Otago Regional Council

Muddy Creek Flood Study

Prepared for
Waitaki District Council
May 2026

28 May 2026

Otago Regional Council

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SECTION 1.0 - INTRODUCTION

1.1 Purpose of this Report

The purpose of this report is to provide a planning-level flood hazard analysis for a portion of the Muddy Creek catchment which is located on the north side of the town of Oamaru, in the Waitaki district of Otago. The Waitaki District Council (WDC) requested this analysis to inform a revision to the district plan which is required under the 1991 Resource Management Act. The existing flood map for Muddy Creek was developed in 2002 (ORC, 2002). The mapping was completed based on a series of observations and correlated to topography using low-resolution topographic maps. The prior mapping did not include any hydrologic/hydraulic modelling, nor was it correlated to a defined discharge or return period. The existing flood map only provides an approximation of the flood prone area, and the accuracy of the map is limited due to the methodology used. Furthermore, since 2002 there has been development within the study area that has altered the hydraulic characteristics. To better inform the district plan update, a revised flood map is needed.

This study is not intended to be a detailed flood hazard analysis and should not be used to determine flood hazards at the property level. Rather, the intent is to develop an approximate flood hazard map using improved modelling techniques to better inform the district plan and to provide more accurate information than what is currently available.

1.2 Study Area

The project location is shown in Figure 1.

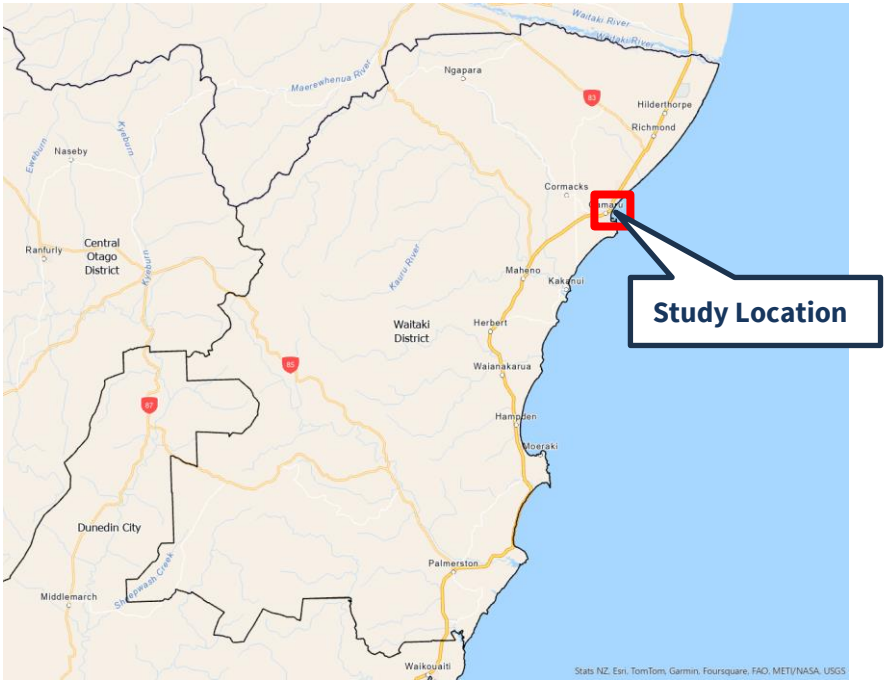

Figure 1: Location Map

The project model extent/domain is shown in Figure 2.

Figure 2: Model Extent

1.3 Principal Flooding Issues

The primary flooding concern in the study area is from over-bank flooding of Muddy Creek. A portion of the study area is located within a mapped alluvial fan (Figure 3) (OPUS, 2009). From the beginning of Muddy Creek, the alluvial fan spreads to the south towards the sea. The Muddy Creek channel was previously straightened and realigned. It no longer conforms to the natural topography of the alluvial fan. Due to the combination of channel realignment and the influence of the alluvial fan, flooding may not be limited to the areas immediately adjacent to the existing channel as the current map implies. Rather, upon overtopping the existing channel banks, the flooding may spread in multiple directions following the topography. In addition to the channel flooding, the study area is partially located in an urbanized region with a developed storm sewer system. The storm system may influence where additional discharge is conveyed during a flood event, thus influencing flood behavior.

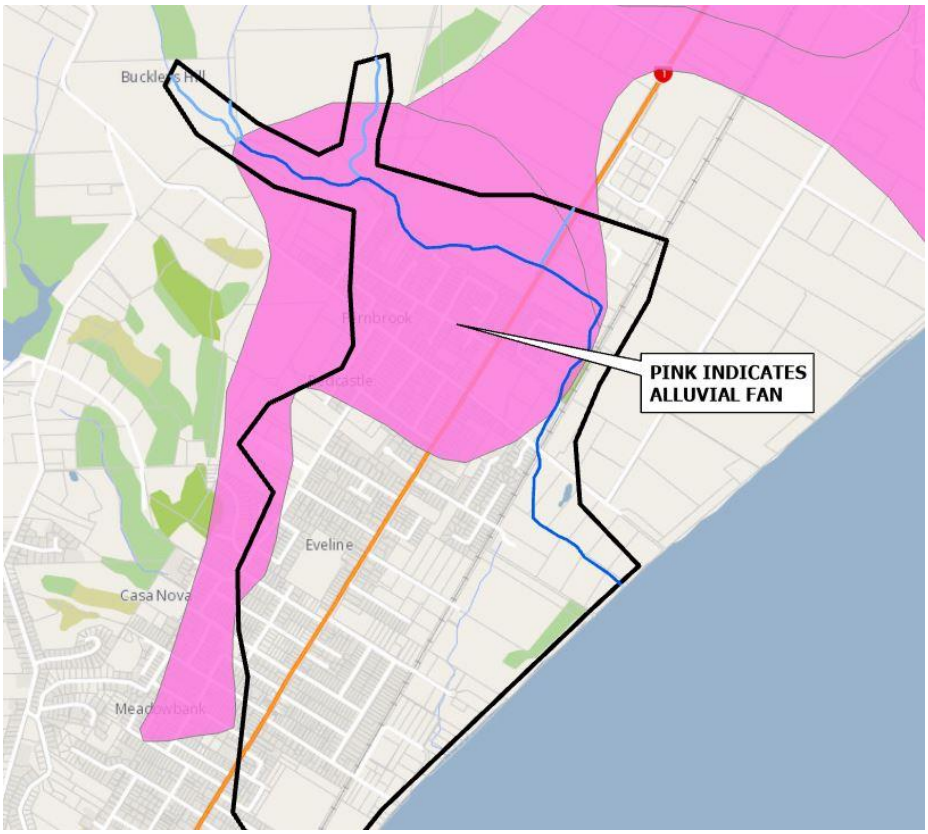

Figure 3: Known Alluvial Fan

For reference purposes, Figure 4 shows the existing flood map for Muddy Creek. The existing map shows flooding primarily west of Highway 1 in areas immediately adjacent to the stream corridor. Several residential areas are within the currently mapped region. However, as noted in Section 1.1 there are concerns regarding the accuracy of this map as it was developed based primarily on observation. The existing flood map implies that the Highway 1 roadway is a significant barrier to flow as there is a visible discontinuity in the width of the mapped floodplain upstream of the highway embankment. The existing map also implies that flooding is limited to areas contiguous to the stream corridor, with little to no effect from the alluvial fan.

Figure 4: Existing Flood Map

SECTION 2.0 – HYDROLOGY

2.1 Overview and Approach

Muddy Creek is an ungauged stream. In lieu of gage data, two sources for hydrologic inputs were considered for this analysis. These included using regional flood estimates from the NIWA Flood Frequency Tool (Henderson & Collins, 2016) and building a catchment-specific rainfall-runoff model. As stated in Part 1, the purpose of this analysis is for planning and therefore a comprehensive hydrologic analysis was not conducted. For this investigation, ORC chose to use a 2-Dimentional unsteady flow model for the hydraulic analysis. Due to the chosen unsteady model approach, the results from the rainfall-runoff model were ultimately selected for use in the hydraulic model because they provided a hydrograph output as opposed to only a peak discharge estimate. The approach attempted to correlate flood events to specific Annual Return Intervals (ARIs) however these should only be considered approximate in lieu of a detailed hydrologic study.

2.2 Flow Input Locations

Prior to building the hydraulic model, a total of five hydrologic (flow) input locations were identified based on the model domain. Three of the input locations (Tribs 1-3) are located on unnamed headwater tributaries to Muddy Creek on the north end of the of the study area. The fourth input location (Trib 4) was located to the east where a ditch along Highway 1 conveys discharge from the adjacent catchment (South of Landon Creek) into the Muddy Creek catchment. An additional discharge location (Storm Outfall) was added near the intersection of Redcastle Road and Lowther Street to simulate discharge from the outfall of the urban storm sewer system. There are several limitations and assumptions to this approach. Specifically, during a large flood event the storm sewer system is likely to be overwhelmed, which will limit the rate of discharge at the outfall location. In addition, the analysis did not include storm sewer modelling. However, for planning purposes the approach was deemed to be adequate as the inputs from the storm sub-catchment are generally less of a concern when compared to inputs from the upper tributaries.

A map showing the discharge (flow boundary condition) locations is provided in Figure 5.

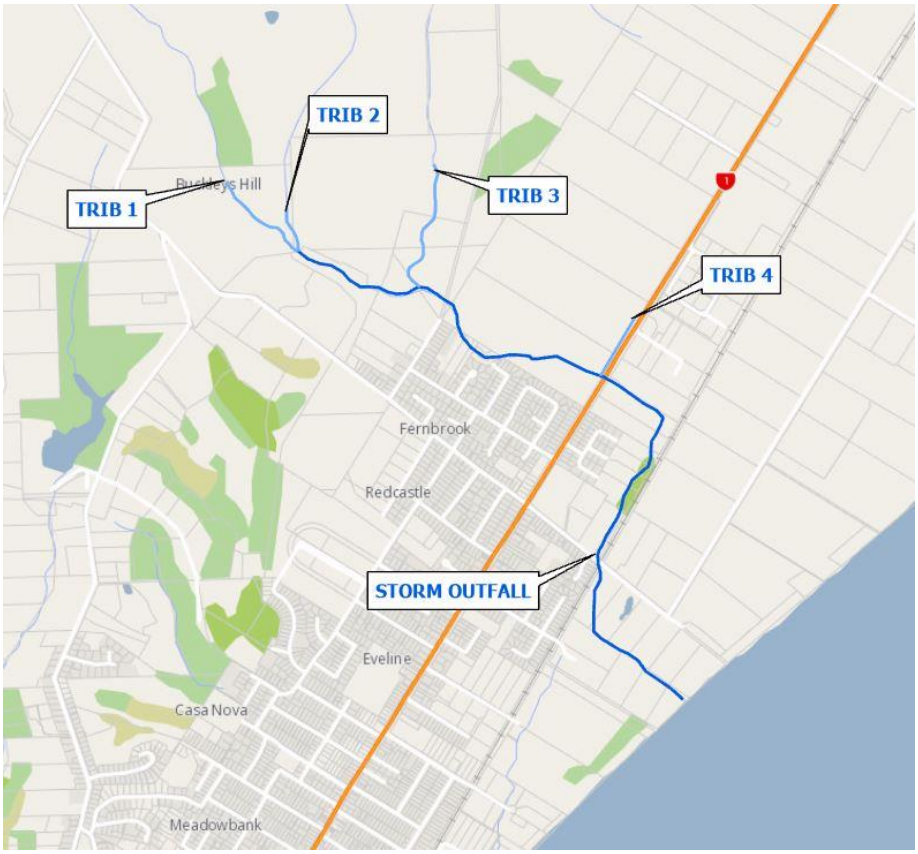

Figure 5: Location of Discharge Inputs

Figure 6 shows the corresponding delineated sub-catchment associated with each of the input locations. The catchment for the storm outfall was delineated based on the layout of the local storm sewer system, which is shown in magenta lines in Figure 6.

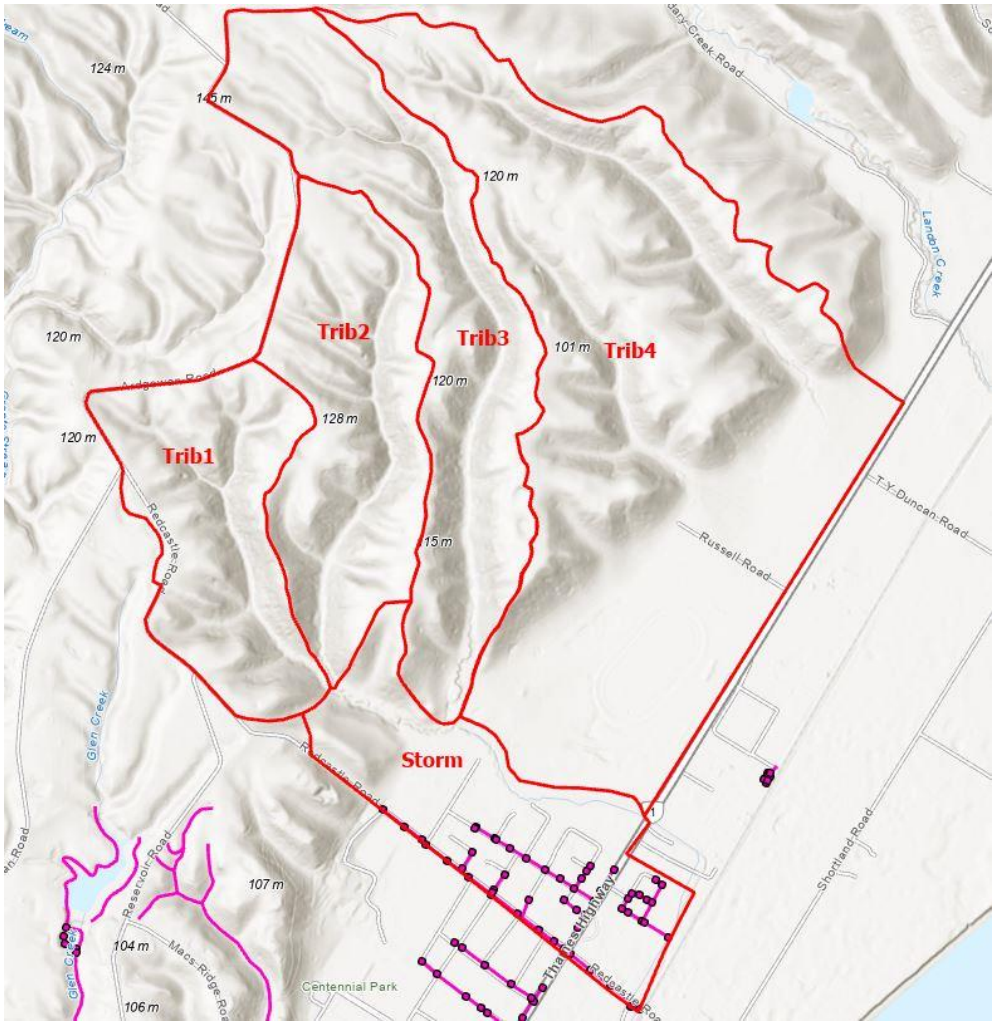

Figure 6: Sub-Catchments

2.2 Precipitation and Hydrologic Parameters

Hydrologic inputs for this investigation were computed for the 10, 50 and 100-year 24-hour rainfall events using the SCS method in Autodesk Hydraflow software. Precipitation values were obtained from NIWA HIRDS data[1]. For example, the 100-year, 24-hour precipitation value for this location is 144 mm. A summary of rainfall amounts for the various (current) ARIs is shown in Table 4.

For this analysis, a SCS Type III rainfall distribution was used. The SCS distributions are "nested" distributions. This means rainfall intensities for shorter durations (e.g., 5 minutes, 1 hour) are embedded within the longer-duration events (e.g., 6 hours, 24 hours). This nesting ensures that the distribution captures the cumulative rainfall over various time intervals, making it suitable for hydrologic modelling across different storm durations.

Catchment parameters were derived/calculated from topographic data, soils data, and land-use data available in the public domain. A summary of the catchment parameter that were used for the study are included in Table 1.

[1] Available from NIWA: High Intensity Rainfall Design System (HIRDS) | NIWA

Table 1: Summary of Catchment Parameters

Location	Contributing Catchment Area (ha)	Catchment Length (m)	Average Catchment Slope (%)	SCS CN	Time of Concentration Tc (min)
Trib 1	72.2	1425	6.3%	69	61.3
Trib 2	86.5	1920	5.5%	70	79.0
Trib 3	113.3	2789	4.3%	75	104.8
Trib 4	284	3143	3.5%	68	154.9
Storm	52	1050	1.5%	80	69.9

2.3 Hydrologic Model Results

A summary of the correlating computed peak discharges for the various events is shown in Table 2. A complete hydrologic model output report is included in Appendix 1.

Table 2: Summary of 24-Hours Peak Discharges

Location	10 YR (m^3/s)	50 YR (m^3/s)	100 YR (m^3/s)
Trib 1	1.7	4.4	5.9
Trib 2	1.9	4.6	6.1
Trib 3	2.8	6.0	7.9
Trib 4	3.3	8.5	11.5
Storm	2.3	4.5	5.6

For the purposes of this analysis, the 100-year event is considered the base-flood elevation and was the primary event considered for analysis and subsequent hazard and risk evaluation. For comparison purposes the 10- and 50-year events were also examined.

2.4 NIWA Regression Comparison

For comparison purposes, estimated peak discharge values for the same flow input locations were obtained from the NIWA Flood Frequency Tool[2] (Henderson & Collins, 2016) for the 100-year ARI. Comparison of the values is shown in Table 3. Except for Trib 4, both methods produce similar results for the peak discharges. The NIWA estimate of Trib 4 was assessed to be unreliable due to the heavily modified nature of the downstream conveyance. Specifically, the various structures (culverts, pipes etc.,) cannot physically convey the discharge estimate from the NIWA tool which implies that during a flood event a limited amount of discharge from Trib 4 reaches the Muddy Creek

[2] Available from NIWA web site: Floods | NIWA

catchment. Therefore, the SCS discharge was a better approximation. The Hydraflow output hydrographs were used as inputs for the hydraulic model.

Table 3: Comparison of SCS and NIWA Regression Results

Location	100 YR Peak Discharge (m^3/s) SCS Method	100 YR Peak Discharge (m^3/s) NIWA Flood Tool
Trib 1	5.9	5.8
Trib 2	6.4	6.1
Trib 3	7.9	9.5
Trib 4	11.5	22.1
Storm	5.6	N/A

2.5 Climate Change

A limited analysis to assess impacts from climate change was conducted based on an RCP8.5 scenario (MfE, 2025), with rainfall amounts obtained from NIWA HIRDS data. Table 4 shows the 24-hour rainfall depths for current conditions and the RCP8.5 climate change scenario.

Table 4: Historic and RCP8.5 24-Hour Rainfall Depth

ARI	Current (mm)	RCP8.5 (mm)
10	83	87
50	124	130
100	144	151

Table 5 shows the modelled peak discharges for the RCP8.5 scenario. Additional modelling information for this scenario is provided in Appendix 1. For hydraulic analysis purposes, only the 100 YR ARI was examined.

Table 5: RCP8.5 Peak Discharges

Location	10 YR (m^3/s)	50 YR (m^3/s)	100 YR (m^3/s)
Trib 1	2.0	4.8	6.4
Trib 2	2.1	5.0	6.6
Trib 3	3.1	6.5	8.3
Trib 4	3.7	9.4	12.5
Storm	2.5	4.8	6.0

SECTION 3.0 – HYDRAULIC ANALYSIS

Analyses of the hydraulic characteristics of flooding from the sources studied were conducted to provide estimates of the 10, 50 and 100-year ARI flood elevations, with the primary focus being the 100-year flood. The analysis was conducted using HEC-RAS 6.6 software. The analysis method utilized a fully 2-dimentional unsteady flow model with average grid spacing of $5m^2$. Elevation data for the model was obtained from 2021 Otago Coastal Catchment LiDAR data[3].

Floodplain resistance was represented in the model using a spatially varying Manning's 'n' coefficient. To account for varying roughness values on the floodplain, a raster of roughness values with a grid size of $2m^2$ was created where each cell was assigned a Manning's 'n' value based on the 2018 New Zealand Land Cover Database[4] (Landcare Research NZ, 2019). A summary of land cover with assigned Manning's numbers is provided in Table 6.

Table 6: Summary of Manning's n Values

Land Cover	Manning's "n"
Short Rotation Cropland	0.035
Built Up Area	0.06
Urban Parkland Open Space	0.03
Exotic Forest	0.08
Low Producing Grassland	0.03
Gorse Broom	0.035
High Producing Exotic Grassland	0.035

The model used a constant downstream boundary condition to simulate discharge into the sea. A conservative tide level of 1.75m (NZVD 2016) was used to simulate the event. A variable sea level to represent tidal fluctuations was determined to be unnecessary as the primary areas of interest are unaffected by changing tidal conditions.

SECTION 4.0 – MAPPING

Flood hazard mapping was completed using the model outputs within the HEC-RAS software. The reference horizontal and vertical datums are NZTM 2000 and NZVD 2016. The modelled flood elevation was placed on top of topographic elevation data to produce a 1% annual flood extent map. Similarly, a flood risk map was calculated based on a combination of flood depth and velocity. For this report, hazard categories have been presented based on the general guidelines from the Australian Rainfall and Runoff Guide (Ball, et al., 2019). The hazard categories are presented graphically in Figure 7. The 1% annual flood map and associated hazard map for the 100-year ARI is shown in the attached Maps 1 and 2, respectively. Map 2A is a variation of Map 2 that shows only areas where flood depths exceed 0.2m. This map was requested by Waitaki District Council. Flood depths less than 0.2m are often considered shallow flooding and fall into the H1 hazard rating. Map

[3] Lidar Available from LINZ Website: LINZ Data Service,
[4] Available from LINZ: LCDB v5.0 - Land Cover Database version 5.0, Mainland, New Zealand | LRIS Portal

2A is provided for easy visual reference to more easily see areas where non-shallow flooding is likely to occur. For reference purposes, the 10% (10YR) and 2%(50YR) annual floods maps are shown in Maps 3 and 4, respectively. Map 5 shows the 100-year ARI superimposed on the results for the RCP8.5 climate change scenario.

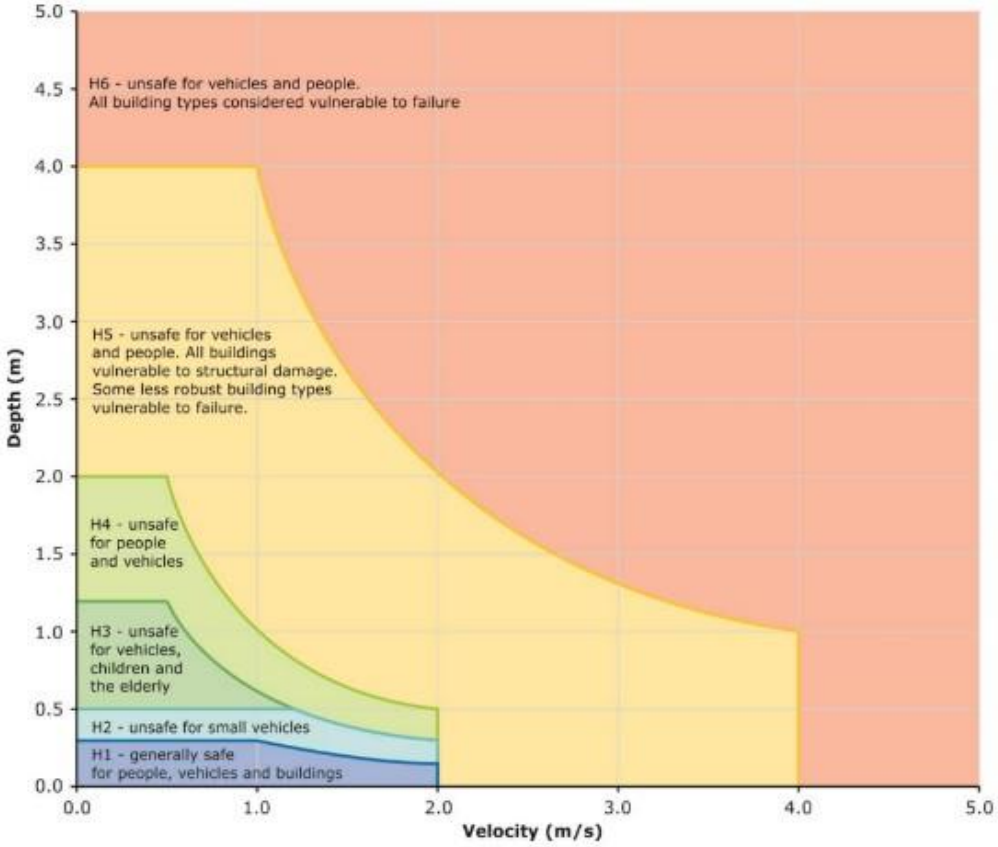

Figure 7: Hazard Classification (Australian Rainfall and Runoff Guide, Ball, et al., 2019)

SECTION 5.0 – LIMITATIONS OF STUDY

Due to the intended conceptual-level scope of this investigation, there are several notable limitations associated with this study. These limitations are noted below.

- This investigation was completed using 2021 LiDAR data combined with limited field reconnaissance. No survey was conducted to identify features of hydraulic control structures such as bridges and culverts. Where the presence of these structures was identified, they were typically removed from the model by modifying the LiDAR terrain as though they were a constricted open channel.
- The model developed for this analysis was not calibrated. While there have been several historic floods in this area, there are no known sources of data (such as gage data or water-mark surveys) to use for calibration purposes.
- A portion of the study area is located within an urban catchment with a developed storm sewer network. This analysis did not fully consider the existing storm sewer network. Influence from the storm network was assumed by adding a discharge boundary condition at the location of the primary storm sewer outfall.

- There is uncertainty associated with the modelled discharge from Tributary 4. The existing roadway ditch, combined with development, has significantly altered the natural hydrology from the catchment south of Landon Creek and to the north of the project area. A significant portion of the runoff from this catchment now discharges into the Muddy Creek catchment via a ditch along Highway 1, near where Muddy Creek crosses Highway 1. However, the conveyance ditch is not large enough to carry all the discharge from the catchment during a major flood event.
- This study did not include a public outreach component which is typically part of a detailed flood study.
- This investigation did not include a comprehensive hydrologic analysis but instead relied on a simulated 100-year 24-hour rainfall event to estimate the 100yr ARI.
- This investigation was primarily intended to inform the planning process and is not intended for flood mapping at the individual property level or for property insurance purposes.

SECTION 6.0 – INTERPRETATION OF RESULTS

This section is provided for Waitaki District Council and is intended to aid in the review process. The results from the modelling effort indicate that the existing flood map as shown in Figure 4 for Muddy Creek is not accurate. Specifically, the existing map does not account for the presence of an existing alluvial fan which causes the water to spread away from the creek in multiple directions. While the potential flooding extents appear to be more widespread than previously estimated, the associated risk for people's safety and building structural stability is low. Most of the mapped hazard area is classified as H1 (minimal risk) as shown in Map 2. As the flood water overtops the banks of Muddy Creek it spreads out and flows at a shallow depth, and at minimal velocity. Much of the overtopped water is confined to existing roadways that further directs flow to the south. The duration of impact from a large flood event is likely to be limited in the shallow flow areas as the full model results show that the area is likely to drain quickly. Some of this water would likely be collected and conveyed via developed storm sewers during an actual flood event. Overtopping of Muddy Creek is unlikely to result in significant damages to existing infrastructure.

Map 5 shows the mapped floodplain for the RCP8.5 climate change scenario. Impacts from climate change are likely to be minimal without significant increases in inundation area. The mapped floodplain for the current 100-YR ARI and the RCP8.5 100-YR ARI are almost indistinguishable in most areas.

Most of the newly mapped area to the south of Muddy Creek is already developed, and the revised mapping is unlikely to have a significant impact on future land use and development. The modelling indicates that there are elevated risks to undeveloped areas to the north of Muddy Creek. Additional study may be warranted should this area be developed in the future.

As stated in Section 1, this study is only intended to be a conceptual-level study that is intended to inform the Waitaki District Plan review. Although the study has several limitations, it represents a significant improvement when compared to the existing flood map. Improvement to the mapped flood hazard areas could be improved by doing a detailed flood study that addresses the limitations presented in Section 5.

REFERENCES

Ball, J., Babister, M., Nathan, R., Weinmann, E., Reltallick, M., & Testoni, I. (2019). *Austraian Rainall and Runoff - A Guide to Flood Estimation.*

Henderson, R., & Collins, D. (2016). *Regional Flood Estimation Tool for New Zealand, Part 1.*

Landcare Research NZ. (2019). LCDB v5.0 - Land Cover Database version 5.0, Mainland, New Zealand.

MfE. (2025, October). *Ministry for the Environment*. Retrieved from https://environment.govt.nz/what-you-can-do/climate-scenarios-toolkit/climate-scenarios-list/ipccs-ssp-rcp-scenarios/#rcp-scenarios

OPUS. (2009). *Otago Alluvial Fan Project, Report # 1205.*

ORC. (2002). *Waitaki District Floodplain Report.* Otago Regional Council.

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FLOOD & HAZARD MAPS

Map 1: 1% Annual Flood Map

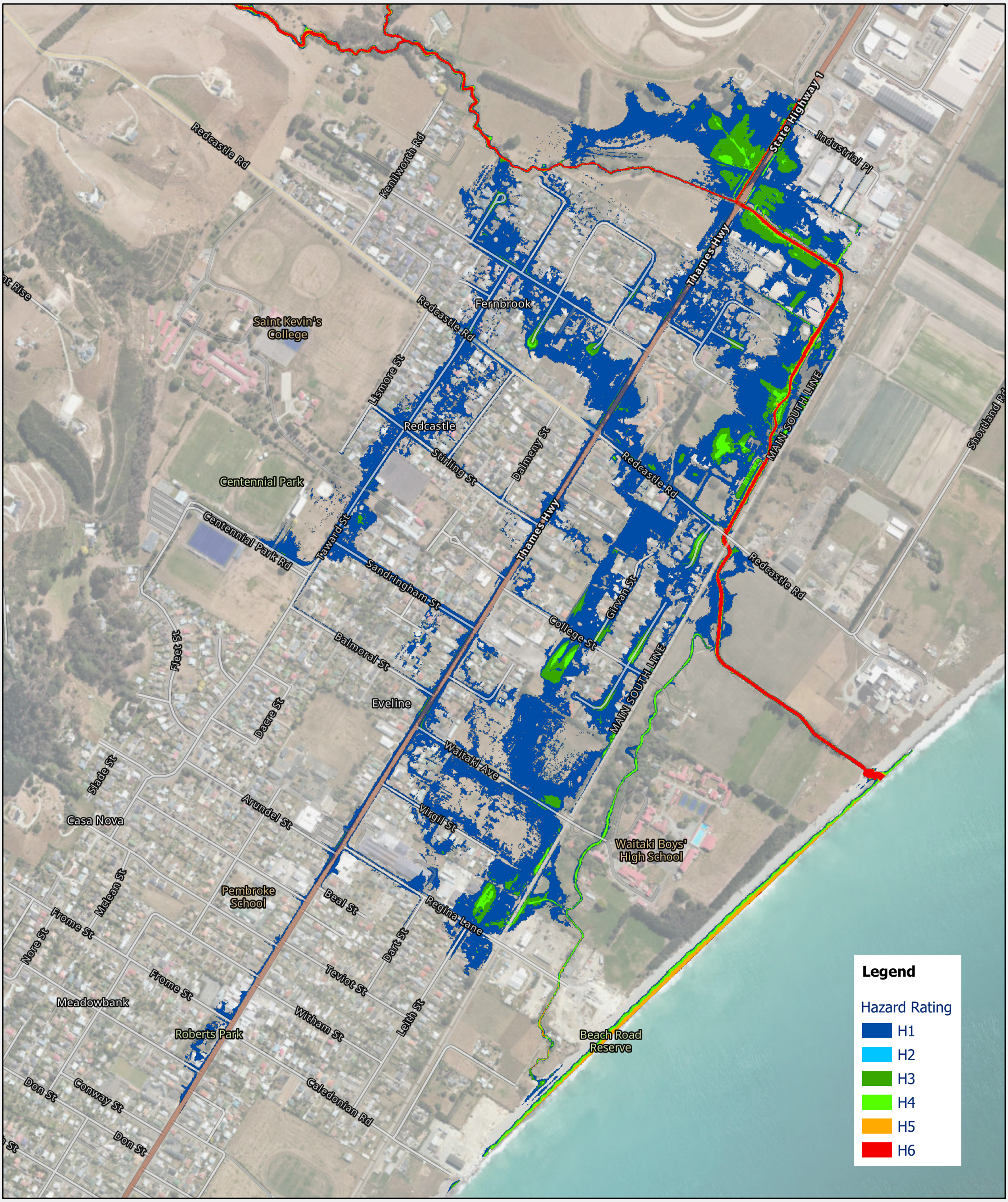
Muddy Creek Catchment
Waitaki District

Otago Regional Council

Map 2: Flood Hazard Rating

Muddy Creek Catchment
Waitaki District

Otago Regional Council



Map 2A: Non-Shallow Flooding

Muddy Creek Catchment
Waitaki District

Otago Regional Council

Map 3: 10% Annual Flood Map

Muddy Creek Catchment
Waitaki District

Otago Regional Council

Map 4: 2% Annual Flood

Muddy Creek Catchment
Waitaki District

Otago Regional Council

Map 5: 1%ARI RCP8.5

Muddy Creek Catchment
Waitaki District

Otago Regional Council

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APPENDIX 1: HYDROLOGIC MODEL OUTPUT

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cms)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	-------	-------	-------	-------	1.737	-------	4.395	5.851	TRIB1_CURRENT
2	SCS Runoff	------	-------	-------	-------	-------	1.863	-------	4.575	6.057	TRIB2_CURRENT
3	SCS Runoff	------	-------	-------	-------	-------	2.761	-------	5.983	7.685	TRIB3_CURRENT
4	SCS Runoff	------	-------	-------	-------	-------	3.269	-------	8.494	11.46	TRIB4_CURRENT
5	SCS Runoff	------	-------	-------	-------	-------	2.287	-------	4.454	5.571	STORM_CURRENT

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025

Hyd. No.	Hydrograph type (origin)	Peak flow (cms)	Time interval (min)	Time to Peak (min)	Hyd. volume (cum)	Inflow hyd(s)	Maximum elevation (m)	Total strge used (cum)	Hydrograph Description
1	SCS Runoff	1.737	6	768	15,000.9	------	------	------	TRIB1_CURRENT
2	SCS Runoff	1.863	6	780	18,767.2	------	------	------	TRIB2_CURRENT
3	SCS Runoff	2.761	6	798	32,435.7	------	------	------	TRIB3_CURRENT
4	SCS Runoff	3.269	6	840	55,956.1	------	------	------	TRIB4_CURRENT
5	SCS Runoff	2.287	6	768	19,550.0	------	------	------	STORM_CURRENT

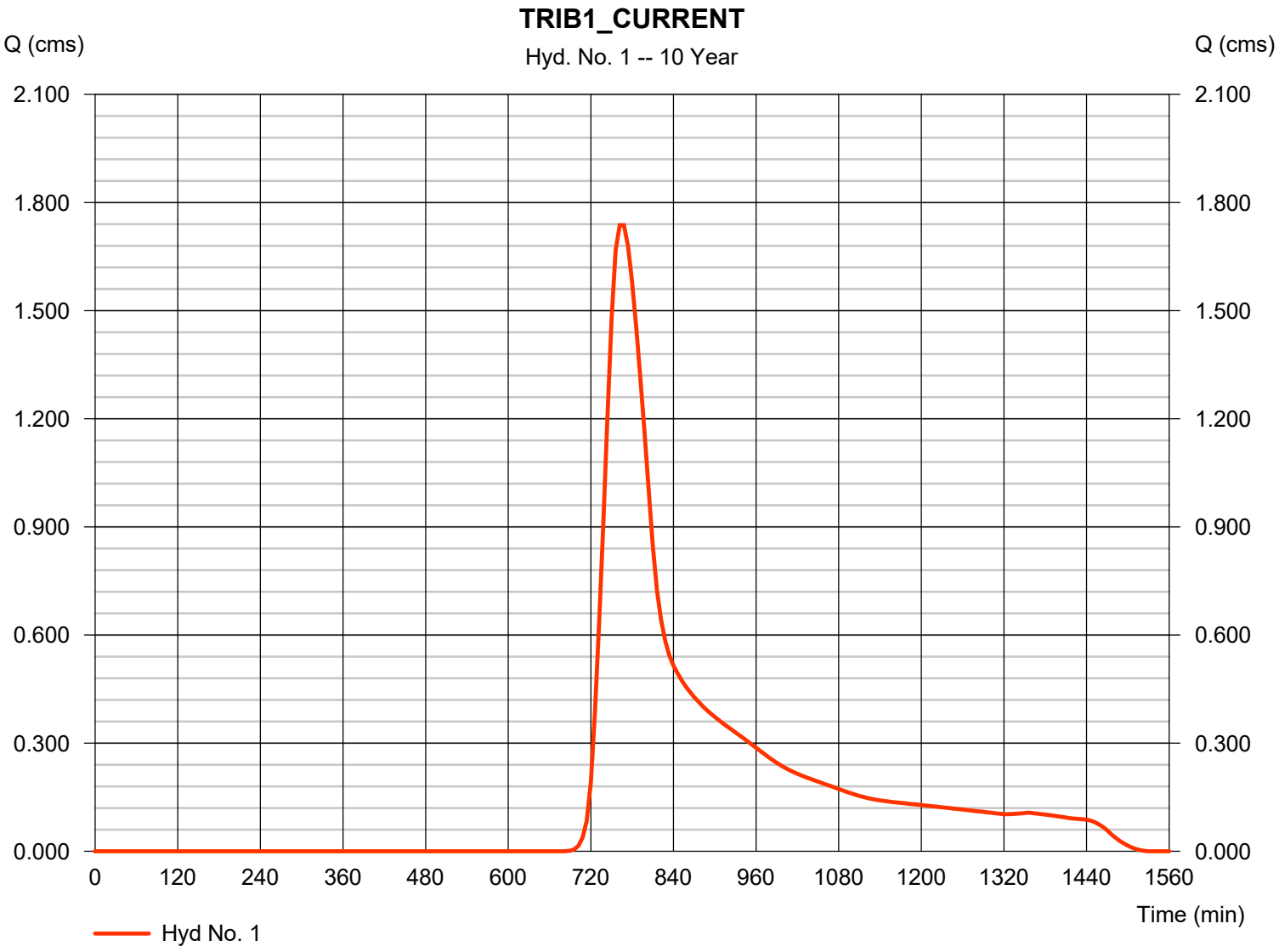
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 1

TRIB1_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.737 cms
Storm frequency	=	10 yrs	Time to peak	=	768 min
Time interval	=	6 min	Hyd. volume	=	15,000.9 cum
Drainage area	=	72.200 hectare	Curve number	=	69
Basin Slope	=	6.3 %	Hydraulic length	=	1425 m
Tc method	=	LAG	Time of conc. (Tc)	=	59.72 min
Total precip.	=	83.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



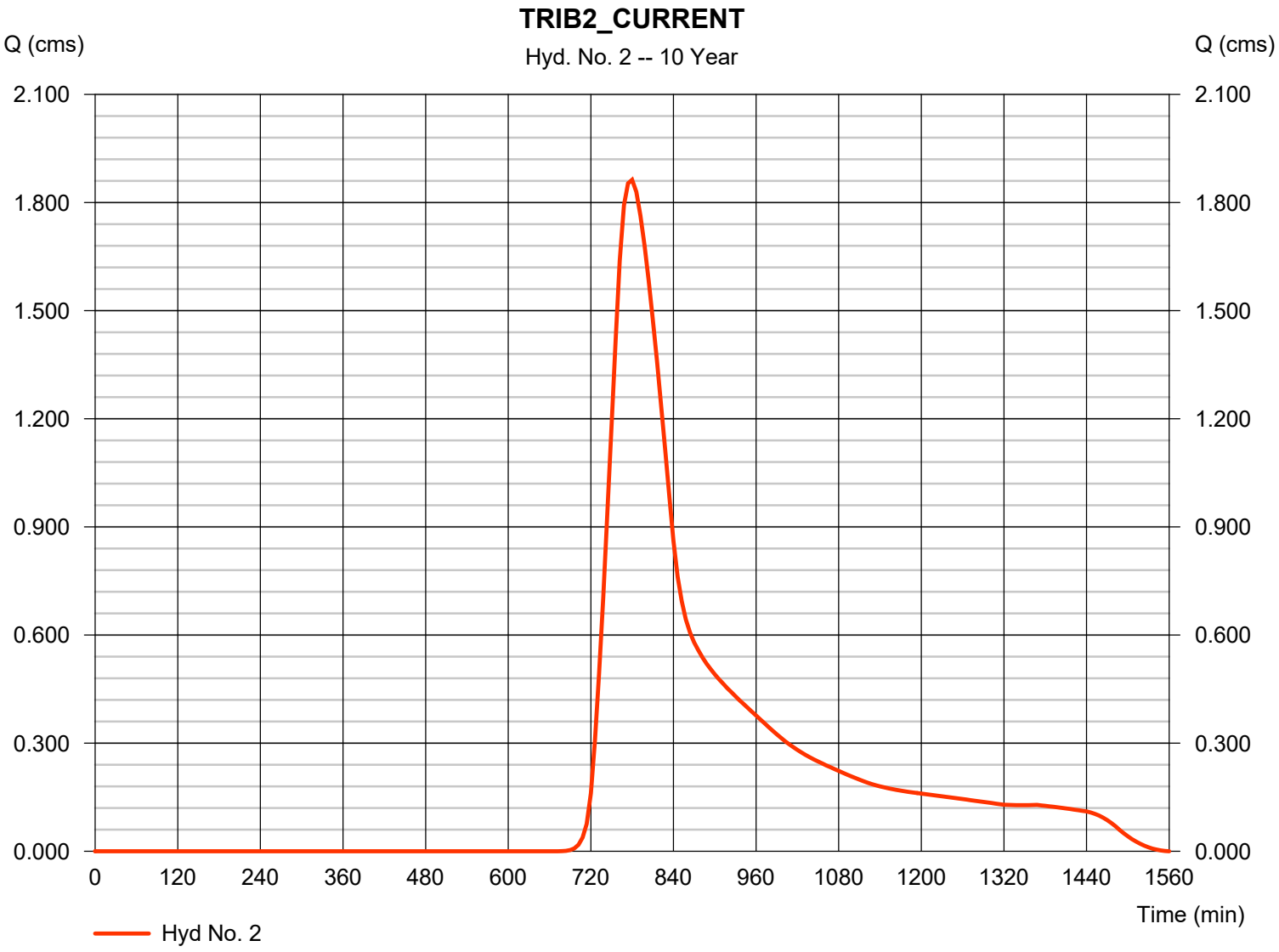
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 2

TRIB2_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.863 cms
Storm frequency	=	10 yrs	Time to peak	=	780 min
Time interval	=	6 min	Hyd. volume	=	18,767.2 cum
Drainage area	=	86.500 hectare	Curve number	=	70
Basin Slope	=	5.5 %	Hydraulic length	=	1920 m
Tc method	=	LAG	Time of conc. (Tc)	=	78.98 min
Total precip.	=	83.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

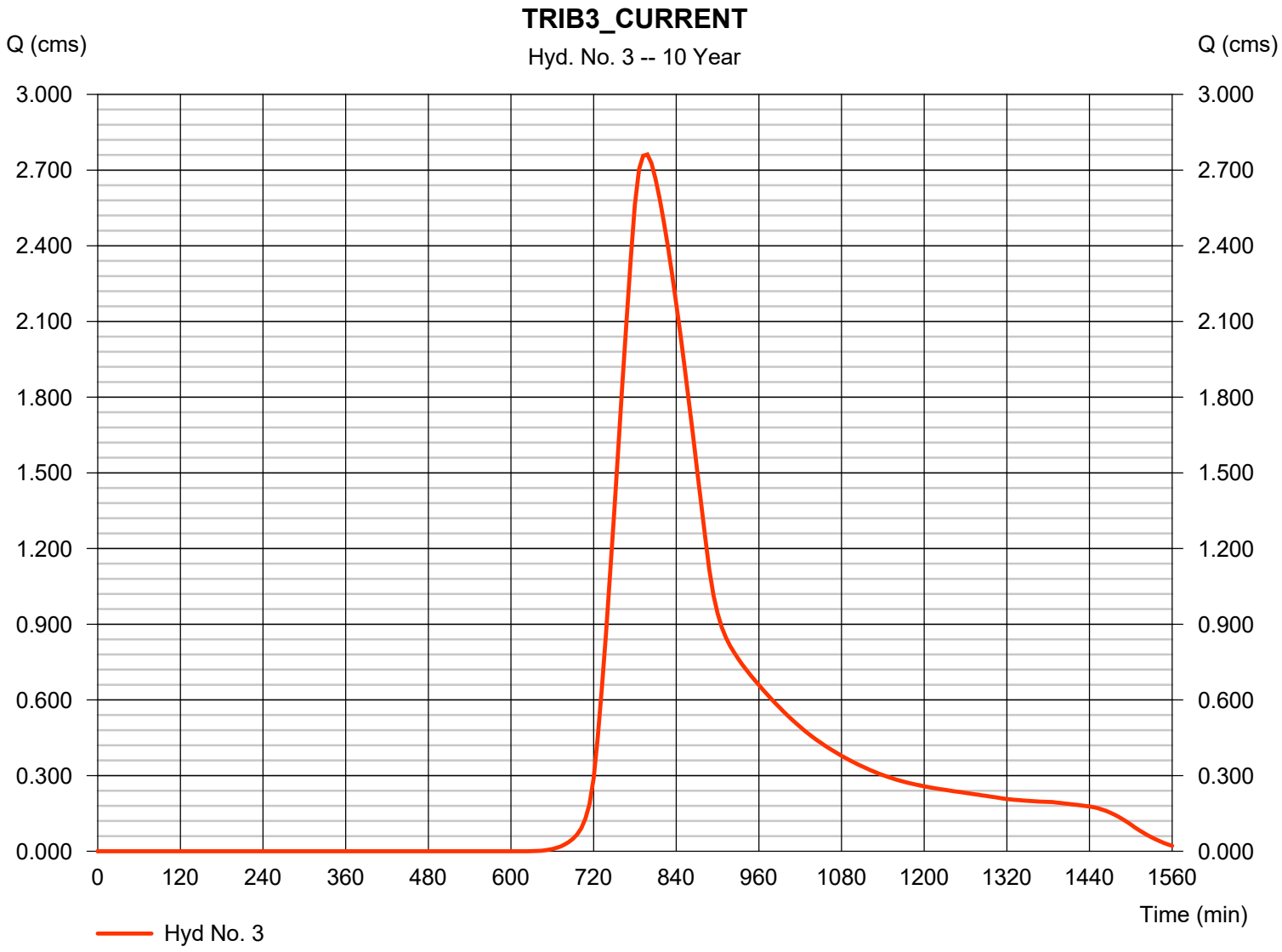


Hydrograph Report

Hyd. No. 3

TRIB3_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.761 cms
Storm frequency	=	10 yrs	Time to peak	=	798 min
Time interval	=	6 min	Hyd. volume	=	32,435.7 cum
Drainage area	=	113.300 hectare	Curve number	=	75
Basin Slope	=	4.3 %	Hydraulic length	=	2789 m
Tc method	=	LAG	Time of conc. (Tc)	=	104.79 min
Total precip.	=	83.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

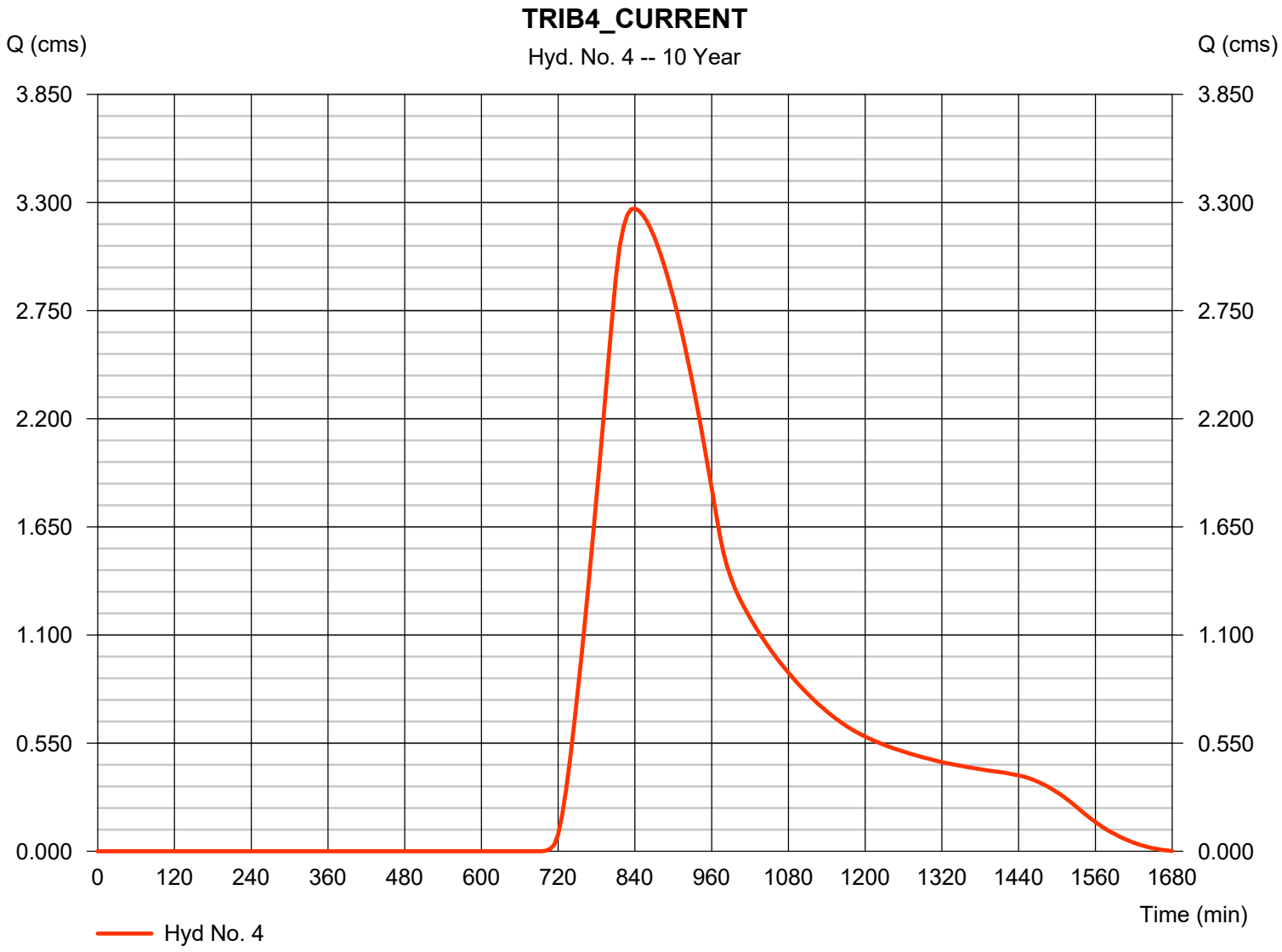


Hydrograph Report

Hyd. No. 4

TRIB4_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.269 cms
Storm frequency	=	10 yrs	Time to peak	=	840 min
Time interval	=	6 min	Hyd. volume	=	55,956.1 cum
Drainage area	=	284.000 hectare	Curve number	=	68
Basin Slope	=	3.5 %	Hydraulic length	=	3143 m
Tc method	=	LAG	Time of conc. (Tc)	=	154.94 min
Total precip.	=	83.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

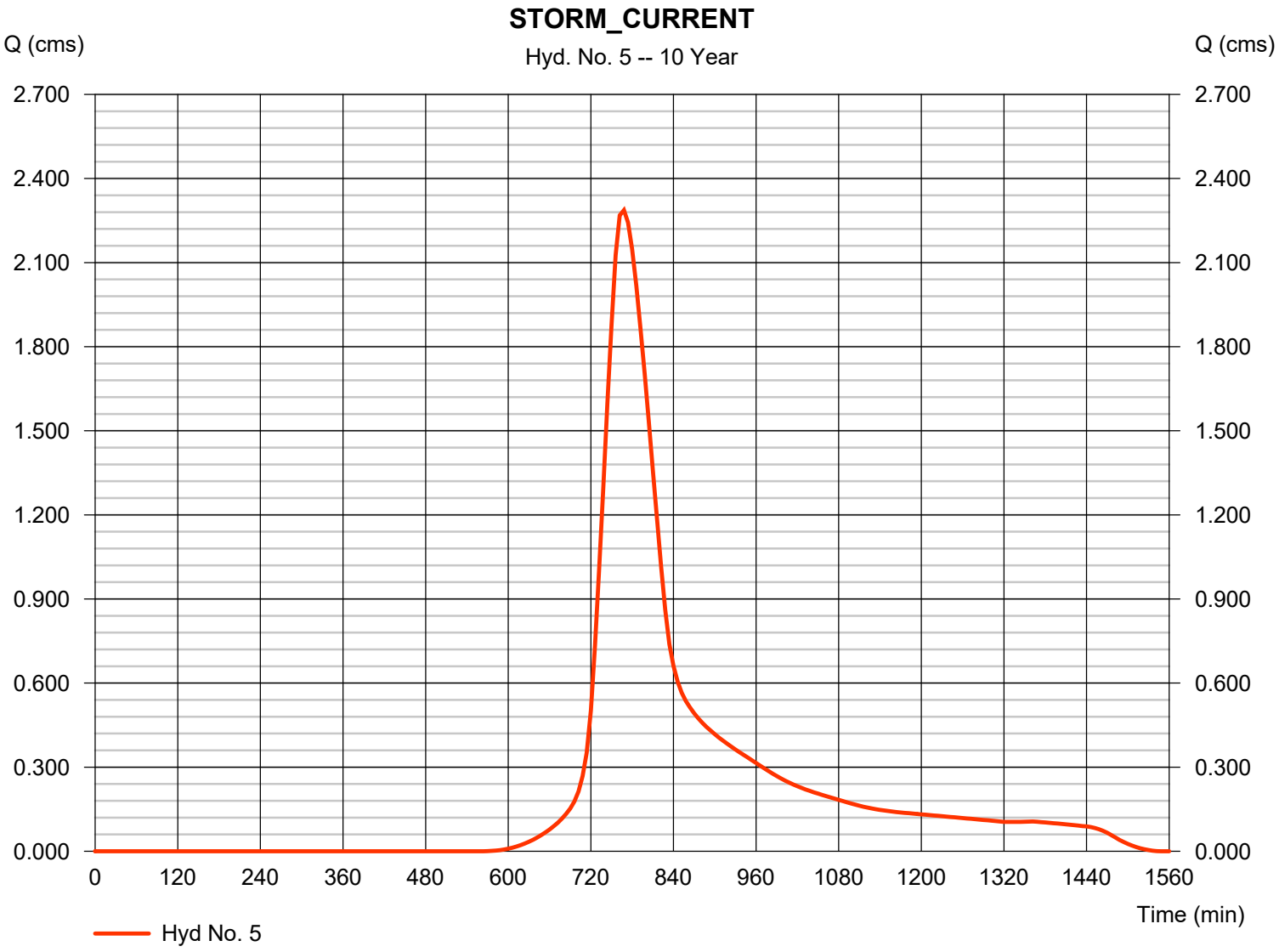


Hydrograph Report

Hyd. No. 5

STORM_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.287 cms
Storm frequency	=	10 yrs	Time to peak	=	768 min
Time interval	=	6 min	Hyd. volume	=	19,550.0 cum
Drainage area	=	52.000 hectare	Curve number	=	80
Basin Slope	=	1.5 %	Hydraulic length	=	1050 m
Tc method	=	LAG	Time of conc. (Tc)	=	69.93 min
Total precip.	=	83.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025

Hyd. No.	Hydrograph type (origin)	Peak flow (cms)	Time interval (min)	Time to Peak (min)	Hyd. volume (cum)	Inflow hyd(s)	Maximum elevation (m)	Total strge used (cum)	Hydrograph Description
1	SCS Runoff	4.395	6	762	34,329.9	------	------	------	TRIB1_CURRENT
2	SCS Runoff	4.575	6	774	42,156.5	------	------	------	TRIB2_CURRENT
3	SCS Runoff	5.983	6	792	66,969.5	------	------	------	TRIB3_CURRENT
4	SCS Runoff	8.494	6	828	130,568.1	------	------	------	TRIB4_CURRENT
5	SCS Runoff	4.454	6	762	37,509.4	------	------	------	STORM_CURRENT

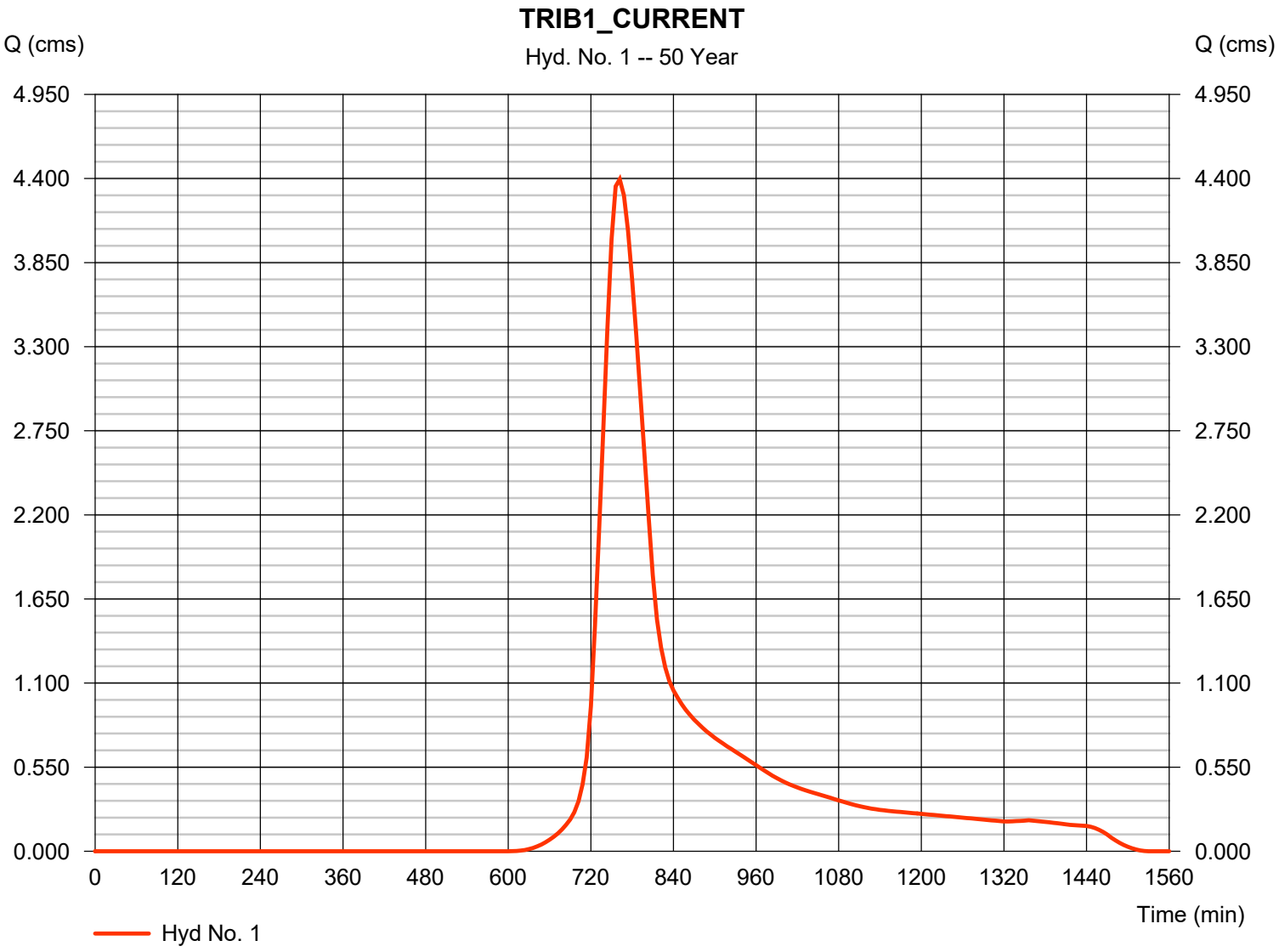
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 1

TRIB1_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.395 cms
Storm frequency	=	50 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	34,329.9 cum
Drainage area	=	72.200 hectare	Curve number	=	69
Basin Slope	=	6.3 %	Hydraulic length	=	1425 m
Tc method	=	LAG	Time of conc. (Tc)	=	59.72 min
Total precip.	=	124.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



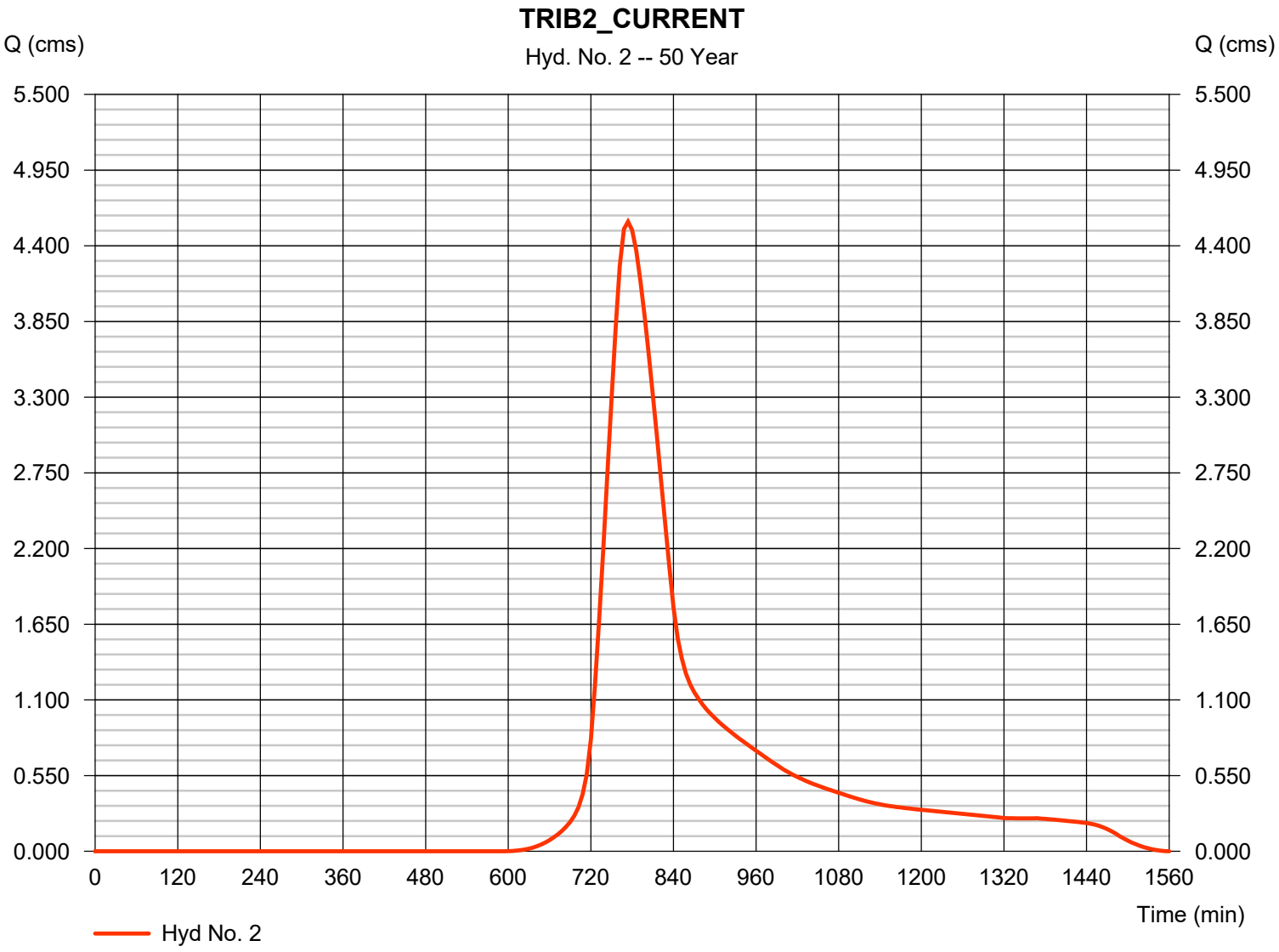
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 2

TRIB2_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.575 cms
Storm frequency	=	50 yrs	Time to peak	=	774 min
Time interval	=	6 min	Hyd. volume	=	42,156.5 cum
Drainage area	=	86.500 hectare	Curve number	=	70
Basin Slope	=	5.5 %	Hydraulic length	=	1920 m
Tc method	=	LAG	Time of conc. (Tc)	=	78.98 min
Total precip.	=	124.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

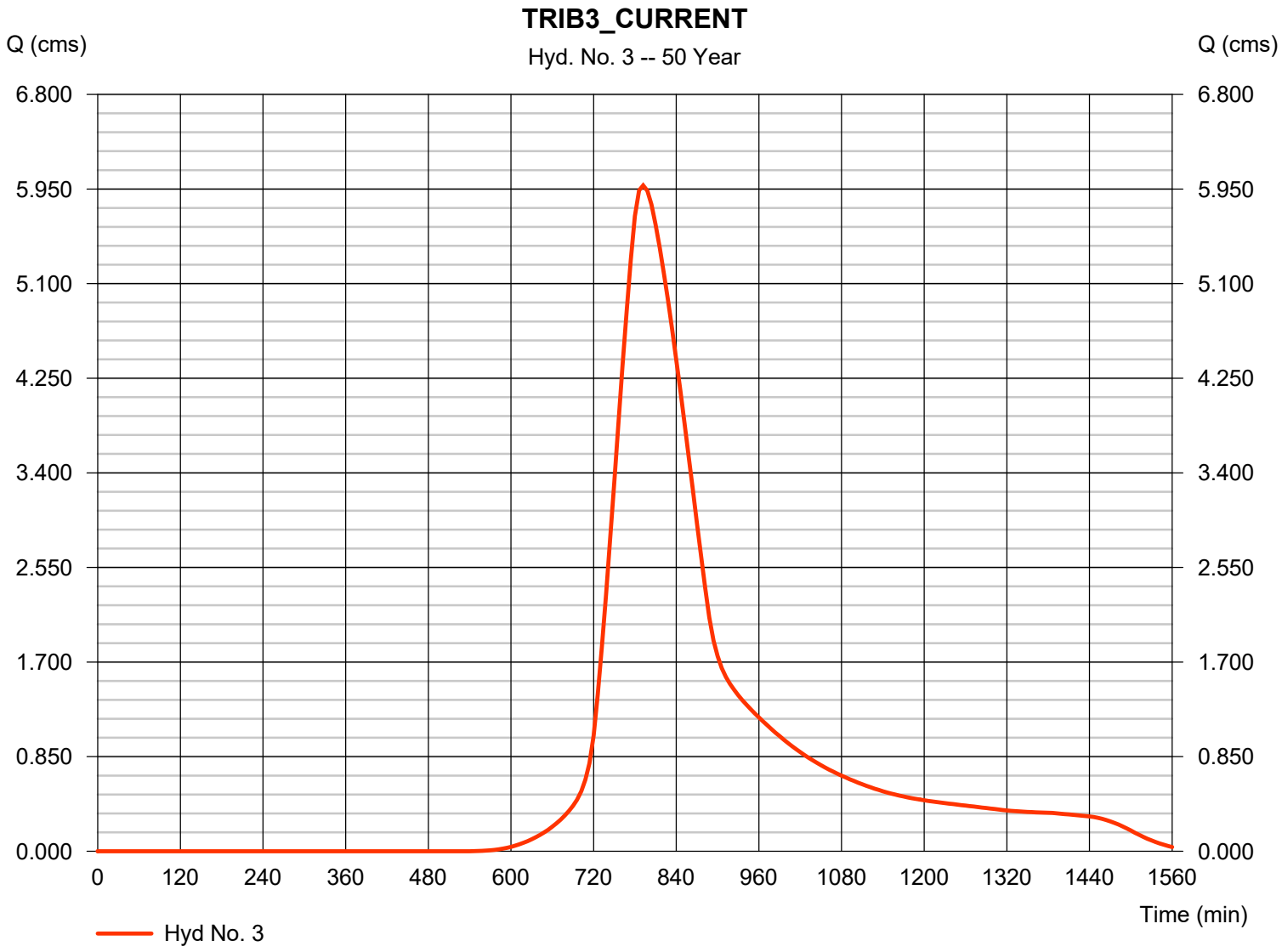


Hydrograph Report

Hyd. No. 3

TRIB3_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.983 cms
Storm frequency	=	50 yrs	Time to peak	=	792 min
Time interval	=	6 min	Hyd. volume	=	66,969.5 cum
Drainage area	=	113.300 hectare	Curve number	=	75
Basin Slope	=	4.3 %	Hydraulic length	=	2789 m
Tc method	=	LAG	Time of conc. (Tc)	=	104.79 min
Total precip.	=	124.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

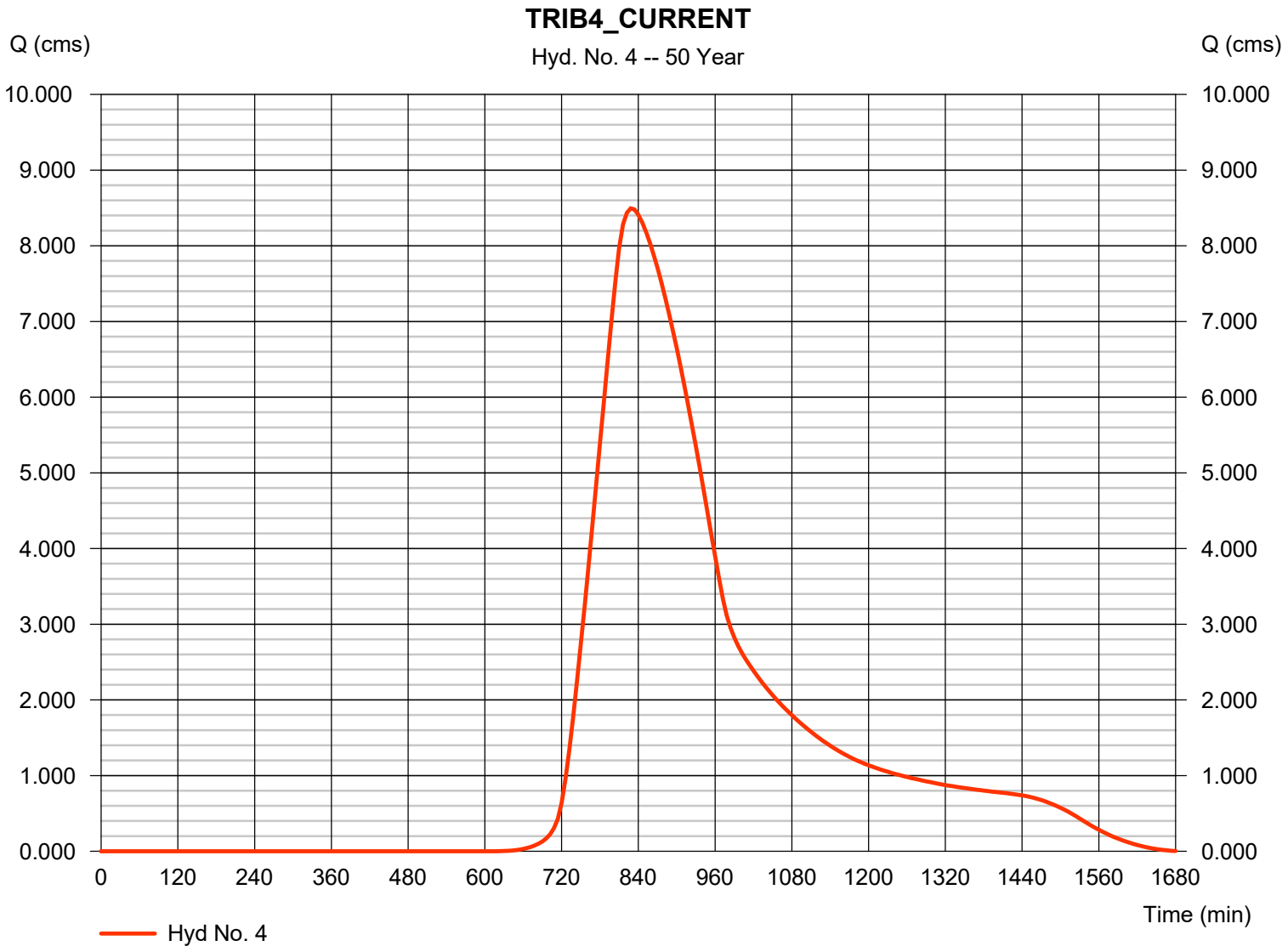


Hydrograph Report

Hyd. No. 4

TRIB4_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	8.494 cms
Storm frequency	=	50 yrs	Time to peak	=	828 min
Time interval	=	6 min	Hyd. volume	=	130,568.1 cum
Drainage area	=	284.000 hectare	Curve number	=	68
Basin Slope	=	3.5 %	Hydraulic length	=	3143 m
Tc method	=	LAG	Time of conc. (Tc)	=	154.94 min
Total precip.	=	124.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



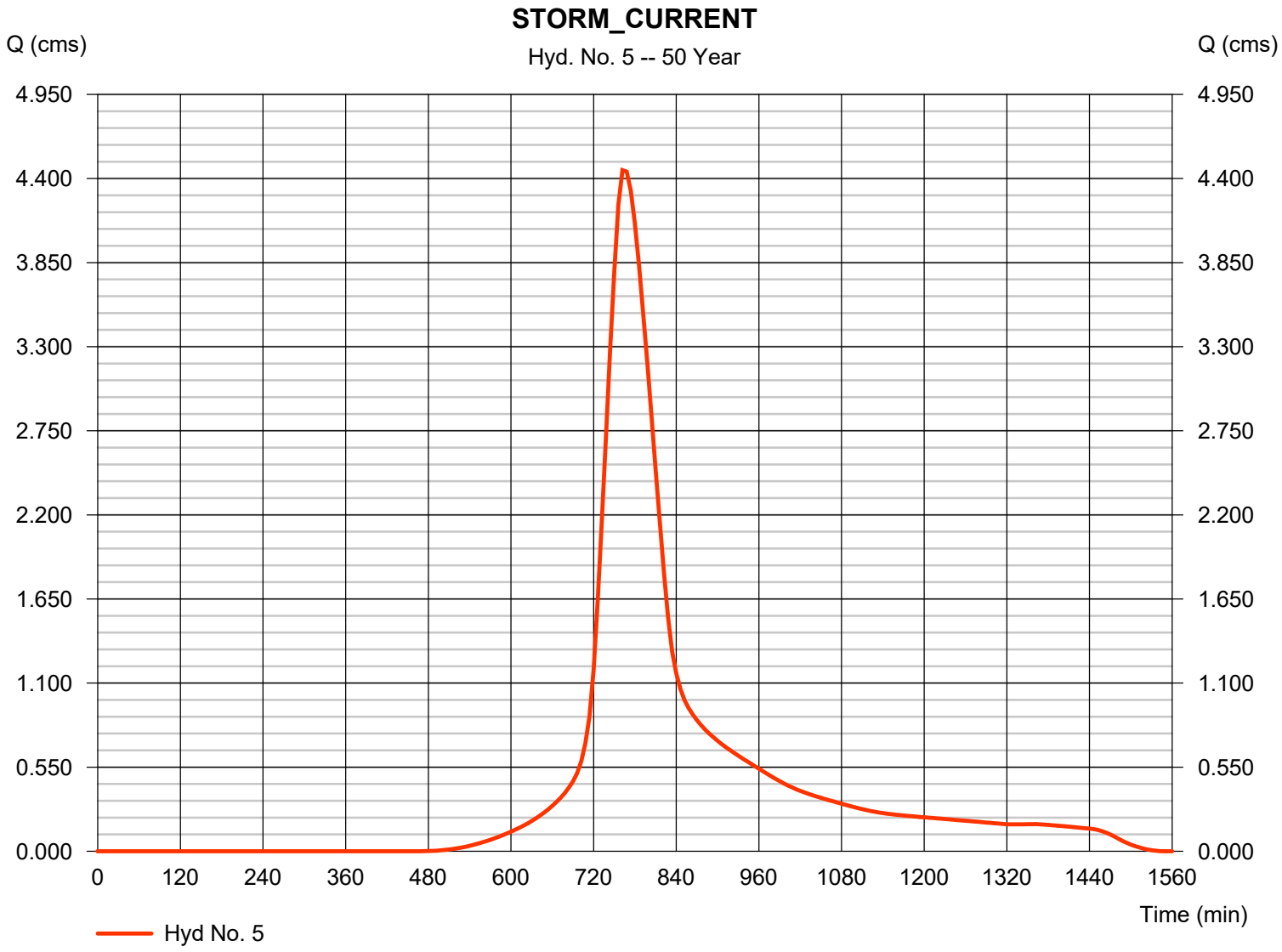
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 5

STORM_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.454 cms
Storm frequency	=	50 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	37,509.4 cum
Drainage area	=	52.000 hectare	Curve number	=	80
Basin Slope	=	1.5 %	Hydraulic length	=	1050 m
Tc method	=	LAG	Time of conc. (Tc)	=	69.93 min
Total precip.	=	124.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025

Hyd. No.	Hydrograph type (origin)	Peak flow (cms)	Time interval (min)	Time to Peak (min)	Hyd. volume (cum)	Inflow hyd(s)	Maximum elevation (m)	Total strge used (cum)	Hydrograph Description
1	SCS Runoff	5.851	6	762	45,057.7	------	------	------	TRIB1_CURRENT
2	SCS Runoff	6.057	6	774	55,048.8	------	------	------	TRIB2_CURRENT
3	SCS Runoff	7.685	6	792	85,416.5	------	------	------	TRIB3_CURRENT
4	SCS Runoff	11.46	6	828	172,272.0	------	------	------	TRIB4_CURRENT
5	SCS Runoff	5.571	6	762	46,841.7	------	------	------	STORM_CURRENT

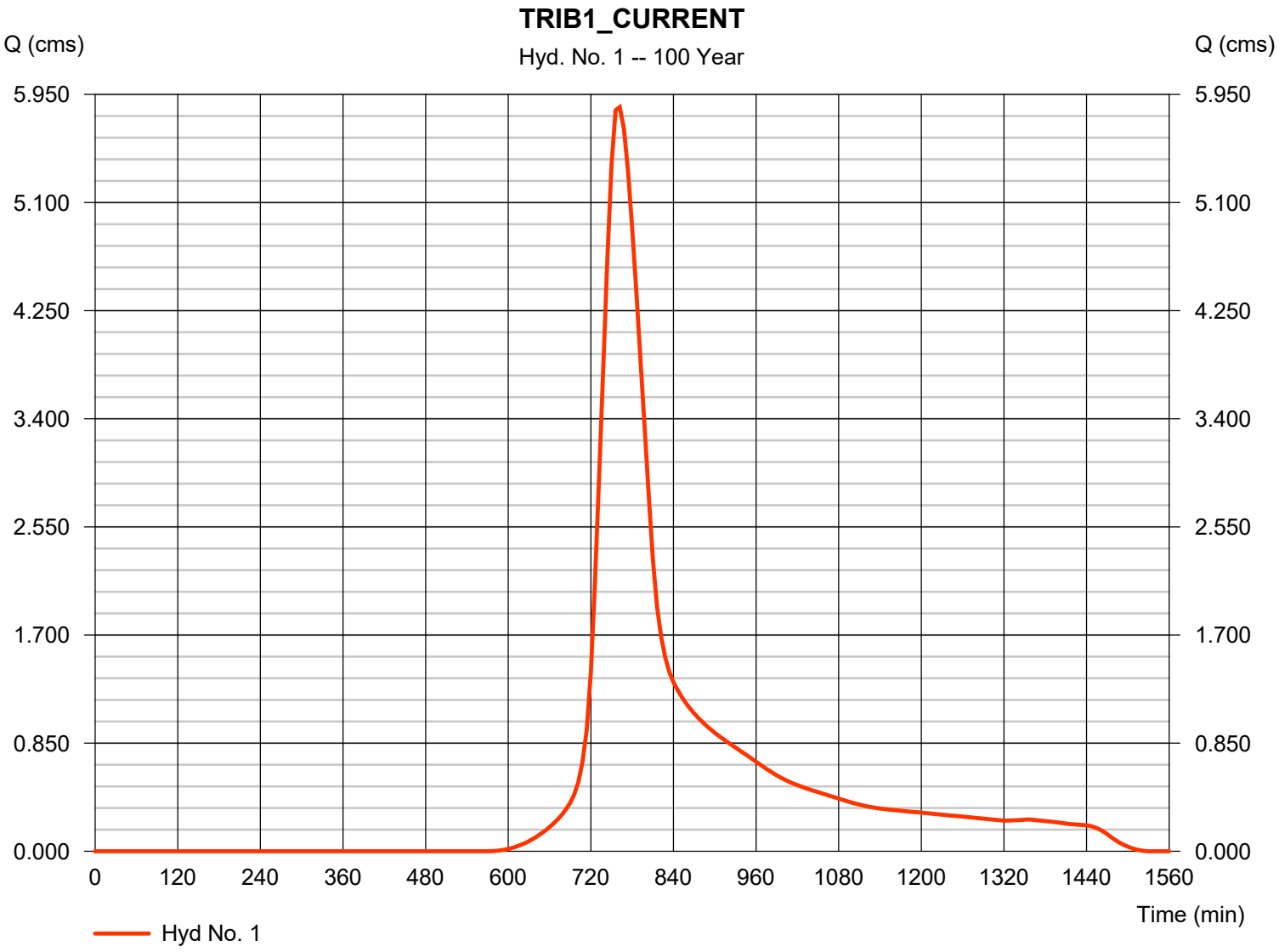
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 1

TRIB1_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.851 cms
Storm frequency	=	100 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	45,057.7 cum
Drainage area	=	72.200 hectare	Curve number	=	69
Basin Slope	=	6.3 %	Hydraulic length	=	1425 m
Tc method	=	LAG	Time of conc. (Tc)	=	59.72 min
Total precip.	=	144.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

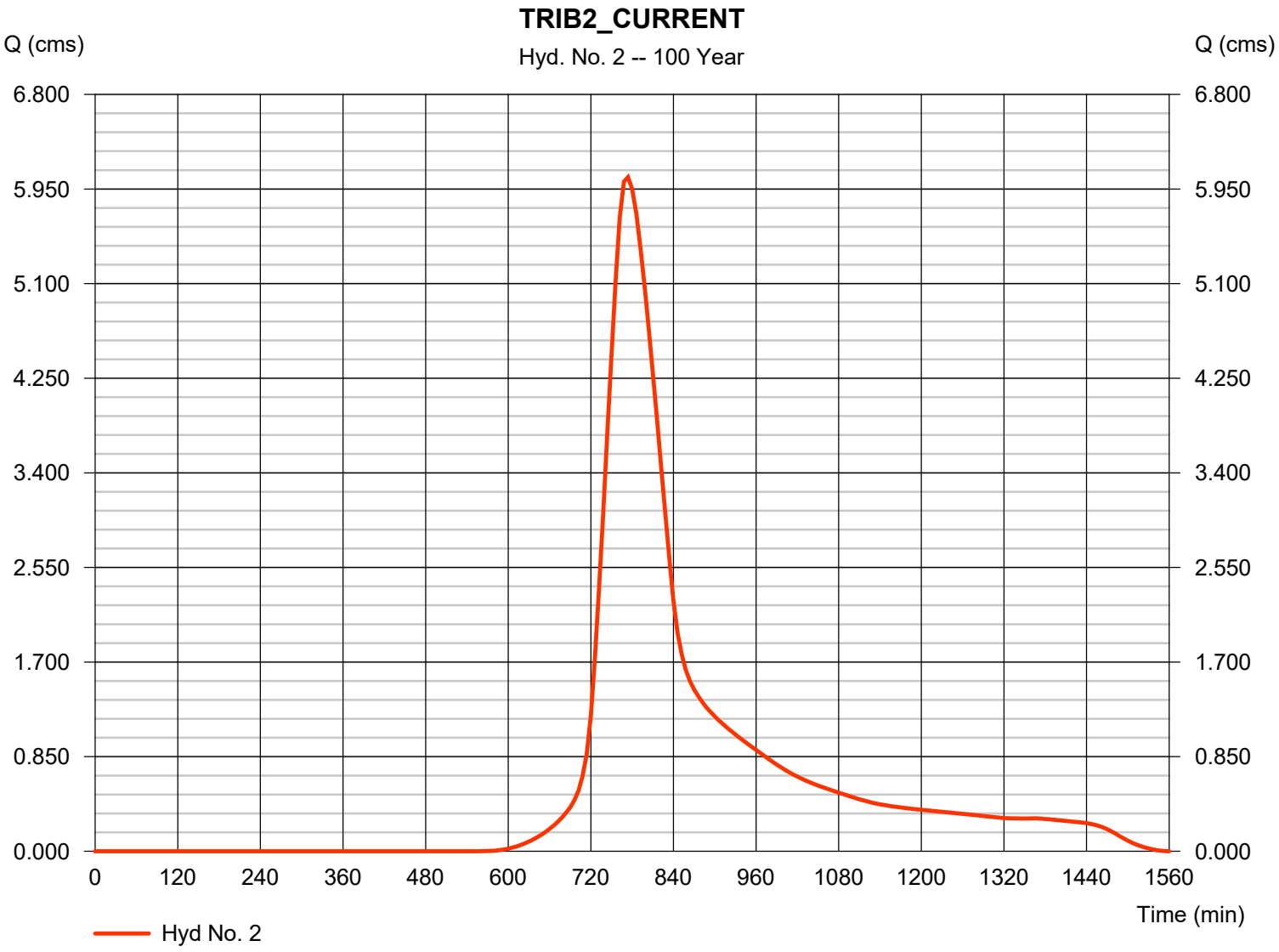


Hydrograph Report

Hyd. No. 2

TRIB2_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	6.057 cms
Storm frequency	=	100 yrs	Time to peak	=	774 min
Time interval	=	6 min	Hyd. volume	=	55,048.8 cum
Drainage area	=	86.500 hectare	Curve number	=	70
Basin Slope	=	5.5 %	Hydraulic length	=	1920 m
Tc method	=	LAG	Time of conc. (Tc)	=	78.98 min
Total precip.	=	144.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

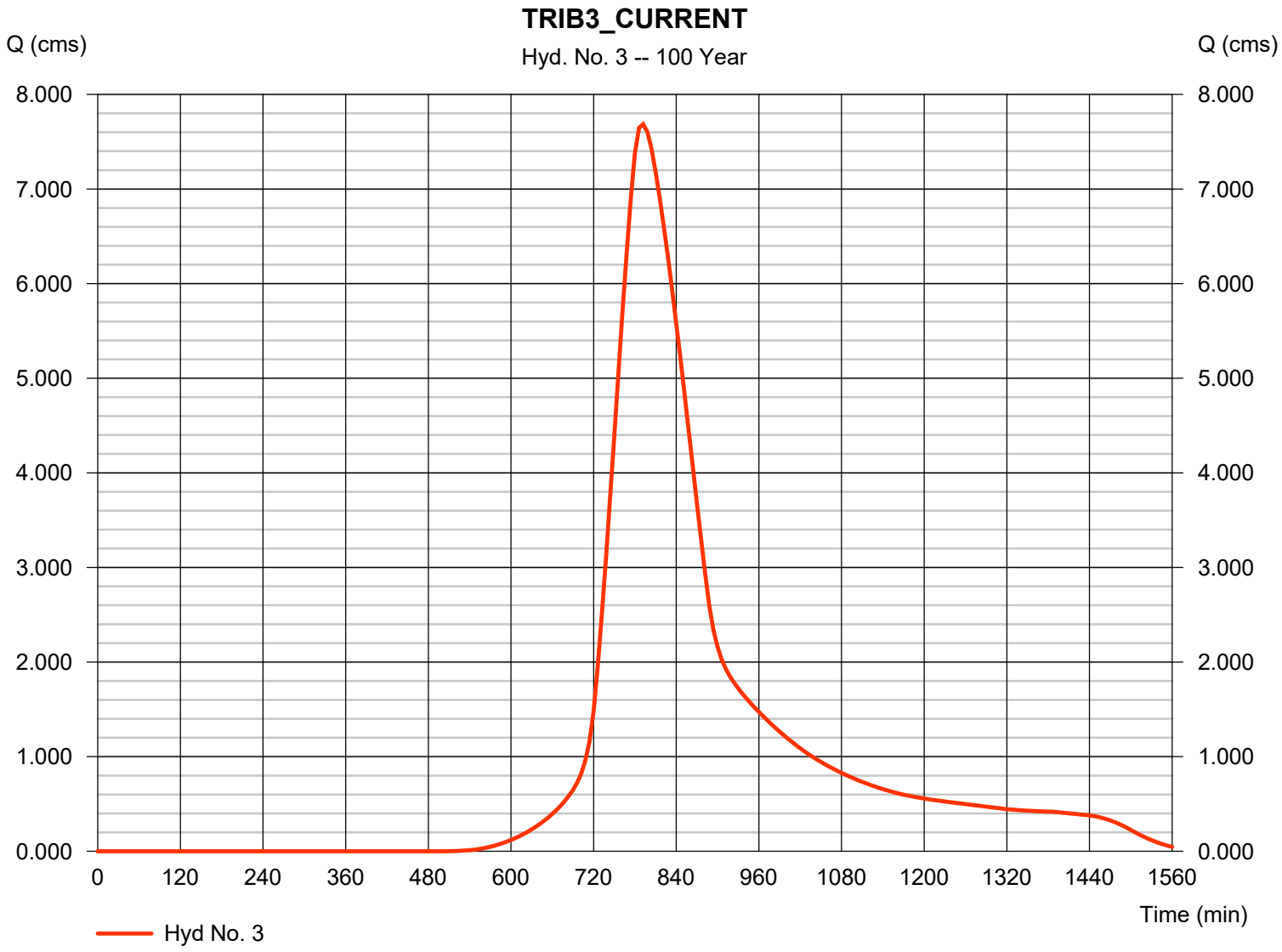


Hydrograph Report

Hyd. No. 3

TRIB3_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	7.685 cms
Storm frequency	=	100 yrs	Time to peak	=	792 min
Time interval	=	6 min	Hyd. volume	=	85,416.5 cum
Drainage area	=	113.300 hectare	Curve number	=	75
Basin Slope	=	4.3 %	Hydraulic length	=	2789 m
Tc method	=	LAG	Time of conc. (Tc)	=	104.79 min
Total precip.	=	144.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

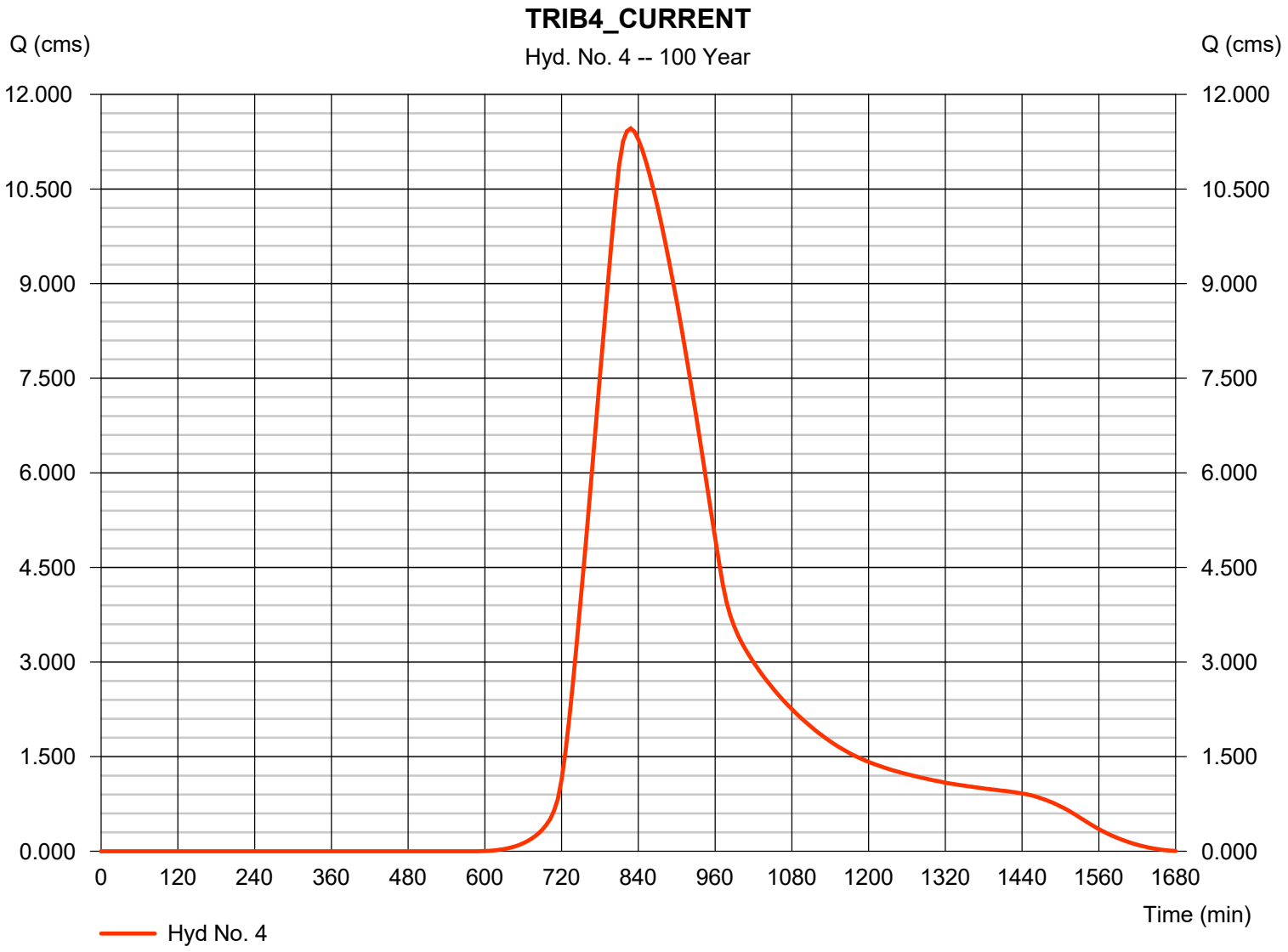


Hydrograph Report

Hyd. No. 4

TRIB4_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	11.46 cms
Storm frequency	=	100 yrs	Time to peak	=	828 min
Time interval	=	6 min	Hyd. volume	=	172,272.0 cum
Drainage area	=	284.000 hectare	Curve number	=	68
Basin Slope	=	3.5 %	Hydraulic length	=	3143 m
Tc method	=	LAG	Time of conc. (Tc)	=	154.94 min
Total precip.	=	144.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



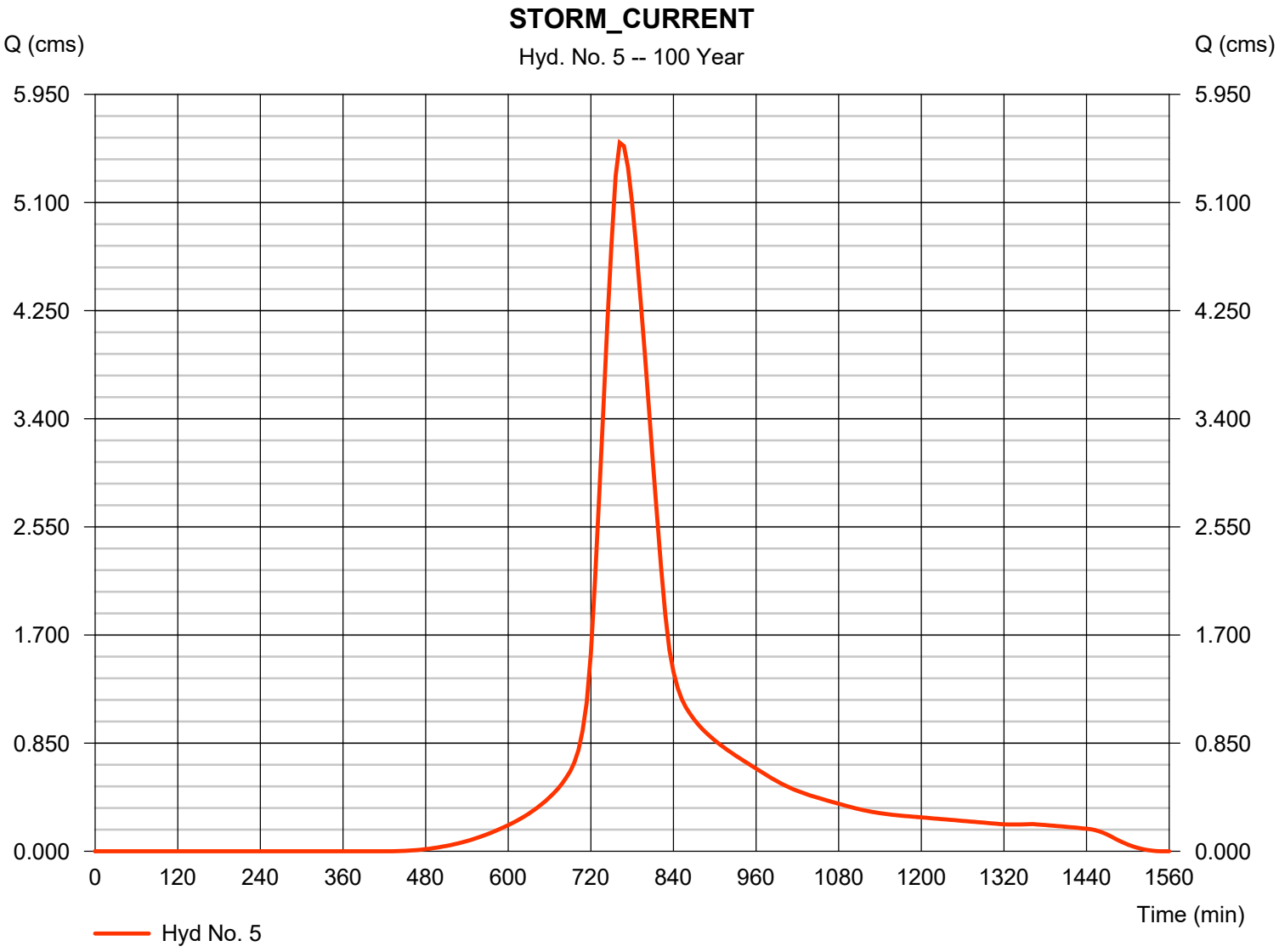
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025 Friday, 10 / 3 / 2025

Hyd. No. 5

STORM_CURRENT

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.571 cms
Storm frequency	=	100 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	46,841.7 cum
Drainage area	=	52.000 hectare	Curve number	=	80
Basin Slope	=	1.5 %	Hydraulic length	=	1050 m
Tc method	=	LAG	Time of conc. (Tc)	=	69.93 min
Total precip.	=	144.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	177.4706	33.2740	2.1992	--------
3	0.0000	0.0000	0.0000	--------
5	201.3197	37.0841	2.1257	--------
10	224.1172	39.3700	2.1029	--------
25	260.6223	41.9101	2.0871	--------
50	291.6410	43.6881	2.0824	--------
100	322.9854	45.2121	2.0794	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (mm/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0	0	0	0	0	0	0	0	0	0	0	0
2	145	117	99	86	76	68	62	57	53	49	46	43
3	0	0	0	0	0	0	0	0	0	0	0	0
5	167	138	118	104	93	84	77	71	66	62	58	55
10	184	153	132	117	105	95	87	81	75	70	66	62
25	209	176	153	136	122	111	102	95	88	83	78	74
50	230	194	169	150	136	124	114	106	99	93	87	83
100	250	212	185	165	149	136	126	117	109	102	97	91

Tc = time in minutes. Values may exceed 60.

Precip. file name: C:\Users\nathan.anderson\OneDrive - Otago Regional Council\GIS\OamaRu_CURRENT.pcp

Storm Distribution	Rainfall Precipitation Table (mm)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	0	49	0	68	83	0	124	144
SCS 6-Hr	0	0	0	0	0	0	0	0
Huff-1st	0	0	0	0	0	0	0	0
Huff-2nd	0	0	0	0	0	0	0	0
Huff-3rd	0	0	0	0	0	0	0	0
Huff-4th	0	0	0	0	0	0	0	0
Huff-Indy	0	0	0	0	0	0	0	0
Custom	0	0	0	0	0	0	0	0

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cms)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	-------	-------	-------	-------	1.970	-------	4.824	6.377	TRIB1_RCP8.5
2	SCS Runoff	------	-------	-------	-------	-------	2.097	-------	5.011	6.592	TRIB2_RCP8.5
3	SCS Runoff	------	-------	-------	-------	-------	3.049	-------	6.487	8.292	TRIB3_RCP8.5
4	SCS Runoff	------	-------	-------	-------	-------	3.707	-------	9.364	12.54	TRIB4_RCP8.5
5	SCS Runoff	------	-------	-------	-------	-------	2.488	-------	4.787	5.966	STORM_RCP8.5

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025

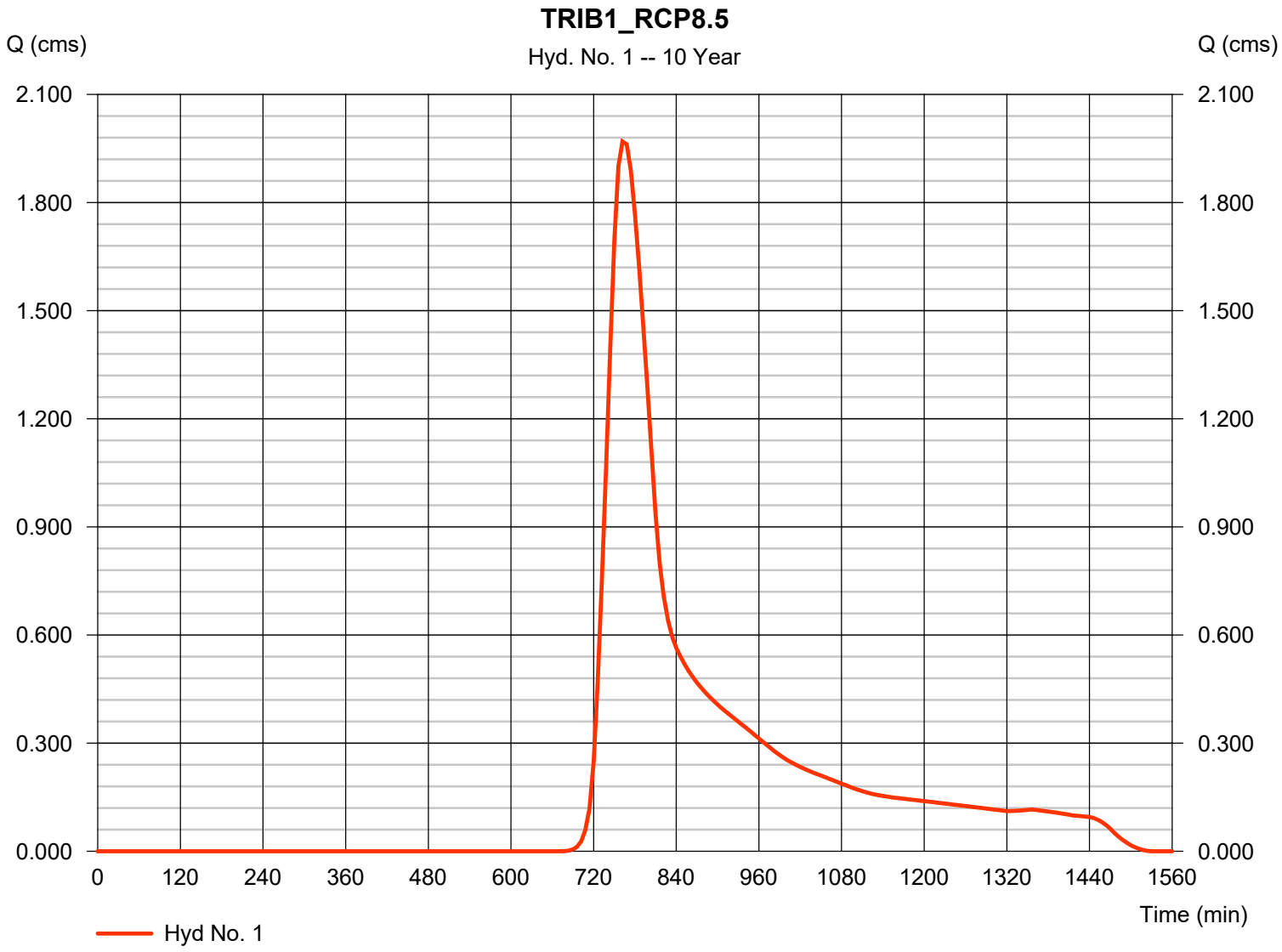
Hyd. No.	Hydrograph type (origin)	Peak flow (cms)	Time interval (min)	Time to Peak (min)	Hyd. volume (cum)	Inflow hyd(s)	Maximum elevation (m)	Total strge used (cum)	Hydrograph Description
1	SCS Runoff	1.970	6	762	16,677.9	------	------	------	TRIB1_RCP8.5
2	SCS Runoff	2.097	6	780	20,810.9	------	------	------	TRIB2_RCP8.5
3	SCS Runoff	3.049	6	798	35,539.2	------	------	------	TRIB3_RCP8.5
4	SCS Runoff	3.707	6	834	62,390.7	------	------	------	TRIB4_RCP8.5
5	SCS Runoff	2.488	6	768	21,204.1	------	------	------	STORM_RCP8.5

Hydrograph Report

Hyd. No. 1

TRIB1_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.970 cms
Storm frequency	=	10 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	16,677.9 cum
Drainage area	=	72.200 hectare	Curve number	=	69
Basin Slope	=	6.3 %	Hydraulic length	=	1425 m
Tc method	=	LAG	Time of conc. (Tc)	=	59.72 min
Total precip.	=	87.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

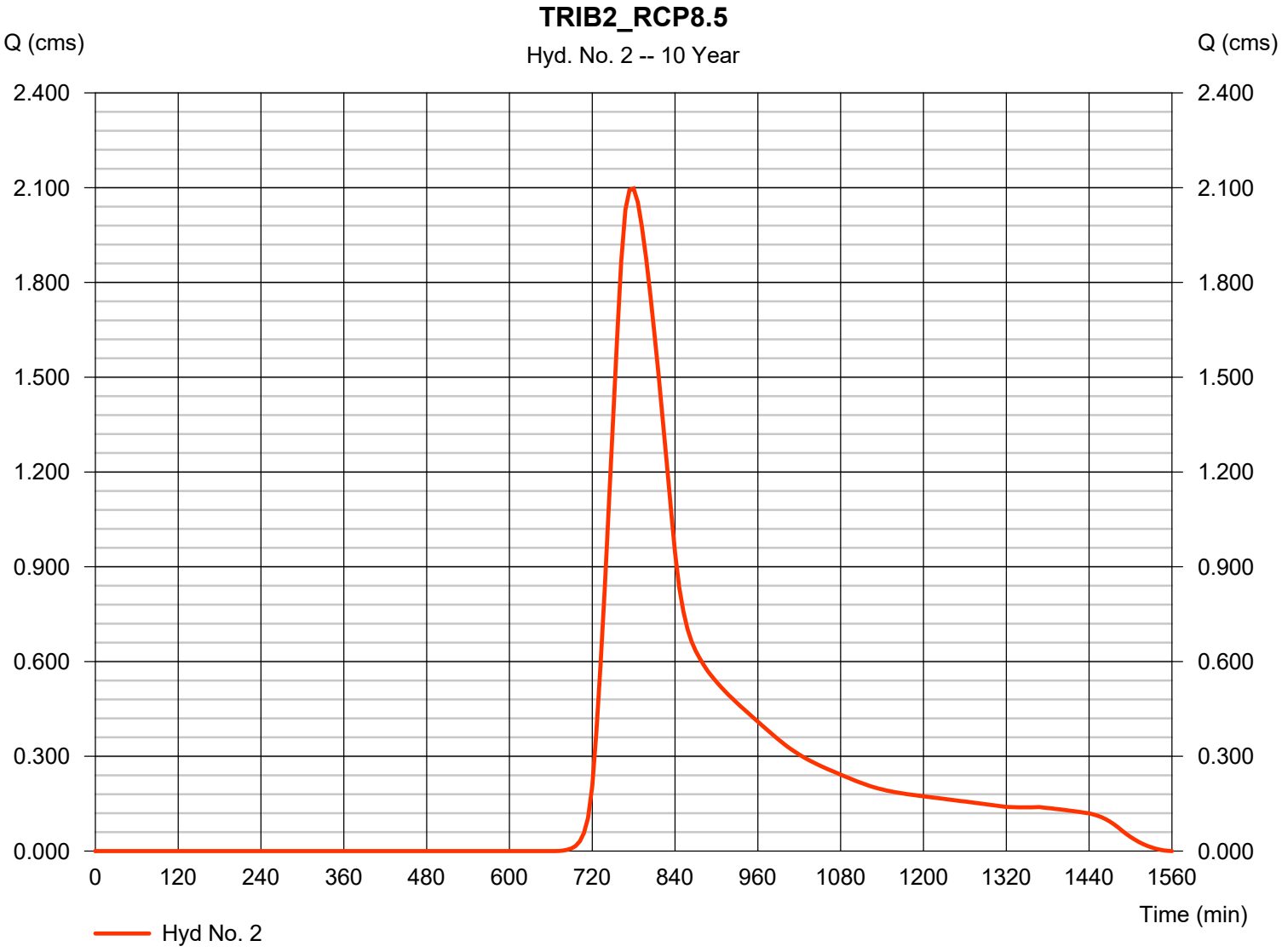


Hydrograph Report

Hyd. No. 2

TRIB2_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.097 cms
Storm frequency	=	10 yrs	Time to peak	=	780 min
Time interval	=	6 min	Hyd. volume	=	20,810.9 cum
Drainage area	=	86.500 hectare	Curve number	=	70
Basin Slope	=	5.5 %	Hydraulic length	=	1920 m
Tc method	=	LAG	Time of conc. (Tc)	=	78.98 min
Total precip.	=	87.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

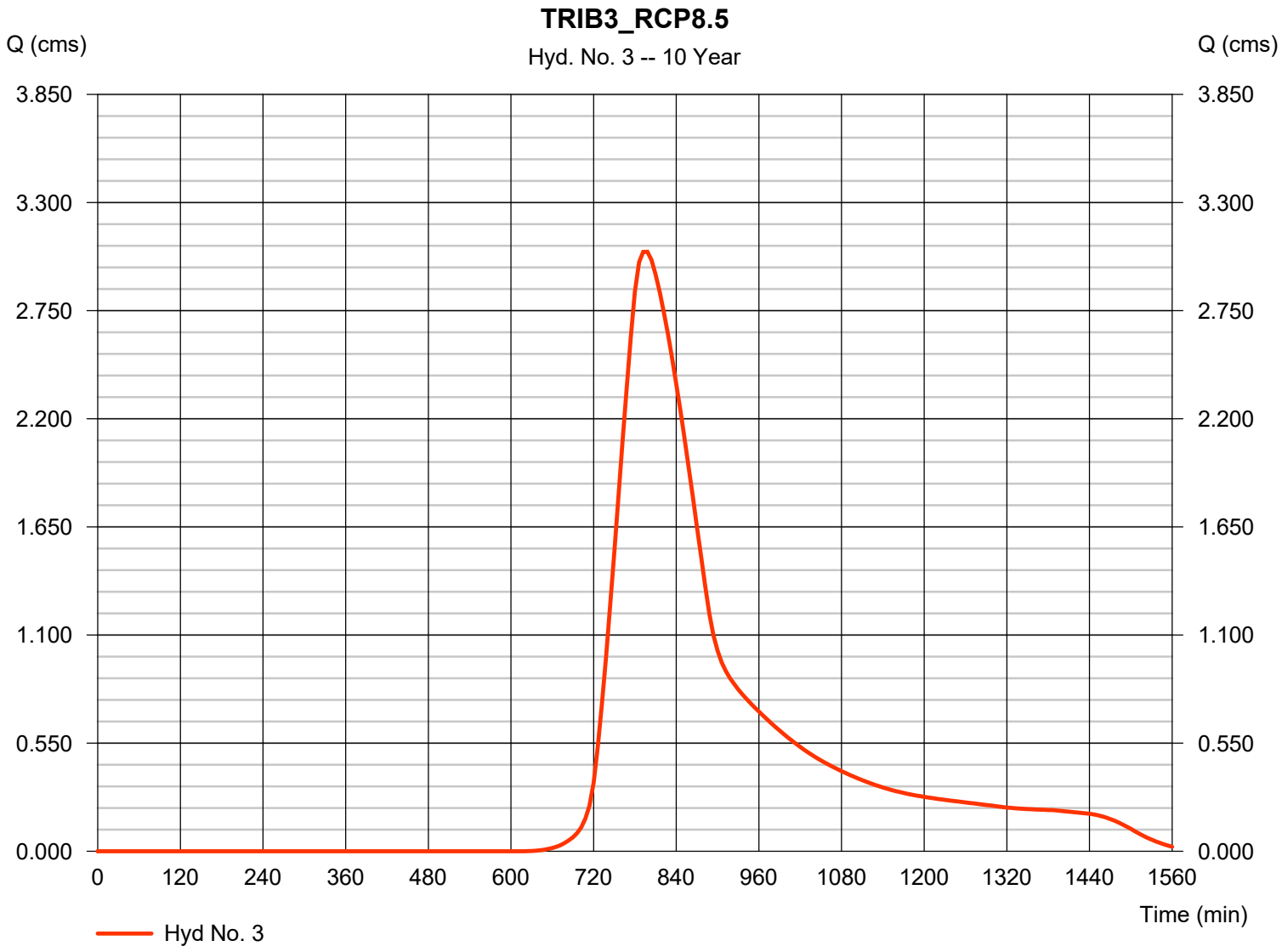


Hydrograph Report

Hyd. No. 3

TRIB3_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.049 cms
Storm frequency	=	10 yrs	Time to peak	=	798 min
Time interval	=	6 min	Hyd. volume	=	35,539.2 cum
Drainage area	=	113.300 hectare	Curve number	=	75
Basin Slope	=	4.3 %	Hydraulic length	=	2789 m
Tc method	=	LAG	Time of conc. (Tc)	=	104.79 min
Total precip.	=	87.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

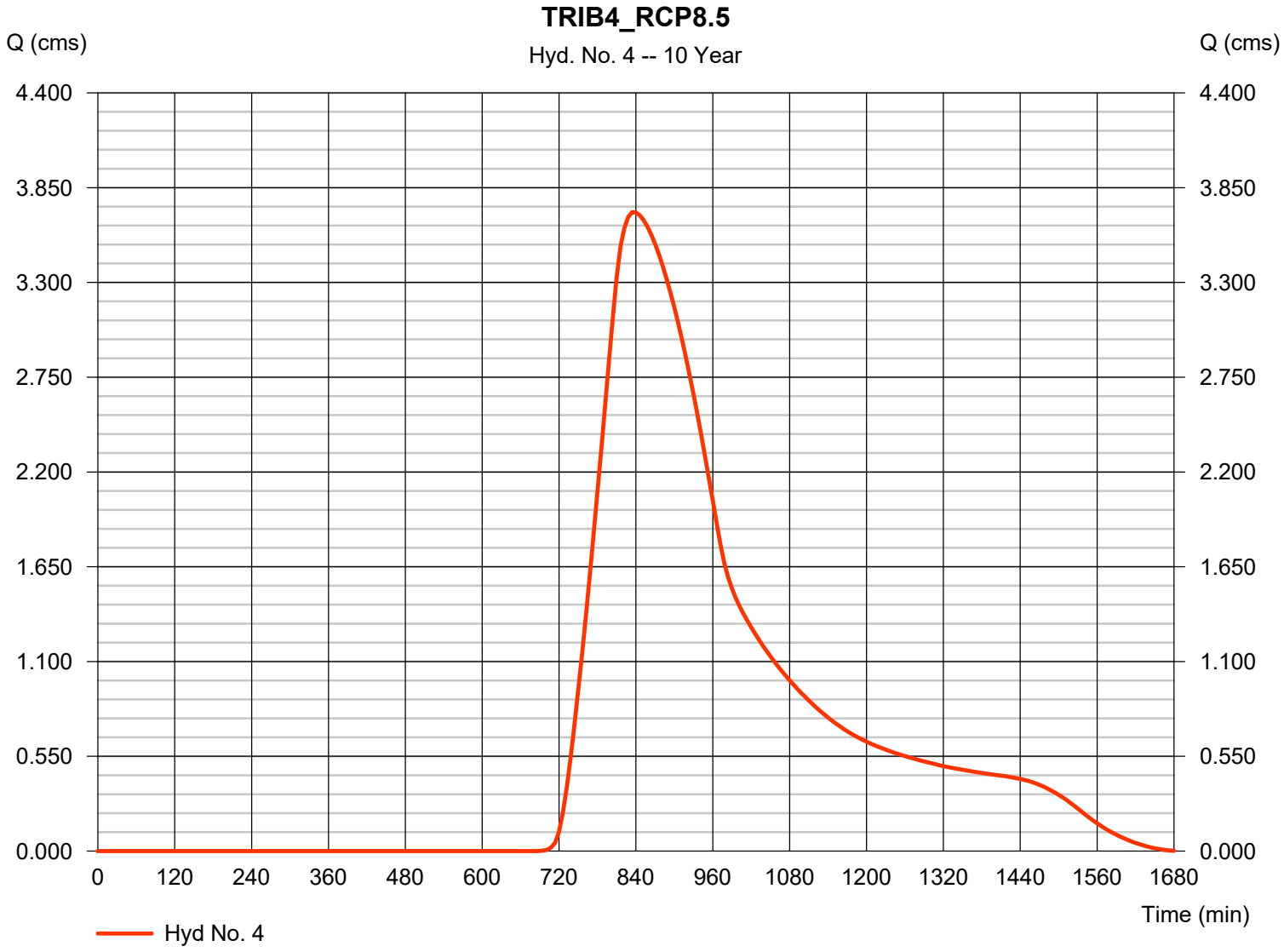


Hydrograph Report

Hyd. No. 4

TRIB4_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.707 cms
Storm frequency	=	10 yrs	Time to peak	=	834 min
Time interval	=	6 min	Hyd. volume	=	62,390.7 cum
Drainage area	=	284.000 hectare	Curve number	=	68
Basin Slope	=	3.5 %	Hydraulic length	=	3143 m
Tc method	=	LAG	Time of conc. (Tc)	=	154.94 min
Total precip.	=	87.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

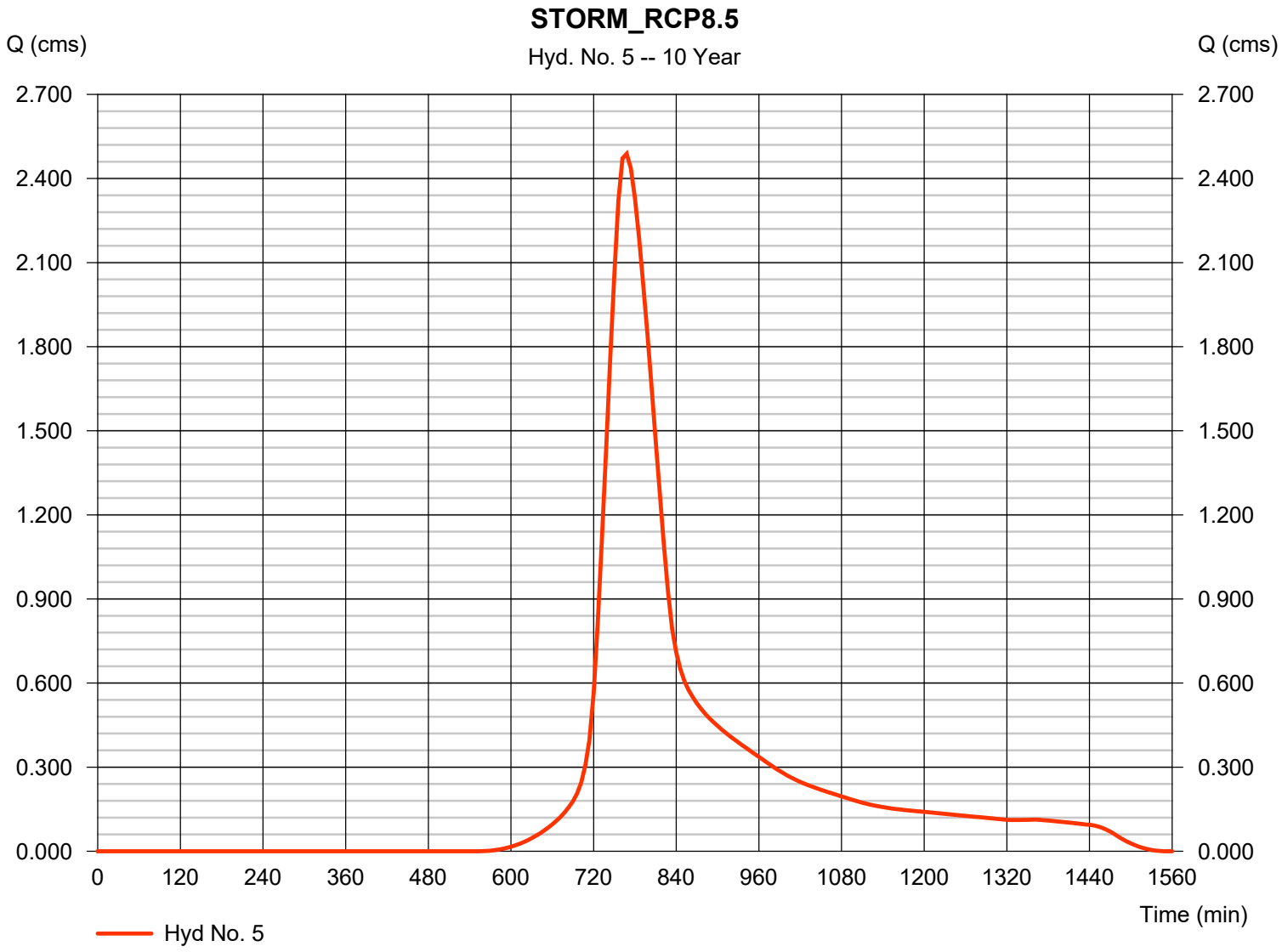


Hydrograph Report

Hyd. No. 5

STORM_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.488 cms
Storm frequency	=	10 yrs	Time to peak	=	768 min
Time interval	=	6 min	Hyd. volume	=	21,204.1 cum
Drainage area	=	52.000 hectare	Curve number	=	80
Basin Slope	=	1.5 %	Hydraulic length	=	1050 m
Tc method	=	LAG	Time of conc. (Tc)	=	69.93 min
Total precip.	=	87.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025

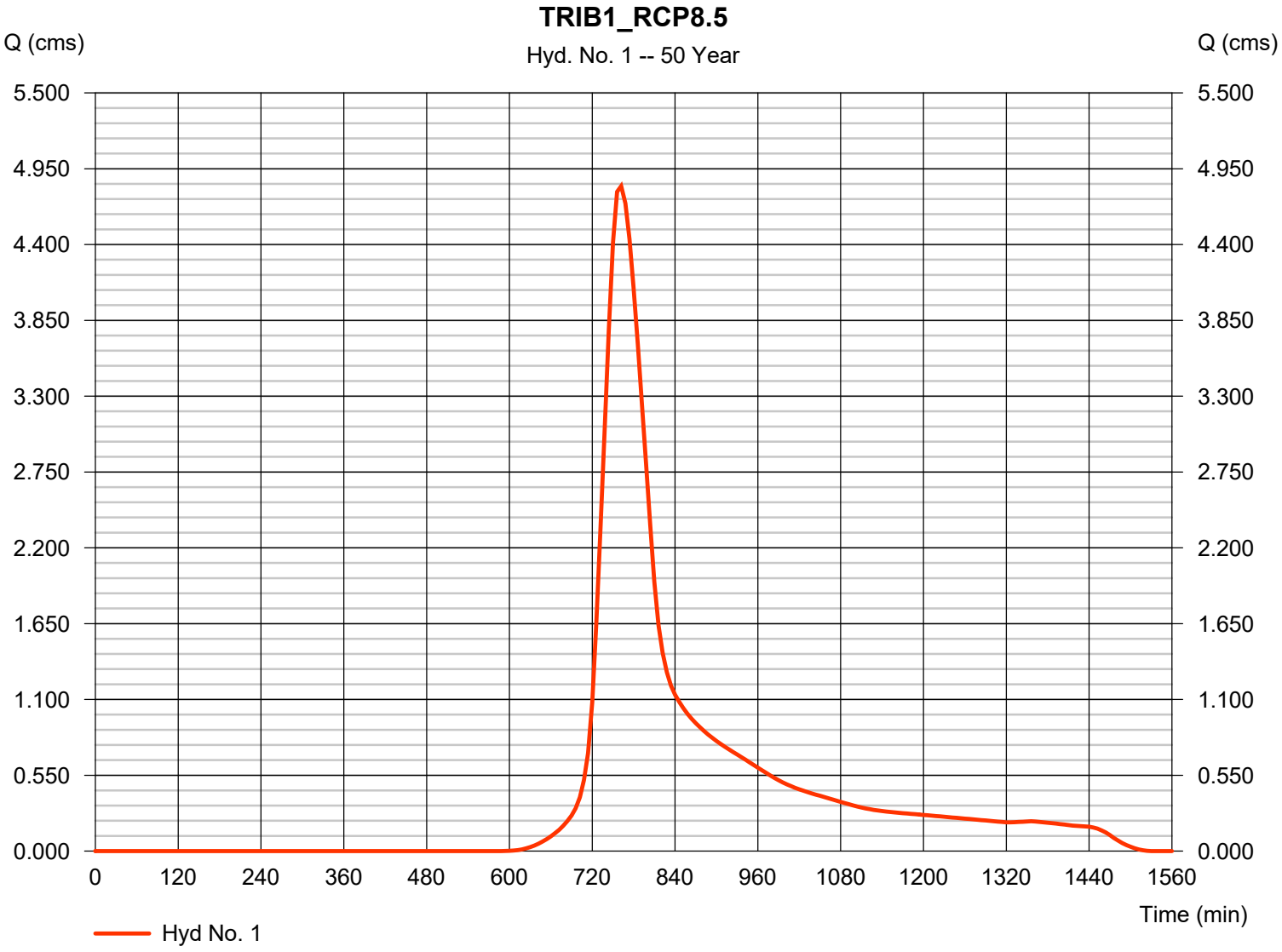
Hyd. No.	Hydrograph type (origin)	Peak flow (cms)	Time interval (min)	Time to Peak (min)	Hyd. volume (cum)	Inflow hyd(s)	Maximum elevation (m)	Total strge used (cum)	Hydrograph Description
1	SCS Runoff	4.824	6	762	37,477.7	------	------	------	TRIB1_RCP8.5
2	SCS Runoff	5.011	6	774	45,944.0	------	------	------	TRIB2_RCP8.5
3	SCS Runoff	6.487	6	792	72,419.5	------	------	------	TRIB3_RCP8.5
4	SCS Runoff	9.364	6	828	142,790.3	------	------	------	TRIB4_RCP8.5
5	SCS Runoff	4.787	6	762	40,280.0	------	------	------	STORM_RCP8.5

Hydrograph Report

Hyd. No. 1

TRIB1_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.824 cms
Storm frequency	=	50 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	37,477.7 cum
Drainage area	=	72.200 hectare	Curve number	=	69
Basin Slope	=	6.3 %	Hydraulic length	=	1425 m
Tc method	=	LAG	Time of conc. (Tc)	=	59.72 min
Total precip.	=	130.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

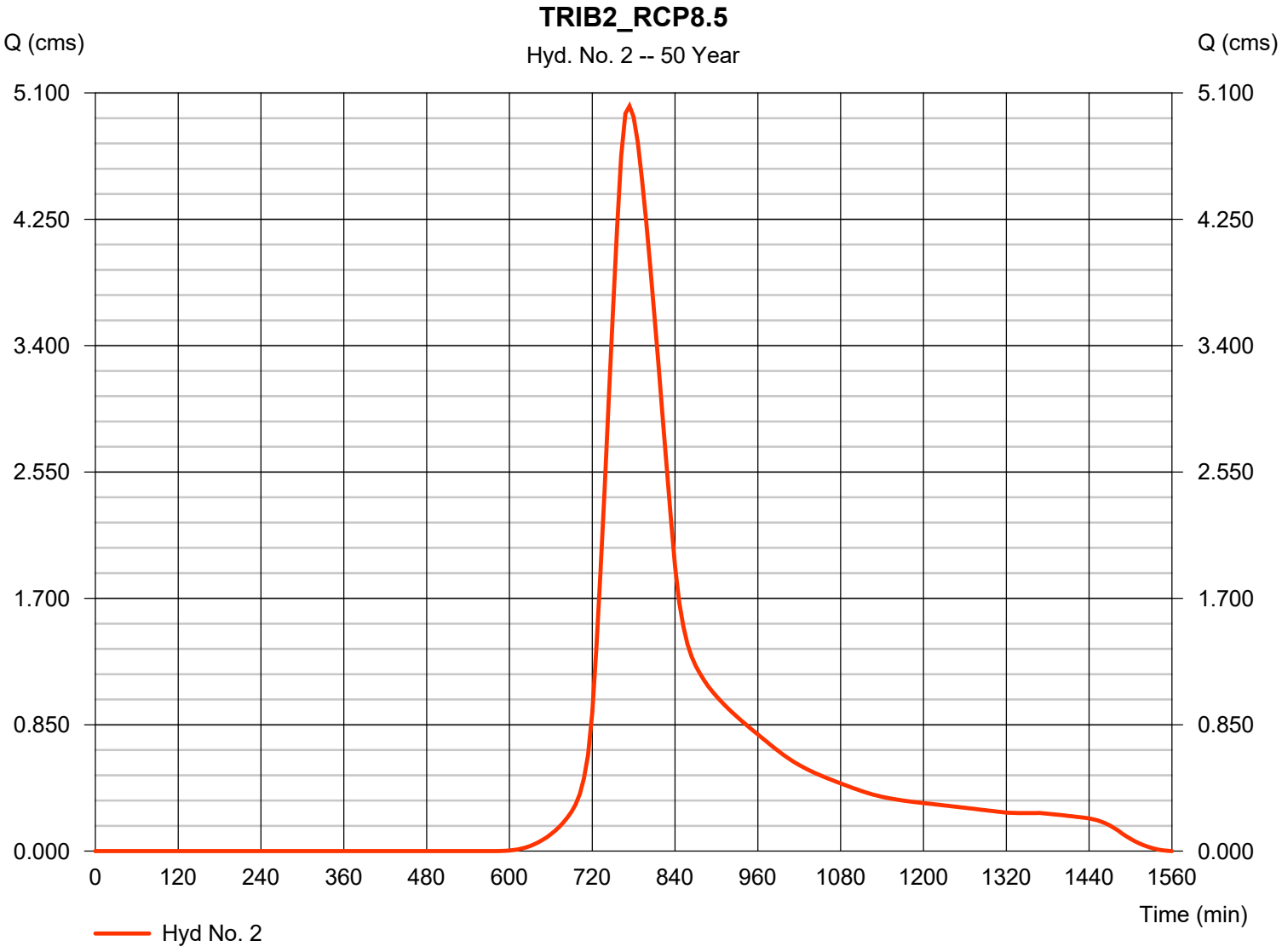


Hydrograph Report

Hyd. No. 2

TRIB2_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.011 cms
Storm frequency	=	50 yrs	Time to peak	=	774 min
Time interval	=	6 min	Hyd. volume	=	45,944.0 cum
Drainage area	=	86.500 hectare	Curve number	=	70
Basin Slope	=	5.5 %	Hydraulic length	=	1920 m
Tc method	=	LAG	Time of conc. (Tc)	=	78.98 min
Total precip.	=	130.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

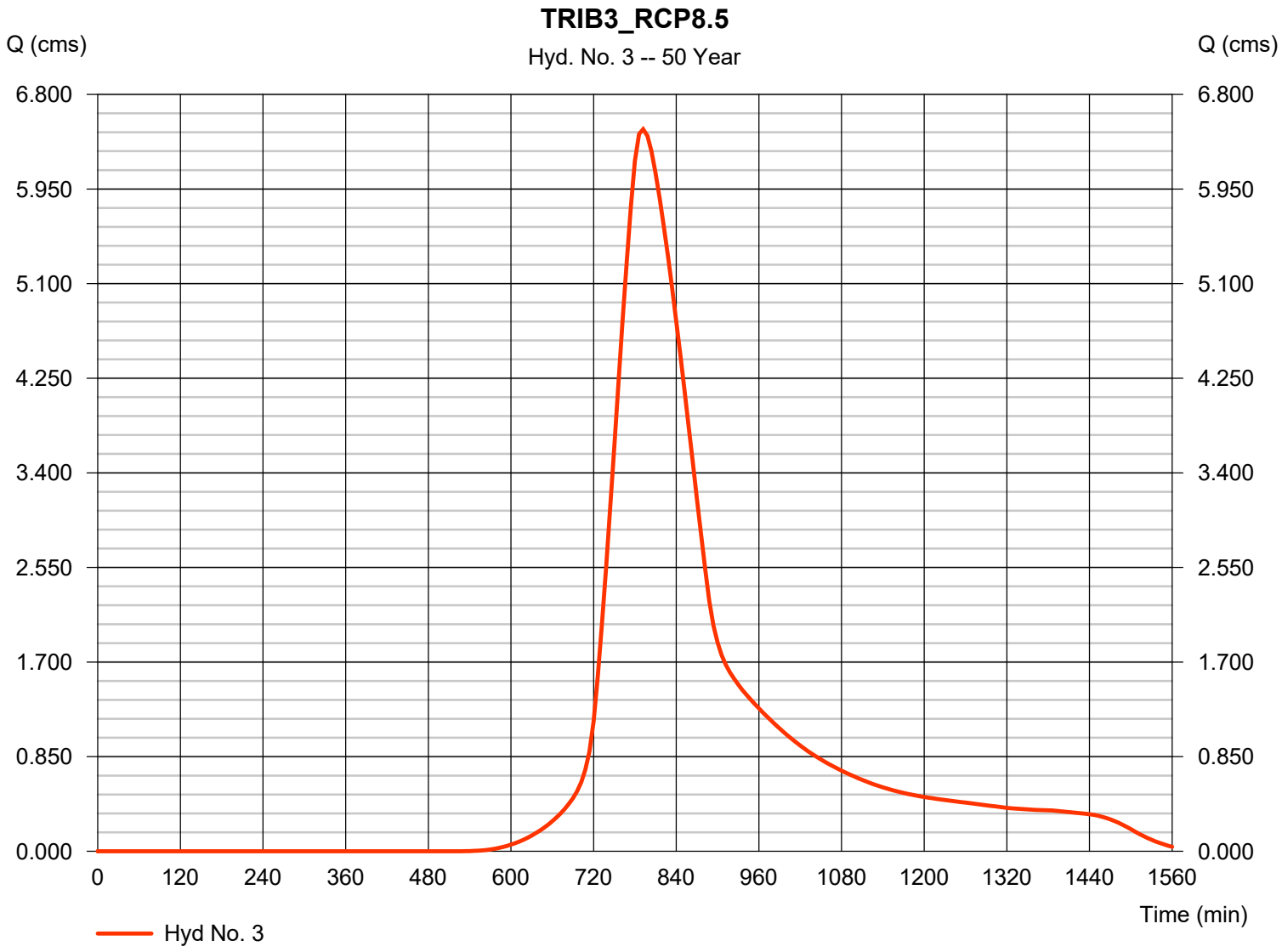


Hydrograph Report

Hyd. No. 3

TRIB3_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	6.487 cms
Storm frequency	=	50 yrs	Time to peak	=	792 min
Time interval	=	6 min	Hyd. volume	=	72,419.5 cum
Drainage area	=	113.300 hectare	Curve number	=	75
Basin Slope	=	4.3 %	Hydraulic length	=	2789 m
Tc method	=	LAG	Time of conc. (Tc)	=	104.79 min
Total precip.	=	130.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

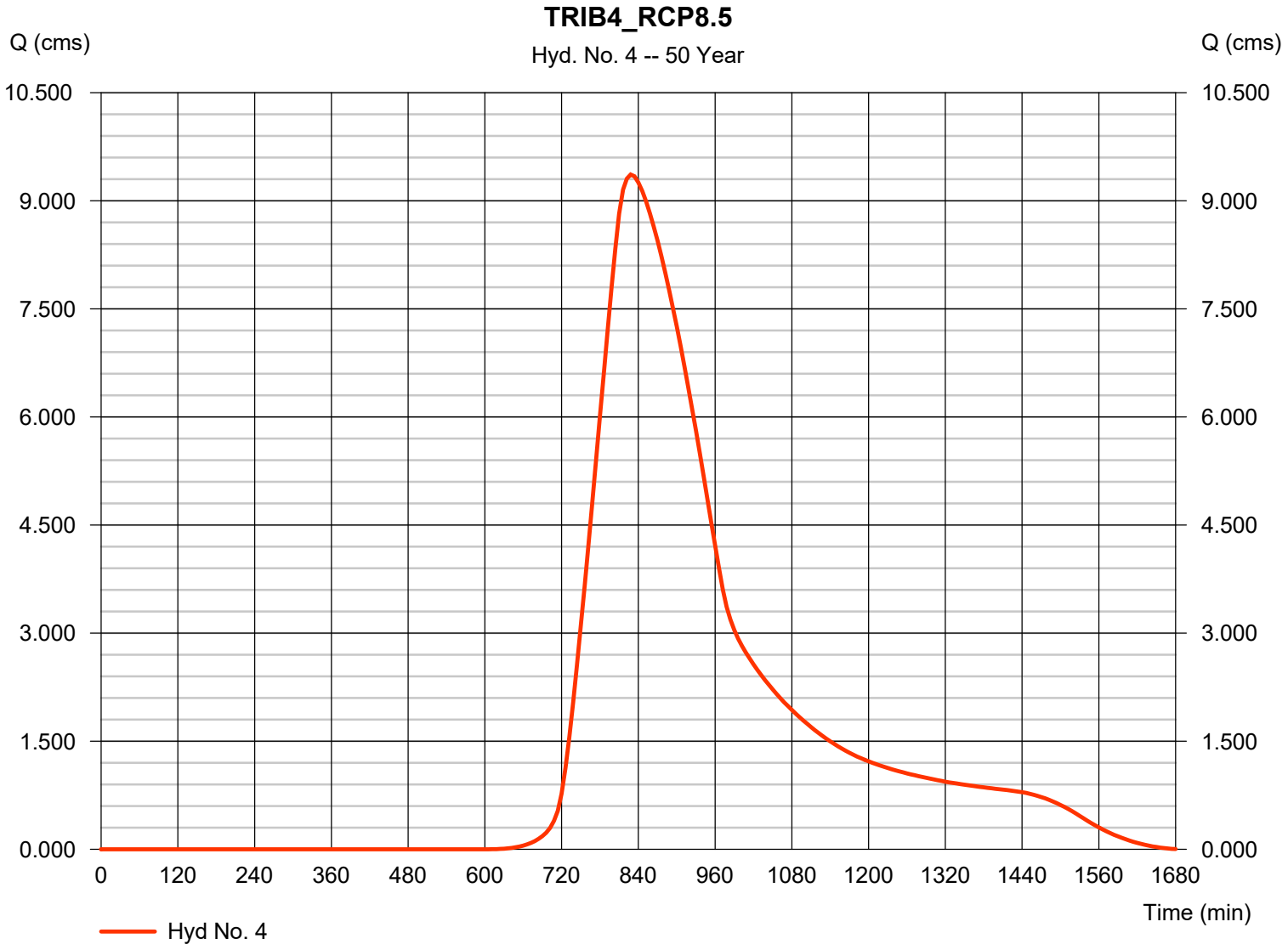


Hydrograph Report

Hyd. No. 4

TRIB4_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	9.364 cms
Storm frequency	=	50 yrs	Time to peak	=	828 min
Time interval	=	6 min	Hyd. volume	=	142,790.3 cum
Drainage area	=	284.000 hectare	Curve number	=	68
Basin Slope	=	3.5 %	Hydraulic length	=	3143 m
Tc method	=	LAG	Time of conc. (Tc)	=	154.94 min
Total precip.	=	130.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

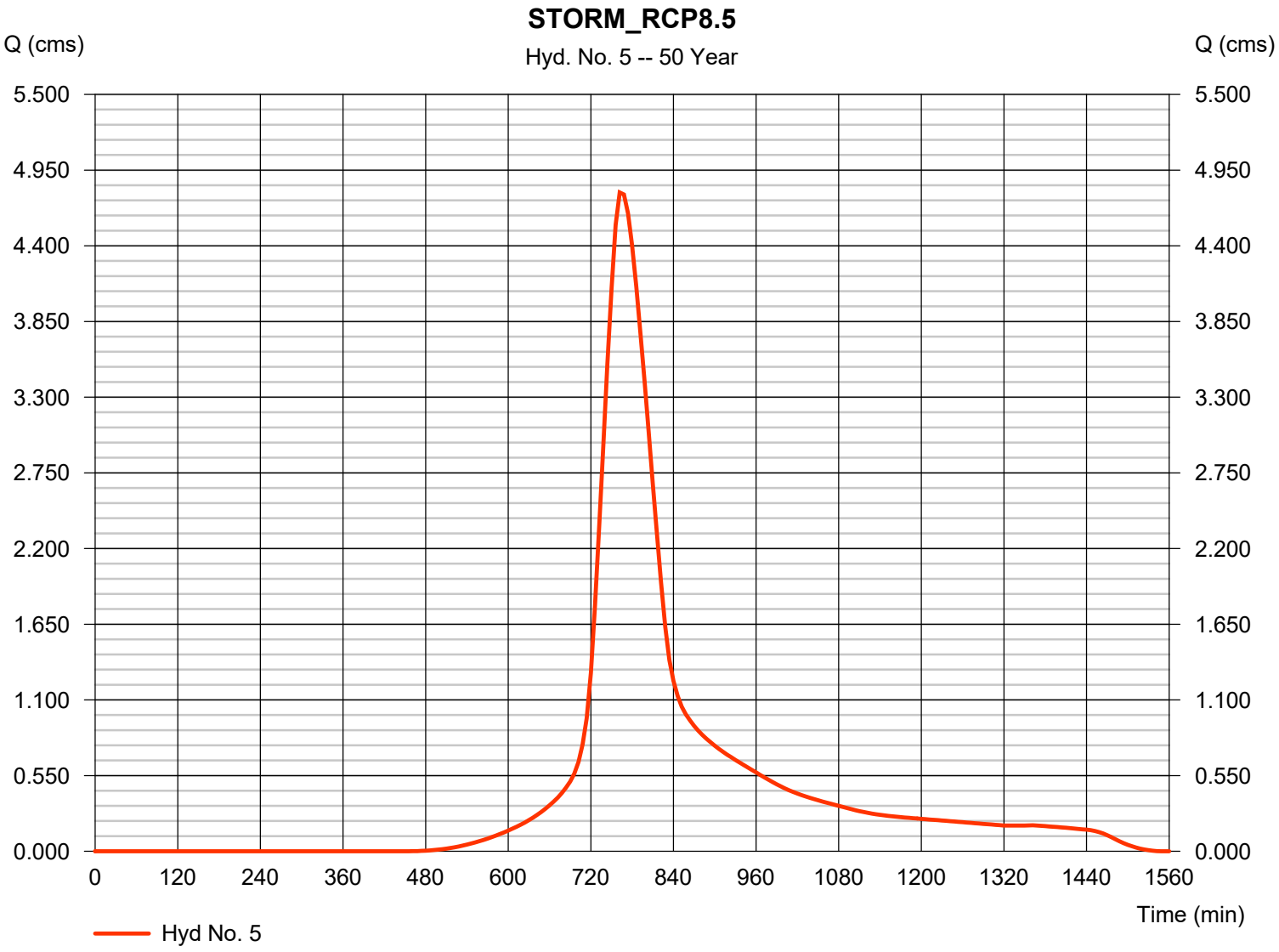


Hydrograph Report

Hyd. No. 5

STORM_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.787 cms
Storm frequency	=	50 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	40,280.0 cum
Drainage area	=	52.000 hectare	Curve number	=	80
Basin Slope	=	1.5 %	Hydraulic length	=	1050 m
Tc method	=	LAG	Time of conc. (Tc)	=	69.93 min
Total precip.	=	130.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2025

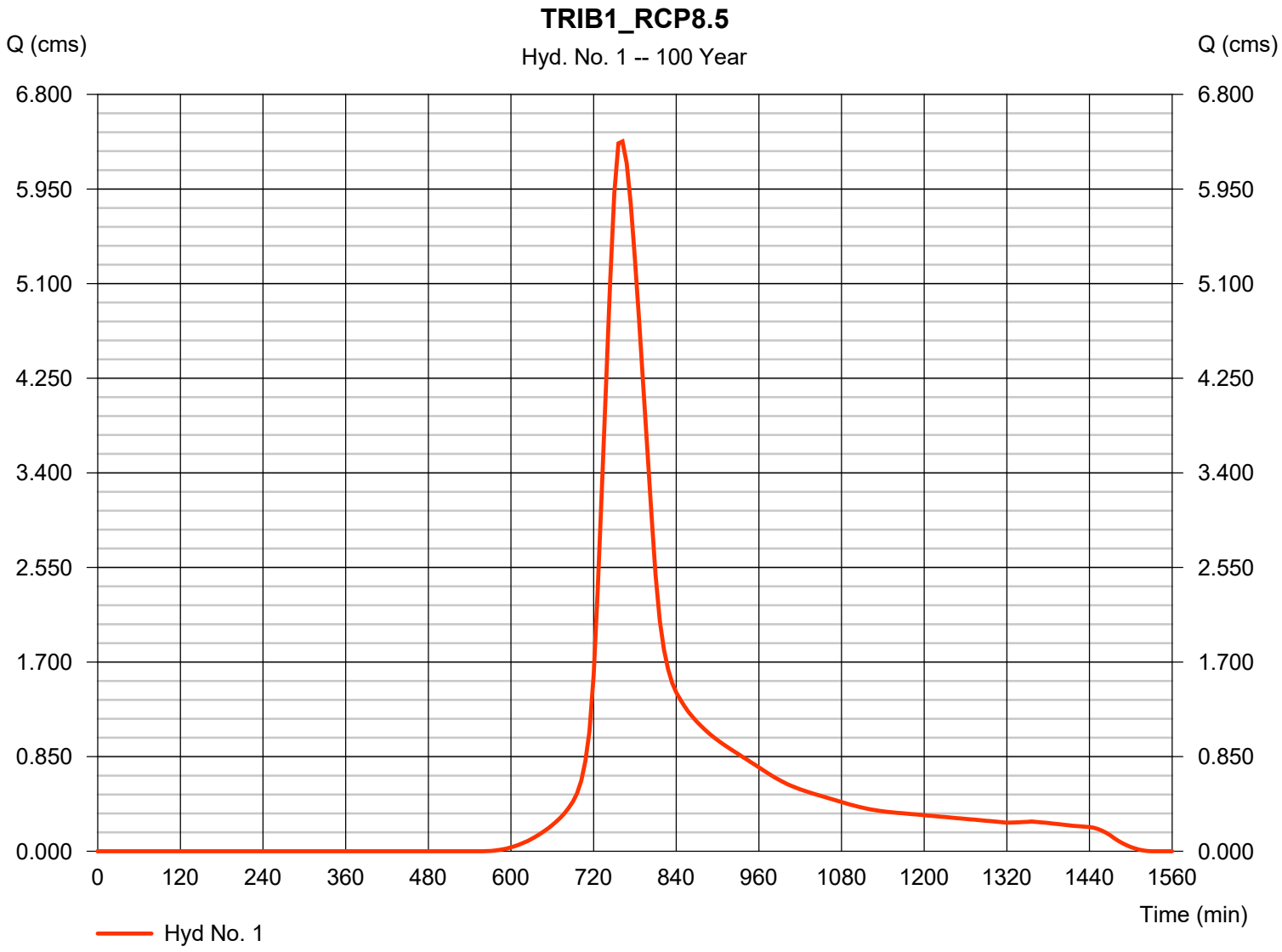
Hyd. No.	Hydrograph type (origin)	Peak flow (cms)	Time interval (min)	Time to Peak (min)	Hyd. volume (cum)	Inflow hyd(s)	Maximum elevation (m)	Total strge used (cum)	Hydrograph Description
1	SCS Runoff	6.377	6	762	48,957.0	------	------	------	TRIB1_RCP8.5
2	SCS Runoff	6.592	6	774	59,725.5	------	------	------	TRIB2_RCP8.5
3	SCS Runoff	8.292	6	792	92,043.8	------	------	------	TRIB3_RCP8.5
4	SCS Runoff	12.54	6	828	187,463.3	------	------	------	TRIB4_RCP8.5
5	SCS Runoff	5.966	6	762	50,166.7	------	------	------	STORM_RCP8.5

Hydrograph Report

Hyd. No. 1

TRIB1_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	6.377 cms
Storm frequency	=	100 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	48,957.0 cum
Drainage area	=	72.200 hectare	Curve number	=	69
Basin Slope	=	6.3 %	Hydraulic length	=	1425 m
Tc method	=	LAG	Time of conc. (Tc)	=	59.72 min
Total precip.	=	151.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

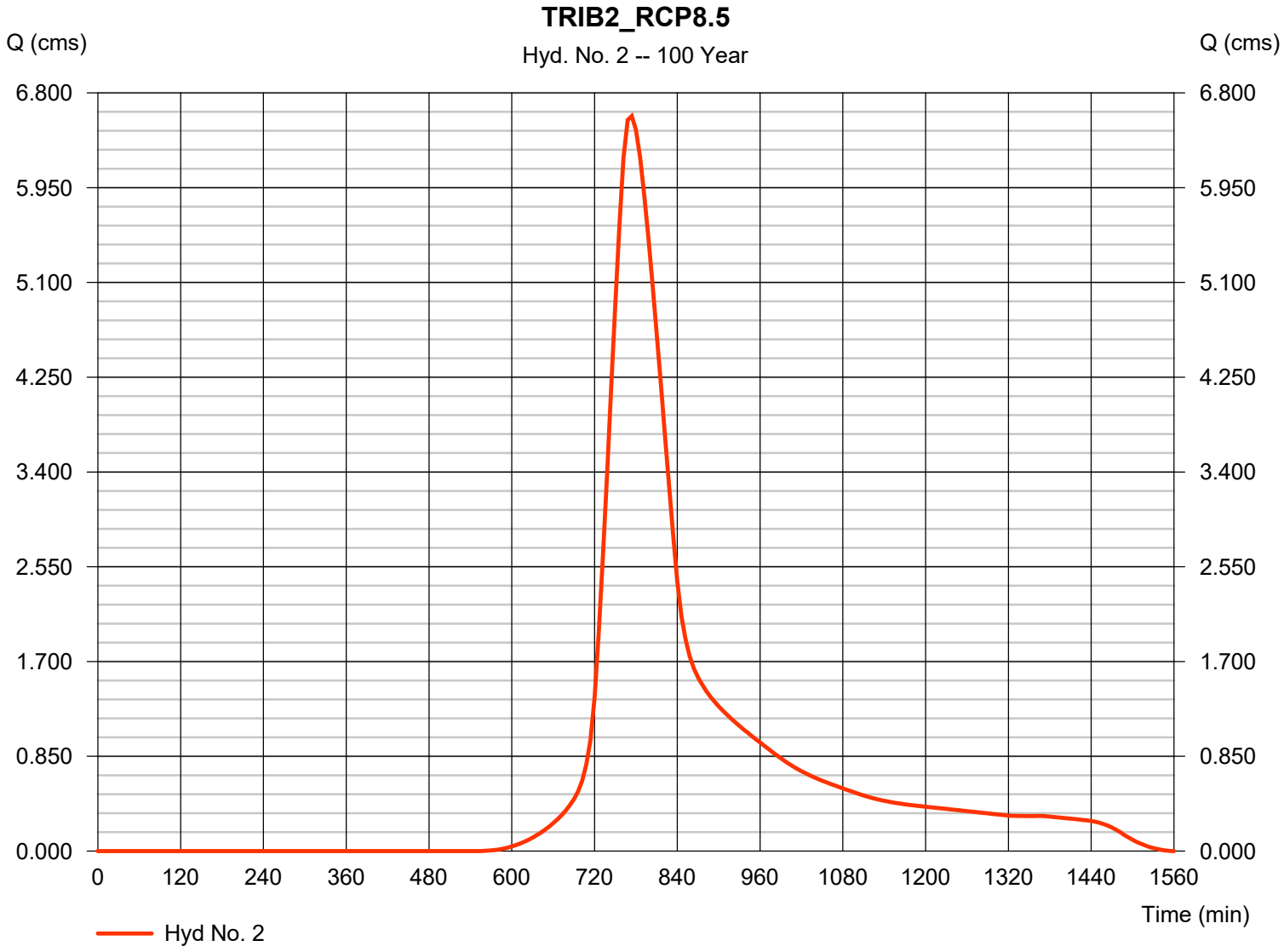


Hydrograph Report

Hyd. No. 2

TRIB2_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	6.592 cms
Storm frequency	=	100 yrs	Time to peak	=	774 min
Time interval	=	6 min	Hyd. volume	=	59,725.5 cum
Drainage area	=	86.500 hectare	Curve number	=	70
Basin Slope	=	5.5 %	Hydraulic length	=	1920 m
Tc method	=	LAG	Time of conc. (Tc)	=	78.98 min
Total precip.	=	151.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

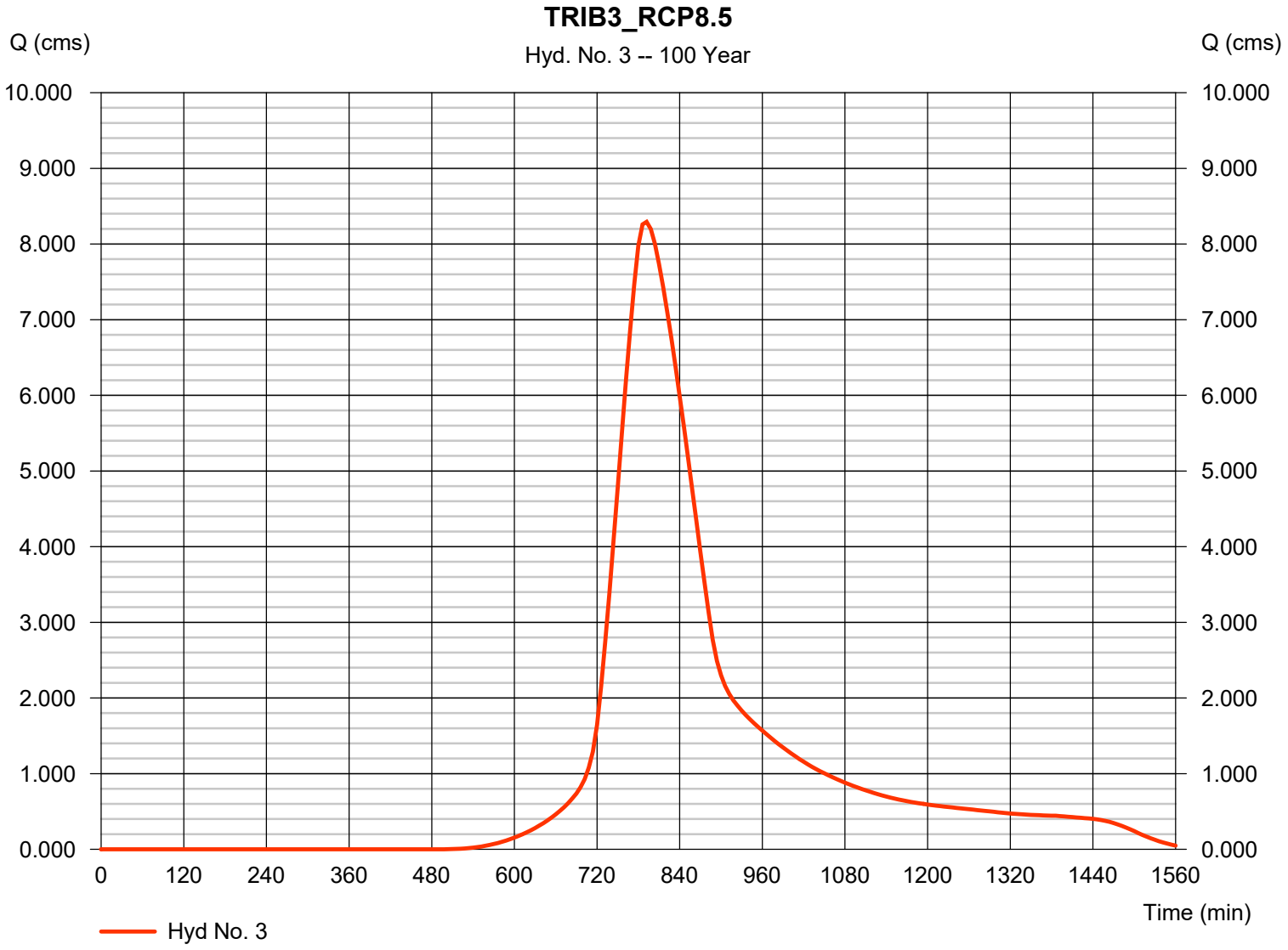


Hydrograph Report

Hyd. No. 3

TRIB3_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	8.292 cms
Storm frequency	=	100 yrs	Time to peak	=	792 min
Time interval	=	6 min	Hyd. volume	=	92,043.8 cum
Drainage area	=	113.300 hectare	Curve number	=	75
Basin Slope	=	4.3 %	Hydraulic length	=	2789 m
Tc method	=	LAG	Time of conc. (Tc)	=	104.79 min
Total precip.	=	151.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

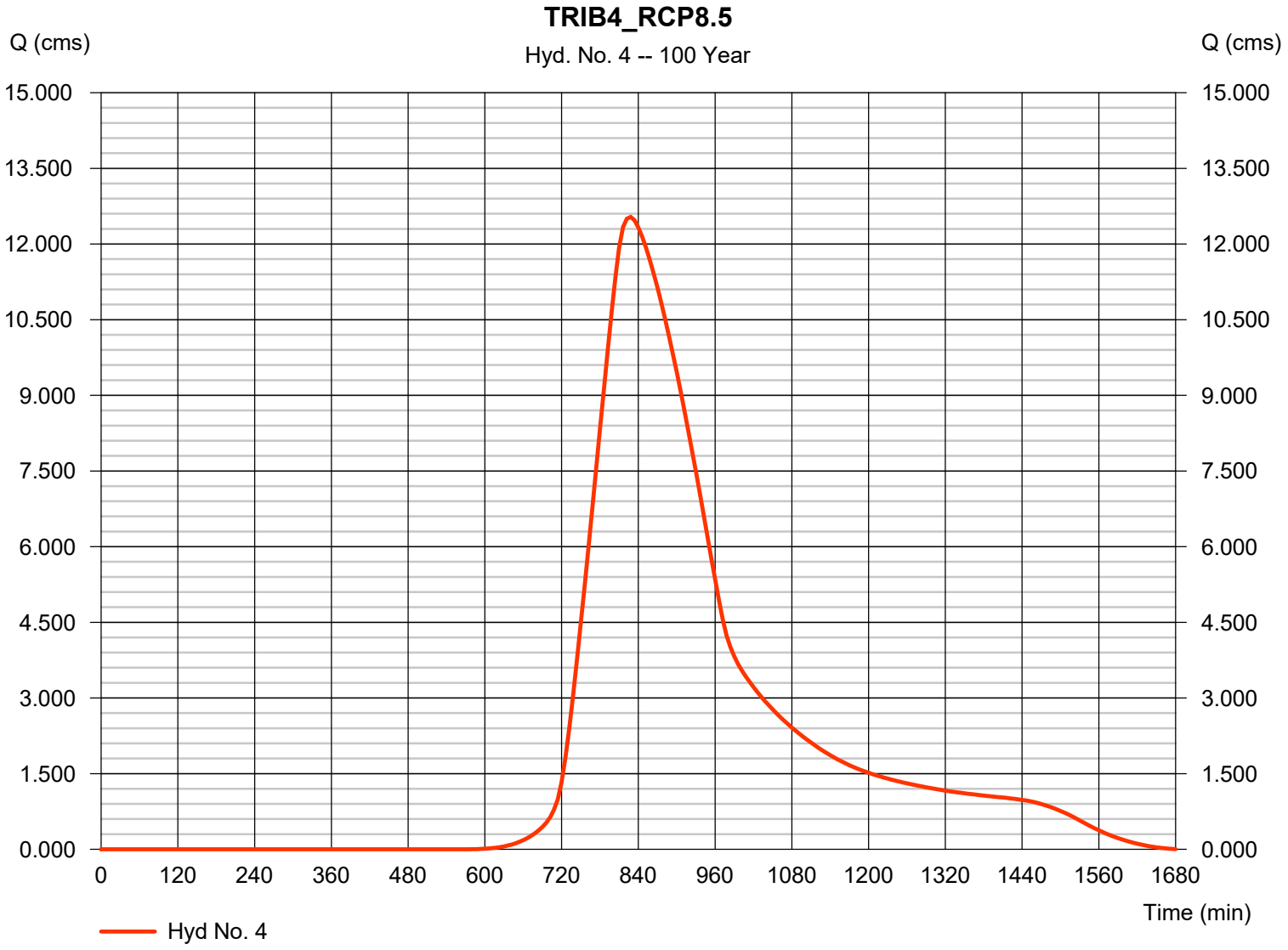


Hydrograph Report

Hyd. No. 4

TRIB4_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	12.54 cms
Storm frequency	=	100 yrs	Time to peak	=	828 min
Time interval	=	6 min	Hyd. volume	=	187,463.3 cum
Drainage area	=	284.000 hectare	Curve number	=	68
Basin Slope	=	3.5 %	Hydraulic length	=	3143 m
Tc method	=	LAG	Time of conc. (Tc)	=	154.94 min
Total precip.	=	151.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484

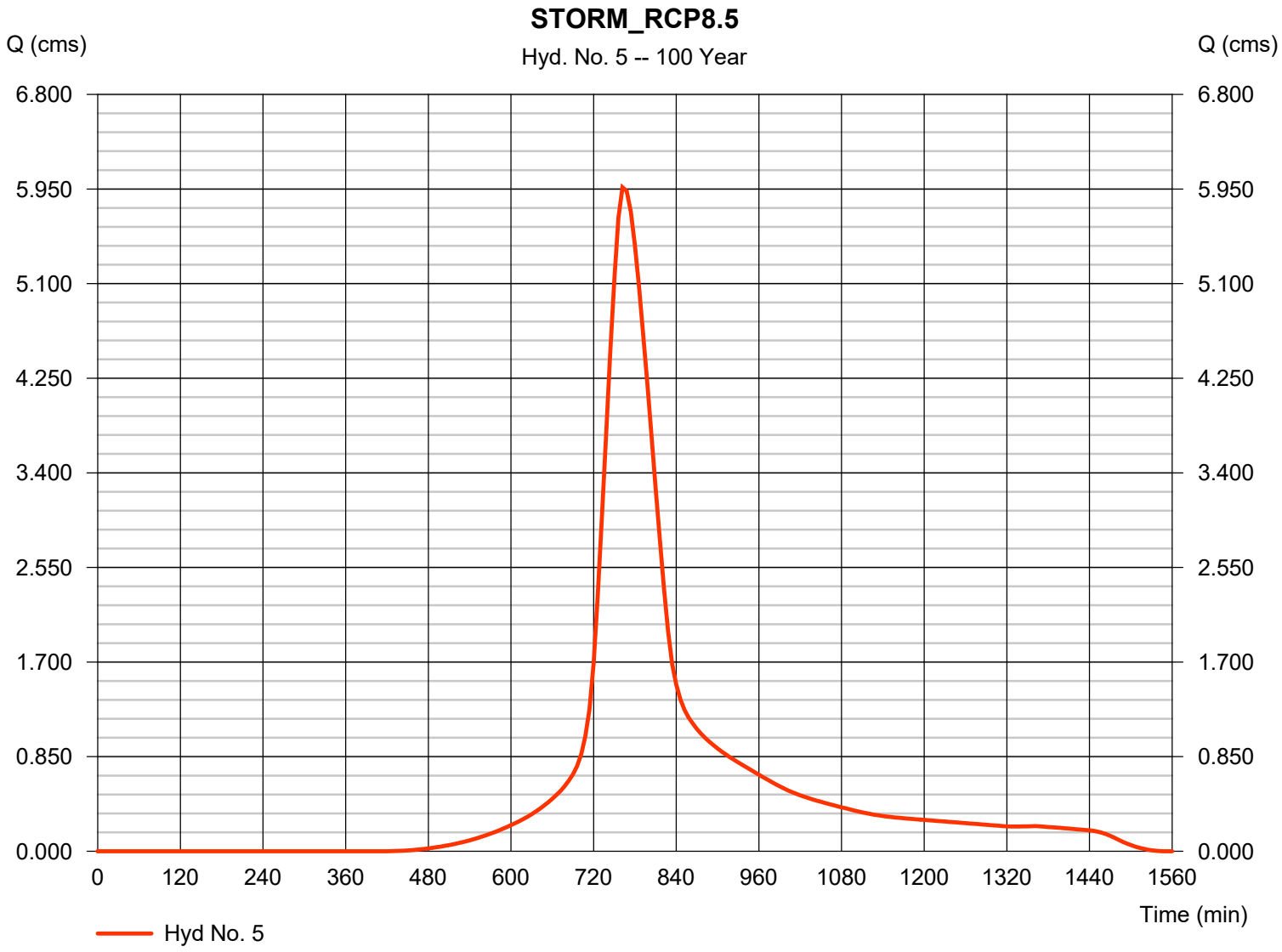


Hydrograph Report

Hyd. No. 5

STORM_RCP8.5

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.966 cms
Storm frequency	=	100 yrs	Time to peak	=	762 min
Time interval	=	6 min	Hyd. volume	=	50,166.7 cum
Drainage area	=	52.000 hectare	Curve number	=	80
Basin Slope	=	1.5 %	Hydraulic length	=	1050 m
Tc method	=	LAG	Time of conc. (Tc)	=	69.93 min
Total precip.	=	151.00 mm	Distribution	=	Type III
Storm duration	=	24 hrs	Shape factor	=	484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	177.4706	33.2740	2.1992	--------
3	0.0000	0.0000	0.0000	--------
5	201.3197	37.0841	2.1257	--------
10	224.1172	39.3700	2.1029	--------
25	260.6223	41.9101	2.0871	--------
50	291.6410	43.6881	2.0824	--------
100	322.9854	45.2121	2.0794	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (mm/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0	0	0	0	0	0	0	0	0	0	0	0
2	145	117	99	86	76	68	62	57	53	49	46	43
3	0	0	0	0	0	0	0	0	0	0	0	0
5	167	138	118	104	93	84	77	71	66	62	58	55
10	184	153	132	117	105	95	87	81	75	70	66	62
25	209	176	153	136	122	111	102	95	88	83	78	74
50	230	194	169	150	136	124	114	106	99	93	87	83
100	250	212	185	165	149	136	126	117	109	102	97	91

Tc = time in minutes. Values may exceed 60.

Precip. file name: C:\Users\nathan.anderson\OneDrive - Otago Regional Council\GIS\OamaRu_RCP8.5.pcp

Storm Distribution	Rainfall Precipitation Table (mm)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	0	49	0	68	87	0	130	151
SCS 6-Hr	0	0	0	0	0	0	0	0
Huff-1st	0	0	0	0	0	0	0	0
Huff-2nd	0	0	0	0	0	0	0	0
Huff-3rd	0	0	0	0	0	0	0	0
Huff-4th	0	0	0	0	0	0	0	0
Huff-Indy	0	0	0	0	0	0	0	0
Custom	0	0	0	0	0	0	0	0