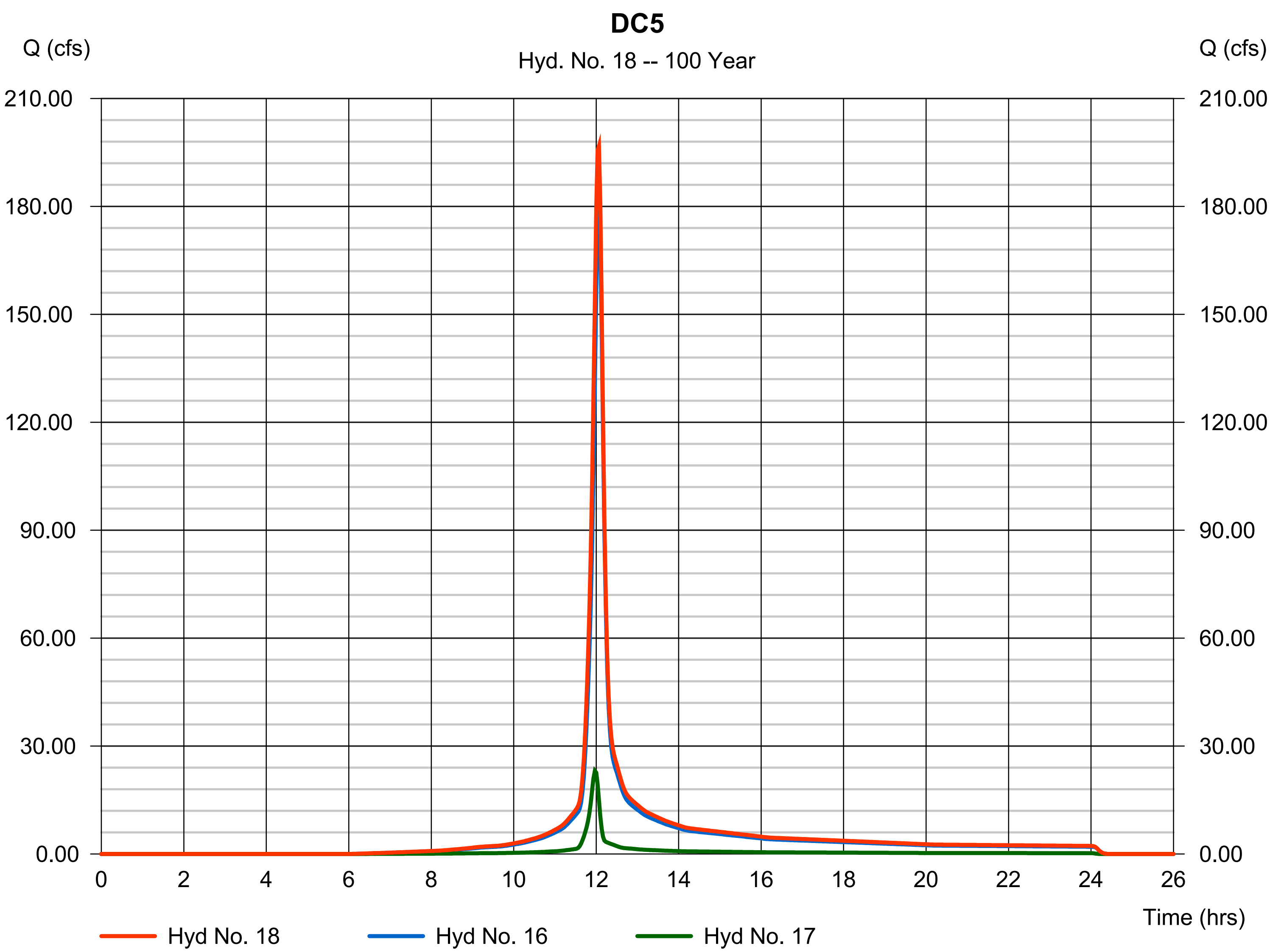
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 18

DC5

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 196.82 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.07 hrs |
| Time interval | 2 min = 16, | Hyd. volume | = 518,154 cuft |
| Inflow hyds. | 17 | Contrib. drain. area | = 3.300 ac |



# Hydrograph Report

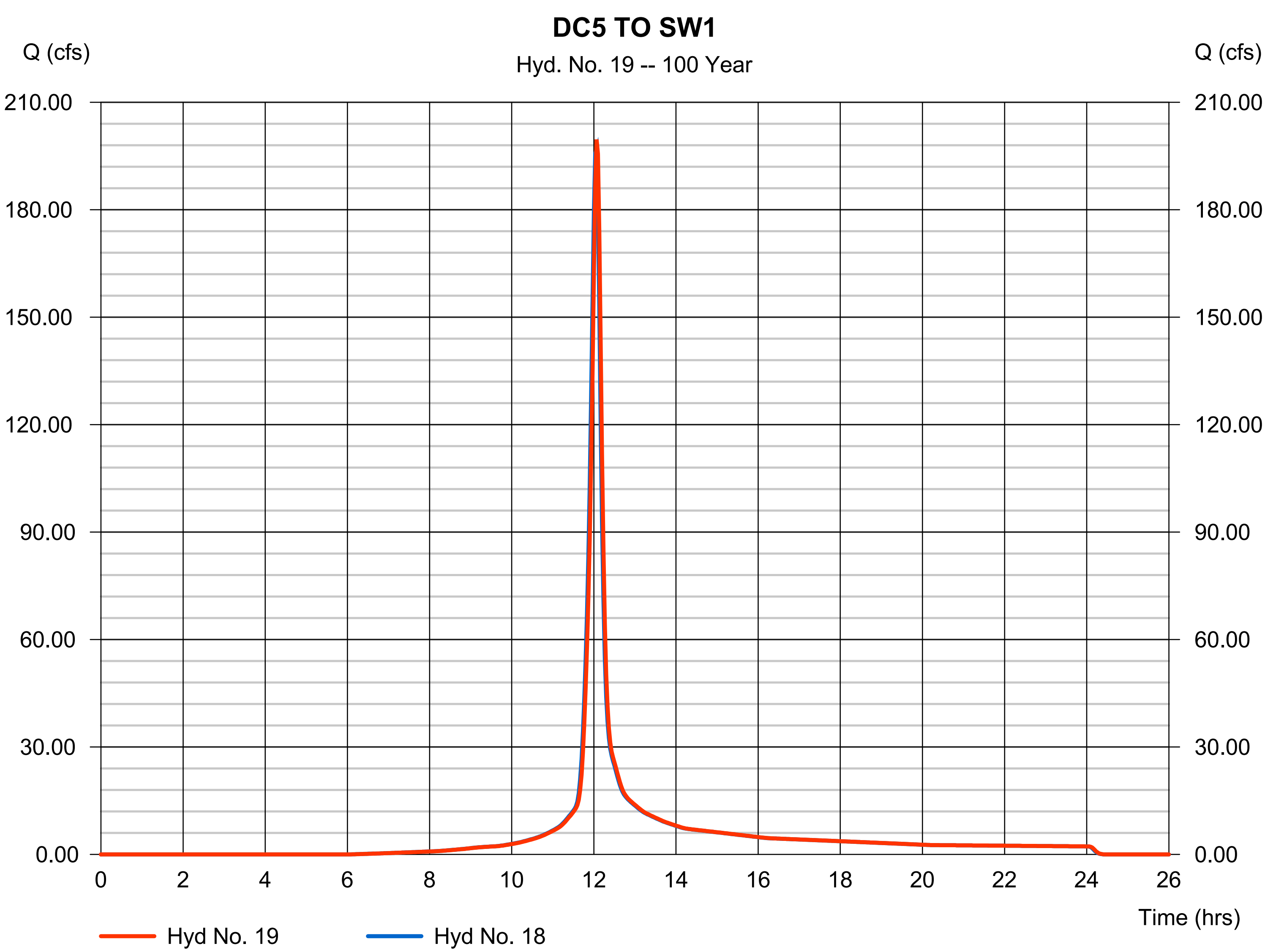
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 19

DC5 TO SW1

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 199.61 cfs |
| Storm frequency | 500 yrs = 2 | Time to peak | = 12.07 hrs |
| Time interval | min = 18 - | Hyd. volume | = 518,154 cuft |
| Inflow hyd. No. | DC5 = | Section type | = Trapezoidal |
| Reach length | 200.0 ft = | Channel slope | = 10.0 % |
| Manning's n | 0.070 = | Bottom width | = 15.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.106 | Rating curve m | = 1.476 |
| Ave. velocity | = 5.88 ft/s | Routing coeff. | = 1.4451 |

Modified Att-Kin routing method used.



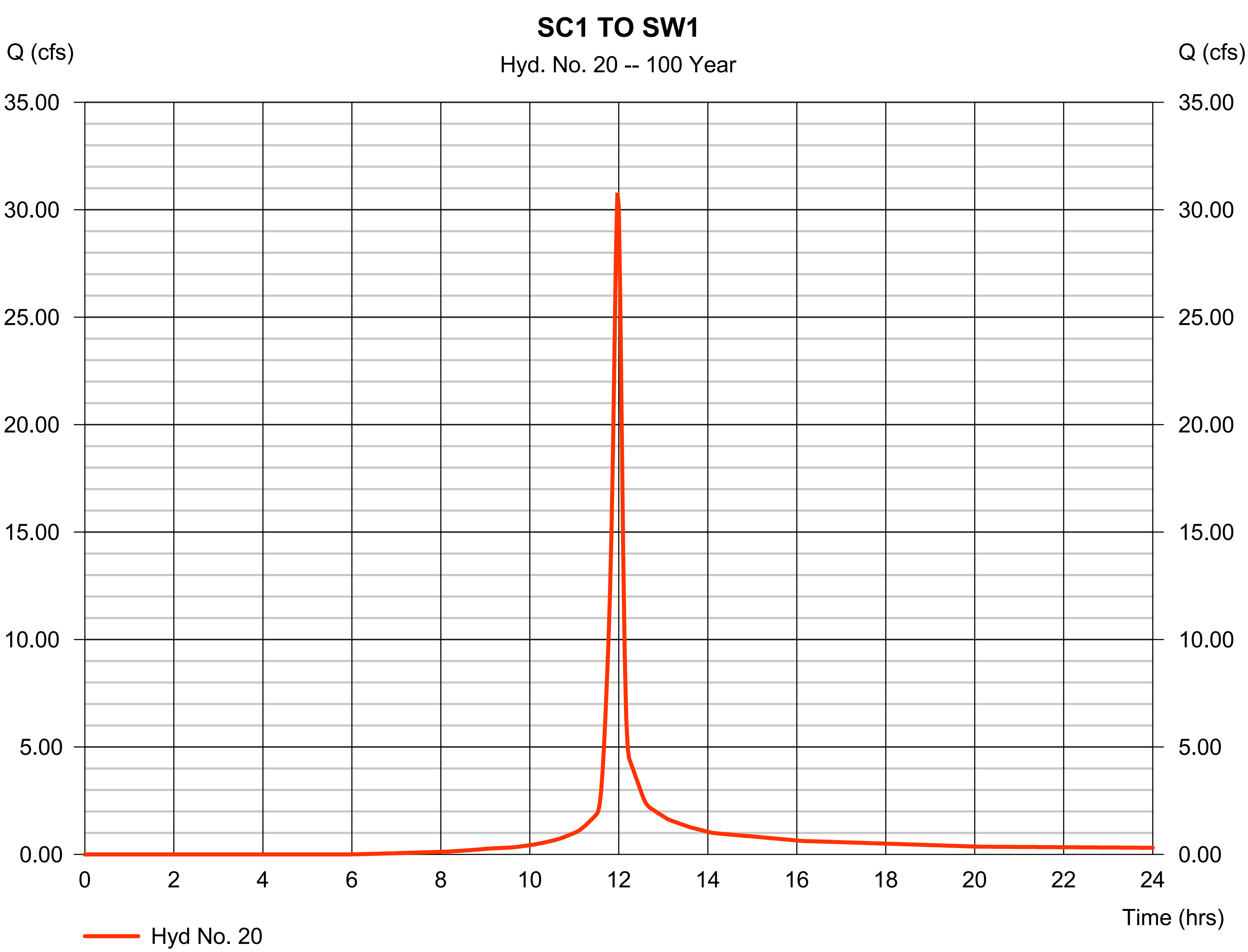
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 20

SC1 TO SW1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 30.80 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.97 hrs |
| Time interval | = 2 min | Hyd. volume | = 71,470 cuft |
| Drainage area | = 4.400 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 8.00 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



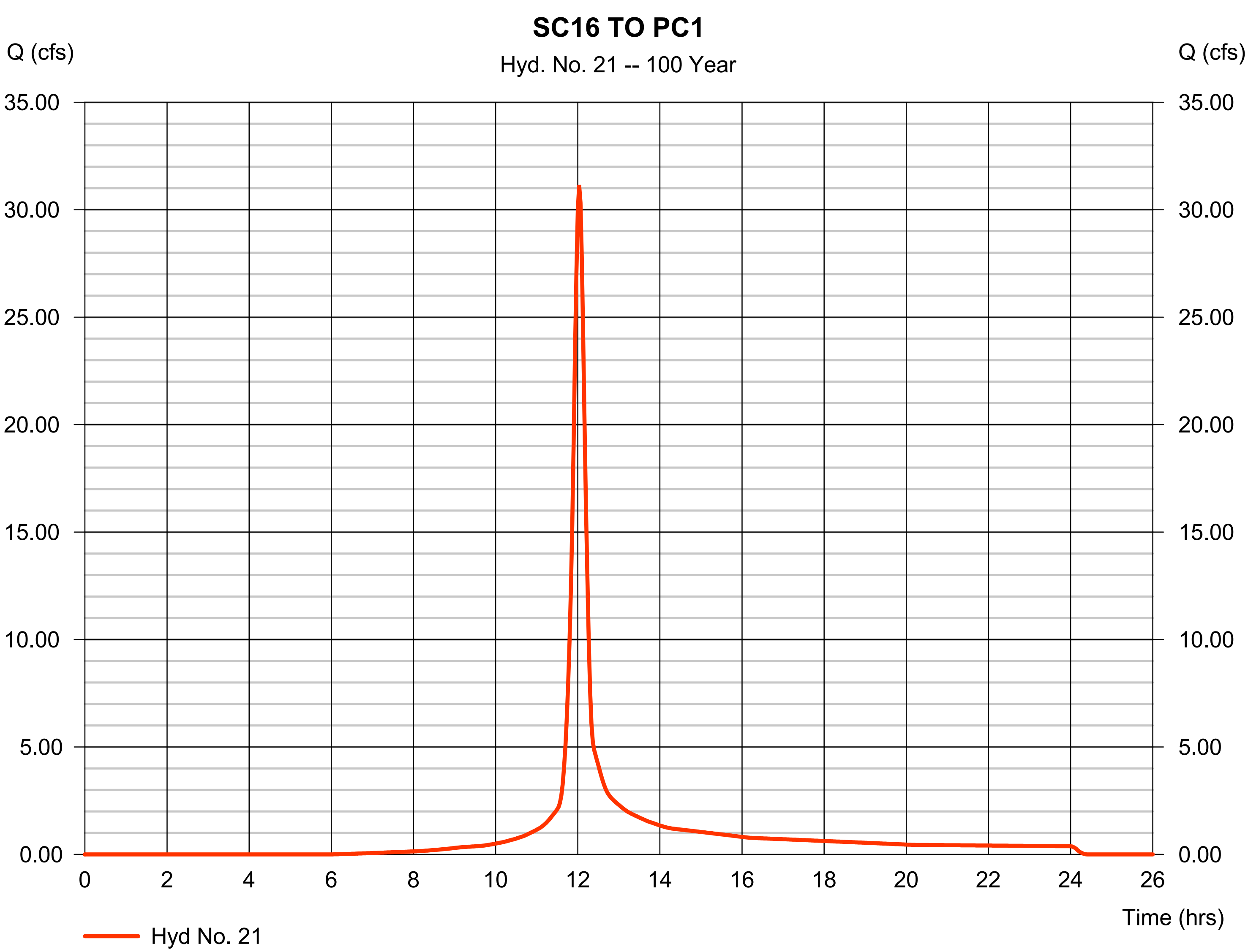
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 21

SC16 TO PC1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 31.15 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.03 hrs |
| Time interval | = 2 min | Hyd. volume | = 88,054 cuft |
| Drainage area | = 5.560 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 14.20 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



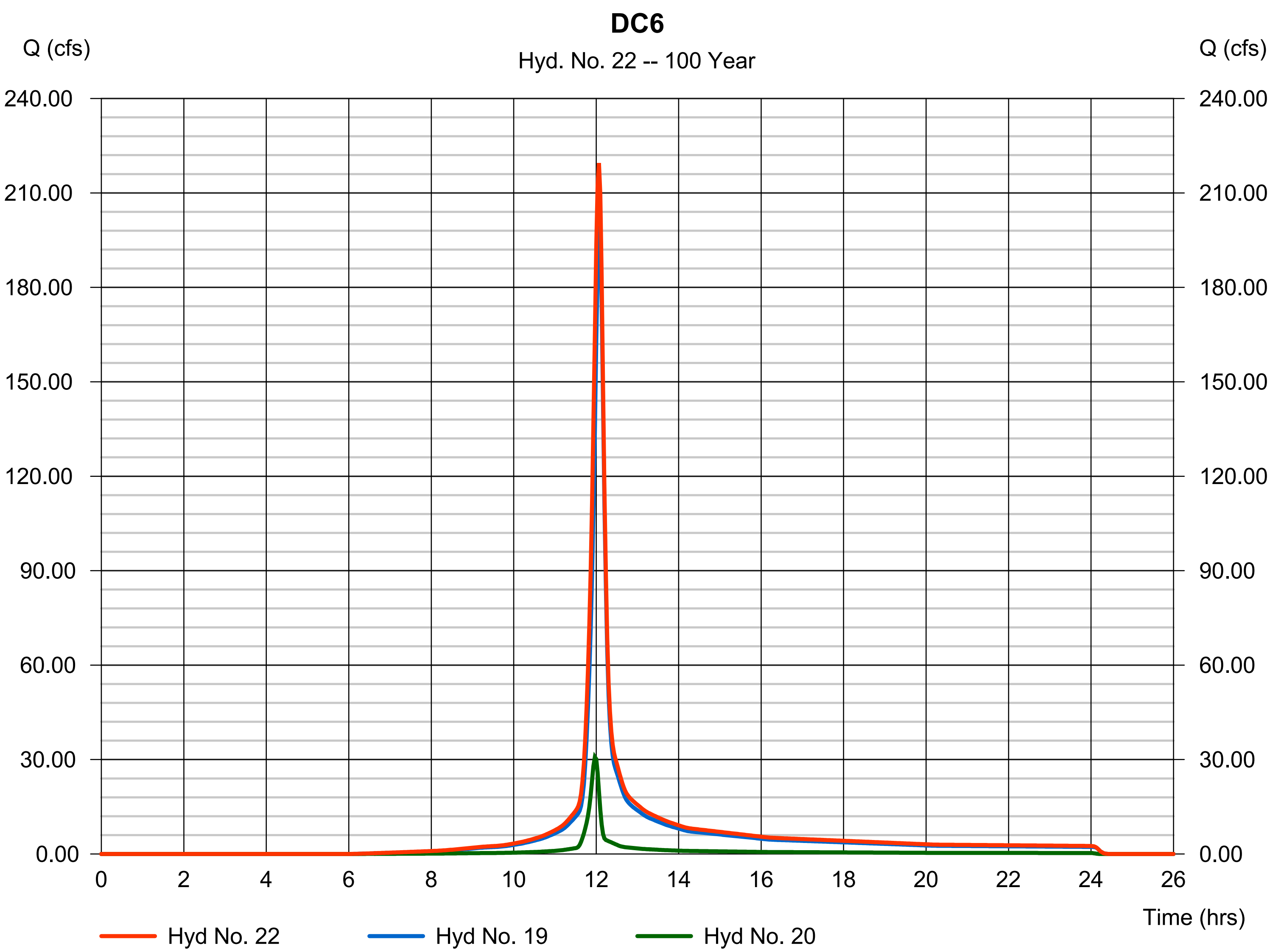
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 22

DC6

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 219.46 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.07 hrs |
| Time interval | 2 min = 19, | Hyd. volume | = 589,624 cuft |
| Inflow hyds. | 20 | Contrib. drain. area | = 4.400 ac |



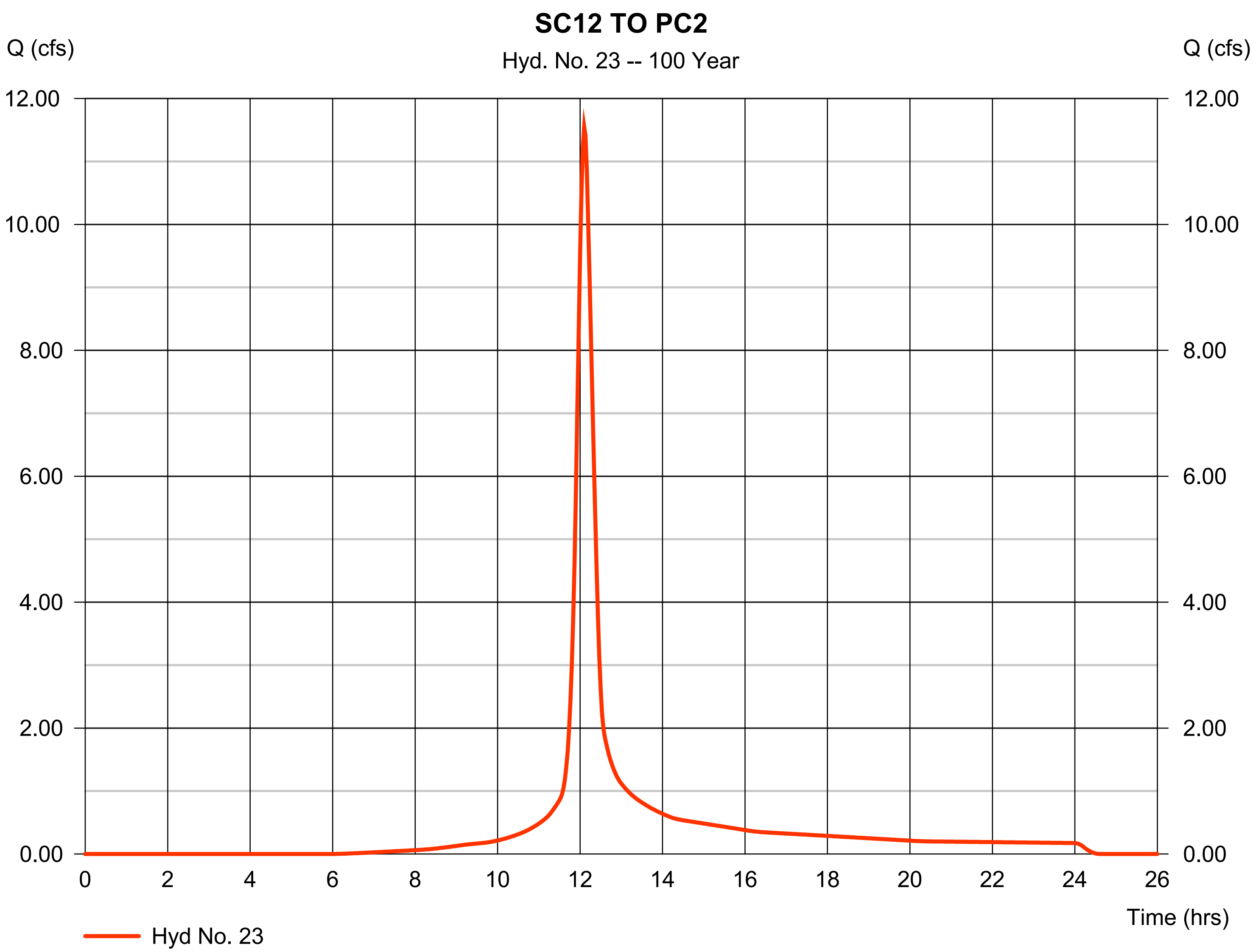
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 23

SC12 TO PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 11.55 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.10 hrs |
| Time interval | = 2 min | Hyd. volume | = 40,010 cuft |
| Drainage area | = 2.420 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 21.40 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



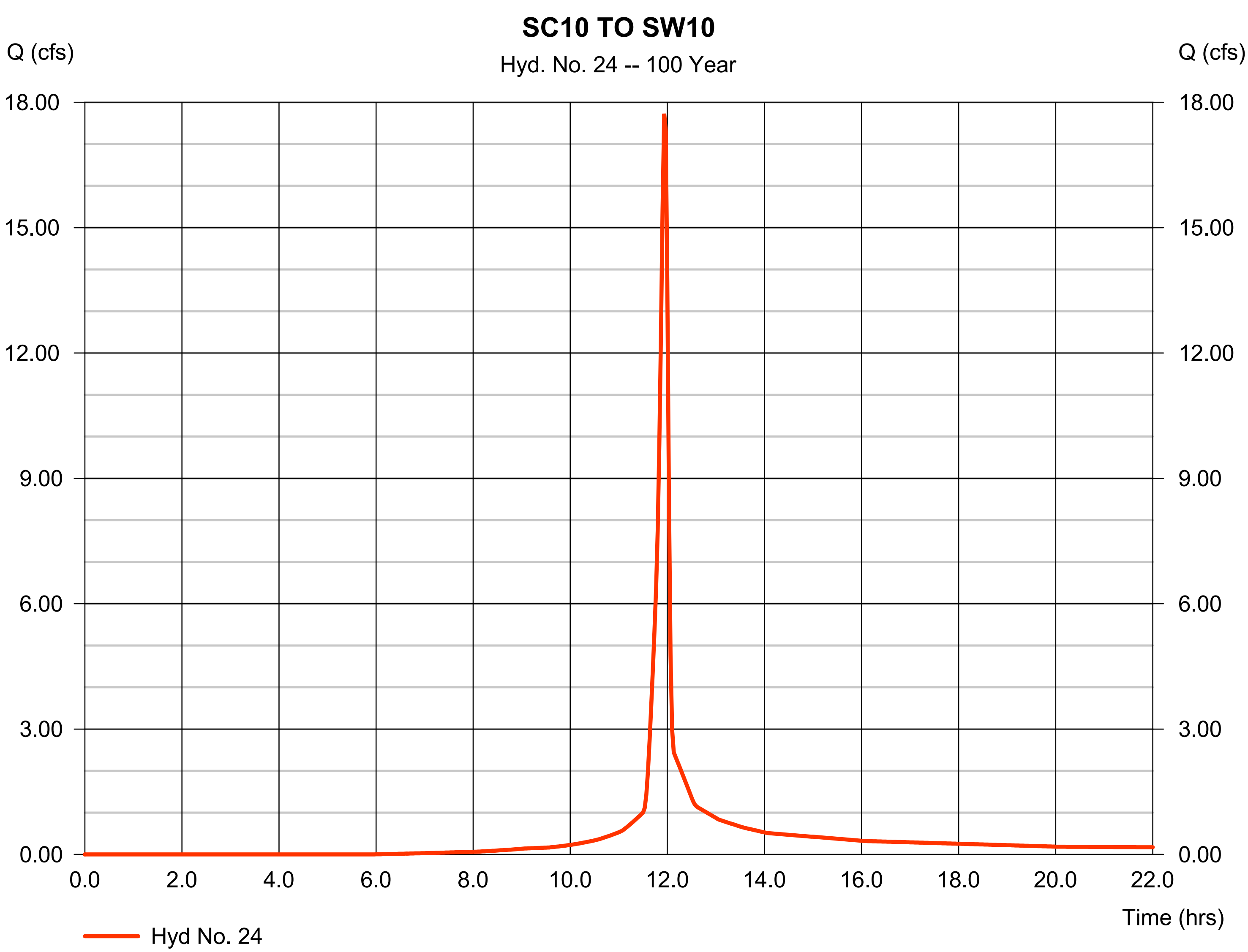
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 24

SC10 TO SW10

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 17.73 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 36,547 cuft |
| Drainage area | = 2.400 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 6.20 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



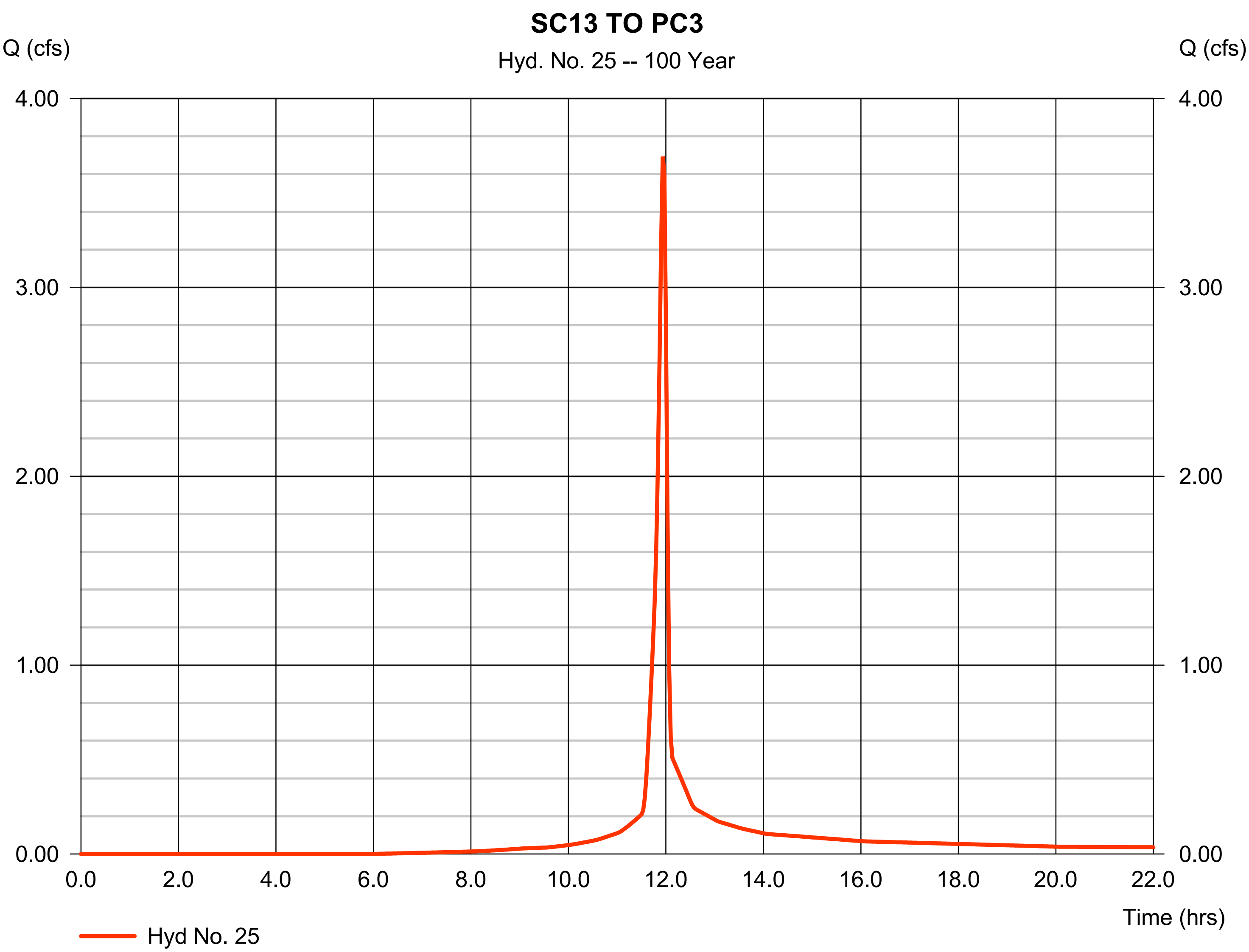
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 25

SC13 TO PC3

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 3.693 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 7,614 cuft |
| Drainage area | = 0.500 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 3.90 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



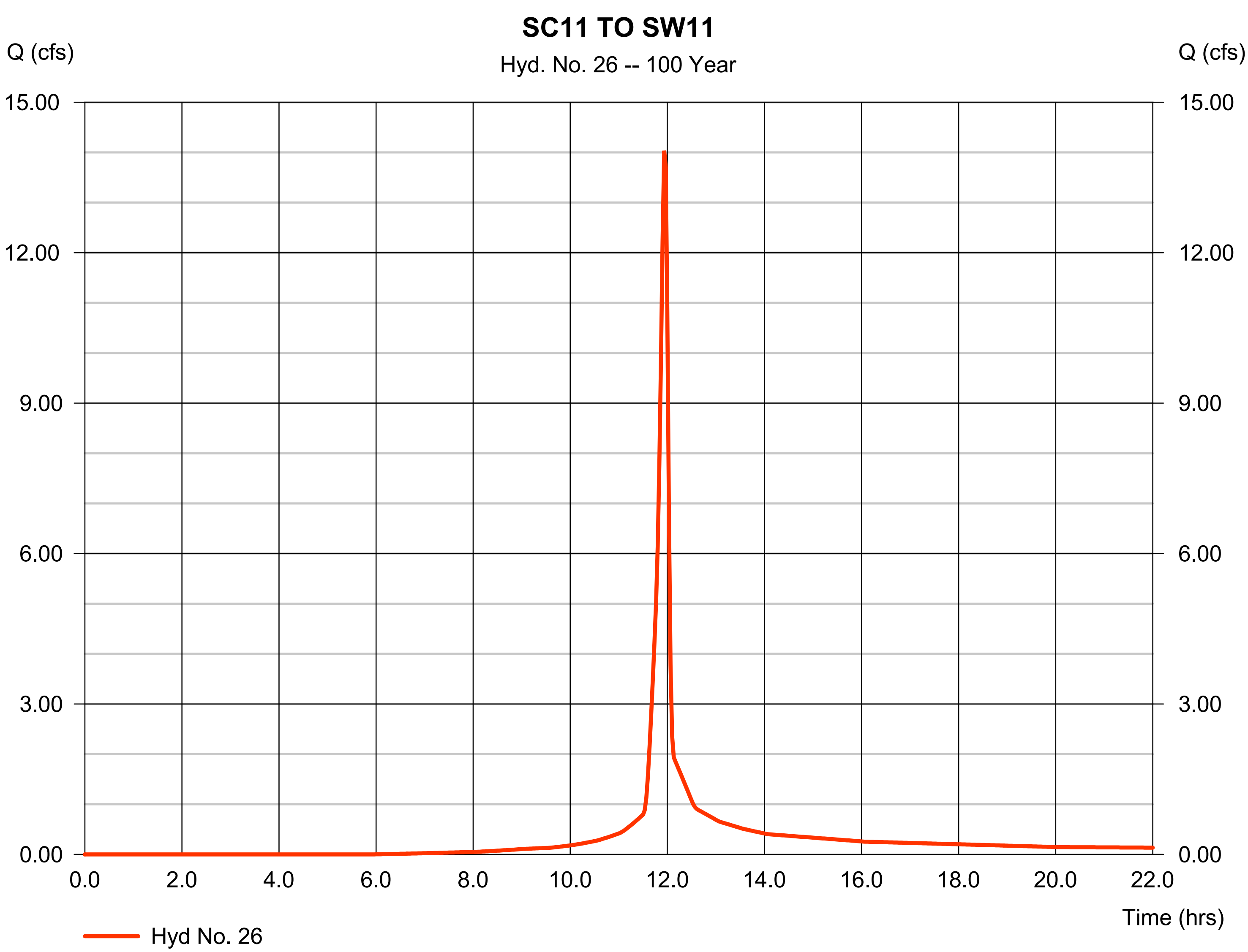
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 26

SC11 TO SW11

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 14.03 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 28,933 cuft |
| Drainage area | = 1.900 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 5.50 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



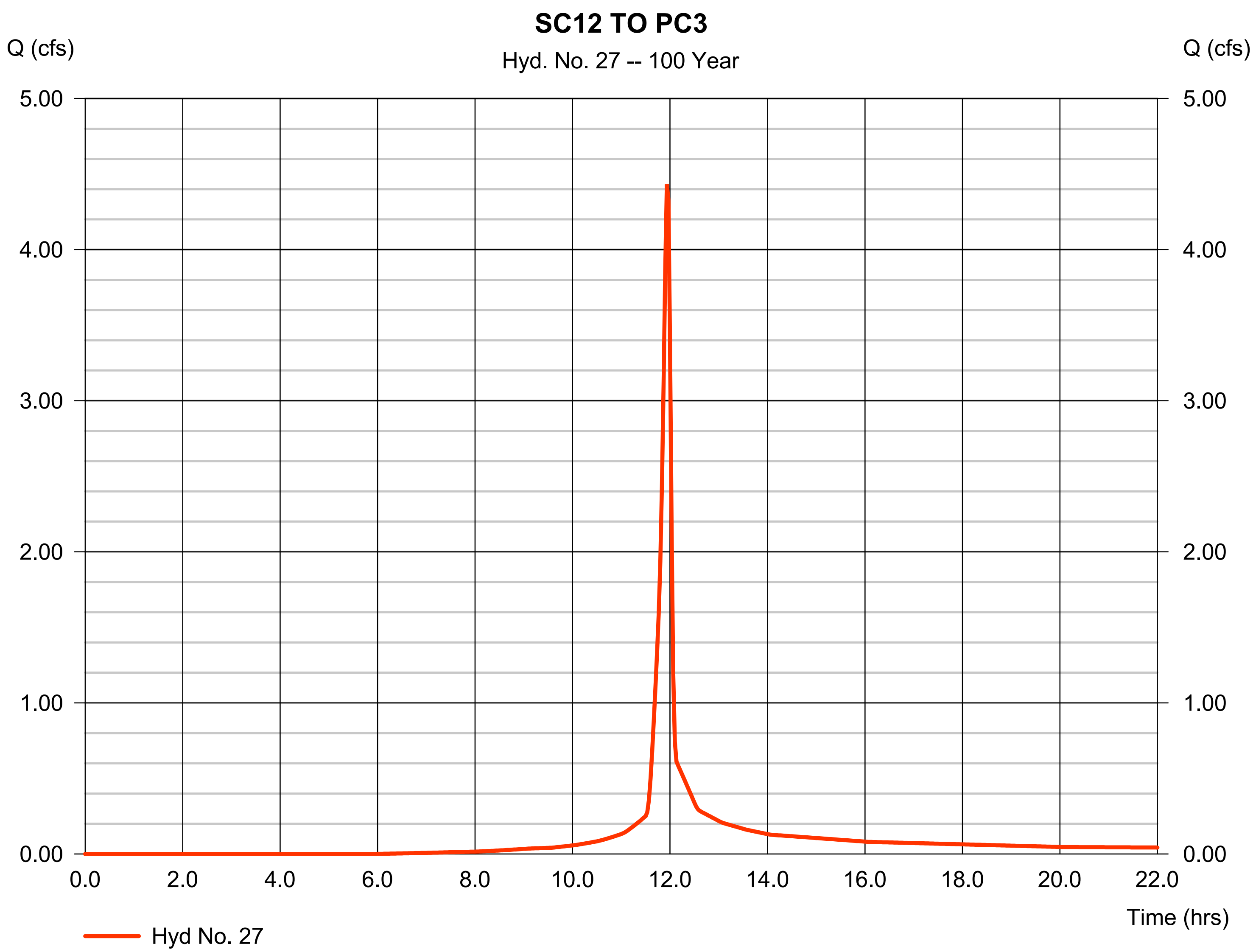
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 27

SC12 TO PC3

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 4.432 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 9,137 cuft |
| Drainage area | = 0.600 ac | Curve number | = 79 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 3.90 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



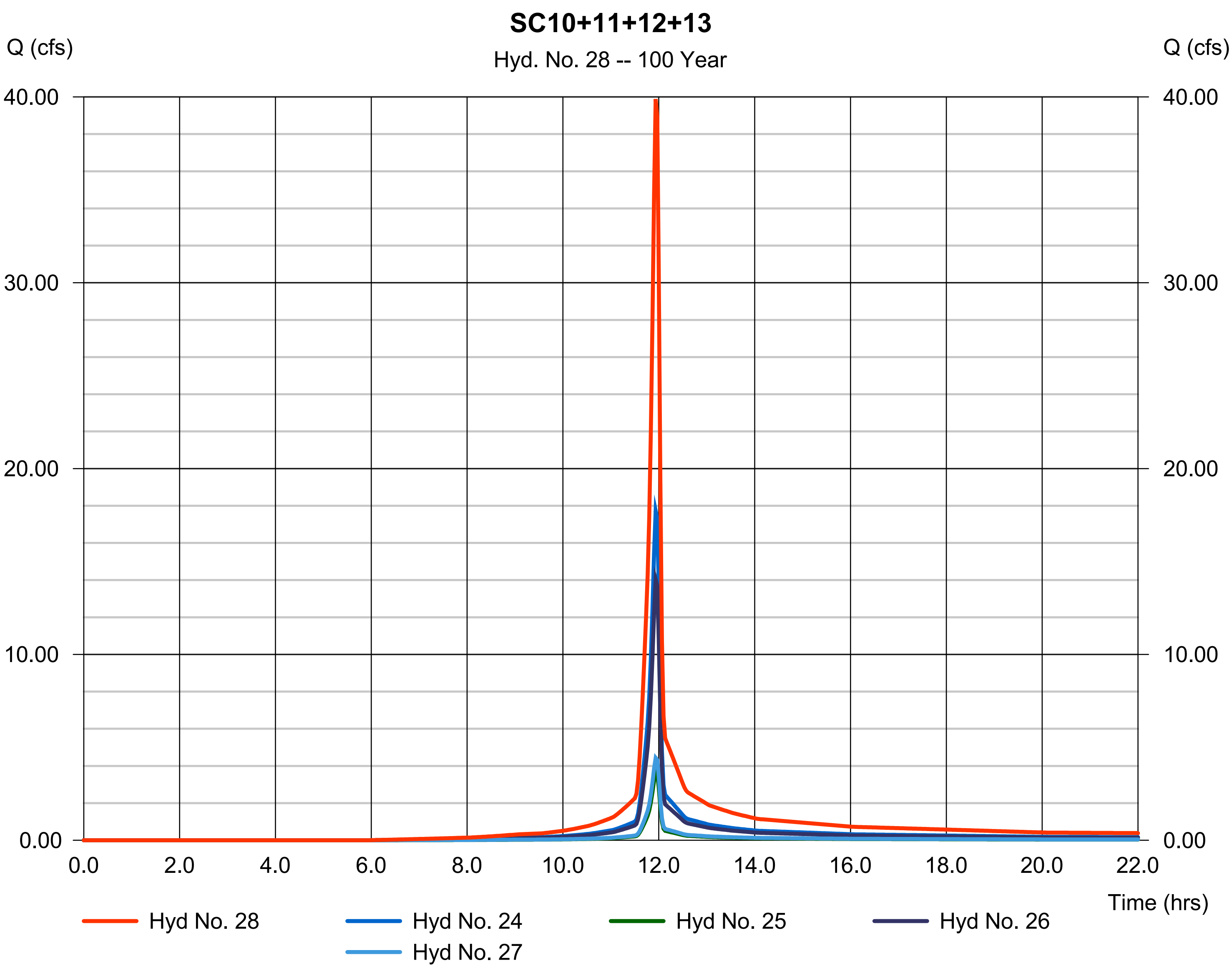
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 — Tuesday, 08 / 4 / 2020

## Hyd. No. 28

SC10+11+12+13

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 39.89 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 82,231 cuft |
| Inflow hyds. | = 24, 25, 26, 27 | Contrib. drain. area | = 5.400 ac |



# Hydrograph Report

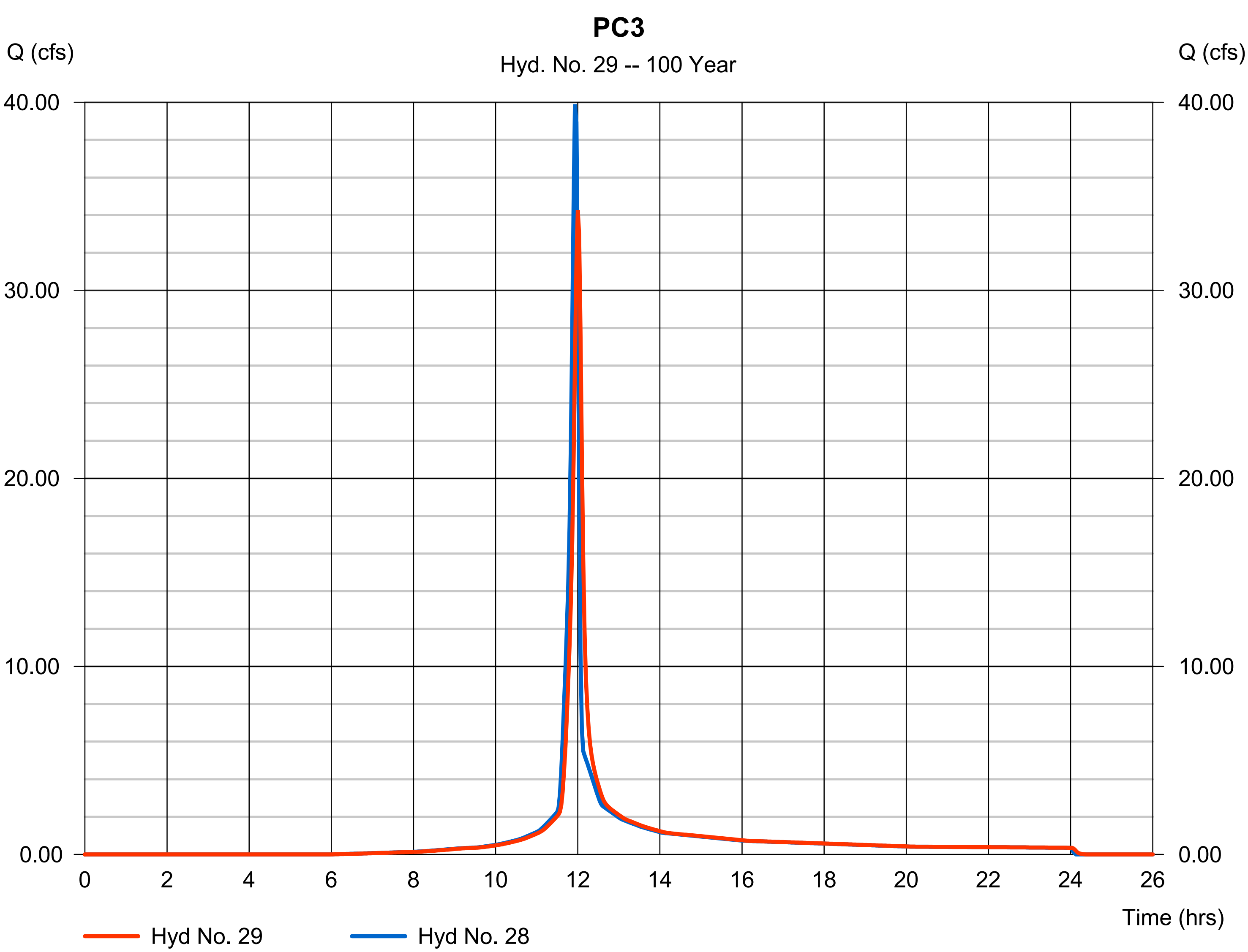
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 29

PC3

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 34.26 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.00 hrs |
| Time interval | = 2 min | Hyd. volume | = 82,229 cuft |
| Inflow hyd. No. | = 28 - SC10+11+12+13 | Section type | = Trapezoidal |
| Reach length | = 1343.0 ft | Channel slope | = 6.0 % |
| Manning's n | = 0.070 | Bottom width | = 5.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 1.8 ft |
| Rating curve x | = 1.782 | Rating curve m | = 1.339 |
| Ave. velocity | = 3.91 ft/s | Routing coeff. | = 0.3795 |

Modified Att-Kin routing method used.



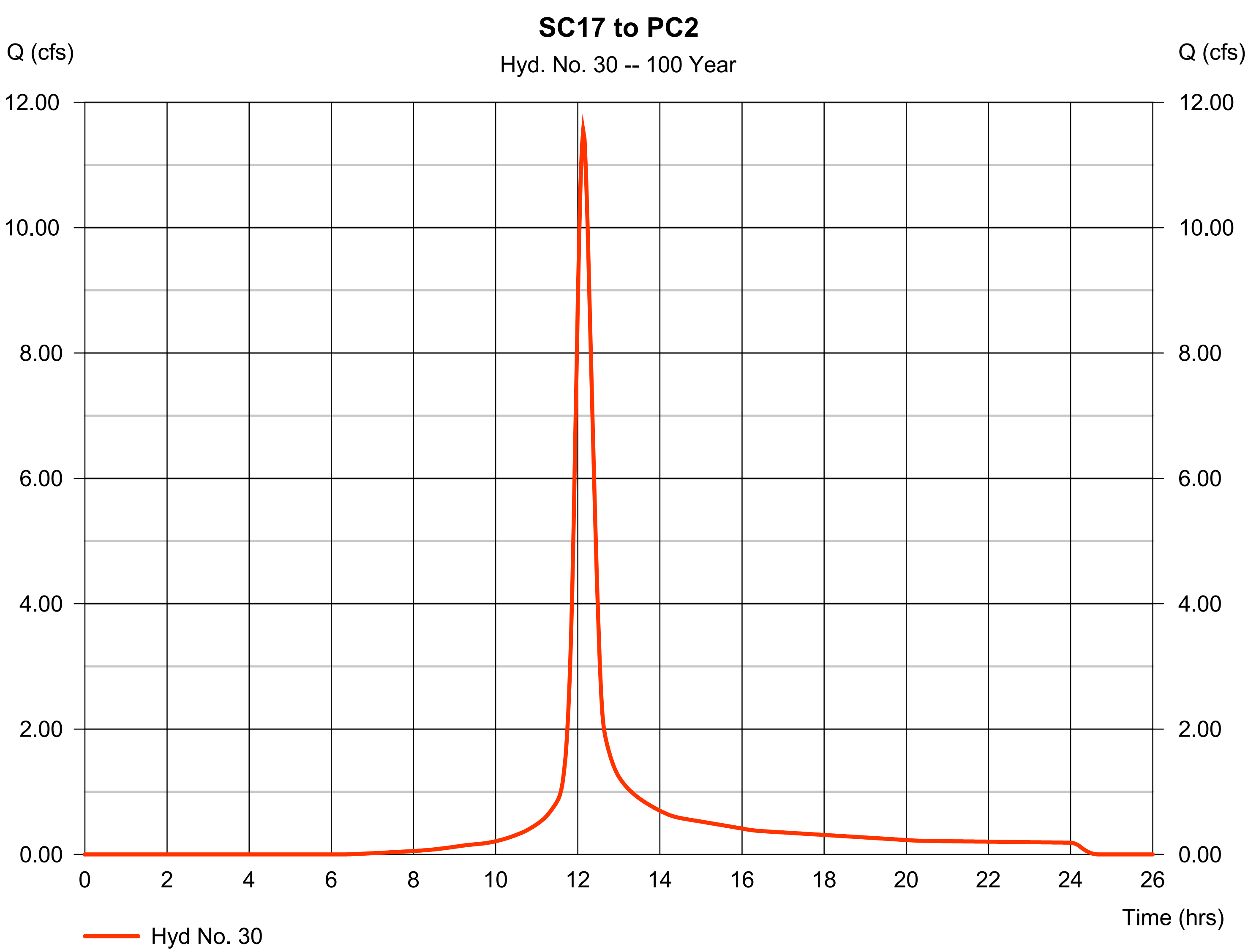
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 30

SC17 to PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 11.55 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.13 hrs |
| Time interval | = 2 min | Hyd. volume | = 42,436 cuft |
| Drainage area | = 2.720 ac | Curve number | = 78 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 24.30 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Hydrograph Report

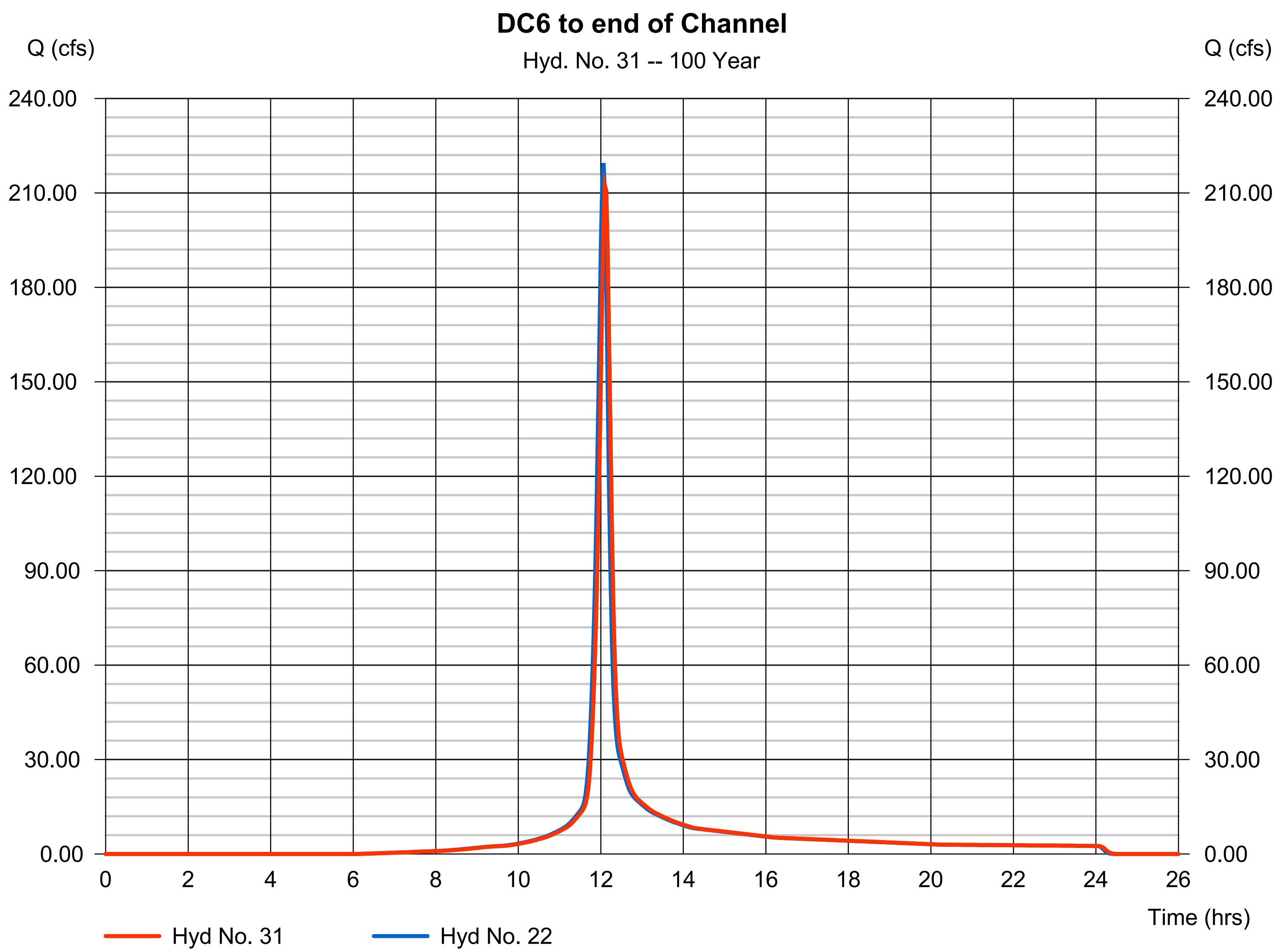
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 — Tuesday, 08 / 4 / 2020

## Hyd. No. 31

DC6 to end of Channel

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 212.41 cfs |
| Storm frequency | 500 yrs = 2 | Time to peak | = 12.10 hrs |
| Time interval | min = 22 - | Hyd. volume | = 589,624 cuft |
| Inflow hyd. No. | DC6 = | Section type | = Trapezoidal |
| Reach length | 700.0 ft = | Channel slope | = 2.0 % |
| Manning's n | 0.070 = | Bottom width | = 5.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.029 | Rating curve m | = 1.346 |
| Ave. velocity | = 4.08 ft/s | Routing coeff. | = 0.6400 |

Modified Att-Kin routing method used.



# Hydrograph Report

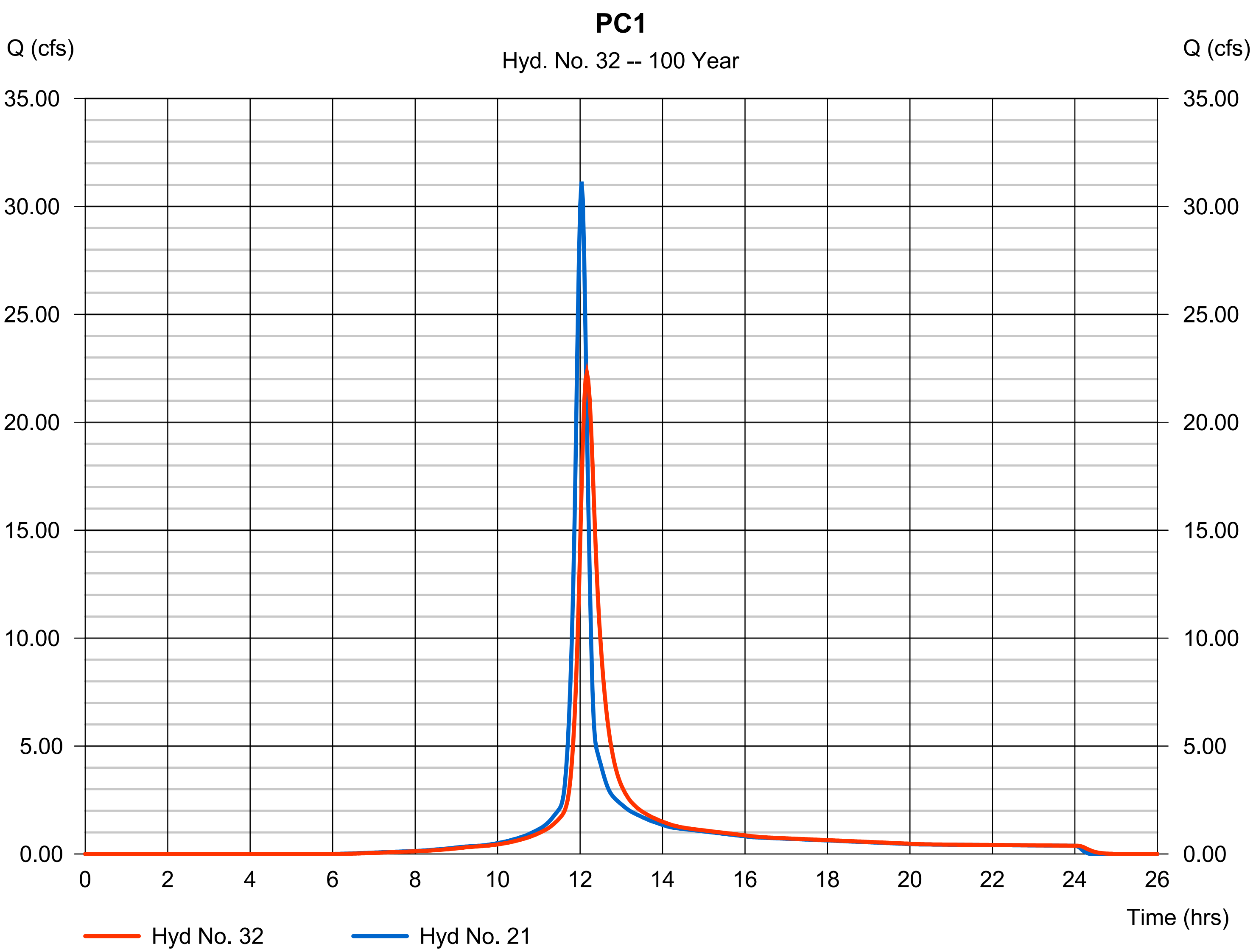
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 32

PC1

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach | Peak discharge | = 22.29 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 12.17 hrs |
| Time interval | = 2 min | Hyd. volume | = 88,047 cuft |
| Inflow hyd. No. | = 21 - SC16 TO PC1 | Section type | = Trapezoidal |
| Reach length | = 2870.0 ft | Channel slope | = 3.7 % |
| Manning's n | = 0.070 | Bottom width | = 5.0 ft |
| Side slope | = 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 1.400 | Rating curve m | = 1.346 |
| Ave. velocity | = 3.11 ft/s | Routing coeff. | = 0.1607 |

Modified Att-Kin routing method used.



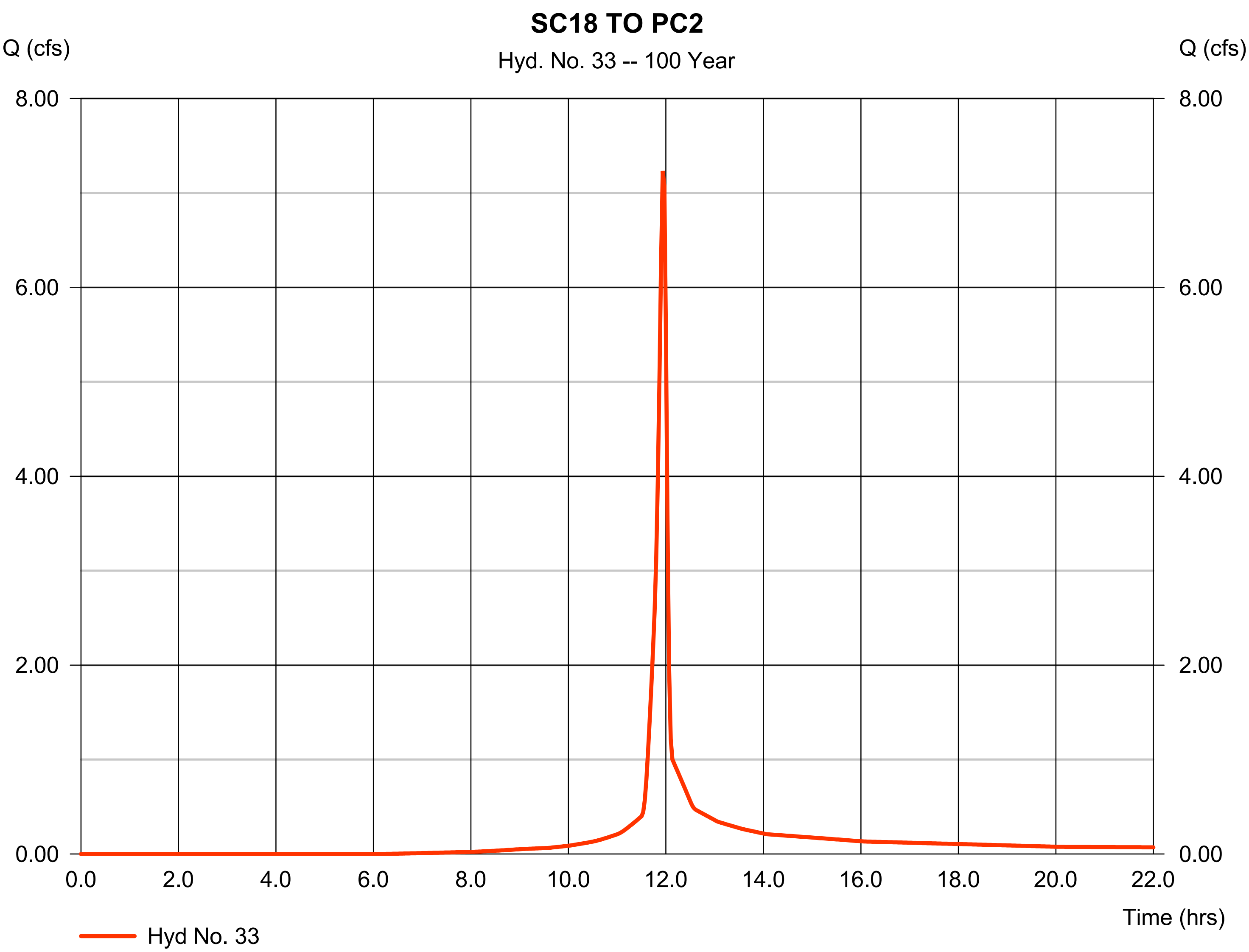
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 33

SC18 TO PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 7.232 cfs |
| Storm frequency | = 500 yrs | Time to peak | = 11.93 hrs |
| Time interval | = 2 min | Hyd. volume | = 14,858 cuft |
| Drainage area | = 1.000 ac | Curve number | = 78 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = TR55 | Time of conc. (Tc) | = 5.80 min |
| Total precip. | = 6.88 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



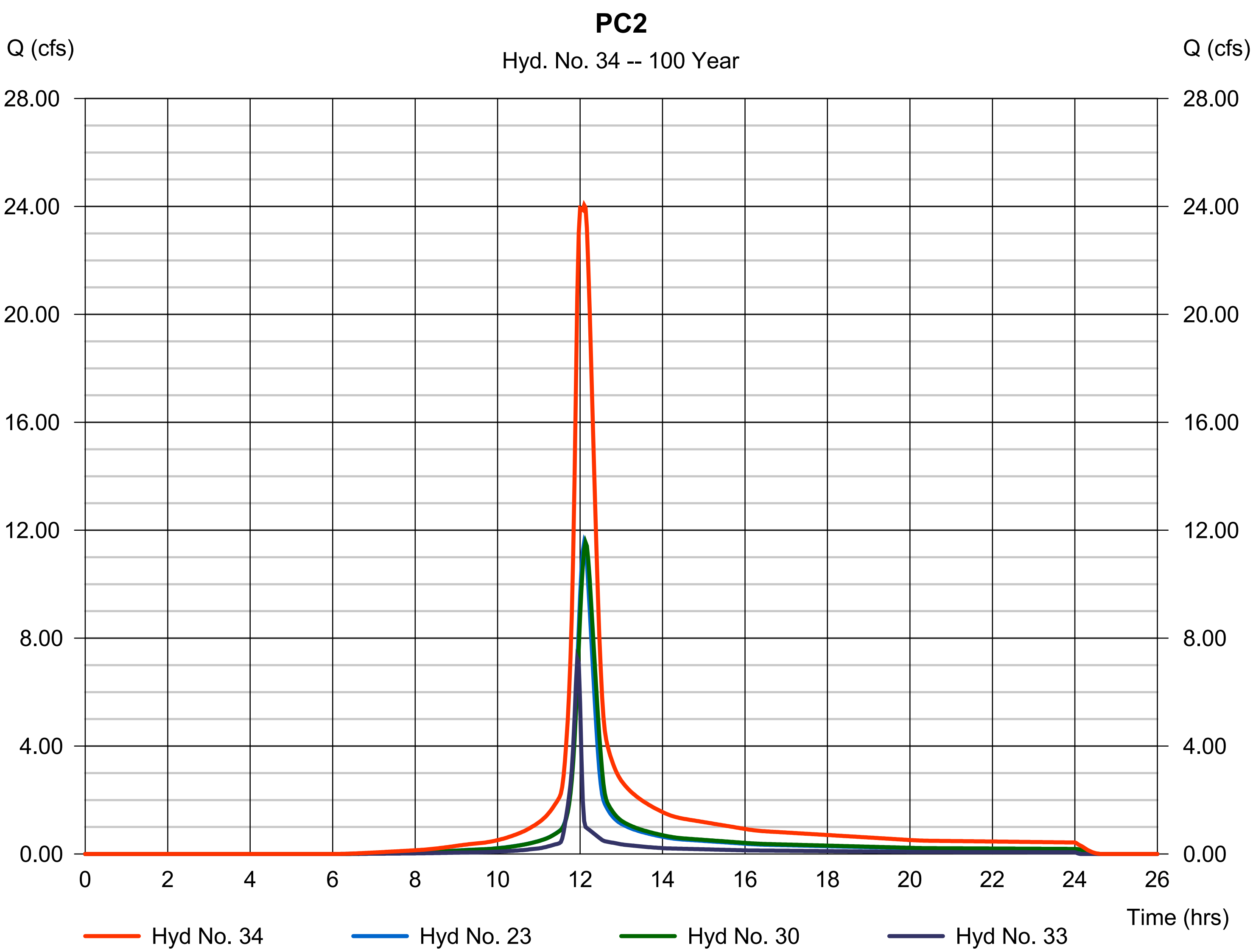
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 34

PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 24.05 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.10 hrs |
| Time interval | 2 min | Hyd. volume | = 97,304 cuft |
| Inflow hyds. | = 23, 30, 33 | Contrib. drain. area | = 6.140 ac |



# Hydrograph Report

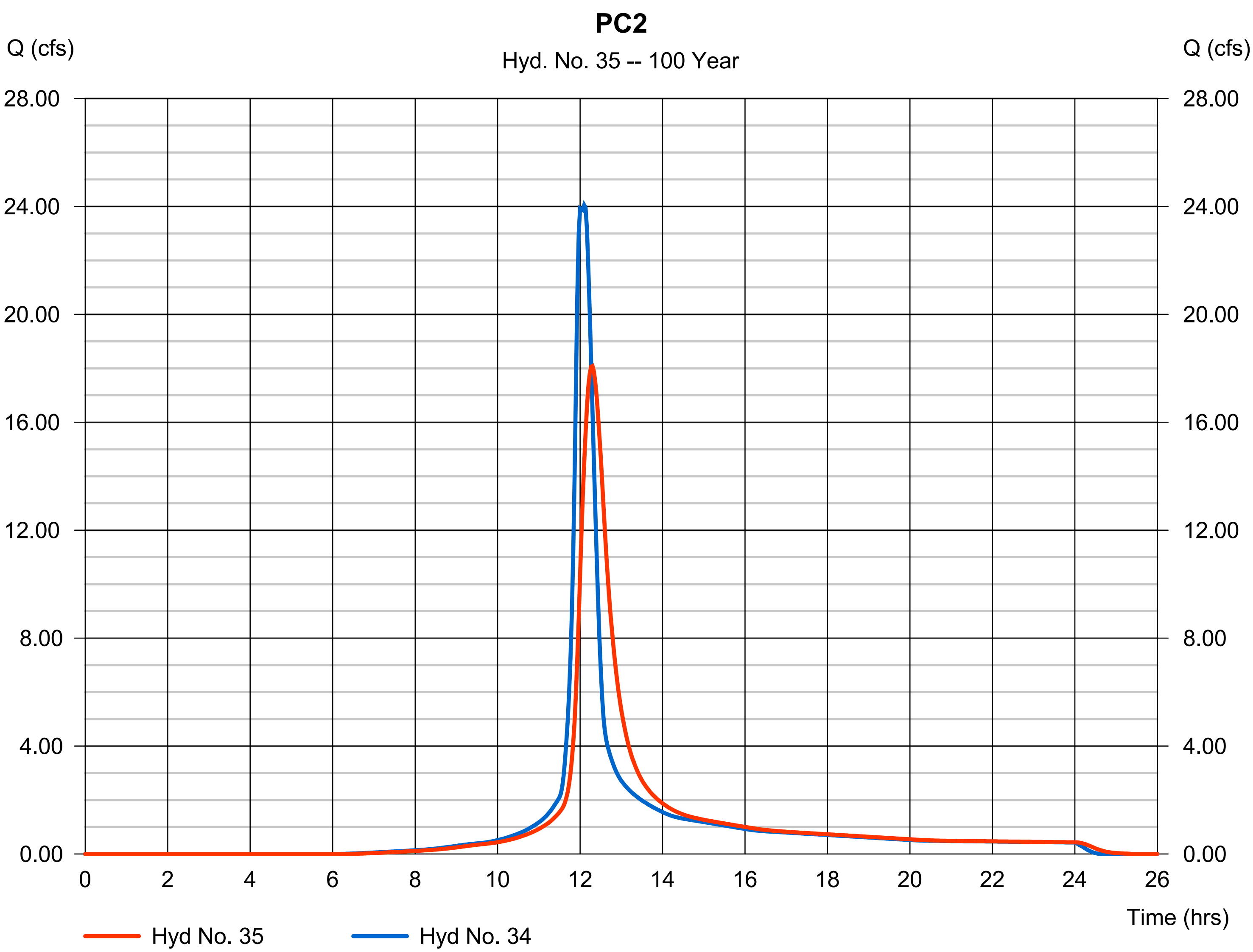
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Tuesday, 08 / 4 / 2020

## Hyd. No. 35

PC2

| | | | |
|---|---|---|---|
| Hydrograph type | = Reach = | Peak discharge | = 18.08 cfs |
| Storm frequency | 500 yrs = 2 | Time to peak | = 12.30 hrs |
| Time interval | min = 34 - | Hyd. volume | = 97,294 cuft |
| Inflow hyd. No. | PC2 = | Section type | = Trapezoidal |
| Reach length | 1700.0 ft = | Channel slope | = 0.4 % |
| Manning's n | 0.070 = | Bottom width | = 5.0 ft |
| Side slope | 2.0:1 | Max. depth | = 2.0 ft |
| Rating curve x | = 0.460 | Rating curve m | = 1.346 |
| Ave. velocity | = 1.27 ft/s | Routing coeff. | = 0.1139 |

Modified Att-Kin routing method used.



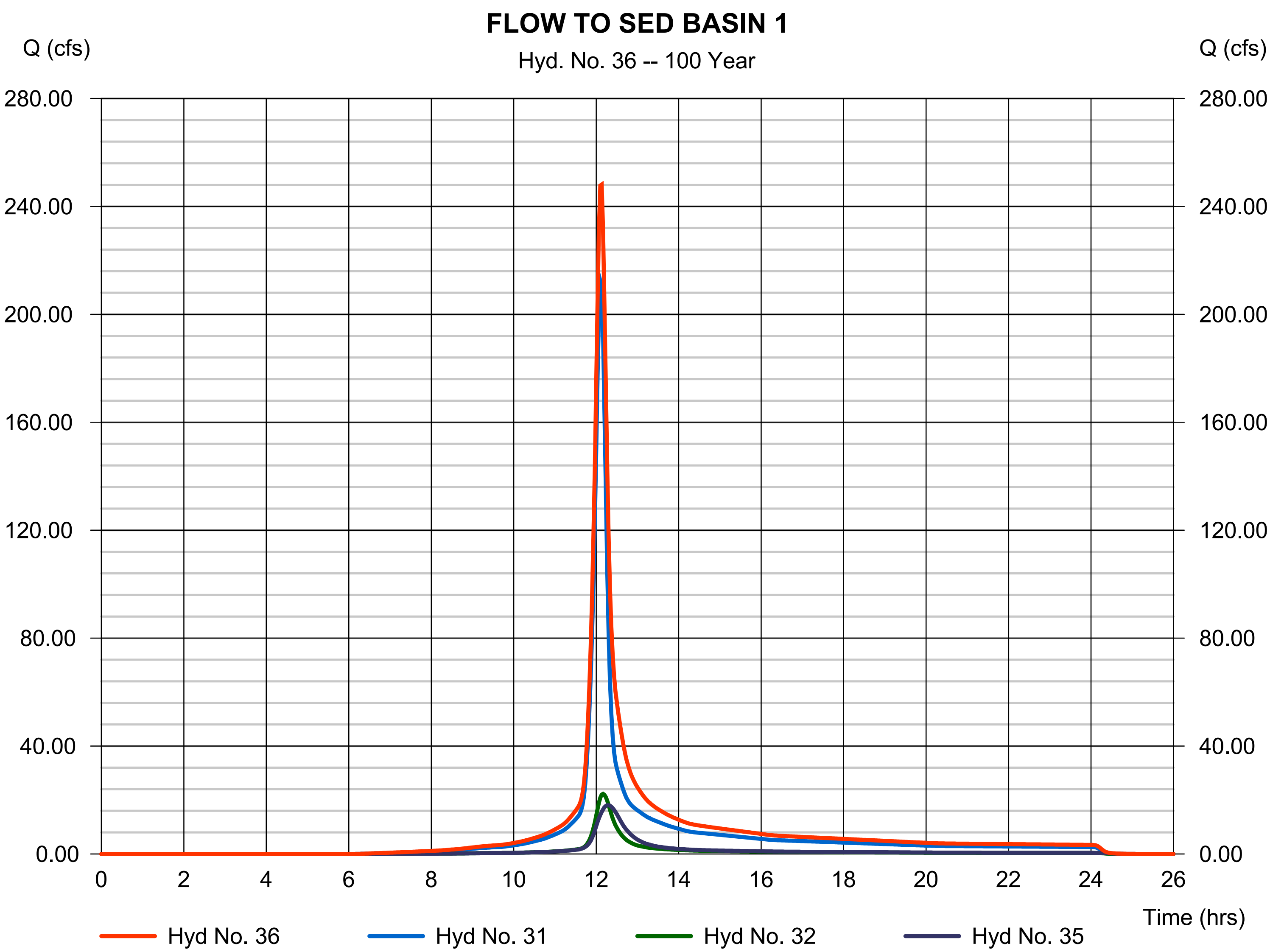
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 | Tuesday, 08 / 4 / 2020

## Hyd. No. 36

FLOW TO SED BASIN 1

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 248.11 cfs |
| Storm frequency | = 500 yrs = | Time to peak | = 12.13 hrs |
| Time interval | 2 min | Hyd. volume | = 774,964 cuft |
| Inflow hyds. | = 31, 32, 35 | Contrib. drain. area | = 0.000 ac |



# Hydraflow Express Reports

# Channel Report



## Channel to Sediment Basin 1 (100-Year Storm)

**Trapezoidal**

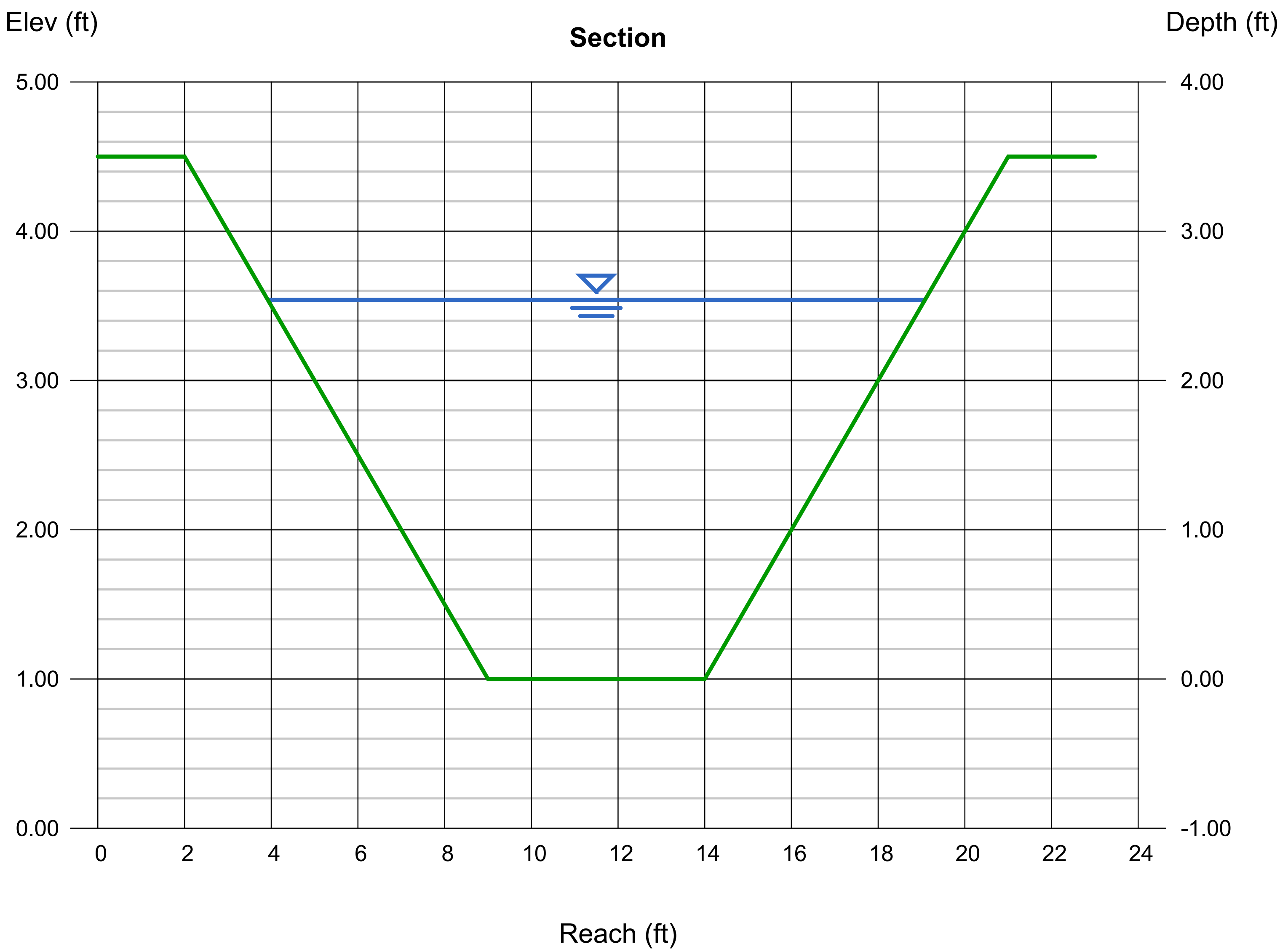
| | |
|---|---|
| Bottom Width (ft) | = 5.00 |
| Side Slopes (z:1) | = 2.00, 2.00 |
| Total Depth (ft) | = 3.50 |
| Invert Elev (ft) | = 1.00 |
| Slope (%) | = 6.00 |
| N-Value | = 0.070 |

**Calculations**

| | |
|---|---|
| Compute by: | Known Q |
| Known Q (cfs) | = 179.43 |

**Highlighted**

| | |
|---|---|
| Depth (ft) | = 2.54 |
| Q (cfs) | = 179.43 |
| Area (sqft) | = 25.60 |
| Velocity (ft/s) | = 7.01 |
| Wetted Perim (ft) | = 16.36 |
| Crit Depth, Yc (ft) | = 2.48 |
| Top Width (ft) | = 15.16 |
| EGL (ft) | = 3.30 |



# Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Aug 4 2020

## Channel to Sediment Basin 1 (500-Year Storm)

**Trapezoidal**

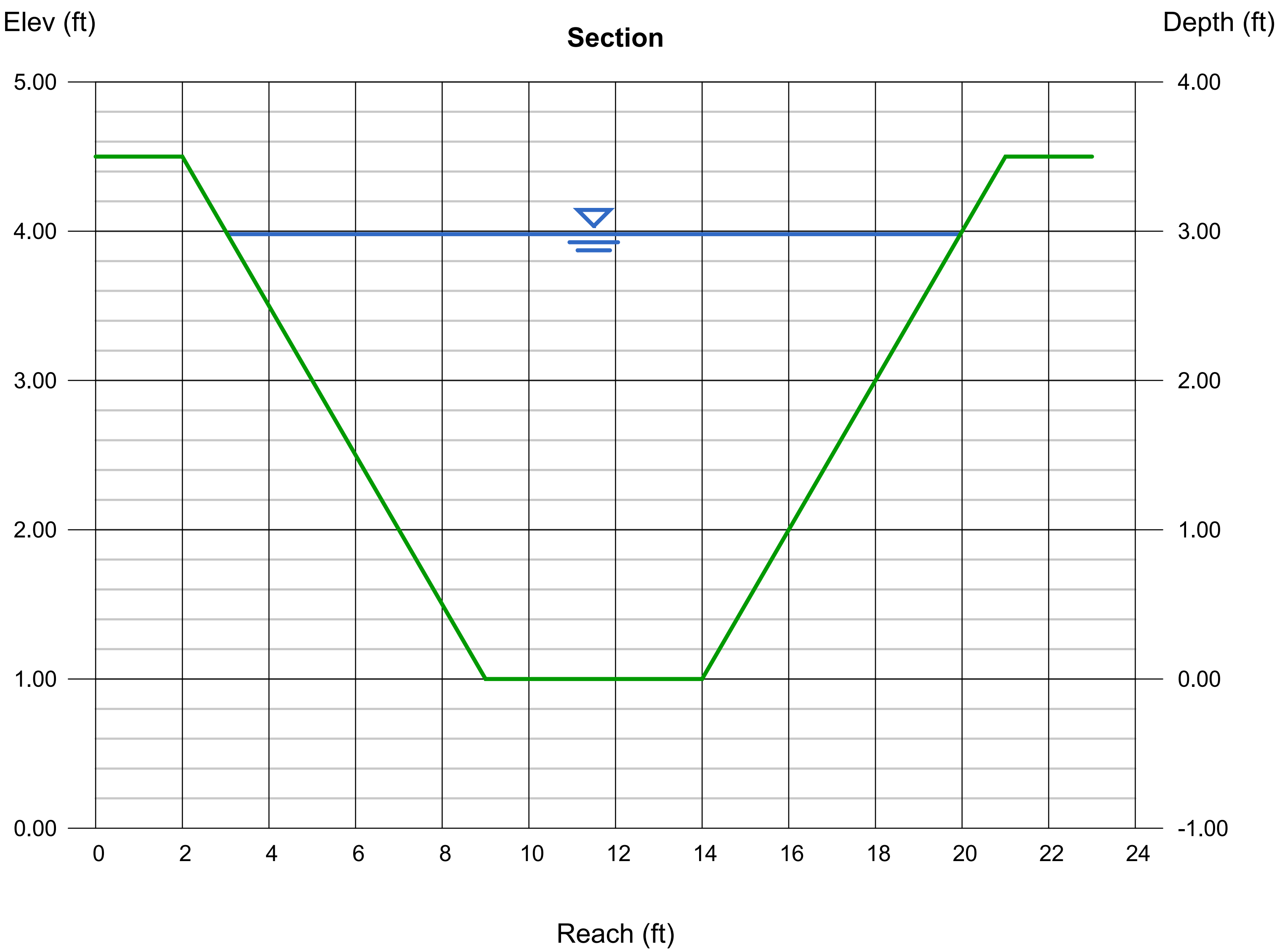
| | |
|---|---|
| Bottom Width (ft) | = 5.00 |
| Side Slopes (z:1) | = 2.00, 2.00 |
| Total Depth (ft) | = 3.50 |
| Invert Elev (ft) | = 1.00 |
| Slope (%) | = 6.00 |
| N-Value | = 0.070 |

**Calculations**

| | |
|---|---|
| Compute by: | Known Q |
| Known Q (cfs) | = 248.00 |

**Highlighted**

| | |
|---|---|
| Depth (ft) | = 2.98 |
| Q (cfs) | = 248.00 |
| Area (sqft) | = 32.66 |
| Velocity (ft/s) | = 7.59 |
| Wetted Perim (ft) | = 18.33 |
| Crit Depth, Yc (ft) | = 2.93 |
| Top Width (ft) | = 16.92 |
| EGL (ft) | = 3.88 |

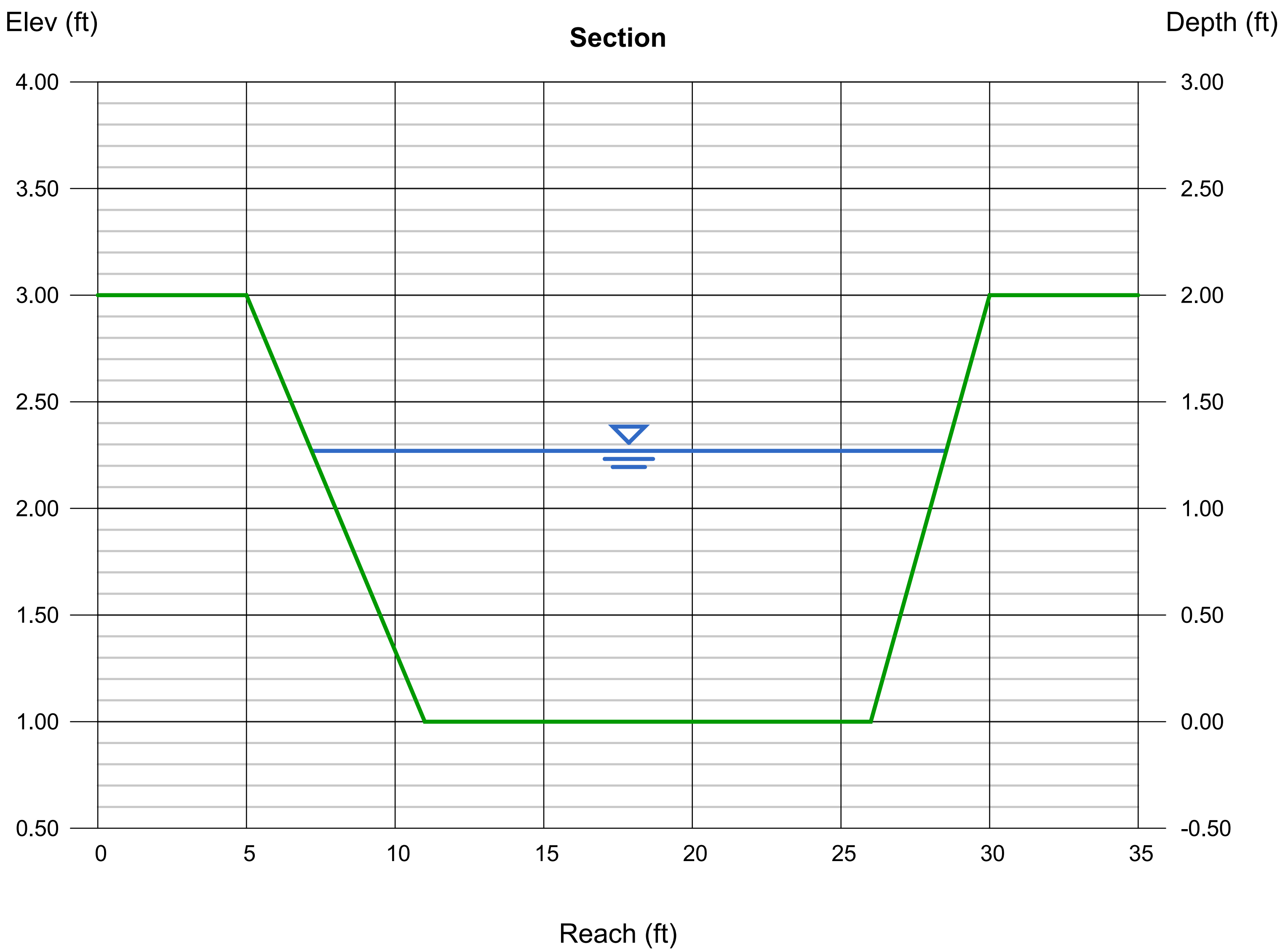


# Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Aug 4 2020

## Downchute (100-Year Storm)

| **Trapezoidal** | | **Highlighted** | |
|---|---|---|---|
| Bottom Width (ft) | = 15.00 | Depth (ft) | = 1.27 |
| Side Slopes (z:1) | = 3.00, 2.00 | Q (cfs) | = 159.32 |
| Total Depth (ft) | = 2.00 | Area (sqft) | = 23.08 |
| Invert Elev (ft) | = 1.00 | Velocity (ft/s) | = 6.90 |
| Slope (%) | = 10.00 | Wetted Perim (ft) | = 21.86 |
| N-Value | = 0.070 | Crit Depth, Yc (ft) | = 1.40 |
| | | Top Width (ft) | = 21.35 |
| **Calculations** | | EGL (ft) | = 2.01 |
| Compute by: | Known Q | | |
| Known Q (cfs) | = 159.32 | | |



# Channel Report



## Downchute (500-Year Storm)

**Trapezoidal**

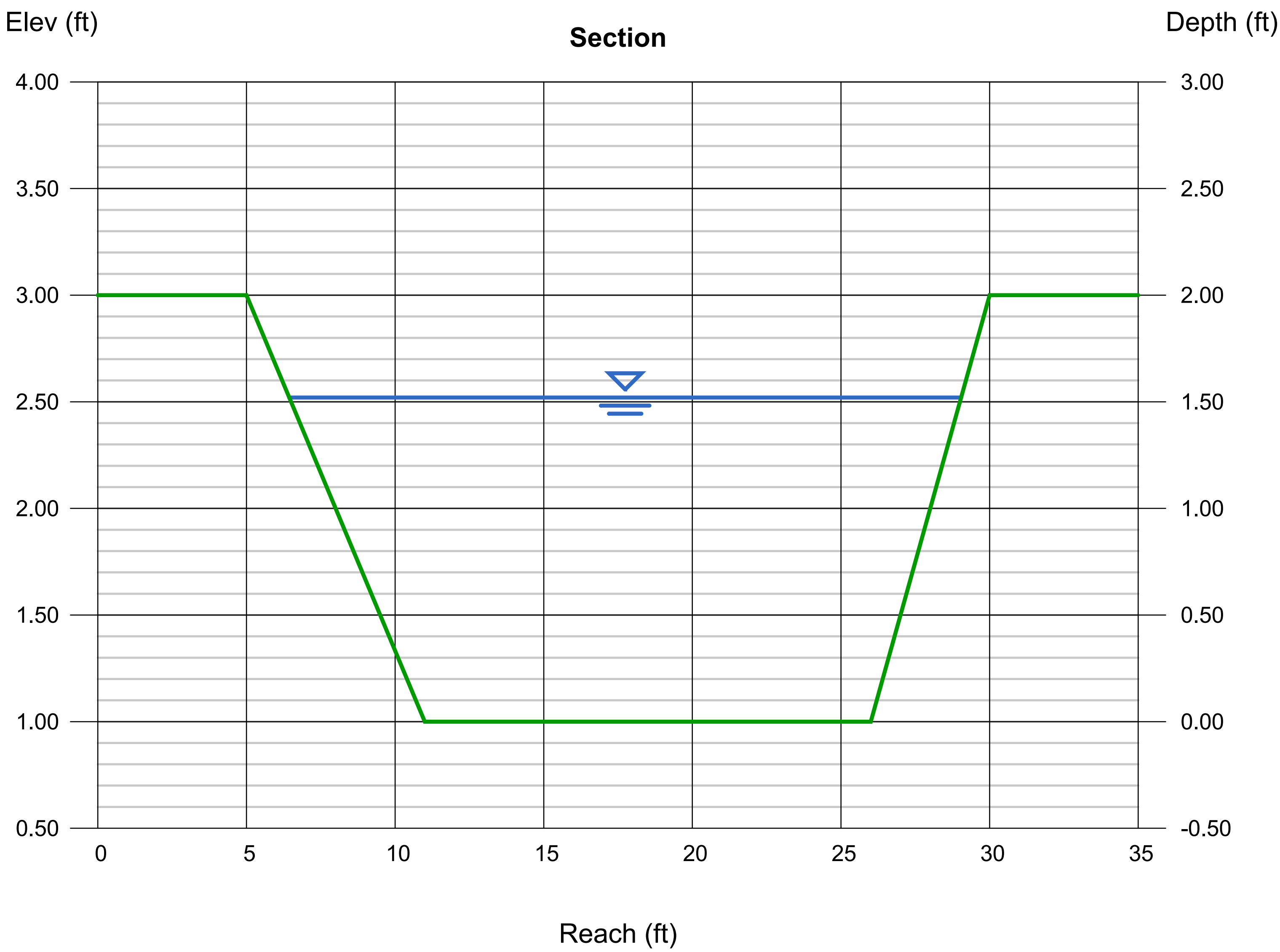
| | | |
|---|---|---|
| Bottom Width (ft) | = | 15.00 |
| Side Slopes (z:1) | = | 3.00, 2.00 |
| Total Depth (ft) | = | 2.00 |
| Invert Elev (ft) | = | 1.00 |
| Slope (%) | = | 10.00 |
| N-Value | = | 0.070 |

**Calculations**

| | | |
|---|---|---|
| Compute by: | | Known Q |
| Known Q (cfs) | = | 219.46 |

**Highlighted**

| | | |
|---|---|---|
| Depth (ft) | = | 1.52 |
| Q (cfs) | = | 219.46 |
| Area (sqft) | = | 28.58 |
| Velocity (ft/s) | = | 7.68 |
| Wetted Perim (ft) | = | 23.21 |
| Crit Depth, Yc (ft) | = | 1.71 |
| Top Width (ft) | = | 22.60 |
| EGL (ft) | = | 2.44 |



# Channel Report

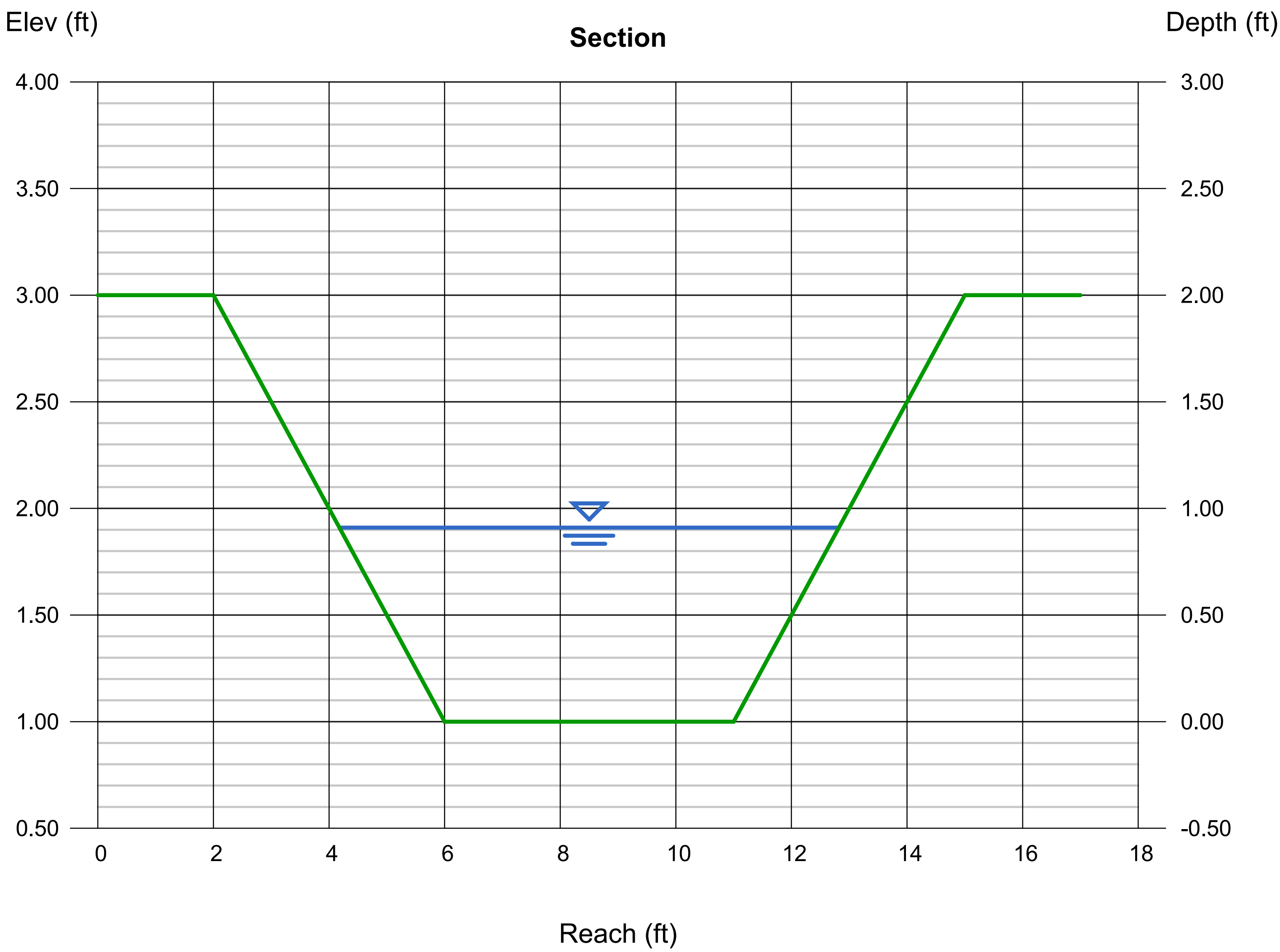


## PC-3 (100-year Storm)

| | |
|---|---|
| **Trapezoidal** | |
| Bottom Width (ft) | = 5.00 |
| Side Slopes (z:1) | = 2.00, 2.00 |
| Total Depth (ft) | = 2.00 |
| Invert Elev (ft) | = 1.00 |
| Slope (%) | = 6.00 |
| N-Value | = 0.070 |

| | |
|---|---|
| **Calculations** | |
| Compute by: | Known Q |
| Known Q (cfs) | = 24.66 |

| | |
|---|---|
| **Highlighted** | |
| Depth (ft) | = 0.91 |
| Q (cfs) | = 24.66 |
| Area (sqft) | = 6.21 |
| Velocity (ft/s) | = 3.97 |
| Wetted Perim (ft) | = 9.07 |
| Crit Depth, Yc (ft) | = 0.82 |
| Top Width (ft) | = 8.64 |
| EGL (ft) | = 1.16 |



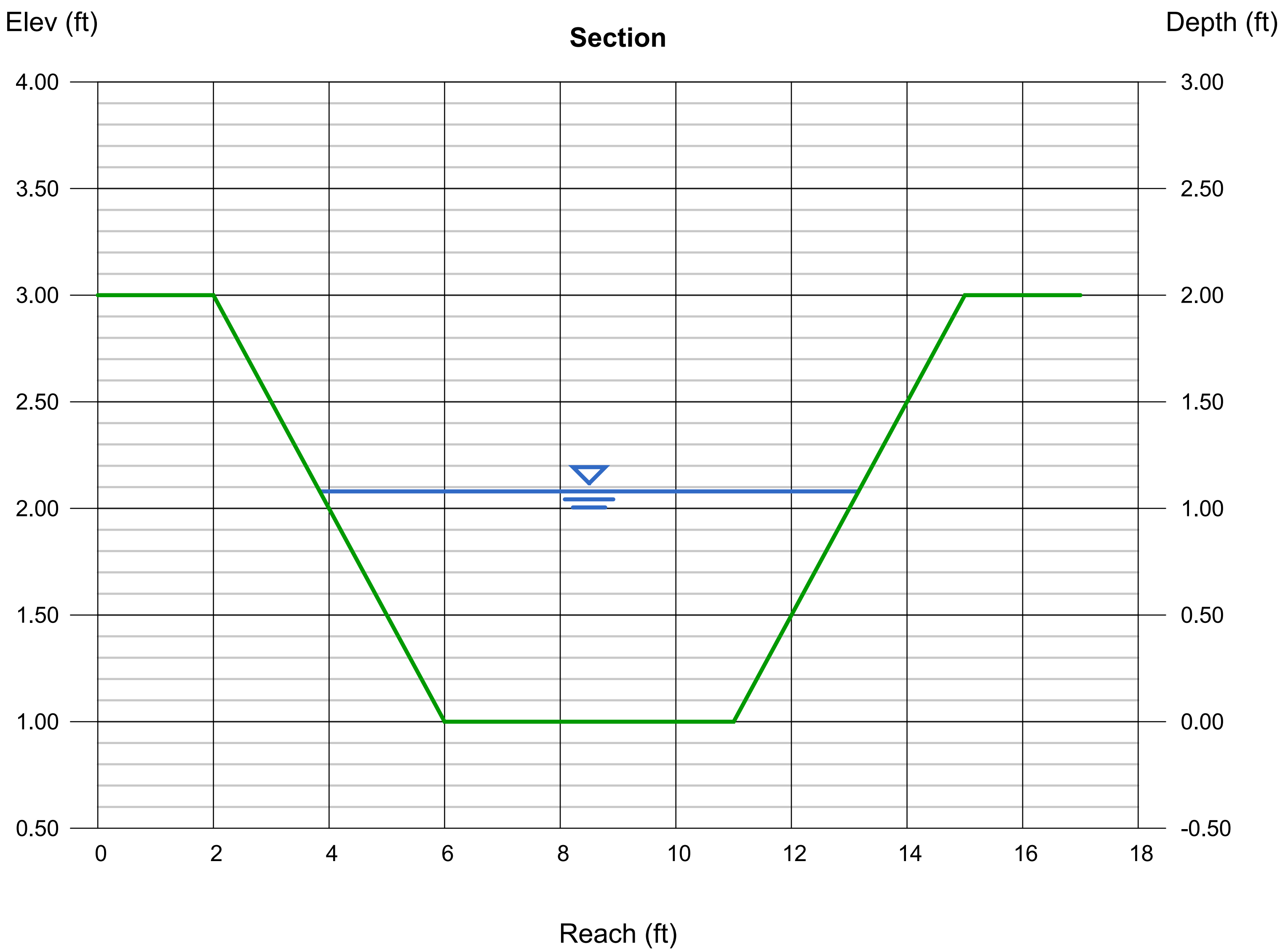
# Channel Report



## PC-3 (500-year Storm)

| | |
|---|---|
| **Trapezoidal** | |
| Bottom Width (ft) | = 5.00 |
| Side Slopes (z:1) | = 2.00, 2.00 |
| Total Depth (ft) | = 2.00 |
| Invert Elev (ft) | = 1.00 |
| Slope (%) | = 6.00 |
| N-Value | = 0.070 |
| **Calculations** | |
| Compute by: | Known Q |
| Known Q (cfs) | = 34.26 |

| | |
|---|---|
| **Highlighted** | |
| Depth (ft) | = 1.08 |
| Q (cfs) | = 34.26 |
| Area (sqft) | = 7.73 |
| Velocity (ft/s) | = 4.43 |
| Wetted Perim (ft) | = 9.83 |
| Crit Depth, Yc (ft) | = 0.99 |
| Top Width (ft) | = 9.32 |
| EGL (ft) | = 1.39 |



# Channel Report



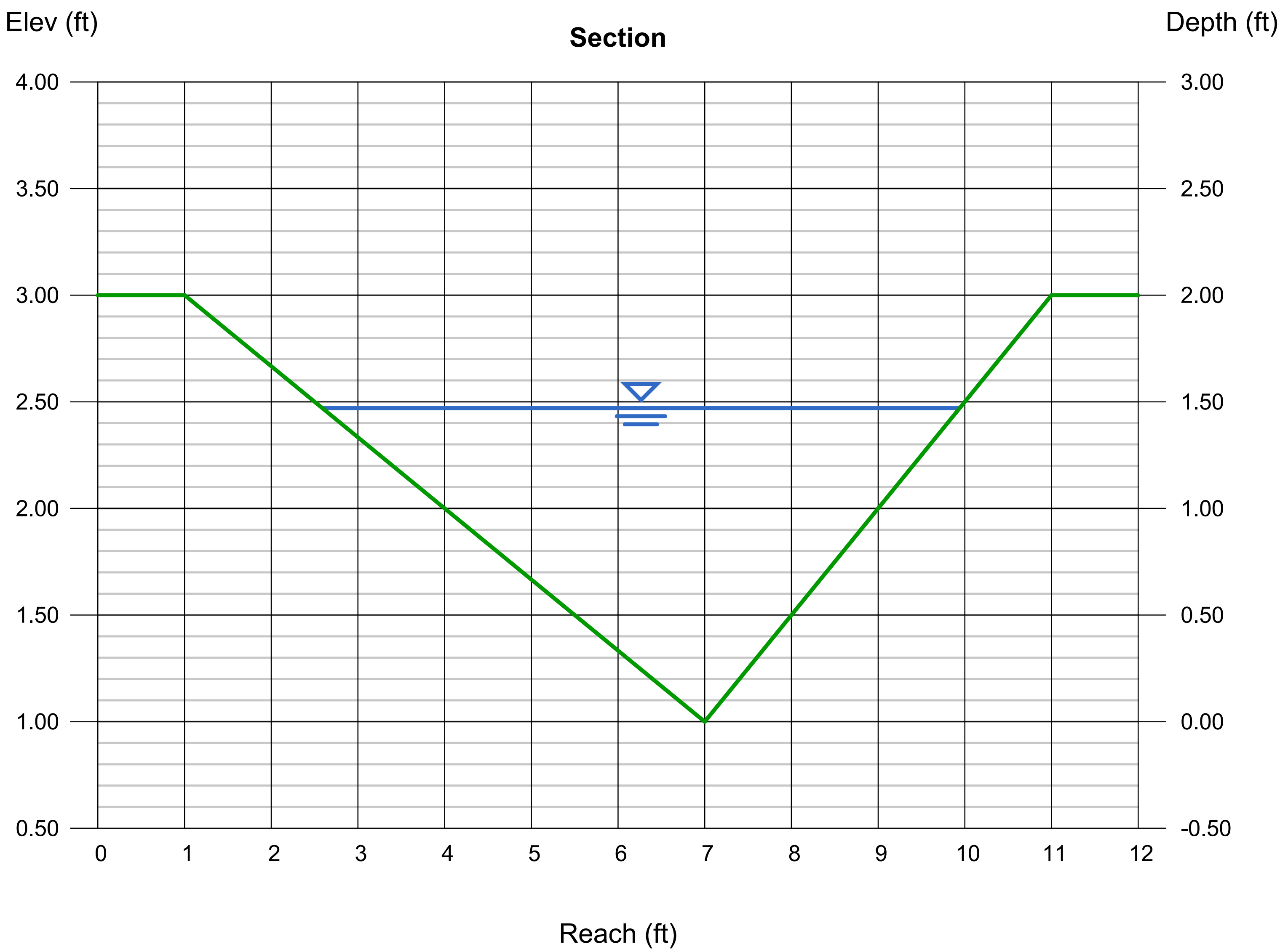
## SW7 (100-year Storm)

**Triangular**
Side Slopes (z:1) = 3.00, 2.00
Total Depth (ft) = 2.00

Invert Elev (ft) = 1.00
Slope (%) = 2.00
N-Value = 0.027

**Calculations**
Compute by: Known Q
Known Q (cfs) = 32.35

**Highlighted**
Depth (ft) = 1.47
Q (cfs) = 32.35
Area (sqft) = 5.40
Velocity (ft/s) = 5.99
Wetted Perim (ft) = 7.94
Crit Depth, Yc (ft) = 1.60
Top Width (ft) = 7.35
EGL (ft) = 2.03

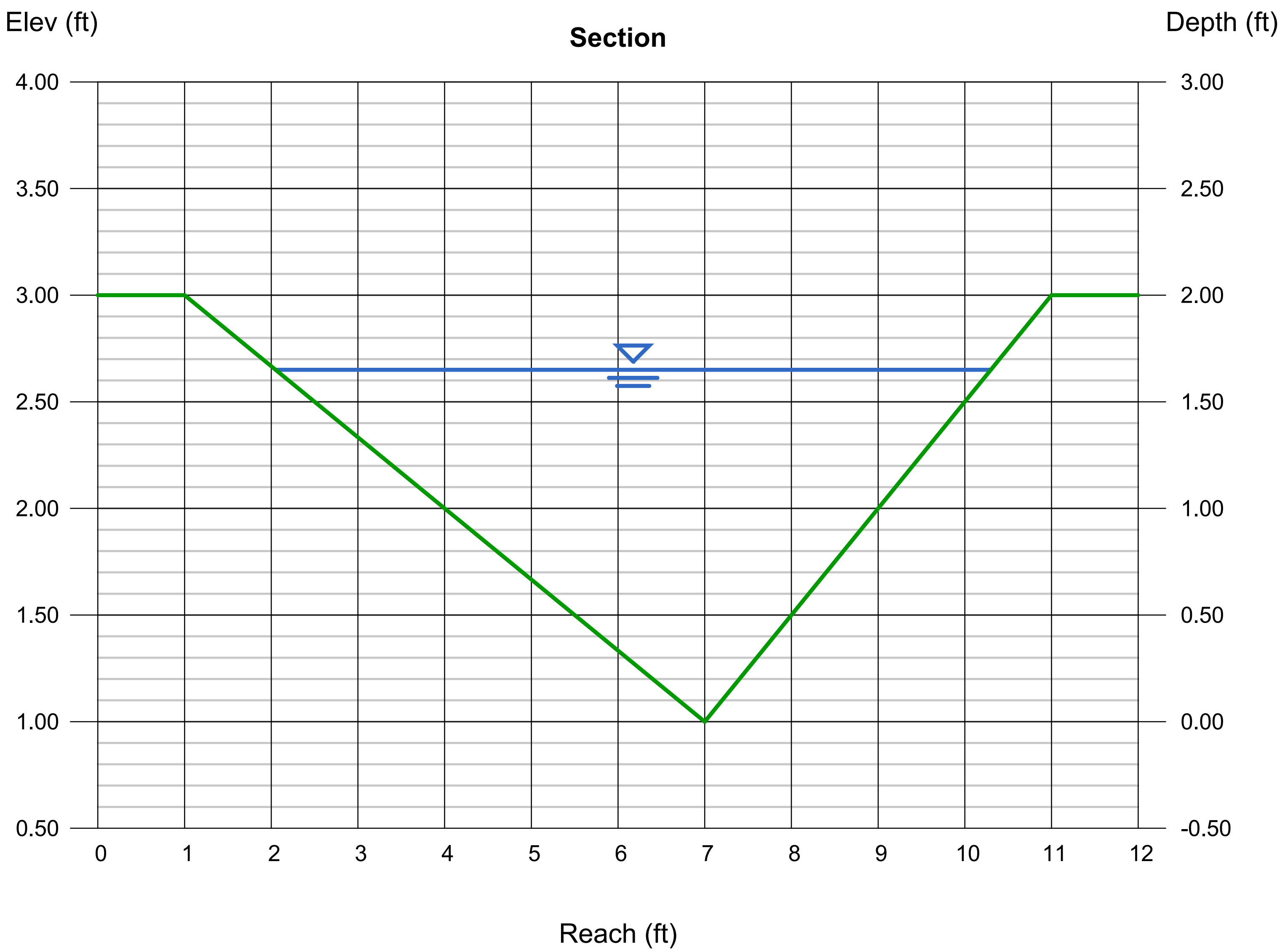


# Channel Report



## SW7 (500-year Storm)

| | | | |
|---|---|---|---|
| **Triangular** | | **Highlighted** | |
| Side Slopes (z:1) | = 3.00, 2.00 | Depth (ft) | = 1.65 |
| Total Depth (ft) | = 2.00 | Q (cfs) | = 44.16 |
| | | Area (sqft) | = 6.81 |
| Invert Elev (ft) | = 1.00 | Velocity (ft/s) | = 6.49 |
| Slope (%) | = 2.00 | Wetted Perim (ft) | = 8.91 |
| N-Value | = 0.027 | Crit Depth, Yc (ft) | = 1.81 |
| | | Top Width (ft) | = 8.25 |
| **Calculations** | | EGL (ft) | = 2.30 |
| Compute by: | Known Q | | |
| Known Q (cfs) | = 44.16 | | |



# ATTACHMENT 2

# Final Cover Veneer Stability Analysis

- **Long Term Stability Analysis**
- **Short Term Stability Analysis**

# Long Term Stability Analysis

# *Veneer Slope Stability Analysis - Long-term Peak Interface Friction Angle Without Adhesion*

| Input parameters | | | |
|---|---|---|---|
| ϒ = | unit weight of the cover soil | 130 | $lb/ft^3$ |
| h = | thickness of the cover soil | 1.5 | ft |
| L = | length of slope measured along the final cover system | 1000 | ft |
| β = | final cover system slope angle | 18.4 | ° |
| ɸ = | friction angle of the cover soil | 30 | ° |
| δ = | interface friction angle between final cover system components | 26.4 | ° |
| $c_a$ = | adhesion between final cover system components | 0 | $lb/ft^2$ |
| c = | cohesion of the cover soil | 0 | $lb/ft^2$ |
| FS = | Required Factor of Safety | 1.5 | |

**Active Wedge Calculations**

$$W_A = \gamma h^2 \left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \qquad N_A = W_A \cos\beta \qquad C_a = c_a\left(L - \frac{h}{\sin\beta}\right)$$

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_A)\sin\beta}{\sin\beta(FS)}$$

| | | | |
|---|---|---|---|
| $W_A$ = | total weight of the active wedge | 194,025 | lbs |
| $N_A$ = | effective force normal to the failure plane of the active wedge | 184,105 | lbs |
| $C_a$ = | adhesive force between cover soil of the active wedge and the geomembrane | 0 | lbs |
| $E_A$ = | interwedge force acting on the active wedge from the passive wedge | 320 | lbs |

**Passive Wedge Calculations**

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \qquad C = \frac{ch}{\sin\beta} \qquad E_P = \frac{C + W_P\tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \qquad N_P = W_P + E_P\sin\beta$$

| | | | |
|---|---|---|---|
| $W_P$ = | total weight of the passive wedge | 488 | lbs |
| C = | cohesive force along the failure plane of the passive wedge | 0 | lbs |
| $E_P$ = | interwedge force acting on the passive wedge from the active wedge | 227 | lbs |
| $N_P$ = | effective force normal to the failure plane of the passive wedge | 560 | lbs |

**Factor of Safety Calculations**

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_\alpha)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)]$$

$$c = (N_A\tan\delta + C_\alpha)\sin^2\beta\tan\phi$$

| | | | |
|---|---|---|---|
| a = | 18,343 | lbs | |
| b = | -30,983 | lbs | |
| c = | 5,257 | lbs | |

| | | |
|---|---|---|
| ɸ = | 30.0 | ° |
| c = | 0 | $lb/ft^2$ |
| δ = | 26.4 | ° |
| $c_a$ = | 0 | $lb/ft^2$ |
| **FS =** | **1.50** | |

Source: Analysis and Design of Veneer Cover Soils by Robert M Koerner and Te-Yang Soong, Sixth International Conference on Geosynthetics, 1998

# Short Term Stability Analysis

P.J.Carey & Associates, P.C.

**CLIENT**

**PROJECT**

**JOB No** na

**CALCULATION BY** Peter J. Carey

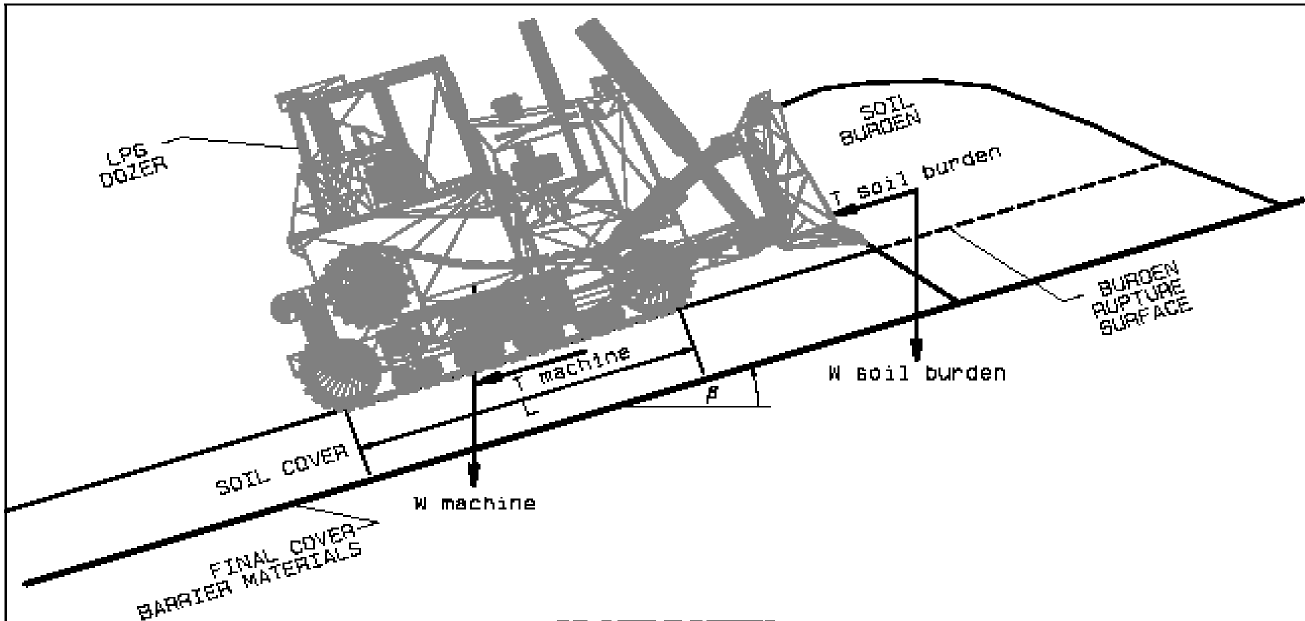
**CHECKED BY** KLH

**DATE** 3/3/2011

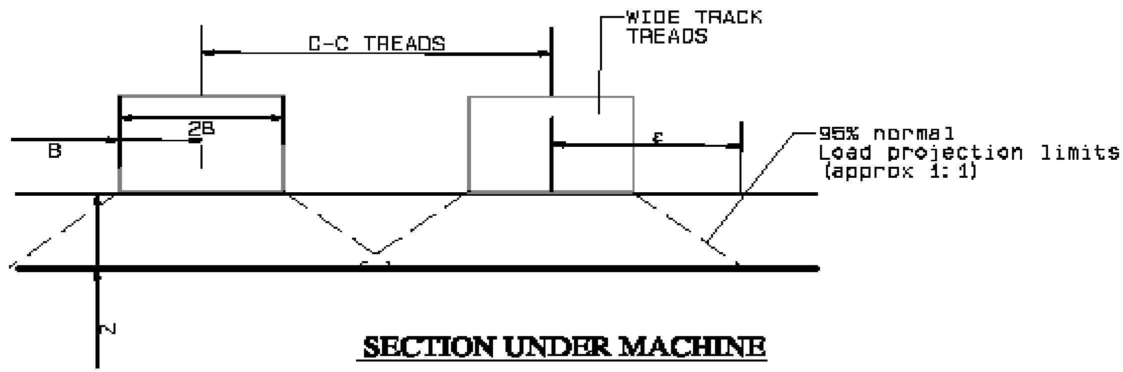
**OBJECT** **Calculate the strength requirements of final cover materials during deployment of cover soils necessary to achieve a minimum factor of safety that does not result in degradation of the peak strength of the interface or materials within the final cover system.**

References: Poulos&Davis, Elastic Solutions for Soil and Rock Mechanics, John Wiley, Sydney,1974.
Spefication pages from Equipment manufacturer's for LPG Dozer operating information and dimensions

This calculation set has been generated for a CAT 6N **LPG** machine with added optional equipment to freflect the higher operational weights anticipated.
The analysis considers the weight of the dozer, the track contact dimensions, the center to center spacing of the treads, the tread width, and the amount of soil burden being pushed up the slope. The use of LPG machines results in overlapping stress zones between treads under the machine, as will be shown in the analysis, resulting in a zone of soils under the dozer that would have to move with the dozer treads relative to the under final cover materials if slippage were to occur. This zone of rupture is conservately limited to the contact length of the treads long by a width as defined by the elastic solution of a strip load needed to result in the 95% of a tread loading at the depth of the cover soil analyzed for a single tread. A general diagram of showing the Dozer and generalized free body diagram is presented below. The factor of saftey is computed by comparing the forces tending to move the zone of rupture down hill, parallel to the final cover surface, to those availabe to resist this movement. As a factor of safety of > or equal to 1.25 is required, residual or large strain behavior is not considered, nor is the development of any tensile forces in any of the geosynthetic layers.




PROFILE VIEW




SECTION UNDER MACHINE

## Driving Forces

Forces tending to move the zone of rupture down hill are those needed to

- move the soil burden up hill, $T_{soil\ burden}$ in the above diagram
- the parallel component of the machine weight
- the acceleration of the machine parallel to the slope

All of the above are summed up in the Vector $T_{machine}$ shown in the above diagram

In addition, the soil cover within the rupture zone has a downhill component ($W_{soil}$ x sin (β)) typical of any infinite slope analysis.

The sum of the above constitutes the driving forces utilized in this analysis.

## Resisting Forces

Forces resisting down hill movement of the rupture zone are computed at the upper surface of the geosynthetic layers of the final cover. The analysis assumes that all the forces are resolved under the zone of rupture and without tension in the geosynthetics. This requires that the shear forces at the upper interface (or interfaces and final cover components within a few inches) are responsible for all resisting forces. The shear forces are computed based on whatever relationship to norma stress the interfaces may exhibit. For the purpose of this calculation it is assumed that the relationship between shear and normal stress, withing the range of normal stresses that will occur, are well approximated by $\tau = \sigma_n \times \tan \varphi$. But, based test results, different relationships could be used.

## Problem Specific Inputs

| | |
|---|---|
| Gross Operating Weight | $GOW = 3.959 \times 10^4\ lbf$ |
| Option Weight (may be included based on purchase options | $Optionalwt = 2 \times 10^3\ lbf$ |
| Total Opertating Weight | $TOW := GOW + Optionalwt = 4.159 \times 10^4\ lbf$ |
| Track Width | $Trackwidth = 33 \cdot in$ |
| B - half track width (used for computation | $B := 0.5 \cdot Trackwidth = 1.375\ ft$ |

Track contact length $L = 61.5 \cdot in$

Contact pressure $p_u := \frac{TOW}{L \cdot 2 \cdot Trackwidth} = 10.247\,psi$

Center to Center tread distance $c\_c_{tread} = 6.2\,ft$

Blade Capacity $V_{sb} = 4.13 \cdot yd^3$

slope angle $\beta = 18.435 \cdot deg$

Depth of cover under tracks $z = 15 \cdot in$

Final cover soil density $\gamma_{soil} = 130 \cdot \frac{lbf}{ft^3}$

density of cover under machine $\gamma_{cover} := 0.90 \cdot \gamma_{soil} = 117 \cdot \frac{lbf}{ft^3}$ limited compaction has occured

density of soil burden $\gamma_{loose} := .7 \cdot \gamma_{soil} = 91 \cdot \frac{lbf}{ft^3}$ accounts for fluffing and no compaction

friction angle for soils $\varphi_{soil} = 30 \cdot deg$

friction angle for soil burden $\varphi_{loose} := atan(0.9\tan(\varphi_{soil})) = 27.457 \cdot deg$ to account for looseness

**Computation of Driving Forces**

$T_{\text{soil burden}}$ $(T_{sb})$

The tractive force needed to move a soil burden uphill can be calculated 1as the component of the soil burden weight that is parallel to the slope plus the shear force needed to create a failure mode at the base of the burden. The latter component can be estimated using a Mohr -Coulomb model, assigning properties to the soil associated with a loose dumped condition. The parallel component of the weight of the soil burden is $T_{.sbparallel}$ and is

$T_{sbparallel} = W_{sb} \cdot \sin(\beta)$ , where $W_{sb}$ is the weight of the burden and β is the slope angle from the horizontal

$W_{sb} := V_{sb} \cdot \gamma_{loose} = 1.015 \times 10^{4}\,\mathrm{lbf}$ $\quad T_{sbparallel} := W_{sb} \cdot \sin(\beta) = 3.209 \times 10^{3}\,\mathrm{lbf}$

The force required to shear the burden along the line parallel to the slope is designated $T_{sbshear}$

$T_{sbshear} := W_{sb} \cdot \cos(\beta) \cdot \tan(\varphi_{loose})$ $\quad T_{sbshear} = 5.002 \times 10^{3}\,\mathrm{lbf}$

$T_{sb} := T_{sbparallel} + T_{sbshear} = 8.211 \times 10^{3}\,\mathrm{lbf}$ This force acts on the blade of the dozer

$T_{machine}$

The machine applies both the $T_{sb}$ force and the force associated with its own weight ($T_{mw}$) and acceleration ($T_{ma}$)

$T_{mw} := TOW \cdot \sin(\beta) = 1.315 \times 10^{4}\,\mathrm{lbf}$

$T_a := a \cdot \frac{TOW}{g} = 831.86\,\mathrm{lbf}$

where a is 0.02g, which is sufficient to reach full spead in a few seconds, keeping in mind full speed with a burden load is just 1.5 mph

$T_{machine} := T_{sb} + T_{mw} + T_a = 2.22 \times 10^{4}\,\mathrm{lbf}$

**Soil Driving Forces**

The soil driving force is the weight of the soil cover under the area L x 2 times (1/2 the c-c tread distance +ε), this is computed later when ε is determined, times the sin (β)

$$T_{Soil}(\varepsilon) := \sin(\beta)\cdot L\cdot 2\cdot z\cdot \gamma_{cover}\cdot\left(\frac{1}{2}\cdot c\_c_{tread} + \varepsilon\right)$$

**Total Driving Force** $$T_{Driving}(\varepsilon) := T_{machine} + T_{Soil}(\varepsilon)$$

__Resiting Force Computation__

**Contact Stress under tracks and determination of ε**

Using the elastic solution for the subsurface vertical stress imparted by a infinite strip load of width 2b, as shown in figure 3.1 from Poulos and Davis

### 3.1.1 UNIFORM VERTICAL LOADING (Fig.3.1)

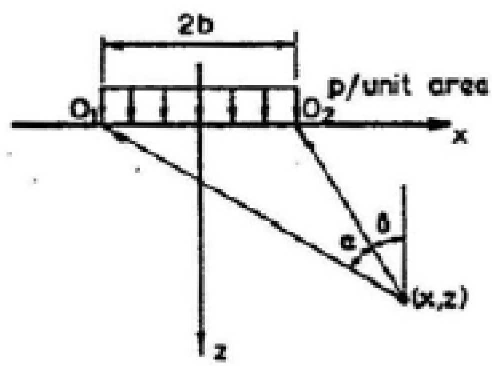



FIG.3.1

$$\sigma_z = \frac{p}{\pi}\left[\alpha + \sin\alpha \cos(\alpha+2\delta)\right] \qquad \ldots (3.1a)$$

$$\sigma_x = \frac{p}{\pi}\left[\alpha - \sin\alpha \cos(\alpha+2\delta)\right] \qquad \ldots (3.1b)$$

$$\sigma_y = \frac{2p}{\pi}\nu\alpha \qquad \ldots (3.1c)$$

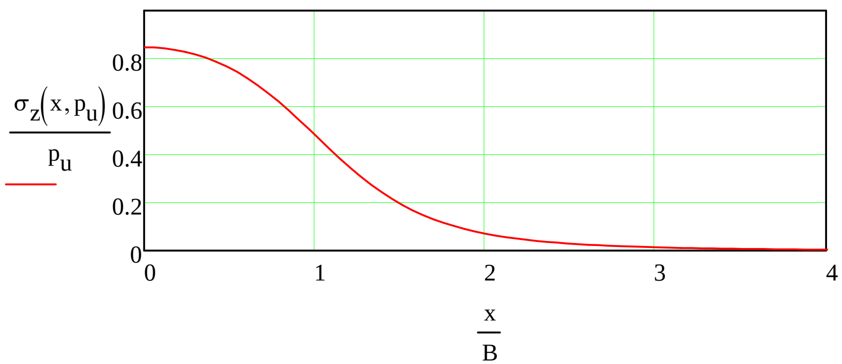
the vertical stress ($\sigma_z$ ) can be computed

$$\delta(x) := -\operatorname{atan}\left(\frac{B - x}{z}\right) \qquad \alpha(x) := \operatorname{atan}\left(\frac{B + x}{z}\right) - \delta(x)$$

where x is measured from the center of the track

$$\sigma_z(x, p_u) := p_u \cdot \frac{\alpha(x) + \sin(\alpha(x)) \cdot \cos(\alpha(x) + 2\,\delta(x))}{\pi}$$

plotted to show an influence chart




the force computed for a given length from the center (ε) is

$$\text{force}_{comp}(\varepsilon) := \int_0^{\varepsilon} \sigma_z(x, p_u)\,dx$$

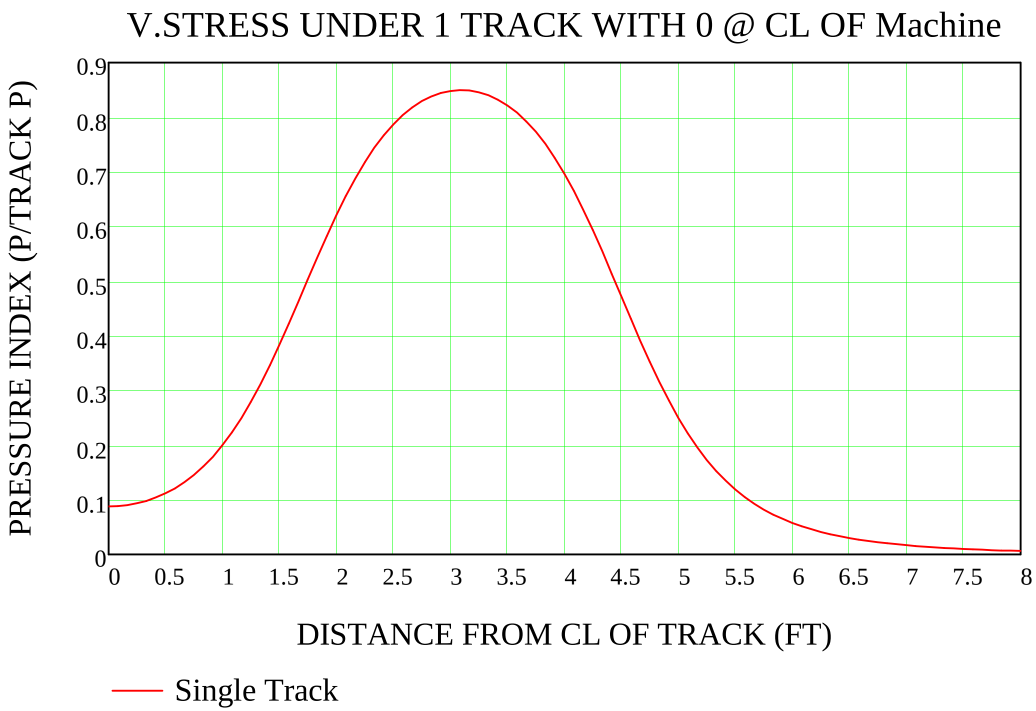
The distance ε that would account for 0.95 of entire weight of one strip can be determined and used to limit the width of the rupture zone. Using a built in solve routing in Mathcad, set the identity to find the length

Given

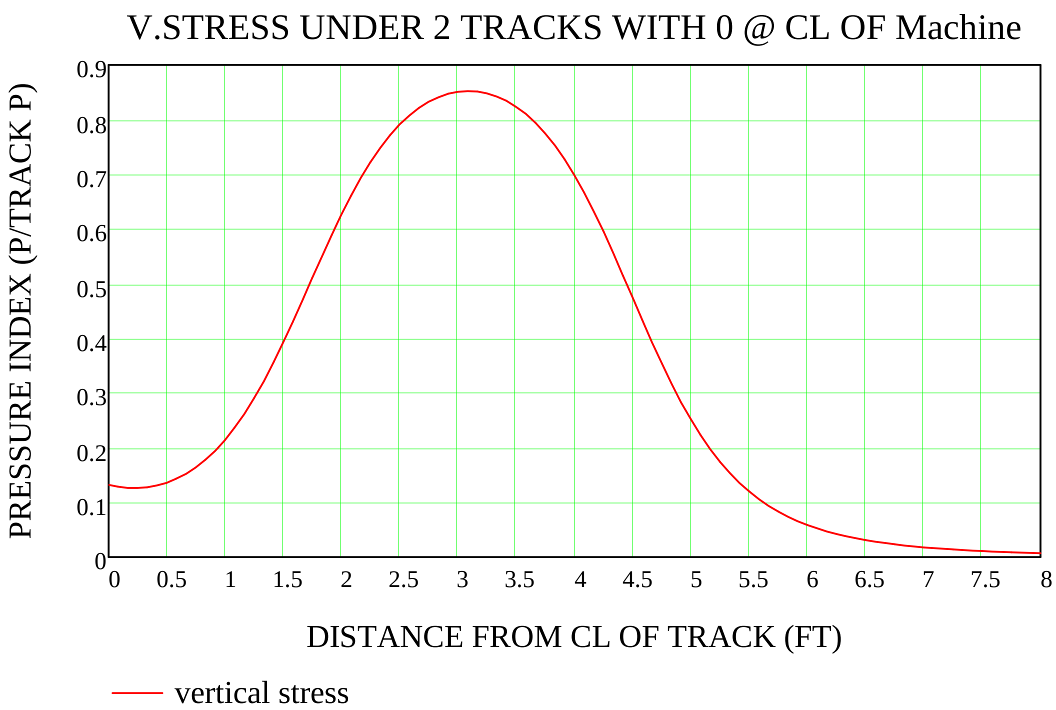
$0.95 = \dfrac{force_{comp}(\varepsilon)}{p_u \cdot B}$ $\quad \varepsilon := Find(\varepsilon)$ $\quad \varepsilon = 2.679\,ft$ $\quad \dfrac{\varepsilon - B}{z} = 1.043$ which is slightly more than a 1:1 projection

sing this limit of lateral spread, the computed stresses should be multiplied by $C_{\varepsilon} := \dfrac{2}{1 + 0.95} = 1.026$ if the total weight of the equipment is to used in the calculations. This is due to fact that in the direction toward the center the calculation will include two tracks with overlapping pressure bulbs, thereby requiring the correction on only outside of the tracks. Adding both sides of machine tracks together is accomplished by offsetting the x axis about the center of the machine as opposed to the center of the tread. For one half the machine this is done with the equation shown below. A graph is presented to demonstrate the stress field

$$\sigma_z\left(\frac{c\_c_{tread}}{2}, p_u\right) + \sigma_z\left[\left(\frac{c\_c_{tread}}{2} + x\right), p_u\right]$$




note that ε occurs at $\frac{c\_c_{tread}}{2} + \varepsilon = 5.779\,\text{ft}$




showing the overlap of the stress bulbs under the machine.

Finally performe a check to show the total opertating weight and the intergration from 0 to ε corrected by Cε, gives the correct answer

$$\text{integratedTOW} := 2\cdot L\left[\int_0^{\varepsilon+\frac{c\_c_{tread}}{2}} \left|\left|\left| C_\varepsilon\cdot\left[\sigma_z\left(\frac{c\_c_{tread}}{2}-x, p_u\right)+\sigma_z\left[\left(\frac{c\_c_{tread}}{2}+x\right), p_u\right]\right]\right|\right|\right| dx\right]$$

the weight per 1/2 machine per foot times the Length x 2

$TOW - integratedTOW = 25.856\,lbf$ very close agreement $integratedTOW = 4.157 \times 10^{4}\,lbf$

**Computing the Shear Resistance**

the normal component of the vertical stress associated with the machine can be computed by multiplying $\sigma_z$ by cos (β)

$$\sigma_n(x, p_u) := \cos(\beta) \cdot p_u \cdot \frac{\alpha(x) + \sin(\alpha(x)) \cdot \cos(\alpha(x) + 2\,\delta(x))}{\pi}$$

and the normal stress from the soil cover within the rupture zone defined as $\cos(\beta) \cdot z \cdot \gamma_{soil}$ per square foot of zone

defining the shear strength parameters for the interface as $\varphi_{int}$ $c_{int}$ the phi and c for the iterfaces

, a general expression for the resisting force is shown below. Where the shear resistance, which a function of the normal stress is integrated across a distance from the center of the machine to ε past the track cl and then multiplied by 2 x L

if for example $\varphi_{int} := 30deg$ $c_{int} := 100psf$

$$T_{resisting}(\varphi_{int}, c_{int}) := 2 \cdot L \cdot \int_{0}^{\varepsilon + \frac{c\_c_{tread}}{2}} \left[ \left[ C_{\varepsilon} \cdot \left[ \sigma_n\left( x - \frac{c\_c_{tread}}{2}, p_u \right) + \sigma_n\left[ \left( \frac{c\_c_{tread}}{2} + x \right), p_u \right] \right] + \cos(\beta) \cdot z \cdot \gamma_{soil} \right] \cdot \tan(\varphi_{int}) + c_{int} \right] dx$$

$$T_{resisting}(\varphi_{int}, c_{int}) = 3.396 \times 10^{4}\,lbf$$

using the solve routine the phi required for a factor of safety of 1.0 can be determined for a given c

Given

$$1 = \frac{T_{resisting}(\varphi_{int}, c_{int})}{T_{Driving}(\varepsilon)}$$

$\varphi_{req}(c_{int}) := \text{Find}(\varphi_{int})$ $\varphi_{req}(c_{int}) = 21.379 \cdot \text{deg}$

for a series of values of c, required phi values can be determine

$$c := \begin{pmatrix} 0 \\ 20 \\ 40 \\ 60 \\ 80 \\ 100 \\ 120 \\ 140 \\ 160 \\ 180 \end{pmatrix} \frac{\text{lbf}}{\text{ft}^2}$$

$i := 1 .. \text{rows}(c)$

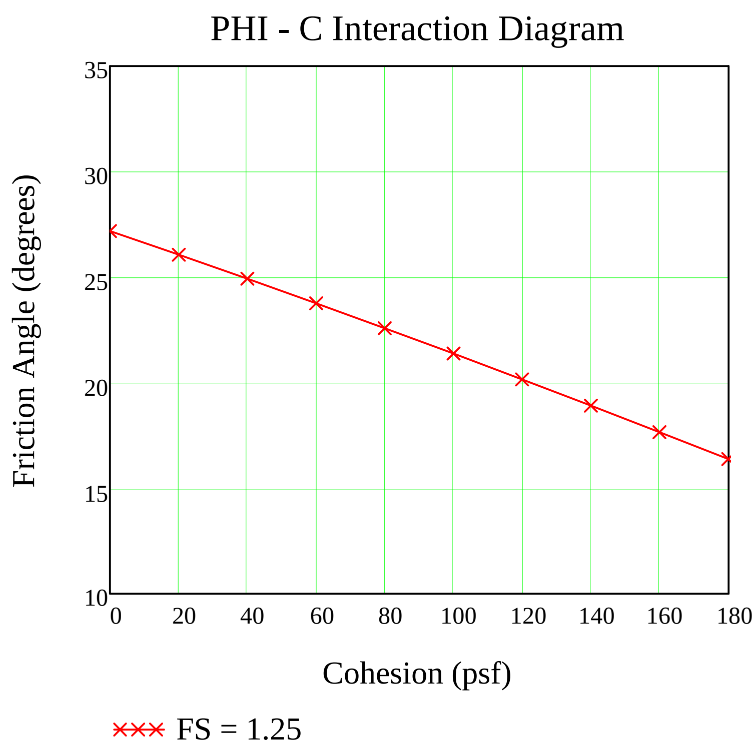
Using a mathcad program this solving routine can be used to determine the φ needed for a given c and factor of safety condition

$$\varphi_{req} := \left| \begin{array}{l} \text{for } i \in 1 .. \text{rows}(c) \\ \quad \left| \begin{array}{l} c_{int} \leftarrow c_i \\ \varphi_{int1.5_i} \leftarrow \varphi_{req}(c_{int}) \end{array} \right. \\ \varphi_{int1.5} \end{array} \right.$$

$\varphi_{req} =$ $\cdot$deg

| | 1 |
|---|---|
| 1 | 27.178 |
| 2 | 26.061 |
| 3 | 24.922 |
| 4 | 23.762 |
| 5 | 22.581 |
| 6 | 21.379 |
| 7 | 20.157 |
| 8 | 18.916 |
| 9 | 17.656 |
| 10 | 16.378 |

A plot of φ and c can be used to determine whether or not test results are acceptable for meeting the stability under machine conditions




Machine = "CAT6N LPG"

peak normal stress

$\left(0.85 \cdot p_u + z \cdot \gamma_{soil}\right) \cdot \cos(\beta) = 1.344 \times 10^3 \cdot psf$

# ATTACHMENT 3

## Settlement Analysis Calculations

- **Cross-Sectional Views**
- **Primary Consolidated Settlement**
- **Secondary Consolidated Settlement**

**Subgrade Settlement Analysis**

| **Input parameters** | | | |
|---|---|---|---|
| $\Upsilon_c$ = | Unit weight of the Soil Liner | 130 | $lb/ft^3$ |
| $h_c$ = | Thickness of the Final Cover and Baseliner Soil (stage IV) | 4 | ft |
| $h_c$ = | Thickness of the Final Cover, Baseliner, and Overfill Soil (OADS) | 6 | ft |
| $\Upsilon_w$ = | Unit Weight of the Waste | 96.3 | $lb/ft^3$ |
| $h_w$= | Thickness of the Waste (ft) | varies | |
| $\Upsilon_s$ = | Unit Weight of the Stone | 100 | $lb/ft^3$ |
| $h_s$= | Thickness of the Baseliner and Overfill Drainage Layer (OADS) | 4.0 | ft |
| $h_s$= | Thickness of the Baseliner Drainage Layer (Stage IV) | 2.0 | ft |
| $\Upsilon_{sa}$ = | Unit Weight of the Sand | 100 | $lb/ft^3$ |
| $h_{sa}$= | Thickness of the Baseliner Sand (Stage IV) | 1.0 | ft |
| $h_{sa}$= | Thickness of the Overfill Sand (OADS) | 1.0 | ft |
| $\Upsilon_{GT}$ = | Buoyant Unit Weight of Glacial Till | 77.6 | $lb/ft^3$ |
| $H_o$= | Thickness of Glacial Till (ft) | varies | |
| $e_o$= | Void Ratio | 0.39 | |
| $C_c$= | Compression Index | 0.16 | |
| $C_r$= | Recompression Index (0.15$C_c$) | 0.024 | |
| t= | Ending Time of period | 30 | years |
| $t_p$= | Starting Time of period | 1 | years |

**Primary Consolidation Settlement Calculations**

$$\sigma_{fin} = \sum(\gamma \times h) \qquad \sigma_{zo} = \gamma_{GT} \text{ x } H_o \qquad P_{pc} = \left(\frac{H_o}{1+eo}\right) C_r \log\frac{\sigma_{fin}}{\sigma_{zo}}$$

| | |
|---|---|
| $\sigma_{fin}$= | Final Vertical Stress ($lb/ft^2$) |
| $\sigma_{zo}$= | Effective Stress at mid-depth of Glacial Till ($lb/ft^2$) |
| $P_{pc}$= | Primary Consolidated Settlement at point (ft) |

**Secondary Consolidation Settlement Calculations**

$$C_\alpha = 0.0225C_c \qquad \Delta e_p = \frac{P_{pc}}{H_o}(1+e_o) \qquad H_{os} = H_o - P_{pc} \qquad e_s = e_o - \Delta e_p$$

$$P_{sc} = \frac{H_{os}}{(1+e_s)} C_\alpha \log\frac{t}{t_p}$$

| | | |
|---|---|---|
| $C_\alpha$= | Secondary Compression Index | 0.0036 |
| $\Delta e_p$= | Change in Void Ratio | |
| $H_{os}$= | Thickness of subgrade before secondary consolidation (ft) | |
| $e_s$= | Initial Void Ratio | |
| $P_{sc}$= | Secondary Consolidated Settlement at point (ft) | |

**Total Settlement**

$$Z_x = P_{pc} + P_{sc}$$

$Z_x$= Total Settlement (ft)

Source: 2nd Edition Soil Mechanics and Foundations, Muni Budhu, 2007

# Lockwood Hills LLC
# Part 360 Permit Modification Application
*Stage IV Leachate Collection Pipe Subgrade Settlement*

| Profile View = | A-A |
|---|---|

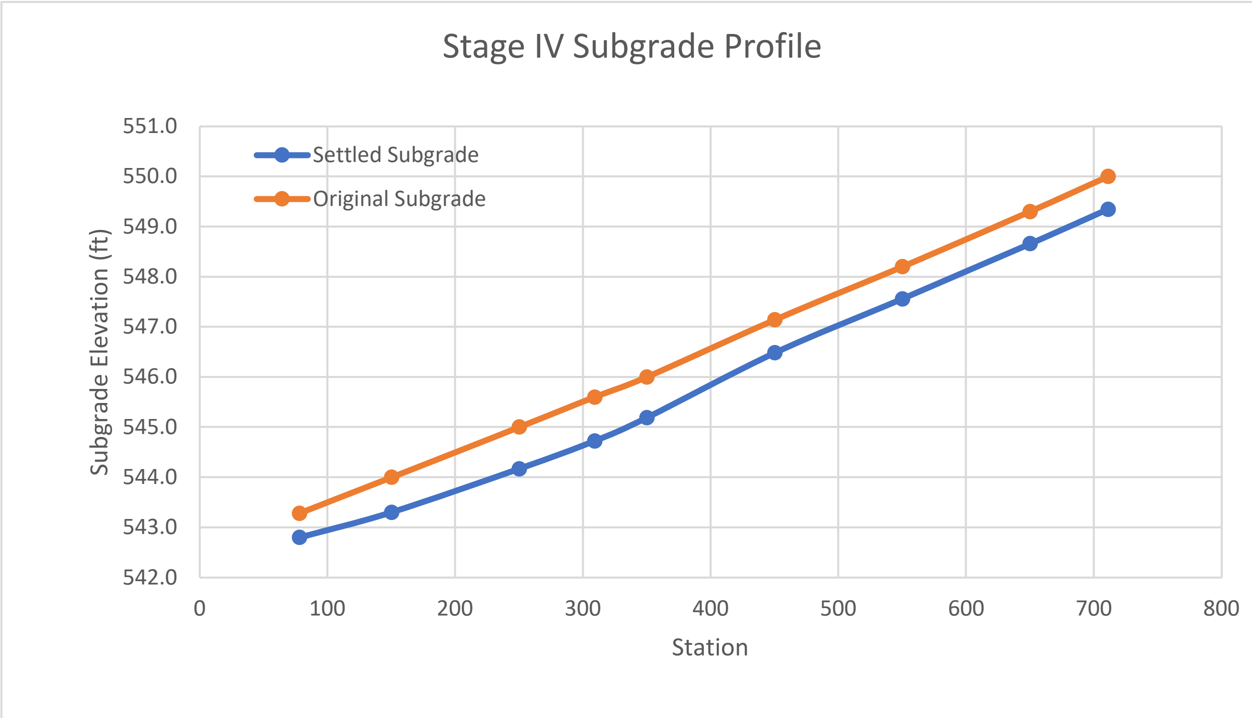
| Point | Station | Glacial Till Thickness (ft) | Waste Thickness (ft) |
|---|---|---|---|
| 1 | 78 | 34 | 21 |
| 2 | 150 | 43.5 | 44 |
| 3 | 250 | 44 | 77 |
| 4 | 309 | 43 | 97 |
| 5 | 350 | 40 | 88 |
| 6 | 450 | 33.5 | 66 |
| 7 | 550 | 37.2 | 47 |
| 8 | 650 | 45.5 | 29.5 |
| 9 | 711 | 49 | 20 |

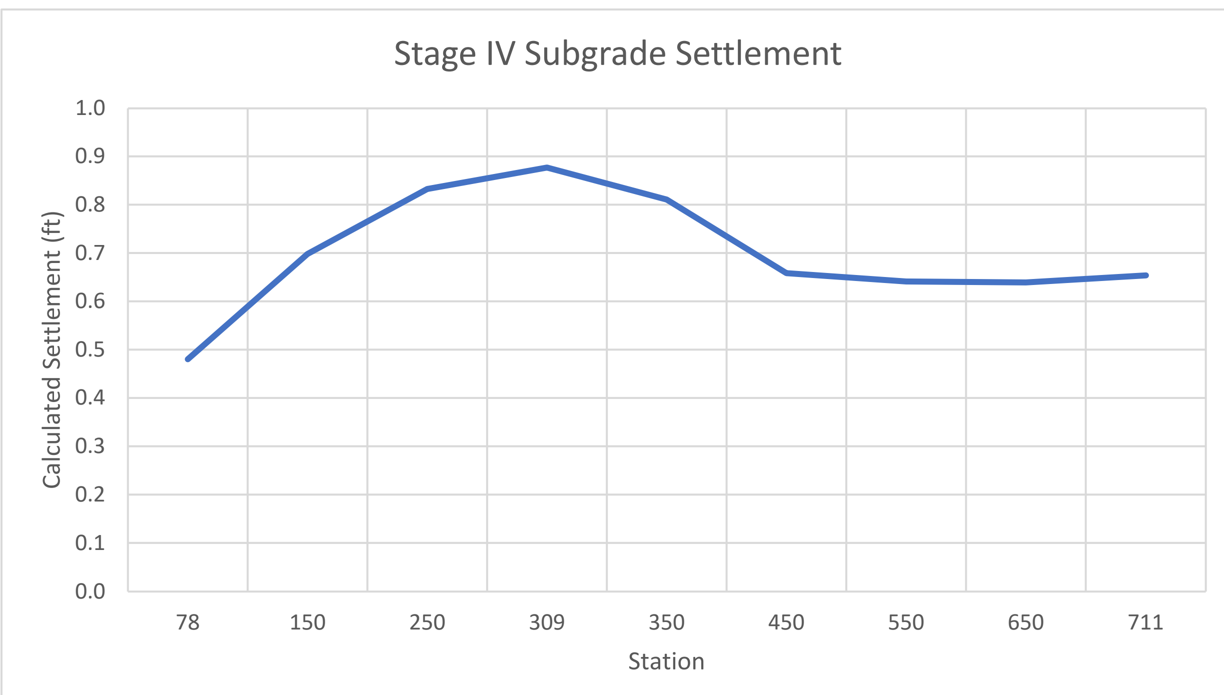
| Point | Station | Primary Settlement (ft) | Secondary Settlement (ft) | Total (ft) |
|---|---|---|---|---|
| 1 | 78 | 0.35 | 0.13 | 0.48 |
| 2 | 150 | 0.53 | 0.17 | 0.70 |
| 3 | 250 | 0.66 | 0.17 | 0.83 |
| 4 | 309 | 0.71 | 0.16 | 0.88 |
| 5 | 350 | 0.66 | 0.15 | 0.81 |
| 6 | 450 | 0.53 | 0.13 | 0.66 |
| 7 | 550 | 0.50 | 0.14 | 0.64 |
| 8 | 650 | 0.47 | 0.17 | 0.64 |
| 9 | 711 | 0.44 | 0.21 | 0.65 |

| Point | Station | Original Subgrade Elevation (ft) | Settled Elevation (ft) | Settled Slope b/w Points |
|---|---|---|---|---|
| 1 | 78 | 543.28 | 542.8 | 0.7% |
| 2 | 150 | 544 | 543.3 | 0.9% |
| 3 | 250 | 545 | 544.2 | 0.9% |
| 4 | 309 | 545.6 | 544.7 | 1.1% |
| 5 | 350 | 546 | 545.2 | 1.3% |
| 6 | 450 | 547.14 | 546.5 | 1.1% |
| 7 | 550 | 548.2 | 547.6 | 1.1% |
| 8 | 650 | 549.3 | 548.7 | 1.1% |
| 9 | 711 | 550 | 549.3 | - |

| Avg. Original Slope |
|---|
| 1.06% |

| Avg. Settled Slope |
|---|
| 1.07% |


Stage IV Subgrade Profile
Settled Subgrade
Original Subgrade
Subgrade Elevation (ft)
551.0
550.0
549.0
548.0
547.0
546.0
545.0
544.0
543.0
542.0
0
100
200
300
400
500
600
700
800
Station


Stage IV Subgrade Settlement
Calculated Settlement (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
78
150
250
309
350
450
550
650
711
Station

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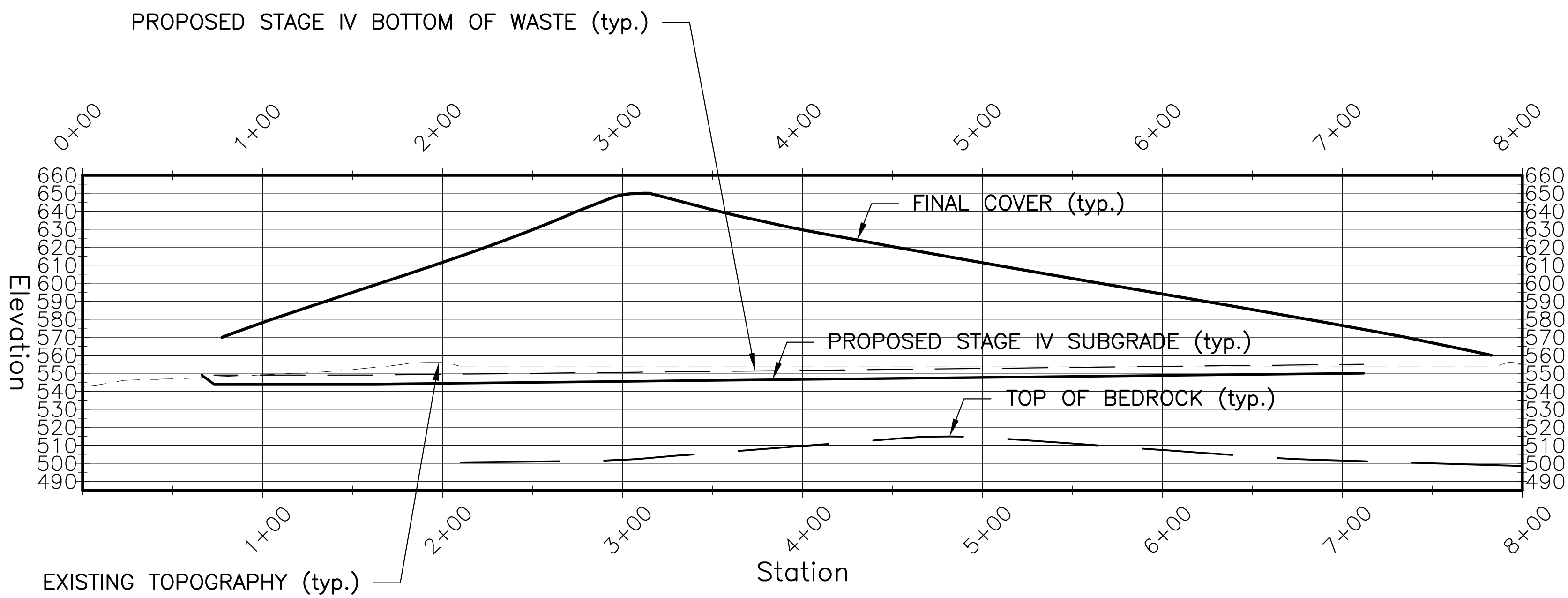


PROFILE VIEW A–A

SCALE: 1" = 100'


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| | | | | | |
|---|---|---|---|---|---|
| LOCKWOOD HILLS LLC | | SETTLEMENT PROFILE A-A<br>LOCKWOOD ASH DISPOSAL SITE | | | FIGURE 1 |
| SCALE: NOTED | REVISION # 0 | | | | |
| July 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

| Profile View = | B-B |
|---|---|

| Point | Station | Glacial Till Thickness (ft) | Waste Thickness (ft) |
|---|---|---|---|
| 1 | 0+66 | 39.6 | 96.0 |
| 2 | 1+50 | 29 | 118.0 |
| 3 | 2+50 | 18 | 146.5 |
| 4 | 3+50 | 11.5 | 163.0 |
| 5 | 4+50 | 9.5 | 158.0 |
| 6 | 5+50 | 7.4 | 152.0 |
| 7 | 5+93 | 7.7 | 148.0 |

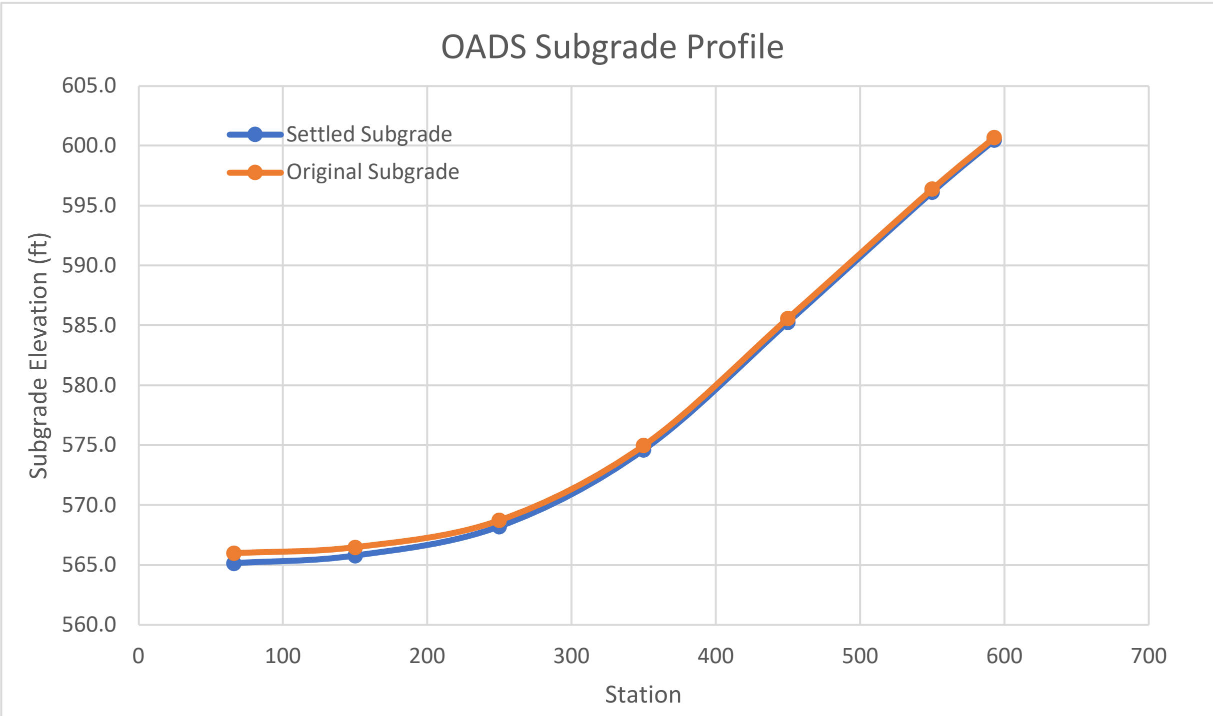
| Point | Station | Primary Settlement (ft) | Secondary Settlement (ft) | Total (ft) |
|---|---|---|---|---|
| 1 | 0+66 | 0.69 | 0.15 | 0.84 |
| 2 | 1+50 | 0.59 | 0.11 | 0.71 |
| 3 | 2+50 | 0.45 | 0.07 | 0.52 |
| 4 | 3+50 | 0.33 | 0.04 | 0.37 |
| 5 | 4+50 | 0.28 | 0.04 | 0.32 |
| 6 | 5+50 | 0.23 | 0.03 | 0.25 |
| 7 | 5+93 | 0.23 | 0.03 | 0.26 |

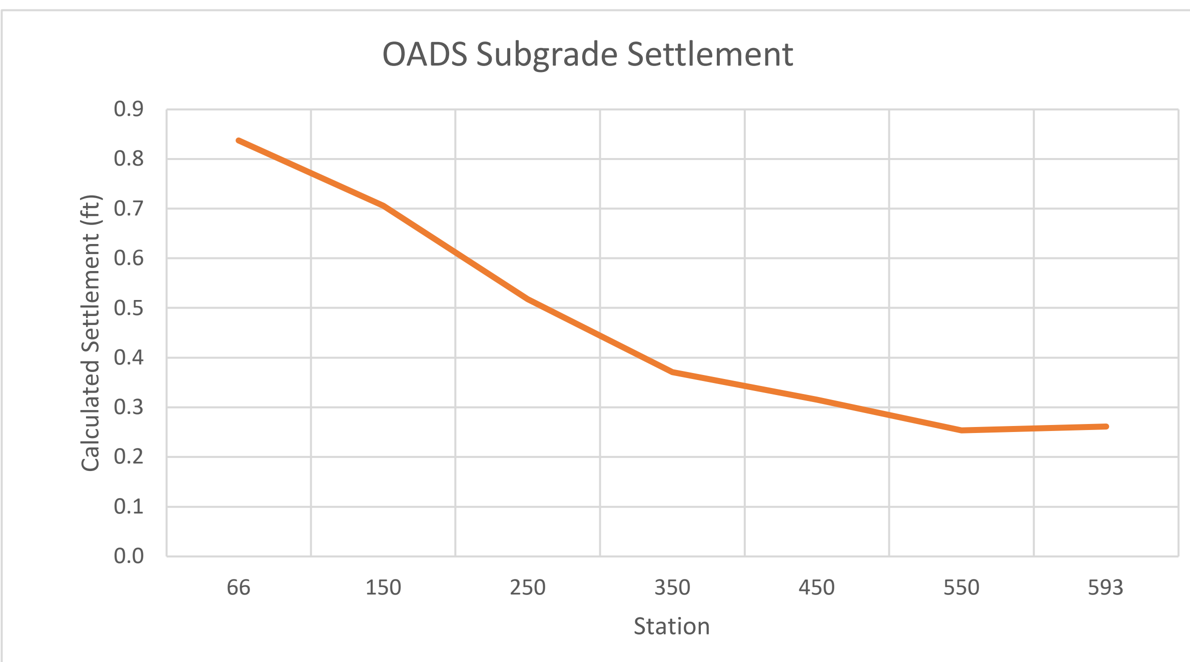
| Point | Station | Original Subgrade Elevation (ft) | Settled Elevation (ft) | Settled Slope b/w Points |
|---|---|---|---|---|
| 1 | 0+66 | 566.0 | 565.2 | 0.8% |
| 2 | 1+50 | 566.5 | 565.8 | 2.4% |
| 3 | 2+50 | 568.8 | 568.2 | 6.4% |
| 4 | 3+50 | 575.0 | 574.6 | 10.7% |
| 5 | 4+50 | 585.6 | 585.3 | 10.9% |
| 6 | 5+50 | 596.4 | 596.1 | 10.1% |
| 7 | 5+93 | 600.7 | 600.5 | - |

| Avg. Original Slope |
|---|
| 6.8% |

| Avg. Settled Slope |
|---|
| 6.9% |

***Orginal Ash Disposal Site Leachate Header Pipe Subgrade Settlement***



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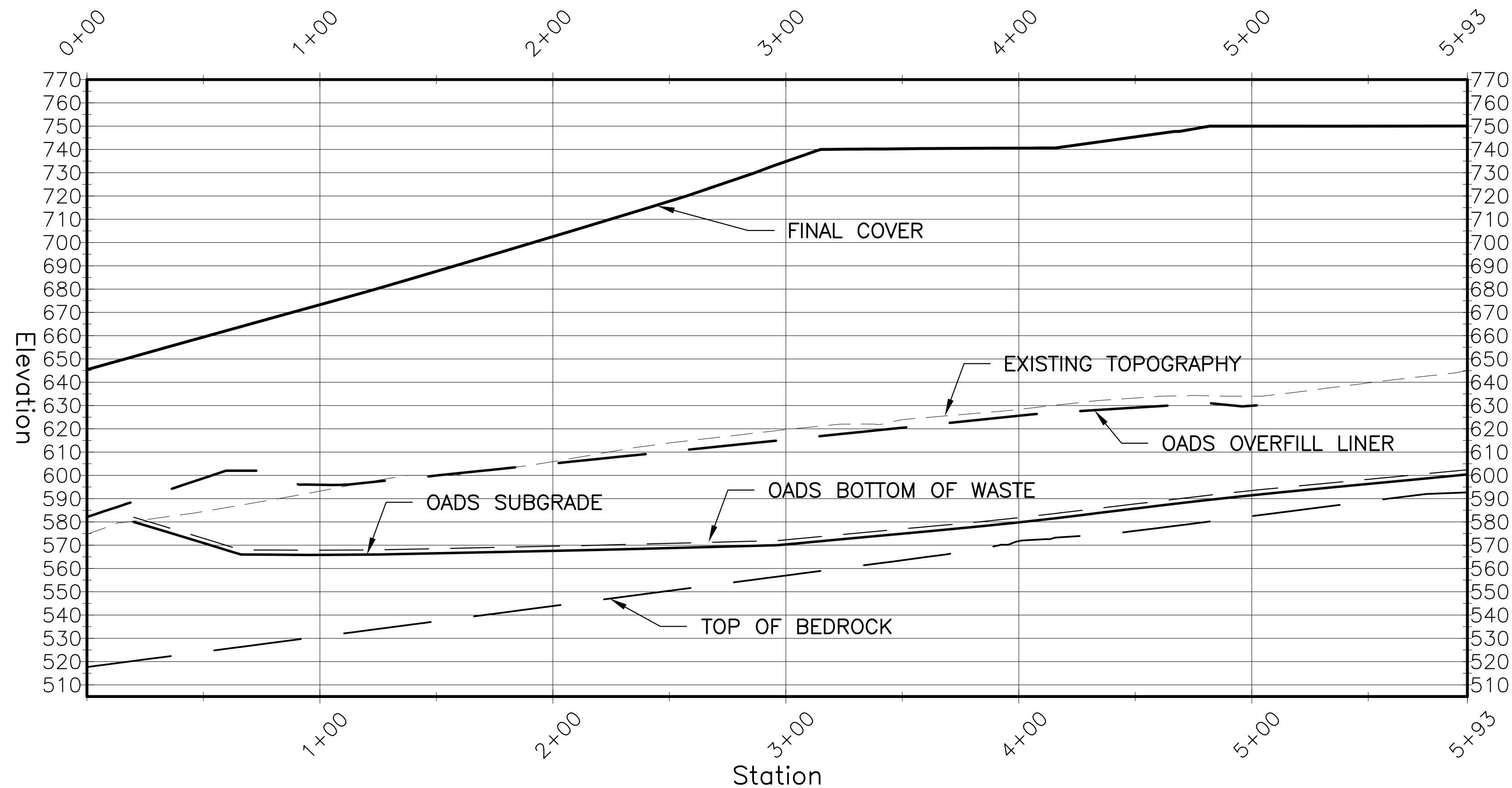


PROFILE VIEW B–B
SCALE: 1" = 75'

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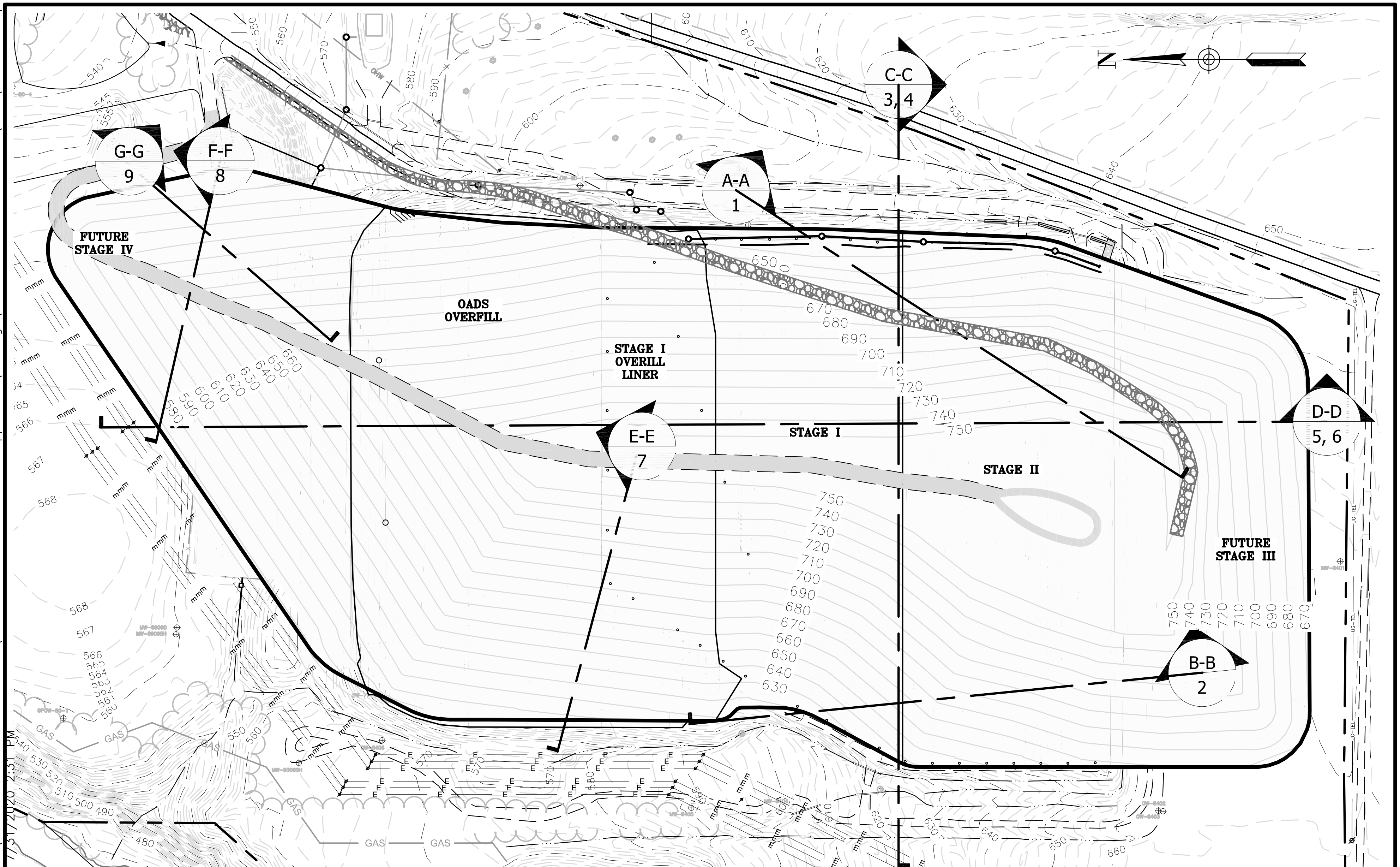
| LOCKWOOD HILLS LLC | | SETTLEMENT PROFILE B-B<br>LOCKWOOD ASH DISPOSAL SITE | | | FIGURE 2 |
|---|---|---|---|---|---|
| SCALE: NOTED | REVISION # 0 | | | | |
| July 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

# ATTACHMENT 4

# Geotechnical Stability Analysis

- **Cross-Sectional Views**

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| | | | | |
|---|---|---|---|---|
| LOCKWOOD HILLS LLC | | STABILITY ANALYSIS CROSS SECTIONS<br>PART 360 SERIES PERMIT RENEWAL/MODIFICATION APPLICATION | | FIGURE 9-1 |
| SCALE: 1" = 250' | REVISION # 0 | | | |
| August 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK |

7200
7000
6800
6600
6400
6200

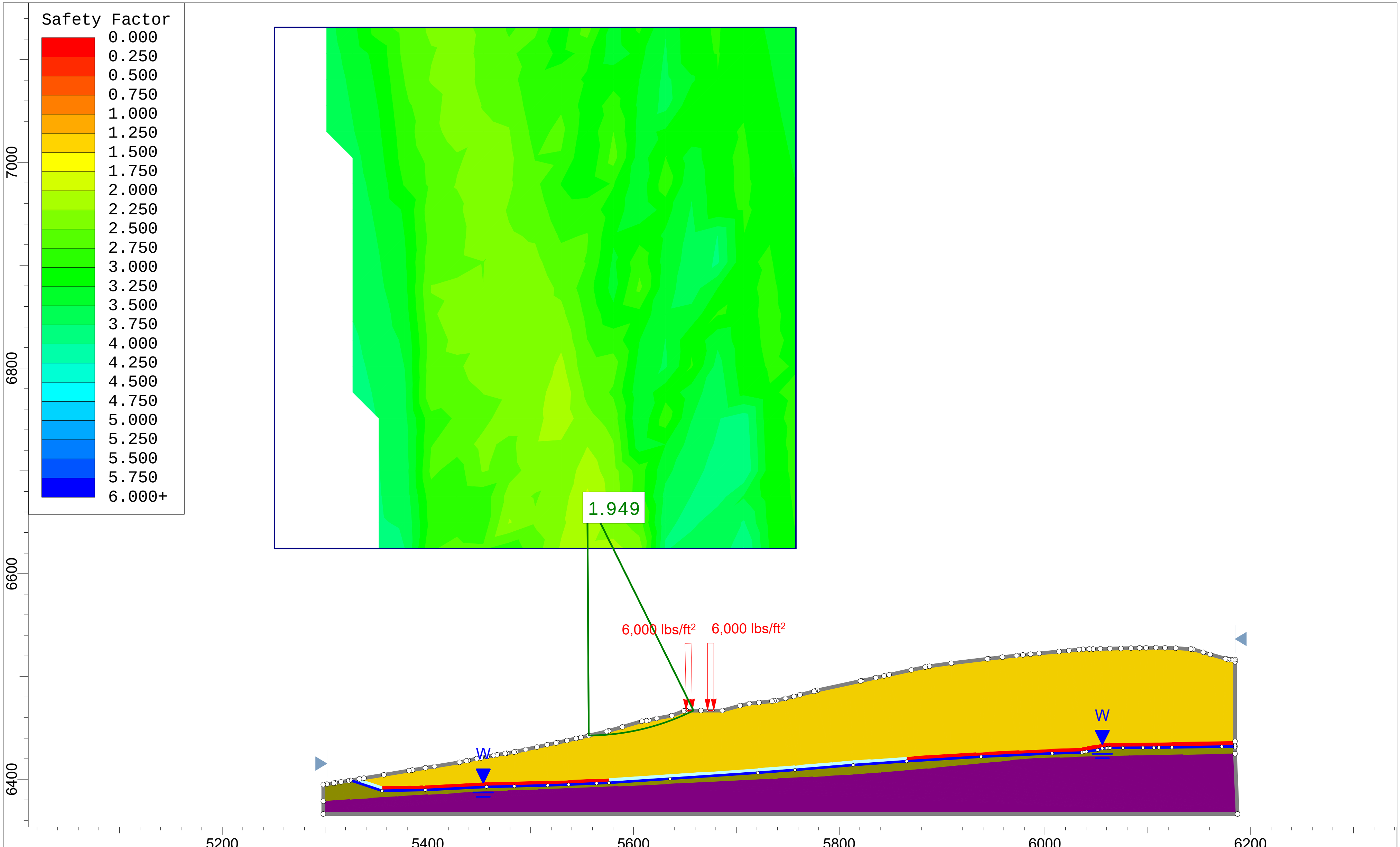
| Material Name | Color |
|---|---|
| Ash | |
| Baseliner <5% | |
| Baseliner >5% | |
| Bedrock | |
| Glacial Till | |

7200 7400 7600 7800 8000 8200 8400 8600 8800 9000 9200

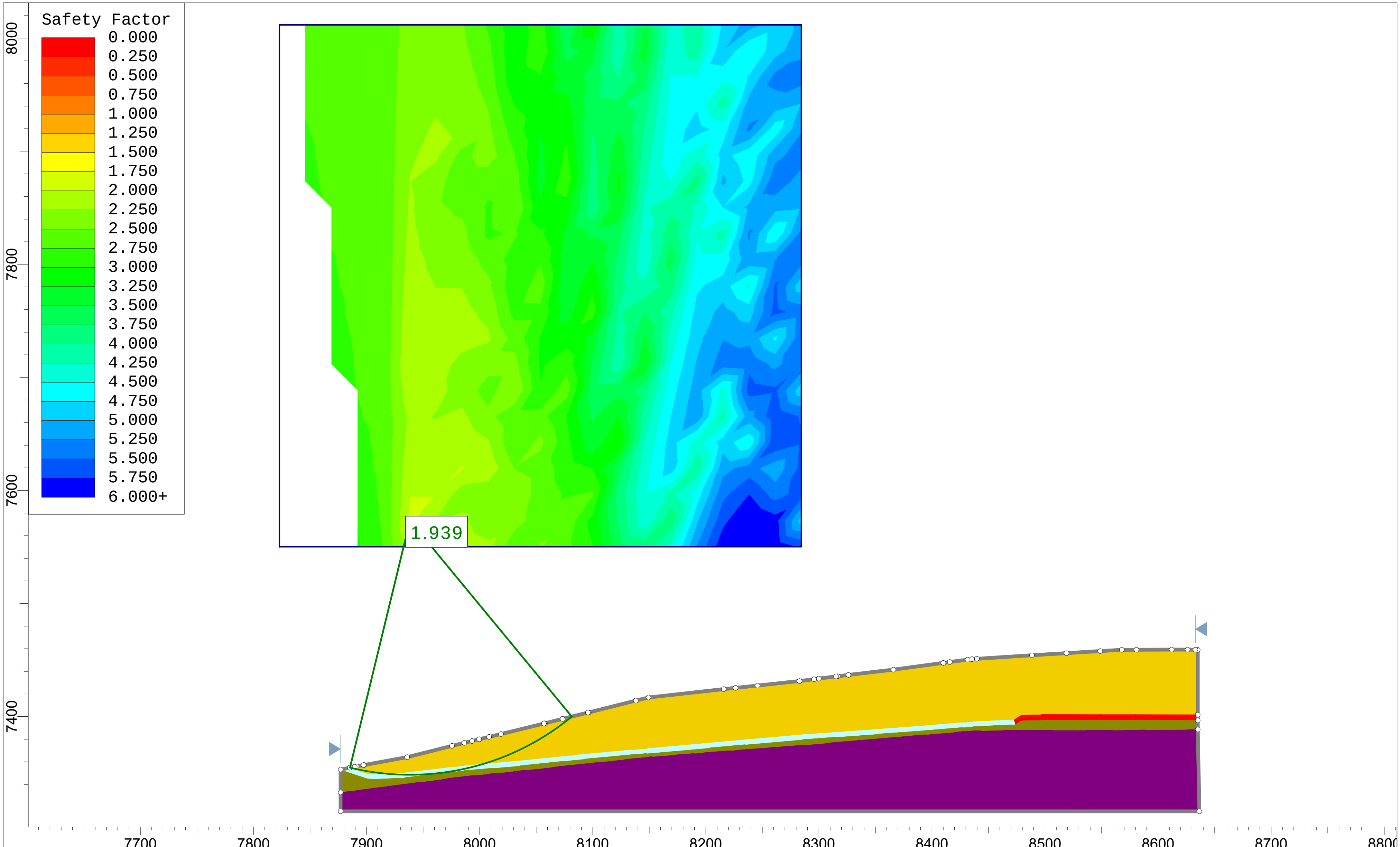
rocscience

| | | | |
|---|---|---|---|
| *Project* | Material Properties | | |
| *Group* | Group 1 | *Scenario* | Master Scenario |
| *Drawn By* | JJ | *Company* | Daigler Engineering P.C. |
| *Date* | 7/31/20 | *File Name* | Material Properties_rev1.slmd |

SLIDEINTERPRET 9.008




| | | | |
|---|---|---|---|
| rocscience | *Project* Section A-A | | |
| | *Group* Group 1 | *Scenario* Master Scenario | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Section A-A_rev.slmd | |

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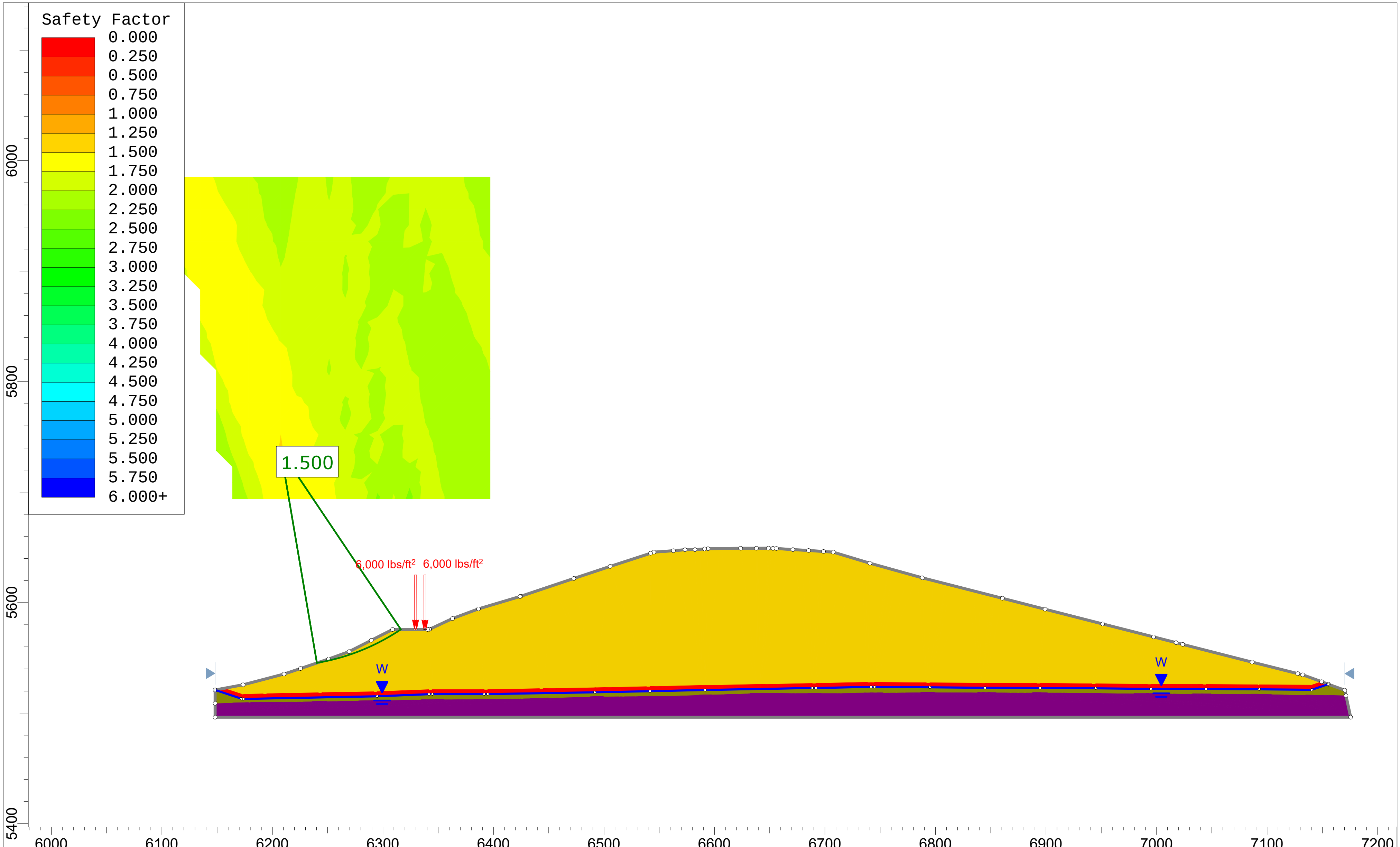
| | | | |
|---|---|---|---|
| *Project* | Section B-B | | |
| *Group* | Group 1 | *Scenario* | Master Scenario |
| *Drawn By* | JJ | *Company* | Daigler Engineering P.C. |
| *Date* | 7/31/20 | *File Name* | Section B-B_rev.slmd |

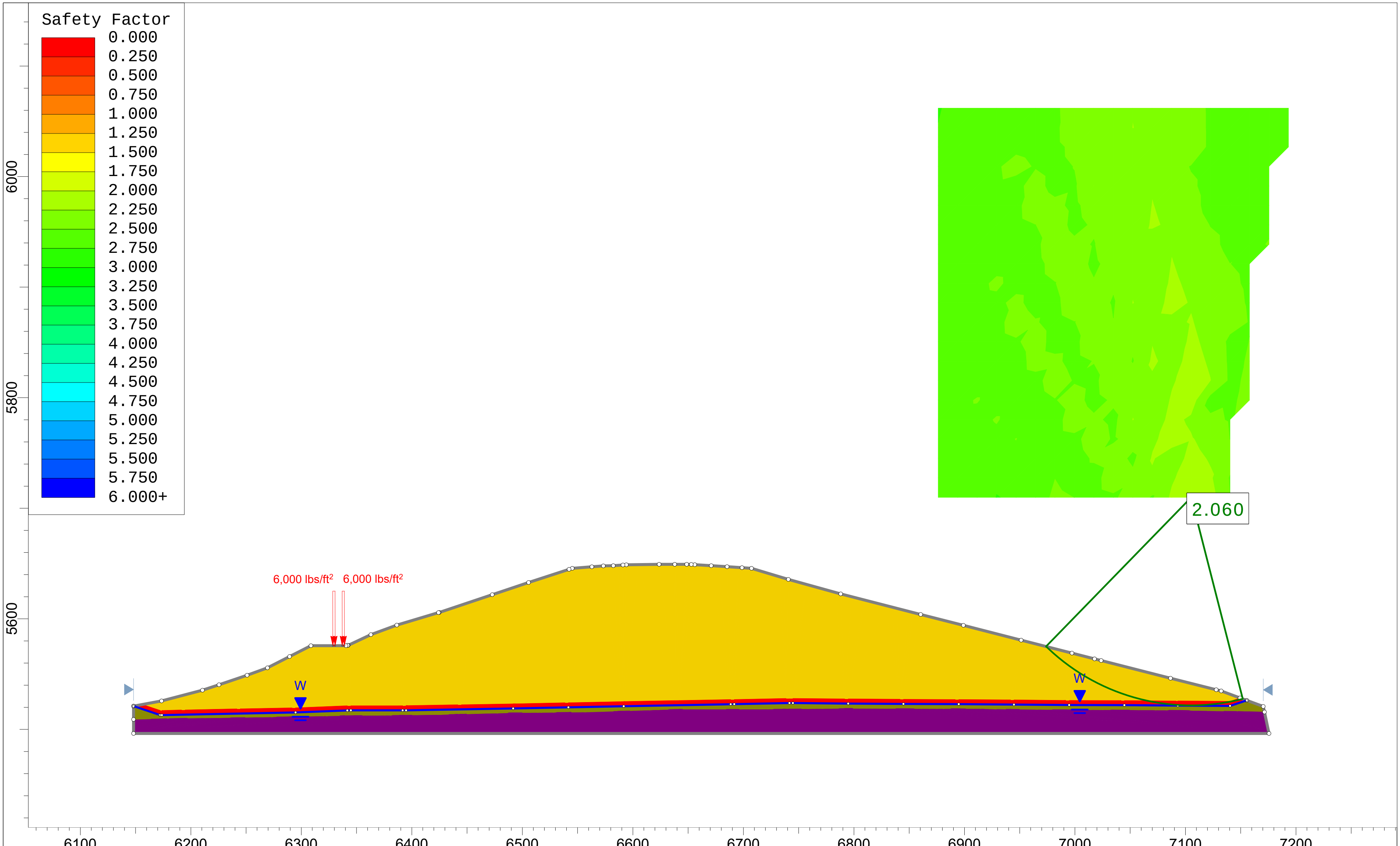
SLIDEINTERPRET 9.008



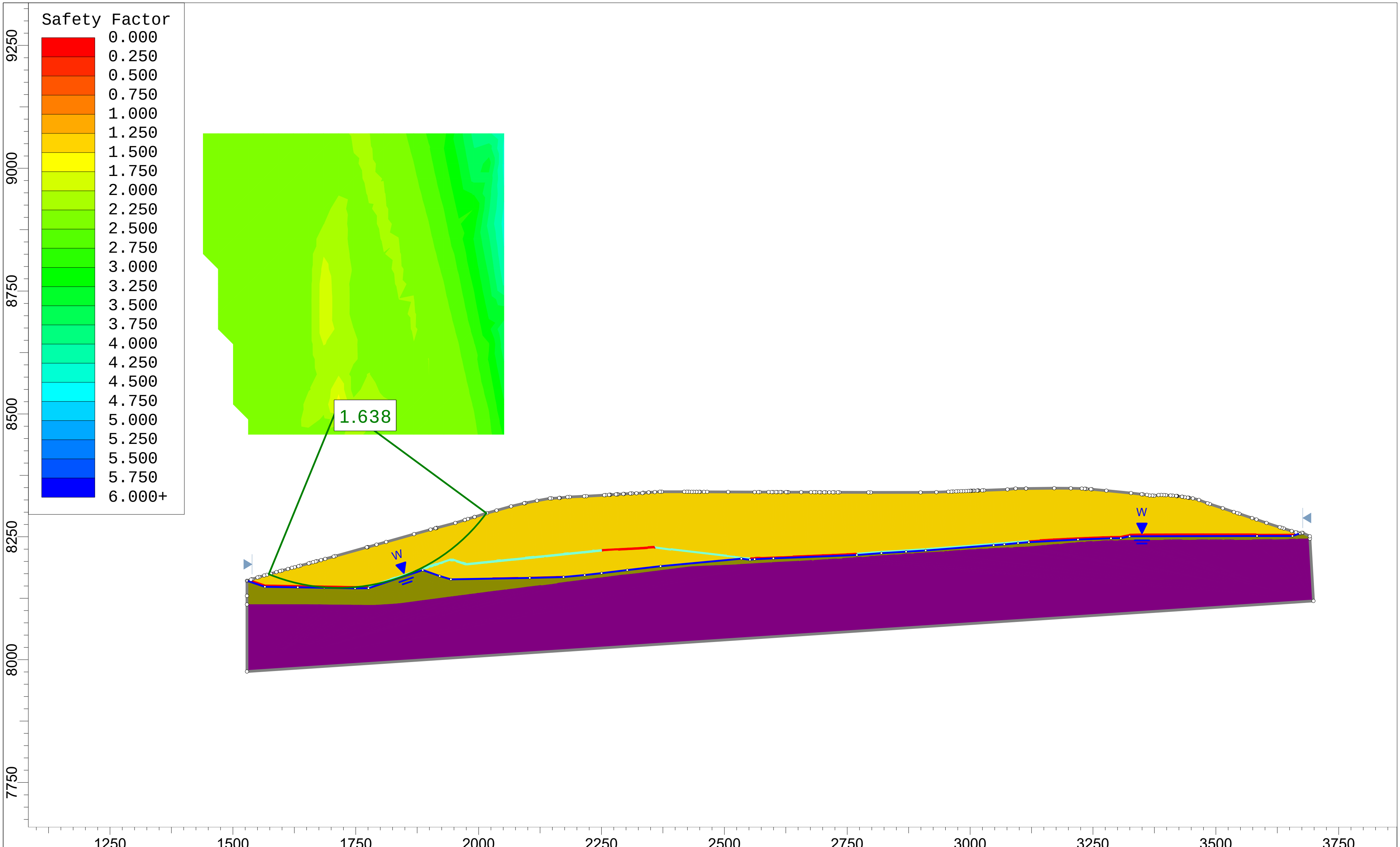

rocscience

SLIDEINTERPRET 9.008

| | | | |
|---|---|---|---|
| *Project* | Section C-C | | |
| *Group* | Group 1 | *Scenario* | Master Scenario |
| *Drawn By* | JJ | *Company* | Daigler Engineering P.C. |
| *Date* | 7/31/20 | *File Name* | Profile C-C rev.slmd |




| | | | |
|---|---|---|---|
| rocscience | *Project* | Section C-C | |
| | *Group* Group 1 | *Scenario* Master Scenario | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Profile C-C rev.slmd | |

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SLIDEINTERPRET 9.008

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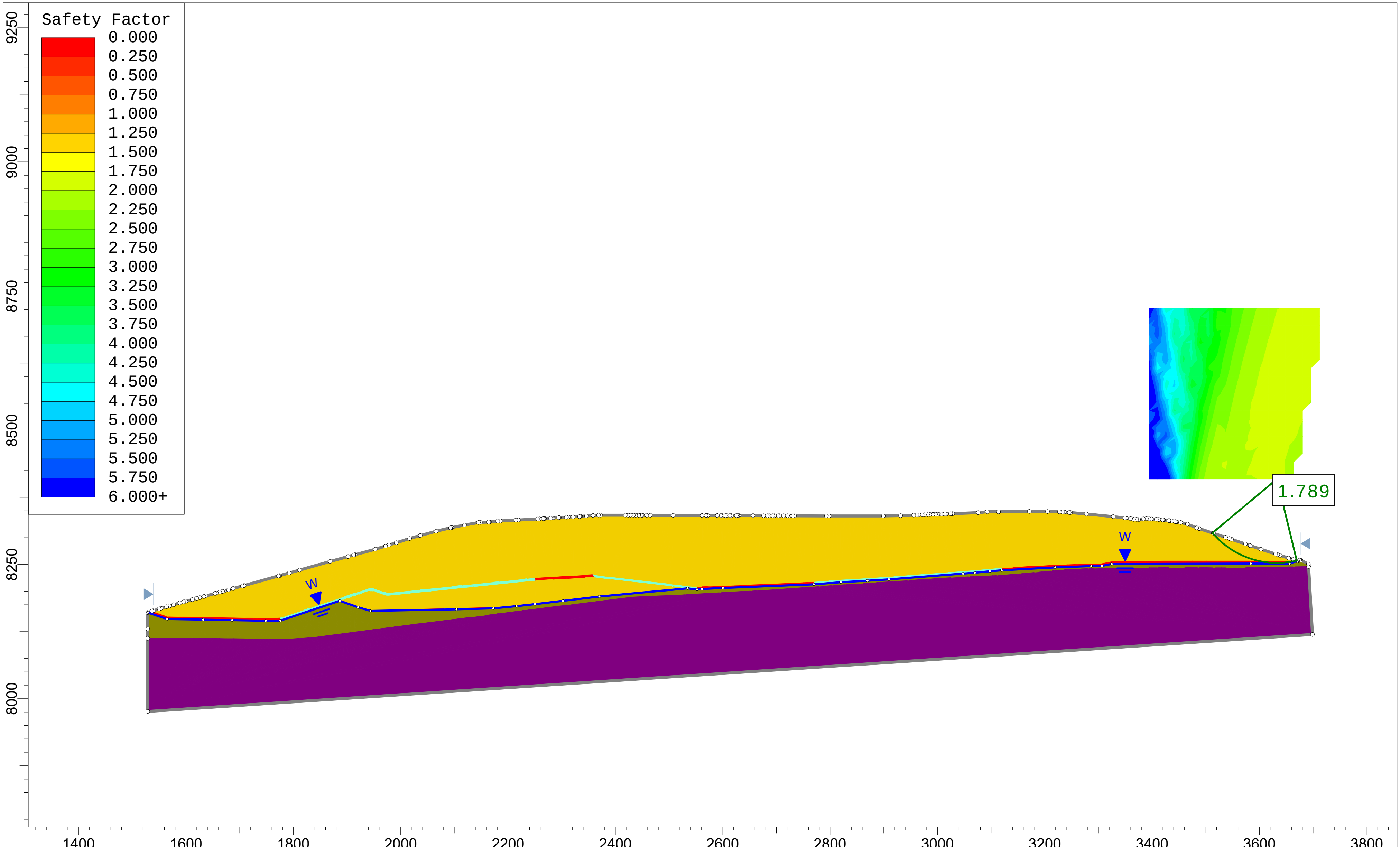
|---|---|---|---|
| *Project* | Profile D-D | | |
| *Group* | Group 1 | *Scenario* | Master Scenario |
| *Drawn By* | JJ | *Company* | Daigler Engineering P.C. |
| *Date* | 7/30/2020 | *File Name* | Profile D-D_rev1.slmd |

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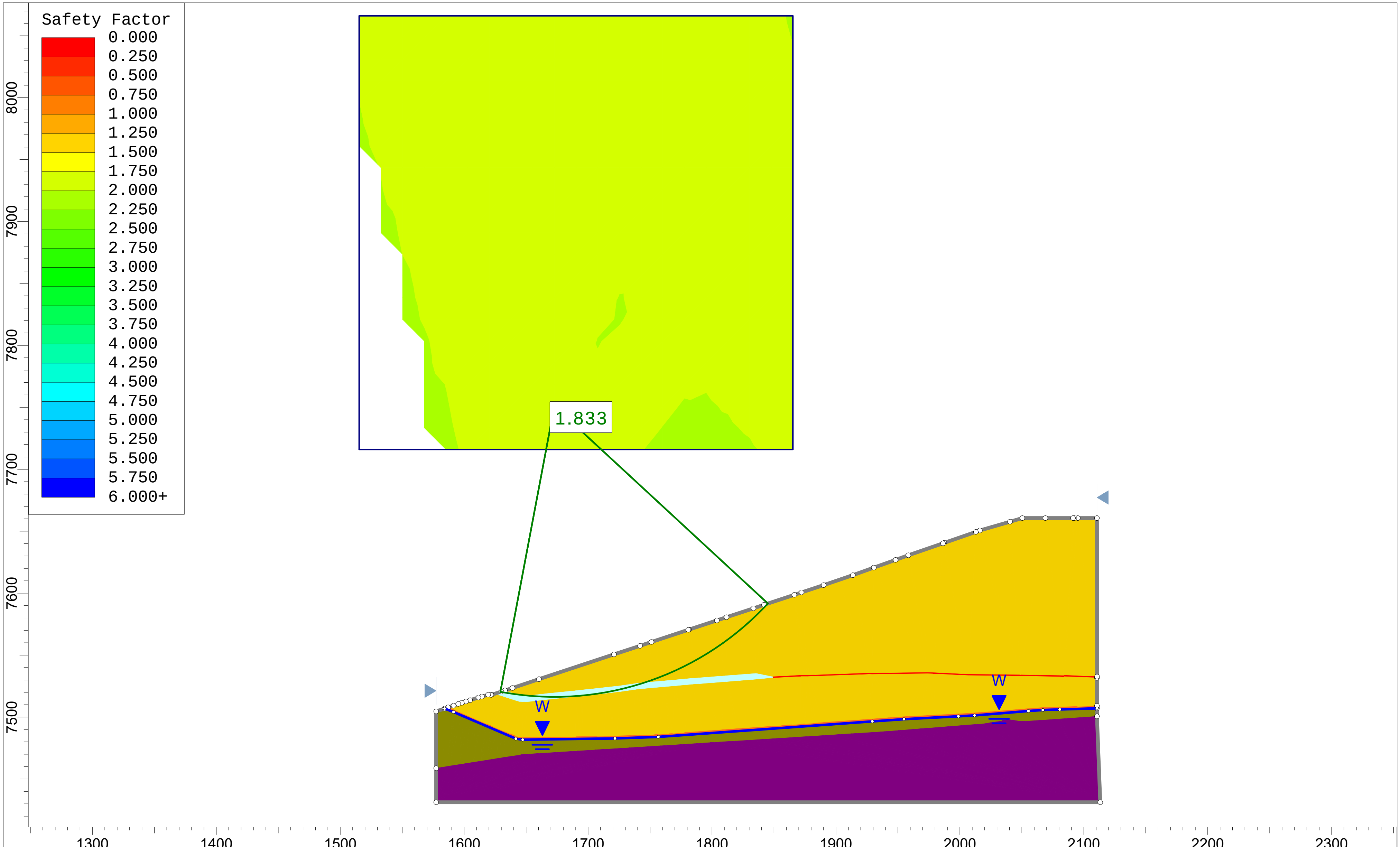
SLIDEINTERPRET 9.008

| | |
|---|---|
| *Project* | Profile D-D |

| | | | |
|---|---|---|---|
| *Group* | Group 1 | *Scenario* | Master Scenario |
| *Drawn By* | JJ | *Company* | Daigler Engineering P.C. |
| *Date* | 7/30/2020 | *File Name* | Profile D-D_rev1.slmd |

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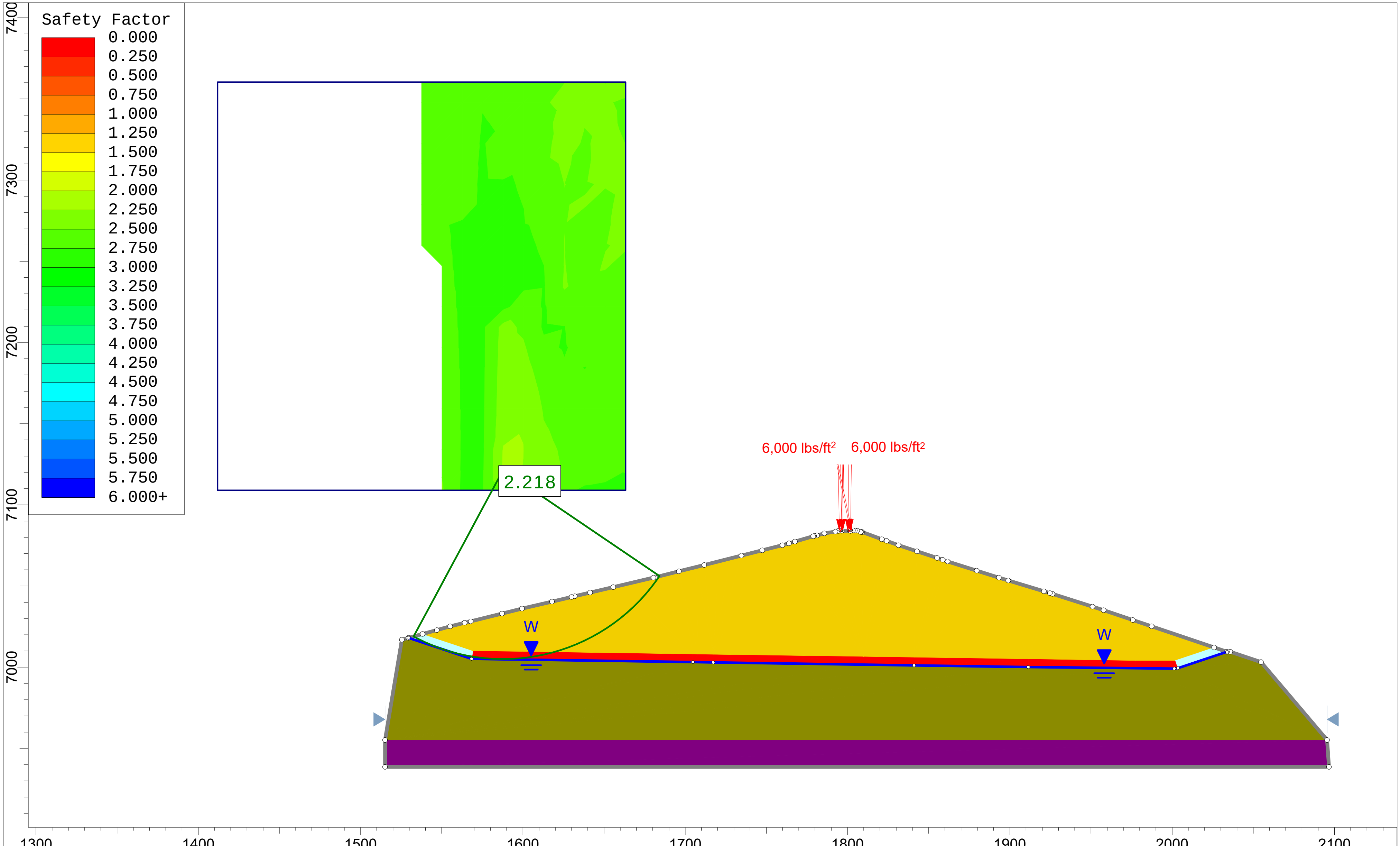
|---|---|---|---|
| rocscience | *Project* Section E-E | | |
| | *Group* Group 1 | *Scenario* Master Scenario | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* | *File Name* Section E-E.slmd | |

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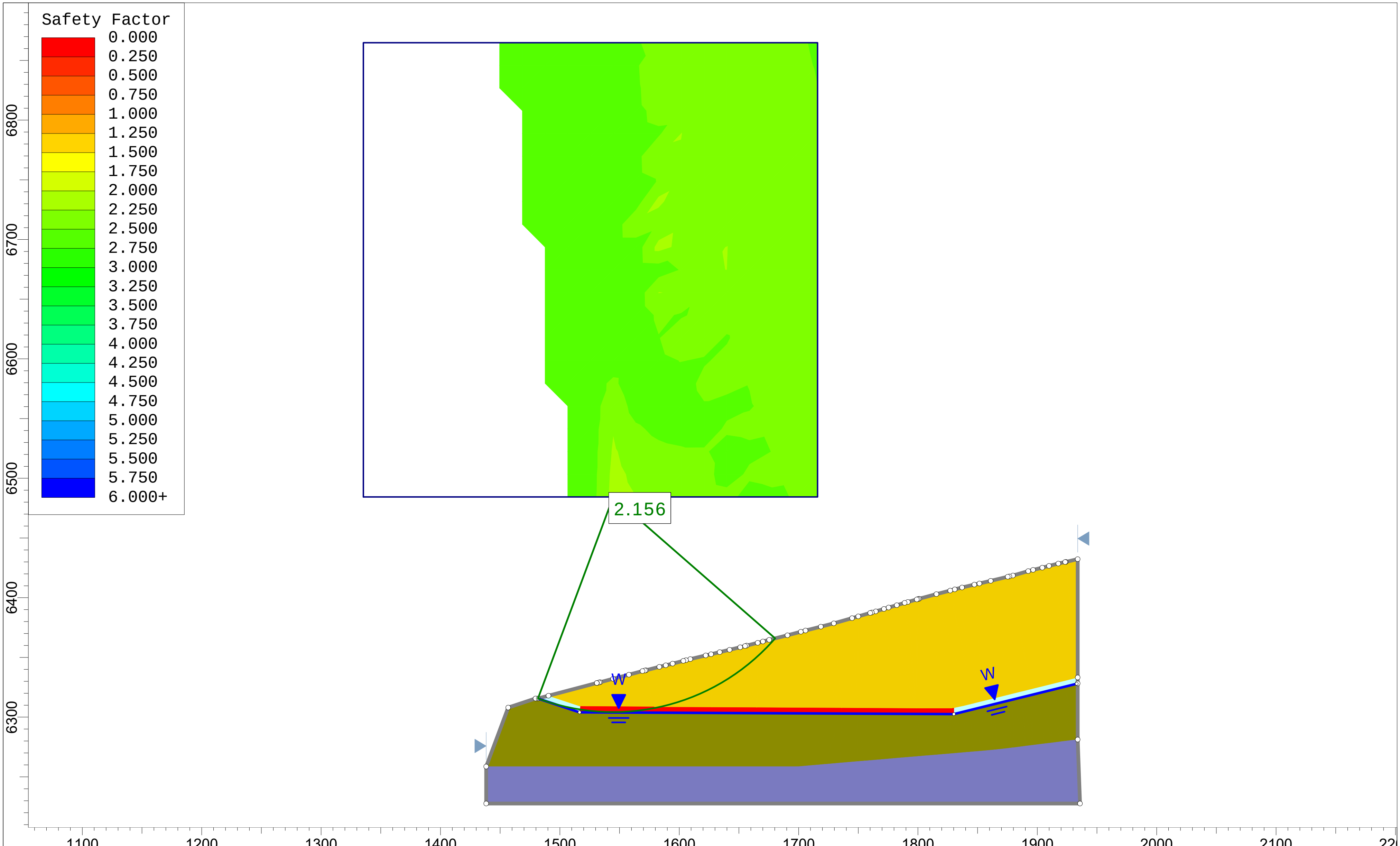
|---|---|---|---|
| rocscience | *Project* Section F-F | | |
| | *Group* Group 1 | *Scenario* Master Scenario | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Section F-F.slmd | |

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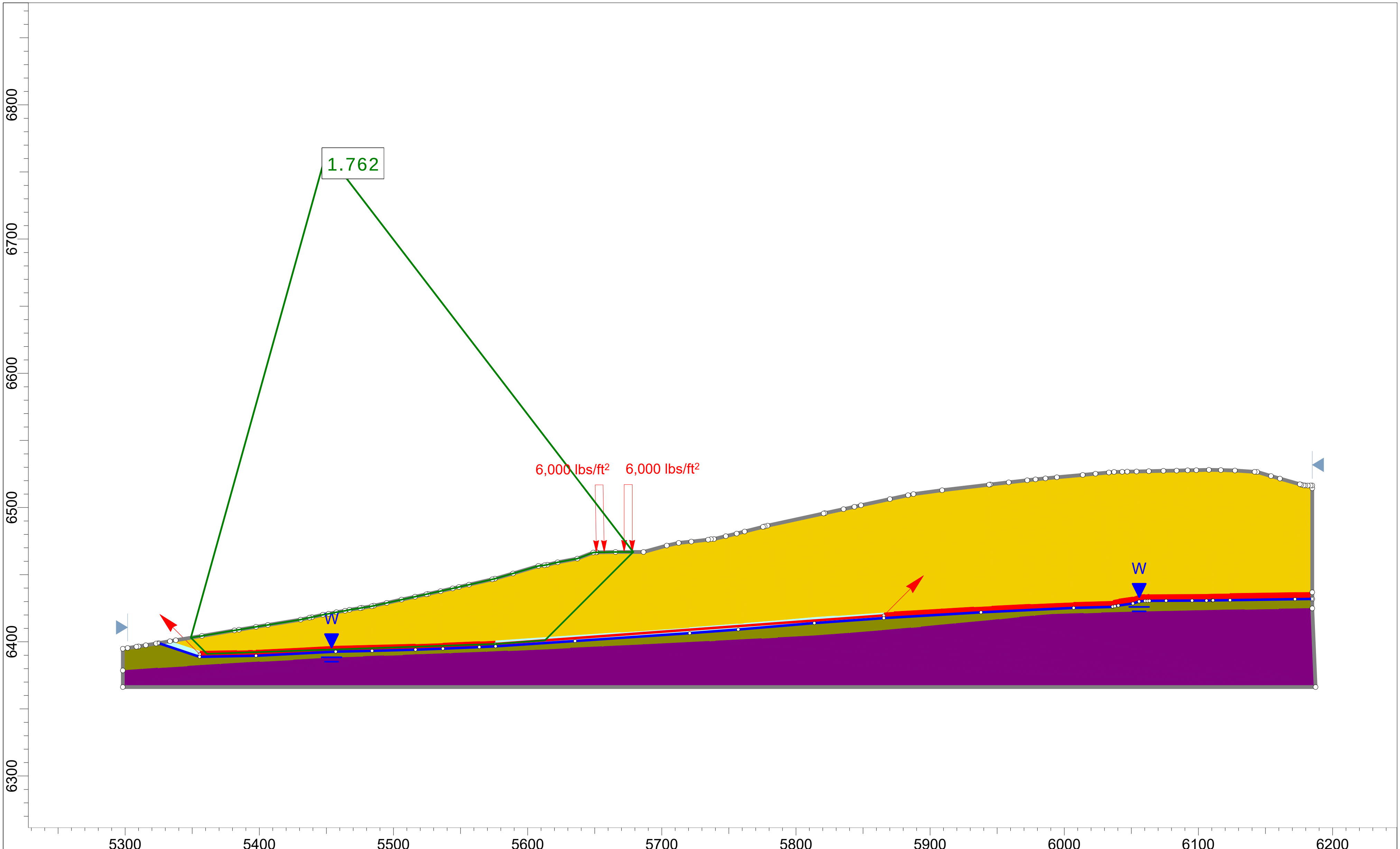
|---|---|---|---|
| rocscience | Project | Section G-G | |
| | Group: Group 1 | Scenario: Master Scenario | |
| | Drawn By: JJ | Company: Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | Date: 7/31/20 | File Name: Section G-G.slmd | |

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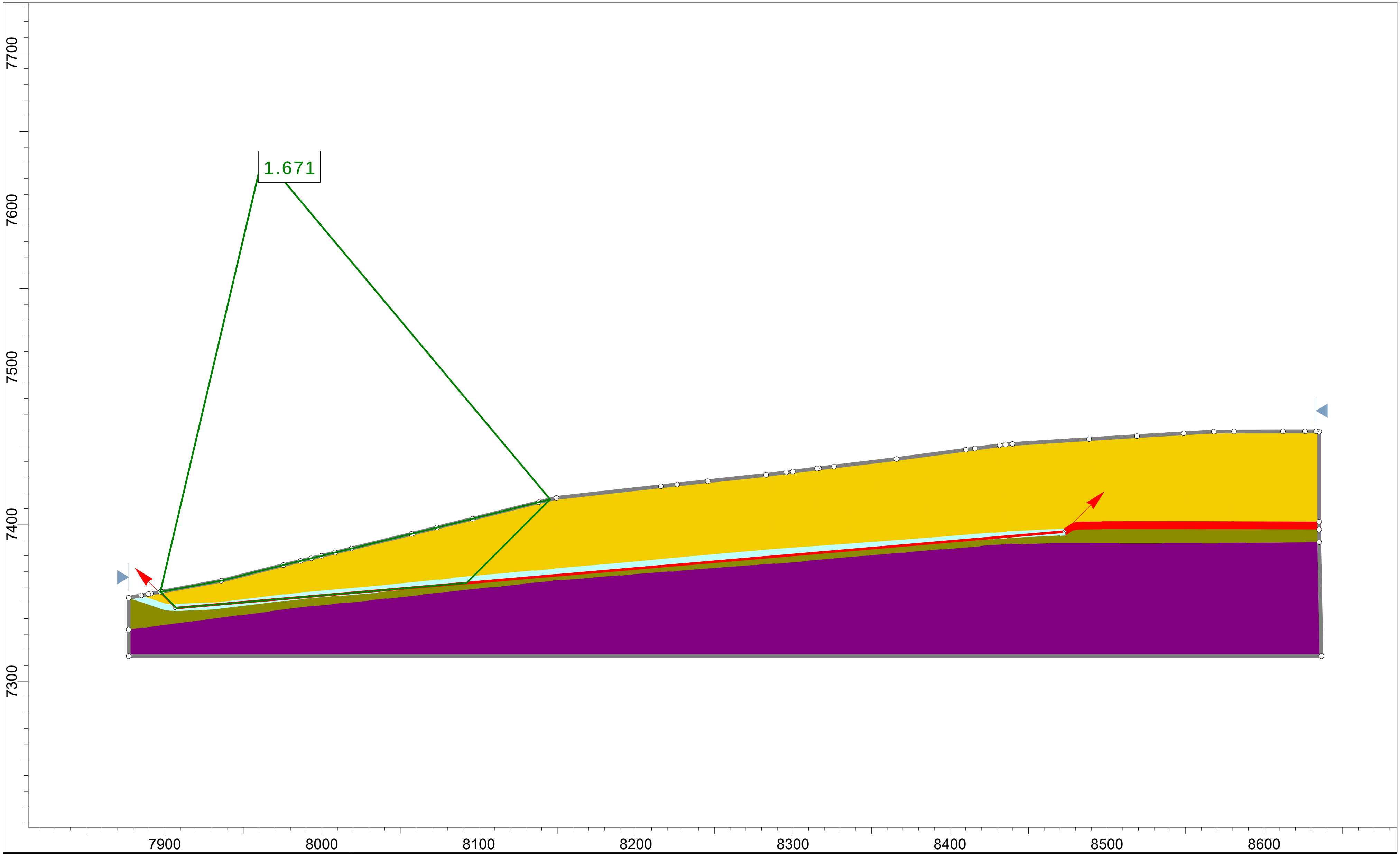
|---|---|---|---|
| rocscience | *Project* Section A-A | | |
| | *Group* Group 1 | *Scenario* Block | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Section A-A_rev.slmd | |

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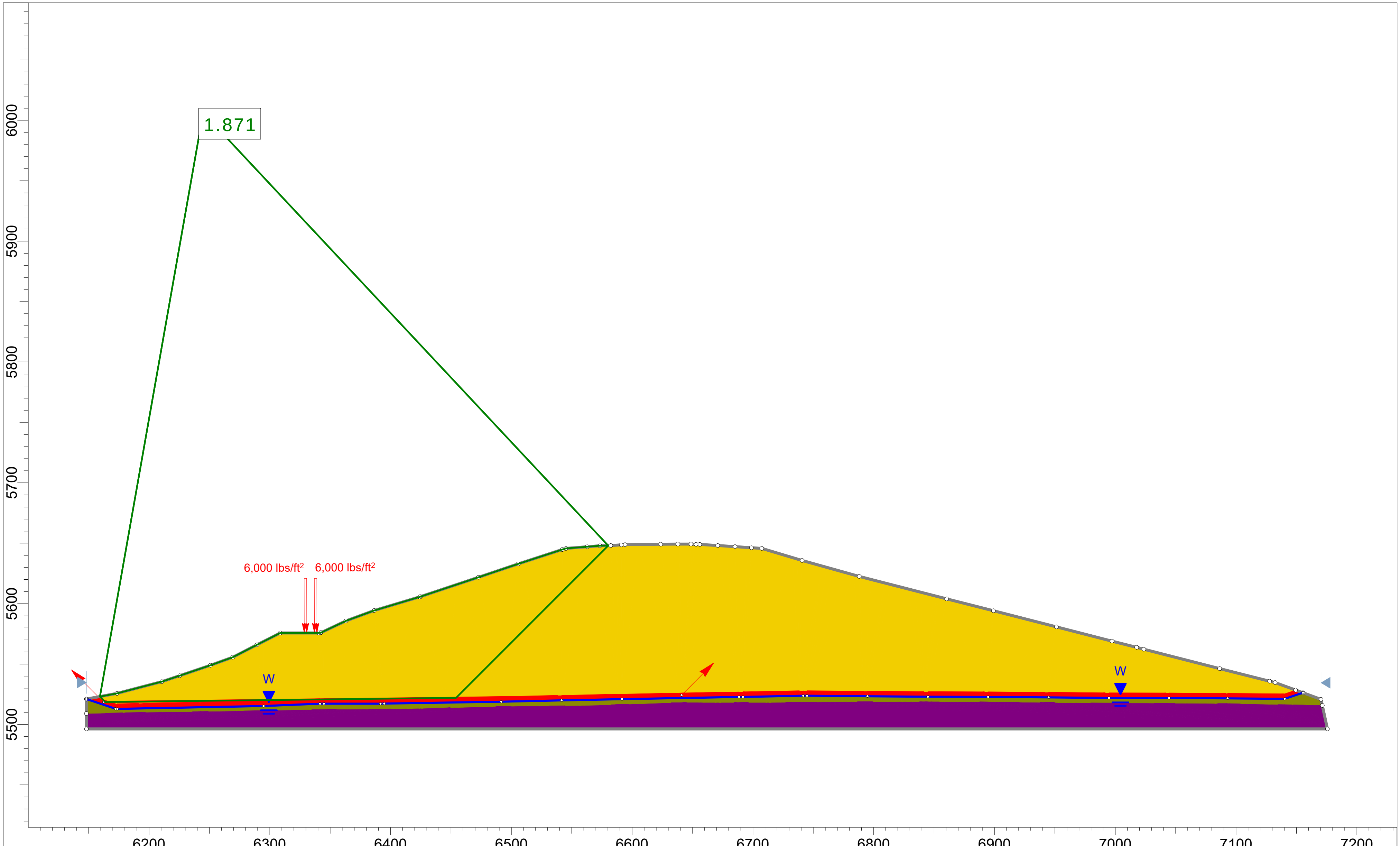
|---|---|---|---|
| rocscience | *Project* Section B-B | | |
| | *Group* Group 1 | *Scenario* Block | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Section B-B_rev.slmd | |

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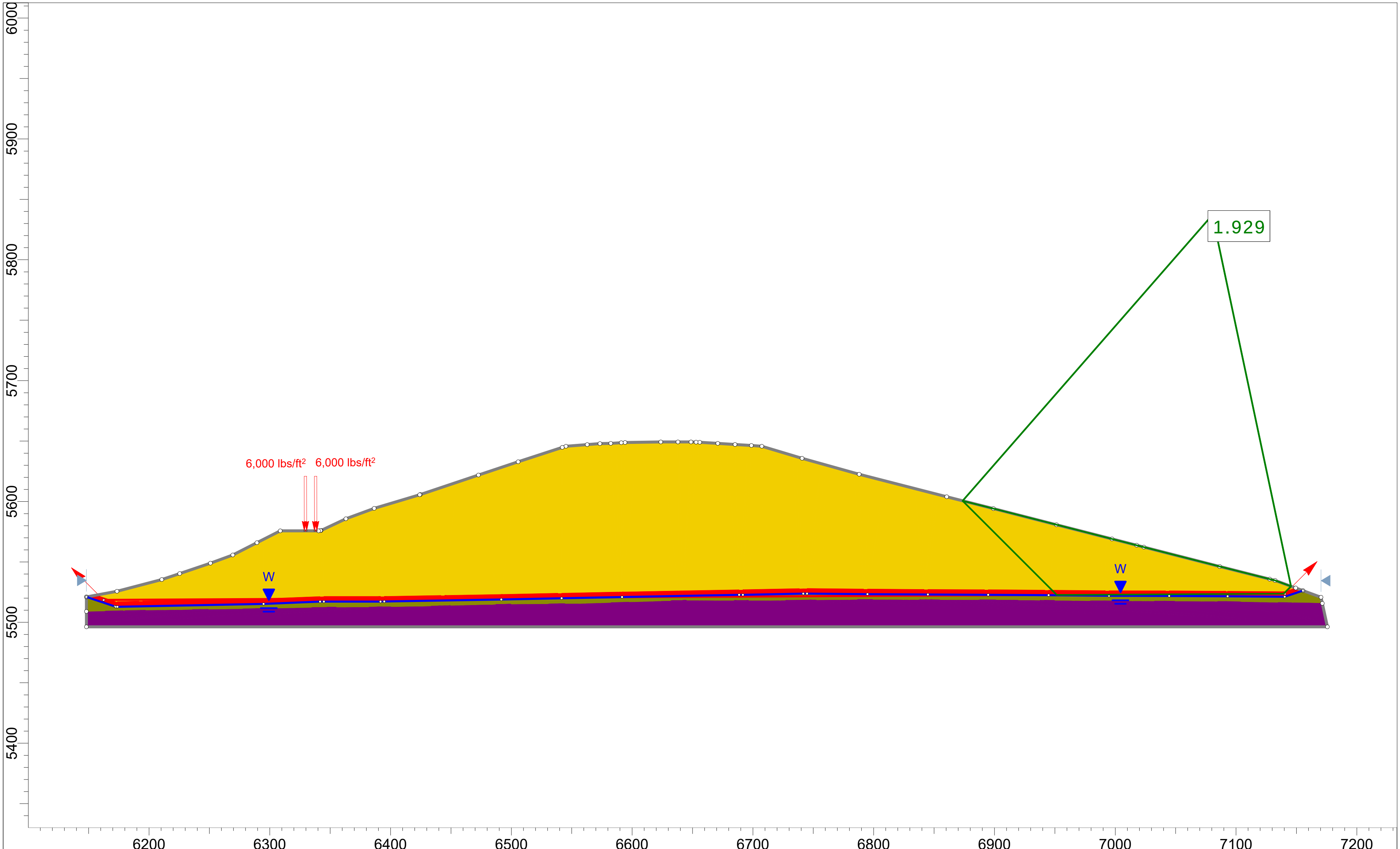
|---|---|---|---|
| rocscience | *Project* Section C-C | | |
| | *Group* Group 1 | *Scenario* BLOCK | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Profile C-C rev.slmd | |

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|---|---|---|---|
| Project | Section C-C | | |
| Group | Group 1 | Scenario | BLOCK |
| Drawn By | JJ | Company | Daigler Engineering P.C. |
| Date | 7/31/20 | File Name | Profile C-C rev.slmd |

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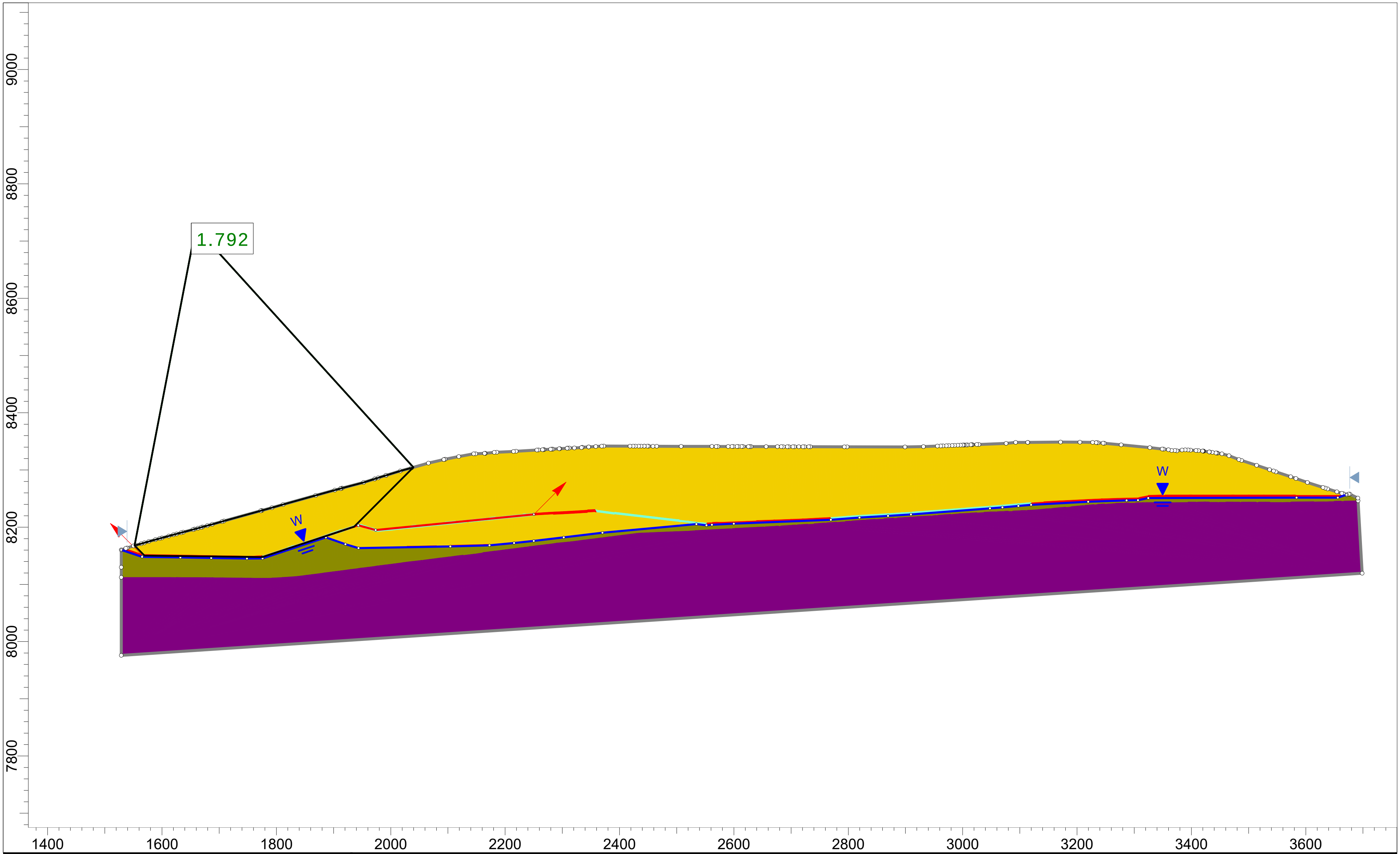


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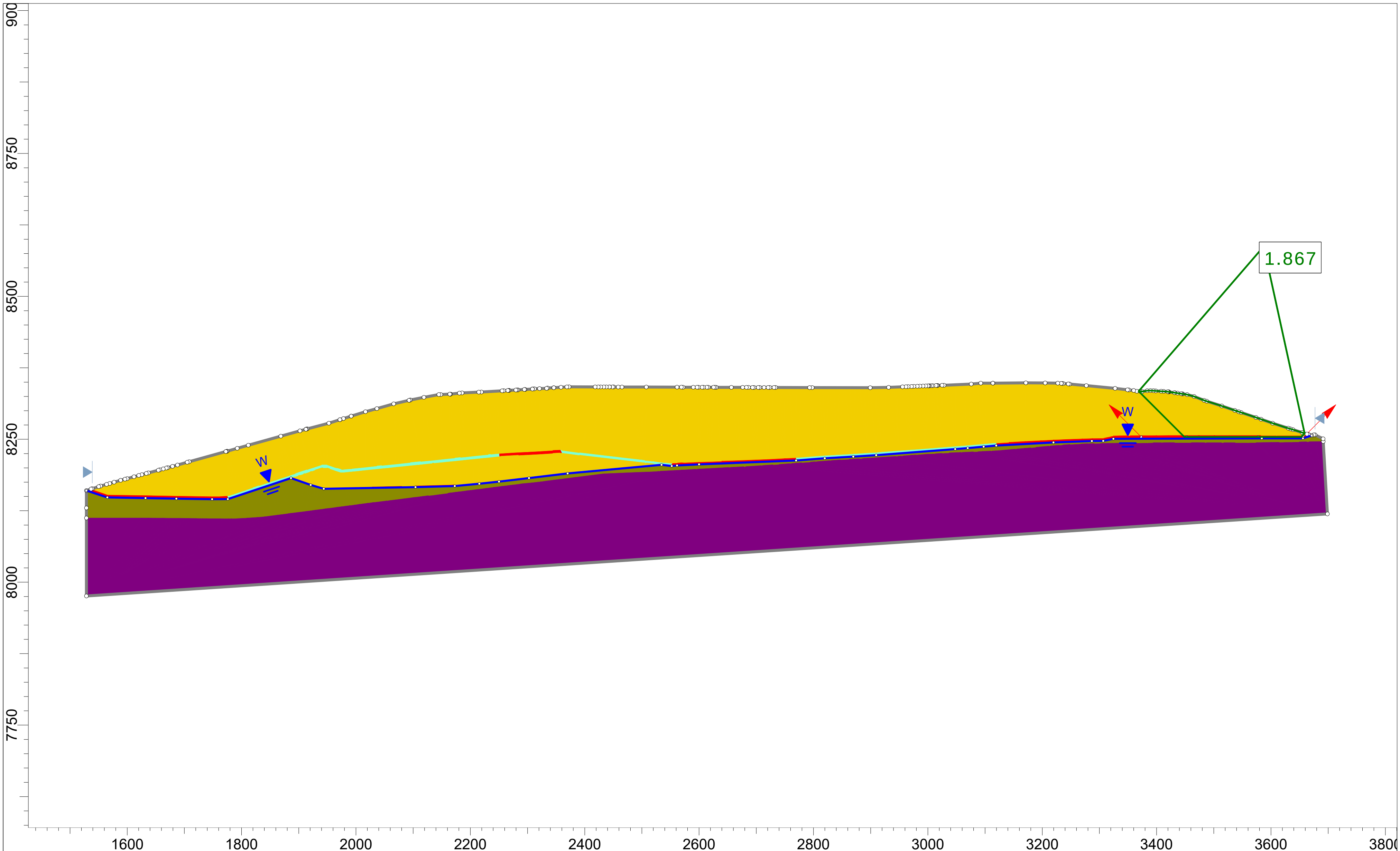
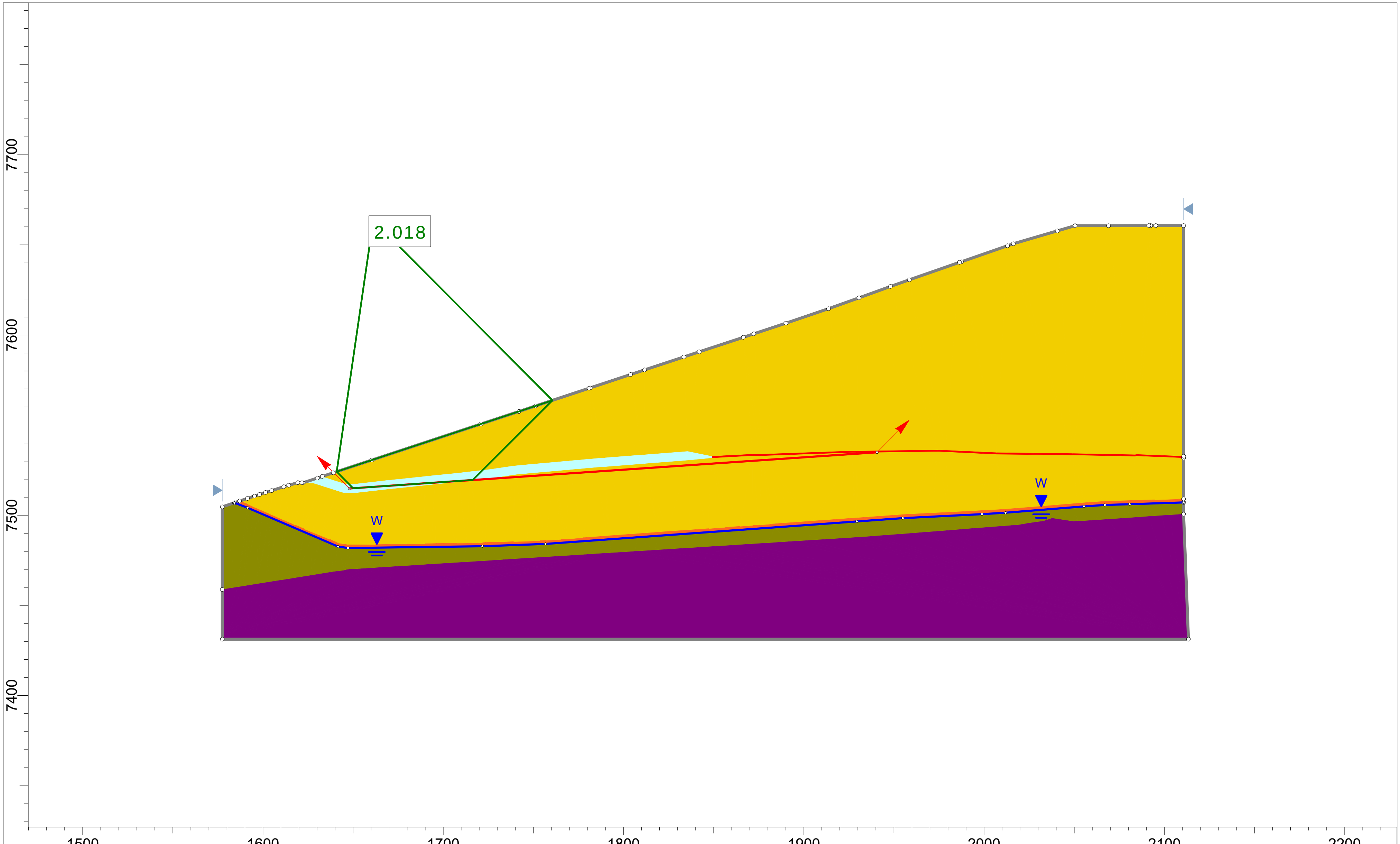
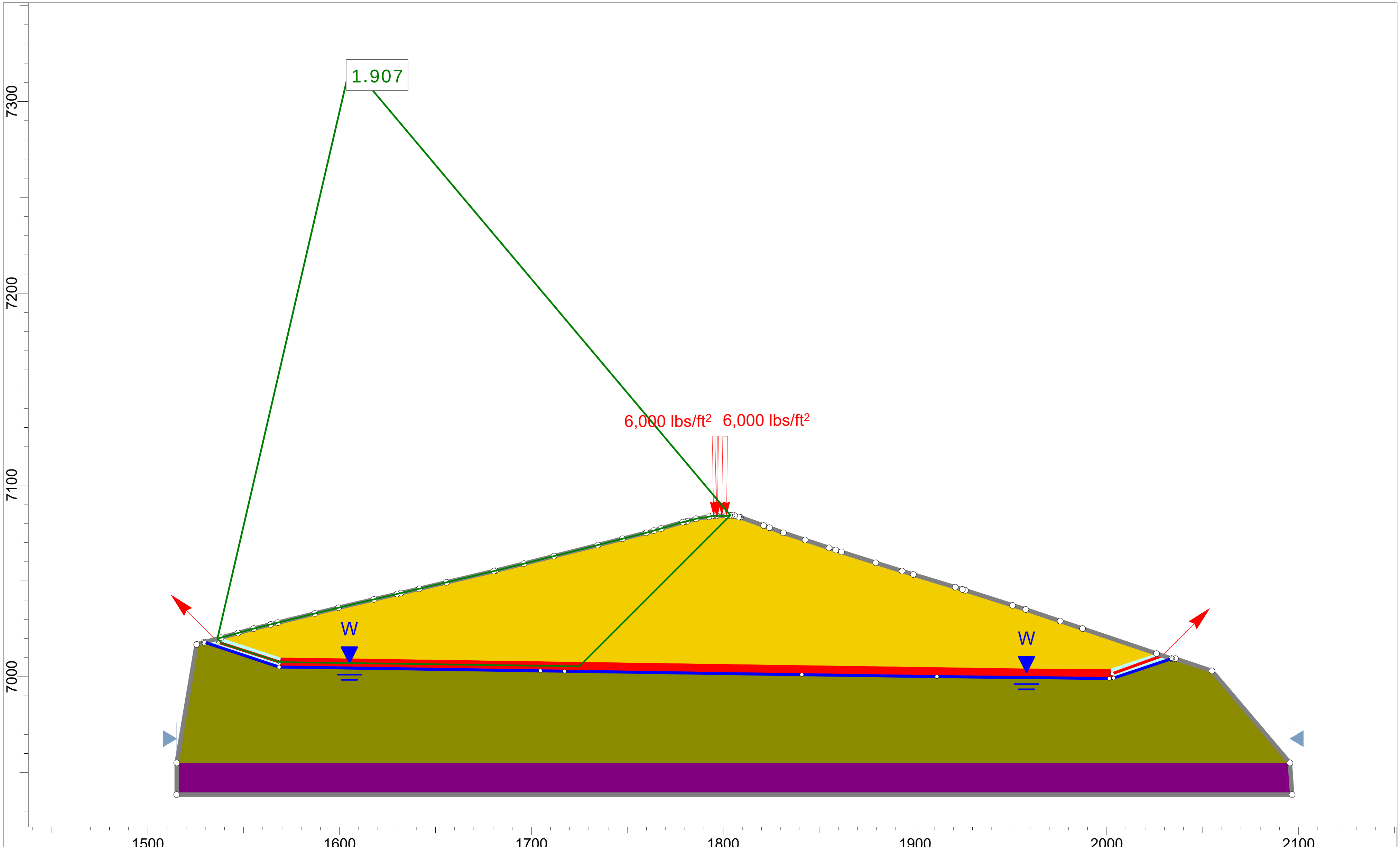
| | | | |
|---|---|---|---|
| *Project* | Profile D-D | | |
| *Group* | Group 1 | *Scenario* | Block |
| *Drawn By* | JJ | *Company* | Daigler Engineering P.C. |
| *Date* | 7/30/2020 | *File Name* | Profile D-D_rev1.slmd |




| | | | |
|---|---|---|---|
| rocscience | *Project* Profile D-D | | |
| | *Group* Group 1 | *Scenario* Block | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/30/2020 | *File Name* Profile D-D_rev1.slmd | |




| | | | |
|---|---|---|---|
| rocscience | *Project* Section E-E | | |
| | *Group* Group 1 | *Scenario* Block | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* | *File Name* Section E-E.slmd | |

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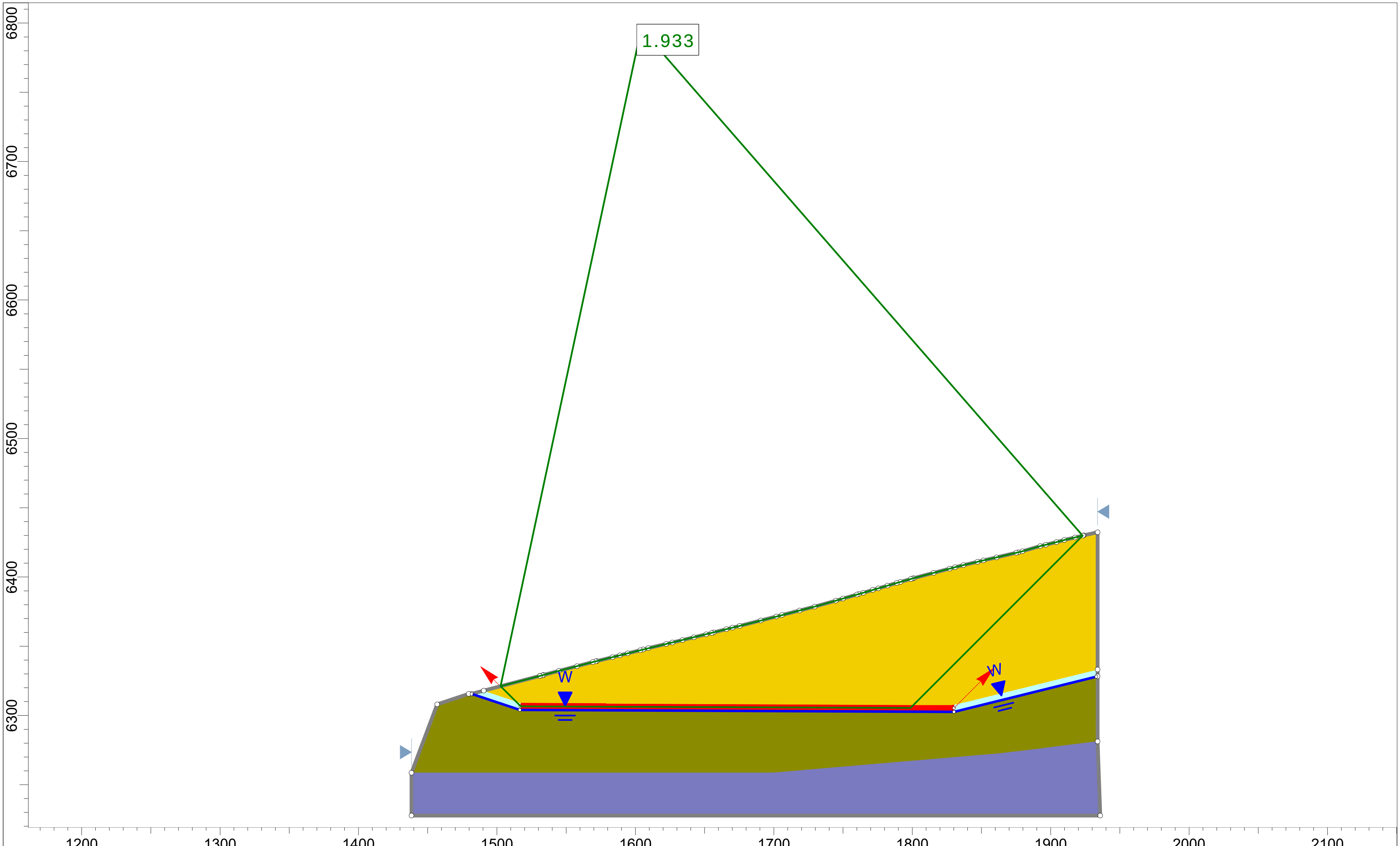
|---|---|---|---|
| rocscience | *Project* Section F-F | | |
| | *Group* Group 1 | *Scenario* Block | |
| | *Drawn By* JJ | *Company* Daigler Engineering P.C. | |
| SLIDEINTERPRET 9.008 | *Date* 7/31/20 | *File Name* Section F-F.slmd | |

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SLIDEINTERPRET 9.008

| Project | Section G-G | | |
|---|---|---|---|
| Group | Group 1 | Scenario | Block |
| Drawn By | JJ | Company | Daigler Engineering P.C. |
| Date | 7/31/20 | File Name | Section G-G.slmd |

# ATTACHMENT 5

# Leachate Generation and Removal System Calculations

- **Pipe Integrity Calculations**
- **Leachate Generation Calculations**
- **Pipe Capacity Calculations**

# Pipe Integrity Calculations

BY JJ DATE 2/11/20

CHKD. BY DL DATE 2/25/20
7/22/20

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2620 Grand Island Blvd. – Grand Island, NY – 14072
Ph: (716) 773-6872 – Fax: (716) 773-6873

JOB NO. 31-1620



SUBJECT Lockwood Hills – Leachate Collection Pipe – Original Disposal Site

Find: Maximum Expected Load:

$$P = \gamma H$$

$\gamma$ = Unit Weight

H = Height

Solution:

Depth of Stone = ~~2.375~~ = 1.95' $\gamma_{stone}$ = 160 lb/ft³ – SELECT FILL AND BOTTOMASH

Depth of Waste = 169' $\gamma_{waste}$ = 96.3 lb/ft³

Depth of Final Cover = 2' $\gamma_{soil}$ = 130 lb/ft³

OVERFILL STONE = 2', OVERFILL SAND (SLERS) = 1', OVERFILL SOIL = 2'

Pipe: 8" Perforated PVC SCH. 40

O.D. = 8.625" T = 0.322"

Pipe Stiffness: Wall Area = $\pi(4.31^2) - \pi(4.15^2)$ = 4.25 in²

Assume: 4 – 3/8" perforations per inch

Hole Area = $[0.375''(0.322)]4$ = $\boxed{0.483 \text{ in}^2}$

Wall Area = 4.25 in² – 0.483 in² = $\boxed{3.77 \text{ in}^2}$

Reduction Factor = $\frac{3.77}{4.25}$ = 0.89

$P_{TOTAL} = (1.95' + 2' + 1')(100 \text{ lb/ft}^3) + 169(96.3) + 4(130)$ = 17,289.7 PSF = $\boxed{120 \text{ PSI}}$

= $\frac{120 \text{ PSI}}{0.89}$ = $\boxed{134.8 \text{ PSI}}$

Deflection:

$$\frac{\Delta}{D} = \frac{D_l K P (100)}{\left[\frac{2E}{3(DR-1)^3}\right] + 0.061 E'}$$

$D_l$ = 1.5 K = 0.083 P = 134.8 PSI E = 400,000 PSI

DR = 8.625/0.322 = 26.79

$E' = 3{,}000 \text{ psi} \left(\frac{178(96.3)}{500}\right)^{0.26}$ = 7,520 psi

(GRANULAR BACKFILL)

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SUBJECT Lockwood Hills - Leachate Collection Pipe - Original Disposal Site

$$\frac{\Delta}{D} = \frac{1.5\,(0.083)(1348)(100)}{\left[\frac{2\,(400{,}000\,psi)}{3(26.79-1)^3}\right] + 0.061\,(7{,}520\,psi)}$$

$$= \frac{1{,}678.26}{474.27} = \underline{3.5}$$

$$= \ /\ 0.89 \ (\ldots) = \boxed{3.5\% < 7.5\% \quad OK}$$

ALLOWABLE PVC DEFLECTION

Pipe Buckling:

CRITICAL PIPE BUCKLING PRESSURE

$$P_{WC} = 5.65\sqrt{\left(\frac{1}{1+4e^{-0.065H}}\right) E'\left(\frac{E_P}{12\,(DR-1)^3}\right)}$$

$$= 5.65\sqrt{\left(\frac{1}{1+4e^{(-0.065\cdot 178)}}\right) \times 7{,}520\,psi \times \left(\frac{400{,}000\,psi}{12\,(26.79-1)^3}\right)}$$

1.94

$$= 5.65\sqrt{14{,}613.11}$$

$$= \boxed{683.\ psi}$$

$$F.S. = \frac{6839\,psi}{1348\,psi} = \boxed{5.07 \quad OK}$$

| | | | |
|---|---|---|---|
| BY JJ | DATE 2/11/20 | **DAIGLER ENGINEERING, P.C.** CIVIL & GEO-ENVIRONMENTAL ENGINEERING | JOB NO. 31-1620 |
| CHKD. BY DL | DATE 2/25/20 7/22/20 | 2620 Grand Island Blvd. – Grand Island, NY – 14072 Ph: (716) 773-6872 – Fax: (716) 773-6873 | SHEET NO. 3 OF 5 |

SUBJECT Lockwood Hills - leachate collection pipe - Original Disposal Site

Find: Compression STRESS

HOOP STIFFNESS FACTOR $S_h = E' \frac{R}{E_p A}$

VERTICAL ARCHING FACTOR $VAF = 1.06 - 0.96 \frac{S_h - 0.7}{S_h + 1.75}$

$$\sigma = \frac{VAF * P * D}{2A}$$

$$R = \frac{8.625'' - 0.322''}{2} = \underline{4.15}$$

Solution:

$$S_h = 7{,}520_{psi} \left( \frac{4.15\ in}{400{,}000_{psi} \times 0.322_{in}} \right) = \underline{0.242}$$

$$VAF = 1.06 - 0.96 \left( \frac{0.242 - 0.7}{0.242 + 1.75} \right) = \underline{1.28}$$

$$\sigma = \frac{1.28 \times 1344_{psi} \times 8.625^{in}}{2(0.322)_{in}} = \boxed{2{,}311\ psi < 4{,}000\ psi} \quad \underline{OK}$$

ALLOWABLE PVC COMPRESSIVE STRESS

BY JJ DATE 2/11/20

CHKD. BY DL DATE 2/25/20
7/22/20

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JOB NO. 31-1620

SHEET NO. 4 OF 5

SUBJECT Lockwood Hills - Leachate Collection Pipe - Original Disposal Site

12" PVC SDR 40 - Solid Wall

O.D. = 12.75" T = 0.406"

Find: Deflection

$$\frac{\Delta}{D} = \frac{D_1 \, K \, P(100)}{\left[\frac{2E}{3(DR-1)^3}\right] + 0.061E'}$$

E' = 7,520 PSI

$DR = \frac{12.75}{0.406} = 31.4$

P = 120 PSI

$$\frac{\Delta}{D} = \frac{1.5(0.083)(120)(100)}{\left[\frac{2(400,000)}{3(31.4-1)^3}\right] + 0.061(7,520)}$$

$$= \frac{1494}{468} = \boxed{3.2\% < 7.5\% \quad OK}$$

ALLOWABLE PVC PIPE DEFLECTION

Find: Critical Buckling Pressure

$$P_{WC} = 5.65\sqrt{\left(\frac{1}{1+4e^{-(0.065 \times 178')}}\right) \times 7{,}520_{PSI} \times \left(\frac{400{,}000\ PSI}{12(31.4-1)^3}\right)}$$

$$= 5.65\sqrt{8{,}922.28}$$

$$= \boxed{534\ PSI}$$

$$F.S. = \frac{534\ PSI}{130\ PSI} = \boxed{4.1 \quad OK}$$

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SUBJECT Lockwood Hills - Leachate Collection Pipe - Original Disposal Site

Find: Compression STRESS

$$\sigma = \frac{VAF \times P \times D}{2t}$$

HOOP STIFFNESS FACTOR - $S_h = E' \frac{R}{E_p t}$   $R = \frac{12.75 - 0.406}{2} = 6.172\text{ in}$

$$S_h = 7520\,\text{psi} \left( \frac{6.172\text{ in}}{400{,}000\,\text{psi} \times 0.406} \right) = 0.29$$

VERICAL ARCHING FACTOR $VAF = 1.06 - 0.96 \left( \frac{0.29 - 0.7}{0.29 + 1.75} \right) = 1.25$

$$\sigma = \frac{1.25 \times 120\,\text{psi} \times 12.75''}{2(0.406)''}$$

$$= \boxed{2355\ \text{PSI} < 4000\ \text{PSI}}$$

ALLOWABLE PVC COMPRESSIVE STRESS

BY JJ DATE 2/10/20

CHKD. BY VC DATE 2/25/20

7/22/20

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JOB NO. 31-1620



SUBJECT Lockwood Hills - Leachate Collection Pipe - Stage IV

Find: Maximum Expected Load

$$P_{design} = P_E \left( \frac{L}{L - L_p} \right)$$

$P_E = H \gamma_w$  L = Unit Length of Pipe

$L_p$ = Length of perforations per Unit Length of pipe

Assumptions:

Depth of Stone = 1.33'  $\gamma_{stone}$ = 100 lb/ft³

Depth of Waste = 110'  $\gamma_{waste}$ = 96.3 lb/ft³

Depth of Final Cover = 2'  $\gamma_{soil}$ = 130 lb/ft³

8" Slotted PVC Pipe SCH. 80

Slot width = 0.125", 1" spacing b/w slots - 3 SLOTS PER 1" SPACING

O.D. = 8.625"  Wall Thickness = 0.5"

$L_p$ = 0.375"  $\frac{L}{L - L_p} = 1.6$

$P_{E\,stone}$ = 1.33'(100 lb/ft³) = 133 psf ABOVE PIPE

$P_{E\,waste}$ = 110'(96.3 lb/ft³) = 10,593 psf

$P_{E\,soil}$ = 2'(130 lb/ft³) = 260 psf

$P_E$ = 10,986 psf

$P_{design}$ = 10,986 psf (1.6) = $\boxed{17,578 \text{ psf} = 122 \text{ psi}}$

BY JJ DATE 2/11/20

CHKD. BY DL DATE 2/25/20 7/22/20

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JOB NO. 31-1620



SUBJECT Lockwood Hills - Leachate Collection Pipe - Stage IV

Find: Ring Deflection

$$DR = \frac{8.625''}{0.5''} = 17.25$$

$$\frac{\Delta}{D} = \frac{D_1 K P(100)}{\left[\frac{2E}{3(DR-1)^3}\right] + 0.061E'}$$

$K = 0.083$ - BEDDING FACTOR  $E = 400{,}000$ PSI  $D_1 = 1.5$ DEFLECTION LAG FACTOR

$DR = 17.25$  $P = 122$ PSI

Solution:

$$E' = E_{initial}\left(\frac{H\gamma_w}{500}\right)^{0.26} = 3000\left(\frac{113.33' \times 96.3\,lb/ft^3}{500}\right)^{0.26} = \underline{6688 \text{ PSI}}$$

H - SOIL COVER HEIGHT - 113.33'

$$\frac{\Delta}{D} = \frac{1.5(0.083)(122_{psi})(100)}{\left[\frac{2(400{,}000)_{psi}}{3(17.25-1)^3}\right] + 0.061(6688)_{psi}} = \frac{1518.9 \text{ psi}}{470.1}$$

470  62.15 + 404.8

$$\frac{\Delta}{D} = \boxed{3.23\% < 7.5\% \quad OK}$$

ALLOWABLE PVC PIPE DEFLECTION

Pipe Buckling: CRITICAL BUCKLING PRESSURE

$$P_{WC} = 5.65\sqrt{\left(\frac{1}{1+4e^{-0.065H}}\right)E'\left(\frac{E_P}{12(DR-1)^3}\right)}$$

$H = 113.33'$  $E_P = 400{,}000$ PSI

$DR = 17.25$  $E' = 6688$ PSI

$$P_{WC} = 5.65\sqrt{\left[\frac{1}{(1+4e^{-(0.065 \times 113.33)})}\right] \times 6688_{psi} \times \left[\frac{400{,}000_{psi}}{12(17.25-1)^3}\right]}$$

.997 × 6688 × 7.77

$$= 5.65\sqrt{6664 \times 7.77}$$

$$\underline{P_{WC} = 1286.7 \text{ psi}}$$

Actual Prism Load = 122 PSI

$$\frac{1286.7}{122} = \boxed{10.5 = F.S.} \quad OK$$

BY JJ DATE 2/11/20

CHKD. BY OC DATE 2/25/20 7/22/20

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JOB NO. 31-1620

SHEET NO. 3 OF 3

SUBJECT Lockwood Hills - Leachate Collection Pipe - Stage IV

Find: Ring Compression STRESS

HOOP STIFFNESS FACTOR $S_h = E'\left(\frac{R}{E_p t}\right)$

VERTICAL ARCHING FACTOR $VAF = 1.06 - 0.96 \frac{S_h - 0.7}{S_h + 1.75}$

R - MEAN RADIUS of PIPE = 4.05''

t = PIPE THICKNESS = .5''

$\sigma = \frac{VAF \times P_{Design} \times D}{2t}$

Solution:

$$S_h = 6646_{PSI}\left(\frac{4.05_{in}}{460{,}000_{PSI} \times 0.5_{in}}\right) = 0.135$$

$$VAF = 1.06 - 0.96\left(\frac{0.135 - 0.7}{0.135 + 1.75}\right) = 1.35$$

$$\sigma = \frac{1.35 \times 122_{PSI} \times 8.625_{in}}{2(0.5_{in})} = \boxed{1420.5_{PSI} < 4{,}000 \text{ PSI}}$$

OK ALLOWABLE PVC COMPRESSION STRESS

# Leachate Generation Calculations

Lockwood Hills LLC
Part 360 Permit Renewal Modification Application
**Leachate Generation Quantities**

| Conditions | GPAD | Method to determine flow rate |
|---|---|---|
| Active Landfilling | 644 | Measured average flow (note 3) |
| Open-25 year Storm | 113,000 | Calculated peak flow (note 4) |
| Open-500 year Storm | 185,000 | Calculated peak flow (note 5) |
| Exposed Geomembrane | 30 | Calculated Leakage Rate Through Exposed Geomembrane, see attached calculation |
| Intermediate Cover | 470 | Measured average flow (note 6) |
| Final Cover | 10 | Calculated Leakage Rate through Final Cover System, see attached calculation |

**PHASE 1a (current landfill, operating condition)**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Exposed Geomembrane | 12.3 | 30 | 7 | 2,583 |
| Intermediate Cover | 17.5 | 470 | 7 | 57,575 |
| **TOTAL** | **29.8** | | | **60,158** |

**PHASE 1b (active landfill of OADS overfill area)**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Active Landfill Area | 9.5 | 644 | 7 | 42,826 |
| Open-25 year | 1.0 | 113,000 | 1 | 113,000 |
| Exposed Geomembrane | 19.3 | 30 | 7 | 4,053 |
| **TOTAL** | **29.8** | | | **159,879** |

**PHASE 2 (25-Year Storm)**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Active Landfill Area | 9.2 | 644 | 7 | 41,474 |
| Open-25 year | 1.0 | 113,000 | 1 | 113,000 |
| Intermediate Cover | 4.2 | 470 | 7 | 13,818 |
| Exposed Geomembrane | 19.4 | 30 | 7 | 4,074 |
| Final Cover | 3.2 | 10 | 7 | 224 |
| **TOTAL** | **37.0** | | | **172,590** |

**PHASE 3**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Active Landfill Area | 7.4 | 644 | 7 | 33,359 |
| Exposed Geomembrane | 11.2 | 30 | 7 | 2,352 |
| Intermediate Cover | 7.5 | 470 | 7 | 24,675 |
| Final Cover | 10.9 | 10 | 7 | 763 |
| **TOTAL** | **37.0** | | | 61,149 |

**PHASE 4 (25-Year Storm)**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Active Landfill Area | 9.5 | 644 | 7 | 42,826 |
| Open-25 year | 1.0 | 113,000 | 1 | 113,000 |
| Intermediate Cover | 10.3 | 470 | 7 | 33,887 |
| Final Cover | 23.4 | 10 | 7 | 1,638 |
| **TOTAL** | **44.2** | | | **191,351** |

**PHASE 5**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Active Landfill Area | 5.6 | 644 | 7 | 25,245 |
| Intermediate Cover | 5.5 | 470 | 7 | 18,095 |
| Final Cover | 33.1 | 10 | 7 | 2,317 |
| **TOTAL** | **44.2** | | | **45,657** |

**PHASE 6**

| Phase Condition | Area (acre) | Generation Rate (gpad) | Duration (days) | Flow (gal) |
|---|---|---|---|---|
| Final Cover | 44.2 | 10 | 7 | 3,094 |
| **TOTAL** | **44.2** | | | **3,094** |

**1** Intermediate cover is defined as minimum 6" thick layer of unclassified soil in the facility's O&M Manual
**2** Areas from Fill Progression Plans (See Attachment Plans)
**3** Average leachate flow rate from Stages I and II prior to May 2011
**4** 25-Year, 24-Hour Storm, see attached calculation and precipitation frequency in Attachment 1
**5** 500-Year, 24-Hour Storm, see attached calculation and precipitation frequency in Attachment 1
**6** From leachate flow meter measurements collected between July 1st, 2016 and November 30, 2017.

**Leachate Generation Quantities**

| PHASE 1b (active landfill of OADS overfill area) | | | | | |
|---|---|---|---|---|---|
| | **Phase Condition** | **Area (acre)** | **Generation Rate (gpad)** | **Duration (days)** | **Flow (gal)** |
| | Active Landfill Area | 9.5 | 644 | 7 | 42,826 |
| | Open-500 year | 1.0 | 185,000 | 1 | 185,000 |
| | Exposed Geomembrane | 19.3 | 30 | 7 | 4,053 |
| | **TOTAL** | **29.8** | | | **231,879** |

| PHASE 2 (500-Year Storm) | | | | | |
|---|---|---|---|---|---|
| | **Phase Condition** | **Size (acre)** | **Generation Rate (gpad)** | **Duration (days)** | **Flow (gal)** |
| | Active Landfill Area | 9.2 | 644 | 7 | 41,474 |
| | Open-500 year | 1.0 | 185,000 | 1 | 185,000 |
| | Exposed Geomembrane | 19.4 | 30 | 7 | 4,074 |
| | Intermediate Cover | 4.2 | 470 | 7 | 13,818 |
| | Final Cover | 3.2 | 10 | 7 | 224 |
| | **TOTAL** | **37.0** | | | **244,590** |

| PHASE 4 (500-Year Storm) | | | | | |
|---|---|---|---|---|---|
| | **Phase Condition** | **Size (acre)** | **Generation Rate (gpad)** | **Duration (days)** | **Flow (gal)** |
| | Active Landfill Area | 9.5 | 644 | 7 | 42,826 |
| | Open-500 year | 1.0 | 185,000 | 1 | 185,000 |
| | Intermediate Cover | 10.3 | 470 | 7 | 33,887 |
| | Final Cover | 23.4 | 10 | 7 | 1,638 |
| | **TOTAL** | **44.2** | | | **263,351** |

BY JPG DATE 8/5/2019

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SHEET NO. 1 OF 1

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SUBJECT Lockwood Exposed Geomembrane Leachate Generation Rate

Use Giroud, et al 1997 Final Cover Infiltration Equation

$$Q = C_{qo}\, n \left(1 + 0.1\left(\frac{h}{t_s}\right)^{0.95}\right) a^{0.1}\, h^{0.9}\, k_s^{0.74}$$ ✓

Where: $Q$ = Leakage rate through the defect ($m^3/sec$)

$C_{qo}$ = Contact quality factor = 0.7 for fair contact

$n$ = # defects in geomembrane

$h$ = Head on geomembrane ($m$)

$t_s$ = Thickness of soil below geomembrane ($m$)

$a$ = area of circular defect ($m^2$)

$K_s$ = Soil permeability ($m/sec$)

Assumptions: $n = 4/acre$ ✓

$h = 6''$ for water trapped behind a wrinkle $= 0.1524\,m$ ✓

$t_s = 6''$ subbase $= 0.1524\,m$ ✓

$a = 3.14 \times 10^{-6}\,m^2$ for $d = 2\,mm$ circular hole ✓

$k_s = 1\times10^{-5}\,cm/sec$ or $1\times10^{-7}\,m/sec$ ✓

$$Q = (0.7)(4)\left[1 + 0.1\left(\frac{.1524}{.1524}\right)^{.95}\right](3.14\times10^{-6}\,m^2)^{.1}(0.1524)^{.9}(1\times10^{-7})^{.74}$$

$$= 1.05\times10^{-6}\,m^3/sec \times \frac{264.172\,gal}{m^3} \times \frac{3600\,sec}{hr} \times \frac{24\,hr}{day}$$ ✓

$Q$ = 24 Gallons per acre per day (gpad) ✓

$\boxed{\text{SAY } Q = 30\,gpad}$ ✓

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SUBJECT Lockwood – Leachate Generation Rates

Final Cover

Use Giroud, et al 1997 – Final Cover Infiltration Eqn.

$Q = n\,0.976\,C_{qo}\left(1 + 0.1\,(h/t_s)^{0.95}\right) a^{0.1}\, h^{0.9}\, K_s^{0.74}$

Q = Leakage Rate through the Defect ($m^3/s$)

$C_{qo}$ = Contact quality factor = 0.21 for good contact

n = # of defects in geomembrane → Assume 2/acre

h = Head on geomembrane = 12" = 0.3048 m

$t_s$ = Thickness of soil below geomembrane = 6" = 0.1524 m

a = Area of circular defect = $3.1416 \times 10^{-6}\ m^2$ for 2 mm diam

$K_s$ = Soil Permeability = $1 \times 10^{-5}$ cm/s = $1 \times 10^{-7}$ m/s

$Q = [1 + 0.1(0.3048/0.1524)^{0.95}](3.1416 \times 10^{-6}\ m^2)^{0.1}(0.3048\ m)^{0.9}(1 \times 10^{-7}\ m/s)^{0.74}$

$= 0.39[1.193](0.282\ m^2)(0.343\ m)(6.61 \times 10^{-6}\ m/s)$

$= \underline{2.97 \times 10^{-7}\ m^3/s}$ $1\ m^3 = 264.17$ gal

$= \underline{7.86 \times 10^{-5}\ g/s}$

$= 7.86 \times 10^{-5}\ g/s \left(\frac{60\ s}{min}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{24\ hr}{1\ day}\right) = \boxed{6.79\ \text{GPAD}}$

→ Use $\boxed{10.0\ \text{GPAD}}$

Intermediate Cover

From Leachate Monitoring and Analysis Report, Jan 2010

Avg. Design = 470 GPAD

→ Use Avg. Design = 470 GPAD

Active Landfill

From historic leachate generation rates prior to 5/2011, use an average flow rate of 644 GPAD

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SUBJECT Lockwood Hills - Leachate Management (25-Year, 500-Year)

Find: Initial Leachate Generation Rate for a 25-Year and 500-Year, 24-hour storm

Assumptions:

25-Year Storm = 4.16 inches
500-Year Storm = 6.8 inches

} NOAA Point Precipitation frequency map

Solution:

$$\text{Open Area Generation} = \frac{\text{Rainfall}}{\text{24-hours}} \times \frac{1\text{ ft}}{12\text{ in}} \times \frac{43{,}560\text{ ft}^2}{\text{Acre}} \times \frac{7.481\text{ Gal}}{\text{ft}^3}$$

25-Year

$$= \frac{4.16\text{ in}}{1\text{ day}} \times \frac{1\text{ ft}}{12\text{ in}} \times \frac{43{,}560\text{ ft}^2}{\text{Acre}} \times \frac{7{,}481\text{ Gal}}{\text{ft}^3}$$

$$= 112{,}969\text{ Gal} = \boxed{113{,}000\text{ Gal/Acre/Day}}$$

500-Year

$$= \frac{6.8\text{ in}}{1\text{ day}} \times \frac{1\text{ ft}}{12\text{ in}} \times \frac{43{,}560\text{ ft}^2}{\text{Acre}} \times \frac{7.481\text{ Gal}}{\text{ft}^3}$$

$$= 184{,}661\text{ Gal} = \boxed{185{,}000\text{ Gal/Acre/Day}}$$

**NOAA Atlas 14, Volume 10, Version 3**
**Location name: Town of Torrey, New York, USA***
**Latitude: 42.677°, Longitude: -76.9633°**
**Elevation: 506.95 ft****
* source: ESRI Maps
** source: USGS

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **0.283** (0.221-0.355) | **0.346** (0.270-0.434) | **0.448** (0.349-0.563) | **0.533** (0.411-0.674) | **0.650** (0.487-0.858) | **0.738** (0.542-0.991) | **0.831** (0.594-1.16) | **0.939** (0.633-1.33) | **1.10** (0.712-1.60) | **1.23** (0.780-1.83) |
| 10-min | **0.401** (0.314-0.503) | **0.490** (0.383-0.615) | **0.635** (0.494-0.800) | **0.756** (0.584-0.956) | **0.922** (0.691-1.22) | **1.05** (0.769-1.41) | **1.18** (0.842-1.64) | **1.33** (0.895-1.88) | **1.56** (1.01-2.27) | **1.75** (1.11-2.59) |
| 15-min | **0.472** (0.369-0.592) | **0.577** (0.450-0.724) | **0.748** (0.581-0.941) | **0.889** (0.687-1.12) | **1.08** (0.812-1.43) | **1.23** (0.904-1.66) | **1.39** (0.990-1.93) | **1.57** (1.05-2.21) | **1.83** (1.19-2.67) | **2.06** (1.30-3.05) |
| 30-min | **0.637** (0.498-0.799) | **0.778** (0.607-0.976) | **1.01** (0.784-1.27) | **1.20** (0.927-1.52) | **1.46** (1.10-1.93) | **1.66** (1.22-2.23) | **1.87** (1.33-2.60) | **2.11** (1.42-2.98) | **2.47** (1.60-3.59) | **2.77** (1.75-4.10) |
| 60-min | **0.802** (0.626-1.00) | **0.979** (0.764-1.23) | **1.27** (0.986-1.60) | **1.51** (1.17-1.91) | **1.84** (1.38-2.42) | **2.09** (1.53-2.81) | **2.35** (1.68-3.27) | **2.65** (1.79-3.75) | **3.10** (2.01-4.52) | **3.48** (2.20-5.16) |
| 2-hr | **0.995** (0.781-1.24) | **1.20** (0.942-1.50) | **1.54** (1.20-1.92) | **1.82** (1.41-2.28) | **2.20** (1.67-2.90) | **2.48** (1.85-3.35) | **2.80** (2.03-3.93) | **3.20** (2.16-4.48) | **3.83** (2.49-5.54) | **4.39** (2.79-6.46) |
| 3-hr | **1.12** (0.884-1.39) | **1.35** (1.06-1.67) | **1.71** (1.35-2.13) | **2.02** (1.58-2.53) | **2.44** (1.85-3.20) | **2.74** (2.05-3.69) | **3.09** (2.26-4.34) | **3.54** (2.39-4.94) | **4.28** (2.78-6.16) | **4.94** (3.14-7.22) |
| 6-hr | **1.37** (1.09-1.69) | **1.63** (1.29-2.02) | **2.07** (1.63-2.56) | **2.42** (1.90-3.01) | **2.92** (2.23-3.80) | **3.28** (2.46-4.37) | **3.68** (2.70-5.12) | **4.21** (2.86-5.83) | **5.06** (3.31-7.23) | **5.83** (3.72-8.45) |
| 12-hr | **1.66** (1.32-2.03) | **1.97** (1.57-2.42) | **2.49** (1.98-3.06) | **2.92** (2.30-3.60) | **3.51** (2.69-4.52) | **3.95** (2.96-5.19) | **4.42** (3.23-6.03) | **5.00** (3.42-6.86) | **5.88** (3.86-8.32) | **6.64** (4.26-9.56) |
| 24-hr | **1.96** (1.57-2.38) | **2.34** (1.87-2.84) | **2.95** (2.35-3.60) | **3.46** (2.74-4.24) | **4.16** (3.19-5.30) | **4.68** (3.52-6.08) | **5.24** (3.82-7.03) | **5.88** (4.04-8.00) | **6.80** (4.49-9.54) | **7.57** (4.87-10.8) |
| 2-day | **2.27** (1.83-2.74) | **2.71** (2.18-3.27) | **3.42** (2.74-4.14) | **4.01** (3.20-4.88) | **4.82** (3.71-6.09) | **5.43** (4.09-6.99) | **6.07** (4.44-8.07) | **6.80** (4.69-9.19) | **7.87** (5.21-10.9) | **8.76** (5.66-12.4) |
| 3-day | **2.50** (2.02-3.00) | **2.97** (2.40-3.57) | **3.73** (3.00-4.50) | **4.36** (3.49-5.29) | **5.23** (4.05-6.59) | **5.89** (4.46-7.55) | **6.58** (4.83-8.72) | **7.37** (5.10-9.91) | **8.53** (5.66-11.8) | **9.49** (6.14-13.3) |
| 4-day | **2.69** (2.18-3.23) | **3.18** (2.58-3.82) | **3.98** (3.21-4.79) | **4.64** (3.72-5.61) | **5.55** (4.31-6.97) | **6.24** (4.73-7.97) | **6.96** (5.12-9.19) | **7.79** (5.40-10.4) | **9.00** (5.98-12.4) | **10.00** (6.48-14.0) |
| 7-day | **3.19** (2.60-3.81) | **3.72** (3.03-4.44) | **4.59** (3.72-5.49) | **5.30** (4.28-6.38) | **6.29** (4.90-7.84) | **7.04** (5.36-8.93) | **7.82** (5.76-10.2) | **8.70** (6.05-11.6) | **9.99** (6.66-13.7) | **11.0** (7.18-15.4) |
| 10-day | **3.67** (3.00-4.36) | **4.23** (3.45-5.03) | **5.14** (4.18-6.13) | **5.90** (4.77-7.07) | **6.95** (5.42-8.62) | **7.74** (5.90-9.76) | **8.56** (6.32-11.1) | **9.48** (6.61-12.6) | **10.8** (7.22-14.7) | **11.9** (7.74-16.5) |
| 20-day | **5.13** (4.22-6.05) | **5.77** (4.74-6.81) | **6.81** (5.58-8.07) | **7.68** (6.25-9.14) | **8.88** (6.96-10.9) | **9.79** (7.49-12.2) | **10.7** (7.91-13.7) | **11.7** (8.22-15.4) | **13.1** (8.79-17.7) | **14.2** (9.26-19.5) |
| 30-day | **6.36** (5.25-7.48) | **7.06** (5.82-8.30) | **8.19** (6.73-9.66) | **9.14** (7.46-10.8) | **10.4** (8.20-12.7) | **11.4** (8.77-14.2) | **12.4** (9.18-15.8) | **13.5** (9.48-17.6) | **14.8** (10.00-19.9) | **15.9** (10.4-21.7) |
| 45-day | **7.91** (6.55-9.26) | **8.66** (7.17-10.2) | **9.90** (8.16-11.6) | **10.9** (8.94-12.9) | **12.3** (9.72-14.9) | **13.4** (10.3-16.5) | **14.5** (10.7-18.2) | **15.5** (11.0-20.2) | **16.9** (11.4-22.5) | **17.8** (11.7-24.3) |
| 60-day | **9.22** (7.65-10.8) | **10.0** (8.30-11.7) | **11.3** (9.34-13.2) | **12.4** (10.2-14.6) | **13.9** (11.0-16.7) | **15.0** (11.6-18.4) | **16.2** (11.9-20.2) | **17.2** (12.2-22.2) | **18.5** (12.5-24.6) | **19.4** (12.7-26.2) |

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

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

Please refer to NOAA Atlas 14 document for more information.

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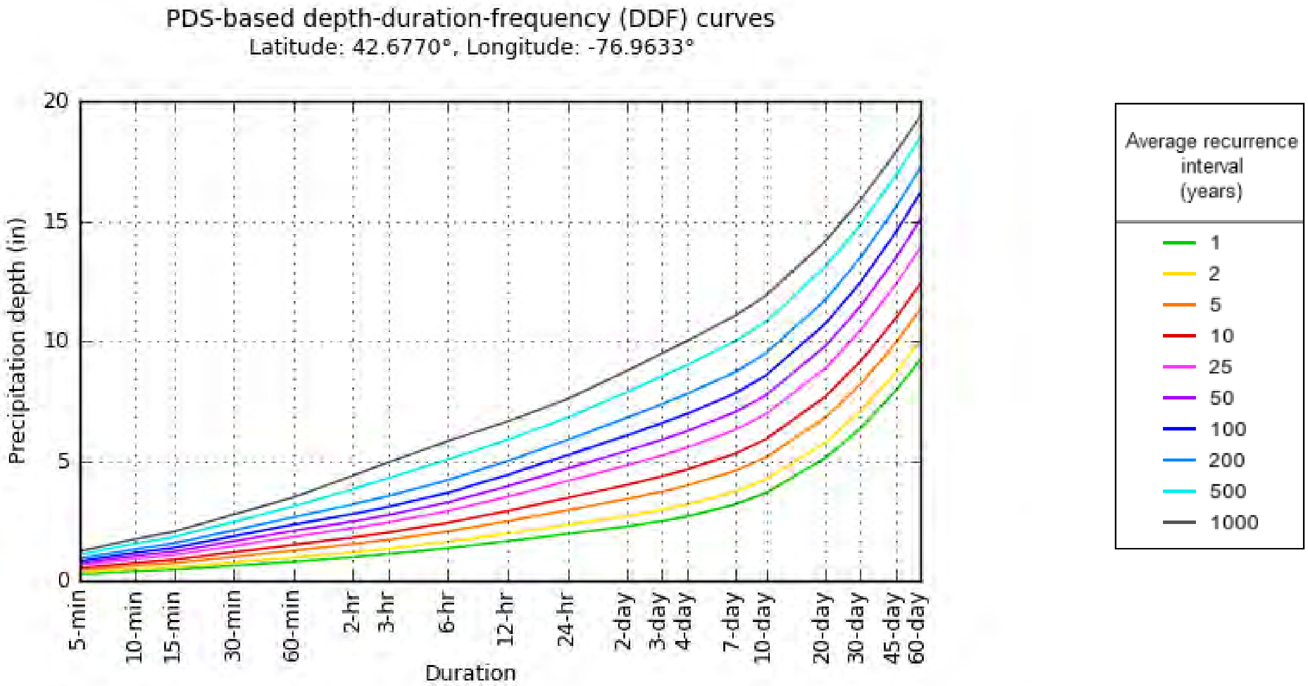
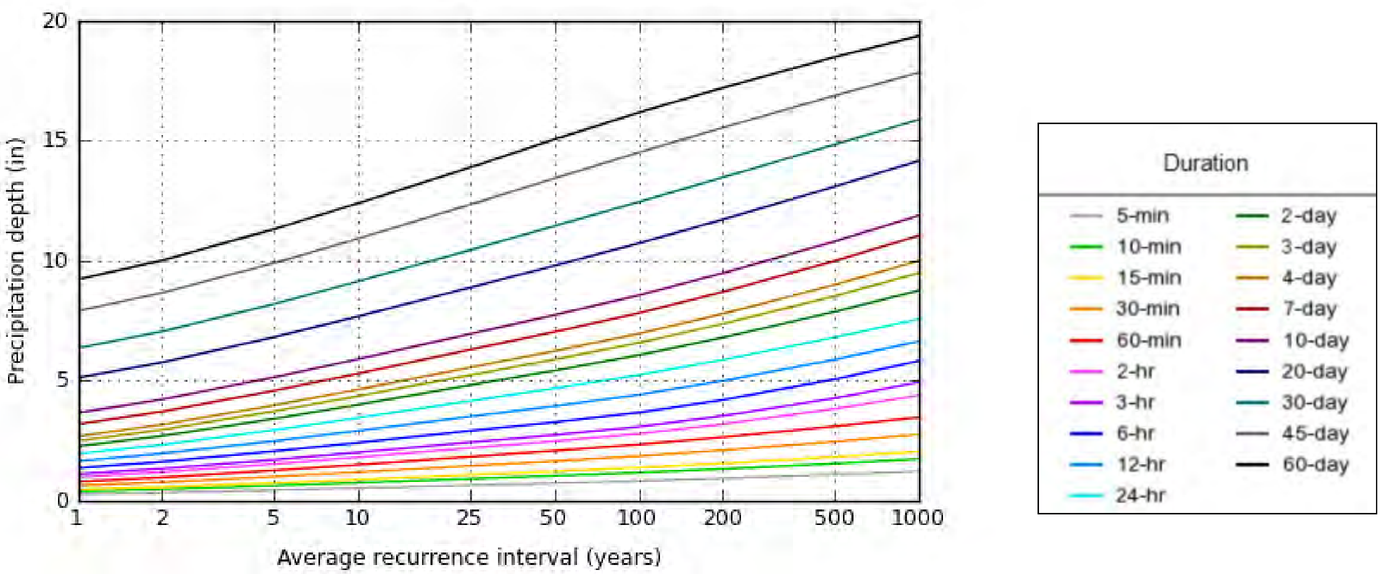
## PF graphical




NOAA Atlas 14, Volume 10, Version 3 Created (GMT): Thu Feb 20 17:48:32 2020

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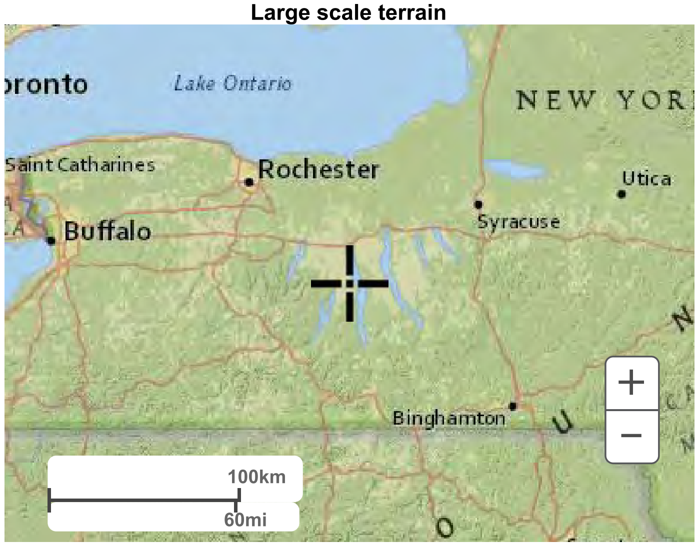
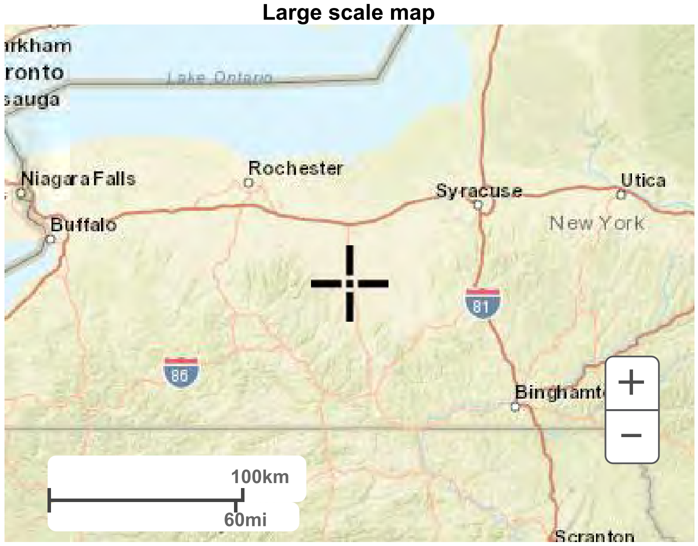
## Maps & aerials

**Small scale terrain**

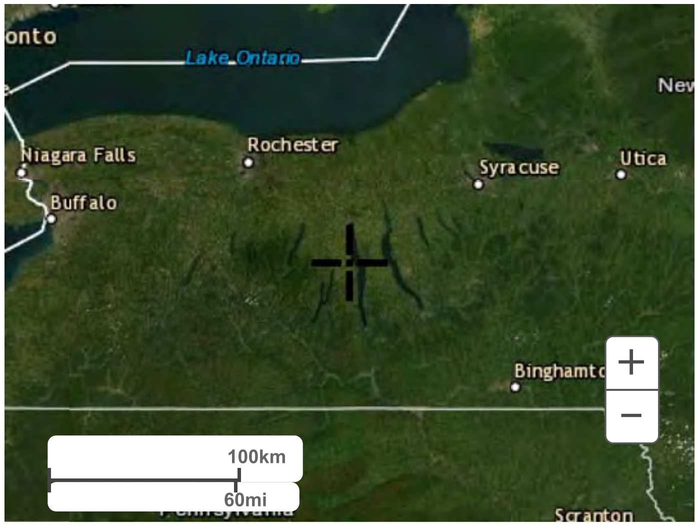

**Large scale terrain**




**Large scale map**




**Large scale aerial**

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Disclaimer

# Pipe Capacity Calculations

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SUBJECT Lockwood – Stage IV Leachate Pipe Expansion

Find: Leachate Collection Pipe Flowrate in relation to 25-Year and 500-Year Storm

Given: Total Acreage = 7.2 Acres

Open = 1.0 Acres (Assume)

Active = 6.2 Acres

Generation Rates: Active = 644 GPAD

Open (25-Year) = 113,000 GPAD

Open (500-Year) = 185,000 GPAD

Method:

7-Day Generation:

$\Sigma$(Area × Duration × Generation Rate) = Flow (Gallons)

Leachate Impingement Rate: $q_h = \frac{Q}{7 \text{days} \times \text{Area}}$ = GPAD

Flow through Pipe = $Q = q_h \times A$

Solution:

25-Year:

7-Day = (6.2 AC × 7 days × 644 gpad) + (1.0 AC. × 1 day × 113,000 gpad)

= 140,950 gal

$q_h = \frac{140{,}950 \text{ gal}}{7 \text{ days} \times 7.2 \text{ AC}}$ = 2,797 gpad

= (2,797 gpad)(0.1337 ft³/gal)(1 acre/43560 ft²)(1 day/86,400 s)

= $9.94 \times 10^{-8}$ ft/s

Flowrate = ($9.94 \times 10^{-8}$ ft/s)(7.2 Ac)(43560 ft²) = $\boxed{0.03 \text{ ft}^3/\text{s}}$

BY JJ DATE 7/31/20

CHKD. BY CL DATE 8/3/20

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SHEET NO. 2 OF 5

SUBJECT Lockwood - Stage IV Leachate Pipe Expansion

500-Year:

7-Day = (6.2 AC × 7 days × 614 GPAD) + (1.0 AC × 1 day × 185,000 GPAD)

= 212950 gal

$q_h = \frac{212{,}950 \text{ gal}}{7 \text{ days} \times 7.2 \text{ AC}} = 4{,}225 \text{ GPAD}$

= (4,225 gpad)(0.1337 ft³/gal)(1 acre/43560 ft²)(1 day/86,400 s)

= $\boxed{1.5 \times 10^{-7} \text{ ft/s}}$

Flowrate = $(1.5 \times 10^{-7} \text{ ft/s})(7.2 \text{ AC})(43560 \text{ ft}^2) = \boxed{0.047 \text{ ft}^3/\text{s}}$

Pipe Size:

Method: Flowrate through a pipe = $Q = \left(\frac{1.49}{n}\right)(A)(r_h^{2/3})(s^{1/2})$

$n = 0.011$

A = Area flow of a half-full pipe

s = slope = 0.01

$r_h$ = Hydraulic radius = D/4

Given: Diameter = 8" = 0.67 ft

Area = $\pi (D^2/8) = \pi (0.67^2/8) = 0.176 \text{ ft}^2$

$r_h = 0.67/4 = 0.1675 \text{ ft}$

Solution:

$Q = \left(\frac{1.49}{0.011}\right)(0.176)(0.1675)^{2/3}(0.01)^{1/2} = \boxed{0.72 \text{ ft}^3/\text{s}}$

$\boxed{0.72 \text{ ft}^3/\text{s} > 0.047 \text{ ft}^3/\text{s} \quad \therefore \text{ Capacity is OK}}$

0.03 ft³/s

BY JJ DATE 8/3/20 CHKD. BY DL DATE 8/3/20

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JOB NO. 31-1619
SHEET NO. 3 OF 5

SUBJECT Lockwood Hills - Stage III Leachate Pipe Expansion

Stage III: Total Acreage = 7.0 Acres

Assume: 1.0 Acres = Open

6.0 Acres = Active

25-Year

7-Day = 140,048 gal (6.0 Acres · 644 GPAD · 7 Days) + (113,000 GPAD · 1 Acre · 1 Day)

$q_h$ = 2,858 GPAD  2,858 GPAD ... · 7 Days

= $\boxed{1.02 \times 10^{-7}\ ft/s}$ (2,858 GPAD)(0.1337 ft³/gal)(1 Acre / 43,560 ft²)(1 Day / 86,400)

$Q = (1.02 \times 10^{-7}\ ft/s)(7.0\ AC.)(43560\ ft^2)$

$= \boxed{0.031\ ft^3/s}$

500-Year

7-Day = 212,048 gal (6 Acres)(644 GPAD)(7 Days) + (185,000 GPAD)(1 Acre)(1 Day)

$q_h$ = 4328 GPAD  212,048 gal / 7 Acres · 7 Days

= $1.54 \times 10^{-7}\ ft/s$  4,328 GPAD)(0.1337 ft³/gal)(1 Acre / 43,560 ft²)(1 Day / 86,400)

$Q = (1.54 \times 10^{-7}\ ft/s)(7.0\ AC)(43560\ ft^2)$

$= \boxed{0.047\ ft^3/s}$

Pipe Design

$\boxed{Q = 0.72\ ft^3/s > 0.047\ ft^3/s}$ OK

0.031 ft³/s

BY JJ DATE 8/3/20

CHKD. BY DL DATE 8/3/20

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JOB NO. 31-1619

SHEET NO. 4 OF 5

SUBJECT Lockwood Hills - Main Header Leachate Collection Pipe Capacity

<u>Phase 4</u> (500-Year Storm) = worst case

Total Area = 44.2 Acres

7-Day = 263,351 gal

$$q_h = \frac{263{,}351 \text{ gal}}{7 \text{days} \times 44.2 \text{ A.C.}} = 851 \text{ gpad}$$

$$q_h = 3.02 \times 10^{-8} \text{ ft/s}$$

(851 g/A/D)(0.1337 ft³/gal)(1 Acre / 43,560 ft²)(1 day / 86,400 s)

$$Q = (3.02 \times 10^{-8} \text{ ft/s})(44.2 \text{ AC})(43560 \text{ ft}^2/\text{Acre})$$

$$= \boxed{0.06 \text{ ft}^3/\text{s}}$$

Main Header Pipe Flow Capacity

$$Q = \left(\frac{1.49}{n}\right) \times A \times r_h^{2/3} \times S^{1/2}$$

$n = 0.011$

$D = 21'' = 1.75'$

$r_h = D/4 = 0.4375'$

$A = \pi r^2 = \pi (1.75/2)^2 = 1.2 \text{ ft}^2$

$S = 0.079 \quad \frac{(601.83 - 558.61)}{550 \text{ ft}}$

$$Q = \left(\frac{1.49}{0.011}\right)(1.2 \text{ ft}^2)(0.4375^{2/3})(0.079^{0.5})$$

$$= \boxed{26.3 \text{ ft}^3/\text{s} > 0.06 \text{ ft}^3/\text{s}}$$ OK

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SUBJECT Lockwood Hills – Expansion Leachate Pipe

8" SCH. 80 PVC Settling Pond Pipe

$n = 0.011$

$D = 8" = 0.67'$

$r_h = 0.1675$

$S = 0.005$

Area = $0.176\ ft^2$ $\pi(0.67^2/4)/2$

$$Q = \left(\frac{1.49}{0.011}\right)(0.176)(0.1675)^{2/3}(0.005)^{0.5}$$

$$= \boxed{0.51\ ft^3/s > 0.06\ ft^3/s \quad OK}$$

BY JJ DATE 8/4/20

CHKD. BY DL DATE 8/14/20

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JOB NO. 31-1619

SHEET NO. 1 OF 1

SUBJECT Lockwood - OADS Overfill Liner Leachate Pipe

OADS OVERFILL Total Acreage = 10.5 Acres

Assume : 1.0 Acres = Open

9.5 Acres = Active (644 GPAD)

25 YR - 113,000 GPAD
500 YR - 185,000 GPAD

25-Year

$$7\text{-Day} = (9.5\ \text{AC} \times 7\ \text{days} \times 644\ \text{gpad}) + (1.0\ \text{AC} \times 1\ \text{day} \times 113{,}000\ \text{GPAD})$$

$$= \underline{155{,}826\ \text{gal}}$$

$$q_h = \frac{155{,}826\ \text{gal}}{7\ \text{days} \times 10.5\ \text{AC}} = \underline{2{,}120\ \text{GPAD}}$$

$$= (2120\ \text{gpad})(0.1337\ ft^3/\text{gal})(1\ \text{acre}/43560\ ft^2)(1\ \text{day}/86{,}400\ s)$$

$$= \underline{7.53 \times 10^{-8}\ ft/s}$$

$$\text{Flowrate} = (7.53 \times 10^{-8}\ ft/s)(10.5\ \text{AC})(43560\ ft^2/\text{Acre}) = \boxed{0.034\ ft^3/s}$$

500-Year

$$7\text{-Day} = \underline{227{,}826\ \text{gal}} \quad (9.5\ \text{Acres})(7\ \text{days})(644\ \text{GPAD}) + (1\ \text{Acre})(1\ \text{Day})(185{,}000\ \text{GPAD})$$

$$q_h = \frac{227{,}826\ \text{gal}}{7\ \text{days} \times 10.5\ \text{ac}} = \underline{3{,}100\ \text{GPAD}}$$

$$= \underline{1.1 \times 10^{-7}\ ft/s} \quad (3{,}100\ \text{GPAD})(0.1337\ ft^3/\text{gal})\left(\frac{1\ \text{Acre}}{43{,}560\ ft^2}\right)\left(\frac{1\ \text{Day}}{86{,}400\ s}\right)$$

$$(1.1 \times 10^{-7}\ ft/s)(10.5\ \text{Acres})(43560\ ft^2/\text{Acre})$$

$$\text{Flowrate} = \boxed{0.05\ ft^3/s}$$

Pipe Size

8" PIPE FLOWING HALF FULL

$$Q = \left(\frac{1.49}{n}\right)(A)(r_h^{2/3})(S^{1/2})$$

$n = 0.011$

$A = 0.176\ ft^2 \quad \pi\left(\frac{0.67'}{2}\right)^2$

$r_h = 0.1675\ ft \quad D/4$

$S = 0.0625$

$$Q = \left(\frac{1.49}{0.011}\right)(0.176\ ft^2)(0.1675\ ft)^{2/3}(0.0625)^{1/2} = \boxed{1.8\ ft^3/s}$$

$$\boxed{1.8\ ft^3/s > 0.05\ ft^3/s \quad \text{OK}}$$

$0.034\ ft^3/s$

Maximum thickness in Downstream Section using equations presented in:

Geosnthetics International, 2000, Volume 7, Nos. 4-6, Special Issue on Liquic Collection Systems, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers ",J.P. Giroud, J.G. Zornberg, and A.Zhao, pages 285 - 380

| Parameters | | | |
|---|---|---|---|
| 500 Year, 7 day leachate generation for Stage III (gal) | 212,048 | | |
| Area Contributing to 7 day leachate generation (acres) | 7.0 | | |
| Maximum Drainage Path to Leachate Collection Pipe L (ft) | 66 | | |
| n | 0.30 | | |
| Leachate Collection Layer Hydraulic Conductivity - k (cm/s) | 1.00 | 2835 | ft/day |
| Minimum Slope Along the Maximum Flow Path (ft/ft) | 0.02 | | |
| Angle of Slope - B (degrees) | 1.14 | | |
| B (radians) | 0.0199 | | |
| tan(B) | 0.0199 | | |
| $tan^2$(B) | 0.0004 | | |
| cos(B) | 0.9998 | | |

Leachate Impingement Rate - qh (gpad) 4,328 1.33E-02 ft/day
1.54E-07 ft/s

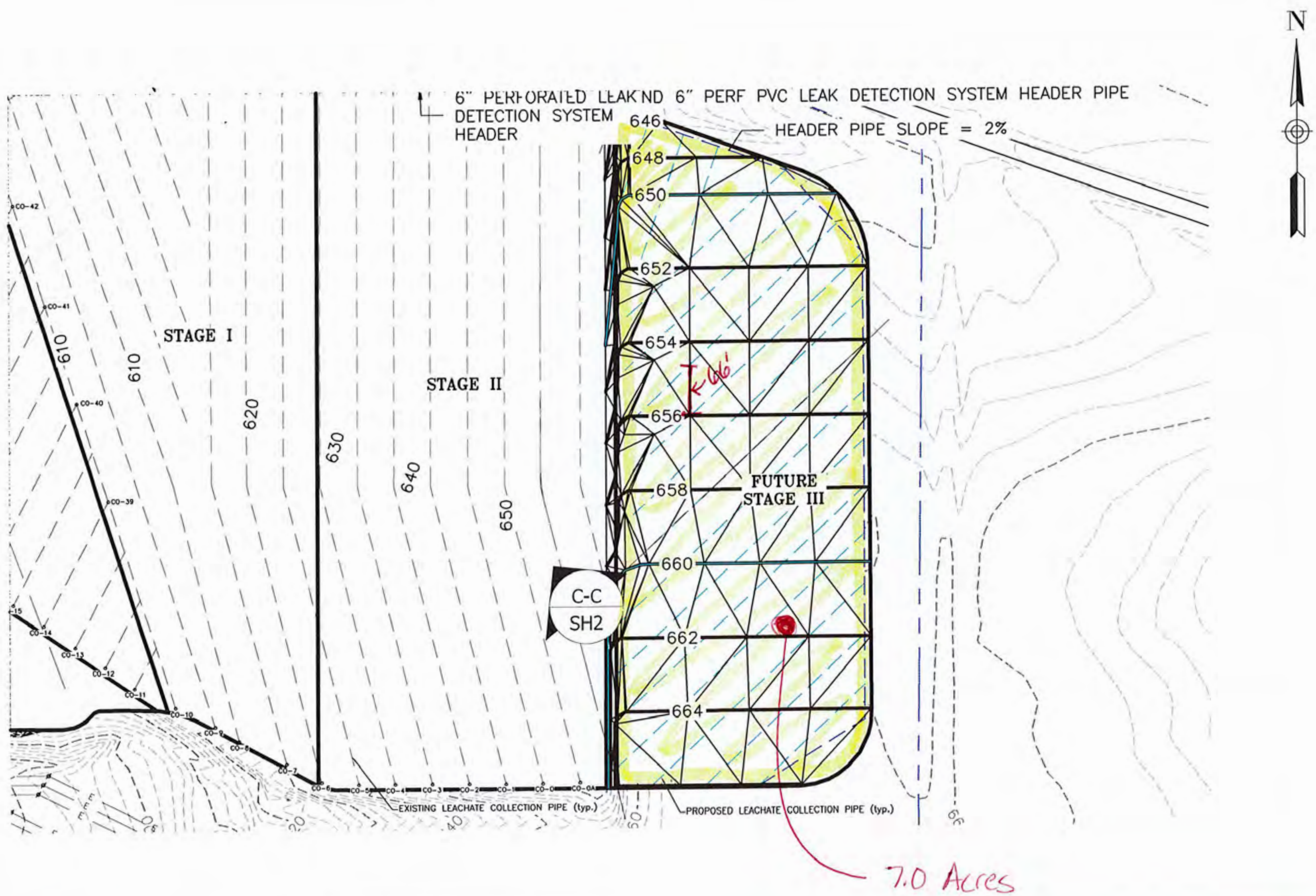
$$q_h = \frac{7\ day\ leachate\ generation}{7\ days \bullet Area}$$

Liquid Profile Parameter
$$\lambda = \frac{q_h}{k\ \tan(\beta)^2}$$
0.0118

Modifying Factor
$$j = 1 - .12\ \exp\left[-\left[\log\left(\frac{8\lambda}{5}\right)^{5/8}\right]^2\right]$$
0.9624

Predicted Maximum Head
$$t_{\max} = j\,\frac{\sqrt{1+4\lambda}-1}{2\cos\beta / \tan\beta}\,L$$
0.01 ft
0.18 inches

Max Head should be below 1.00 ft according to NYS DEC

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| LOCKWOOD HILL LLC | | STAGE III PLAN | | | FIGURE 1 |
|---|---|---|---|---|---|
| SCALE: 1" = 250' | REVISION # 0 | LOCKWOOD ASH DISPOSAL SITE | | | |
| February 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

Maximum thickness in Downstream Section using equations presented in:

Geosnthetics International, 2000, Volume 7, Nos. 4-6, Special Issue on Liquic
Collection Systems, "Hydraulic Design of Geosynthetic and Granular Liquid
Collection Layers ",J.P. Giroud, J.G. Zornberg, and A.Zhao, pages 285 - 380

| Parameters | | | |
|---|---|---|---|
| 500-year, 7 day leachate generation for Stage IV (gal) | 212,950 | | |
| Area Contributing to 7 day leachate generation (acres) | 7.2 | | |
| Maximum Drainage Path to Leachate Collection Pipe L (ft) | 60 | | |
| n | 0.30 | | |
| Leachate Collection Layer Hydraulic Conductivity - k (cm/s) | 1.00 | 2835 | ft/day |
| Minimum Slope Along the Maximum Flow Path (ft/ft) | 0.02 | | |
| Angle of Slope - B (degrees) | 1.14 | | |
| B (radians) | 0.0199 | | |
| tan(B) | 0.0199 | | |
| $\tan^2$(B) | 0.0004 | | |
| cos(B) | 0.9998 | | |

| | | | |
|---|---|---|---|
| Leachate Impingement Rate - qh (gpad) | 4,225 | 1.30E-02 | ft/day |
| | | 1.50E-07 | ft/s |

$$q_h = \frac{7\ day\ leachate\ generation}{7\ days \bullet Area}$$

Liquid Profile Parameter 0.0116

$$\lambda = \frac{q_h}{k\ \tan(\beta)^2}$$

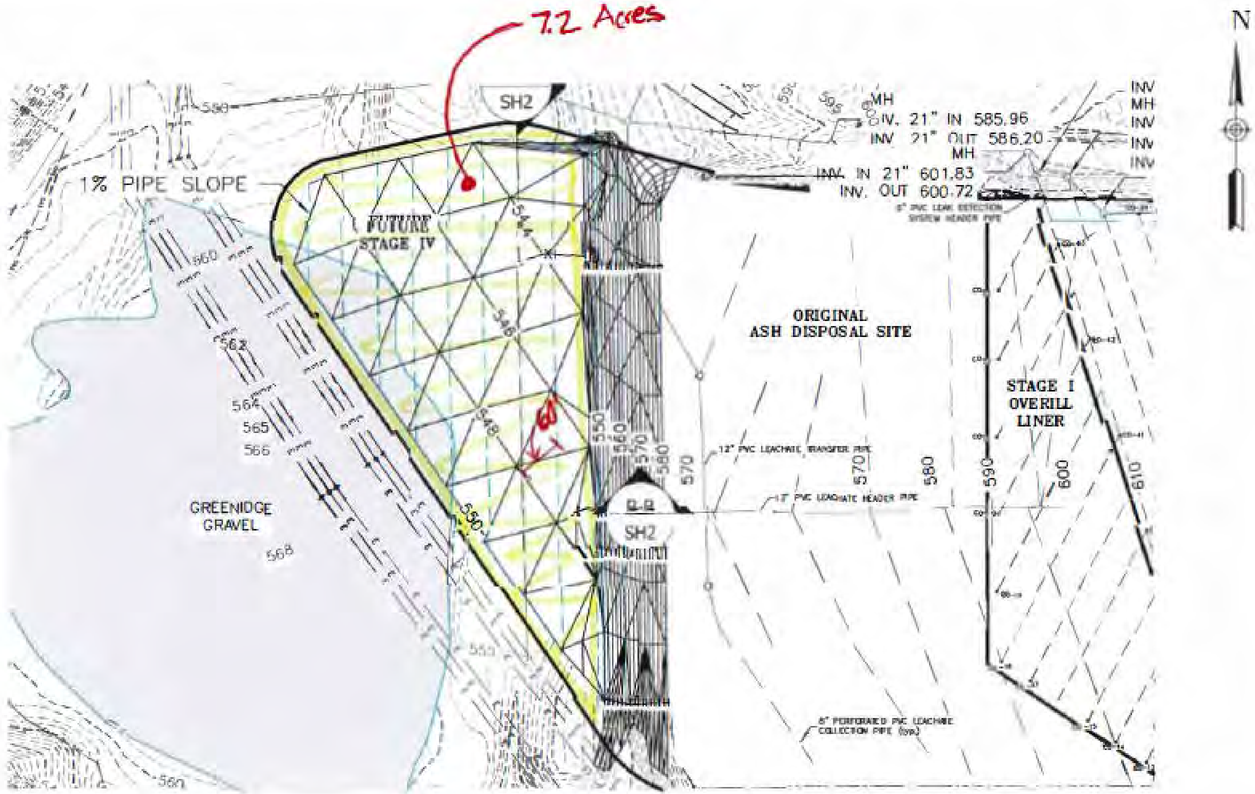
Modifying Factor 0.9629

$$j = 1 - .12\ \exp\left[-\left[\log\left(\frac{8\lambda}{5}\right)^{5/8}\right]^2\right]$$

Predicted Maximum Head 0.01 ft; 0.16 inches

$$t_{\max} = j\,\frac{\sqrt{1+4\lambda}-1}{2\cos\beta/\tan\beta}L$$

Max Head should be below 1.00 ft according to NYS DEC

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| LOCKWOOD HILL LLC | | STAGE IV PLAN | | | FIGURE 1 |
|---|---|---|---|---|---|
| SCALE: 1" = 250' | REVISION # 0 | LOCKWOOD ASH DISPOSAL SITE | | | |
| February 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

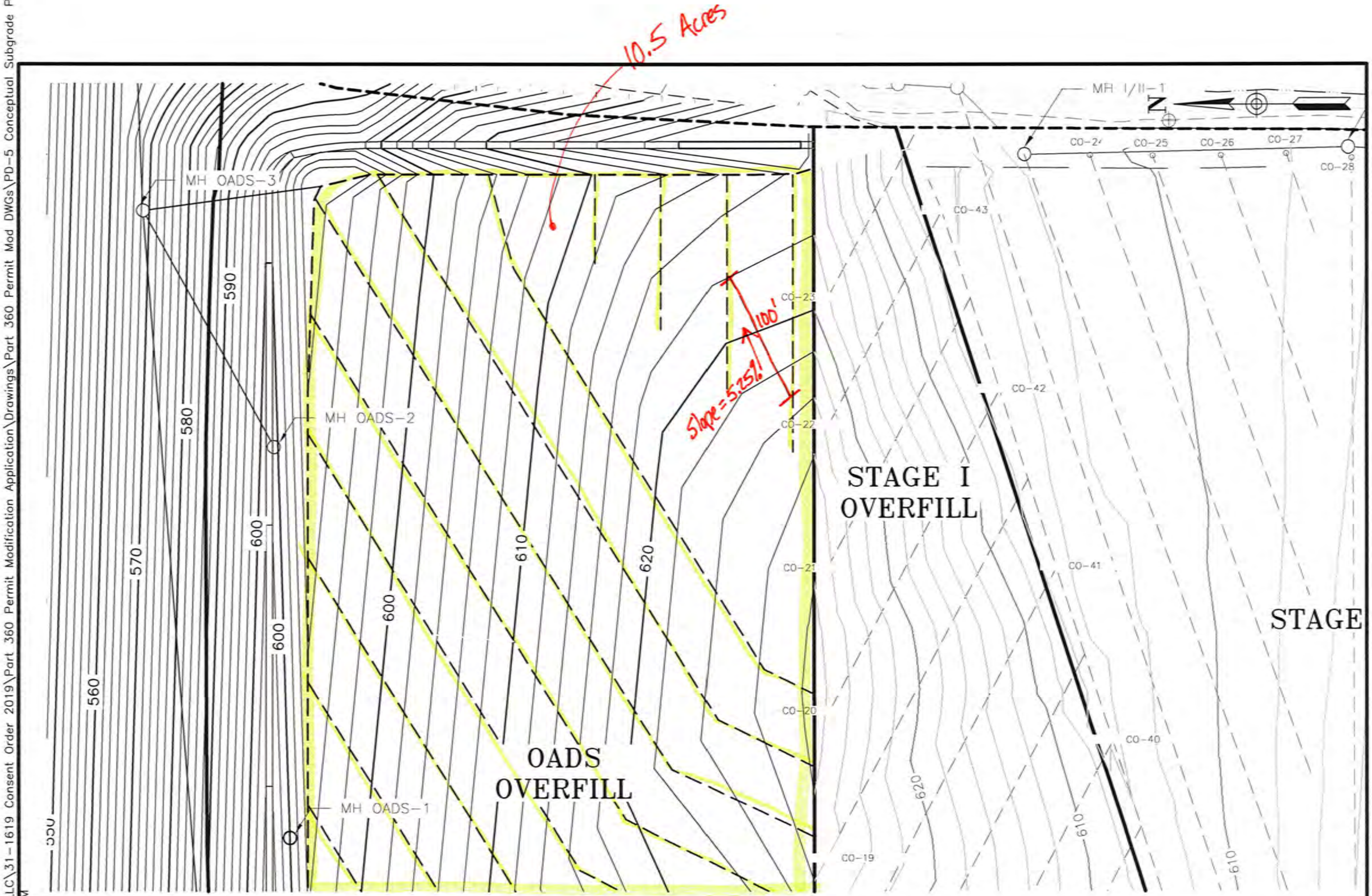
Maximum thickness in Downstream Section using equations presented in:

Geosnthetics International, 2000, Volume 7, Nos. 4-6, Special Issue on Liquic
Collection Systems, "Hydraulic Design of Geosynthetic and Granular Liquid
Collection Layers ",J.P. Giroud, J.G. Zornberg, and A.Zhao, pages 285 - 380

| Parameters | | | |
|---|---|---|---|
| 500-year, 7 day leachate generation for OADS Overfill (gal) | 227,826 | | |
| Area Contributing to 7 day leachate generation (acres) | 10.5 | | |
| Maximum Drainage Path to Leachate Collection Pipe L (ft) | 100 | | |
| n | 0.30 | | |
| Leachate Collection Layer Hydraulic Conductivity - k (cm/s) | 1.00 | 2835 | ft/day |
| Minimum Slope Along the Maximum Flow Path (ft/ft) | 0.0525 | | |
| Angle of Slope - B (degrees) | 3.00 | | |
| B (radians) | 0.0524 | | |
| tan(B) | 0.0524 | | |
| $\tan^2$(B) | 0.0027 | | |
| cos(B) | 0.9986 | | |

| | | | |
|---|---|---|---|
| Leachate Impingement Rate - qh (gpad) $q_h = \frac{7\ day\ leachate\ generation}{7\ days \bullet Area}$ | 3,100 | 9.51E-03 | ft/day |
| | | 1.10E-07 | ft/s |
| Liquid Profile Parameter $\lambda = \frac{q_h}{k \tan(\beta)^2}$ | 0.0012 | | |
| Modifying Factor $j = 1 - .12 \exp\left[-\left[\log\left(\frac{8\lambda}{5}\right)^{5/8}\right]^2\right]$ | 0.9932 | | |
| Predicted Maximum Head $t_{\max} = j \frac{\sqrt{1+4\lambda}-1}{2\cos\beta / \tan\beta} L$ | 0.01 | ft | |
| | 0.08 | inches | |

Max Head should be below 1.00 ft according to NYS DEC

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| LOCKWOOD HILLS LLC | | OADS OVERFILL PLAN<br>LOCKWOOD ASH DISPOSAL SITE | | | FIGURE<br>1 |
|---|---|---|---|---|---|
| SCALE: 1" = 100' | REVISION # 0 | | | | |
| August 2020 | | TOWN OF TORREY | YATES COUNTY | NEW YORK | |

BY JJ DATE 2/14/20 | CHKD. BY DL DATE 4/22/20

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JOB NO. 31-1620

SHEET NO. 1 OF 2

SUBJECT Leakage Rate through a composite liner

$$\frac{Q}{A} = n \cdot 0.976\, C_{q0} \left[1 + 0.1 (h/t_s)^{0.95}\right] d^{0.2} h^{0.9} k_s^{0.74}$$

Q = leakage rate through the geomembrane

A = Considered geomembrane area

$n$ = # of defects per area

$C_{q0}$ = Contact quality factor

$h$ = Hydraulic Head on top of the geomembrane

$t_s$ = thickness of the low-permeability soil component of the composite

$d$ = diameter of circular effect

$K_s$ = Hydraulic conductivity of low permeability soil

Assumptions:

$C_{q0} = 1.15$ (conservative) $\quad A = 1 \text{ acre} = 4047\ m^2$

$n = 4$ defects

$h = 12$ in (worst-case) $= 0.3$ m

$t_s = 7\text{ mm} + 300\text{ mm} = 307\text{ mm} = 0.307\text{ m}$

$d = 0.01$ m

$K_s = b / \Sigma\, b_i/k_i$ $\quad k_{GCL} = 5 \times 10^{-9}$ cm/s $\quad k_{S.F.} = 0.1$ cm/s

$$K_s = \frac{30.7\text{ cm}}{\left(\frac{0.7\text{ cm}}{5\times10^{-9}\text{ cm/s}} + \frac{30.0\text{ cm}}{0.1\text{ cm/s}}\right)} = 2.19 \times 10^{-7}\text{ cm/s} = \underline{2.19 \times 10^{-9}\text{ m/s}}$$

$$\frac{Q}{A} = 4(0.976)(1.15)\underbrace{\left[1+0.1\left(0.3/0.307\right)^{0.95}\right]}_{4.93}(0.01^{0.2})(0.3^{0.9})\left(2.19\times10^{-9}\text{ m/s}\right)^{0.74}$$

$2.95\times10^{-10}$

$$\frac{Q}{A} = 4.93\left(5.19\times10^{-8}\right) = \underline{2.6 \times 10^{-7}\ m^3/s \cdot acre}$$

$$(2.6 \times 10^{-7}\ m^3/s\cdot acre)(264.2\ gal/m^3)(86{,}400\ s/day) = \underline{5.93\ gpad}$$

Efficiency of Primary Liner:

$$\text{Efficiency} = \left(1 - \frac{\text{Leakage Rate}}{\text{Leakage Impingement}}\right) \times 100\%$$

Leakage Impingement = 4,328 gpad (STAGE IV)

$$= \left(1 - \frac{5.93}{4{,}328\text{ gpad}}\right) \times 100 = \boxed{99.86\%}$$

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SUBJECT Lockwood Hills Expansion required Transmissivity

Find: Req'd transmissivity for secondary geocomposite drain

Method:

$$\phi_{req} = \frac{q_h (L)}{\sin\beta}$$

$\phi_{req}$ = req'd transmissivity

L = flow length

$q_h$ = impingement rate

$\beta$ = Slope Angle

Assumptions:

L = 60 ft

Slope = 2% $\rightarrow$ $\beta = 1.15°$

$q_h$ = 1000 gPAD

Solution:

$$q_h = 1000\ \text{gPAD} \times \left(\frac{1\ \text{Acre}}{43560\ \text{sf}}\right)\left(\frac{ft^2}{0.0929\ m^2}\right)\left(\frac{1\ \text{day}}{86{,}400\ s}\right)\left(\frac{0.1337\ ft^3}{1\ \text{gal}}\right)\left(\frac{0.0283\ m^3}{1\ ft^3}\right)$$
$$= \underline{1.1 \times 10^{-8}\ m/s}$$

$$L = 60\ ft \times 0.3048\ m/ft = \underline{18.3\ m}$$

$$\phi_{req} = \frac{(1.1 \times 10^{-8}\ m/s)(18.3\ m)}{\sin(1.15)} = \boxed{1.0 \times 10^{-5}\ m^2/s}$$

Find: Maximum Head in secondary geocomposite drain

Method:

$$\lambda = \frac{q_h}{k \tan(\beta)^2}$$

$$t_{max} = \frac{\sqrt{1+4\lambda} - 1}{2\cos\beta / \tan\beta}(L)$$

$q_h = 1.1 \times 10^{-8}$ m/s

L = flow length = 18.3 m

k = Hydraulic Conductivity
$= \phi / t$

$\beta$ = 1.15

t = thickness of geonet = 0.0084 m

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SUBJECT Lockwood Hills expansion req'd Transmissivity

Solution:

$$K = \frac{1.0 \times 10^{-5}\ m^2/s}{0.0084\ m} = \underline{0.0012\ m/s}$$

$$\lambda = \frac{1.1 \times 10^{-8}\ m/s}{(0.0012\ m/s)\tan(1.15)^2} = 0.023$$

$$t_{max} = \frac{\sqrt{1+4(.023)}-1}{2\cos(1.15)/\tan(1.15)}(18.3) = \frac{0.045}{99.6}(18.3) = \boxed{0.0083\ m}$$

Find: Leakage Rate through the Secondary Liner

Method: $\frac{Q}{A} = n \times 0.976 \times C_{q0}\left[1 + 0.1\left(h/t_s\right)^{0.95}\right] d^{0.2}\, h^{0.9}\, K_s^{0.74}$

$n$ = # of defects
$C_{q0}$ = Contact Quality factor
$h$ = hydraulic head
$t_s$ = thickness of soil component
$d$ = diameter of circular defect
$K_s$ = Hydraulic Conductivity of Soil

Assumptions: $n = 4$ $\quad C_{q0} = 1.15$ (conservative) $\quad h = 0.0083\ m$
$t_s = 0.61\ m$ $\quad d = 0.01\ m$ $\quad K_s = 1 \times 10^{-9}\ m/s$

Solution:

$$\frac{Q}{A} = 4 \times 0.976 \times 1.15\left[1 + 0.1\left(\frac{0.0083\ m}{0.61\ m}\right)^{0.95}\right] 0.01^{0.2}\,(0.0083)^{0.9}\,(1 \times 10^{-9})^{0.74}$$

$$= 4.497\left[1 \times 10^{-9}\right] = 4.4 \times 10^{-9}\ m^3/Acre \cdot s$$

$$(4 \times 10^{-9}\ m^3/Acre \cdot s) \times (264.2\ gal/m^3) \times 86{,}400\ s/day = \boxed{0.1027\ gPAD}$$

$$Efficiency = \left(1 - \frac{Leakage\ Rate}{Leakage\ Impingement}\right) \times 100\%$$

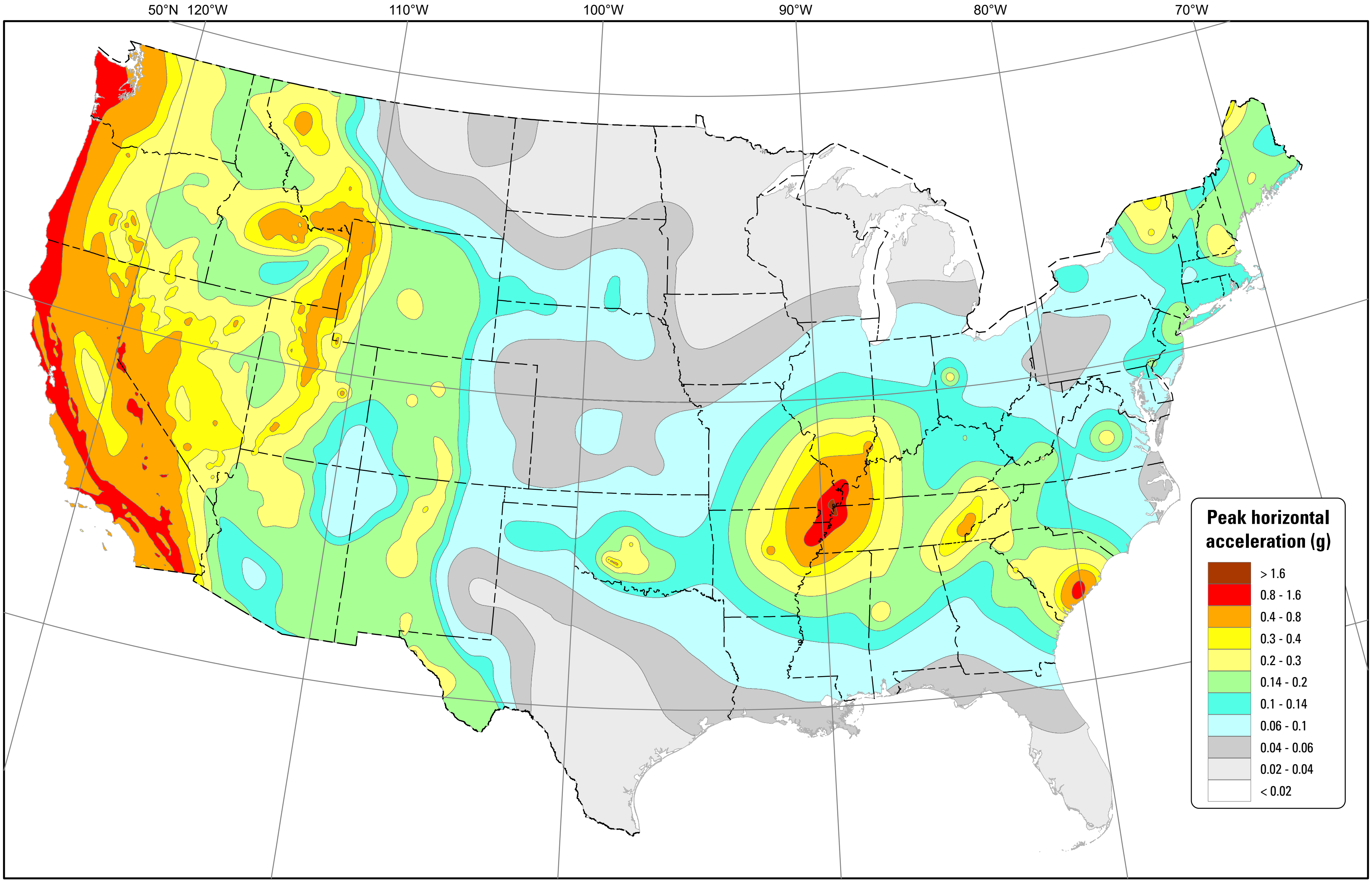
Leakage Impingement = 1,000 GPAD

$$Efficiency = \left(1 - \frac{0.1027\ GPAD}{1{,}000\ GPAD}\right) \times 100 = \boxed{99.9897\%}$$

# ATTACHMENT 6

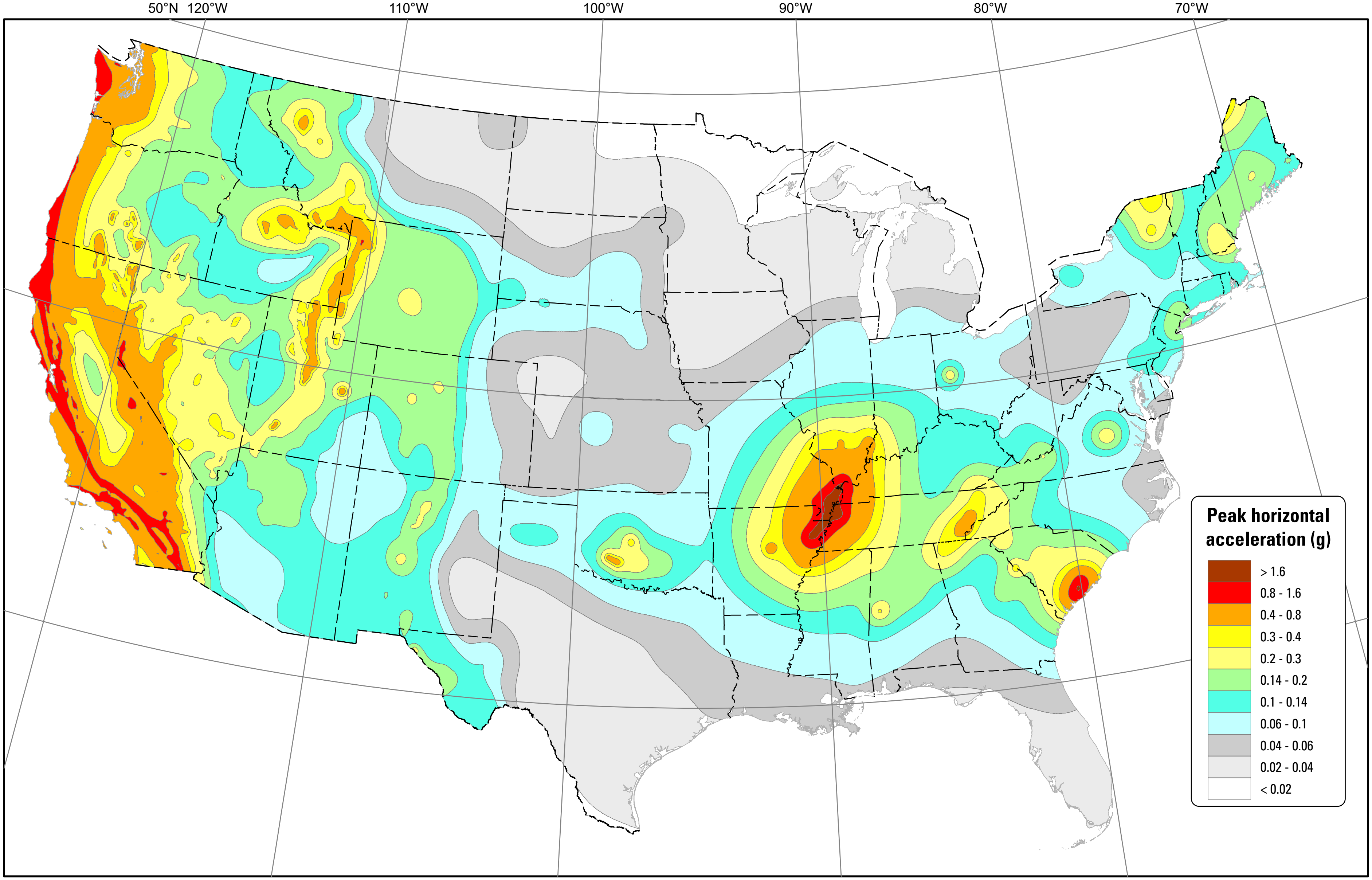
# Seismic Stability Analysis

- **USGS Probability Map**




# 2018 National Seismic Hazard Model for the conterminous United States

**Peak horizontal acceleration**
**with a 2% probability of exceedance in 50 years**
**NEHRP site class D ($V_{s30}$ = 260 m/s)**




# 2018 National Seismic Hazard Model for the conterminous United States

**Peak horizontal acceleration**
**with a 2 % probability of exceedance in 50 years**
**NEHRP site class B/C ($V_{s30}$ = 760 m/s)**