



Nose Creek Hydrologic, Hydraulic, and Water Quality Model

Phase II: Model Development, HEC-RAS Model Component

Prepared for
Nose Creek Watershed Partnership (NCWP)

January 30, 2024

Foreword



The Nose Creek Hydrologic, Hydraulic, and Water Quality Model project (Model Project) was ranked by the Nose Creek Watershed Partnership (NCWP) as the highest priority recommendation in the updated Nose Creek Watershed Water Management Plan (2018). The project's Phase I: Model Scoping Study was completed in 2020. The Nose Creek Model Project (Phase II: Model Development) was completed in December 2022. Following several conversations with the NCWP Technical Team members during the Model Development phase, the scope of Phase II was changed. The HEC-RAS modeling was deferred to develop it as a full-scale model that can be run separately as an event-based model. The full-scale HEC-RAS model allows the NCWP to make use of the high-quality bathymetric survey that was completed to support the development of the model. It will also better capture a wide range of processes for both low-flow and high-flow events. This report was prepared by Barr Engineering and Environmental Science Canada Ltd. (Barr) to document the HEC-RAS model creation and calibration of Nose and West Nose creeks.

Nose Creek Hydrologic, Hydraulic, and Water Quality Model Phase II: Model Development, HEC-RAS Model Component

January 30, 2024 - Final

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Certification

Hossein Kheirkhah Gildeh

January 30, 2024

Date

Abbreviations

1D	One-dimensional
2D	Two-dimensional
AAFC	Agriculture and Agri Food Canada
AEP	Annual Exceedance Probability
AEPA	Alberta Environment and Protected Areas
CPR	Canadian Pacific Railway
DTM	Digital Terrain Model
EFDC	Environmental Fluid Dynamics Code
FAMA	Flood Awareness Map Application
GIS	Geographic Information System
HWM	Highwater Mark
HWY	Highway
LiDAR	Light Detection and Ranging
LPI	Local Partial Inertia
MASL	Meters Above Sea Level
NCMP	Nose Creek Model Project
NCWP	Nose Creek Watershed Partnership
PCSWMM	CHI Water EPA SWMMM5 Software
PM	Project Manager
Q	Flow
QA/QC	Quality Assurance and Quality Control
Rd	Road
RMSE	Root Means Square Error
SWAT	Soil & Water Assessment Tool
SWE-ELM	Shallow Water Equations – Eulerian-Lagrangian Method
TWP	Township
USACE	United States Army Corps of Engineers
WL	Water Level
WSC	Water Survey Canada

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Executive Summary

The Nose Creek Hydrologic, Hydraulic, and Water Quality Model project (Nose Creek Model Project; NCMP) was ranked by the Nose Creek Watershed Partnership (NCWP) as the highest priority recommendation in the updated Nose Creek Watershed Water Management Plan (2018). The project's Phase I: Model Scoping Study was completed in 2020. The Nose Creek Model Project (Phase II) was completed in December 2022. Following several conversations with the NCWP Technical Team members during the Model Development phase, the scope of Phase II was changed. The HEC-RAS modeling was deferred to develop it as a model that can be run separately as an event-based model. The HEC-RAS model allows the NCWP to make use of the high-quality bathymetric survey that was completed to support the development of the model. It will also better capture a wide range of processes for both low-flow and high-flow events.

This report documents the methodology and results for tasks completed as part of this study. The study tasks include the following:

- Project data compilation
- Hydraulic model construction
- Hydraulic model calibration
- Hydraulic model sensitivity analysis
- Hydraulic model infrequent flood simulations

The Nose Creek headwaters originate near the northern boundary of Rocky View County and the Town of Crossfield. Nose Creek is approximately 75 km long and flows southward, passing through the City of Airdrie and the City of Calgary before discharging into the Bow River just East of the Calgary Zoo. Nose Creek has a gross drainage area of 989 km² and an effective drainage area of about 743 km². Most tributaries of Nose Creek are ephemeral. West Nose Creek, with a total length of about 65 km, is the main perennial tributary of Nose Creek and drains approximately 33% of the entire watershed. The gross drainage area of West Nose Creek is approximately 325 km², with an effective drainage area of about 217 km².

A coupled 1D/2D HEC-RAS modeling approach was initially adopted after discussions with the NCWP to better capture a wide range of processes for both low-flow (within main channel) and high-flow (overtopping banks into floodplain) events. Due to undefined channels in the upper-most reaches of Nose and West Nose Creeks, a full 2D modeling approach was adopted for approximately 12 km of Nose Creek and approximately 30 km of West Nose Creek. This model was tested for flows up to approximately 25 m³/s at the outlet of Nose Creek (i.e., Nose Creek at the Mouth). In spite of investing considerable time to improve the model, it was deemed that significant additional effort would be necessary to achieve adequate model stability to run it to completion for higher flows. Barr discussed potential options with the NCWP to overcome the stability issues for very low and high flows. One of the options discussed was a full 2D model that runs for a range of flows from very low flows to an extreme flood event. This report

summarizes the efforts for both modeling approaches (i.e., coupled 1D/2D HEC-RAS model and full 2D HEC-RAS model).

Bathymetric data for the study area was collected by Compass Geomatics (Compass), and the LiDAR data was provided by the NCWP. The hydraulic features in this study are summarized in Table i, which shows that the hydraulic model is complex with over 168 hydraulic structures.

Table i **Summary of Survey Features**

Feature	Nose Creek	West Nose Creek	Total
Cross-Sections	3,875	6,800	10,675
Bridges	71	64	135
Culverts	17	14	31
Dams/Weirs	2	0	2

The preliminary coupled 1D/2D model consisted of 7,488 cross-sections in the 1D areas (2,913 cross-sections on the Nose Creek and 4,575 cross-sections on the West Nose Creek). This preliminary model included a total number of 227,331 cells ranging from 1 m to 50 m for the 2D areas of the model for floodplains. A numerical time step of 10 s was used in the full unsteady flow model.

The final full 2D model consists of 443,000 cells with sizes ranging from 2 m in the main channel to 25 m on the floodplain close to the model domain boundaries. All hydraulic structures were implemented in the 2D model using 2D connections. The full 2D model has a large domain and, therefore, model run times are long. Low-flow events can take up to 2 weeks of simulation time to reach a steady-state solution. To help reduce model runtime, restart files were used to initialize the model. During model construction and initial testing, a series of time steps were tested starting from 10 seconds. Given the size of the model and the variety of mesh sizes and flow conditions throughout, a small time step of one second is required.

The 2D model is capable of modeling flows from approximately 0.2 m³/s up to 407 m³/s (and potentially higher that are not tested) at the mouth of Nose Creek. However, the model begins to be unstable once flow enters extreme low-flow conditions below 0.05 m³/s. Therefore, a threshold was established for the modeling, limiting flow to greater than 0.05 m³/s. In regions where the flow is below the threshold, these areas are modeled as dry.

Since there was no highwater mark (HWM) available along the Nose and West Nose creeks, the hydrometric gauge data were used to calibrate the model for low-flow and moderate-flow conditions. Five calibration scenarios were selected in this study (two low-flow scenarios and three moderate-flow scenarios). The calibrated Nose Creek and West Nose Creek channel Manning's *n* values are in the range of 0.04 to 0.055 for calibration flow conditions. The calibrated model was used to simulate the water surface profiles for three infrequent flood events in the study area: "high" (Q=36.1 m³/s at Nose Creek at the Mouth), "very high" (Q=130.0 m³/s at Nose Creek at the Mouth), and "extreme" (Q=407.0 m³/s at Nose Creek at the Mouth).

The model sensitivity was evaluated using the “very high” ($Q=130.0 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth) flood simulation results. The results of the sensitivity analysis show that variation of the channel roughness values has a higher influence on the simulated water levels than variation of the floodplain roughness, as expected. However, overall model sensitivity to roughness remained low.

1 Introduction

The Nose Creek Hydrologic, Hydraulic, and Water Quality Model project (Nose Creek Model Project; NCMP) was ranked by the Nose Creek Watershed Partnership (NCWP) as the highest priority recommendation in the updated Nose Creek Watershed Water Management Plan (PESL, 2018). The project's Phase I: Model Scoping Study was completed in 2020. The Model Scoping Study proposed the use of four models to best describe the Nose Creek watershed hydrology, hydraulics, and water quality: the PCWSMM and SWAT models for urban and rural hydrology, respectively, the HEC-RAS model for instream hydrodynamics, and the EFDC model for water quality.

The Nose Creek Model Project (Phase II: Model Development) was completed in December 2022. The original scope of work for the NCMP Phase II included the development of a HEC-RAS model for the hydrodynamics of Nose and West Nose creeks, as well as the development of an EFDC model for the water quality of selected reaches (of water quality importance). However, through discussion between Barr and NCWP during Phase II, the NCWP recommended a different modeling approach. In the new approach, pollutant transport and in-stream water quality processes in Nose and West Nose creeks will be modeled by the watershed-scale EFDC model in Phase III, rather than the original scope where conservative water quality constituents were routed through the HEC-RAS model. A separate and stand-alone HEC-RAS model with finer resolution would be developed to help the NCWP with future assessment and project designs, as aimed for in Phases III, IV and V of the project (such as channel morphology evaluation, stream bed scour, stream bank erosion and protection, flood assessment, etc.). The HEC-RAS model was built to a fine resolution that was obtained by the bathymetric survey conducted in 2021. This survey produced 10,675 cross-sections which captures the creeks numerous riffle and pool sections. Therefore, the purpose of this study was to create and calibrate an event-based HEC-RAS model that can be used for the management of Nose Creek and West Nose Creek such as channel morphology evaluation, stream bed scour, stream bank erosion and protection, flood assessment.

This report describes the development of the HEC-RAS model.

1.1 Study Tasks

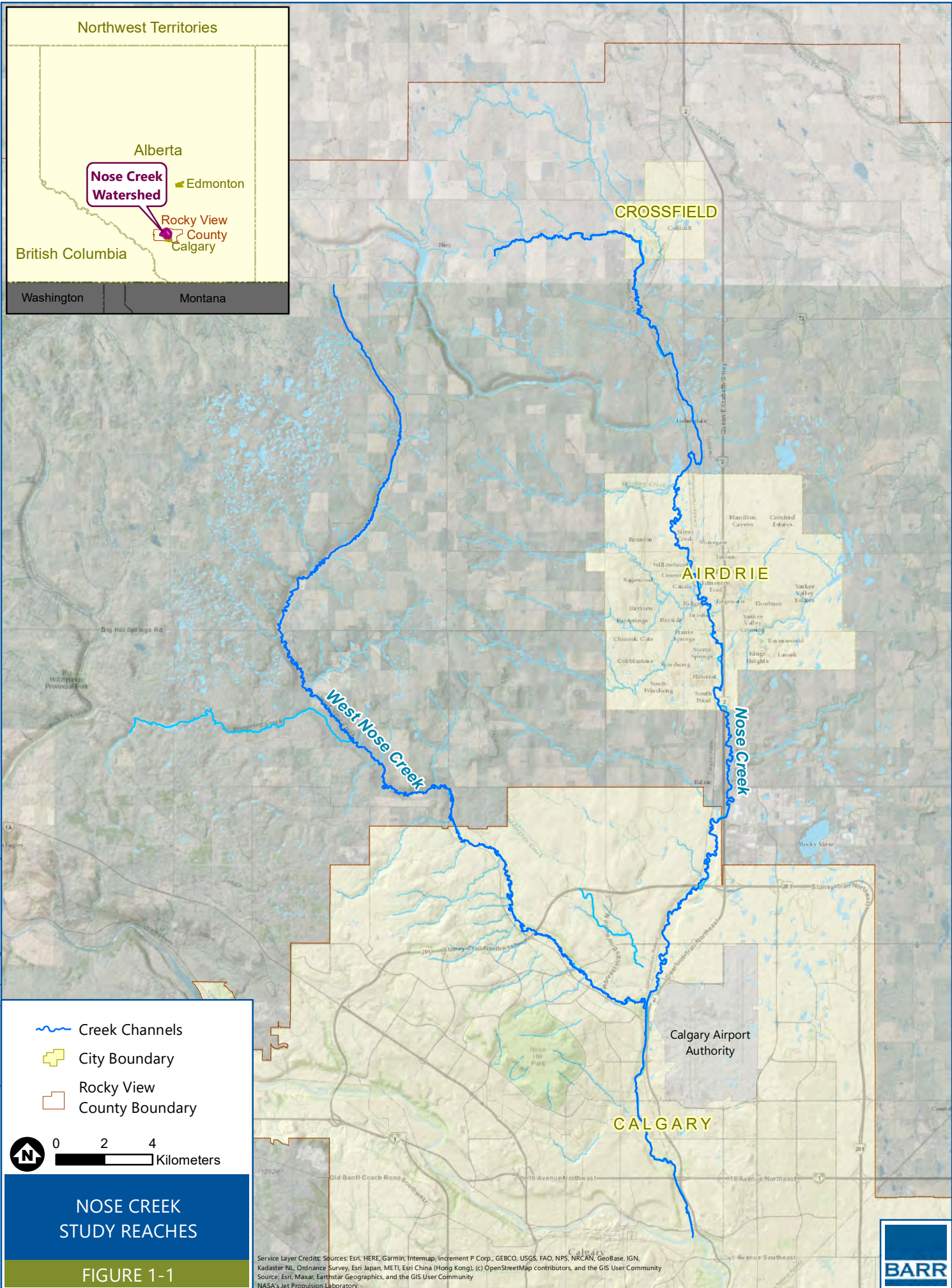
This report documents the methodology and results for tasks completed as part of this study. The study tasks include the following:

- Project data compilation
- Hydraulic model construction
- Hydraulic model calibration
- Hydraulic model sensitivity analysis
- Hydraulic model infrequent flood simulations

1.2 Study Reaches

1.2.1 General Description

The Nose Creek watershed, which includes the West Nose Creek sub-watershed, has a gross drainage area of 989 km² and an effective drainage area of 733 km² (Alberta Environment, 2000). The mainstem of Nose Creek is approximately 75 km in length and descends approximately 100 m from the source to the mouth. West Nose Creek is approximately 65 km in length and descends approximately 177 m from the source to the confluence with Nose Creek, as shown in Figure 1-1 (Alberta Environment, 2000). The study area includes parts of the Town of Crossfield, City of Airdrie, and the City of Calgary. Within the study area, Nose Creek and West Nose Creek flow through grassland, agricultural areas, natural areas, golf courses, residential areas, and commercial developments.



Northwest Territories

Alberta

Edmonton

Nose Creek Watershed

Rocky View
County
Calgary

British Columbia

Washington

Montana

CROSSFIELD

AIRDRIE

CALGARY

West Nose Creek

Nose Creek

Calgary Airport Authority

Creek Channels

City Boundary

Rocky View

County Boundary



0 2 4 Kilometers

**NOSE CREEK
STUDY REACHES**

FIGURE 1-1

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
NASA's Jet Propulsion Laboratory.



Barr Footer: ArcGIS 10.8.1, 2023-04-03 15:28 File: \\Projects\611011236\Maps\Reports\Figure 1-1 Nose Creek Study Reaches.mxd User: EMA

1.2.2 Channel Characteristics

Generally, within the rural areas, Nose Creek is well-defined and meanders freely within its natural valley, except for some sections which have been affected by roadway development. The general channel geometry and vegetation along the creek is relatively uniform (Hydrocon, 1980). Within the cities of Airdrie and Calgary, Nose Creek is more confined to a narrow, man-made valley through channelization and the construction of flood control berms in sections where it flows through or adjacent to light industrial areas and park developments (Golder, 2005). Abandoned channel scars are visible within the natural valley adjacent to the present Nose Creek channel.

The majority of West Nose Creek remains in its natural state as it meanders along a broad flat valley in the upper study reaches, within the rural areas. The channel is narrow, shallow, and sometimes vegetated with frequent tortuous meander bends. Abandoned channels and meander scars are visible adjacent to the present creek channel. The lower reaches of the West Nose Creek watershed within the City of Calgary are being encroached upon by extensive residential subdivision and commercial development, which limits channel's lateral movement. West Nose Creek has been able to flow somewhat naturally in the confines of the golf course and the pathway network in the Confluence Park. In some locations where the West Nose Creek channel threatened the pathway system, the channel was relocated, and meander bends and habitat features incorporated at the site.

1.2.3 Floodplain Characteristics

Human development is prominent in the watershed, with anthropogenic land cover types (e.g., agriculture and urban development) accounting for approximately 80% of the watershed.

In the upper segments of the Nose Creek study reach, the floodplain areas are primarily grazing lands comprised mostly of grasses. Within the urban centers of Airdrie, Crossfield, and Calgary and in developed areas of Rocky View County, the floodplain consists mainly of residential areas, golf courses, parks, and areas of commercial development.

The floodplain of West Nose Creek is mainly used as pasture or cropland in the upper reaches. The valley is several times larger than that of Nose Creek (Alberta Environment, 1983) and the topography is undulating. The floodplain is largely grass-covered, although extensive willow growth occurs in some locations (Hydrocon, 1980). The floodplain land use along the lower reaches is similar to developed reaches of Nose Creek, predominantly residential areas, golf courses, parks, and areas of commercial development.

In an effort to better understand riparian condition at a watershed scale, the NCWP retained Fiera Biological Consulting to assess riparian habitat within the Nose Creek watershed. Riparian vegetation intactness was assessed along the shorelines of interest using a desktop-based assessment tool that utilizes a current land cover layer derived from satellite imagery (Fiera, 2023).

1.3 History of Flooding

Although this study is not a flood hazard study and the scope of work does not include flood modeling, it is helpful to briefly review the historical floods within the study area.

A comprehensive investigation of the history of flooding along Nose Creek and West Nose Creek within the City of Calgary was conducted as part of the Calgary Floodplain Study (Alberta Environment, 1983). It appears that flooding along Nose Creek and West Nose Creek is usually associated with local events caused by heavy rainstorms and/or ice jams (Hydrocon, 1980; Alberta Environment, 1983). The development of Municipal infrastructure such as roads, bridges, and culverts along with urbanization, farming, changing weather conditions, and lowering of the local water table has been cited in the earlier studies as possible factors that could be affecting flows in the basin and may have helped to alleviate some of the past flooding problems (Golder, 2005).

On Nose Creek, major flooding occurred in 1902, 1906, 1915, 1923, 1941, and 1948 (Alberta Environment, 1983). Unfortunately, useable flood data is virtually non-existent for either creek as flood levels were not correlated with flow data. No major flood is known to have occurred on Nose Creek or West Nose Creek within the past 70 years. Even in 2005, when much of Southern Alberta experienced significant flooding, the Bow River Basin, including Nose Creek, only experienced high flows as opposed to flooding, and the water was primarily contained within the main channels (Golder, 2005).

Some early flooding on Nose Creek has been attributed to snowmelt and ice blockage (Golder, 2005). No details on the severity of ice jamming or jam locations are available. The hydraulic model used in this study does not account for ice effects on Nose Creek or West Nose Creek.

2 Project Data

This section summarizes the data used for NCMP Phase II – HEC-RAS Model. Some of the data discussed in this section is available to view and download via the web map developed as part of Phase II of the project.

2.1 Datum

Project data in GIS format was received in multiple horizontal coordinate systems. Data was reprojected into 3-degree Transverse Mercator (3TM) as needed. The CGVD28 vertical datum was used for the combined terrain (i.e., survey data for the main channel and LiDAR for the floodplain).

2.2 Bathymetric and Topographic Data

Bathymetric data for the study area was collected by Compass Geomatics (Compass) in late 2021. This survey consisted of creek bathymetry and crossing details. A cross-section was taken of the creek, depicting both bank, water lines and several streambed points. In some cases, vegetation and other useful points were collected. Photos were taken in the upstream and downstream direction at each cross-section.

At Nose Creek, cross-sections were spaced on average approximately 20 m apart. On the West Nose Creek, cross-sections were spaced on average approximately 10 m apart. In total, 10,675 cross-sections were surveyed. Structure survey detailed the length and width of the crossings as well as structural information such as low chord, railing, piers, and culvert diameters. LiDAR data was provided by the NCWP. Compass processed the survey data and combined the channel bathymetry with floodplain LiDAR to create one surface (in Esri File GeoDatabase raster format) for modeling. This digital terrain model (DTM) has a 1-meter cell size and a horizontal datum in NAD 1983 using the 3-degree Transverse Mercator (3TM) mapping plane. This surface was combined at the waterline produced by Compass. The combined surface utilized the accuracy of the bathymetric survey below the waterline as well as the coverage and consistency of the LiDAR above the waterline. The combined surface provided for this study was reviewed by the NCWP for accuracy and details.

2.3 Land Use and Land Cover Data

The cities of Calgary and Airdrie and the Town of Crossfield each provided a current land use vector dataset for their urban areas. These three polygon datasets were consolidated, and Barr simplified land uses to create one consistent land use coverage for urban areas in the Nose Creek watershed. Barr also acquired the 2010 AAFC Semi Decadal Land Use dataset from the Government of Canada (<https://open.canada.ca/en>) in a 30 m raster format for the watershed. Since this dataset was relatively coarse, it was compared to the dataset developed by Fiera Biological Consulting (2023), that was sourced to Barr in April 2023, and it was deemed that the latter provides more details. Therefore, the land cover developed by Fiera Biological Consulting (2023) was used as an initial roughness that will be refined during the model calibration.

2.4 Hydrometric Data

Hydrometric data were mainly sourced by the NCWP. Table 2-1 summarizes the streamflow data used in this study. The gauging station locations are shown in Figure 2-1. This data was compiled into the web map tool, where it can be viewed, downloaded, and used. Barr investigated the data at a high level to identify obvious errors during the standardization.

Table 2-1 Streamflow Data Summary

Gauge Name	Gauge ID	Gauge Owner	Variables ²	Data Interval	Data Duration ³	Additional Comments
Nose Creek above Airdrie	05BH014	WSC ¹	Q, WL	Hourly	2019– 2021	Vertical Datum: CGVD2013:epoch2010 ⁴
West Nose Creek at Calgary	05BH016	WSC		Hourly		No datum conversion available on the WSC website—this gauge is on the list of benchmarks to be surveyed by the WSC.
Airdrie - Downstream	AIR-DS	City of Airdrie		Hourly		Vertical Datum: CGVD28
Nose Creek 15th St.	SUR_NC-15	City of Calgary		15 min		Vertical Datum: CGVD28
Nose Creek Mouth	SUR_NC-M	City of Calgary		15 min		Vertical Datum: CGVD28
West Nose Creek Mouth	SUR_WNC-M	City of Calgary		15 min		Vertical Datum: CGVD28
West Nose Creek Stream Gauging Station	WNCSGS	University of Calgary		30 min		Vertical Datum: CGVD28

1 WSC=Water Survey of Canada

2 Q=flow; WL=water level

3 Data is collected during the open water season

4 Water levels (WL) at this gauge were converted to CGVD28 using this formula: $WL (CGVD28) = WL (CGVD2013:epoch2010) - 0.142$ m. Vertical datum transformation was calculated from Government of Canada website: <https://webapp.csr-scrs.nrcan-rncan.gc.ca/geod/data-donnees/datum-transformation.php?locale=en>

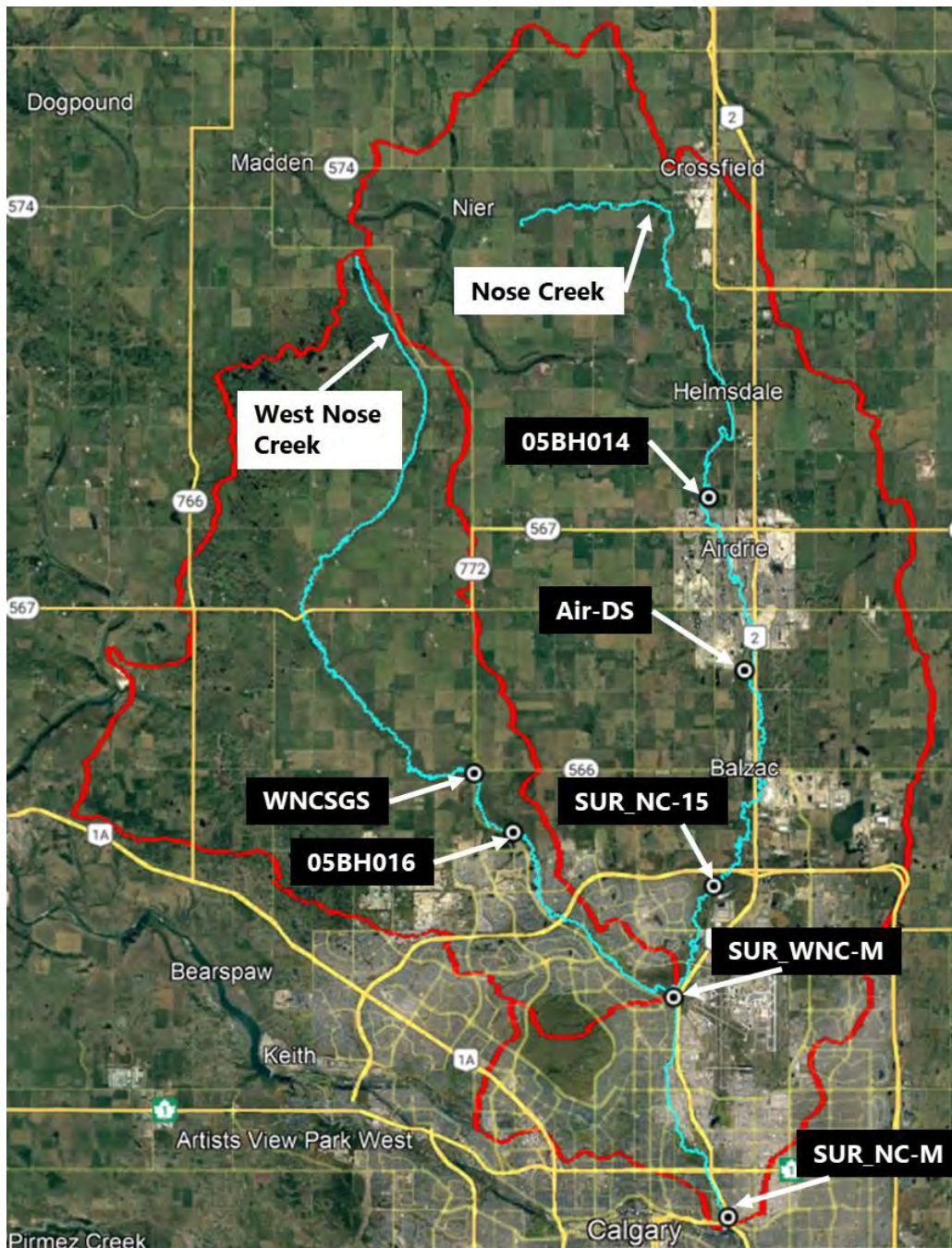


Figure 2-1 The Streamflow Gauging Station Locations

2.5 Highwater Mark Data

Barr contacted AEPA regarding availability of highwater marks (HWMs) along the study reaches and they confirmed (in an email correspondence dated 8/19/2022) that they are not aware of any HWM along Nose Creek or West Nose Creek. As reported by Golder (2005), Calgary Floodplain Study Report (Alberta Environment, 1983) contains the available HWM data on Nose Creek. The information was obtained through resident interviews and review of Alberta Transportation, the City of Calgary, and Canadian Pacific Railway (CPR) bridge plans. A summary of the HWMs obtained from bridge plans is presented in

Table 2-2. The quality (reliability) of the HWM data for these bridges is considered poor as local constrictions due to ice and debris jamming may have affected the recorded water surface elevations (Hydrocon, 1980). These HWMs were not used for model calibration because no flow data was available for the HWMs (Golder, 2005).

Table 2-2 Summary of HWM (Alberta Environment, 1983)

Bridge	Water Level (m)	Date
CPR bridge (first upstream of confluence with the Bow River)	1046.11	1902
16 th Avenue NE	1040.25	Calculated flood level, no date
Goddard Avenue NE	1046.04	Calculated flood level, no date
CPR bridge north of 6 th Street NE	1053.36	July 1916

3 Coupled 1D/2D Model Construction

A coupled 1D/2D HEC-RAS modeling approach was initially adopted after discussions with the NCWP, in order to better capture a wide range of processes for both low-flow (within the main channel) and high-flow (overtopping banks into floodplain) events. This model was tested for flows up to approximately 25 m³/s at the outlet of Nose Creek (i.e., Nose Creek at the Mouth). In spite of investing considerable time to improve the model, it was deemed that significant additional effort would be necessary to achieve adequate model stability to run it to completion for higher flows. Barr discussed potential options with the NCWP to overcome the stability issues for very low and high flows. One of the options discussed was a full 2D model that would run for a range of flows from very low flows to an extreme flood event. This section (Section 3) documents the preliminary coupled 1D/2D HEC-RAS model construction. Section 4 summarizes the final model (HEC-RAS 2D) construction.

3.1 Initial HEC-RAS Modeling Approach

As discussed in Section 2.2, cross-sections were surveyed at approximately 20-30 m intervals along the stream centerlines. With the objective of incorporating geomorphic detail, all cross-sections were to be incorporated into the model. Nose Creek and West Nose Creek are both relatively small meandering streams with respectively large floodplains. Therefore, two modeling approaches were considered:

1. A conventional 1D steady state model, which is numerically stable and incorporates structures in a standard format. However, due to the number of cross-sections and meanders, the cross-section delineation was extremely inefficient and subjective in areas with sharp meanders. Additionally, the distance between cross-sections at each overbank would likely be inaccurate.
2. As an alternative to the 1D steady state model, a coupled 1D/2D domain to incorporate a 1D channel and a 2D floodplain using lateral structures as connections. This method is suitable for meandering streams and provides more accurate flow and velocity fields on the floodplain. This approach is, however, numerically less stable than the 1D steady state model because it must overcome stability concerns of both 1D and 2D domains as well as complex lateral structures that exchange flows between the 1D channel and 2D floodplain. It is noted that the 2D domain requires an unsteady flow simulation.

In discussions between Barr and the NCWP, it was determined that in spite of the challenges, the coupled 1D/2D domain was less subjective and a better approach moving forward.

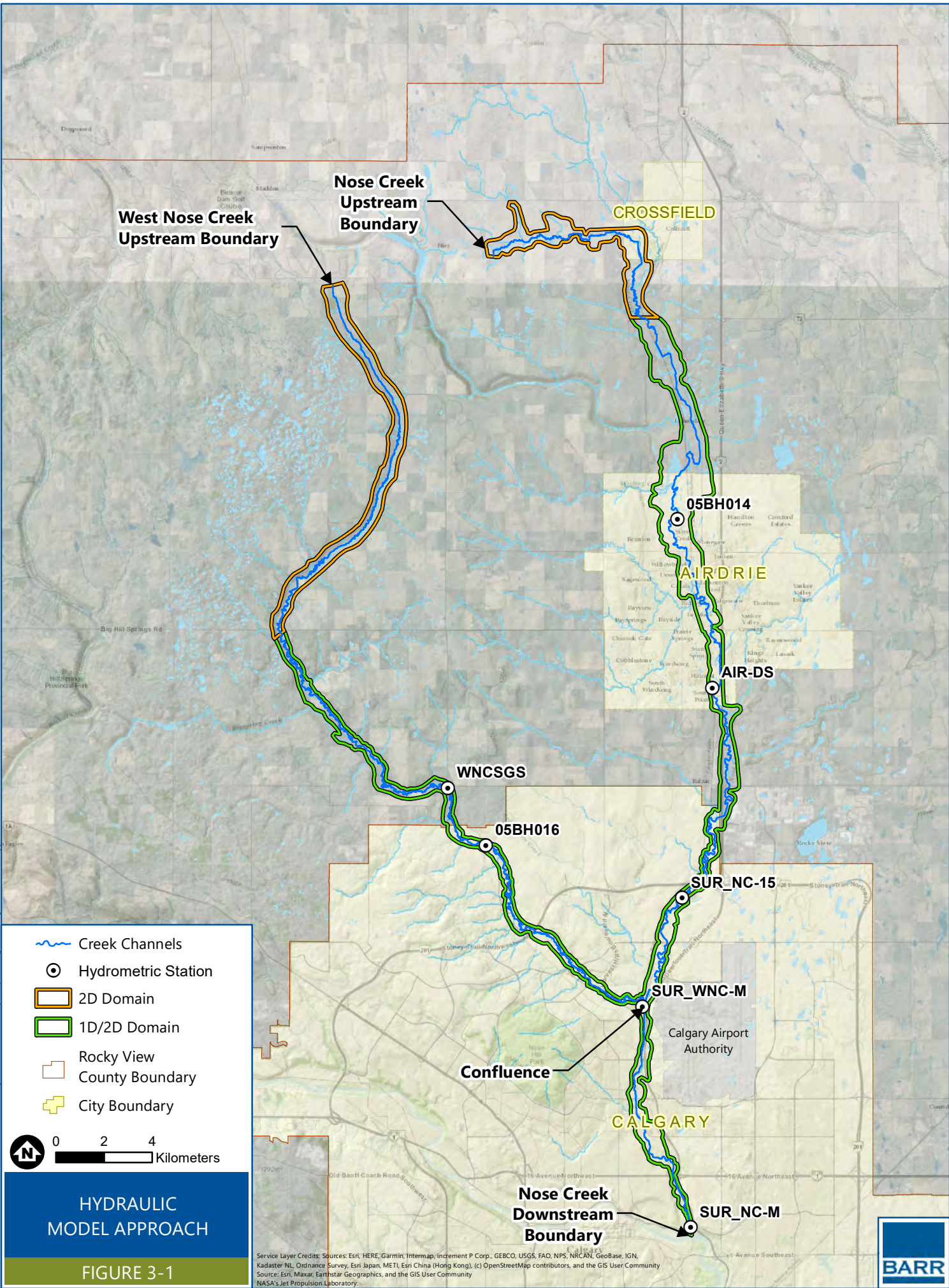
During cross-section delineation, it was discovered that some cross-sections were undefined within the study area. This was found to occur most frequently in the upper half of West Nose Creek and the upper 14 km of Nose Creek. This issue was primarily due to the narrow nature of the channel in these areas (1-2 m). It was therefore decided with consent from the NCWP that a 2D domain would be used in the upper reaches. Structures within this area were modeled as 2D connections to maintain accuracy at these structures.

All reaches in the study area were included in one integrated model setup. The model consisted of three 1D/2D reaches as listed in Table 3-1 and Figure 3-1.

Table 3-1 Reaches in the Hydraulic Model

River	Reach	Model Domain	Length (km)
Nose Creek	NC 2D	2D	14.0
Nose Creek	Above Airdrie to Confluence	1D/2D	48.4
Nose Creek	Confluence to Bow	1D/2D	11.5
West Nose Creek	WNC 2D	2D	23.5
West Nose Creek	West Nose Creek	1D/2D	45.6
Total			143

Recent version of the HEC-RAS model (version 6.3.1) was used in the creation of the hydraulic model for this study.



- Creek Channels
- Hydrometric Station
- 2D Domain
- 1D/2D Domain
- Rocky View County Boundary
- City Boundary

0 2 4 Kilometers

HYDRAULIC MODEL APPROACH

FIGURE 3-1

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
NASA's Jet Propulsion Laboratory.



3.2 Cross-Section Delineation

Cross-sections were delineated in the coupled 1D/2D domain at each survey cross-section location. These cross-sections were then extended to tie-in with the high ground (i.e., top of the banks), where the lateral structures were defined to connect the 1D and 2D areas. The cross-section geometries within waterlines of the channels were based on the bathymetric survey data collected by Compass and beyond the waterlines LiDAR was used for the overbank areas.

Table 3-2 provides summaries of the study reaches and the number of cross-sections in each reach.

Table 3-2 Summary of Study Reaches and Number of Cross-Sections

Stream Name	Reach Name	Description of Reach	From Station (m)	To Station (m)	Length (km)	Number of Cross-Sections	Average Cross-Section Spacing (m)
Nose Creek	Above Airdrie to Confluence	Upper Nose Creek from headwater to the confluence with West Nose Creek.	59,919 ¹	11,496	48.4	2,413	20
	Confluence to Bow River	Lower Nose Creek from the confluence with West Nose Creek to the confluence with the Bow River.	11,480	0	11.5	500	23
West Nose Creek	West Nose Creek	The west tributary to Nose Creek.	45,611 ²	0	45.6	4,575	10
TOTAL					105.5	7,488	17

1 From station 74,156 to Station 59,919 on Nose Creek has been modeled in full 2D domain (reach length of 14 km).

2 From station 69,006 to Station 45,611 on Nose Creek has been modeled in full 2D domain (reach length of 23.5 km).

3.3 1D/2D Model Area Connection

The 1D/2D connection was achieved using lateral structures which bound the 1D channel cross-sections to the 2D areas. 1D cross-sections were carefully delineated to make sure the channel geometry is captured properly. All cross-sections were reviewed for properly located bank points and the bank points were manually adjusted where needed. Generally, the 1D model was connected to the 2D areas with lateral structures along high points (i.e., top of banks). Lateral structures can often cause instability, particularly when placed in areas where both inflows and outflows to the floodplain occur. Therefore, lateral structures were split at bend sections and other areas where inflow and outflow direction may change. Lateral structures were also split at structures and the confluence. Figure 3-2 shows an example of 1D/2D connection in the model.

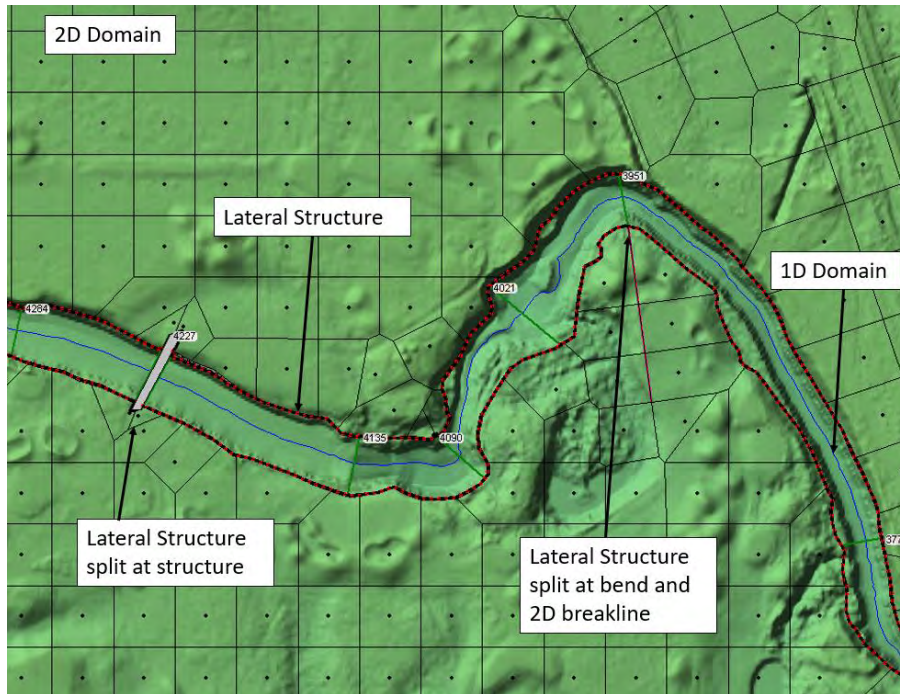


Figure 3-2 An Example of 1D/2D Connection in the Nose Creek HEC-RAS Model

3.4 Storage Area

One storage area was used in the model in the lower West Nose Creek to increase stability. This storage area is located in an area where West Nose Creek is confined by two bridges and acts more like a reservoir than an overland flow area (adjacent to West Nose Creek cross-sections 8,700-9,500). A small 2D domain produced instabilities at the transition points to and from 1D where the cross-sections had the tendency to run dry. The solution to this issue was using a storage area representing the ponded storage within the reservoir. The less complex storage area computations are simpler as they utilize a storage rating curve and are able to reach a solution at the bounding cross-sections for a variety of flows.

3.5 2D Mesh and Breakline

Both the 2D mesh in the coupled 1D/2D domain and the 2D mesh in the full 2D domain were built with a base cell size of 25 m with the exception of the West Nose Creek 2D domain which was built with a base cell size of 50 m. Additionally, numerous sharp bend sections were isolated as small 2D areas. These areas were assigned base cell sizes of 1 to 10 m. Given the meandering nature of the creek in the coupled 1D/2D domain, the cell size was greatly reduced in the immediate area of the creeks by HEC-RAS's mesh algorithm. In the full 2D domain of the model, a refinement region was used with a mesh size of 2 m within 3 m of the creek centerline (e.g., for a width of 6 m, three cells represented the main channel). In both model domains, the 2D mesh was refined using breaklines on topographically significant areas such as roads and berms. A summary of 2D mesh details for the coupled 1D/2D domain and full 2D domain can be seen in Table 3-3 and Table 3-4, respectively. Figure 3-3 and Figure 3-4 show examples of mesh quality in the coupled 1D/2D and full 2D domains, respectively.

Table 3-3 Summary of Coupled 1D/2D Domain Mesh

Study Reach	Reach Length (km)	2D Mesh Size Range	Number of Cells	Number of Breaklines
Nose Creek (Above Airdrie to Confluence & Confluence to Bow River)	59.9	2 – 25 m	46,556	156
West Nose Creek	45.6	1 – 25 m	19,452	200
TOTAL	105.5	-	66,008	356

Table 3-4 Summary of Full 2D Domain Mesh

Study Reach	Reach Length (km)	2D Mesh Size Range	Number of Cells	Number of Breaklines
Nose Creek	14.0	2 – 25 m	56,241	42
West Nose Creek	23.5	2 – 50 m	105,082	39
TOTAL	37.5	-	161,323	81

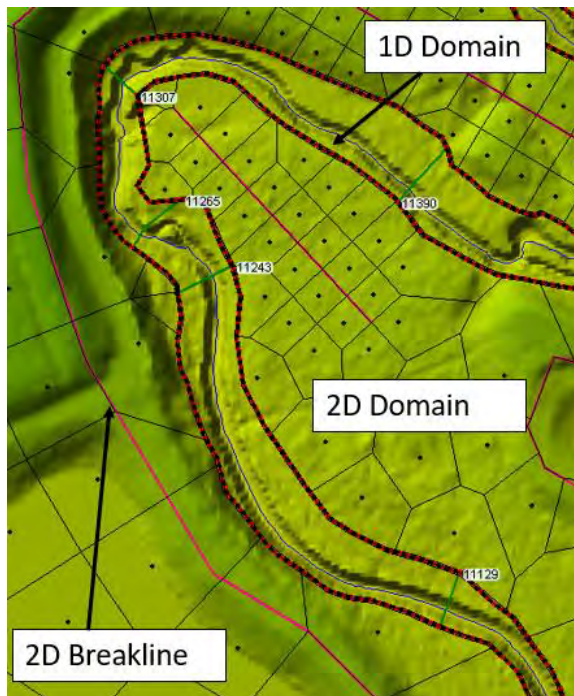


Figure 3-3 An Example of Mesh and Breakline in the Coupled 1D/2D Domain

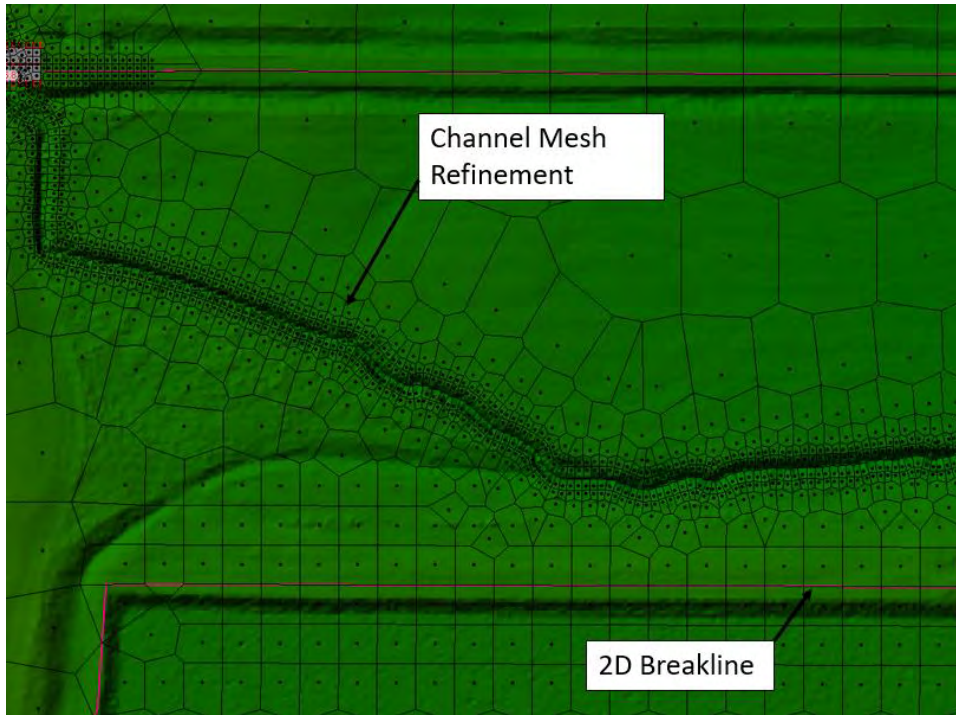


Figure 3-4 An Example of Mesh and Breakline in the Full 2D Domain

3.6 Boundary Conditions

Boundary conditions were assigned at the upstream extents of both West Nose Creek and Nose Creek reaches, as well as the downstream extent at the confluence with the Bow River. Upstream boundary conditions were comprised of hydrographs with constant flows applied to the upstream extent of both 2D domains. At the junction of West Nose Creek and Nose Creek, the model uses the energy balance method for improved 1D/2D stability. Finally, the downstream boundary condition was set to known water surface elevation recorded at the mouth of Nose Creek during the calibration/simulation event. Table 3-5 summarizes the boundary conditions used in the model. Additionally, 18 inflows within the 2D domains were used as explained in Section 3.9.

Table 3-5 Summary of Model Boundary Conditions

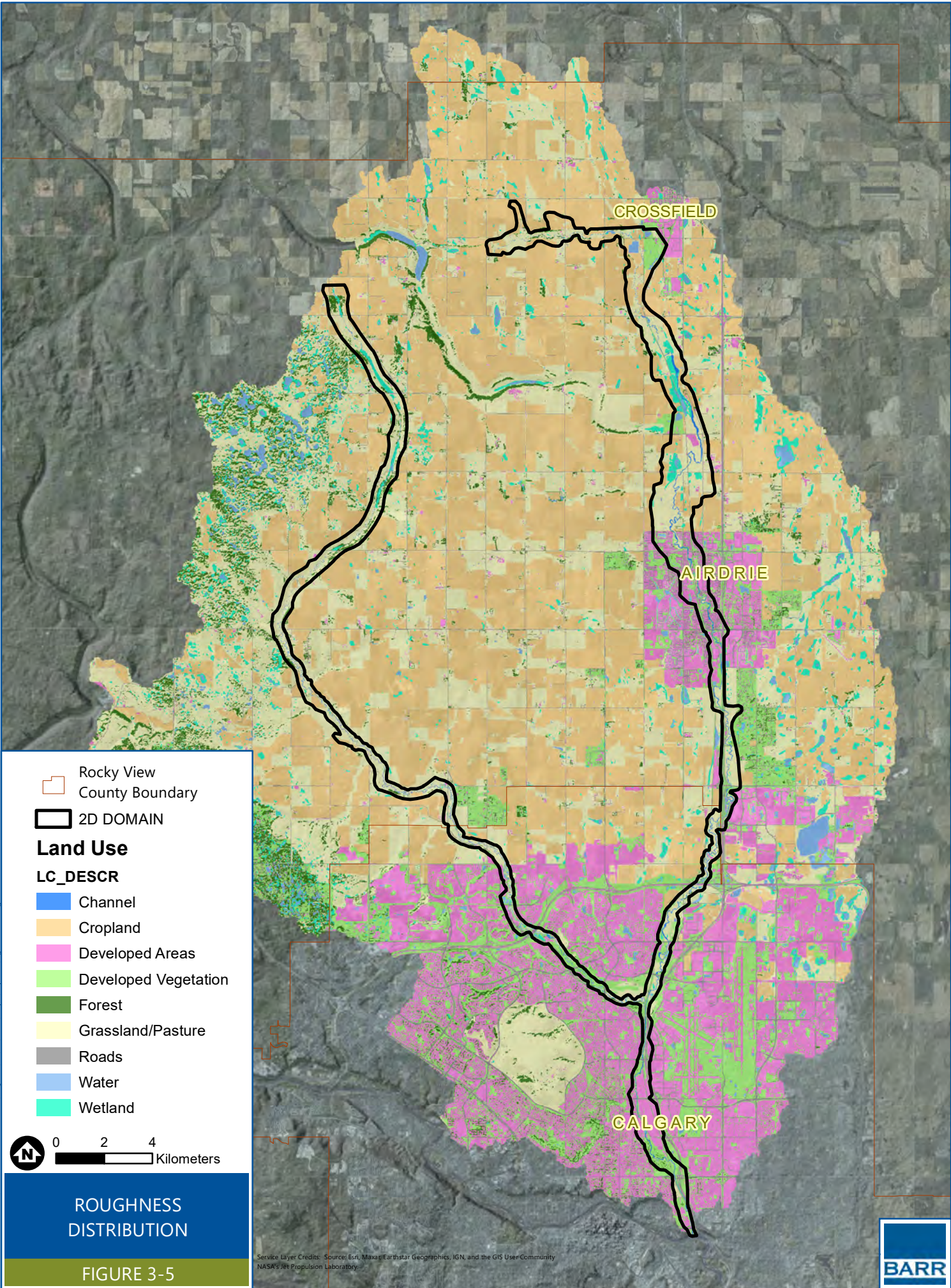
Study Creek	Study Reach	Upstream Boundary Condition	Downstream Boundary Condition
Nose Creek	Airdrie to Confluence	Flow Hydrograph	Energy Balance Method at Junction
Nose Creek	Confluence to Bow River	Energy Balance Method at Junction	Water Level
West Nose Creek	West Nose Creek	Flow Hydrograph	Energy Balance Method at Junction

3.7 Roughness Distribution

The initial roughness distribution for the main channel of the model was aligned with the previous modeling conducted by Golder (2005), ranging from 0.04 to 0.055. These values will be adjusted and refined during the calibration process. The roughness values for the 2D domains on the floodplain were based on land use layers sourced from Fiera Biological Consulting (2023), City of Calgary, City of Airdrie, and Town of Crossfield. These layers were simplified into eight land use types and assigned Manning's n roughness values. The Manning's n -values for floodplain areas are listed in Table 3-6 and the associated land use layers are shown in Figure 3-5.

Table 3-6 Floodplain Land Use Classes and Initial Floodplain Manning's n Values

Number	Description	Initial Manning's n
1	Developed Areas	0.085
2	Roads	0.020
3	Water	0.030
4	Forest	0.100
5	Cropland	0.060
6	Grassland/Pasture	0.060
7	Wetland	0.045
8	Developed Vegetation	0.05
9	Channel	0.04-0.055



Barr Footer: ArcGIS 10.8.1, 2023-04-03 15:28 File: \\Projects\611011236\Maps\Reports\Figure 3-5 Roughness Distribution.mxd User: EMA

Rocky View County Boundary

2D DOMAIN

Land Use

LC_DESCR

- Channel
- Cropland
- Developed Areas
- Developed Vegetation
- Forest
- Grassland/Pasture
- Roads
- Water
- Wetland



0 2 4 Kilometers

ROUGHNESS DISTRIBUTION

FIGURE 3-5

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, IGN, and the GIS User Community
NASA's Jet Propulsion Laboratory



3.8 Hydraulic Structures

Hydraulic structures present on West Nose Creek and Nose Creek include culverts, bridges, and two weir structures. In the Nose Creek reach, 17 culvert crossings, 71 bridges and 2 weirs were modeled. In the West Nose Creek reach, 14 culvert crossings and 64 bridges were modeled. Survey data, notes, topographic data, and photographs were used to incorporate these structures into the model. Losses through bridges are calculated in the model using the energy equation (i.e., standard step method).

Hydraulic structures were modeled with a variety of methods depending on model approach and location. In the coupled 1D/2D domain, bridges and culverts were modeled as 1D structures in the channel. For the majority of bridges, the 1D area was extended to the bridge opening at the crossing. At certain bridges, where the opening extended well into the floodplain, the bridge opening was modeled as a 1D opening within the banks and a 1D/2D connection in the floodplain. In the full 2D domain, bridges and culverts were modeled entirely as 1D/2D connections. The remaining high ground or roadway was captured in the full 2D domain using a breakline. Two bridges located just upstream of the confluence, on West Nose Creek, were modeled as cross-section lids to improve model stability. This method may not represent losses that could occur due to bridge overtopping, but it was found that these structures are not overtopped within the approximately 1:100 annual exceedance probability (AEP) flood event (obtained from Golder, 2005). This is a common method used to mitigate unstable structures in an unsteady model or a quasi-unsteady model. The weir structures were modeled as Inline structures with 1D/2D connections depending on the location.

All bridges within the study area are approximately perpendicular to the main channel flow direction, so it was not necessary to include any skew for them in the model.

The initial values of the contraction and expansion coefficients at the bridges within the 1D areas were selected to be 0.3 and 0.5, respectively. These are typical values listed in the HEC-RAS user manual.

A summary of the culverts and bridges within the model can be seen in Appendix A.

3.9 Model Construction Stages and Model Stability

Model construction was done in stages, following HEC-RAS manual guidelines, to detect areas with stability issues (USACE, 2023). The stages of the full model construction are explained below. In each one of these stages the numerical parameters were selected in order to improve model stability.

3.9.1 1D Areas – Steady State Model Run

A model with only 1D features (i.e., cross-sections, road crossings and junction) was constructed to test road crossings and junction impact on water surface profile. This test did not show any issues with the model geometry.

3.9.2 1D Areas – Unsteady State Model Run

The 1D steady flow model was converted to a 1D unsteady flow model in which inflows were uniformly distributed for a range of flows up to 103 m³/s (approximately 1:100 AEP flood flow based on Golder,

2005). During this stage, it was found that two bridges on West Nose Creek immediately upstream of the confluence with Nose Creek were causing instabilities in the model solution. To address this, those bridges were converted to HEC-RAS lid features. Additionally, an optimal stable time step of 30 seconds was found for the range of flows tested when a Local Partial Inertia (LPI) filter is used. The LPI method applies a reduction factor to the inertia terms in the momentum equation as the Froude number goes toward a user-defined Froude number threshold, which in this case, was set to a value of 10. These parameters were carried forward in the next stages of model construction.

3.9.3 1D/2D Areas – Unsteady State Model Run

The 2D domains representing the floodplain (adjacent to the 1D cross-sections) were added to the model developed in the previous stage. To improve stability in the 2D domains, it is possible to reduce the time step locally for each 2D domain. This is accomplished by using time step slices, which divides the general time step for a specific 2D domain based on the number of slices input by the modeler. For example, for a 2D domain it is possible to use five slices and therefore, reduce the time step by 5 times. Initially, all of the 2D domains used a diffusion wave solver with an initialization time of one hour and no slices (i.e., the time step used for the 1D domains was the same as in the 2D domains). Regarding the inflows, they were placed next to 1D cross-sections as well as inside the 2D domains. The inflows that were placed next to 1D cross-sections represented flows that will remain in the main channel, whereas inflows in the 2D domains were set in such a way that they could be used for events that overtop the main channel banks. Appendix B shows the location of the inflows placed in the 2D domains. These inflow locations were identified by physical features in the terrain (e.g., tributaries). During this stage of modeling, it was found that the optimal time step when adding the 2D domains is 10 seconds. Additionally, it was found that the model was unstable in a number of 2D domains. To improve the model stability in those 2D domains, the number of slices were increased to 20. A special case of instability were locations where a meander bend was near neck-cutoff. In those areas, the 2D domains were split to attain a greater control of time step and 2D solver selection in a smaller localized area.

3.9.4 Full Model – Unsteady State Model Run

As stated in Section 3.1 the upper part of Nose Creek and West Nose Creek were constructed as full 2D domains. This was done because the main channels in these upper reaches were too narrow to be represented with cross-sections. These 2D domains were added and connected to the 1D/2D model developed in the previous stage. Model settings such as time step, solver selection and tolerances remained the same as in the previous stage. It was found that the model requires about 3 days of simulation time to route the flows from the most upstream end of the model to the connection with the 1D/2D domain downstream.

The model is particularly unstable on sharp stream bends (i.e., bends near to experience a neck-cutoff event) where the flow exchanges back and forth between 1D and 2D domains (i.e., from channel to floodplain and vice versa). To improve stability at such locations, a small 2D domain next to the inner bank was added, as shown in Figure 3-6.



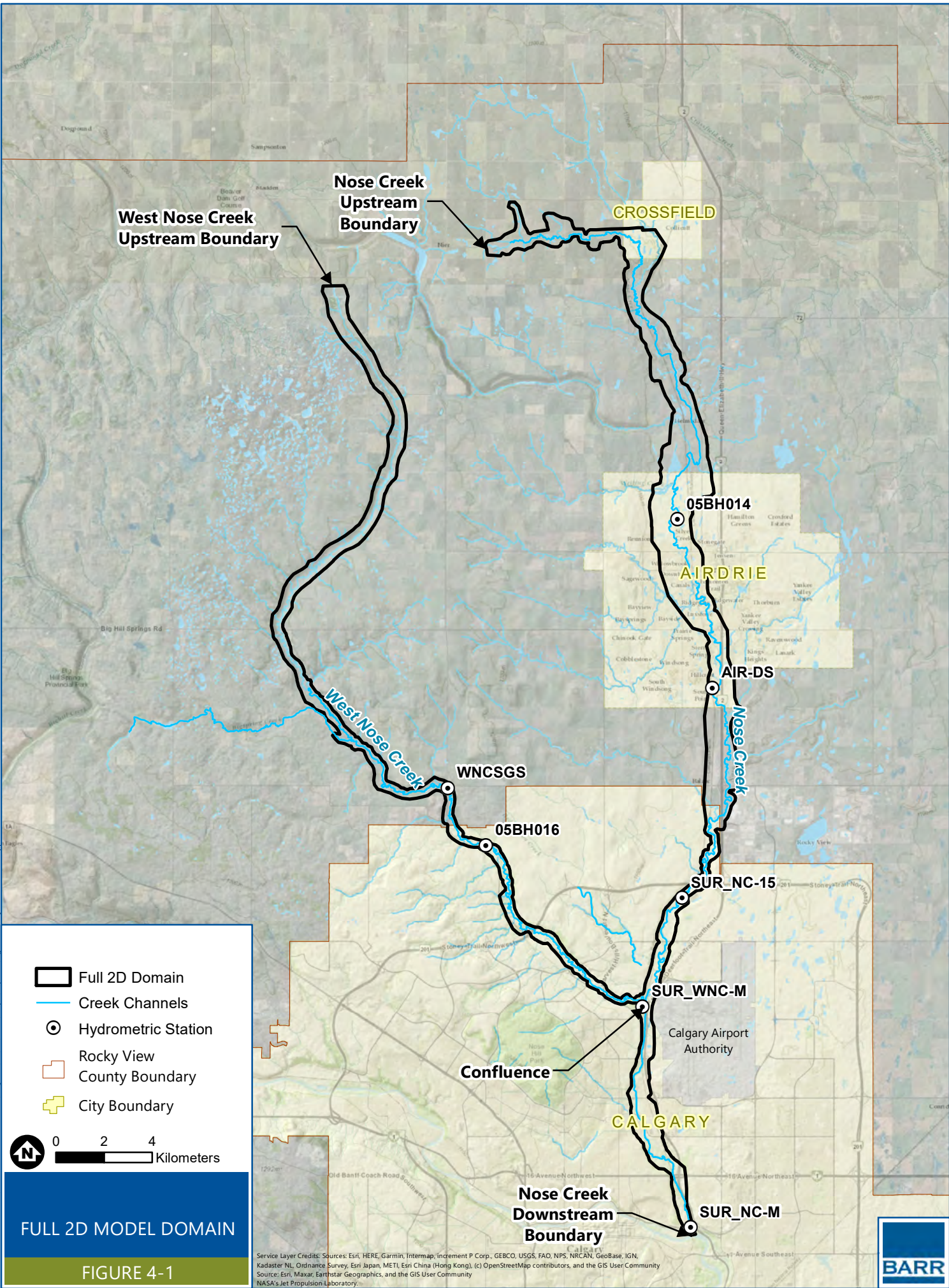
Figure 3-6 2D Domain Used to Improve Stability Adjacent to a Bend






4 Full 2D Model Construction


As mentioned earlier, the coupled 1D/2D model construction proved that the instabilities in such a large model will require extensive effort to be able to run the model for flows ranging from very low flows to very high flows. After detailed discussions with the NCWP, it was decided to stop troubleshooting the coupled 1D/2D model and invest in constructing a full 2D HEC-RAS (version 6.4.1) model that would be stable for a wide range of flows and achieve modeling objectives (such as evaluation of channel morphology, stream bed scour, stream bank erosion, protection design, flood assessment, etc.). This section (Section 4) summarizes the model construction steps for the full 2D model.

4.1 Model Domain

A 2D domain was created encompassing an “extreme” (proxy for the 1:1,000 AEP) flood inundation extent. The hydrology assessment used for the “extreme” flood event in the model is based on Golder (2020). The model domain was further expanded following the preliminary simulations of the “extreme” flood event. The final model domain is shown in Figure 4-1.



-  Full 2D Domain
-  Creek Channels
-  Hydrometric Station
-  Rocky View County Boundary
-  City Boundary

 0 2 4 Kilometers

FULL 2D MODEL DOMAIN

FIGURE 4-1

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
 Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
 NASA's Jet Propulsion Laboratory.



4.2 Mesh and Breakline

The 2D model domain was constructed using a base cell size of 20 m with the exception of the upper half of West Nose Creek where it was constructed using a base cell size of 25 m. This reduced the overall cell count where the floodplain was considerably larger than the channel. In total, there are 443,000 cells over the entire model domain. Breaklines were placed on topographically significant areas such as roads, berms, and locations that may influence flow into the floodplain. A breakline was also utilized in the wider channel section of Nose Creek from the confluence with West Nose Creek to the mouth in order to better align cells within the banks. A summary of 2D mesh details can be seen in Table 4-1. Figure 4-2 shows an example of mesh quality in the 2D model domain.

Table 4-1 Full 2D Model Mesh Summary

Study Reach	Reach Length (km)	2D Mesh Size Range (m)	Number of Cells	Number of Breaklines
Nose Creek/West Nose Creek	143	2 to 25	443,000	672

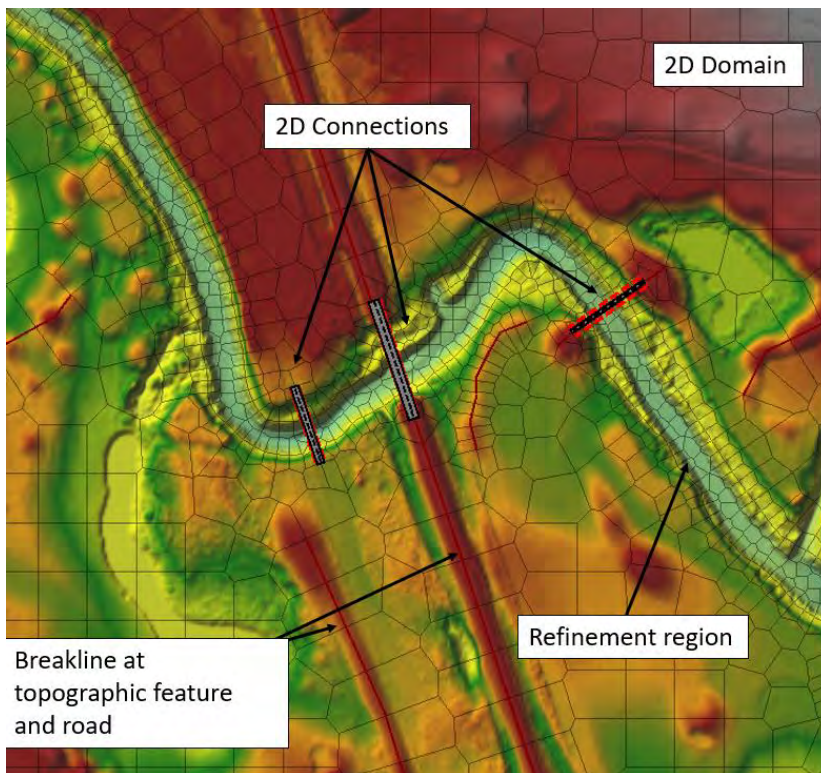


Figure 4-2 Fully 2D Mesh Quality in the 2D Domain

A refinement region was utilized within the main channel to incorporate the bathymetric detail of the channel bed. The cell size refinement was based on the channel width, incorporating one or more cells within the immediate main channel, while maintaining a manageable cell count and courant number (i.e., the smallest cell size often governs the time step to satisfy the courant number stability criteria). Table 4-2

shows the various cell refinement sizes according to reach location and Figure 4-3 shows an example of mesh quality in the refinement region.

Table 4-2 Full 2D Model Mesh Refinement Summary

Reach	Location	Refinement Mesh Size
Nose Creek	Upstream of Crossfield	2 m
	Downstream of Crossfield	5 m
	Wide bank area upstream of Airdrie only	10 m
West Nose Creek	Upper half (upstream of Highway 567)	2 m
	Lower half (downstream of Highway 567)	3 – 5 m

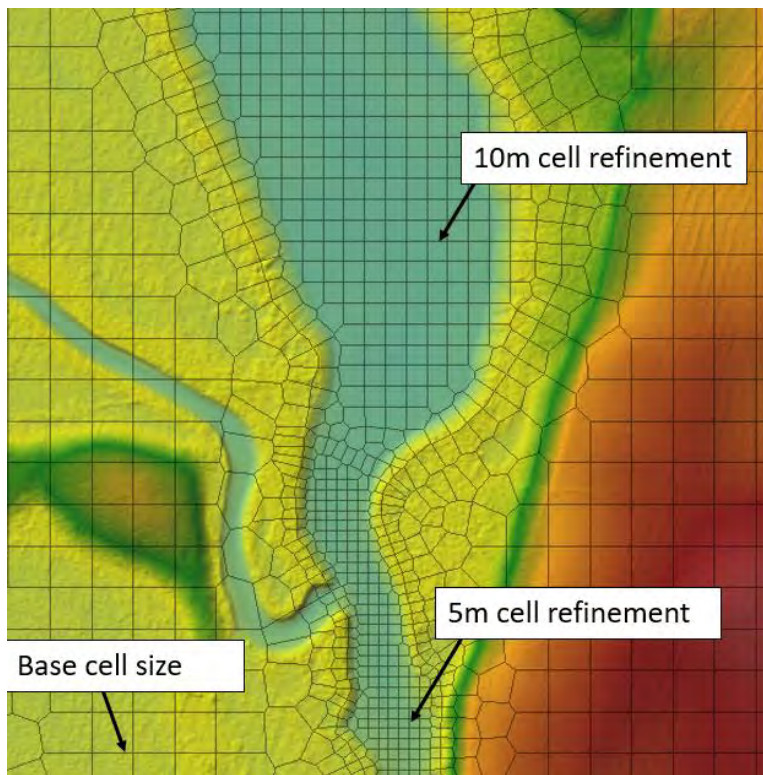


Figure 4-3 Fully 2D Mesh Quality in the Refinement Region

Barr also tested the mesh sensitivity on a smaller domain (i.e., a clipped model) by further refining the mesh in the main channel by applying the breakline. This test showed negligible change in water surface elevations and model stability, suggesting the current configuration of the model is suitable. Further refining the mesh in the entire domain would increase the overall cell count significantly. Given the extreme run times already experienced, it was decided that the current configuration is suitable for the purpose of this study.

4.3 Numerical Details

The full 2D model has a large domain and, therefore, model run times are long. Low-flow events require up to 2 weeks of simulation time to reach a steady-state solution. To help reduce model runtime, restart files were used to initialize the model. The restart files were produced using the same geometry but using the less robust, more stable diffusion wave solver. This allowed for a larger timestep (2-3 seconds) and, therefore, shorter run times. In the low-flow calibration events, it was determined that initializing the model from dry was impractical due to the large volume required to fill the wide upper reaches and behind grade structures throughout. Therefore, the model was drained from a constant steady state flow of $2 \text{ m}^3/\text{s}$ in both Nose Creek and West Nose Creek until it reached steady state for the desired event.

The restart file was then used as an initial condition for simulations that would use a more robust but less stable solver (which involves smaller time steps and longer runtimes). Those simulations used the full momentum solver (SWE-ELM). As the model is already initialized at a reasonable discharge and depth, the model requires a shorter run time. During model construction and initial testing, a series of time steps were tested starting from 10 seconds. Given the size of the model and the variety of mesh sizes and flow conditions throughout, a small time step of one (1) second is required. Calibration models were run for 48-120 hours simulation time, taking approximately equal time to run. Flood scenario models were run for less time, given the quicker travel time. These models were run for 48-72 hours depending on flow magnitudes and flow travel time through the model domain. Restart files were enabled for all model runs and were used if the run needed to be extended to achieve steady state.

The 2D model is capable of modeling flows from approximately $0.2 \text{ m}^3/\text{s}$ up to an extreme flood event ($Q = 407 \text{ m}^3/\text{s}$) at the mouth of Nose Creek. However, the model begins to become unstable once flow enters extreme low-flow conditions below $0.05 \text{ m}^3/\text{s}$. Therefore, a threshold was established for modeling, limiting flow to greater than $0.05 \text{ m}^3/\text{s}$. In regions where the flow is below the threshold, these areas are modeled as dry.

Minor instabilities at a few of the 2D connections are present when viewing the internal hydrographs of the structures. The flow through the structure oscillates around the passing discharge slightly as it cannot reach a stable solution. This is considered a minor instability as the oscillation magnitude is a small percentage of the total passing flow (i.e., mostly smaller than 3-5%). The resulting headwater and tailwater, however, remains relatively steady with oscillations in the 100ths of a meter. Therefore, these instabilities are having an insignificant effect on water level and inundation results. A summary of these locations and instabilities is shown in Table 4-3.

Table 4-3 HEC-RAS 2D Connection Instability Summary

Stream	Station	Nature of Instability	Extent of Instability
Nose Creek	3,531	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
Nose Creek	3,654	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
Nose Creek	11,013	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
Nose Creek	31,694	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
Nose Creek	65,897	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
Nose Creek	67,147	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
West Nose Creek	3,667	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
West Nose Creek	3,697	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
West Nose Creek	9,114	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection
West Nose Creek	10,129	Minor Flow/WSEL Oscillation within 2D Connection	2D Connection

4.4 Hydraulic Structures

As discussed in Section 3.8, there are 174 structures on West Nose Creek and Nose Creek that were implemented in the model. In the 2D model, all hydraulic structures were modeled as 2D connections. Structures were then assigned to be either bridge, weir, or culvert features. Table 4-4 summarizes the number of each type of structure.

Table 4-4 2D Model Structure Summary

Structure Type	Nose Creek	West Nose Creek	Total ¹
Bridges	73	67	140
Culvert	13	19	32
Weirs	2	0	2
Total	88	86	174

Note(s):

The total structure count is higher than total surveyed structures (Table i), as there were several structures that were missed during the survey and Barr assumed dimensions to include them into the full 2D model (see Appendix B).

Bridge expansion and contraction coefficients of 0.3 and 0.5 were assigned, respectively (USACE, 2023). The internal roughness was assigned to match the channel assigned in the region. The energy step method was used for low flows and the pressure/weir method was used for high flows exceeding the low chord of the opening.

Culvert entrance and exit losses were assigned according to the culvert opening (0.5-0.9) with a standard exit loss coefficient of 1.0 (USACE, 2023). Culvert roughness values were assigned based on their materials.

4.5 Boundary Conditions

Boundary conditions were assigned at the upstream ends of both West Nose Creek and Nose Creek, as well as the downstream extent of the model at the confluence with the Bow River. Upstream boundary

conditions were comprised of hydrographs with constant flows applied to the upstream extent of both 2D domains. The downstream boundary condition was set to a normal depth flow condition with a slope of 0.0008 m/m. It is noted that Barr initially used a known water level (i.e., observed water level at Nose Creek at the Mouth gauge), however, NCWP Technical Team requested to change it to a normal depth flow condition with a slope. In the infrequent flood (i.e., flood frequency) model geometry, an additional normal depth boundary with a constant slope of 0.0001 m/m was used at the domain boundary to simulate the outflow of floodwater into the City of Airdrie stormwater conveyance system. This boundary condition is shown in Figure 4-4.

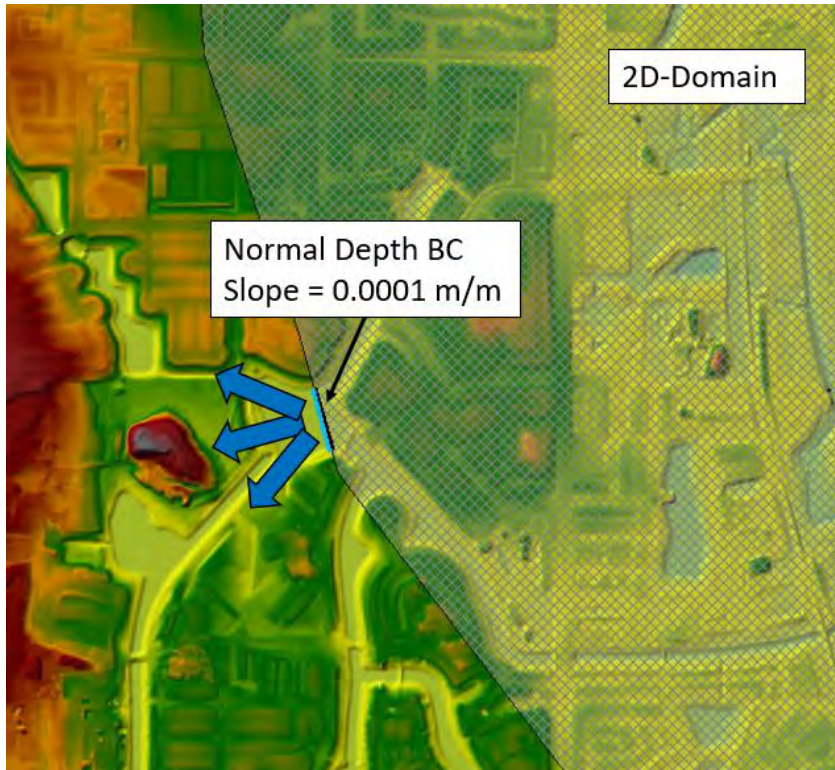


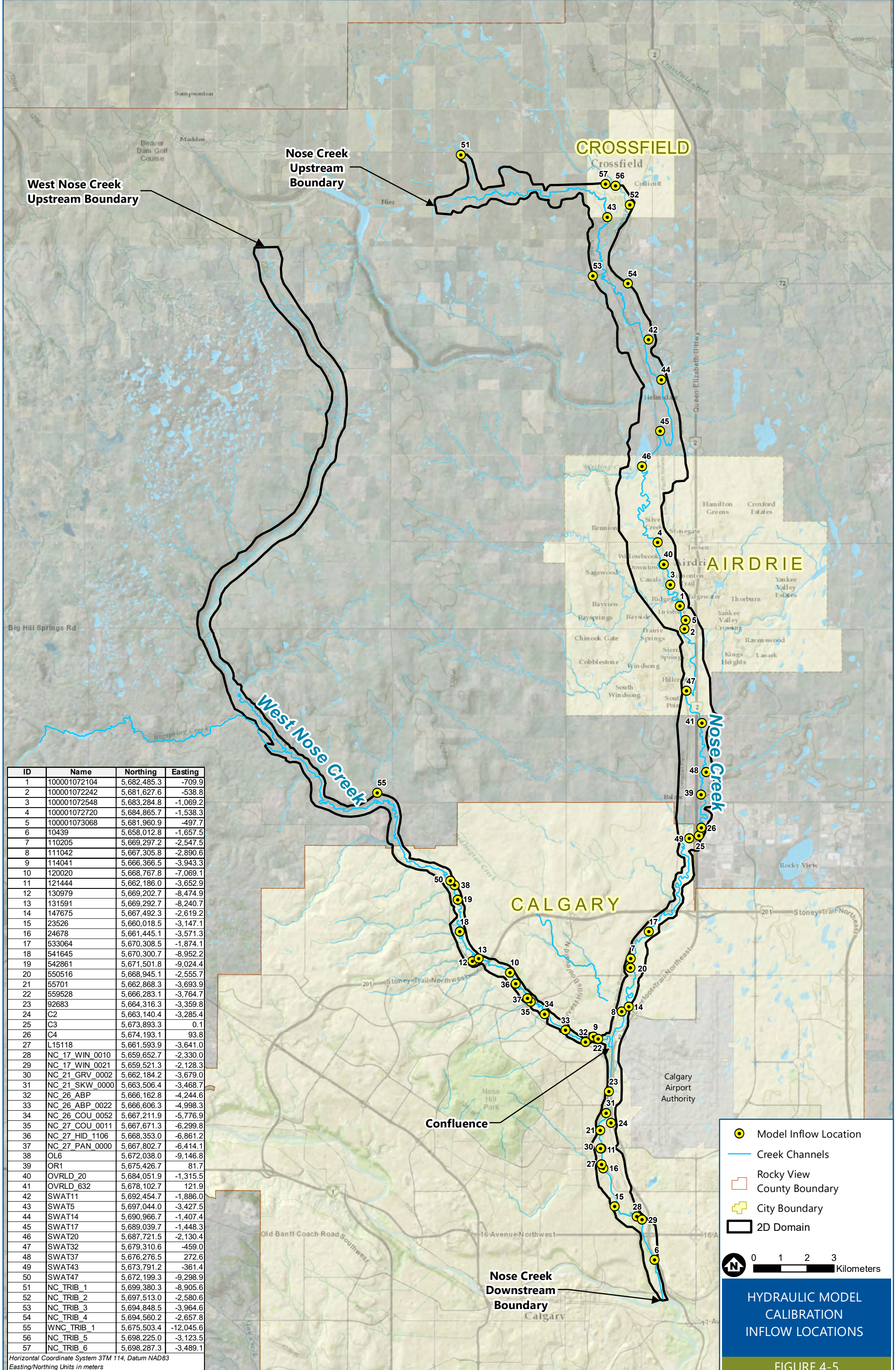
Figure 4-4 Airdrie Normal Depth Boundary Conditions

4.6 Model Inflows

4.6.1 Calibration Events

Throughout the 2D domain, 57 inflow locations were utilized to introduce flow into the creeks in the calibration events as seen in Figure 4-5. The detailed table of these inflow locations can also be found in Appendix C. Of the 57 inflow locations, seven were used to simulate backwater effect into flow paths/tributaries during large storm events and were assigned a minimal flow of 0.001 m³/s. The remaining 50 inflow locations were selected and scaled based on the results of the hydrology models (PCSWMM and SWAT) developed for this watershed as part of Phase II study of the Nose Creek Model Project (Barr, 2022). These locations were selected by isolating all conduits and junctions contributing flow directly to the creeks. Each inflow location was then categorized by the river reach and downstream hydrometric gauge as identified in Section 2.4. Given the number of contributing flows and watershed areas, 35 locations were selected in Nose Creek and 15 locations were selected in West Nose Creek. The

PCSWMM model simulated a period of precipitation from 2019-2020. July 23, 2020, was selected as the scaling event as there was a large response from the watershed to the storm event, resulting in 42.77 m³/s flow at the mouth of Nose Creek. The peak flow at each inflow location within 24 hours of the event was extracted and totaled for each applicable downstream hydrometric gauge. With the total peak inflows at each downstream hydrometric gauge, the corresponding inflows were represented as percent of total inflow upstream of the gauge. These inflows were then scaled to match the applicable calibration flow at each gauge station. This process was applied to both the moderate-flow and low-flow calibration events.



ID	Name	Northing	Easting
1	100001072104	5,682,485.3	-709.9
2	100001072242	5,681,627.6	-538.8
3	100001072548	5,683,284.8	-1,069.2
4	100001072720	5,684,865.7	-1,538.3
5	100001073068	5,681,960.9	-497.7
6	10439	5,658,012.8	-1,657.5
7	110205	5,669,297.2	-2,547.5
8	111042	5,667,305.8	-2,890.6
9	114041	5,666,366.5	-3,943.3
10	120020	5,668,767.8	-7,069.1
11	121444	5,662,186.0	-3,652.9
12	130979	5,669,202.7	-8,474.9
13	131591	5,669,292.7	-8,240.7
14	147675	5,667,492.3	-2,619.2
15	23526	5,660,018.5	-3,147.1
16	24678	5,661,445.1	-3,571.3
17	533064	5,670,308.5	-1,874.1
18	541645	5,670,300.7	-8,952.2
19	542861	5,671,501.8	-9,024.4
20	550516	5,668,945.1	-2,555.7
21	55701	5,662,868.3	-3,693.9
22	559528	5,666,283.1	-3,764.7
23	92683	5,664,316.3	-3,359.8
24	C2	5,663,140.4	-3,285.4
25	C3	5,673,893.3	0.1
26	C4	5,674,193.1	93.8
27	L15118	5,661,593.9	-3,641.0
28	NC 17_WIN_0010	5,659,652.7	-2,330.0
29	NC 17_WIN_0021	5,659,521.3	-2,128.3
30	NC 21_GRV_0002	5,662,184.2	-3,679.0
31	NC 21_SKW_0000	5,663,506.4	-3,468.7
32	NC 26_ABP	5,666,162.8	-4,244.6
33	NC 26_ABP_0022	5,666,606.3	-4,998.3
34	NC 26_COU_0052	5,667,211.9	-5,776.9
35	NC 27_COU_0011	5,667,671.3	-6,299.8
36	NC 27_HID_1106	5,668,353.0	-6,861.2
37	NC 27_PAN_0000	5,667,802.7	-6,414.1
38	OL6	5,672,038.0	-9,146.8
39	OR1	5,675,426.7	81.7
40	OVRD_20	5,684,051.9	-1,315.5
41	OVRD_632	5,678,102.7	121.9
42	SWAT11	5,692,454.7	-1,886.0
43	SWAT5	5,697,044.0	-3,427.5
44	SWAT14	5,690,966.7	-1,407.4
45	SWAT17	5,689,039.7	-1,448.3
46	SWAT20	5,687,721.5	-2,130.4
47	SWAT32	5,679,310.6	-459.0
48	SWAT37	5,676,276.5	272.6
49	SWAT43	5,673,791.2	-361.4
50	SWAT47	5,672,199.3	-9,298.9
51	NC_TRIB_1	5,699,380.3	-8,905.6
52	NC_TRIB_2	5,697,513.0	-2,580.6
53	NC_TRIB_3	5,694,848.5	-3,964.6
54	NC_TRIB_4	5,694,560.2	-2,657.8
55	WNC_TRIB_1	5,675,503.4	-12,045.6
56	NC_TRIB_5	5,698,225.0	-3,123.5
57	NC_TRIB_6	5,698,287.3	-3,489.1

Horizontal Coordinate System 3TM 114, Datum NAD83
Easting/Northing Units in meters

- Model Inflow Location
- Creek Channels
- Rocky View County Boundary
- City Boundary
- 2D Domain

0 1 2 3 Kilometers

HYDRAULIC MODEL CALIBRATION INFLOW LOCATIONS

FIGURE 4-5

4.6.2 Infrequent Flood Events

For the flood event simulations, a simpler approach was utilized for inflows. A total of 12 inflows were placed based on the hydrology report developed by Alberta Environment (2000). These inflow locations are shown in Figure 4-6. A more recent study of the Bow, Elbow, Highwood and Sheep River Basins has been completed with three locations on Nose Creek and one location on West Nose Creek (Golder, 2020). Using relative flow at comparable locations in 2020, the 12 inflow locations were scaled to the most recent discharges for the three flood events in the study area: “high” ($Q=36.1 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth), “very high” ($Q=130.0 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth), and “extreme” ($Q=407.0 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth). In addition to the 12 scaled inflows, two inflows were assumed in the upper reaches of the model domain (shown in Figure 4-6) and seven inflows were used for the backwater areas in the tributaries with an assumed flow of $0.001 \text{ m}^3/\text{s}$ (shown in Figure 4-5). The 12 scaled inflow locations as well as the two upstream discharges are summarized in Table 4-5. It is noteworthy that “high”, “very high”, and “extreme” flood events were adopted for naming convention in this study for two reasons: 1) a scaling method was used to project the 2020 hydrology to the inflow locations in the model, as described above (i.e., several inflows are synthetic and not based on actual hydrology assessment), 2) although “high”, “very high”, and “extreme” flood events are proxies for 1:10, 1:100, and 1:1,000 AEPs, they are considered as approximate due to scaling method used in this study as well as the absence of a recent hydrology assessment.

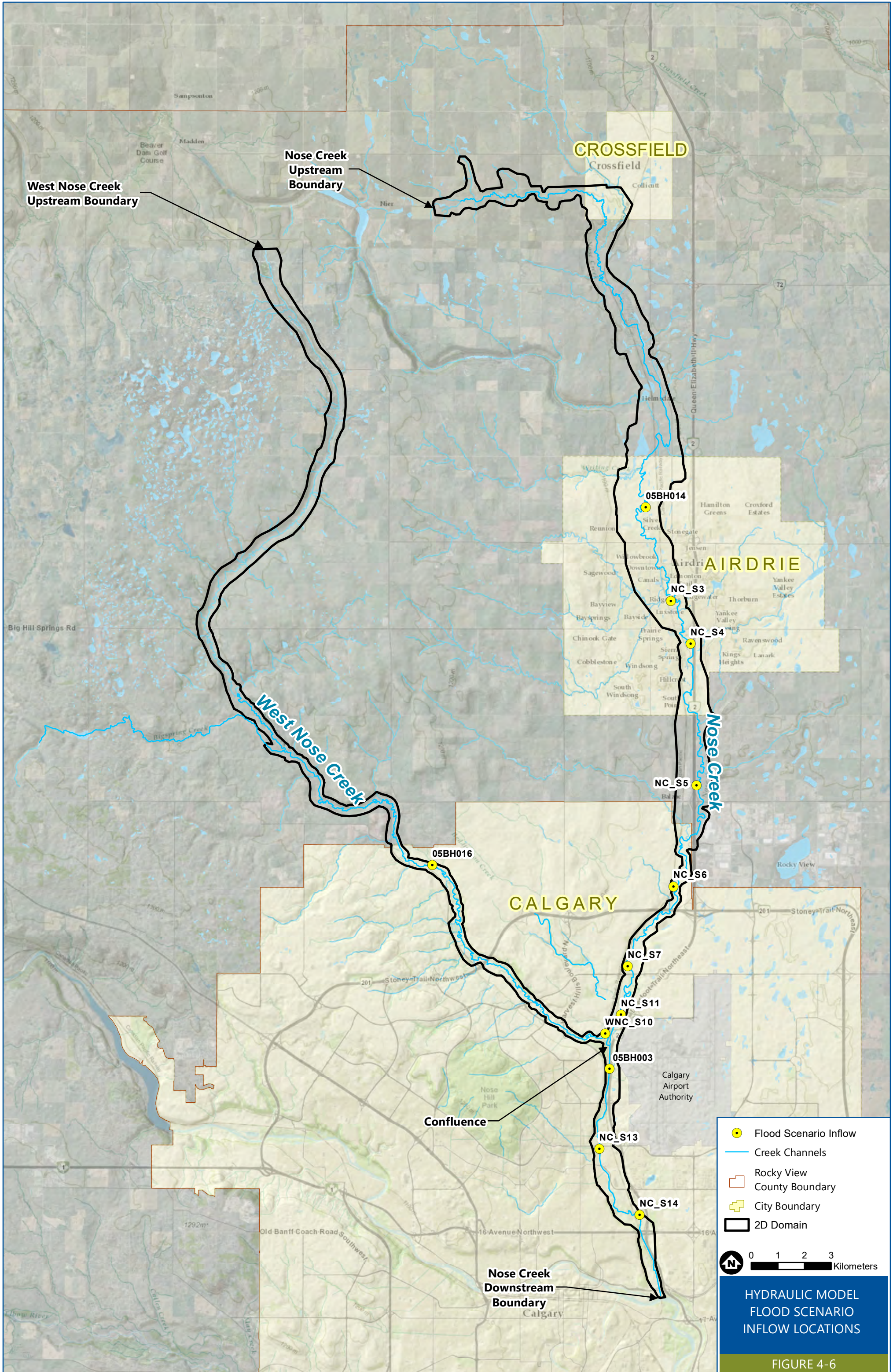


FIGURE 4-6

Table 4-5 Infrequent Flood Discharges at Inflow Locations

Site ¹	High Flood Event Discharge (m ³ /s)	Very High Flood Event Discharge (m ³ /s)	Extreme Flood Event Discharge (m ³ /s)	Source
WNC_US	5.0	15.0	50.0	Assumed
WNC_S9/05BH016	11.6	33.4	89.4	2020 ²
WNC_S10	13.6	39.0	104.5	2000 ³
NC_US	5.0	15.0	50.0	Assumed
NC_S1/05BH014	12.0	33.6	88.4	2020 ²
NC_S3	14.1	46.5	137.9	2000 ³
NC_S4	14.3	47.3	141.0	2000 ³
NC_S5	15.7	56.1	174.9	2000 ³
NC_S6	17.0	64.0	205.0	2000 ³
NC_S7	17.8	68.9	223.8	2000 ³
NC_S11	18.7	74.0	243.5	2000 ³
NC_S12/BH003	32.3	113.0	348.0	2020 ²
NC_S13	35.5	127.8	400.2	2000 ³
NC_14/05BH901	36.1	130.0	407.0	2020 ²

1 The locations were selected based on Alberta Environment (2000).

2 Golder, 2020.

3 Alberta Environment, 2000.

4.7 Manning's n Roughness

The roughness distribution was assigned in the full 2D model as discussed in Section 3.7. A preliminary channel roughness was assigned according to the reach characteristics and varied from 0.04 to 0.055.

5 Model Calibration

5.1 Methodology

The Manning's n roughness values and the hydraulic structure contraction/expansion coefficients were the two primary model parameters used in calibrating the HEC-RAS model. The latter does not play a significant role in 2D models where calibrating water levels are not in the vicinity of a hydraulic structure. Selection of initial Manning's n values included consideration of stream bed and bank materials, land use cover, site information collected during the field inspection, 2012 Alberta Environment's hydraulic model for Nose and West Nose Creeks, and Barr's experience with previous hydraulic model studies.

The Manning's n value is an empirical parameter which may decrease with increased water depth. Model calibration was conducted based on the pertinent flow and water level information of the low-flow and moderate-flow (note that "moderate-flow" was adopted here instead of "high-flow" as it was recognized the range of flood peaks in the records used for this study are not very high) conditions to determine Manning's n values across a wide range of flows.

Since there is no record of HWM available along the study reaches, moderate-flow and low-flow events for model calibration were selected based on the hydrometric data available at gauges along the study reaches (Figure 2-1 in Section 2.4). As summarized in Table 2-1 (Section 2.4), the hydrometric data was recorded at different time intervals. For the purpose of this study, the flow and water level data were averaged to hourly data, if the time step was sub-hourly.

Event selection for moderate-flow and low-flow calibration was as follows:

1. Flow and water level data from 2019 to 2021 were used in this study.
2. Event was governed by the most downstream gauge on Nose Creek at the Mouth:
 - a. Flow data was averaged to obtain the hourly data at Nose Creek at the Mouth.
 - b. Data was sorted in descending order.
 - c. Three events were selected for moderate-flow and two for low-flow.
3. Corresponding date and time selected in step 2 above (for the Nose Creek at the Mouth gauge) was compared with the other gauges to determine their corresponding flow and water level peaks.
4. Since the Nose Creek watershed is large, the flow peak timing could be different, especially within urban areas (due to impervious surfaces) versus rural areas. Therefore, timing of some gauges on Nose and West Nose creeks may not precisely match the peak flow time of Nose Creek at the Mouth.

Since there is no HWM available along the Nose Creek and West Nose Creek, the 2019 to 2021 flow and water level data at the gauging stations were used for model calibration. These events are summarized in Table 5-1.

Table 5-1 Summary of Model Calibration Events (Governed by Nose Creek at the Mouth)

Event Type	Date (mm/dd/yyyy)	Time (hh:mm)	Flow (m ³ /s)	Water Level (m)
Moderate Flow 1 (MF1)	2021/07/02	20:00	28.23	1037.04
Moderate Flow 2 (MF2)	2020/07/08	12:50	14.58	1036.56
Moderate Flow 3 (MF3)	2020/07/03	07:35	6.23	1036.17
Low Flow 1 (LF1)	2021/07/13	20:30	0.90	1035.70
Low Flow 2 (LF2)	2021/08/11	07:15	0.20	1035.55

It is noteworthy that WSC Station 05BH016 (West Nose Creek at Calgary) does not have a vertical datum for the measured water levels and could not be used for water level calibration. However, the flow data was used at this gauge as an inflow in the model. Moreover, University of Calgary Station WNCSGS on West Nose Creek has limitations and uncertainties regarding the measured flows and water levels. As communicated to Barr by Professor Masaki Hayashi of the University of Calgary (in email correspondence dated 11/15/2022), the water level-flow rating curve is constrained to an upper limit of 1 m³/s, meaning that higher flow values are extrapolated, and errors are expected for flow events higher than 1 m³/s. Therefore, a thorough water level calibration for West Nose Creek, especially for moderate-flow events, might be impossible to achieve with currently available data. Both Nose Creek and West Nose Creek can experience extreme low flows during the summer months. Given the limitations of the model in low-flow conditions, the threshold of 0.05 m³/s was applied to the low-flow calibration events. Therefore, these areas were modeled as dry for flows below this threshold and therefore could not be calibrated.

The calibration events, flows, and water levels for all gauges are summarized in Table 5-2.

Table 5-2 Calibration Events Summary

Station	MF1		MF2		MF3		LF1		LF2	
	Q ² (m ³ /s)	WL ³ (m)	Q (m ³ /s)	WL (m)	Q (m ³ /s)	WL (m)	Q (m ³ /s)	WL (m)	Q (m ³ /s)	WL (m)
05BH014	NF ⁴	NF ⁴	0.93	1082.84	1.28	1082.73	TH ⁸	TH ⁸	TH ⁸	TH ⁸
AIR-DS	0.08	1073.97	4.76 ⁶	1074.91	2.63	1074.41	ND ⁵	ND ⁵	NF ⁴	NF ⁴
SUR_NC-15	0.25	1057.40	7.36	1058.25	2.76	1057.84	0.43	1057.46	TH ⁸	TH ⁸
SUR_NC-M	28.23	1037.04	14.58	1036.56	6.23	1036.17	0.90	1035.70	0.20	1035.55
WNCSGS	0.07	1107.92	1.63	1108.57	EX ⁷	EX ⁷	0.08	1107.93	0.07	1107.92
05BH016 ¹	0.16	ND ⁵	1.38	ND ⁵	1.41	ND ⁵	0.09	ND ⁵	0.08	ND ⁵
SUR_WNC-M	3.30	1052.77	2.57	1052.70	2.17	1052.66	0.17	1052.34	0.11	1052.29

- 1 No datum available and thus water level could not be calibrated at this gauge.
- 2 Q = flow. Flows reported in this table are addition of flows at each gauge (i.e., incremental flows and not cumulative), due to the nature of unsteady simulation in HEC-RAS.
- 3 WL = water level.
- 4 NF = Zero flow was reported at the gauge and therefore, the water level could not be calibrated.
- 5 ND = No data available
- 6 No flow was available at gauge. Barr utilized the PCSWMM results to derive a discharge during this period (Barr, 2022).
- 7 EX = Flow exceeded the downstream gauge and was excluded to maintain a mass balance.
- 8 TH = Threshold, the flow at the gauge was below the model threshold of 0.05 m³/s.

The model calibration process involved multiple iterations to adjust the model parameter values, conduct simulations, and compare the simulated water levels with the measured water levels at the gauges. The objective of the model calibration was to achieve a reasonable agreement between the simulated and measured water levels.

The results of the model calibration are described in the following sections.

5.2 Low-Flow Calibration

The two low-flow calibration events were limited in the upper reach of Nose Creek due to the low-flow threshold (i.e., flow of 0.05 m³/s, as described in Section 5.1). However, the remaining gauges were calibrated reasonably well. The low-flow calibration results are summarized in Table 5-3 and Table 5-4. The average differences between the simulated and observed water surface elevations and root mean square error (RMSE) results are provided. It is also noted that the choice of downstream boundary condition (i.e., normal depth versus observed water level at Nose Creek at the Mouth) does not impact the calibration results, as other gauges are located far enough from the downstream boundary not to be impacted by it. The simulated channel profiles in comparison to observed water levels can be seen in Appendix D.

Table 5-3 Low Flow 1 Calibration Results

Gage	Observed Water Surface Elevation (masl.)	Simulated Water Surface Elevation (masl.)	Difference (Simulated – Observed) (m)
05BH014	TH ¹	TH ¹	NA ²
AIR-DS	TH ¹	TH ¹	NA ²
SUR_NC-15	1057.46	1057.37	-0.09
WNC_SGS	1107.93	1108.08	0.15
SUR_WNC-M	1052.34	1052.26	-0.08
SUR_NC-M	1035.70	1035.50	-0.20
Average (m)			-0.05
RMSE (m)			0.14

1 TH = Threshold, the flow at the gauge was below the model threshold of 0.05 m³/s.

2 NA = Not applicable.

Table 5-4 Low Flow 2 Calibration Results

Gage	Observed Water Surface Elevation (masl.)	Simulated Water Surface Elevation (masl.)	Difference (Simulated – Observed) (m)
05BH014	TH ¹	TH ¹	NA ³
AIR-DS	NF ²	NF ²	NA ³
SUR_NC-15	TH ¹	TH ¹	NA ³
WNC_SGS	1107.92	1108.07	0.15
SUR_WNC-M	1052.29	1052.22	-0.07
SUR_NC-M	1035.55	1035.35	-0.20
Average (m)			-0.04
RMSE (m)			0.15

1 TH = Threshold, the flow at the gauge was below the model threshold of 0.05 m³/s.

2 NF = Zero flow was reported at the gauge and therefore, the water level could not be calibrated.

3 NA = Not applicable.

The Low Flow 1 and Low Flow 2 calibration results are in good agreement at the two West Nose Creek gauges. The simulated water surface elevation was higher at WNC_SGS, and lower at SUR_WNC-M, comparing the observed water levels. Both of these gauges were within 0.15 m of the observed water surface elevation for both events. The flow calibration at NC_SUR-15 was limited to Low Flow 1 but matched the observed data with a difference of 0.09 m in water surface elevation. For both low-flow calibration events, the simulated water surface elevation at SUR_NC-M was 0.2 m lower than observed. Overall, the average of the difference between observed and simulated water surface elevation was low.

The average difference between simulated and observed water surface elevations for Low Flow 1 and Low Flow 2 events falls to -0.05 m and -0.04 m, respectively, indicating an excellent model calibration. A RMSE of 0.15 m is considered very good for the calibration of water levels for these two low-flow events.

5.3 Moderate-Flow Calibration

The moderate-flow calibration was more complete than that of the low-flow calibration, as only two locations in all three events were not calibrated, due to missing data. Although the three events had, in general, moderate flows at the mouth, flows in the upper regions were still around bankfull or lower for most events. This presented the opportunity to better calibrate the Manning’s n values in the main channel in the upper reaches. The moderate-flow calibration results are summarized in Table 5-5 through Table 5-7. The simulated channel profiles in comparison to observed water levels can be seen in Appendix E.

Table 5-5 Moderate Flow 1 Calibration Results

Gage	Observed Water Surface Elevation (masl.)	Simulated Water Surface Elevation (masl.)	Difference (Simulated – Observed) (m)
05BH014	NF ¹	NF ¹	NA ²
AIR-DS	1073.97	1074.11	0.14
SUR_NC-15	1057.40	1057.36	-0.04
WNC_SGS	1107.92	1108.07	0.15
SUR_WNC-M	1052.77	1052.78	0.01
SUR_NC-M	1037.04	1037.17	0.13
		Average (m)	0.08
		RMSE (m)	0.11

1 NF = Zero flow was reported at the gauge and therefore, the water level could not be calibrated.

2 NA = Not applicable.

Table 5-6 Moderate Flow 2 Calibration Results

Gage	Observed Water Surface Elevation (masl.)	Simulated Water Surface Elevation (masl.)	Difference (Simulated – Observed) (m)
05BH014	1082.84	1082.52	-0.32
AIR-DS	1074.91	1075.34	0.43
SUR_NC-15	1058.25	1058.61	0.36
WNC_SGS	1108.57	1108.80	0.23
SUR_WNC-M	1052.70	1052.70	0.00
SUR_NC-M	1036.56	1036.58	0.02
		Average (m)	0.12
		RMSE (m)	0.28

Table 5-7 Moderate Flow 3 Calibration Results

Gage	Observed Water Surface Elevation (masl.)	Simulated Water Surface Elevation (masl.)	Difference (Simulated – Observed) (m)
05BH014	1082.73	1082.62	-0.11
AIR-DS	1074.41	1075.01	0.60
SUR_NC-15	1057.84	1058.02	0.18
WNC_SGS	EX ¹	EX ¹	NA ²
SUR_WNC-M	1052.66	1052.65	-0.01
SUR_NC-M	1036.17	1036.08	-0.09
		Average (m)	0.11
		RMSE (m)	0.29

1 EX = Flow exceeded the downstream gauge and was excluded to maintain a mass balance.

2 NA = Not applicable.

The moderate-flow calibration was generally very successful throughout the model with average difference between simulated and observed water surface elevations (i.e., simulated minus observed) of 0.08 m, 0.12 m, and 0.11 m, for the Moderate Flow 1, Moderate Flow 2, and Moderate Flow 3 calibration events, respectively. Similar to the low-flow calibration, simulated water surface elevations at both West Nose Creek gauges agreed well with observed data with a deviation ranging from -0.01 m to 0.23 m (simulated minus observed). In general, the simulated water surface elevation was slightly higher than observed at both gauges. Simulated water levels at the Nose Creek gauge SUR_NC-15, generally agreed with the observed water levels with a deviation ranging from -0.04 m to 0.36 m (simulated minus observed). Simulated water surface levels at the Nose Creek at the Mouth gauge matched observed data well with a deviation ranging from -0.09 m to 0.13 m (simulated minus observed). The two upper gauges on Nose Creek were difficult to calibrate. The simulated water levels at the northernmost gauge 05BH014, was typically lower than the observed water levels, while at the gauge below Airdrie was consistently higher than observed water levels. These could be attributed to uncertainty in measured data and

probably scaling of the inflow, as described in Section 4.6.1. Iterations of roughness and bridge expansion/contraction coefficients were explored at these locations, but with limited success. Barr has also observed several potential issues with the monitoring data that may explain why the observed and simulated water levels differ for these events as described below.

5.4 Uncertainty in Calibration Data

The model calibration for the selected low and moderate-flow events are considered successful with the statistics presented above. Calibrating the water levels at the upper reaches of Nose Creek were in general more difficult and less successful. In attempting to better understand the differences between simulated and observed data, Barr found instances of uncertainty in the gauge rating curves. Within gauges AIR-DS and 05BH014, there were several instances where the water level deviated up to 0.50 m at recorded flows within 0.1 m³/s. These inconsistencies are highlighted in Table 5-8 as well as Figure 5-1 and Figure 5-2.

Table 5-8 Gauge Rating Curve Inconsistency

Gage	AIR-DS	
Date and Time	Flow (m ³ /s)	Recorded Water Surface Elevation (masl.)
6/14/20 9:00	2.61	1074.67
6/15/20 11:00	2.68	1074.45
7/3/20 8:00	2.63	1074.40
7/6/20 1:00	2.67	1074.42
7/12/20 20:00	2.69	1074.43
7/12/20 21:00	2.65	1074.42
7/12/20 22:00	2.61	1074.42
7/8/21 5:00	2.69	1074.85
7/8/21 12:00	2.62	1074.66
8/27/21 23:00	2.63	1074.44
Maximum Difference (m)		0.45
Gage	05BH014	
Date and Time	Flow (m ³ /s)	Recorded Water Surface Elevation (masl.)
3/30/20 16:00	0.94	1082.60
4/29/20 8:00	0.94	1082.38
7/4/20 3:00	0.94	1082.71
7/8/20 13:00	0.93	1082.84
7/16/20 0:00	0.94	1082.85
7/28/20 18:00	0.94	1082.79
8/5/20 12:00	0.94	1082.70
8/5/20 14:00	0.93	1082.70
8/15/20 0:00	0.94	1082.59
8/16/20 3:00	0.93	1082.58
Maximum Difference (m)		0.47

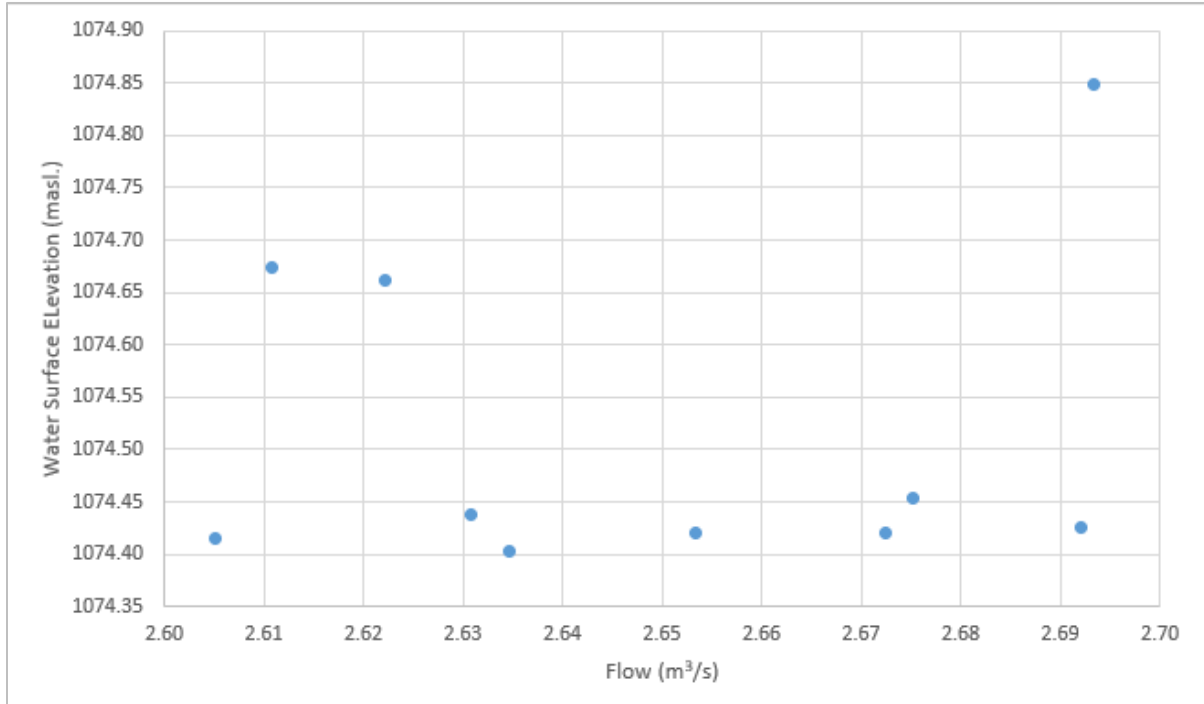


Figure 5-1 AIR-DS Flow and Recorded Water Surface Elevation Over Time

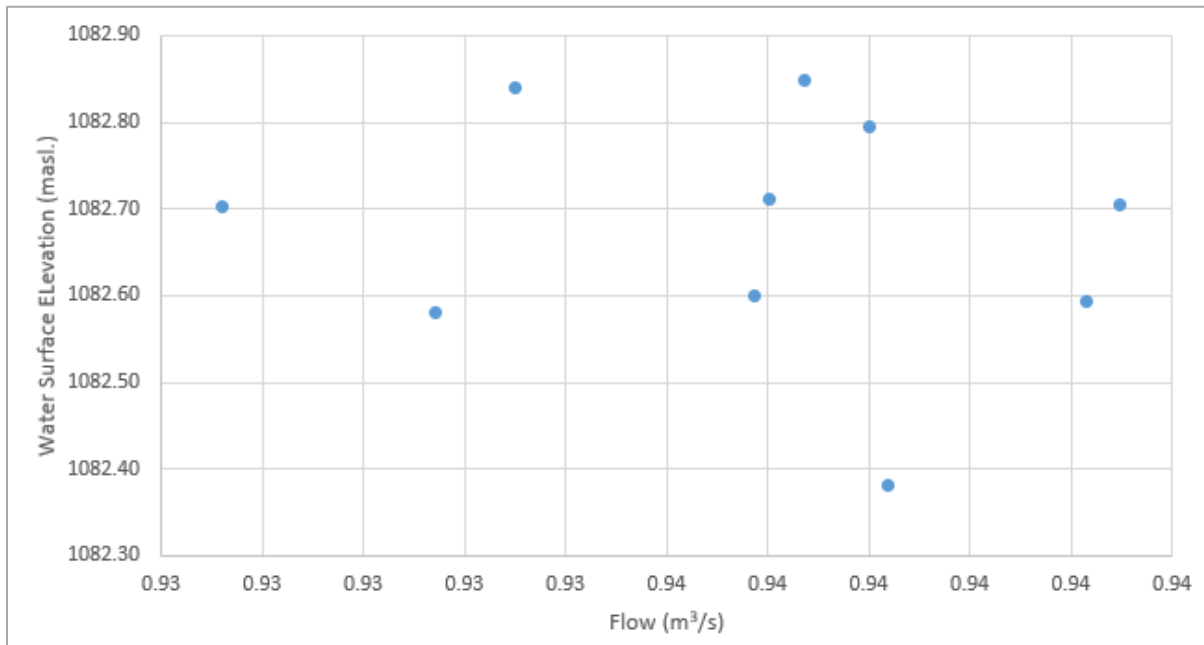


Figure 5-2 05BH014 Flow and Recorded Water Surface Elevation Over Time

There is a significant difference in the 2020 and 2021 AIR-DS gauge water level for the same approximate flow. This suggests that a physical change may have occurred around the gage and or a change in the method of reporting. It is worth noting that the City of Airdrie has seen significant growth south towards this gauge, including major construction directly upstream.

The 05H014 gauge also has significantly varied water surface elevation for approximately the same flow within the year 2020. This may be due to the gauge being positioned directly upstream of a low-level stream crossing as seen in Figure 5-3.



Figure 5-3 05BH014 Aerial Image from May 2021 (Image Source: Google Earth)

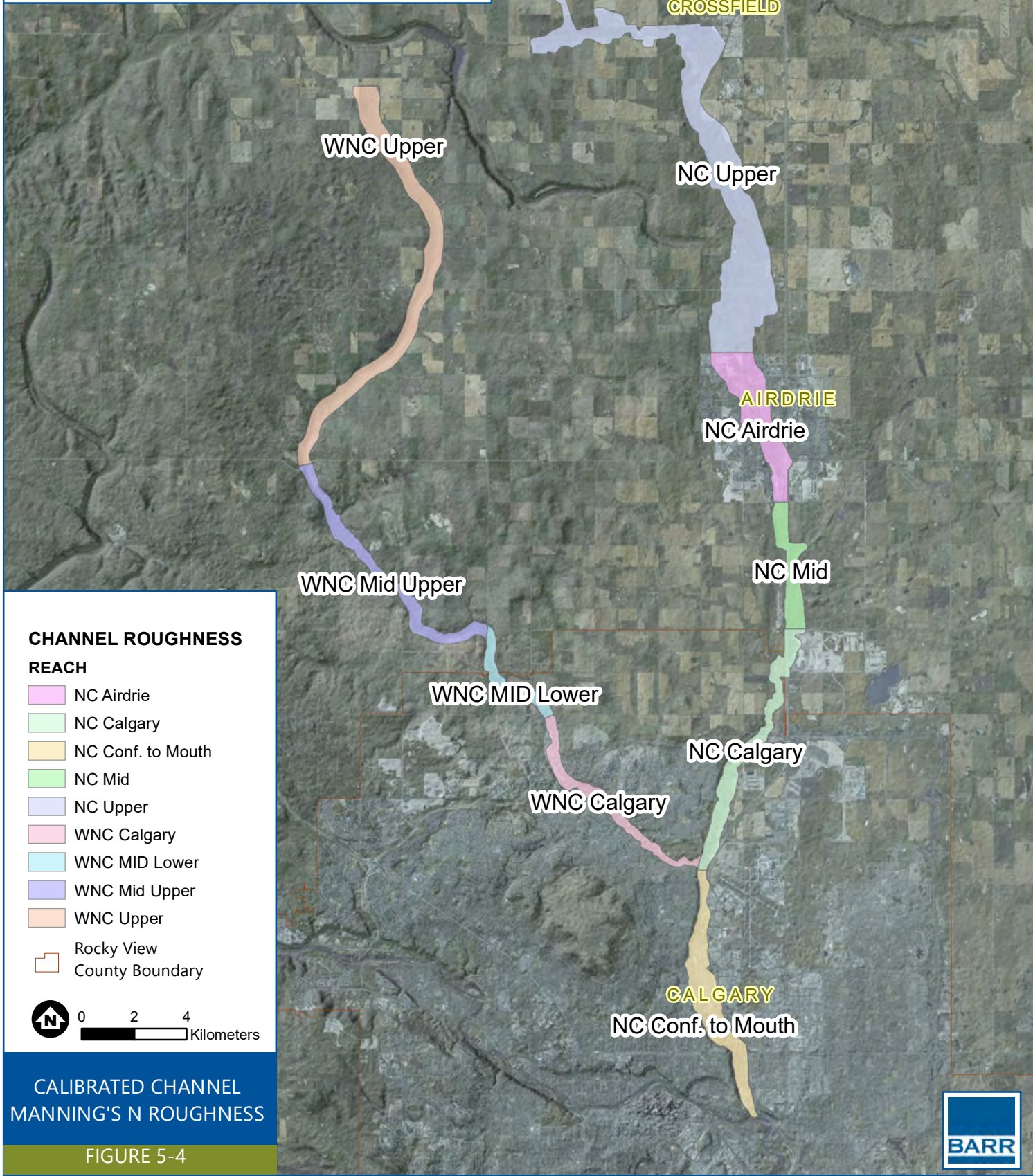
The above uncertainties can be attributed to changes to the channel, floodplain, and other variations over time. However, tailwater (or backwater) effect is another likely contributor given the proximity of 05BH014 to the City of Airdrie. Regardless of the cause, the uncertainties presented above were considered when finalizing the calibration parameters. Although the difference between simulated and observed water surface elevations were higher for the two gauges discussed above, Barr did not have the confidence in the observed data to deviate from a reasonable range of roughness values at these gauges.

5.5 Calibrated Parameters

Channel Manning's n roughness in the calibrated model remained within the preliminary selection range of 0.04 to 0.055. However, a greater portion of the reach was assigned the channel Manning's n roughness of 0.045. Note that a Manning's n value of 0.055 is associated with a channel that is highly affected by vegetation. Based on the photos provided by surveyors, the very upstream reaches of both creeks are highly vegetated and a Manning's n -value of 0.055 can be physically justified. The final calibrated model distribution of the channel Manning's n roughness is shown in Figure 5-4.

The overbank roughness values remained unchanged during the model calibration (compared to those initially selected, as described in Table 3-6). The bridge expansion and contraction coefficients also remained at 0.3 and 0.5, respectively.

REACH	CALIBRATED CHANNEL MANNING'S N
WNC Upper	0.055
NC Upper	0.055
NC Airdrie	0.045
NC Mid	0.045
NC Conf. to Mouth	0.04
NC Calgary	0.045
WNC Calgary	0.045
WNC Mid Upper	0.05
WNC MID Lower	0.045



Barr Footer: ArcGIS 10.8.1, 2023-04-03 15:28 File: I:\Projects\61101\1236\Maps\Reports\Figure 3-5 Roughness Distribution.mxd User: EMA

CALIBRATED CHANNEL MANNING'S N ROUGHNESS

FIGURE 5-4



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, IGN, and the GIS User Community
NASA's Jet Propulsion Laboratory.

6 Model Sensitivity Analysis

The sensitivity of the model to the calibrated roughness described above was conducted with the “very high” flood event (i.e., proxy to the 1:100 AEP flood event). In this analysis the main channel roughness, floodplain roughness, and combined main channel and floodplain roughness were varied by $\pm 10\%$. The water surface elevations from these sensitivity analyses were compared to the base “very high” flood event using the calibrated roughness values, as summarized in Table 6-1. The water level profiles for the sensitivity analysis can be found in Appendix F.

Table 6-1 Model Sensitivity Analyses Summary

Model Sensitivity Scenario	Sensitivity Change	Average Water Level Difference (m)	Max/Min Water Level Difference (m)	Station ¹ of Max/Min Water Level Difference (m)	Average Water Level Difference (m)	Max/Min Water Level Difference (m)	Station ¹ of Max/Min Water Level Difference (m)
		Nose Creek	Nose Creek	Nose Creek	West Nose Creek	West Nose Creek	West Nose Creek
Main Channel Only	10%	0.03	0.12	11,200	0.01	0.07	68,900
	-10%	-0.03	-0.13	11,400	-0.01	-0.06	2,800
Floodplain Only	10%	0.02	0.04	11,400	0.01	0.03	56,400
	-10%	-0.02	-0.05	23,900	-0.01	-0.03	56,400
Main Channel and Floodplain	10%	0.05	0.16	11,400	0.03	0.08	68,900
	-10%	-0.05	-0.17	11,400	-0.02	-0.08	69,000

1. Water level profile stations in meters as shown in Appendix F.

The 2D HEC-RAS model has a low sensitivity to the roughness coefficient. A 10% increase or decrease in both the floodplain and channel Manning’s n roughness values results in a maximum of 0.05 m of water surface elevation change, on average. The most sensitive reaches for a combined channel and floodplain roughness change along Nose Creek and West Nose Creek are around stations 11,400 m and 68,900 m with water level differences of -0.17 m and 0.08 m, respectively.

7 Infrequent Flood Model Simulation Results

Flood simulation was not part of the current study scope; however, Barr used the calibrated model to run three flood events in the study area: “high” ($Q=36.1 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth), “very high” ($Q=130.0 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth), and “extreme” ($Q=407.0 \text{ m}^3/\text{s}$ at Nose Creek at the Mouth). Model inflows were set based on existing hydrology for Nose Creek and West Nose Creek, as described in Section 4.6.2.

Water surface profiles for the three selected flood events are shown in Appendix G. Figure 7-1 to Figure 7-3 show the comparisons between the full 2D model simulated “high”, “very high”, and “extreme” (as proxies for 1:10, 1:100, and 1:1,000 AEP) flood inundation extents and that from Flood Awareness Map Application ([FAMA](#)) of Government of Alberta. FAMA is the official flood mapping for Nose Creek and West Nose Creek. Assuming that the official models have been properly created and calibrated, the close agreement between Barr’s full 2D model and the FAMA maps supports the current full 2D model calibration and its capability to simulate a large range of flows. It is noted that the FAMA maps are only available for 1:10 and 1:100 AEP flood events and not the 1:1,000 AEP flood event for Nose Creek and West Nose Creek. As one would expect, the full 2D model simulated “extreme” (as proxy for 1:1,000 AEP) flood inundation extents shown in Figure 7-3 are larger than those from the 1:100 AEP flood event FAMA map.

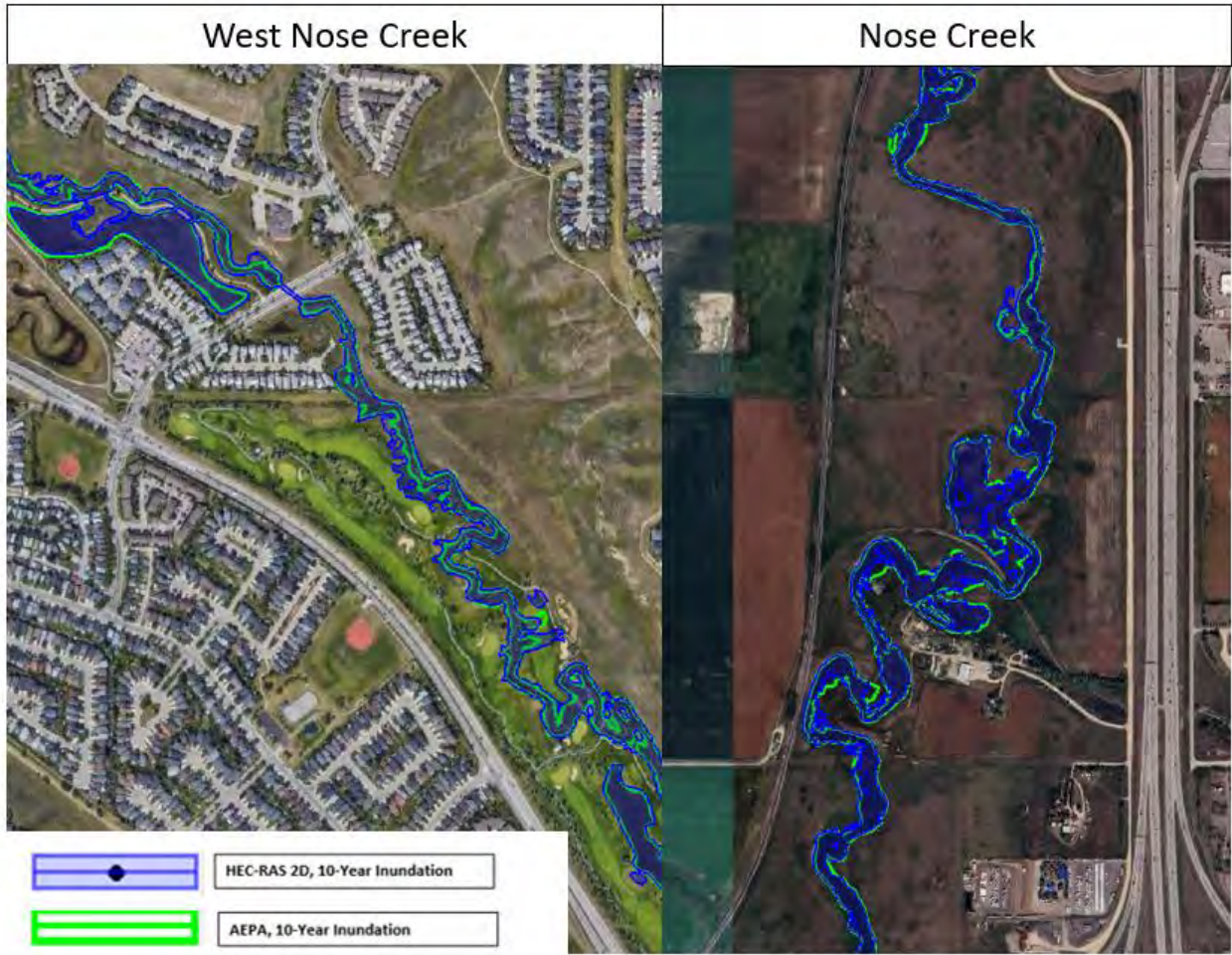


Figure 7-1 “High” (as proxy for 1:10 AEP) Flood Event - Comparison of Simulated Inundation Extent (This Study) to FAMA Mapping

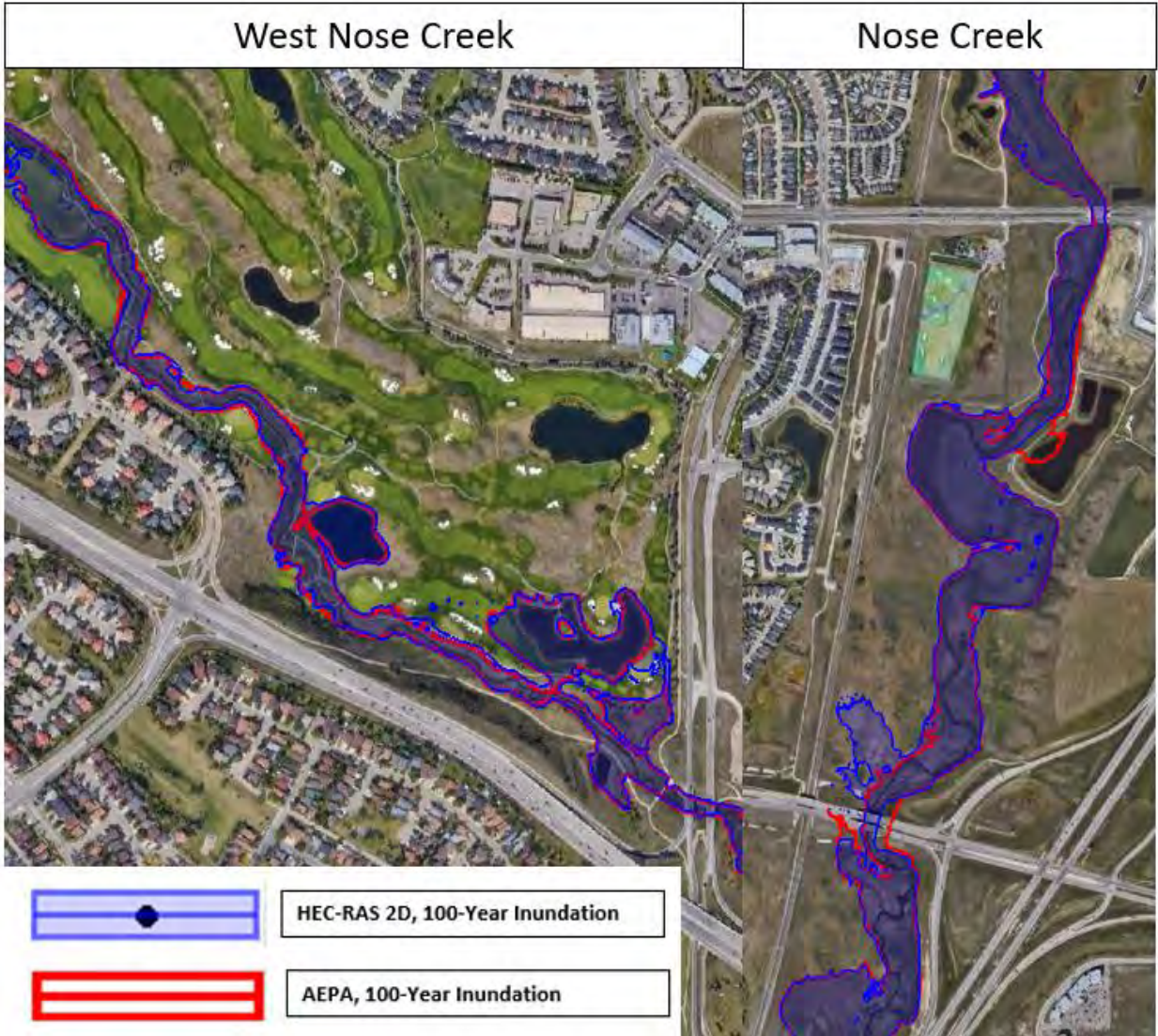


Figure 7-2 “Very High” (as proxy for 1:100 AEP) Flood Event - Comparison of Simulated Inundation Extent (This Study) to FAMA Mapping

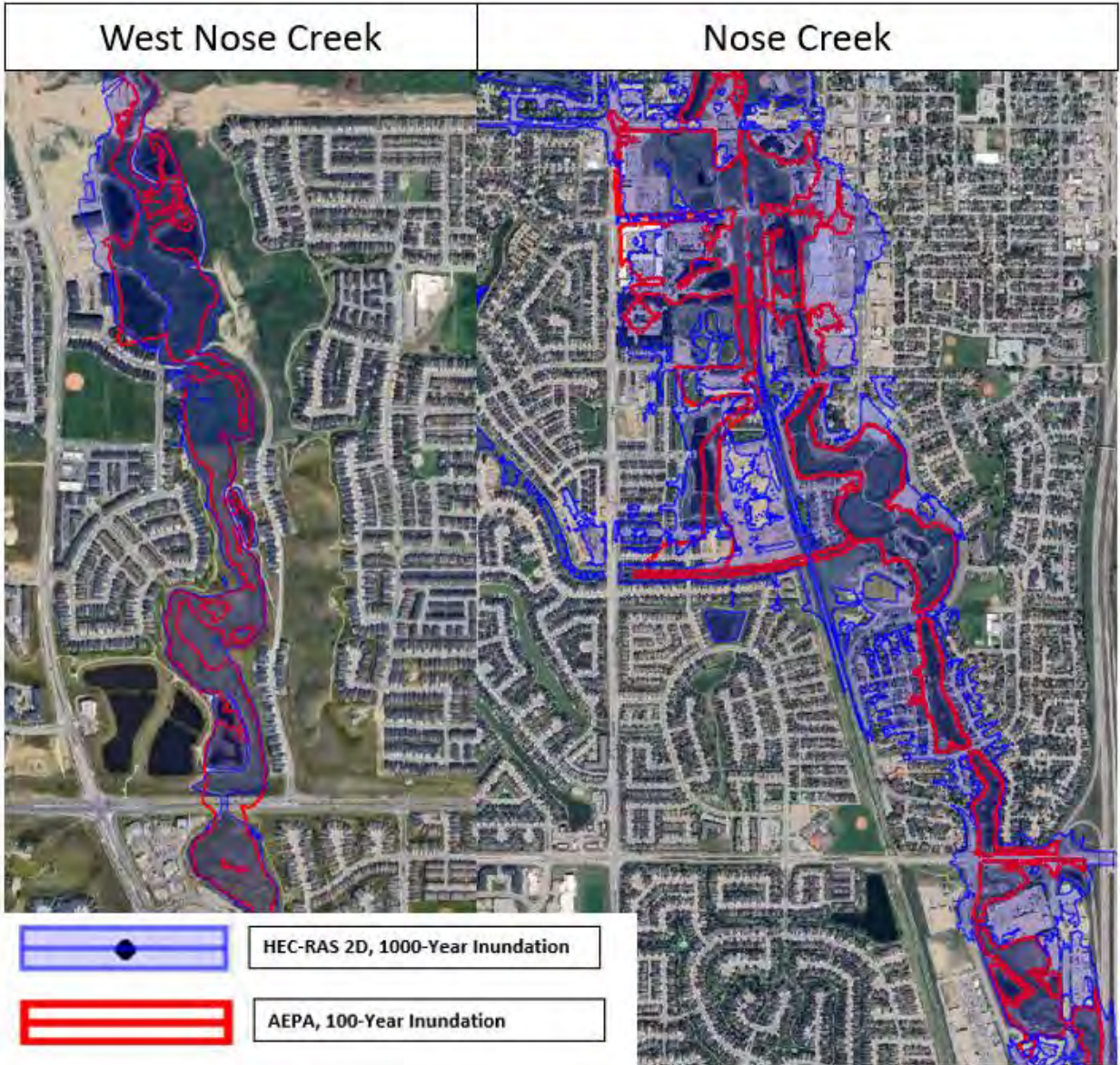


Figure 7-3 “Extreme” (as proxy for 1:1,000 AEP) Flood Event - Comparison of Simulated Inundation Extent (This Study) to 1:100 AEP FAMA Mapping

8 Conclusions

8.1 Model Calibration

The 2D HEC-RAS model for the study reach was calibrated based on five selected scenarios (two low-flow scenarios and three moderate-flow scenarios). The calibrated 2D HEC-RAS model in this study can be reliably used in modeling flows from approximately 0.2 m³/s up to an extreme flood event (407 m³/s) at the mouth of Nose Creek.

The channel Manning's n roughness coefficient is the main model parameter used in calibrating the HEC-RAS model. The calibrated channel Manning's n values are in the range of 0.04 to 0.055 for calibration flow conditions. These Manning's n values are within the typical ranges of roughness values for similar water courses (Chow, 1959).

8.2 Model Sensitivity

Model sensitivity was evaluated using the "very high" (as proxy for 1:100 AEP) flood simulation results. The results of the sensitivity analysis show that variation of the main channel roughness values has a higher influence on the simulated water levels than variation of the floodplain roughness values along Nose and West Nose creeks. A variation of the main channel and floodplain Manning's n values by $\pm 10\%$ resulted in changes of the simulated water levels within 0.05 m. Overall model sensitivity to roughness remained low.

8.3 Infrequent Flood Simulations

The calibrated HEC-RAS model provides a reliable tool for simulating the infrequent flood events. Three flood events were simulated using the calibrated full 2D model in this study (i.e., "high", "very high", and "extreme" flood events). The simulated water surface profiles for these three events are shown in Appendix H.

8.4 Supplemental Materials

This report is accompanied by a HEC-RAS model package that consists of all full 2D HEC-RAS models (calibration, sensitivity, infrequent floods). The table in Appendix H provides naming conventions of geometry, flow, and plan files for all model scenarios. NCWP has reviewed the full 2D HEC-RAS model and this report in two rounds and provided Barr with comments. The review comments and Barr's responses to those comments are included in Appendix I.

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Appendices

Appendix A

Hydraulic Structures

Table A-1 Nose Creek Bridge Summary

Station	Survey ID	Description	Length of Span (m)	Width of Bridge (m)	Top of Curb Elev. (masl.)	Top of Handrail/Guardrail Elev. (masl.)	Type of handrail/guardrail	Low Chord (masl.)	Bridge Thickness (Rail-Low Chord) (masl.)	Bridge Thickness (Curb-Low Chord) (masl.)	Number of Piers	Width of Piers	Footnote
271	1	Service	30.4	6.8	1040.65	1041.49	Concrete	1039.36	2.13	1.29	NA	NA	
319	2	Memorial Drive NE	108.9	25.1	1048.69	1049.52	Concrete	1047.51	2.01	1.18	3	1	
346	3	LRT	109.4	4.7	1048.87	1049.78	Steel	1048.18	1.60	0.69	3	1	
374	4	LRT	100.3	4.7	1049.35	1050.21	Steel	1047.60	2.61	1.75	3	1	
428	5	Memorial Drive SE	96.7	17.8	1049.28	1050.13	Concrete	1047.62	2.51	1.66	3	1	
1460	6	CPR	32.8	5.1	1041.25	1042.05	Concrete	1040.53	1.52	0.72	1	1	1
1460	7	CPR	34.9	7.3	1041.50	1042.06	Concrete	1040.00	2.06	1.50	1	1	1
1838	8	8 Ave. NE	229.2	12.1	1050.24	1051.24	Concrete	1049.29	1.95	0.95	4	1	
2720	9	Trans-Canada Highway	105.3	15.5	1050.70	1054.79	Concrete	1049.68	5.11	1.02	3	1	
2817	10	Trans-Canada Highway	99.9	15.6	1050.70	1052.23	Concrete	1049.69	2.54	1.01	2	1	2
2878	11	Pedestrian	32.1	3.5	1042.88	1044.27	Wood	1042.81	1.46	0.07	NA	NA	
3531	12	Pedestrian (Golf)	31.6	3.1	1043.29	1042.66	Concrete	1042.13	0.53	1.16	NA	NA	
3654	13	CPR	31.9	4.0	1043.43	1044.51	Concrete	1041.33	3.18	2.11	1	1.5	
3698	14	Pedestrian	22.8	2.7	1041.37	1042.58	Wood	1041.32	1.26	0.05	NA	NA	
4225	15	Pedestrian (Golf)	25.5	3.6	1042.19	1042.38	Concrete	1041.73	0.65	0.46	2	0.5	
4614	16	Pedestrian (Golf)	18.9	1.9	1041.48	1042.27	Steel	1041.21	1.06	0.27	NA	NA	
5272	17	Pedestrian (Golf)	30.6	3.8	1043.41	1044.41	Steel	1042.25	2.16	1.16	NA	NA	
5936	18	36 Ave. NE	36.2	14.2	1046.76	1047.82	Concrete	1045.84	1.98	0.92	NA	NA	
6582	19	32 Ave. NE	28.2	27.2	1046.03	1047.48	Concrete	1044.88	2.60	1.15	NA	NA	
7315	20	McKnight Blvd. NE	30.3	24.8	1047.08	1048.10	Metal	1046.70	1.40	0.38	NA	NA	
7489	21	Goddard Ave. NE	27.4	11.8	1047.84	1048.79	Concrete	1046.48	2.31	1.36	NA	NA	
8063	22	Beaver Dam Rd. NE	32.74	12.01	1048.74	1049.85	Concrete	1047.43	2.42	1.31	NA	NA	
8773	23	Service	37.47	4.93	1050.23	1051.45	Concrete	1049.14	2.31	1.09	1	1	
8902	24	CPR	32.9	5.4	1051.23	1051.53	Metal	1049.55	1.98	1.68	3	1	
10906	25	Beddington Tr. NE	145.2	12.4	1064.48	1065.60	Concrete	1062.91	2.69	1.57	3	1.45	3
11013	26	Beddington Tr. NE	214.5	11.5	1064.48	1065.60	Concrete	1062.91	2.69	1.57	5	1.45	2
13292	27	96 Ave. NE	86.2	14.7	1065.27	1066.30	Concrete	1063.73	2.57	1.54	2	0.75	1
13292	28	96 Ave. NE	85.8	18.1	1066.14	1067.65	Concrete	1063.67	3.98	2.47	2	0.75	1
16022	29	Country Hills Blvd. NE	30.2	36.3	1059.98	1060.99	Metal	1059.08	1.91	0.89	NA	NA	
19154	30	15 St. NE	28.7	7.9	1061.45	1062.32	Concrete	1060.85	1.47	0.60	NA	NA	
20655	31	Stoney Tr. NE	91.8	24.5	1077.50	1078.53	Concrete	1076.25	2.28	1.25	NA	NA	
20698	32	Stoney Tr. NE	91.2	24.3	1077.50	1078.53	Concrete	1076.16	2.37	1.34	NA	NA	
23791	33	CPR	36.8	3.1	1071.65	NA	NA	1069.93	NA	1.72	NA	NA	
27756	100	Path	14.1	2.4	1070.58	1071.99	Concrete	1070.59	1.40	~0	NA	NA	
31694	36	Twp. Rd. 263	25.8	8.8	1074.55	1075.57	Concrete	1074.45	1.12	0.10	2	0.3	
34266	37	Misc.	18.3	4.3	1077.46	1077.86	Steel	1076.82	1.04	0.64	NA	NA	

Station	Survey ID	Description	Length of Span (m)	Width of Bridge (m)	Top of Curb Elev. (masl.)	Top of Handrail/Guardrail Elev. (masl.)	Type of handrail/guardrail	Low Chord (masl.)	Bridge Thickness (Rail-Low Chord) (masl.)	Bridge Thickness (Curb-Low Chord) (masl.)	Number of Piers	Width of Piers	Footnote
37739	38	Sierra Springs Drive South-east	18.5	8.9	1081.51	1083.21	Steel	1081.25	1.96	0.26	NA	NA	
38348	39	Co-op Access Sierra Springs	13.5	8.5	1082.19	1083.60	Steel	1081.10	2.50	1.09	NA	NA	
38681	40	Pedestrian	7.0	2.8	1078.90	1079.95	Wood	1078.44	1.51	0.46	NA	NA	
38717	41	Yankee Valley Boulevard South-east	20.8	40.0	1081.18	1081.81	Steel	1080.28	1.53	0.90	2	0.3	
38751	42	Path	18.4	3.0	1080.28	1081.69	Wood	1079.22	2.48	1.07	NA	NA	
39122	101	Summerfield Blvd	11.2	27.4	1081.10	1081.40	Steel	1080.71	0.69	0.39	NA	NA	
39616	102	Main Street South	13.6	25.9	1082.81	1083.28	Steel	1081.31	1.97	1.50	NA	NA	
40026	45	Path	7.4	2.8	1080.02	1081.22	Wood	1079.57	1.65	0.45	NA	NA	1
40157	46	Path	7.5	2.9	1080.19	1081.39	Wood	1079.74	1.65	0.45	NA	NA	1
40517	47	Path	7.6	2.9	1080.60	1081.80	Wood	1080.15	1.65	0.45	NA	NA	
40869	48	Path	7.6	2.9	1080.45	1081.65	Wood	1080.00	1.65	0.45	NA	NA	
41027	49	Path	7.6	2.8	1080.77	1081.97	Wood	1080.32	1.65	0.45	NA	NA	
41375	50	Path	7.5	2.7	1081.19	1082.39	Wood	1080.74	1.65	0.45	NA	NA	
41869	51	Path	24.7	3.3	1082.71	1083.91	Metal	1082.31	1.60	0.40	NA	NA	
42195	52	Railway Avenue South-west	15.6	11.6	1082.65	1083.75	Concrete	1081.78	1.97	0.87	2	0.25	
42538	53	CPR	19.8	5.4	1083.44	1084.41	Metal	1082.20	2.21	1.24	NA	NA	
42653	54	Bridge	24.7	5.5	1083.61	1085.04	Metal	1082.46	2.58	1.15	NA	NA	
43022	55	1 Avenue North-west	31.2	17.0	1084.90	1085.72	Concrete	1083.85	1.87	1.05	NA	NA	4
43819	56	Willowbrook Road North-west	12.7	10.8	1084.67	1085.76	Concrete	1083.77	1.99	0.89	NA	NA	
43970	57	Veterans Boulevard North-west	11.3	37.0	1084.49	1085.62	Concrete	1083.59	2.03	0.90	3	0.5	
44307	58	Path	18.3	2.3	1084.36	1085.62	Metal	1083.95	1.67	0.41	NA	NA	
44373	59	8 Street North-west	18.3	8.5	1084.09	1085.11	Concrete	1083.19	1.92	0.90	NA	NA	
45047	60	Path	24.5	3.0	1082.88	1084.01	Metal	1082.52	1.49	0.36	NA	NA	
45348	61	Path	22.0	3.0	1082.92	1084.11	Metal	1082.62	1.49	0.30	NA	NA	
50045	62	Township Road 274	18.0	8.2	1085.93	1086.87	Concrete	1085.54	1.33	0.39	4	0.3	
50331	63	Private Bridge	14.6	5.2	1084.61	NA	NA	1084.20	NA	0.41	NA	NA	
50823	64	Private Bridge	13.6	4.9	1084.31	NA	NA	1084.00	NA	0.31	NA	NA	
51950	65	Private Bridge	13.7	3.7	1084.46	NA	NA	1084.11	NA	0.35	NA	NA	
52292	66	Private Bridge	16.0	2.4	1084.86	NA	NA	1084.61	NA	0.25	NA	NA	
52856	67	Private Bridge	15.9	2.6	1084.91	NA	NA	1084.59	NA	0.32	NA	NA	
53256	68	Township Road 275	12.1	8.1	1086.49	1086.66	Concrete	1086.03	0.63	0.46	1	0.3	
59759	69	CPR	14.7	4.8	1091.02	NA	NA	1089.11	NA	1.91	NA	NA	
59926	70	Township Road 282	8.5	7.3	1089.10	1089.79	Concrete	1088.22	1.57	0.88	NA	NA	
60156	71	Private Driveway	10.1	7.7	1088.80	1089.10	Concrete	1088.10	1.00	0.70	NA	NA	
65897	72	Township Road 284	8.2	9.1	1102.00	1102.27	Concrete	1101.57	0.70	0.43	1	0.5	

- 1 Two surveyed structures modeled as one 2D connection.
- 2 Assumed pier widths based off surrounding bridges and photographs.
- 3 Assumed elevations of Beddington bridges were the same, unsafe to access for GPS shots.
- 4 Width was assumed using terrain and LiDAR.

Table A-2 Nose Creek Culvert Summary

Station	Survey ID	Description	Length of Culvert (m)	Width of Culvert (m)	Downstream Invert (mas.)	Downstream Obvert (masl.)	Upstream Invert (masl.)	Upstream Obvert (masl.)	Material	Footnote
9222	1	64 Ave. NE	100.2	11.5	1045.012	1051.51	1044.808	1051.28	Concrete	
26954	2	Hwy. 2	174.9	5.8	1065.07	1067.77	1065.727	1068.23	Concrete	
29226	3	Hwy. 566	21.8	4.3	1067.59	1073.45	1067.53	1073.39	Concrete	1
34046	4	Hwy. 2 (S)	124.9	5.9	1073.258	1075.997	1073.44	1076.3	Steel	
	5	Hwy. 2 (N)	121.8	5.9	1073.31	1076.16	1073.01	1076.28	Steel	
41615	6	Ridegate Way SW (W)	34.1	6.5	1078.67	1082.63	1078.89	1082.64	Concrete	
	7	Ridegate Way SW (E)	34.2	6.5	1078.68	1082.63	1078.93	1082.71	Concrete	
50417	8	CP Rail (1) North	11.9	0.9	1083.34	1084.28	1083.34	1084.24	Steel	
	9	CP Rail (2)	11.9	0.9	1083.24	1084.17	1083.23	1084.18	Steel	
	10	CP Rail (3)	11.9	0.9	1083.25	1084.18	1083.26	1084.18	Steel	
	11	CP Rail (4)	11.9	0.9	1083.28	1084.18	1083.28	1084.22	Steel	
	12	CP Rail (5)	11.9	0.9	1083.26	1084.2	1083.31	1084.25	Steel	
	13	CP Rail (6) South	11.9	0.9	1083.38	1084.32	1083.41	1084.31	Steel	
59618	17	Field (1) North	6	0.6	1086.23	1086.78	1086.297	1086.934	Steel	
	18	Field (2)	6	0.6	1086.31	1086.86	1086.377	1087.003	Steel	
	19	Field (3)	6	0.9	1086.092	1087.001	1086.162	1087.071	Steel	
	20	Field (4) South	6	0.6	1086.237	1086.841	1086.25	1086.85	Steel	
62503	21	Field	8	0.9	1089.613	1090.44	1089.479	1090.416	Steel	
63741	22	Field	10	0.4	1092.478	1092.834	1092.52	1092.915	Steel	
63843	23	Field	10	0.3	1092.926	1093.243	1093.158	1093.478	Steel	
63904	24	Field	5.1	0.3	1093.366	1093.699	1093.365	1093.688	Steel	
65236	25	Trail	18.6	0.4	1097.69	1098.094	1097.906	1098.301	Steel	
67566	26	Rge. Rd. 13	20.2	3	1105.53	1108.52	1105.7	1108.71	Steel	
69151	27	Trail	6.4	1.8	1111.774	1113.511	1111.933	1113.918	Steel	
70131	28	Rge. Rd. 14	19.4	2.1	1116.86	1119.05	1117.19	1119.29	Steel	
72501	29	Rge. Rd. 15	13.9	1.6	1125.09	1126.72	1125.129	1126.698	Steel	
74023	30	Trail	7.4	0.6	1136.165	1136.689	1136.355	1136.829	Steel	

1 Only the culvert was modeled as this was the restrictive portion of the bridge.

Table A-3 West Nose Creek Bridge Summary

Station	Survey ID	Description	Length of Span (m)	Width of Bridge (m)	Top of Curb Elev. (masl.)	Top of Handrail/Guardrail Elev. (masl.)	Type of handrail/guardrail	Low Chord (masl.)	Bridge Thickness (Rail-Low Chord) (masl.)	Bridge Thickness (Curb-Low Chord) (masl.)	Number of Piers	Width of Piers	Footnote
45	1000	Rail	12.9	3.6	1056.20	1057.30	Metal	1056.10	1.20	0.10	NA	NA	
71	1001	Pedestrian	17.1	3.4	1055.04	1056.40	Metal	1054.70	1.70	0.34	NA	NA	
304	1002	Pedestrian	14.0	3.6	1056.01	1057.40	Metal	1055.60	1.80	0.41	NA	NA	
887	1003	Pedestrian	14.0	3.6	1057.40	1058.80	Metal	1057.10	1.70	0.30	NA	NA	
1369	1004	Pedestrian	14.0	3.6	1059.30	1060.80	Metal	1059.02	1.78	0.28	NA	NA	
1628	1005	Pedestrian	14.1	3.5	1060.19	1061.60	Metal	1059.80	1.80	0.39	NA	NA	
2057	1006	Pedestrian	14.0	3.6	1062.08	1063.50	Metal	1061.70	1.80	0.38	NA	NA	
3667	1007	Harvest Hills Blvd N	36.9	10.5	1073.10	1075.20	Metal	1071.20	4.00	1.90	NA	NA	
3697	1008	Harvest Hills Blvd N	36.9	12.0	1072.73	1074.60	Metal	1070.94	3.66	1.79	NA	NA	
3741	1009	Pedestrian	14.0	3.6	1068.46	1069.87	Metal	1068.09	1.78	0.37	NA	NA	
4342	1010	Pedestrian (Golf)	8.1	1.0	1070.24	1070.35	Wood	1069.88	0.47	0.36	NA	NA	
4389	1011	Pedestrian (Golf)	6.5	2.4	1070.10	1070.20	Wood	1069.90	0.30	0.20	NA	NA	
4455	1012	Pedestrian (Golf)	9.2	1.2	1070.30	1070.50	Wood	1070.20	0.30	0.10	NA	NA	
4608	1013	Pedestrian (Golf)	6.0	3.5	1071.26	1071.60	Wood	1071.18	0.42	0.08	NA	NA	
4778	1014	Pedestrian (Golf)	12.4	2.3	1072.20	1072.44	Wood	1071.80	0.64	0.40	NA	NA	
4963	1015	Pedestrian (Golf)	12.3	2.4	1072.80	1073.00	Wood	1072.67	0.33	0.13	NA	NA	
5077	1016	Pedestrian (Golf)	5.2	2.6	1072.92	1073.10	Concrete	1072.80	0.30	0.12	NA	NA	
5155	1017	Pedestrian (Golf)	5.2	2.6	1072.60	1072.70	Concrete	1072.50	0.20	0.10	NA	NA	
5302	1018	Pedestrian (Golf)	5.2	2.7	1073.15	1073.55	Concrete	1072.98	0.57	0.17	NA	NA	
5388	1019	Pedestrian (Golf)	6.8	1.2	1073.50	1073.65	Wood	1073.13	0.52	0.37	NA	NA	
5454	1020	Pedestrian (Golf)	5.2	2.7	1073.40	1073.84	Concrete	1073.29	0.55	0.11	NA	NA	
5525	1021	Pedestrian (Golf)	6.3	1.2	1073.40	1073.70	Wood	1073.37	0.33	0.03	NA	NA	
5555	1022	Pedestrian (Golf)	5.2	2.7	1073.50	1073.99	Concrete	1073.40	0.59	0.10	NA	NA	
5669	1023	Pedestrian (Golf)	13.7	1.7	1074.20	1074.50	Wood	1074.04	0.46	0.16	NA	NA	
5831	1024	Pedestrian (Golf)	14.3	1.2	1074.60	1075.01	Wood	1073.08	1.93	1.52	NA	NA	
5872	1025	Pedestrian (Golf)	4.2	2.9	1073.90	NA	NA	1073.60	NA	0.30	NA	NA	
5907	1026	Pedestrian (Golf)	10.2	3.0	1075.00	1075.30	Wood	1074.30	1.00	0.70	NA	NA	
5961	1027	Country Hills Blvd NW	41.3	16.3	1082.85	1084.55	Metal	1081.38	3.17	1.47	NA	NA	
5983	1028	Country Hills Blvd NW	41.3	15.4	1082.93	1084.11	Metal	1080.60	3.51	2.33	NA	NA	
6044	1029	Pedestrian (Golf)	7.5	2.4	1075.66	1075.08	Metal	1075.50	-0.42	0.16	NA	NA	
6147	1030	Pedestrian (Golf)	5.2	2.7	1075.40	1075.68	Concrete	1075.20	0.48	0.20	NA	NA	
6379	1031	Pedestrian (Golf)	12.3	1.5	1076.65	1076.75	Wood	1076.30	0.45	0.35	NA	NA	
6420	1032	Pedestrian (Golf)	9.3	1.5	1075.80	1076.10	Wood	1075.70	0.40	0.10	NA	NA	
6575	1033	Pedestrian (Golf)	5.2	2.8	1076.15	1076.40	Concrete	1076.00	0.40	0.15	NA	NA	
7130	1034	Pedestrian (Golf)	5.2	2.8	1076.70	1076.95	Concrete	1076.60	0.35	0.10	NA	NA	
7277	1035	Pedestrian (Golf)	8.5	3.0	1078.00	1078.10	Concrete	1077.50	0.60	0.50	NA	NA	
7360	1036	Pedestrian (Golf)	5.2	2.7	1077.00	1077.10	Concrete	1076.90	0.20	0.10	NA	NA	

Station	Survey ID	Description	Length of Span (m)	Width of Bridge (m)	Top of Curb Elev. (masl.)	Top of Handrail/Guardrail Elev. (masl.)	Type of handrail/guardrail	Low Chord (masl.)	Bridge Thickness (Rail-Low Chord) (masl.)	Bridge Thickness (Curb-Low Chord) (masl.)	Number of Piers	Width of Piers	Footnote
7415	1037	Pedestrian (Golf)	7.5	1.2	1076.60	1076.80	Wood	1076.50	0.30	0.10	NA	NA	
7522	1038	Pedestrian (Golf)	7.4	1.2	1076.80	1077.00	Wood	1076.60	0.40	0.20	NA	NA	
7662	1039	Pedestrian (Golf)	7.4	1.2	1077.00	1077.10	Wood	1076.70	0.40	0.30	NA	NA	
7926	1040	Pedestrian (Golf)	5.2	2.8	1077.65	1077.90	Concrete	1077.60	0.30	0.05	NA	NA	
8944	1041	Pedestrian	9.6	3.6	1082.50	1083.96	Wood	1082.17	1.79	0.33	NA	NA	
9114	1042	Pedestrian	9.6	3.6	1082.50	1083.97	Wood	1082.14	1.83	0.36	NA	NA	
10183	1043	Stoney Trail NW	46.0	10.2	1092.45	1093.90	Steel	1090.65	3.25	1.80	NA	NA	1
	1044	Stoney Trail NW	43.0	22.1	1091.75	1092.15	Steel	1090.33	1.82	1.42	NA	NA	1
10129	1045	Stoney Trail NW	37.0	22.1	1090.70	1091.34	Steel	1089.79	1.55	0.91	NA	NA	1
	1046	Stoney Trail NW	34.8	10.2	1089.60	1090.54	Steel	1088.74	1.80	0.86	NA	NA	1
10706	1047	Pedestrian	20.8	3.5	1087.70	1089.10	Steel	1087.36	1.74	0.34	NA	NA	
11902	1048	Pedestrian	7.8	3.7	1090.05	1091.89	Steel	1089.72	2.17	0.33	NA	NA	
13092	1049	Symons Valley Pkwy NW	15.1	15.1	1095.40	1096.65	Steel	1094.87	1.78	0.53	NA	NA	
13092.1	1049	Symons Valley Pkwy NW	15.1	15.1	1096.00	1096.85	Steel	1094.90	1.79	1.10	NA	NA	
15728	1050	Sage meadows Park NW	16.1	8.9	1098.50	1099.28	Concrete	1097.48	1.80	1.02	NA	NA	
18838	1051	Mountain View Road	21.6	8.5	1103.25	1104.03	Steel	1102.89	1.14	0.36	4	0.15	
21328	1052	Private Driveway	10.1	4.0	1106.46	1106.56	Concrete	1105.77	0.78	0.69	NA	NA	
22885	1053	Path	4.9	1.2	1106.80	NA	NA	1106.62	NA	0.18	NA	NA	
23102	1054	Path	16.4	1.3	1107.50	NA	NA	1107.17	NA	0.33	NA	NA	
24341	1055	Symons Valley Road NW	15.1	9.8	1113.40	1113.87	Steel	1112.59	1.28	0.81	NA	NA	
27818	1056	Private Driveway	5.7	4.4	1113.67	1114.30	Wood	1113.16	1.14	0.51	NA	NA	
41915	1057	Range Road 24A	8.3	7.6	1147.80	1148.30	Concrete	1147.30	1.00	0.50	NA	NA	
56518	1058	Field Path	8.6	2.6	1168.29	NA	NA	1168.10	NA	0.19	NA	NA	
57047	1059	Field Path	11.7	1.4	1170.30	NA	NA	1170.15	NA	0.15	NA	NA	
60934	1060	Field Path	11.7	2.4	1177.65	NA	NA	1177.50	NA	0.15	NA	NA	
61061	1061	Field Path	5.8	1.5	1177.77	NA	NA	1177.62	NA	0.15	NA	NA	
61189	1062	Field Path	8.0	1.5	1177.82	NA	NA	1177.67	NA	0.15	NA	NA	
61328	1063	Field Path	24.9	2.2	1178.24	NA	NA	1178.09	NA	0.15	NA	NA	
62270	1064	Field Path	13.4	1.8	1180.12	NA	NA	1179.97	NA	0.15	NA	NA	
62293	1065	Field Path	73.5	0.9	1181.15	NA	NA	1181.00	NA	0.15	30	0.13	
64844	NA	Assumed	4.7	3.0	1187.40	NA	NA	1187.10	NA	0.30	NA	NA	2

1 Two surveyed structures modeled as one 2D connection.

2 Bridge was not included in the survey and was assumed.

Table A-4 West Nose Creek Culvert Summary

Station	Survey ID	Description	Length of Culvert (m)	Width of Culvert (m)	Downstream Invert (mas.)	Downstream Obvert (masl.)	Upstream Invert (masl.)	Upstream Obvert (masl.)	Material	Footnote
8697	1	Hidden Creek Drive	47.9	7.9	1079.26	1081.774	1079.26	1081.05	Concrete	
9300	NA	Assumed	5	1	1080.8	1082.3	1080.8	1082.3	Concrete	1
9335	NA	Assumed	5	1	1081.28	1082.78	1081.28	1082.78	Concrete	1
38970	2	Field (1) North	13.1	0.6	1140.67	1141.2	1141.009	1141.62	Steel	
	3	Field (2)	11.9	0.9	1140.358	1141.24	1140.391	1141.322	Steel	
	4	Field (3)	12.9	0.6	1141.154	1141.786	1141.243	1141.85	Steel	
	5	Field (4)	11.9	0.9	1140.438	1141.318	1140.513	1141.435	Steel	
	6	Field (5) South	12.9	0.6	1141.168	1141.772	1141.186	1141.808	Steel	
45725	7	Hwy. 567 (S)	59.6	2.1	1150.58	1152.88	1150.456	1152.839	Steel	
	8	Hwy. 567 (N)	61.2	2.1	1151.423	1154.117	1150.62	1153.2	Steel	
49281	9	Rge. Rd. 24A	16.5	1.2	1154.872	1156.056	1154.99	1156.12	Steel	
53245	10	Twp. Rd. 272 (W)	21.6	1.2	1162.36	1163.419	1162.58	1163.86	Steel	
	11	Twp. Rd. 272 (E)	21.6	1.2	1162.685	1163.415	1162.567	1163.708	Steel	
59623	12	Twp. Rd. 274	26.3	2.1	1173.83	1175.999	1174.413	1176.63	Concrete	
61846	13	Trail	10	0.6	1178.95	1179.562	1179.118	1179.718	Steel	
62112	NA	Assumed	4	0.6	1179.4	1180	1179.35	1179.95	Steel	
62478	14	Trail	7.5	0.4	1180.393	1180.778	1180.67	1180.994	Steel	
63109	15	Trail	8.2	0.9	1182.142	1182.998	1182.221	1183.126	Steel	
63528	16	Twp. Rd. 280	58.7	1.8	1183.096	1184.899	1183.44	1185.105	Steel	
66205	17	Field (E)	6.4	0.6	1194.145	1194.661	1194.35	1194.905	Steel	
	18	Field (W)	4.9	0.6	1195.197	1195.9	1195.311	1196.026	Steel	
66676	NA	Assumed	15	0.6	1198.7	1199.3	1198.65	1199.25	Steel	1
67489	19	Field	3.6	0.6	1200.843	1201.515	1200.732	1201.423	Steel	
67594	NA	Assumed	14	0.9	1201.5	1202.4	1201.45	1202.35	Steel	1
68068	NA	Assumed	6	0.6	1201.77	1202.37	1201.82	1202.42	Steel	1
68092	20	Field	6.1	0.6	1201.809	1202.425	1201.964	1202.587	Steel	
68501	21	Trail	4.9	0.6	1201.532	1202.093	1201.577	1202.336	Steel	

1 Culvert was not included in the survey and was assumed.

Table A-5 Nose Creek Dam/Weir Summary

Reach	Station	Length (m)	Elevation (masl.)
Nose Creek	14803	13	1053.83
Nose Creek	67566	4.8	1107.15

Appendix B

Two-Dimensional Inflow Locations for the Initial Coupled 1D/2D

Figure B-1 Nose Creek 2D Inflow Locations

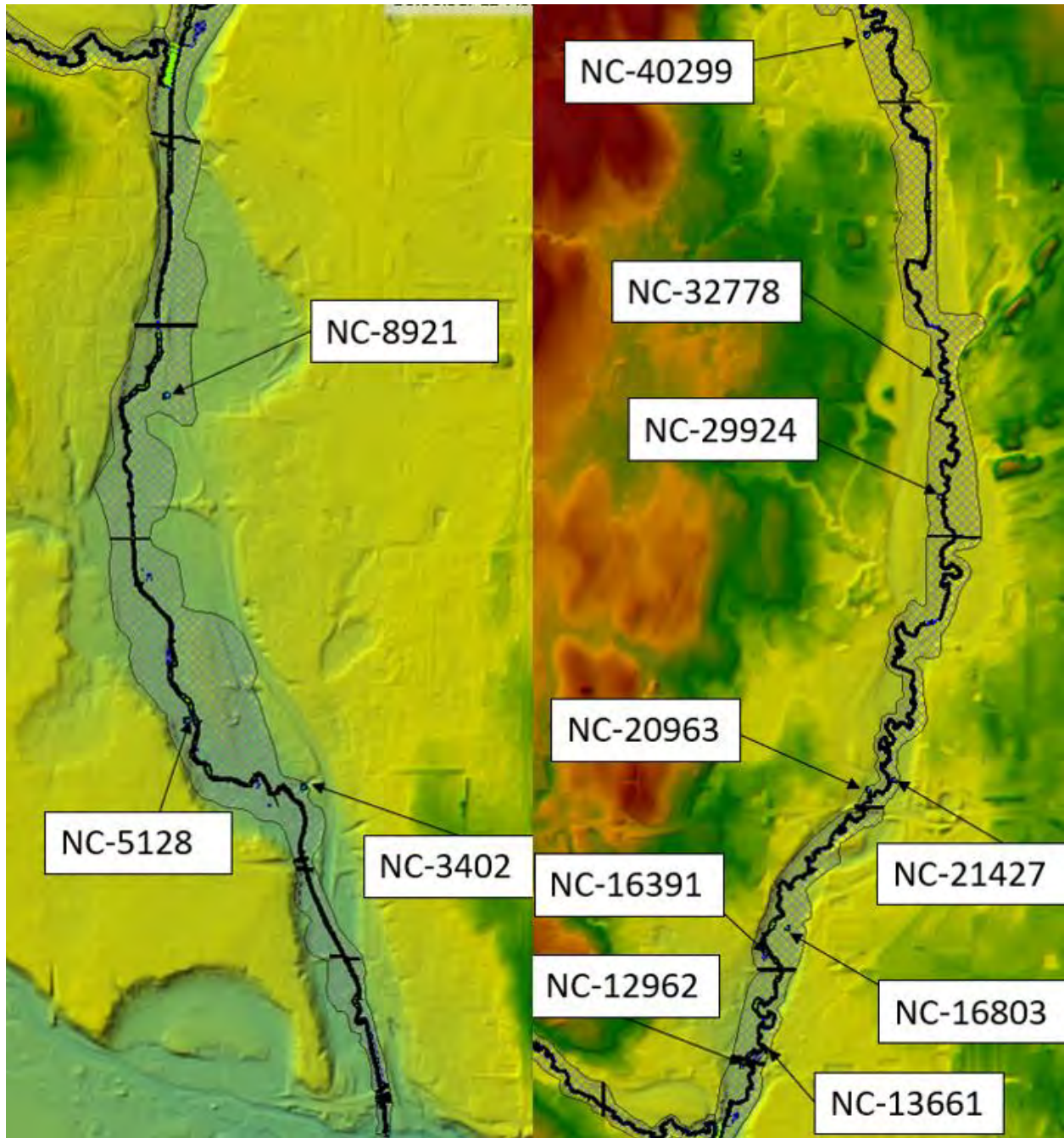
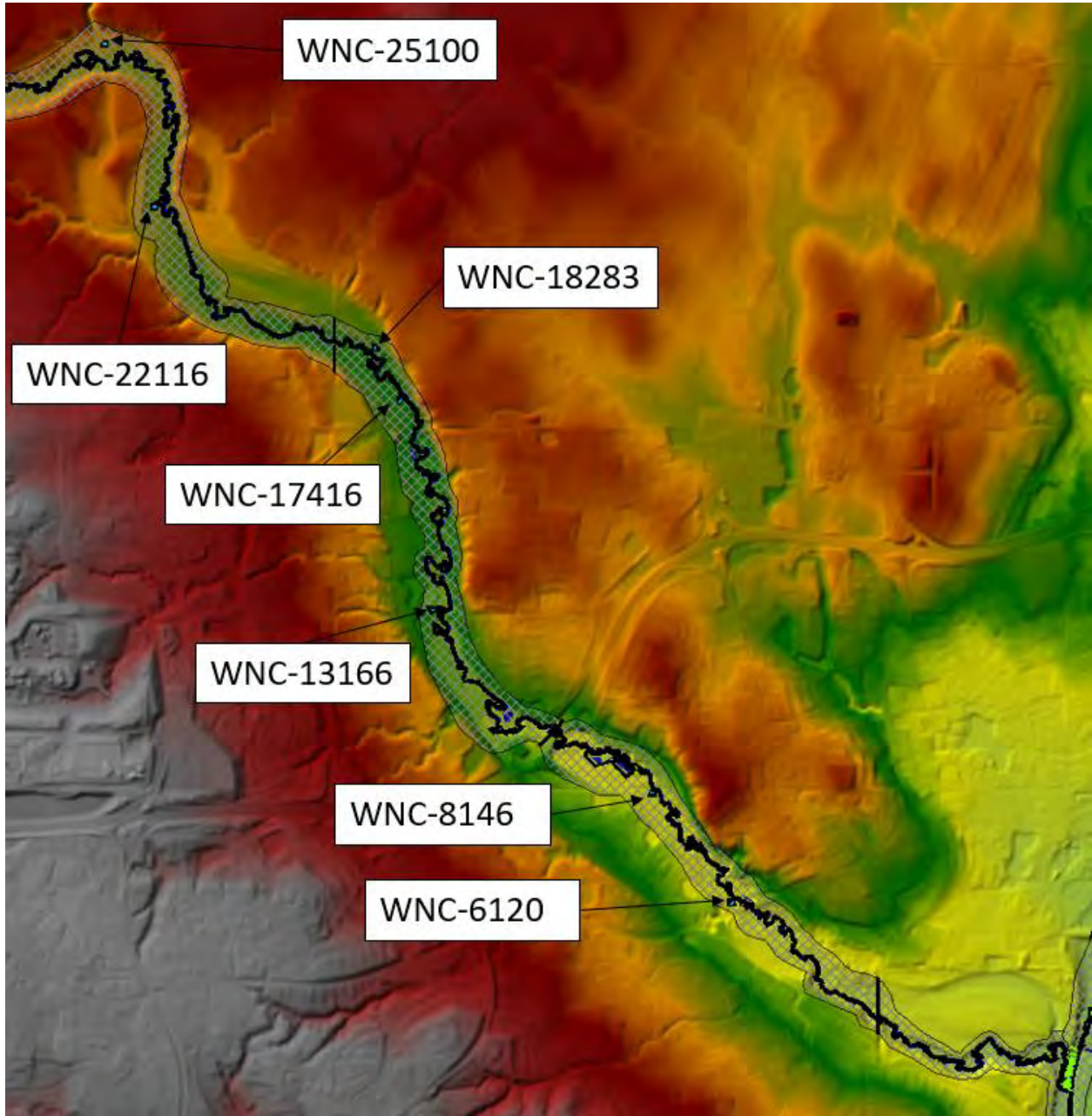


Figure B-2 West Nose Creek 2D Inflow Locations



Boundary Condition Name: NC-3402

River: Nose Creek

Reach: Conf. to Bow

2D Area: NC_LOB_N1

Image:



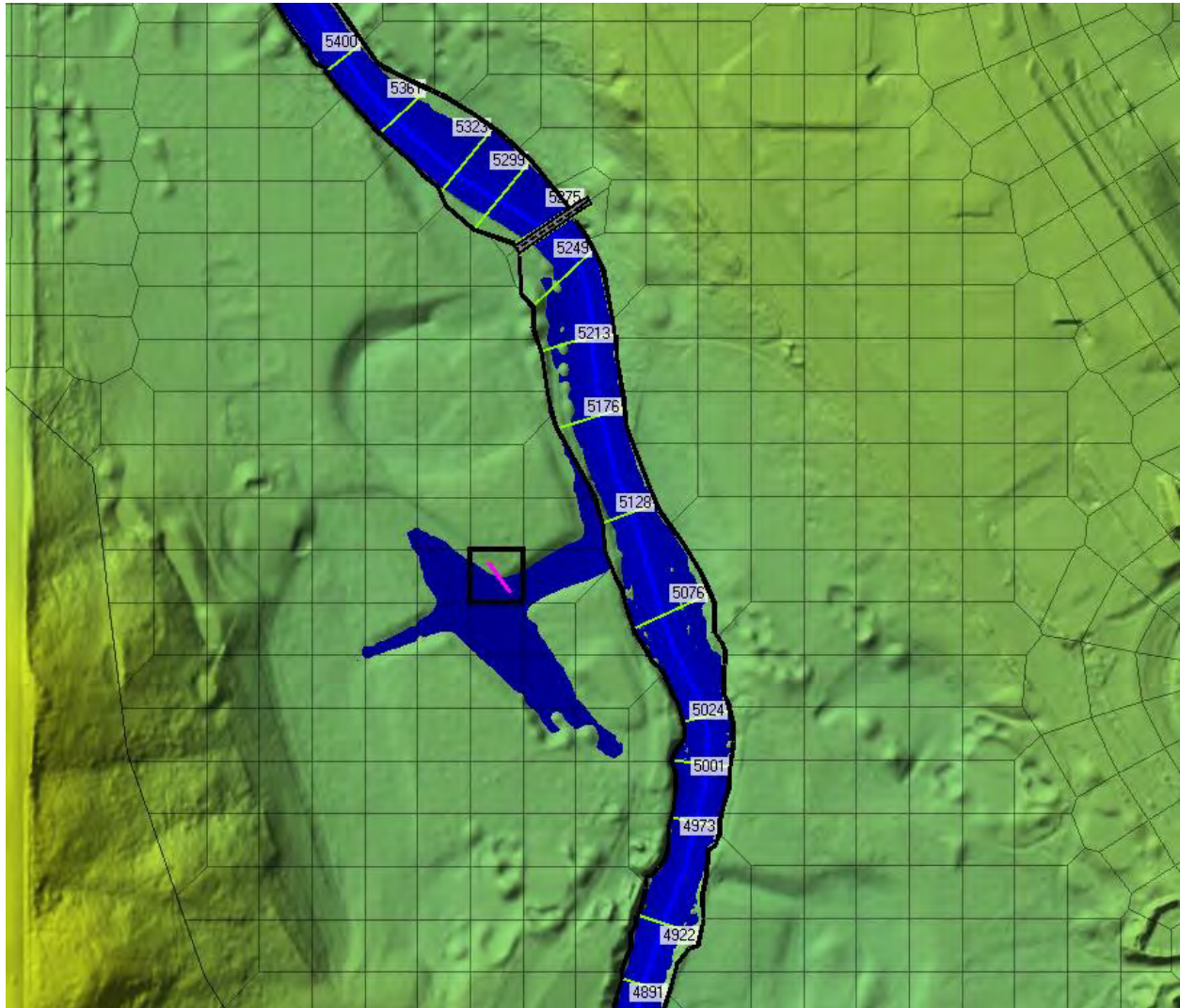
Boundary Condition Name: NC-5128

River: Nose Creek

Reach: Conf. to Bow

2D Area: NC_ROB_N1

Image:



Boundary Condition Name: NC-8921

River: Nose Creek

Reach: Conf. to Bow

2D Area: NC_LOB_N2

Image:



Boundary Condition Name: NC-12962

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_CONF_ROB

Image:



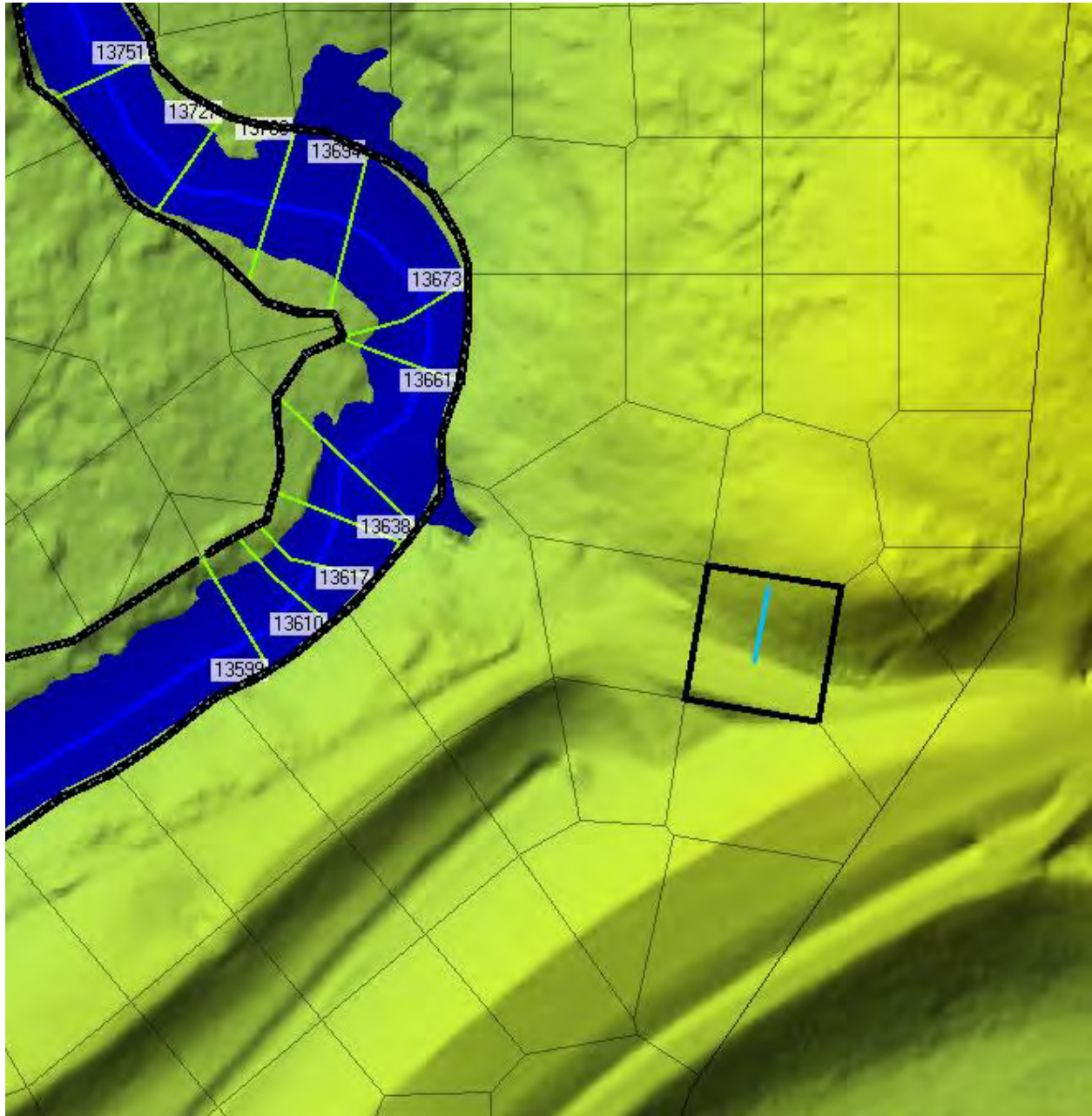
Boundary Condition Name: NC-13661

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_LOB_N4

Image:



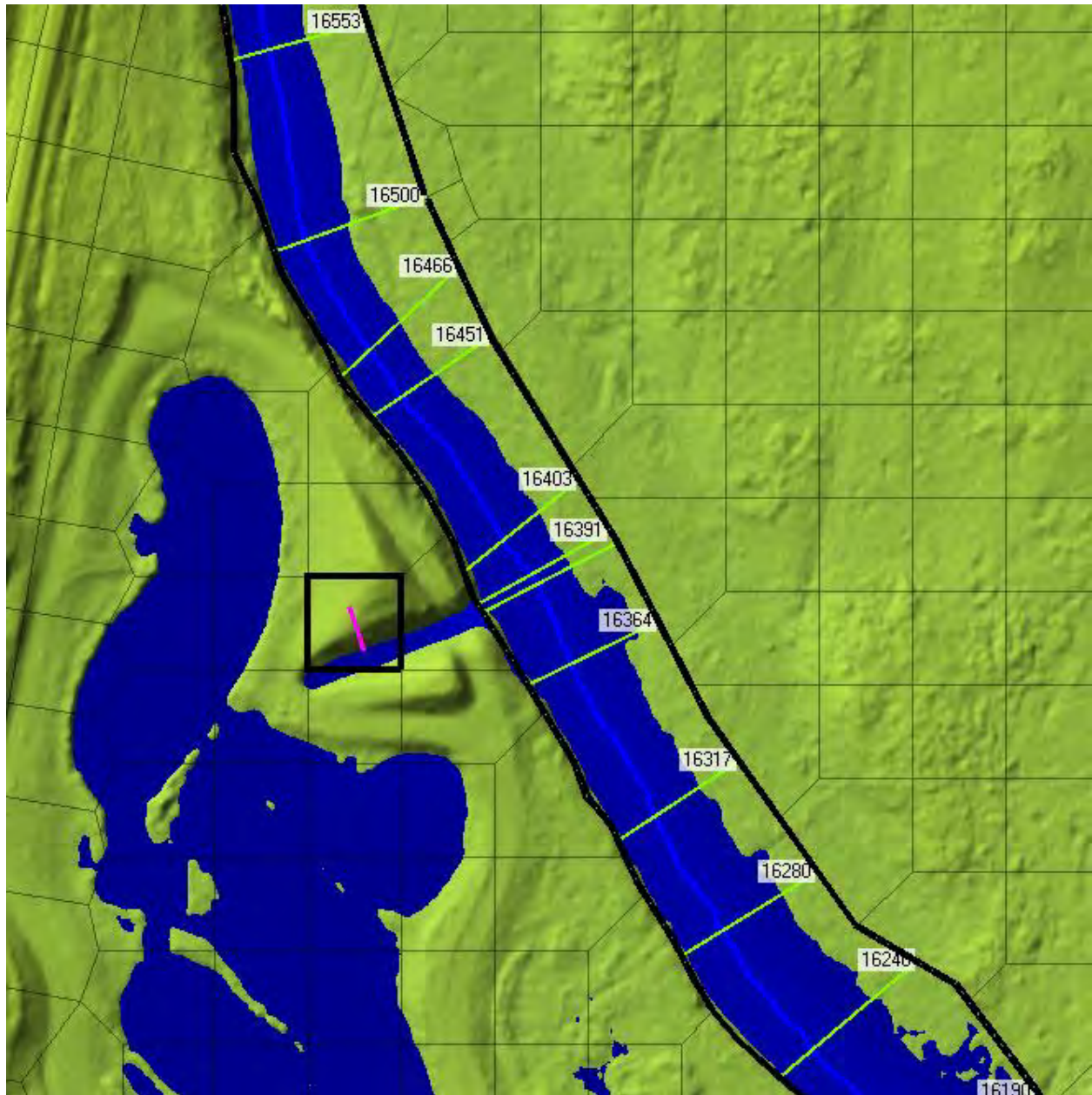
Boundary Condition Name: NC-16391

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_ROB_N5

Image:



Boundary Condition Name: NC-16803

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_LOB_N5

Image:



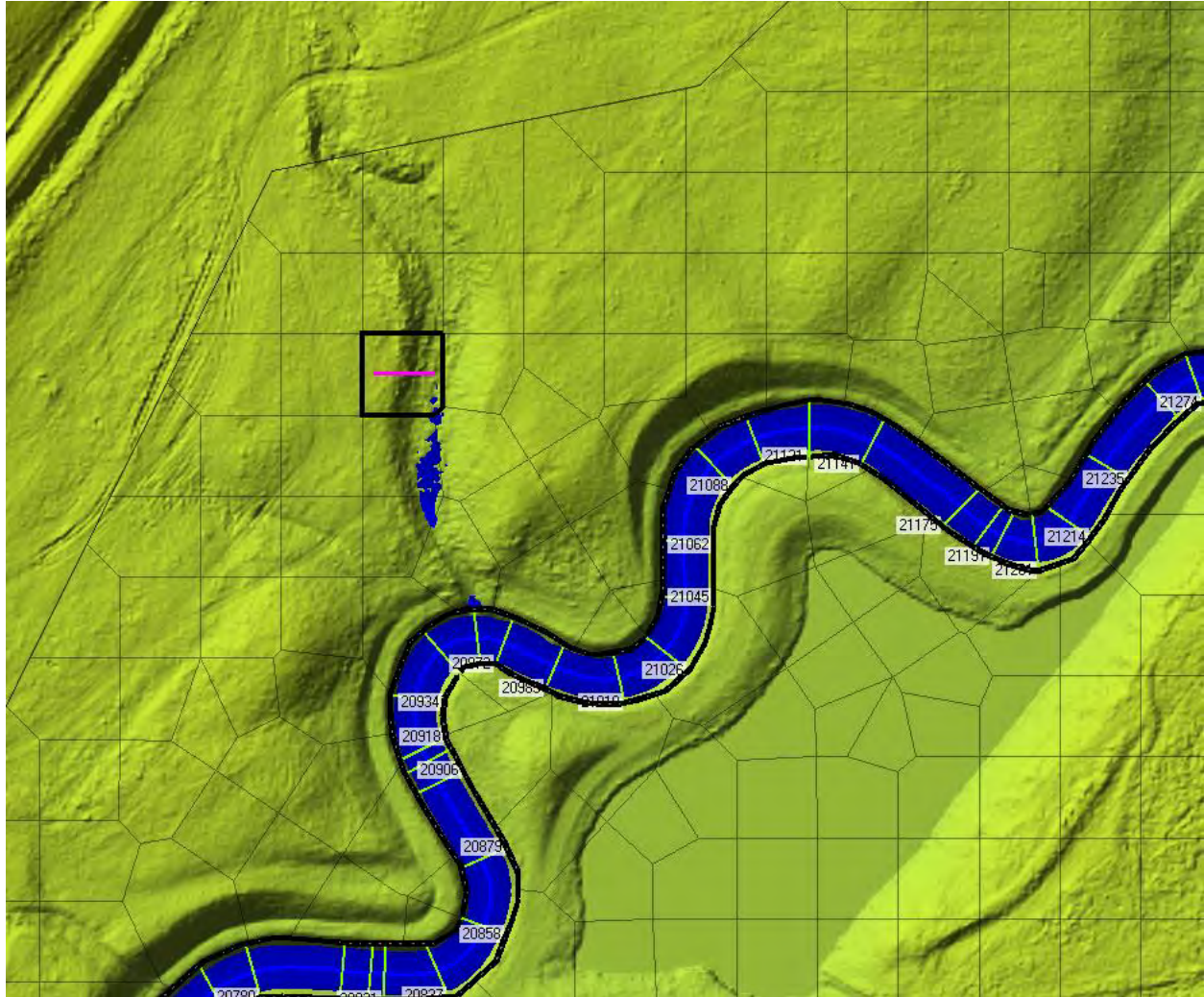
Boundary Condition Name: NC-20693

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_ROB_N6

Image:



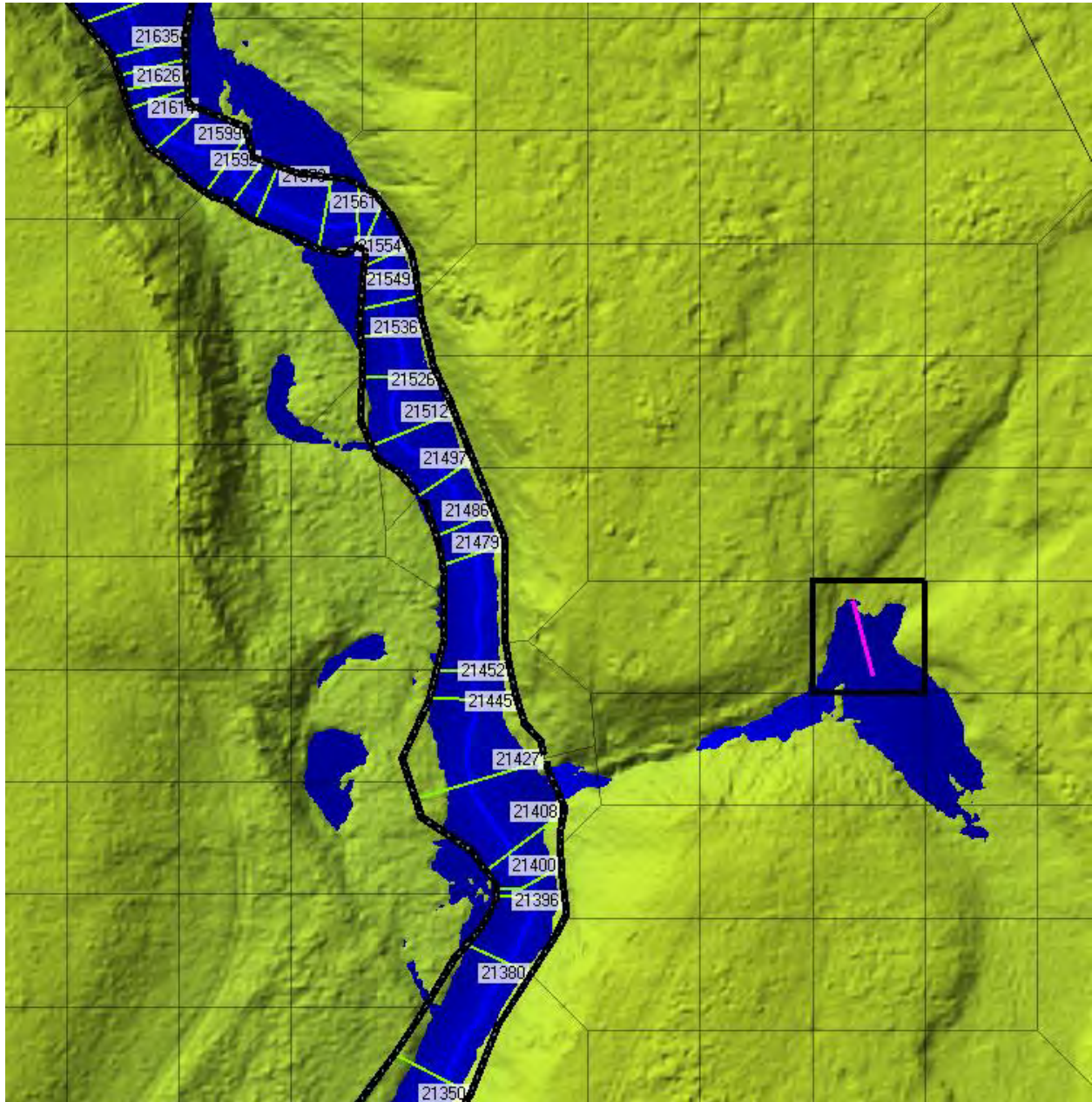
Boundary Condition Name: NC-21427

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_LOB_N6

Image:



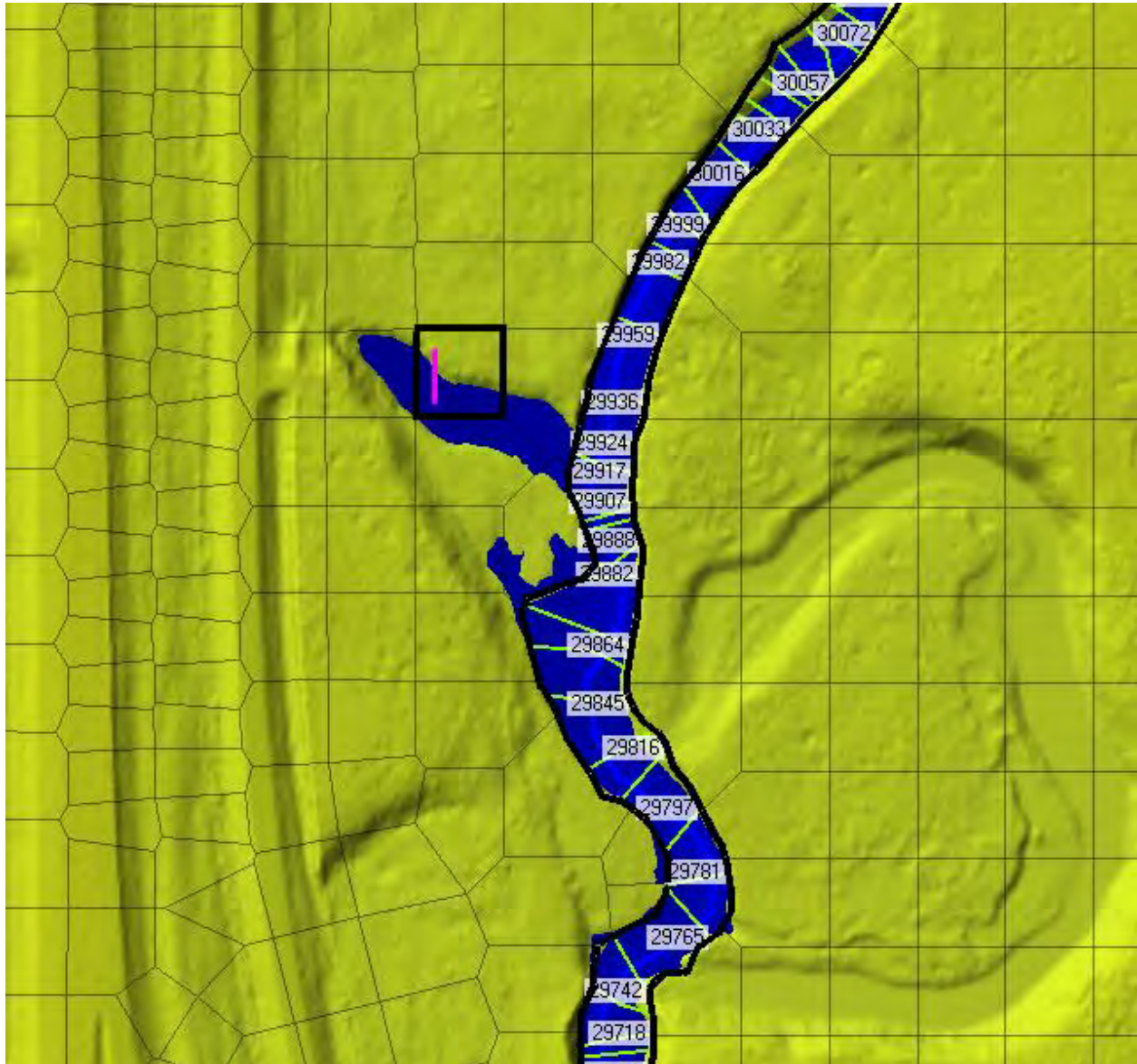
Boundary Condition Name: NC-29924

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_ROB_N7

Image:



Boundary Condition Name: NC-32778

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_ROB_N7

Image:



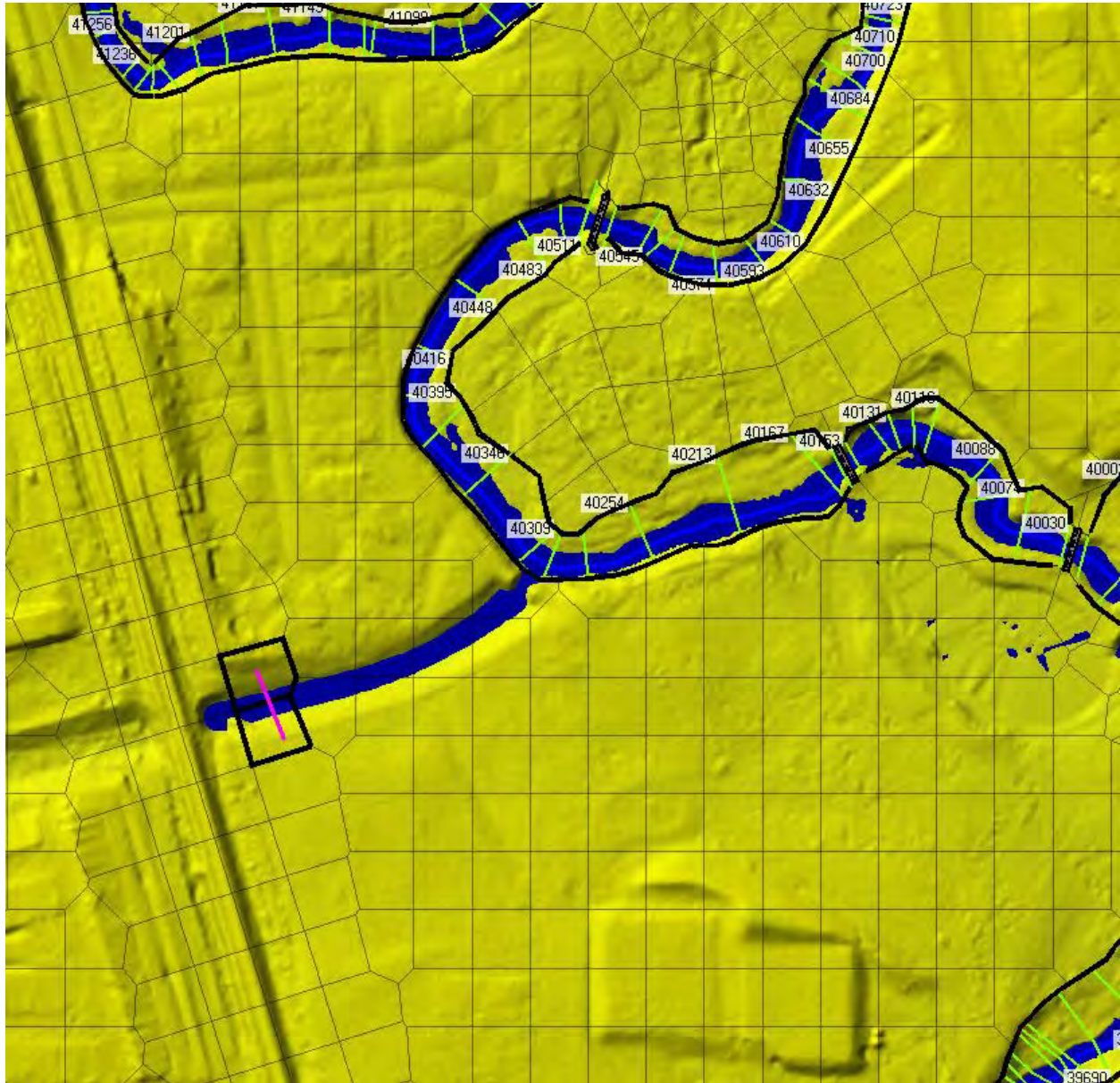
Boundary Condition Name: NC-40299

River: Nose Creek

Reach: Airdrie to Conf.

2D Area: NC_ROB_N8

Image:



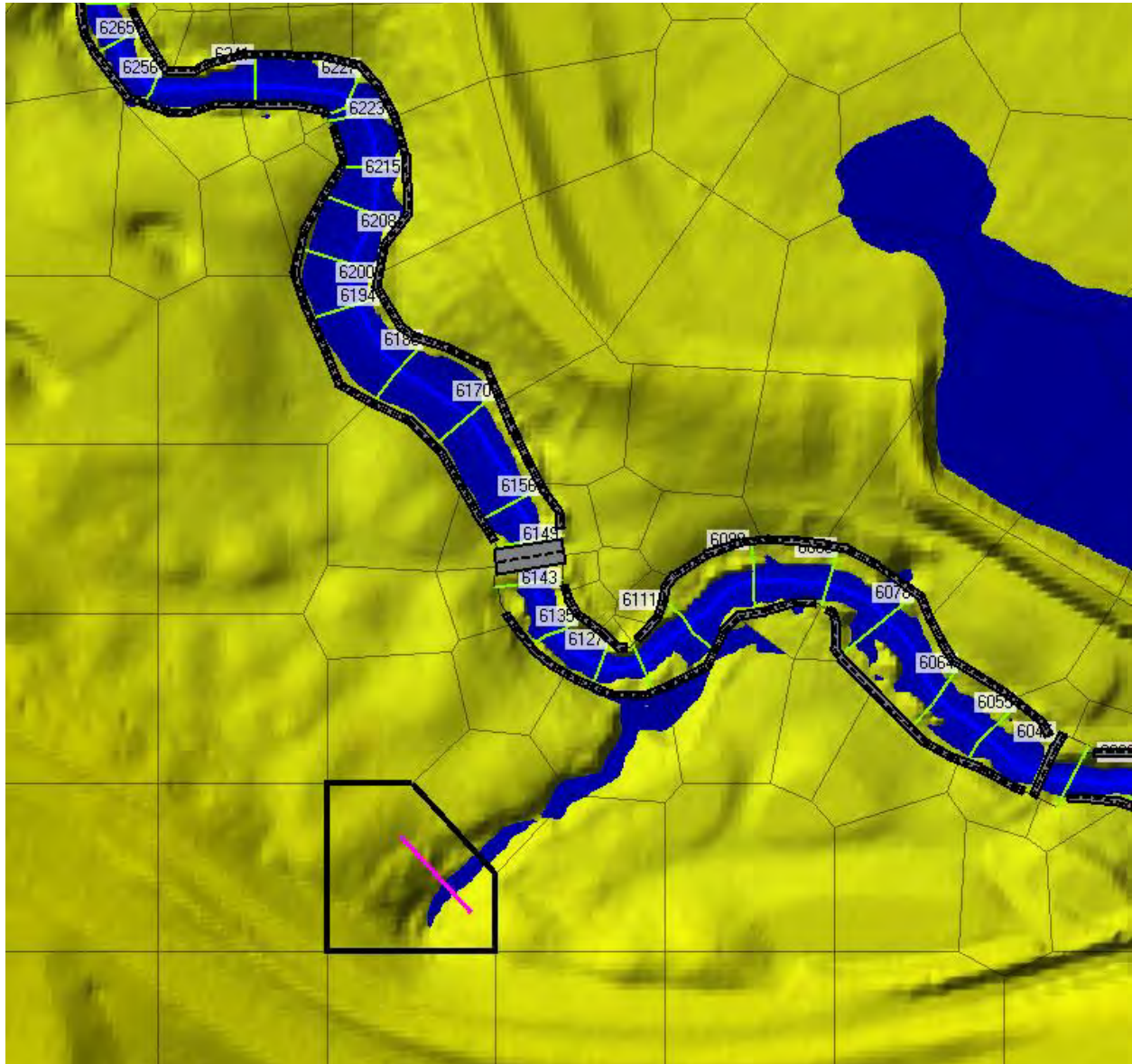
Boundary Condition Name: WNC-6120

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_ROB_N1

Image:



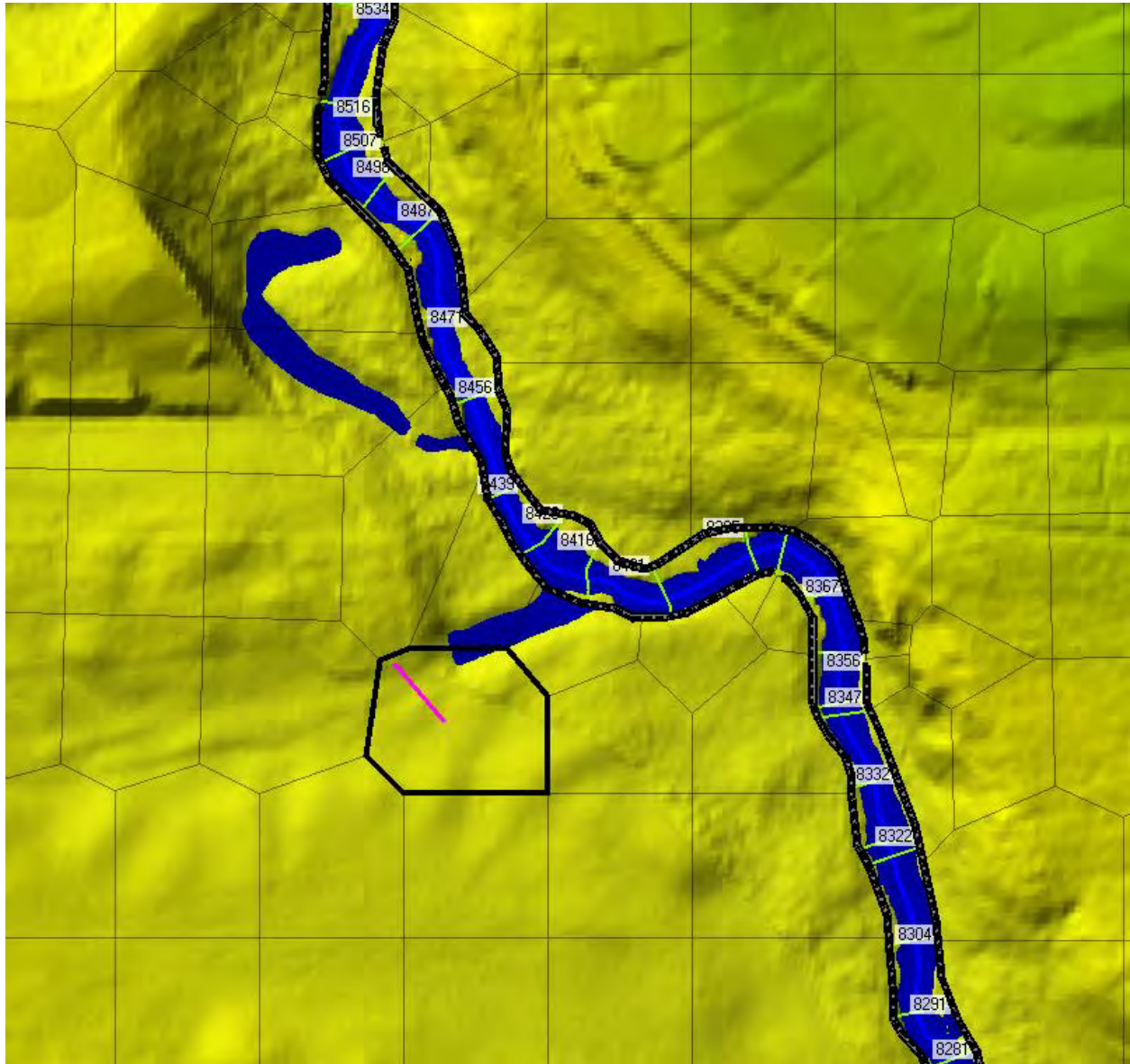
Boundary Condition Name: WNC-8146

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_ROB_N1

Image:



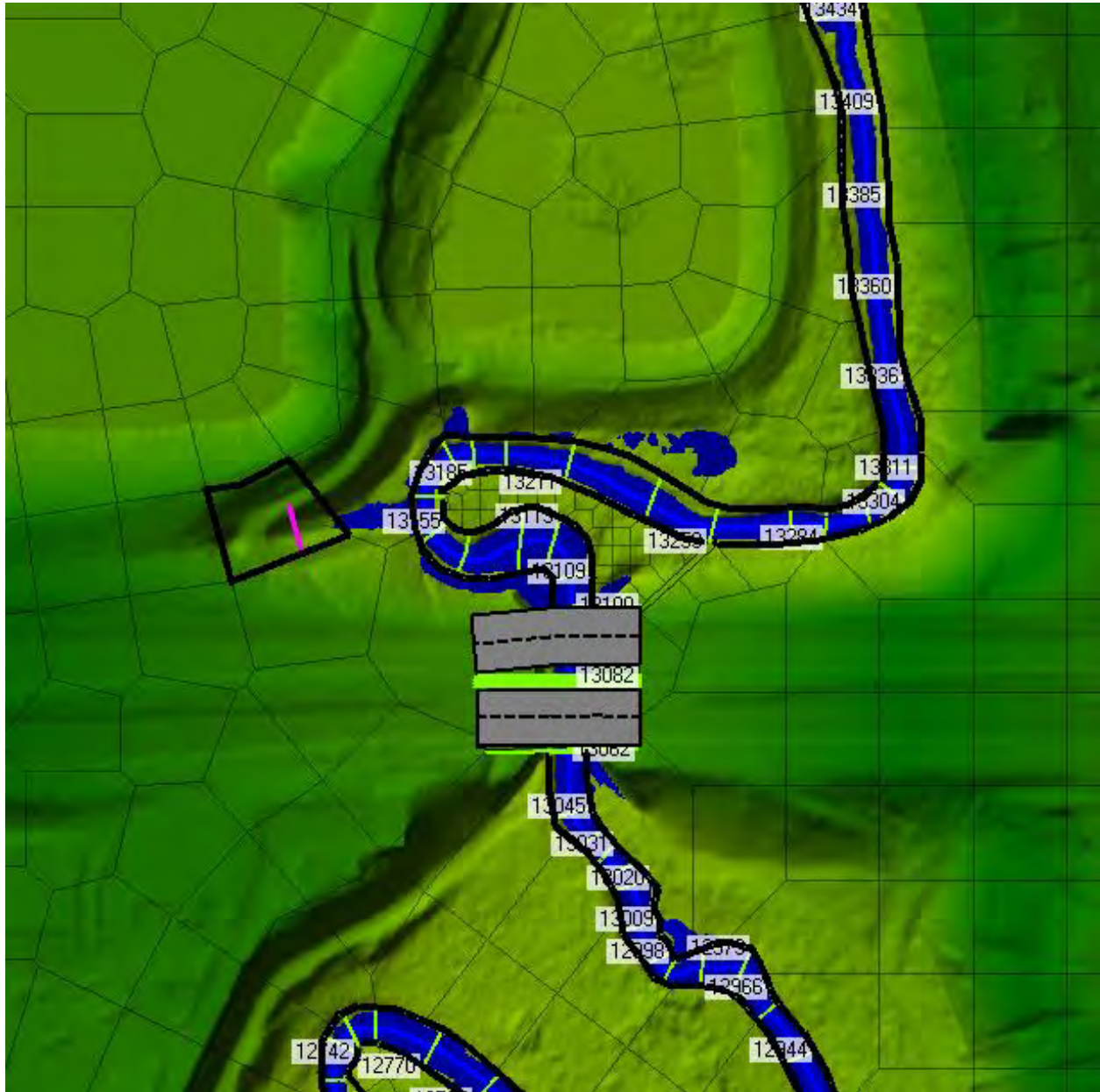
Boundary Condition Name: WNC-13166

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_ROB_N2

Image:



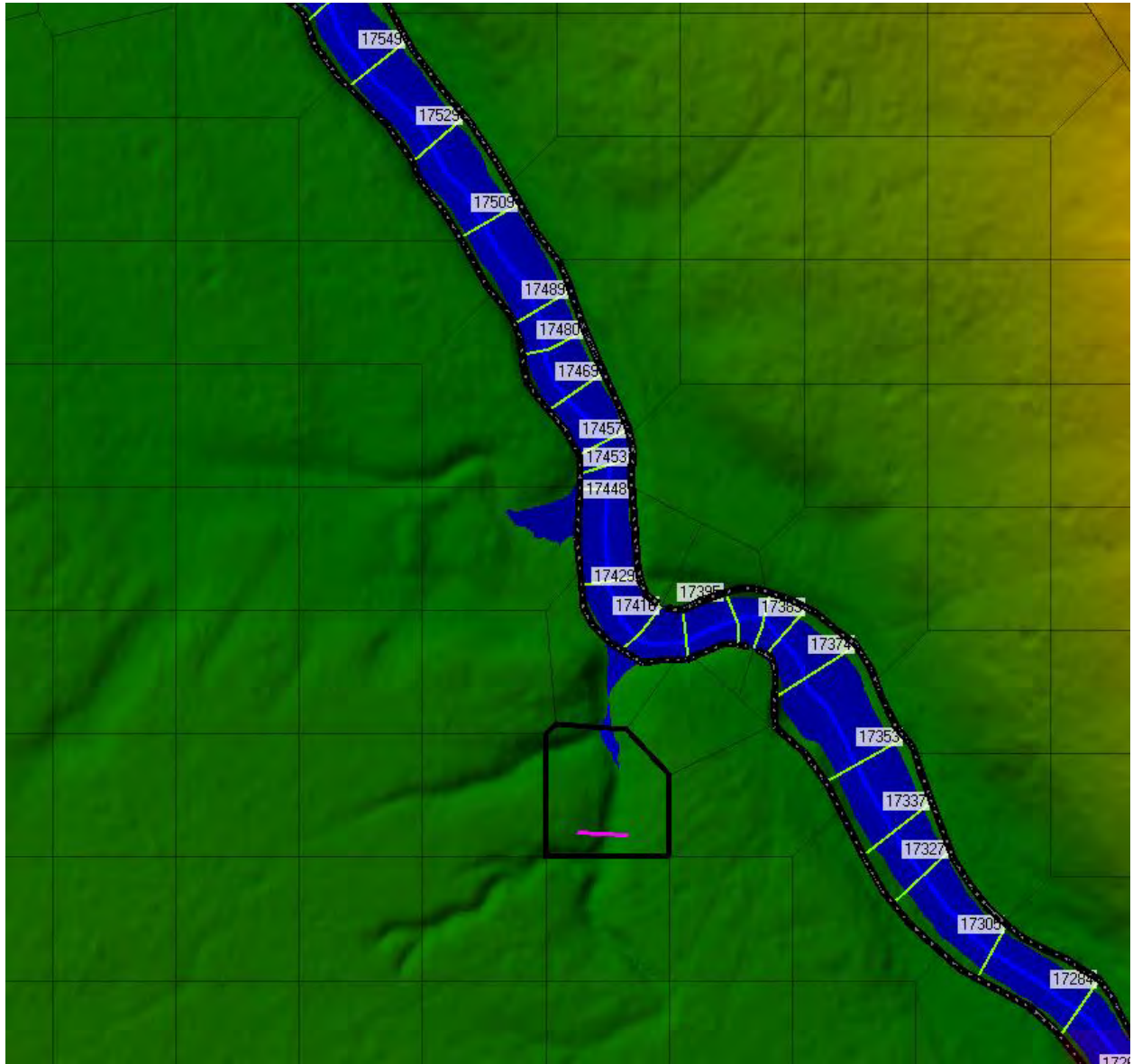
Boundary Condition Name: WNC-17416

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_ROB_N2

Image:



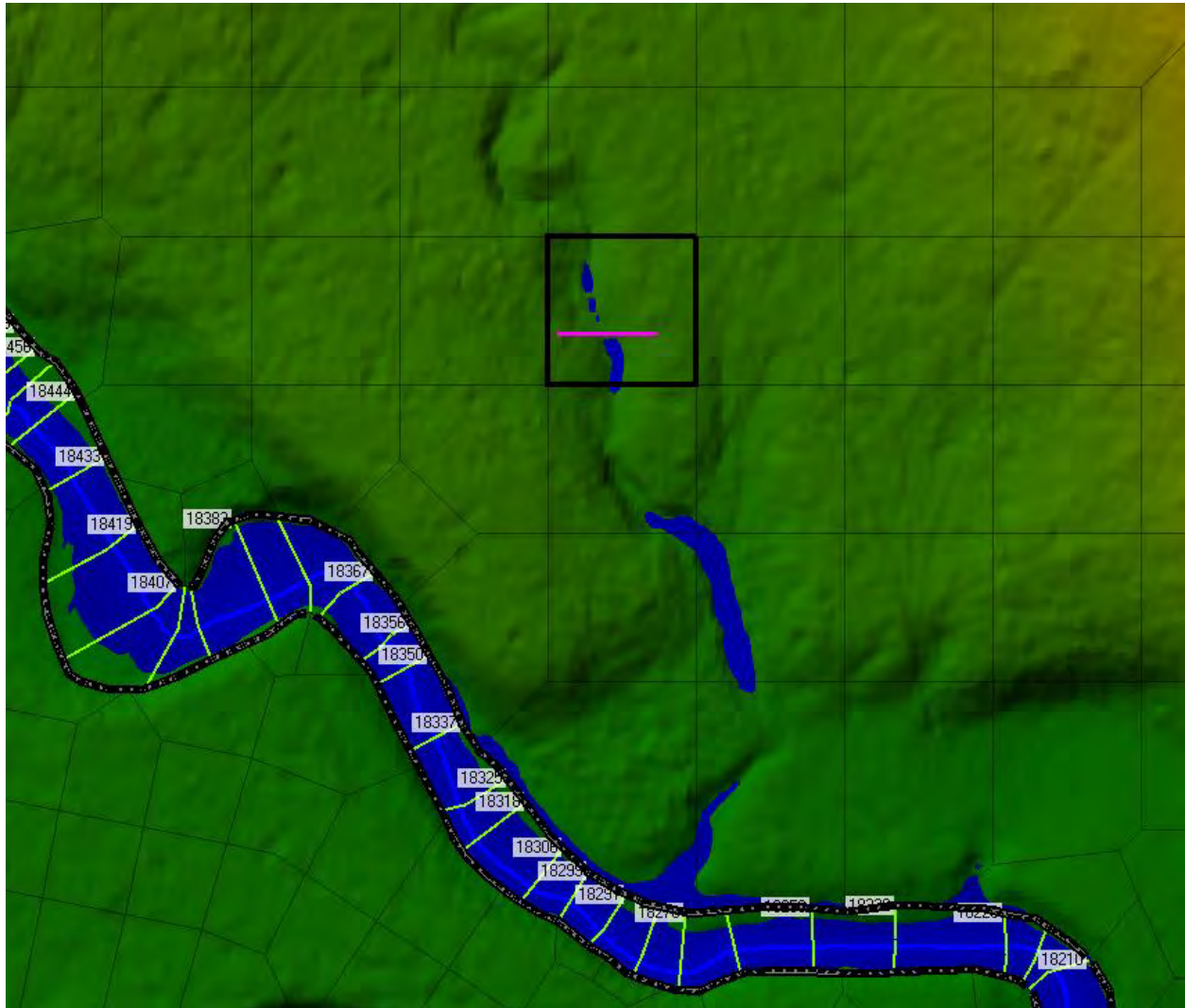
Boundary Condition Name: WNC-18283

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_LOB_N2

Image:



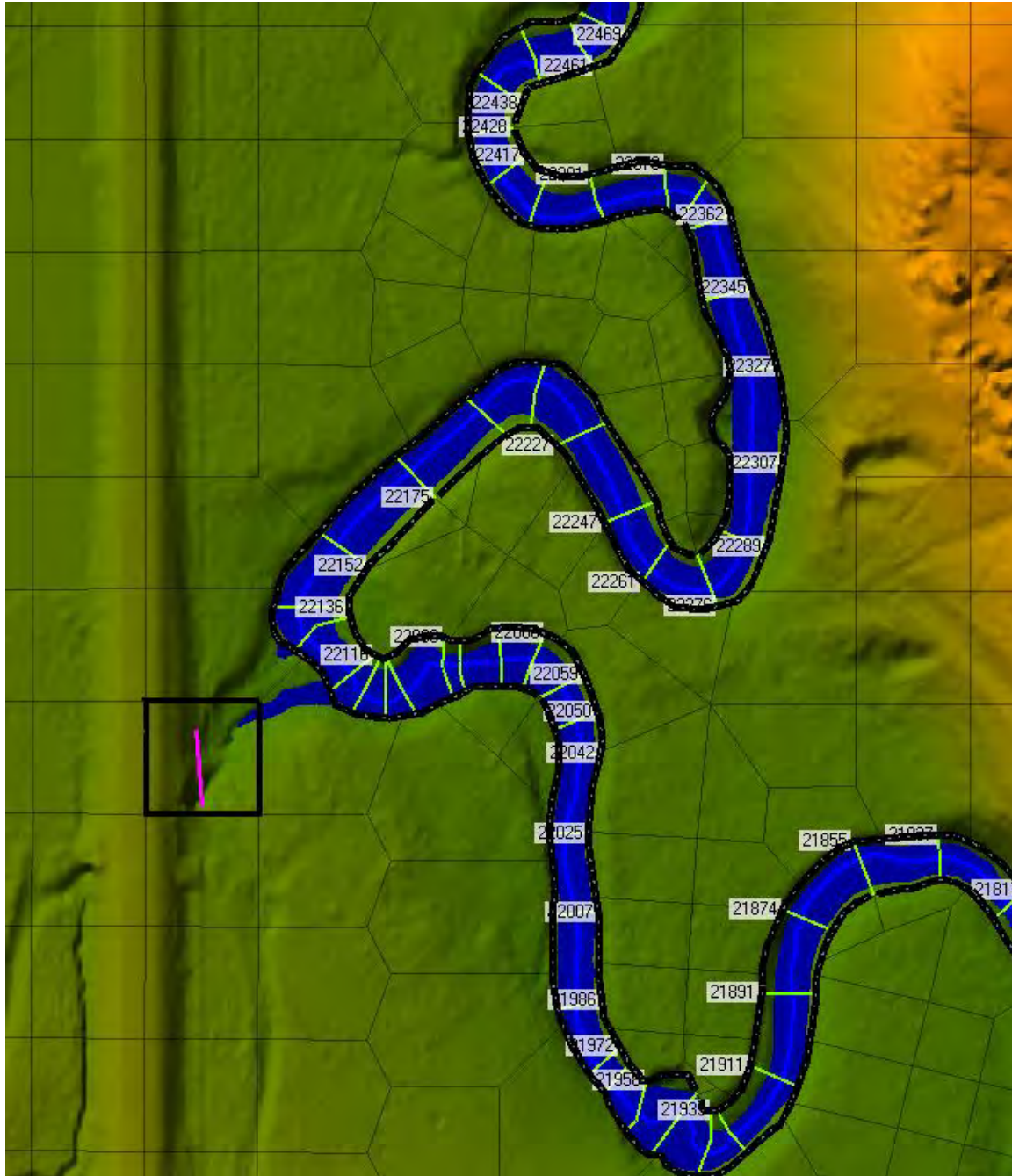
Boundary Condition Name: WNC-22116

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_ROB_N3

Image:



Boundary Condition Name: WNC-25100

River: West Nose Creek

Reach: West Nose Creek

2D Area: WNC_LOB_N3

Image:



Appendix C

Two-Dimensional Inflow Location Table for the Full 2D Model

Inflow Name	Northing	Easting	Reach	Downstream Gauge	Low Flow 1	Low Flow 2	Moderate Flow 1	Moderate Flow 2	Moderate Flow 3
	(m)	(m)			Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)
100001072104	5,682,485	-710	NC	AIR-DS	0.000	0.000	0.000	1.671	0.589
100001072548	5,683,285	-1,069	NC	AIR-DS	0.000	0.000	0.000	0.497	0.175
100001072720	5,684,866	-1,538	NC	AIR-DS	0.000	0.000	0.000	0.359	0.127
100001073068	5,681,961	-498	NC	AIR-DS	0.000	0.000	0.000	0.159	0.056
10439	5,658,013	-1,657	NC	SUR_NC-M	0.012	0.002	0.990	0.187	0.052
110205	5,669,297	-2,548	NC	SUR_NC-M	0.002	0.000	0.184	0.035	0.010
111042	5,667,306	-2,891	NC	SUR_NC-M	0.041	0.005	3.346	0.630	0.176
114041	5,666,367	-3,943	WNC	SUR_WNC-M	0.001	0.000	0.046	0.013	0.011
120020	5,668,768	-7,069	WNC	SUR_WNC-M	0.004	0.002	0.141	0.041	0.034
121444	5,662,186	-3,653	NC	SUR_NC-M	0.006	0.001	0.485	0.091	0.026
130979	5,669,203	-8,475	WNC	SUR_WNC-M	0.002	0.001	0.061	0.018	0.015
147675	5,667,492	-2,619	NC	SUR_NC-M	0.019	0.003	1.561	0.294	0.082
23526	5,660,018	-3,147	NC	SUR_NC-M	0.005	0.001	0.445	0.084	0.023
24678	5,661,445	-3,571	NC	SUR_NC-M	0.005	0.001	0.441	0.083	0.023
533064	5,670,308	-1,874	NC	SUR_NC-M	0.014	0.002	1.116	0.210	0.059
541645	5,670,301	-8,952	WNC	SUR_WNC-M	0.001	0.000	0.036	0.011	0.009
550516	5,668,945	-2,556	NC	SUR_NC-M	0.002	0.000	0.131	0.025	0.007
55701	5,662,868	-3,694	NC	SUR_NC-M	0.005	0.001	0.396	0.075	0.021
559528	5,666,283	-3,765	WNC	SUR_WNC-M	0.000	0.000	0.016	0.005	0.004
92683	5,664,316	-3,360	NC	SUR_NC-M	0.011	0.001	0.877	0.165	0.046
C3	5,673,893	0	NC	SUR_NC-15	0.097	0.000	0.043	0.665	0.033
NC_17_WIN_0010	5,659,653	-2,330	NC	SUR_NC-M	0.021	0.003	1.715	0.323	0.090
NC_17_WIN_0021	5,659,521	-2,128	NC	SUR_NC-M	0.021	0.003	1.735	0.327	0.091

Inflow Name	Northing	Easting	Reach	Downstream Gauge	Low Flow 1	Low Flow 2	Moderate Flow 1	Moderate Flow 2	Moderate Flow 3
	(m)	(m)			Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)
NC_21_GRV_0002	5,662,184	-3,679	NC	SUR_NC-M	0.014	0.002	1.152	0.217	0.061
NC_21_SKW_0000	5,663,506	-3,469	NC	SUR_NC-M	0.030	0.004	2.482	0.468	0.131
NC_26_ABP	5,666,163	-4,245	WNC	SUR_WNC-M	0.011	0.005	0.404	0.118	0.096
NC_26_ABP_0022	5,666,606	-4,998	WNC	SUR_WNC-M	0.009	0.004	0.326	0.095	0.078
NC_26_COU_0052	5,667,212	-5,777	WNC	SUR_WNC-M	0.036	0.016	1.271	0.370	0.303
NC_27_COU_0011	5,667,671	-6,300	WNC	SUR_WNC-M	0.002	0.001	0.065	0.019	0.016
NC_27_HID_1106	5,668,353	-6,861	WNC	SUR_WNC-M	0.008	0.004	0.294	0.086	0.070
NC_27_PAN_0000	5,667,803	-6,414	WNC	SUR_WNC-M	0.001	0.000	0.025	0.007	0.006
OL6	5,672,038	-9,147	WNC	SUR_WNC-M	0.006	0.003	0.203	0.059	0.048
OR1	5,675,427	82	NC	SUR_NC-15	0.021	0.000	0.009	0.142	0.007
OVRLD_20	5,684,052	-1,316	NC	AIR-DS	0.000	0.000	0.000	0.454	0.160
OVRLD_632	5,678,103	122	NC	SUR_NC-15	0.178	0.000	0.080	1.218	0.061
131591	5,669,293	-8,241	WNC	SUR_WNC-M	0.005	0.002	0.183	0.053	0.044
C4	5,674,193	94	NC	SUR_NC-15	0.026	0.000	0.012	0.179	0.009
100001072242	5,681,628	-539	NC	AIR-DS	0.000	0.000	0.000	0.069	0.024
L15118	5,661,594	-3,641	NC	SUR_NC-M	0.064	0.009	5.285	0.995	0.278
C2	5,663,140	-3,285	NC	SUR_NC-M	0.029	0.004	2.349	0.442	0.124
542861	5,671,502	-9,024	WNC	SUR_WNC-M	0.000	0.000	0.009	0.003	0.002
SWAT05	5,697,044	-3,427	NC	05BH014	0.000	0.000	0.000	0.000	0.079
SWAT11	5,692,455	-1,886	NC	05BH014	0.000	0.000	0.000	0.000	0.009
SWAt14	5,690,967	-1,407	NC	05BH014	0.000	0.000	0.000	0.000	0.023

Inflow Name	Northing	Easting	Reach	Downstream Gauge	Low Flow 1	Low Flow 2	Moderate Flow 1	Moderate Flow 2	Moderate Flow 3
	(m)	(m)			Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)	Inflow (m ³ /s)
SWAT17	5,689,040	-1,448	NC	05BH014	0.000	0.000	0.000	0.000	0.049
SWAT20	5,687,722	-2,130	NC	05BH014	0.050	0.050	0.000	0.000	0.120
SWAT32	5,679,311	-459	NC	AIR-DS	0.000	0.000	0.000	0.621	0.219
SWAT37	5,676,277	273	NC	SUR_NC-15	0.044	0.000	0.020	0.304	0.015
SWAT43	5,673,791	-361	NC	SUR_NC-15	0.013	0.000	0.006	0.092	0.005
SWAT47	5,672,199	-9,299	WNC	SUR_WNC-M	0.004	0.002	0.148	0.043	0.035
WNC_TRIB_1	5,675,503	-12,046	WNC	WNC_SGS	0.000	0.000	0.000	0.000	0.000
WNC_US	5,695,927	-16,186	WNC	NA	0.080	0.070	0.070	1.630	1.400
NC_US	5,697,176	-9,593	NC	NA	0.000	0.000	0.080	0.930	1.000

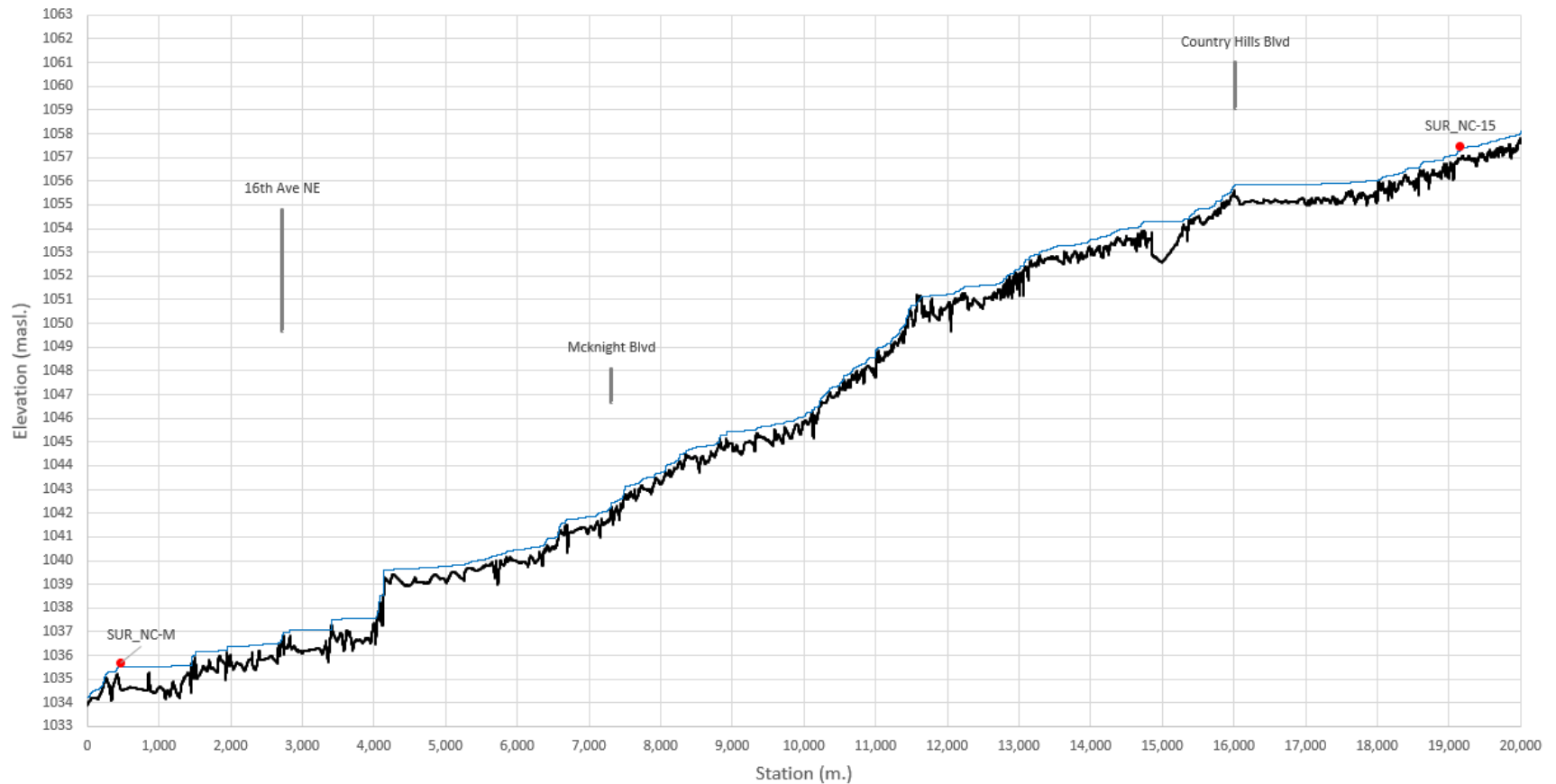
Horizontal Coordinate System 3TM 114, Datum NAD83

Appendix D

Low-Flow Event Simulated Channel Profiles and Observed Water Levels

Low Flow 1 Calibration Event Simulated Water Level Profiles

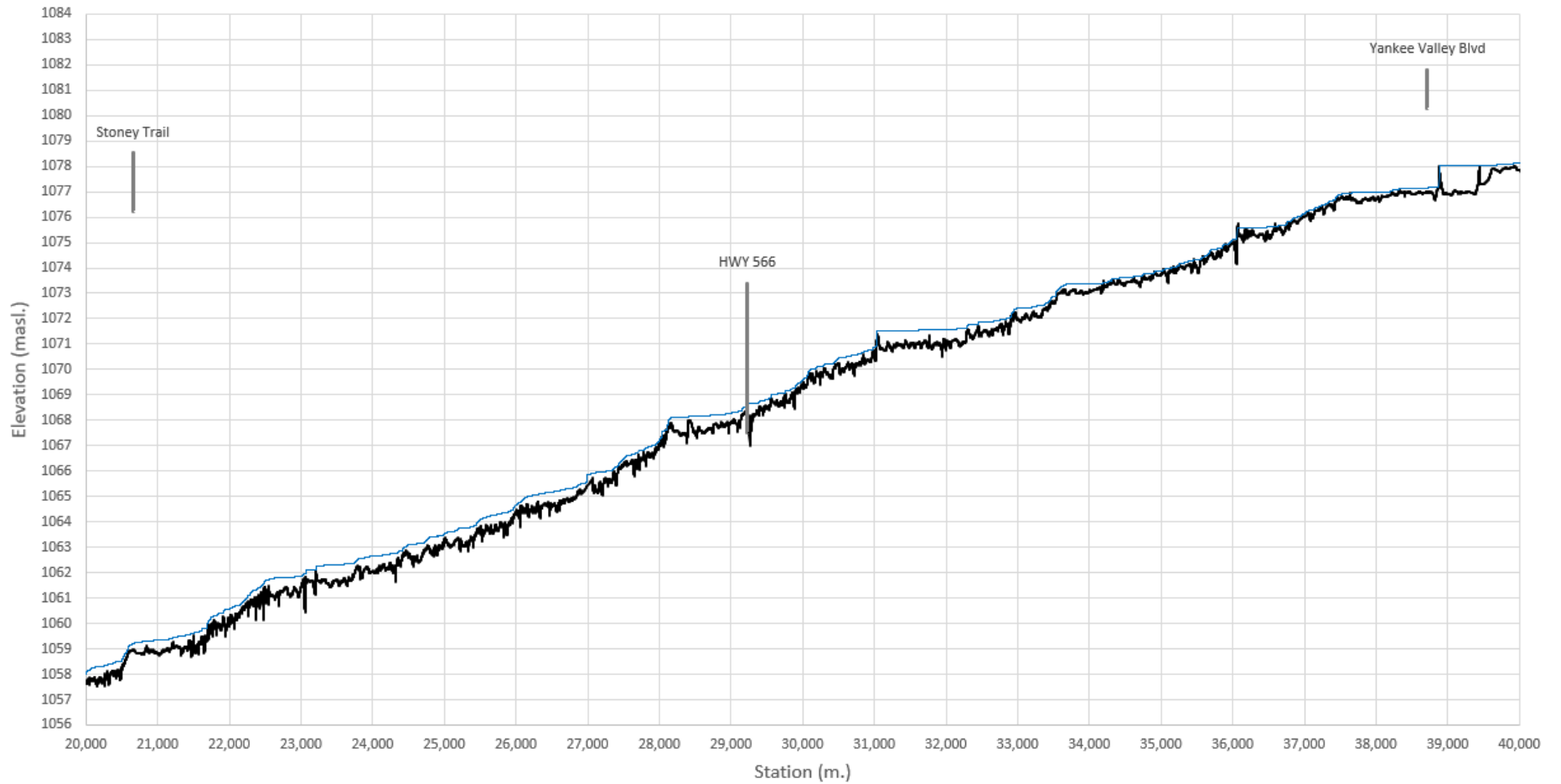
Nose Creek Station 0-20,000 m



— Channel Centerline Bed — LF1 Simulated Water Level ● LF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

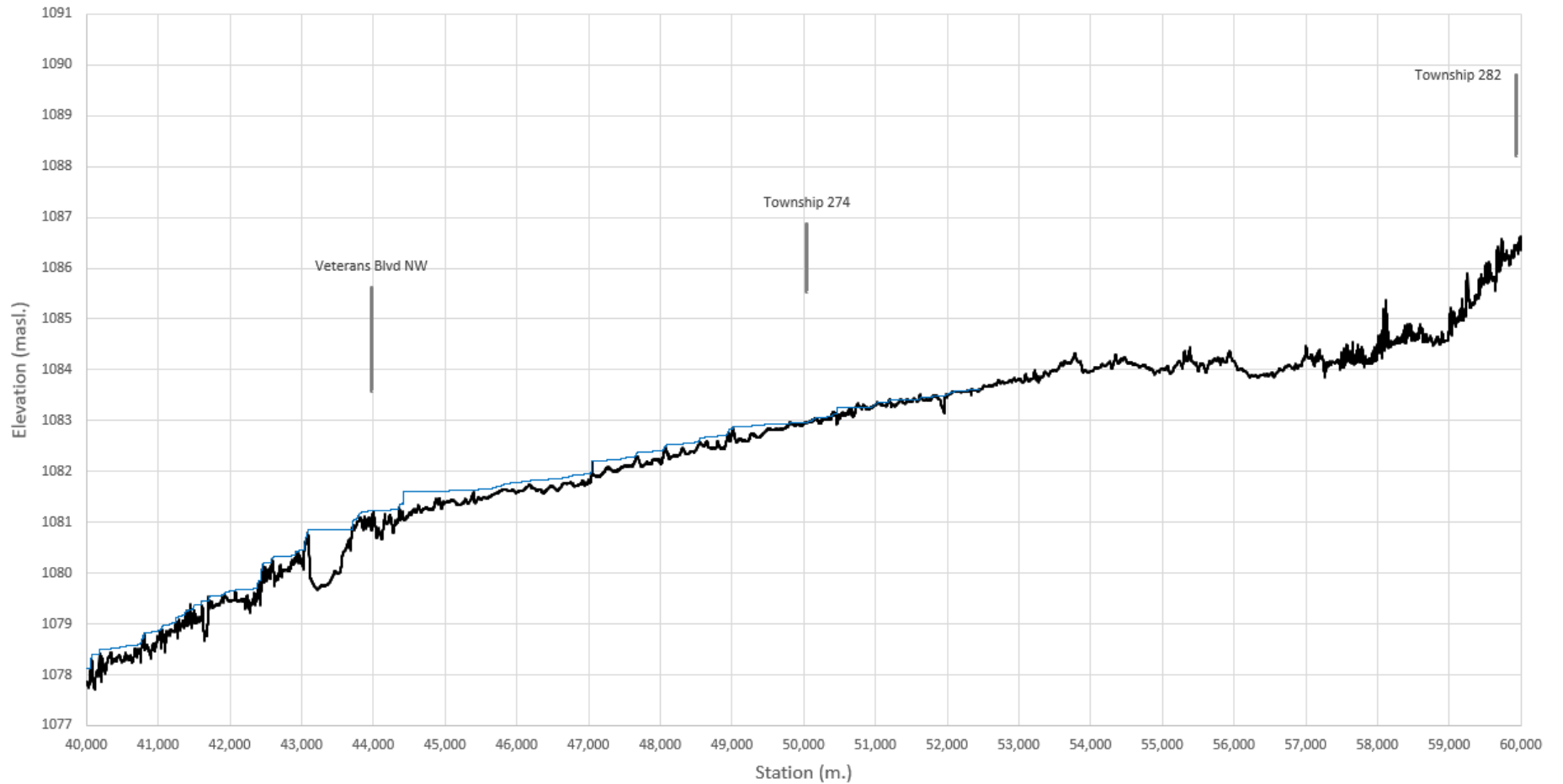
Nose Creek Station 20,000-40,000 m



— Channel Centerline Bed — LF1 Simulated Water Level ● LF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

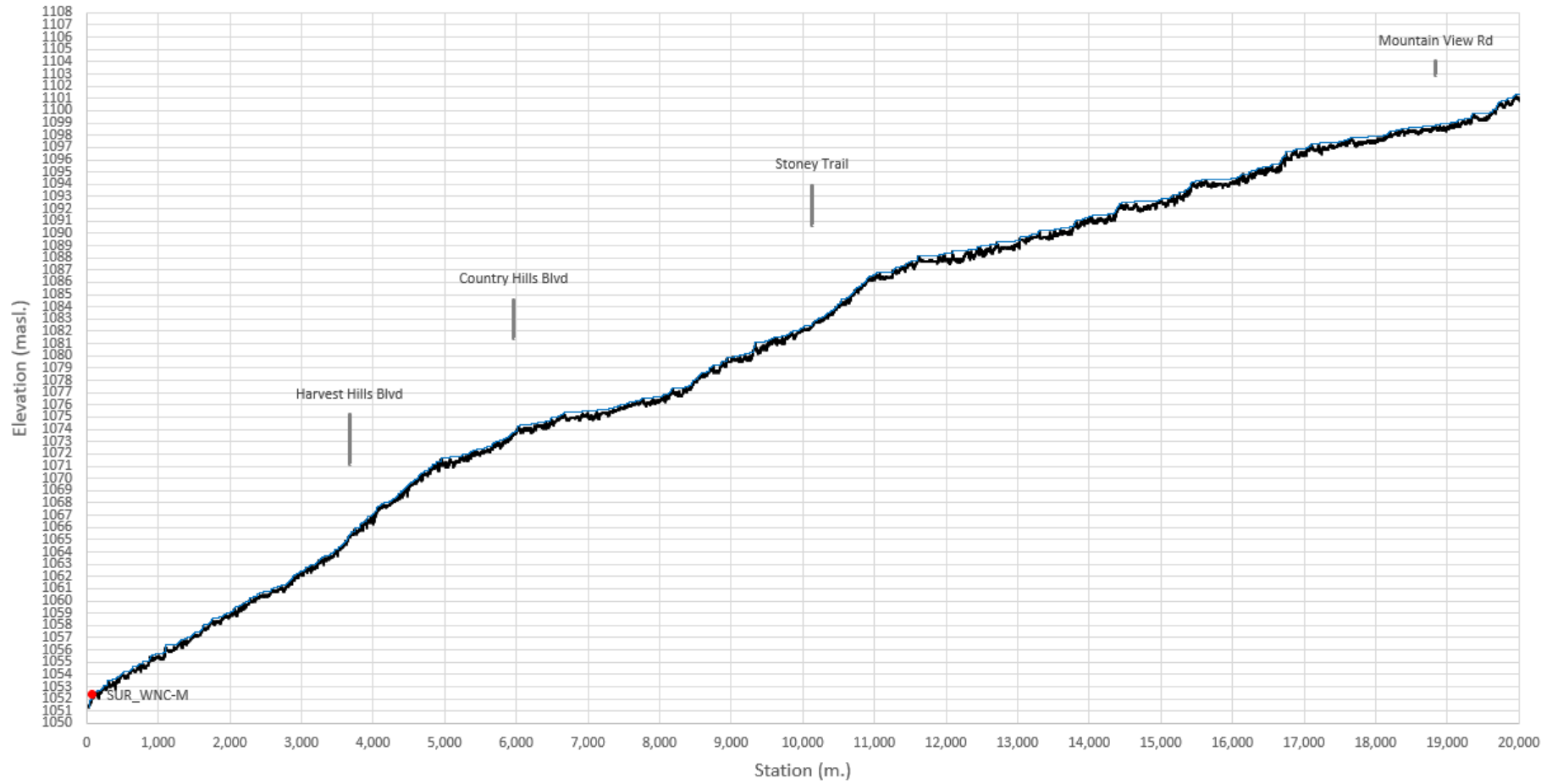
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — LF1 Simulated Water Level • LF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

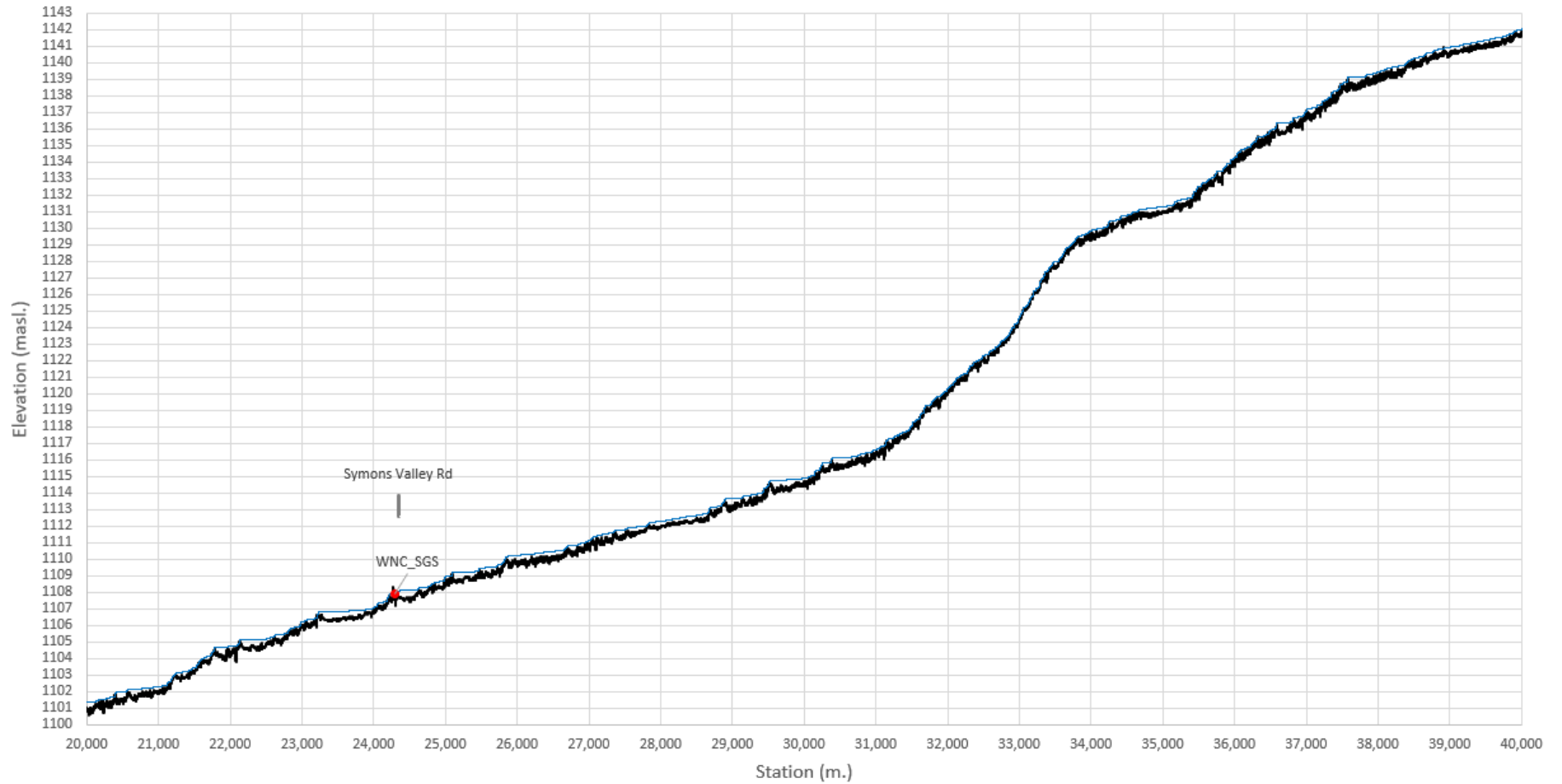
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 LF1 Simulated Water Level
 LF1 Observed Water Level
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

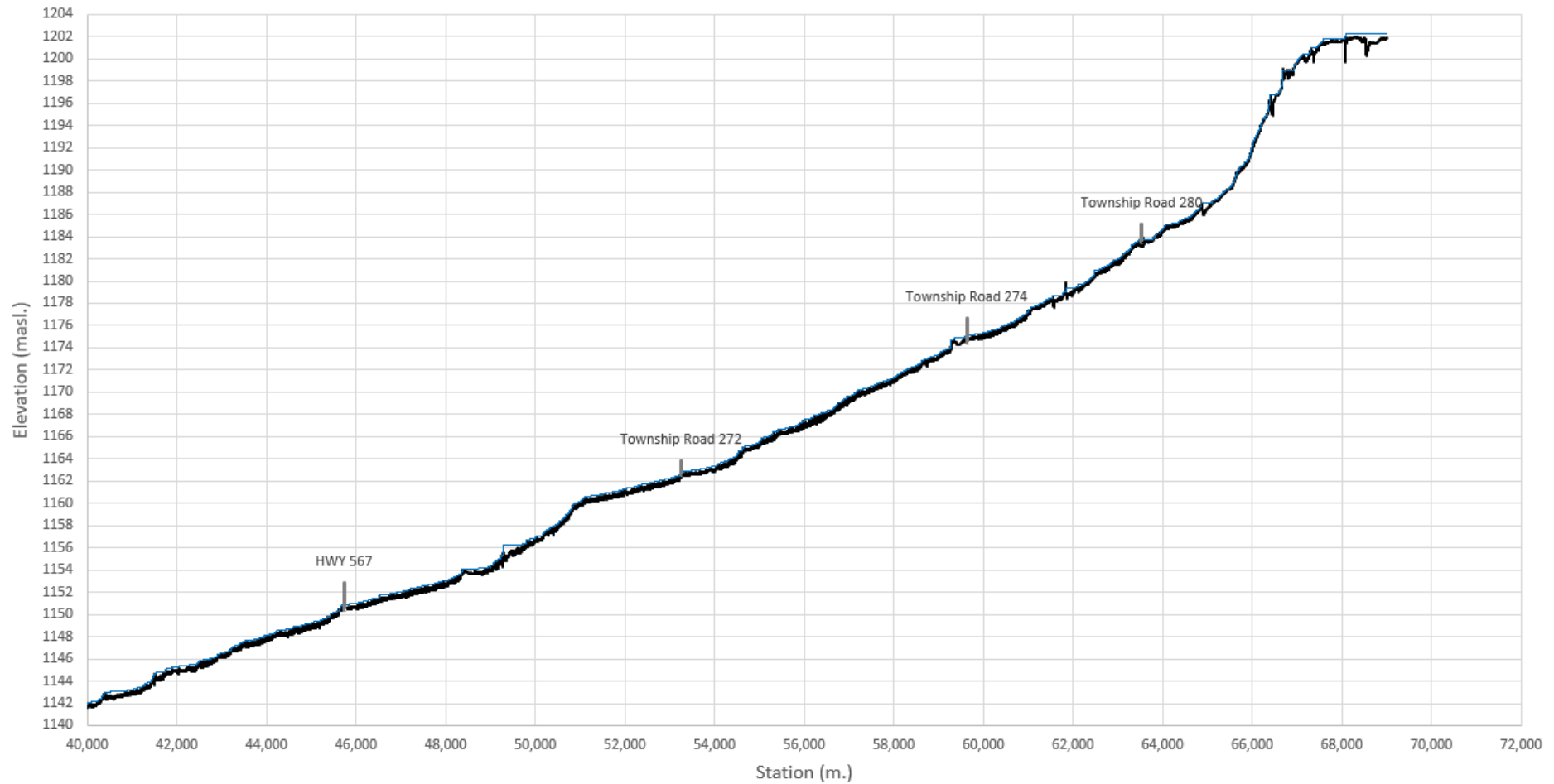
West Nose Creek Station 20,000-40,000 m



— Channel Centerline Bed — LF1 Simulated Water Level ● LF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m



— Channel Centerline Bed — LF1 Simulated Water Level • LF1 Observed Water Level — Reference Crossings

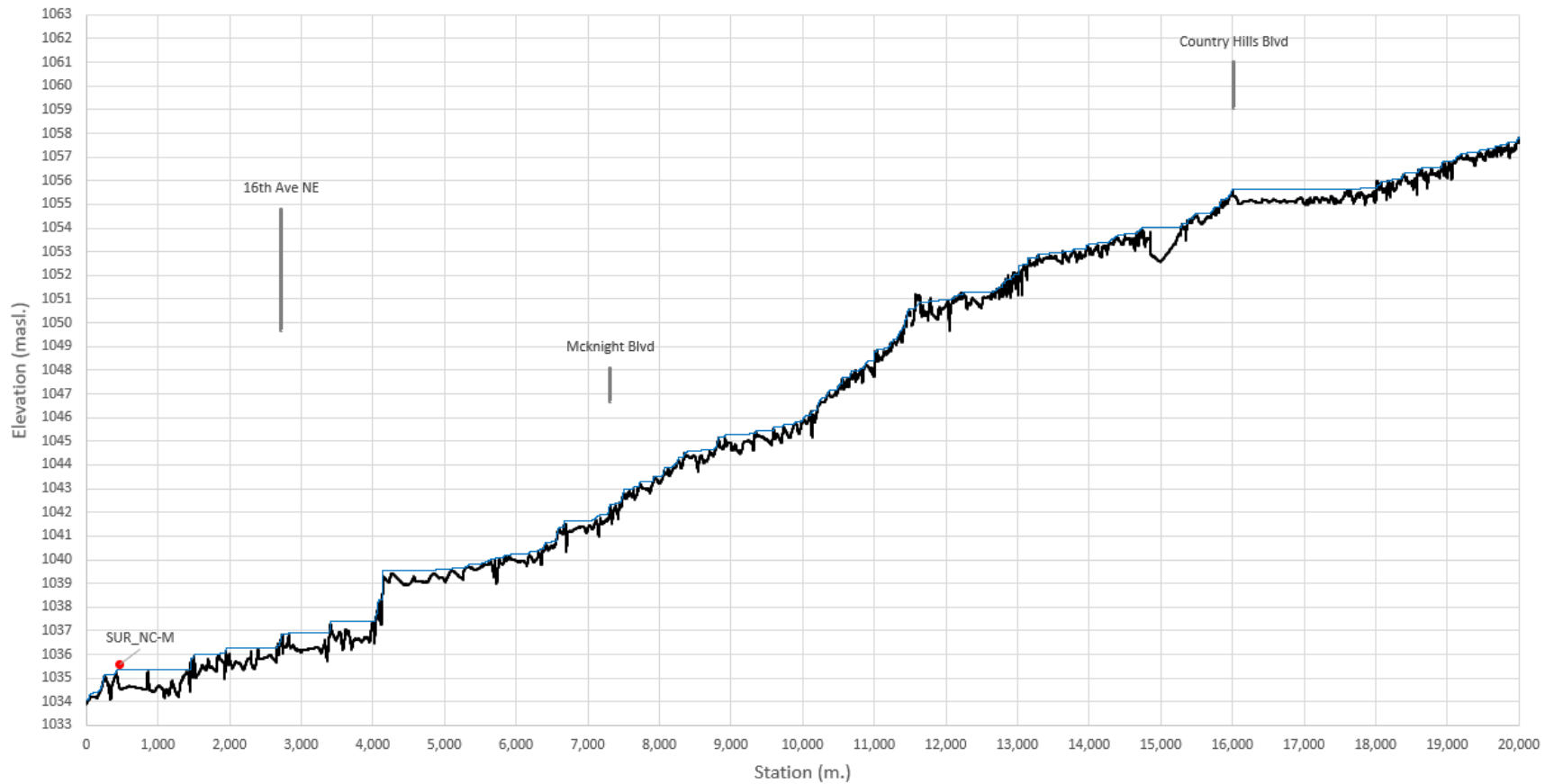
Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

Low Flow 2 Calibration Event Simulated Water Level Profiles

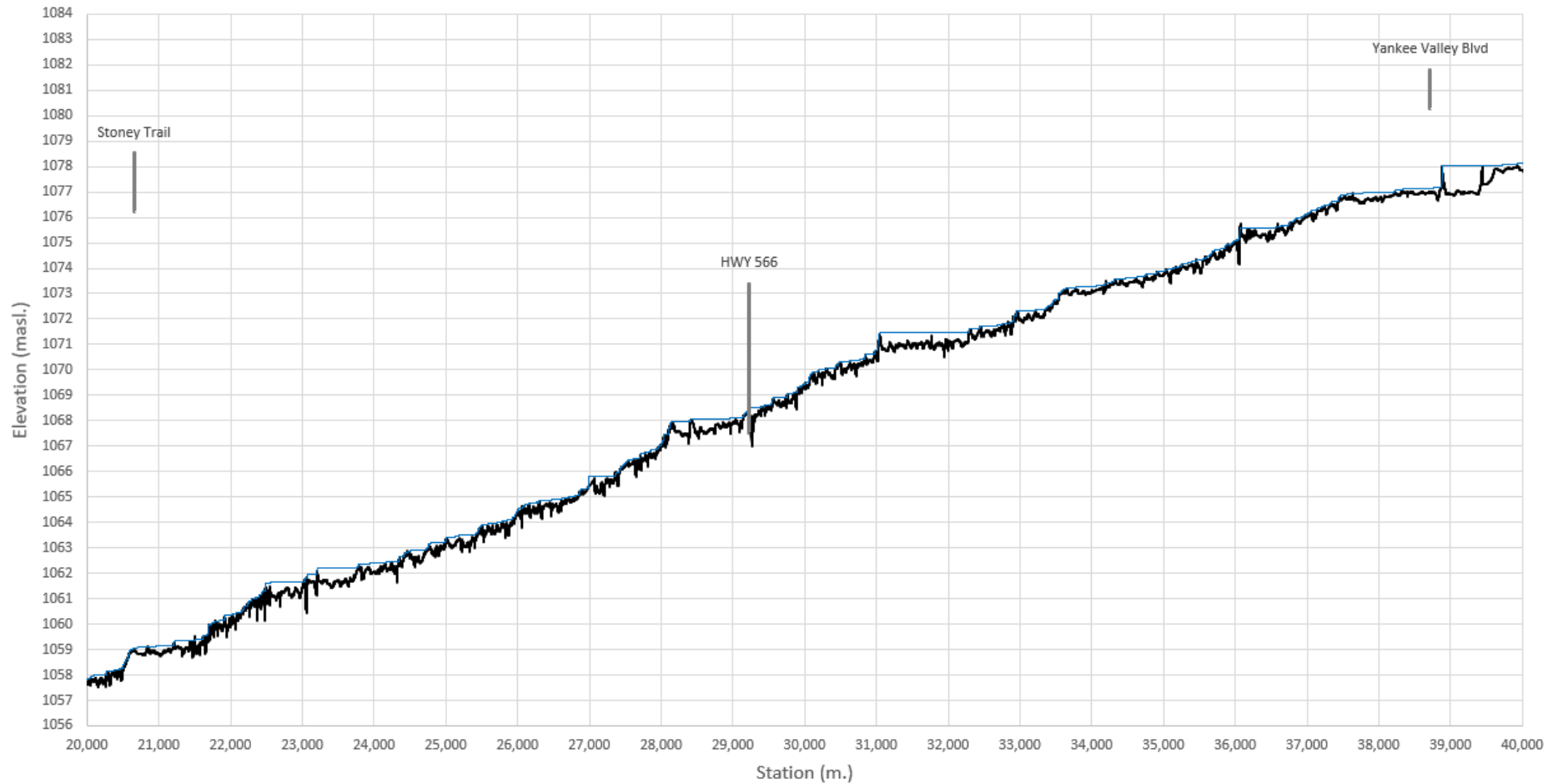
Nose Creek Station 0-20,000 m



— Channel Centerline Bed — LF2 Simulated Water Level ● LF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

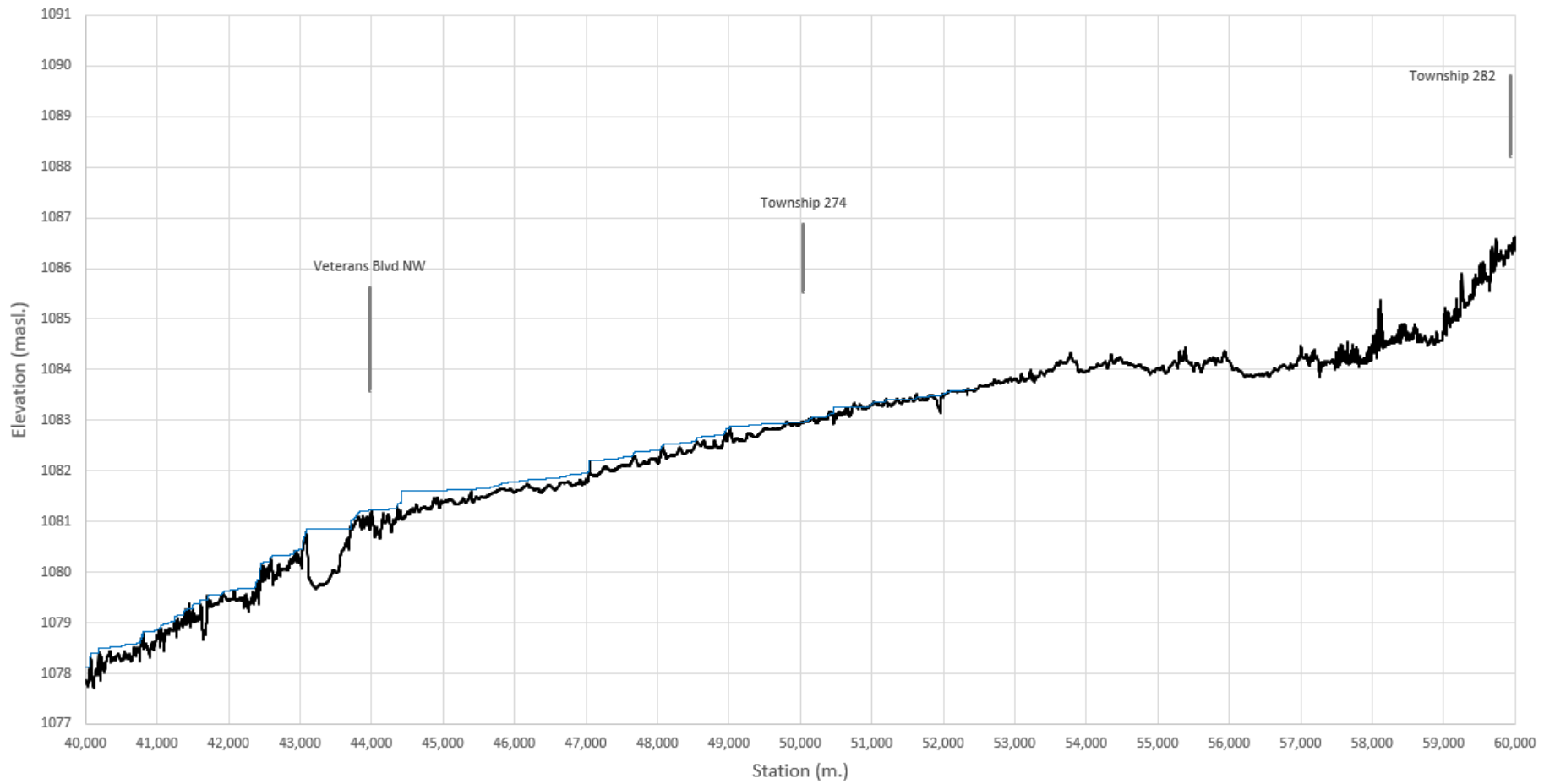
Nose Creek Station 20,000-40,000 m



— Channel Centerline Bed — LF2 Simulated Water Level • LF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

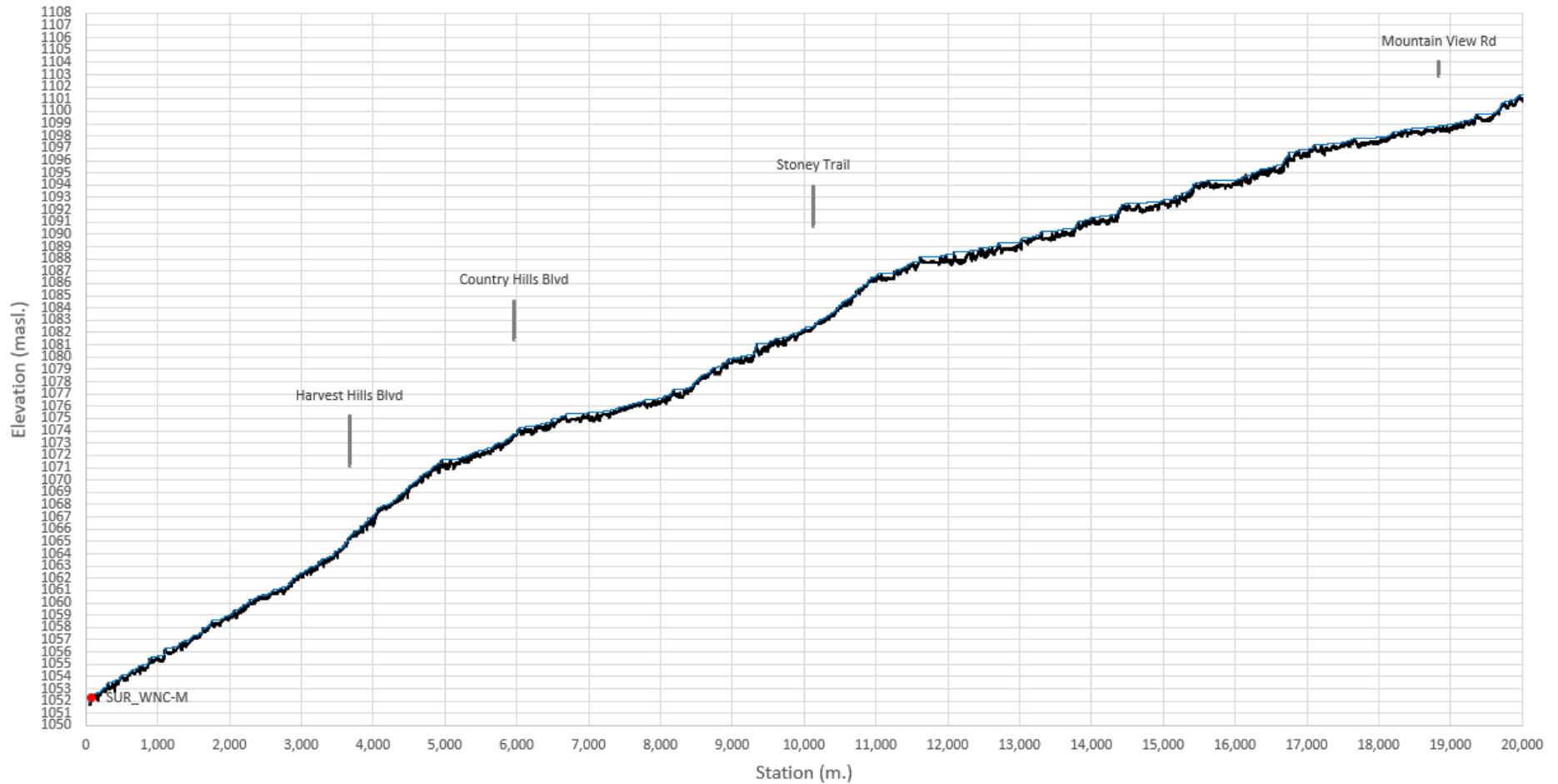
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — LF2 Simulated Water Level • LF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

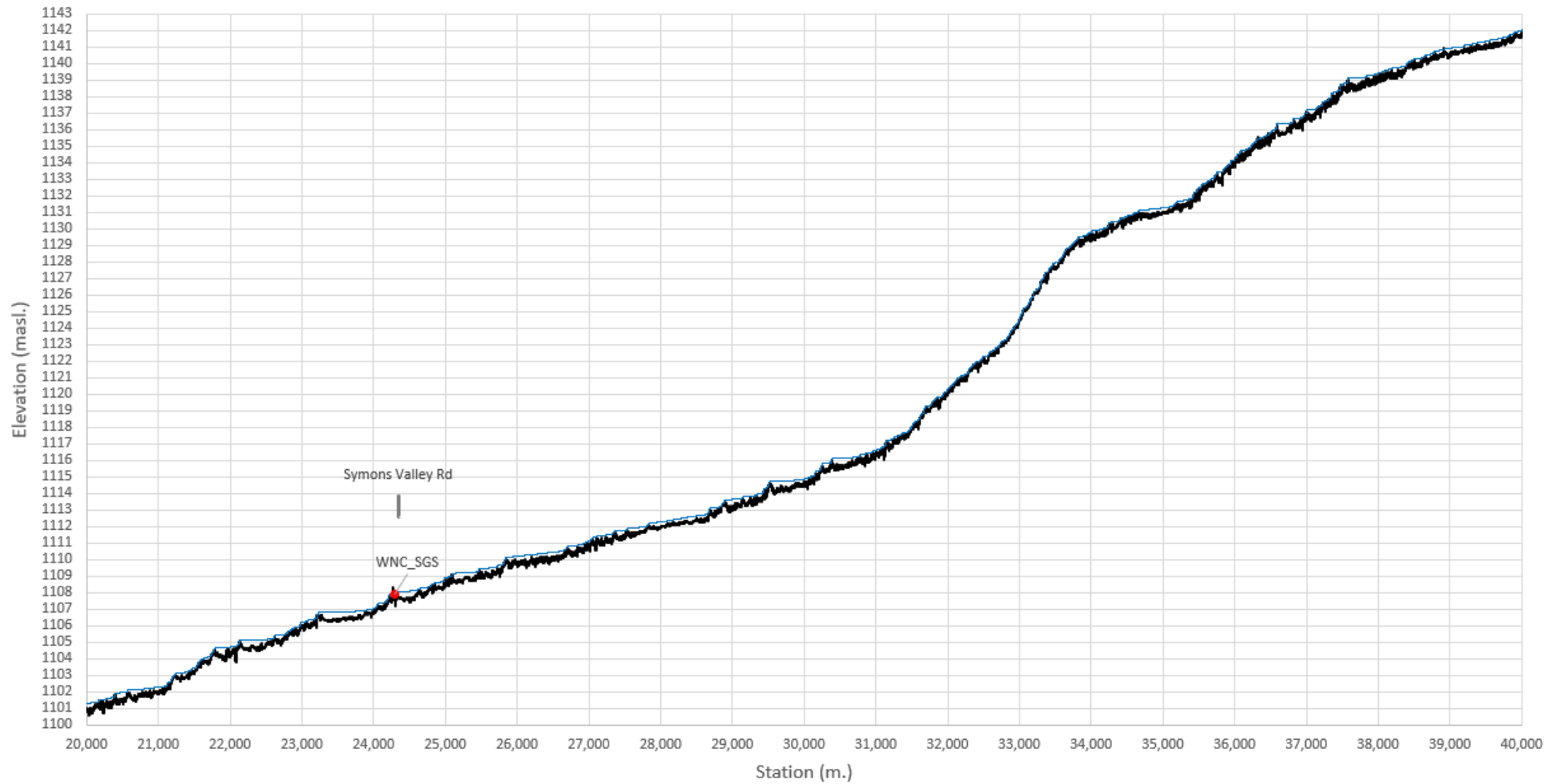
West Nose Creek Station 0-20,000 m



— Channel Centerline Bed — LF2 Simulated Water Level ● LF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

West Nose Creek Station 20,000-40,000 m



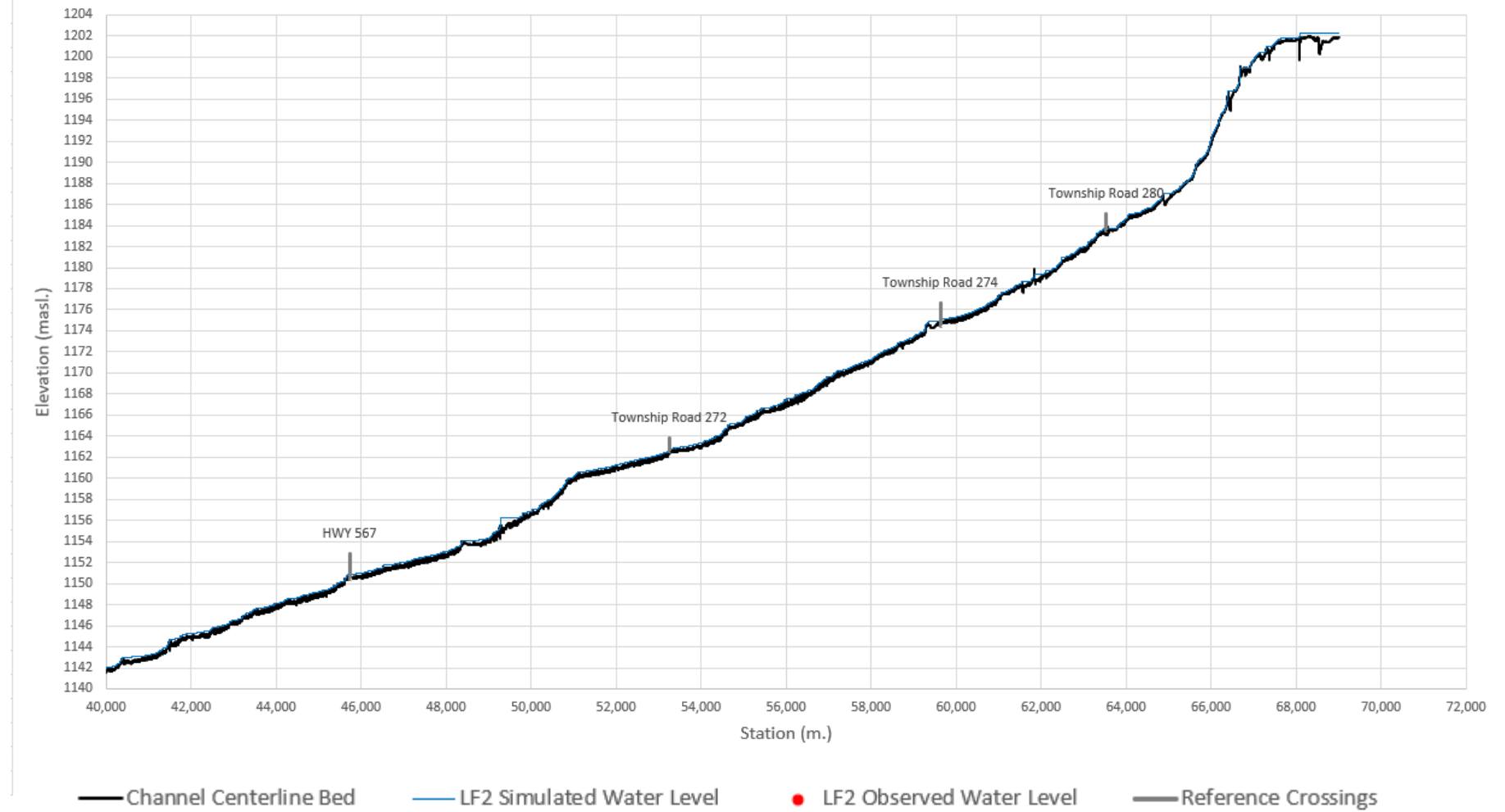
— Channel Centerline Bed — LF2 Simulated Water Level ● LF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m



Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

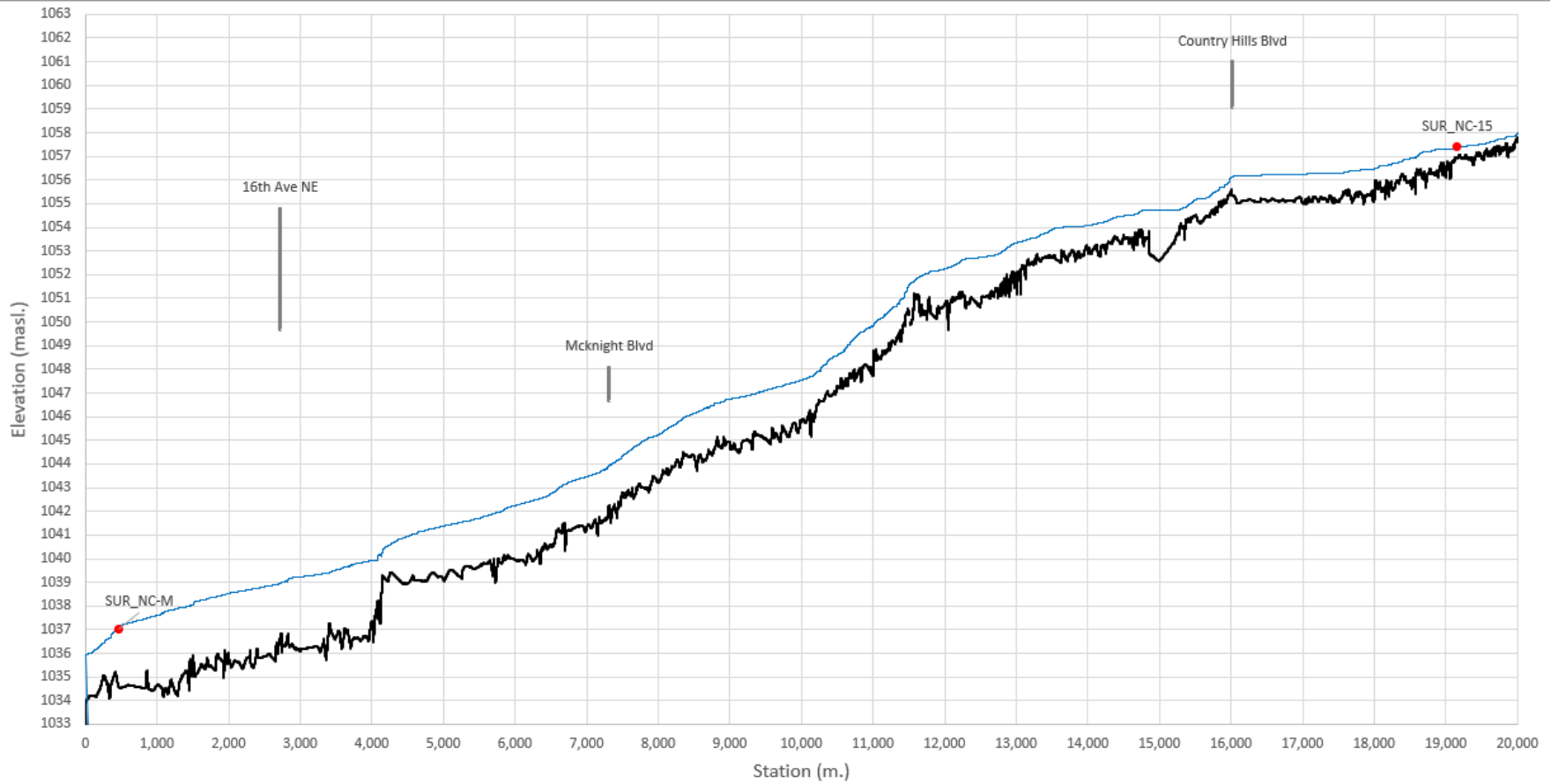
Culverts are represented by the obvert and invert.

Appendix E

Moderate-Flow Event Simulated Channel Profiles and Observed Water Levels

Moderate Flow 1 Calibration Event Simulated Water Level Profiles

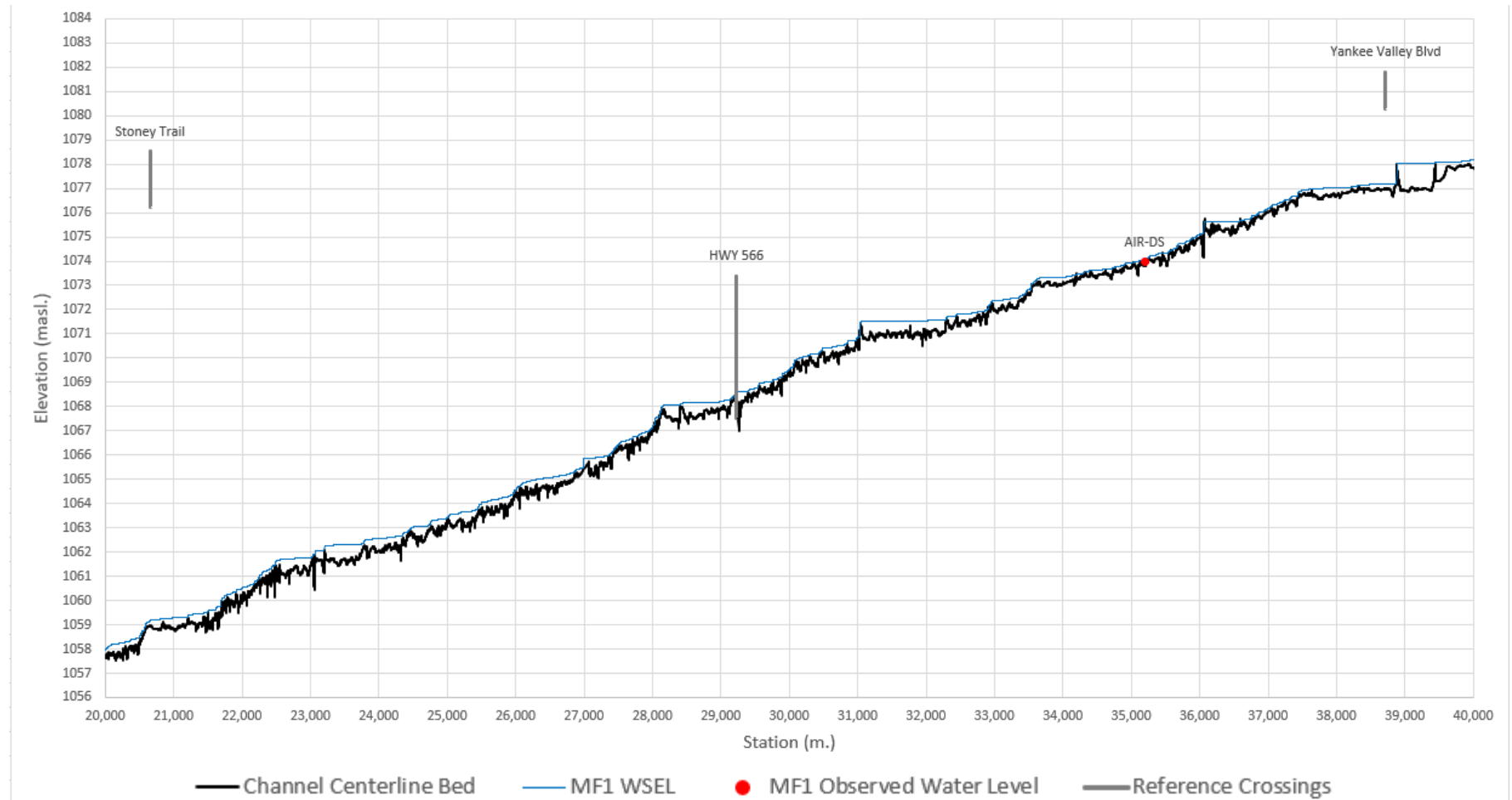
Nose Creek Station 0-20,000 m



— Channel Centerline Bed — MF1 WSEL ● MF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

Nose Creek Station 20,000-40,000 m

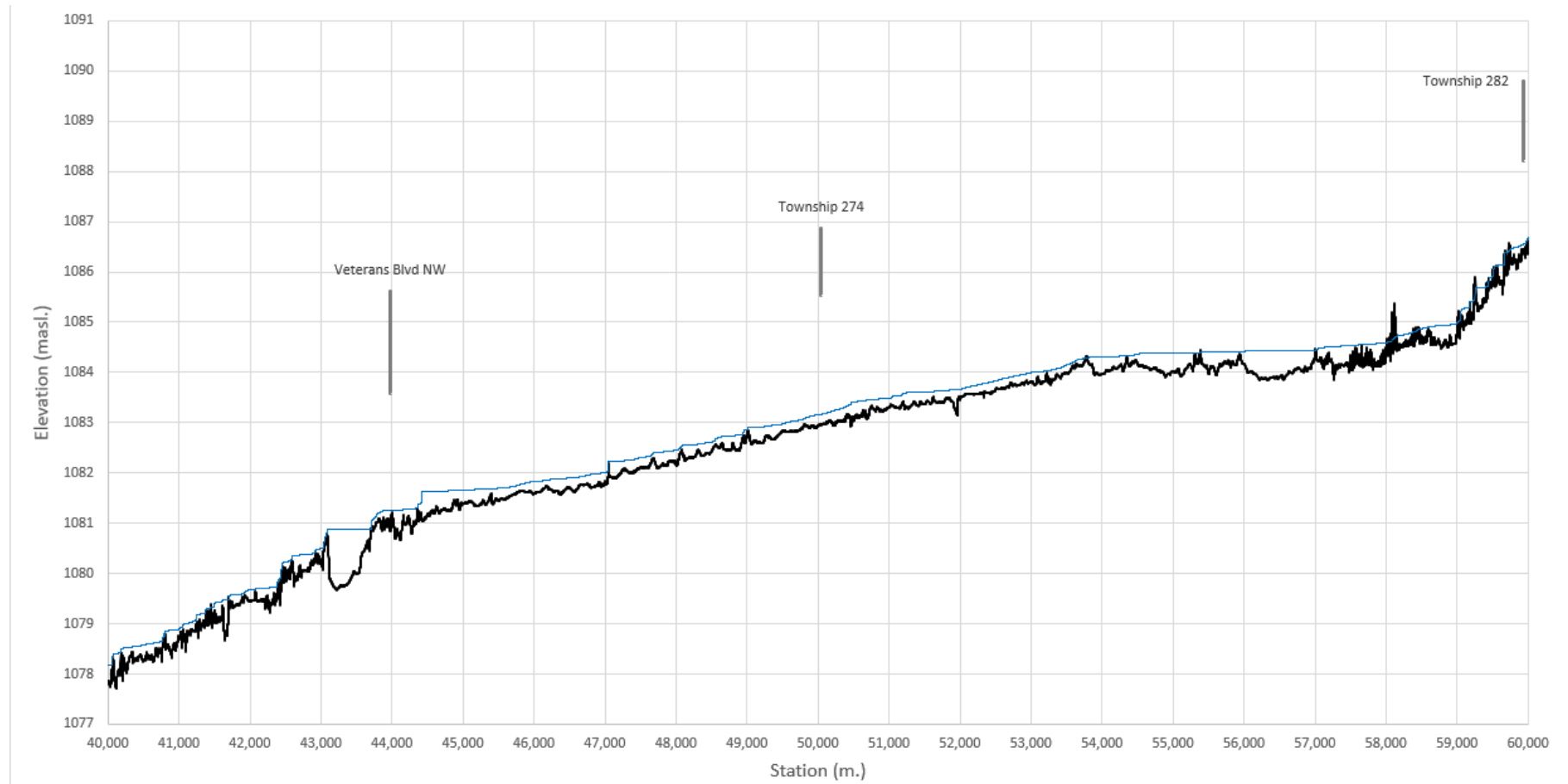


Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

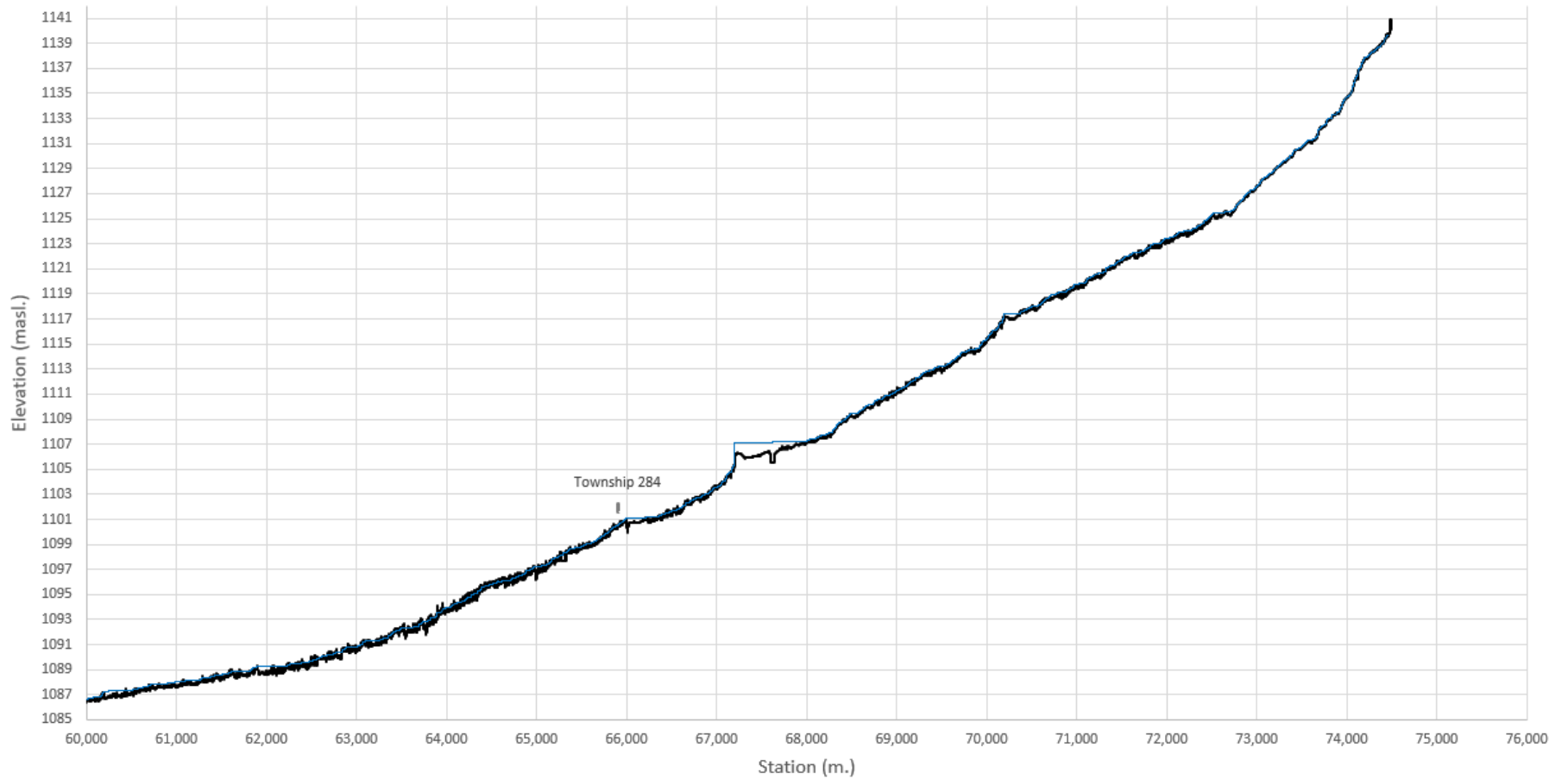
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — MF1 WSEL ● MF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

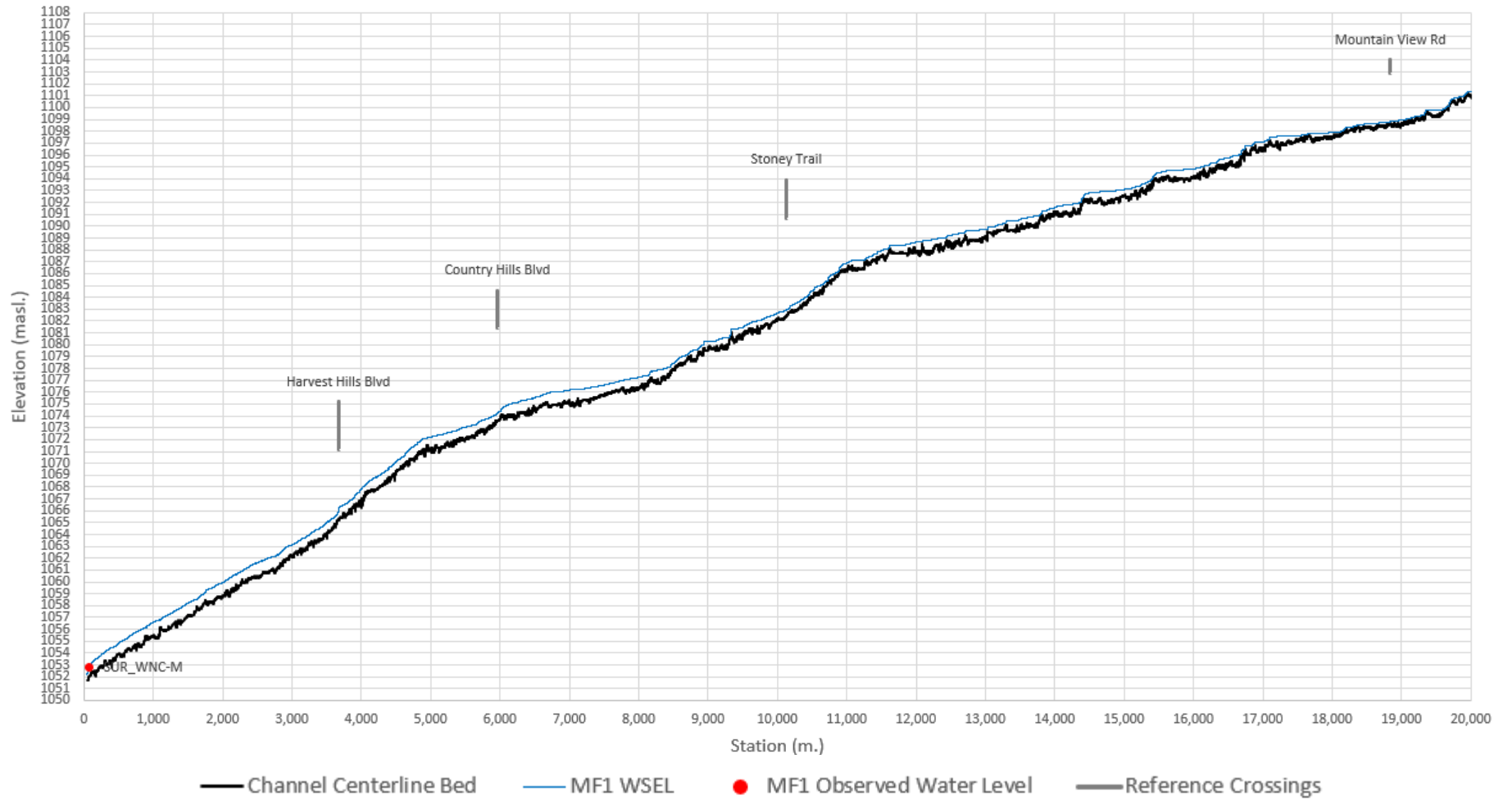
Nose Creek Station 60,000-76,000 m



— Channel Centerline Bed — MF1 WSEL ● MF1 Observed Water Level — Reference Crossings

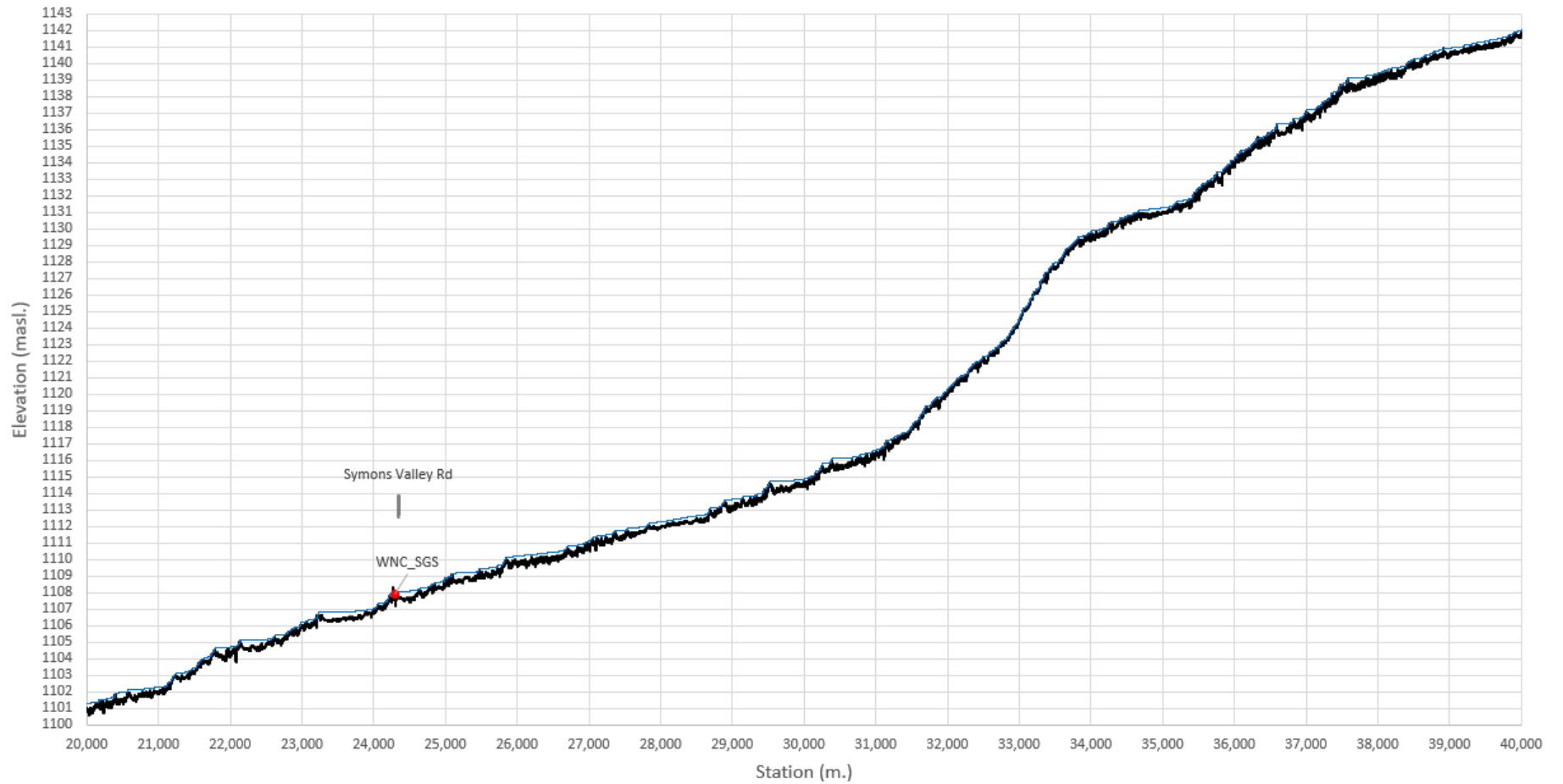
Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

West Nose Creek Station 0-20,000 m



Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

West Nose Creek Station 20,000-40,000 m



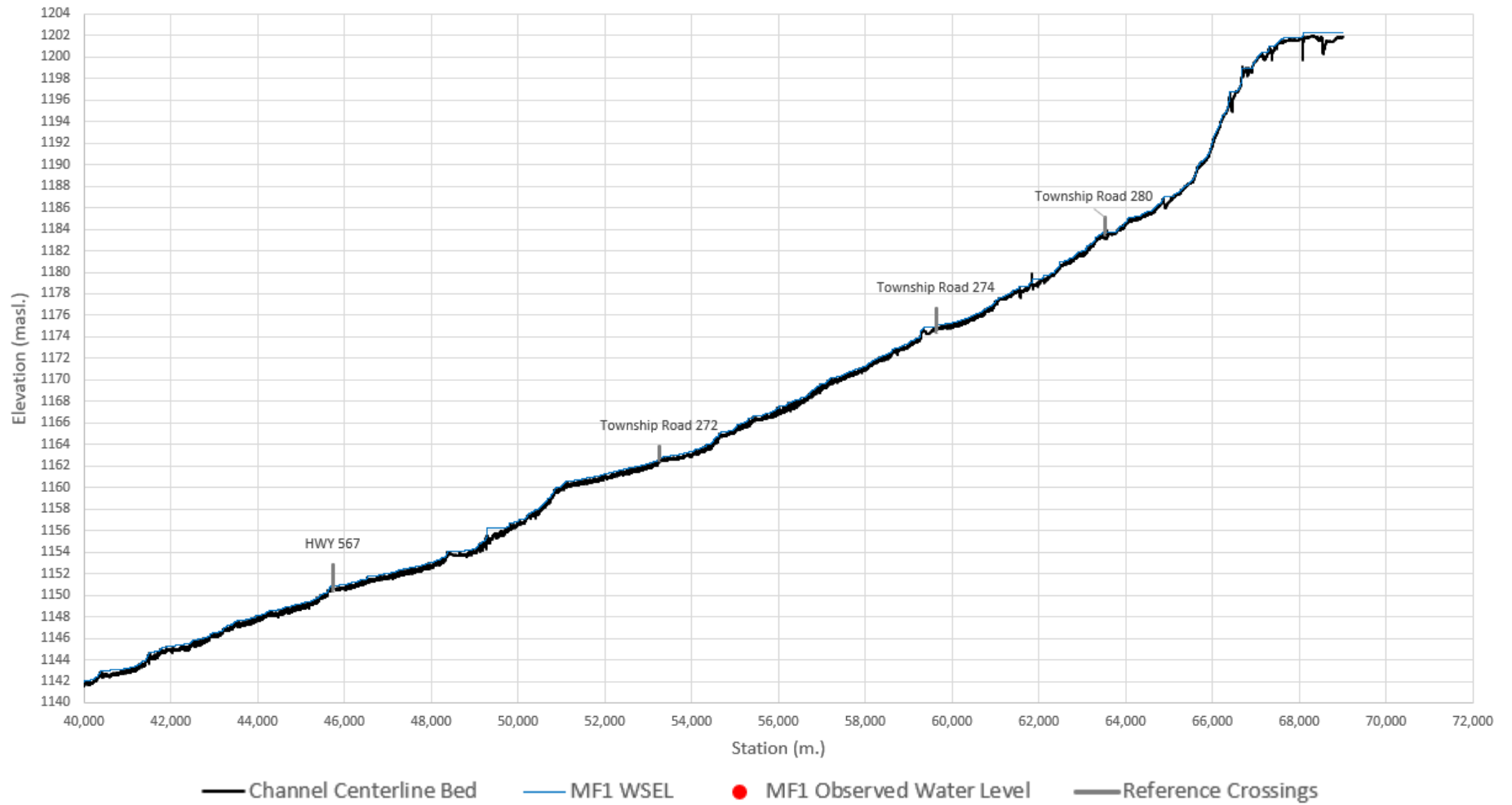
— Channel Centerline Bed — MF1 WSEL ● MF1 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m



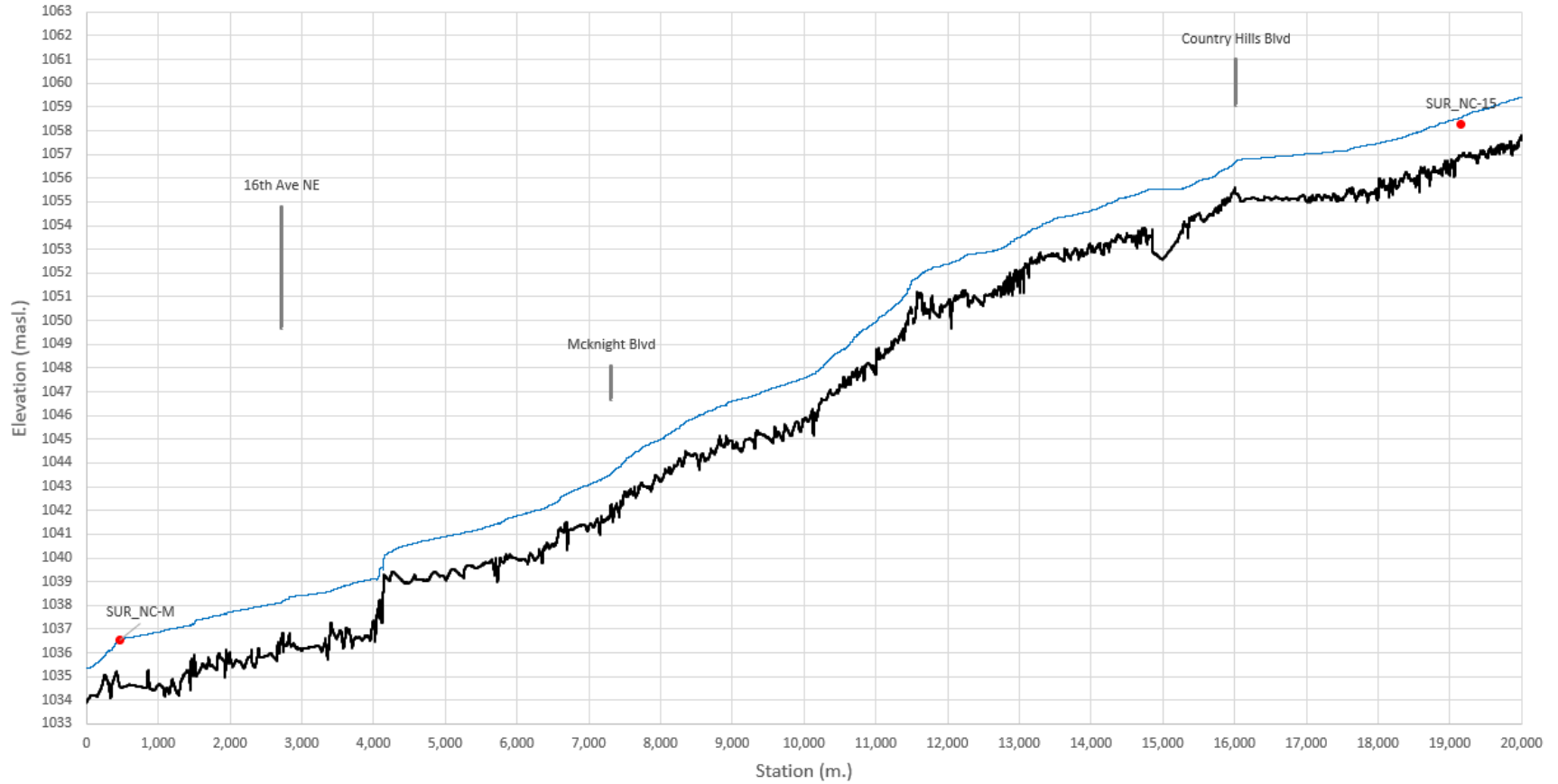
Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

Moderate Flow 2 Calibration Event Simulated Water Level Profiles

Nose Creek Station 0-20,000 m



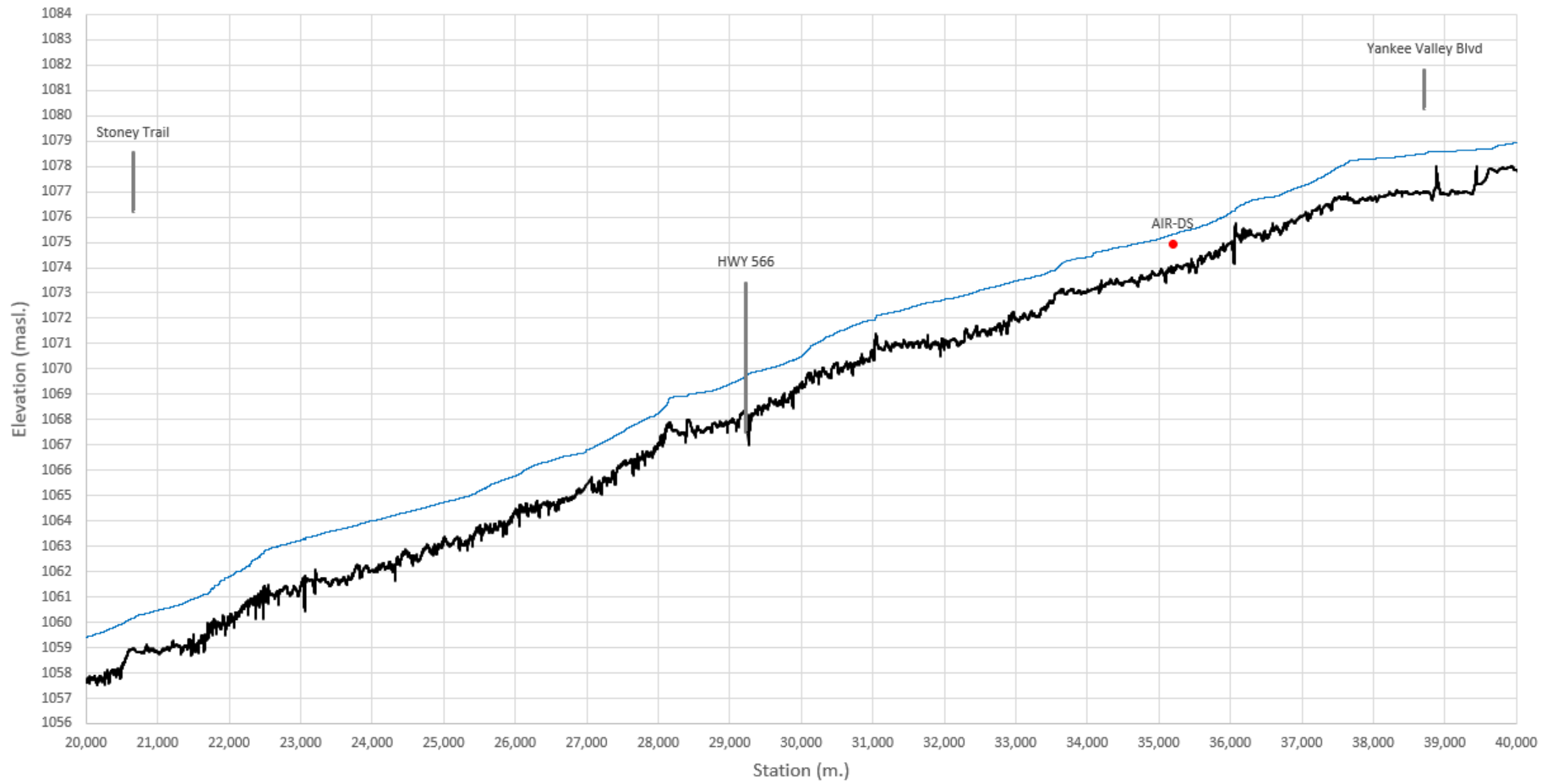
— Channel Centerline Bed — MF2 WSEL • MF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

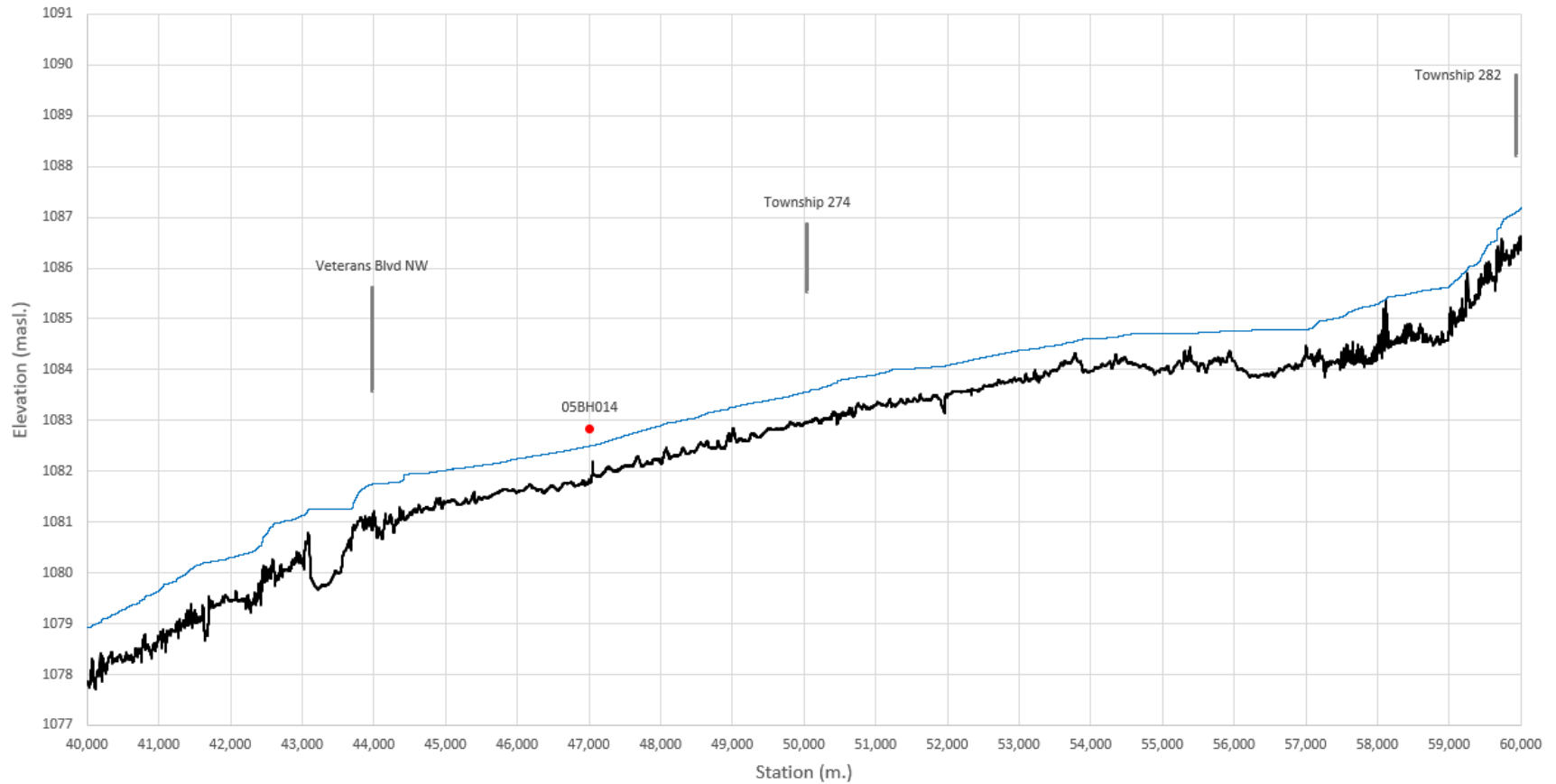
Nose Creek Station 20,000-40,000 m



Channel Centerline Bed
 MF2 WSEL
 MF2 Observed Water Level
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

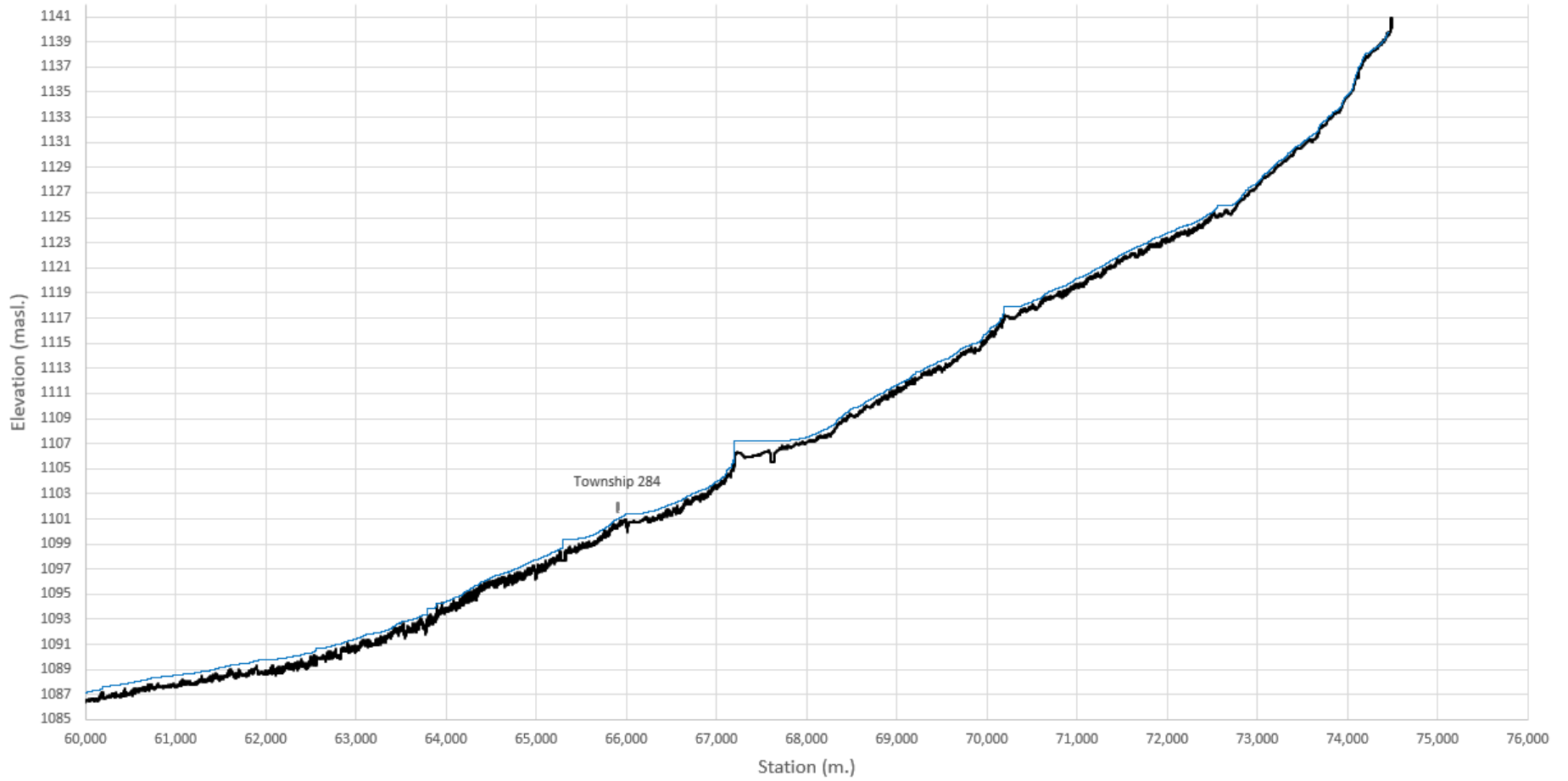
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — MF2 WSEL ● MF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

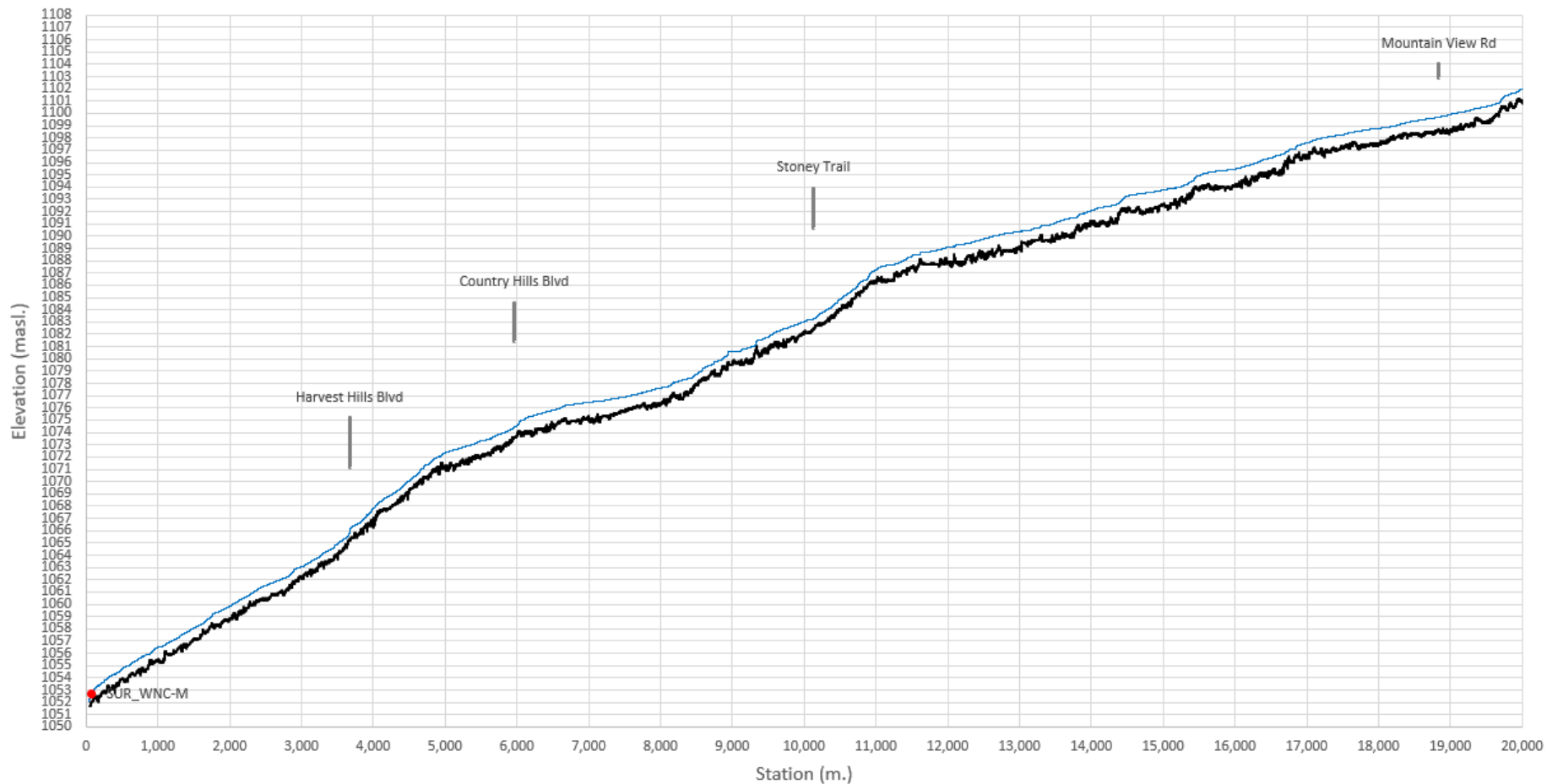
Nose Creek Station 60,000-76,000 m



— Channel Centerline Bed — MF2 WSEL ● MF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

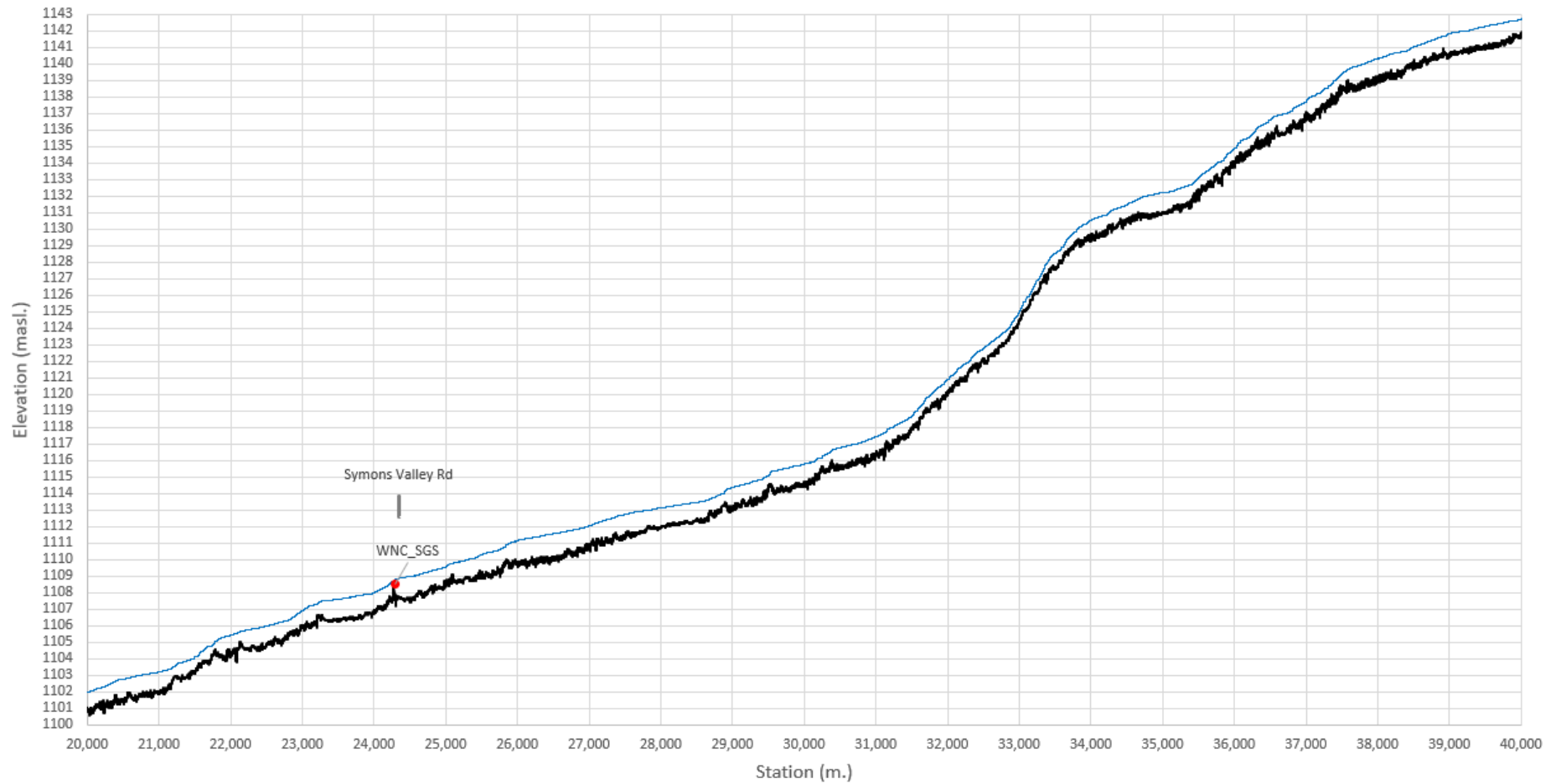
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 MF2 WSEL
 MF2 Observed Water Level
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

West Nose Creek Station 20,000-40,000 m



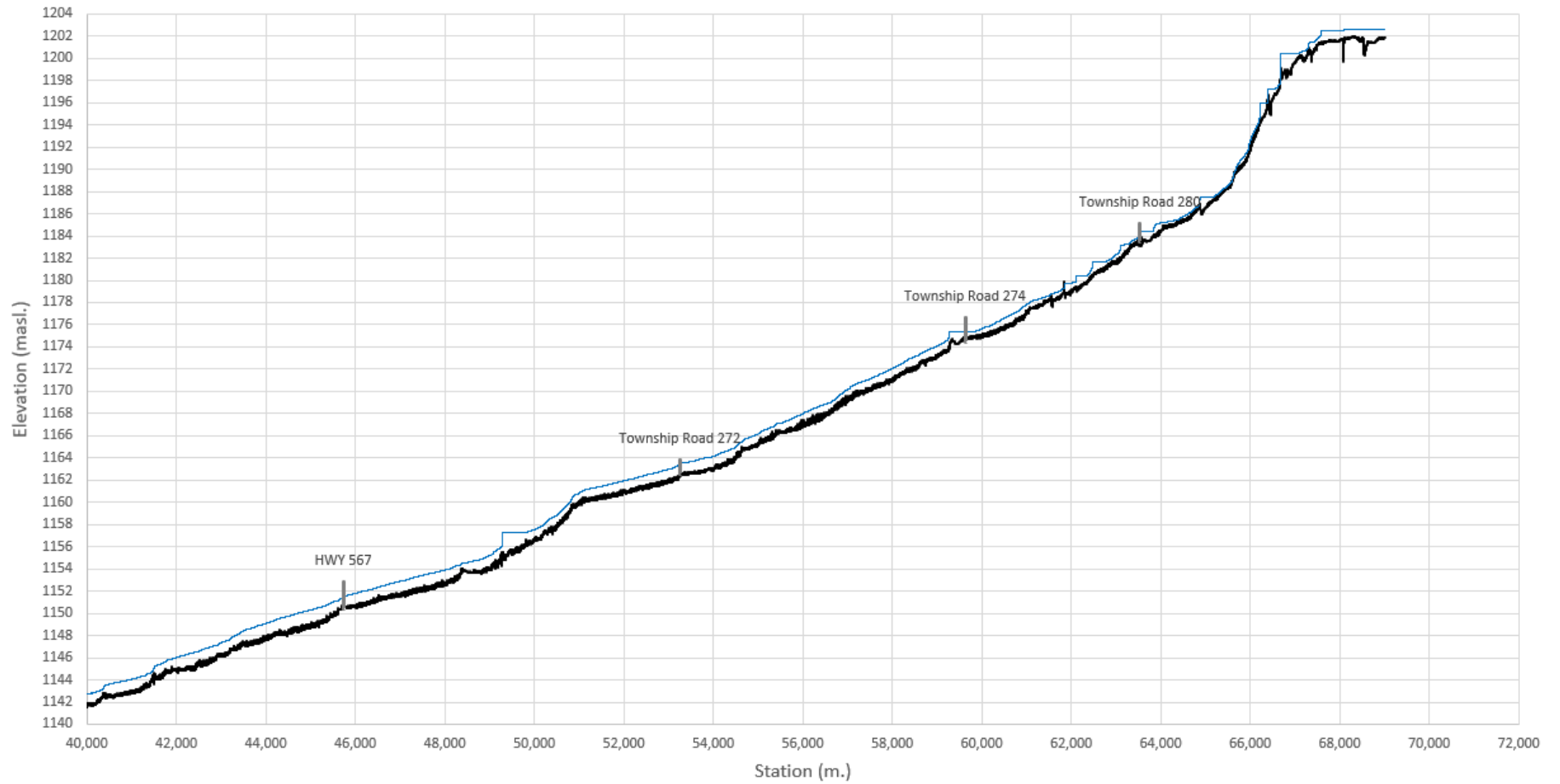
— Channel Centerline Bed — MF2 WSEL ● MF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m

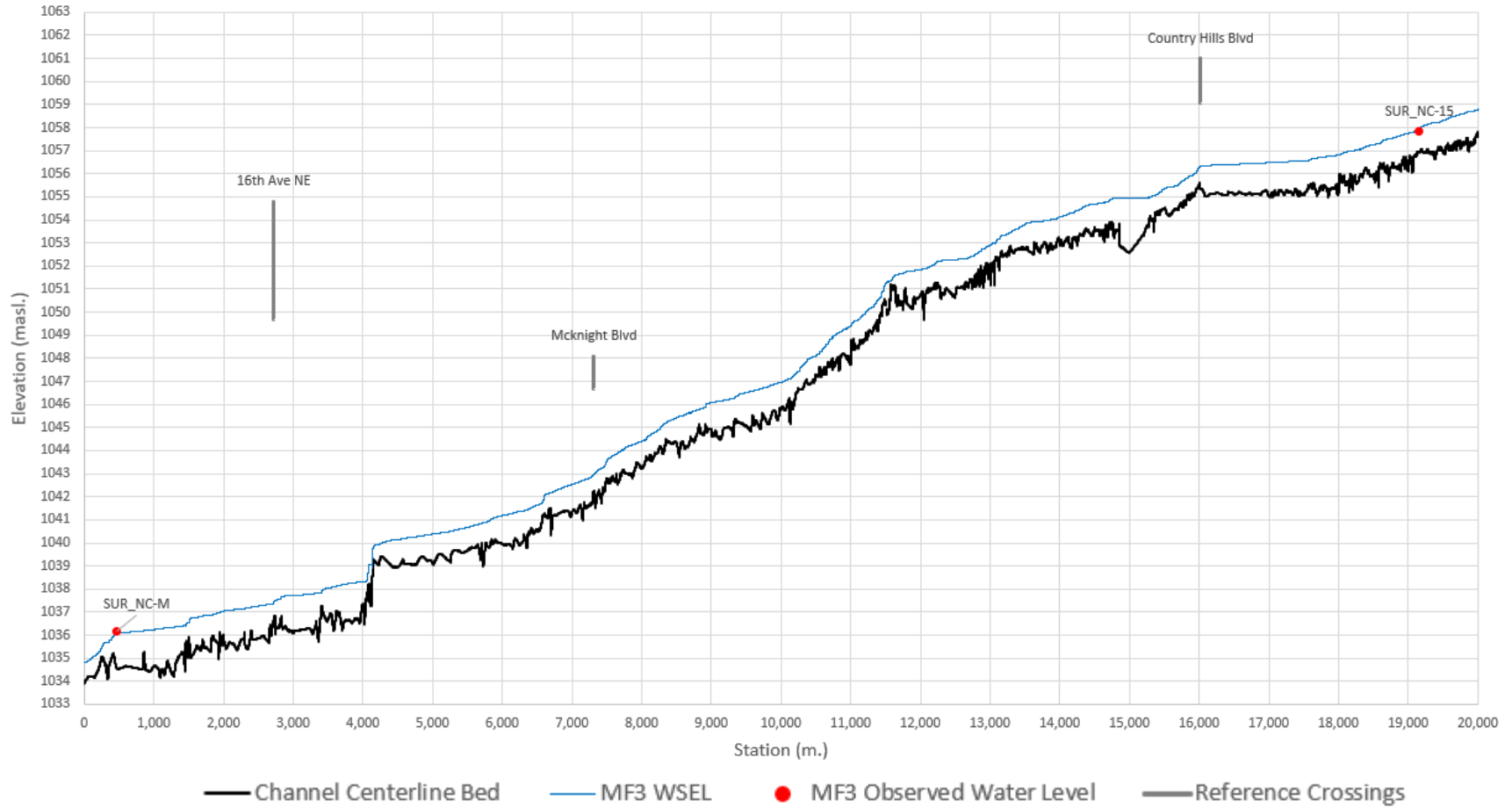


— Channel Centerline Bed — MF2 WSEL ● MF2 Observed Water Level — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

Moderate Flow 3 Calibration Event Simulated Water Level Profiles

Nose Creek Station 0-20,000 m

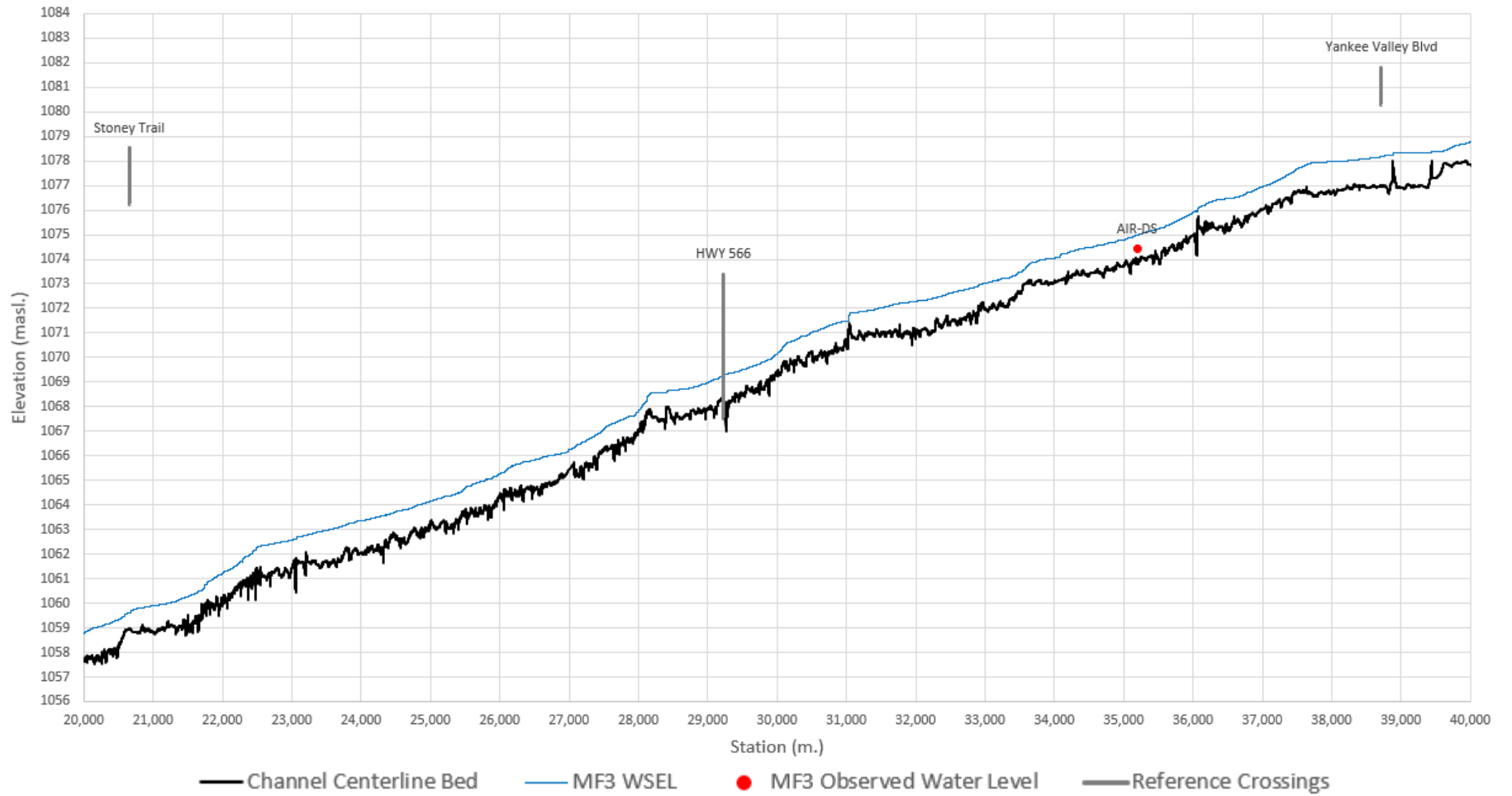


Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

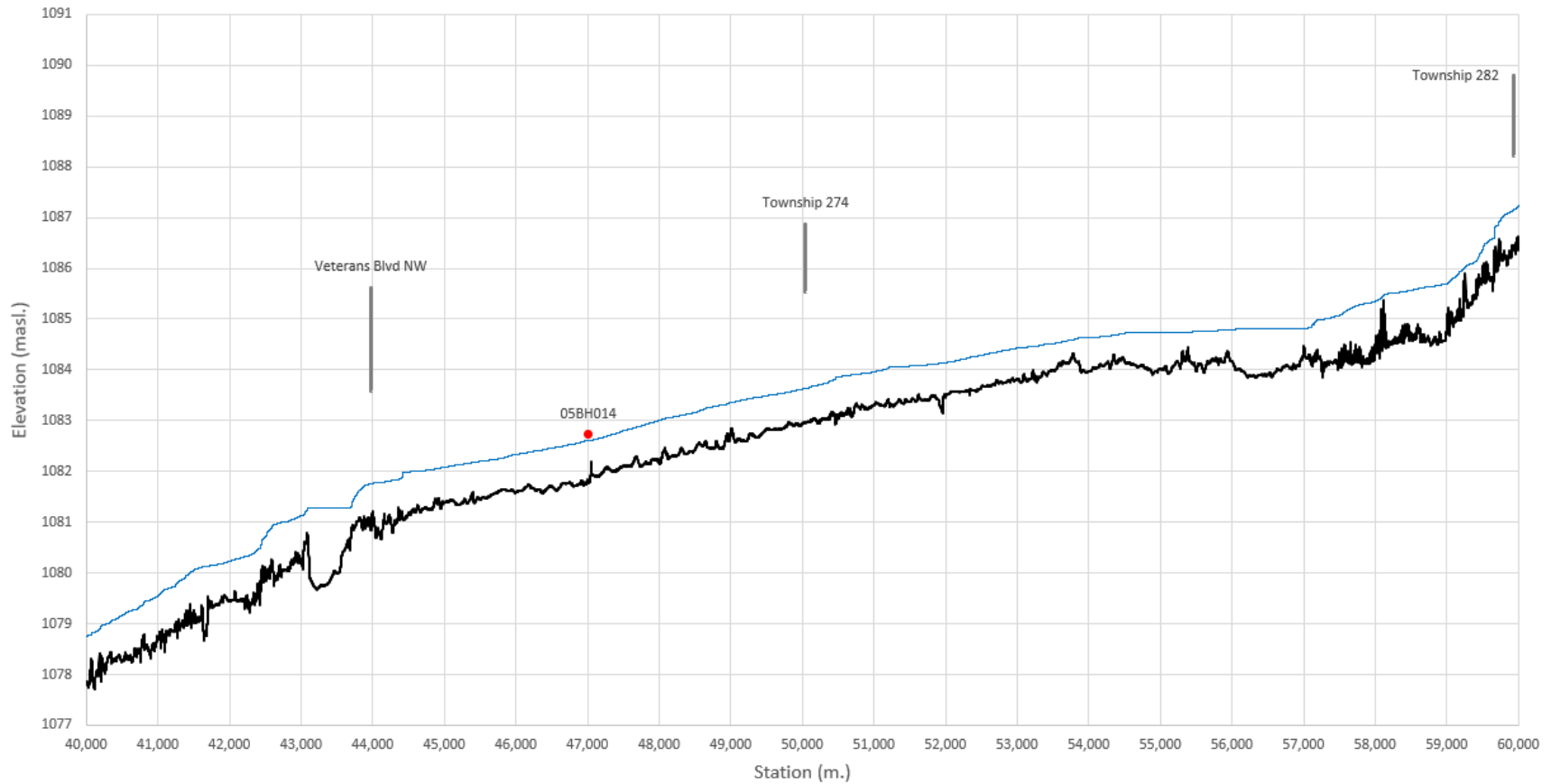
Culverts are represented by the obvert and invert.

Nose Creek Station 20,000-40,000 m



Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

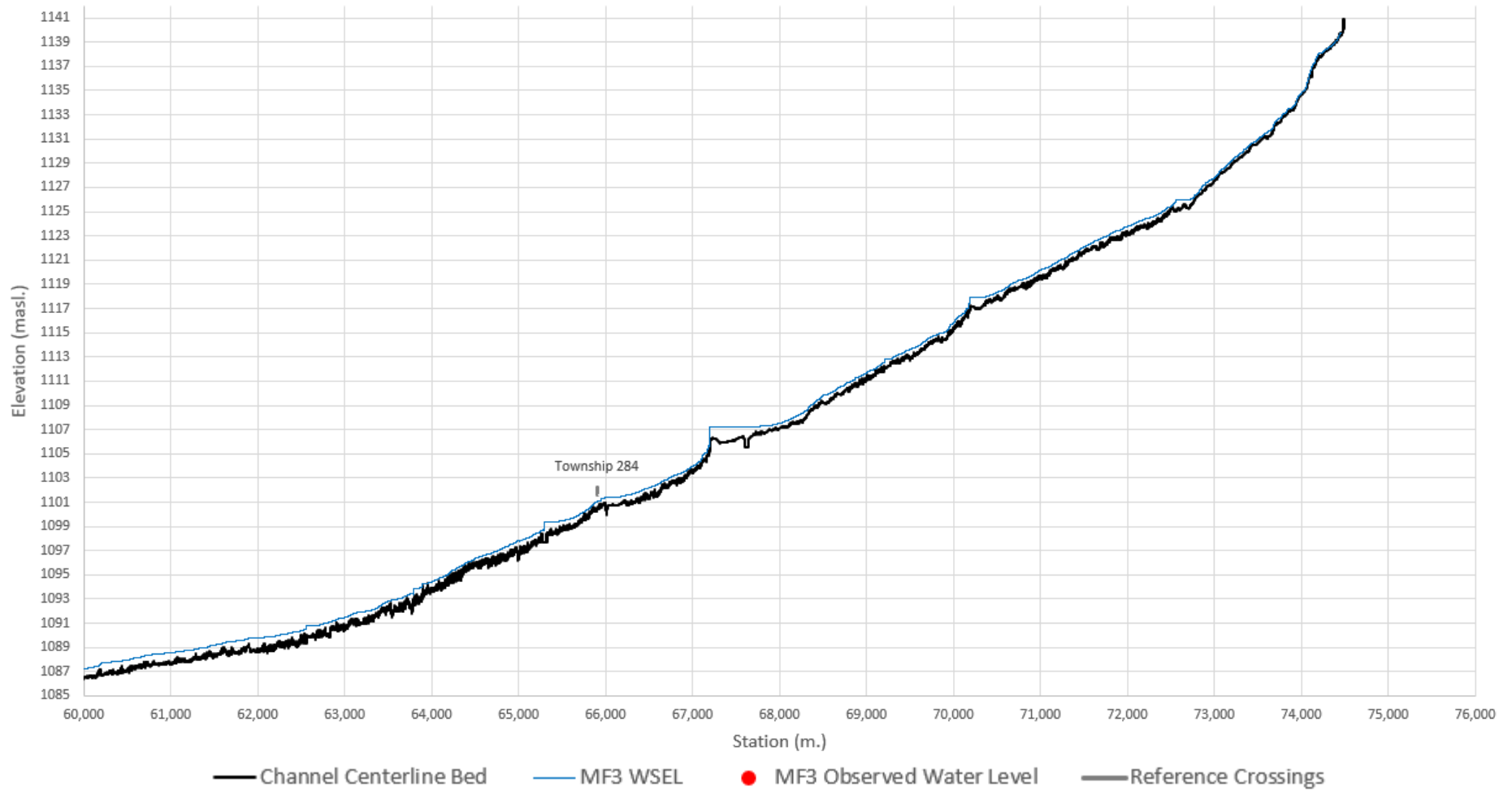
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — MF3 WSEL ● MF3 Observed Water Level — Reference Crossings

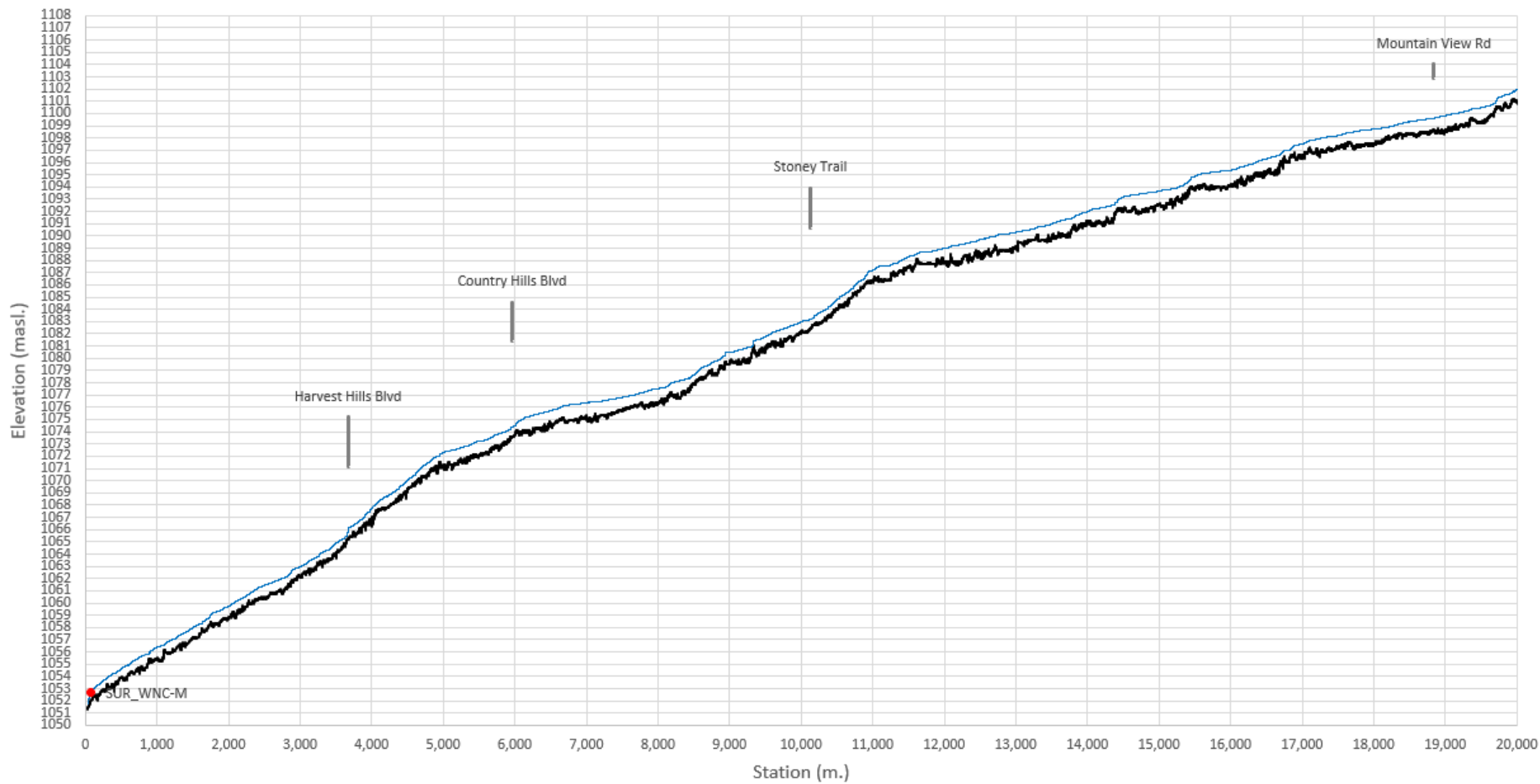
Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

Nose Creek Station 60,000-76,000 m



Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

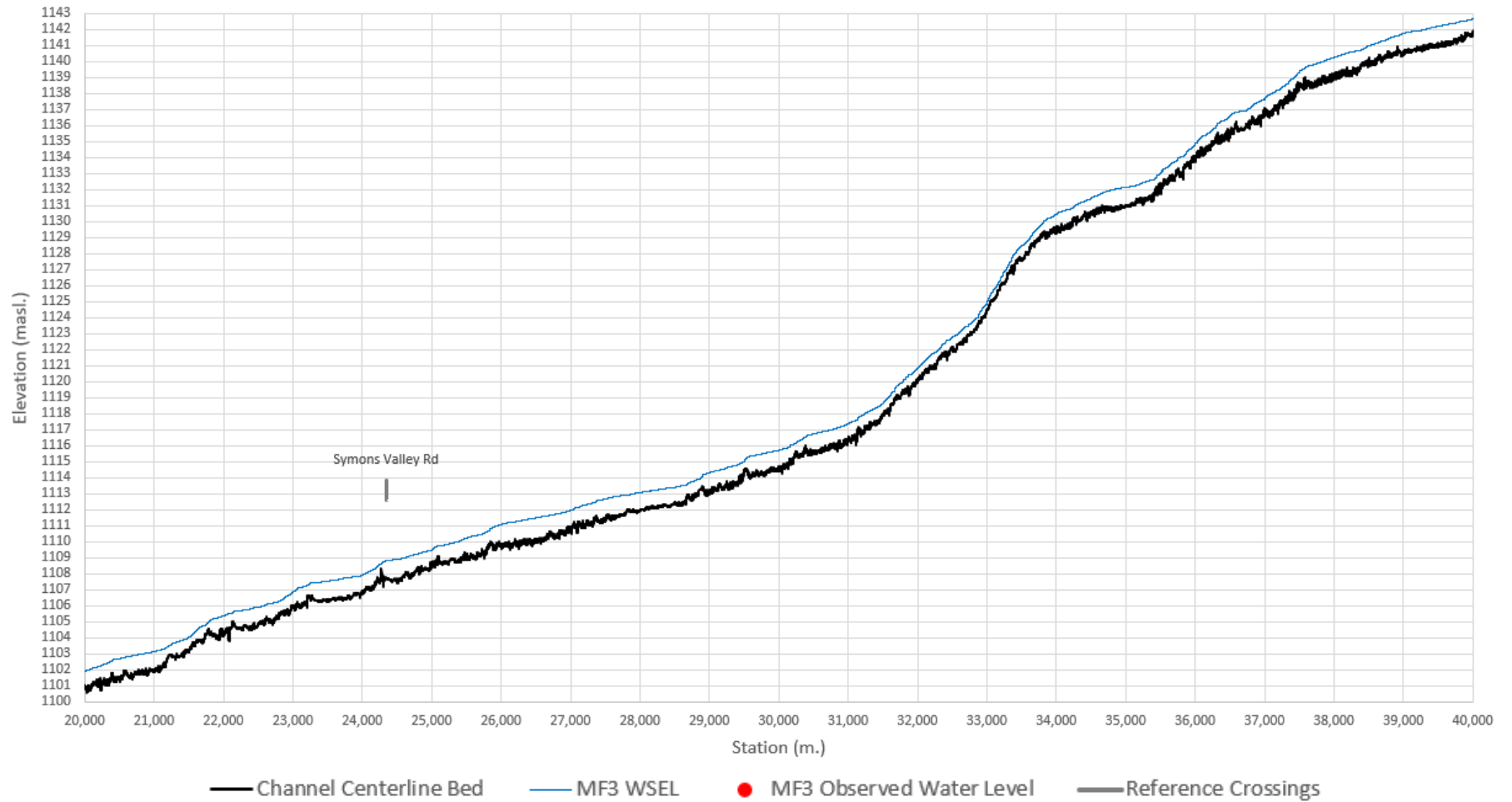
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 MF3 WSEL
 MF3 Observed Water Level
 Reference Crossings

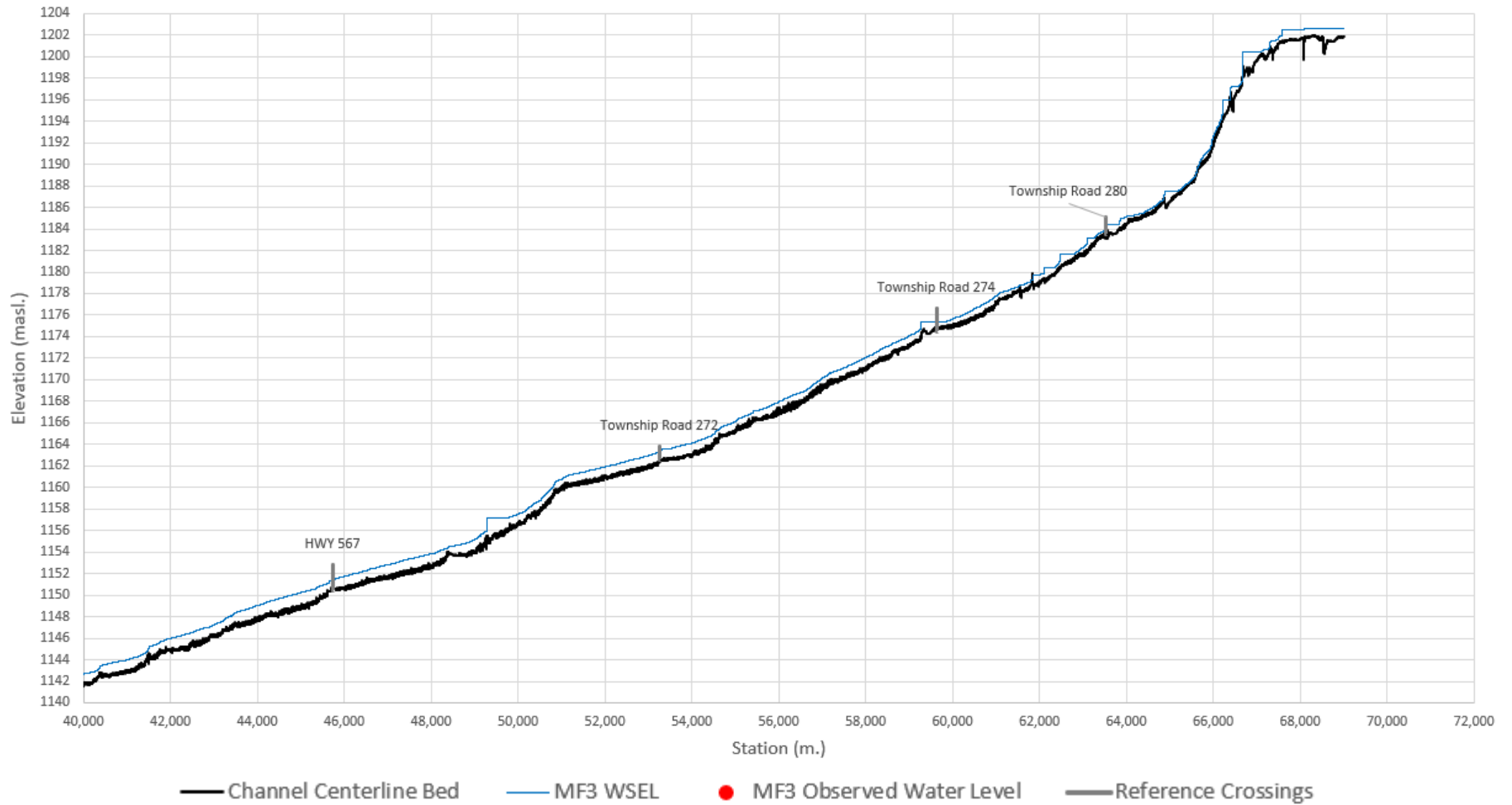
Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

West Nose Creek Station 20,000-40,000 m



Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m



Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

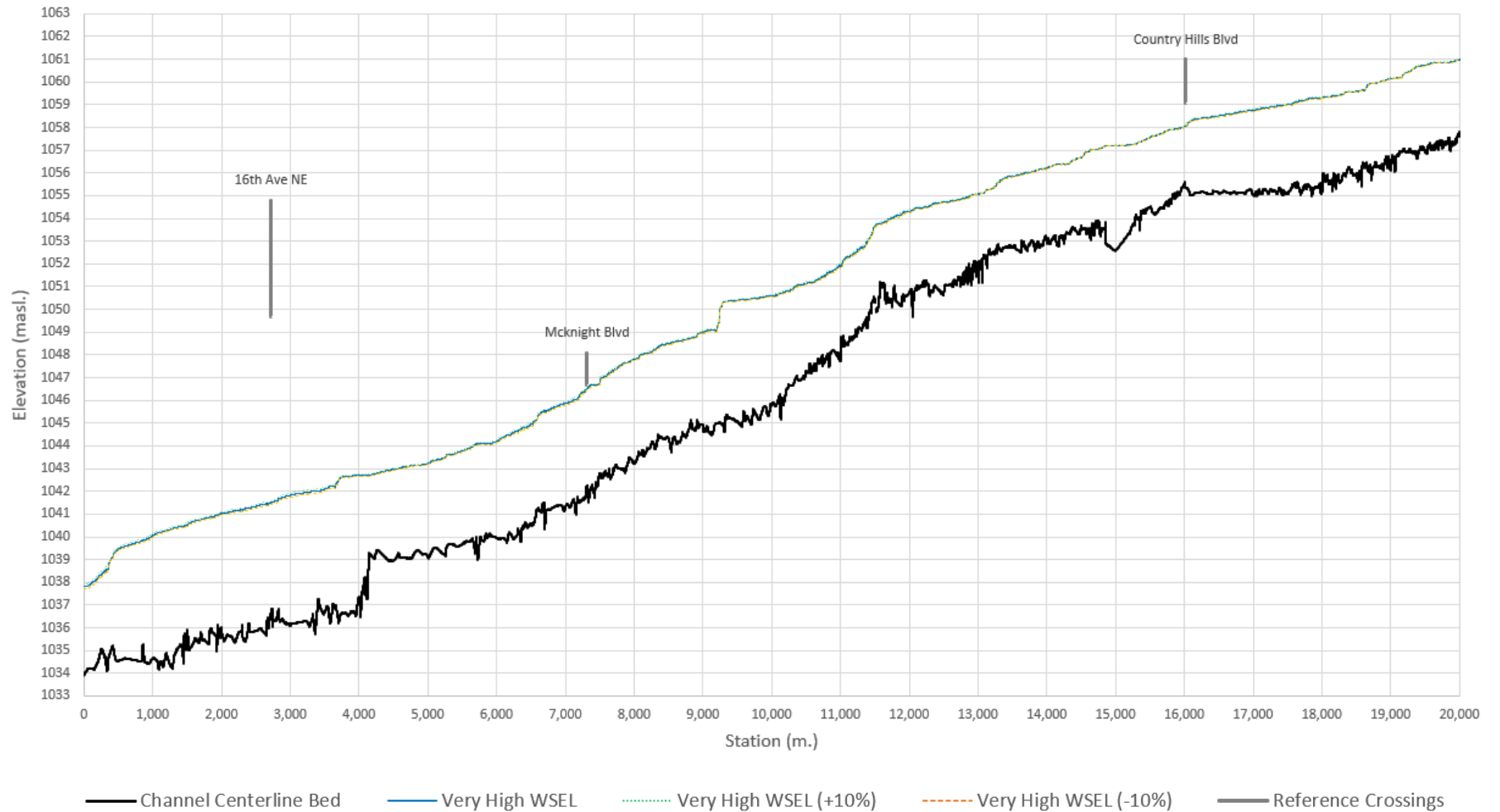
Culverts are represented by the obvert and invert.

Appendix F

Sensitivity Scenario Simulated Channel Profiles

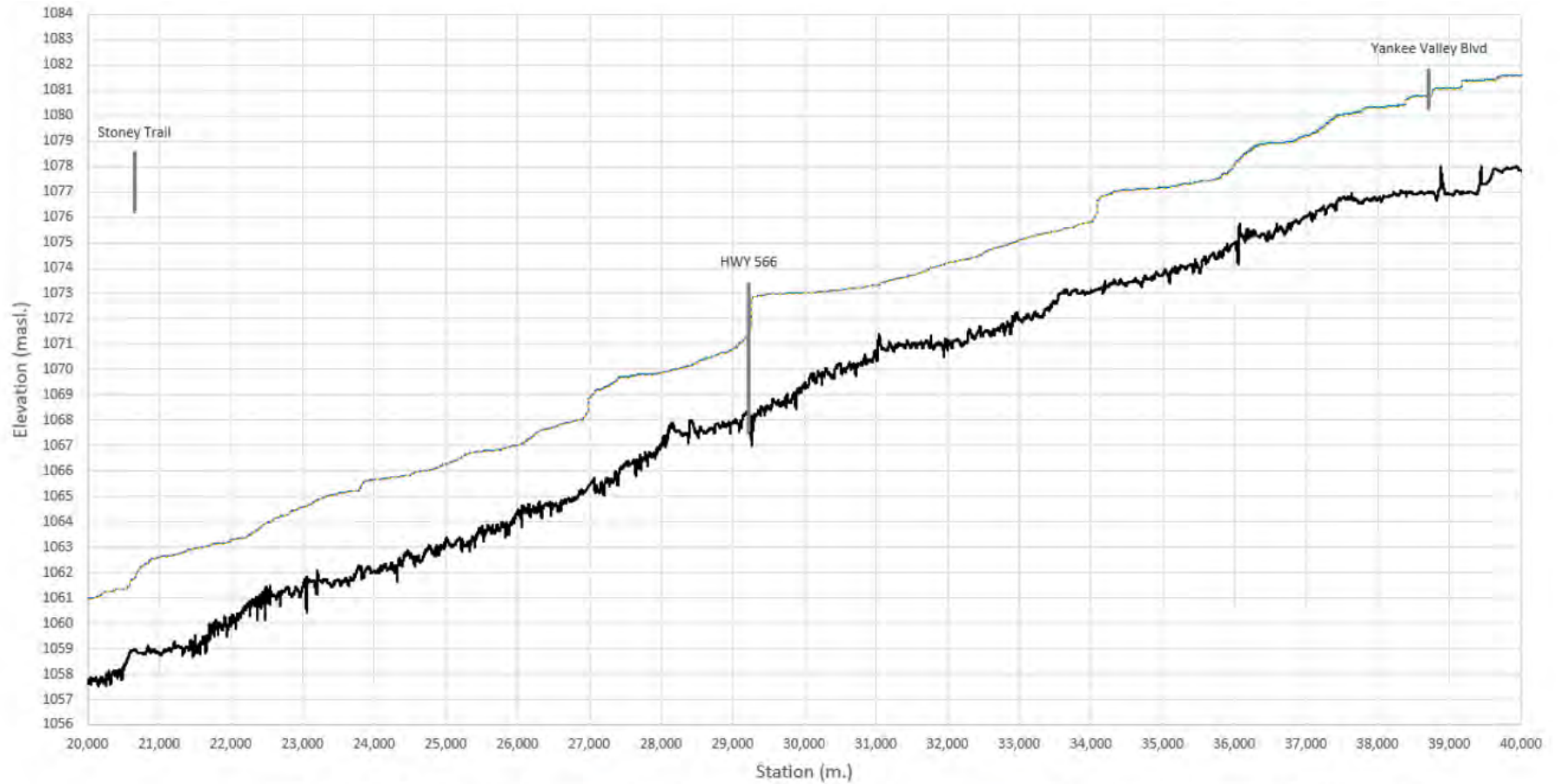
Sensitivity Channel Roughness +/-10% Simulated Water Level Profiles

Nose Creek Station 0-20,000 m



Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

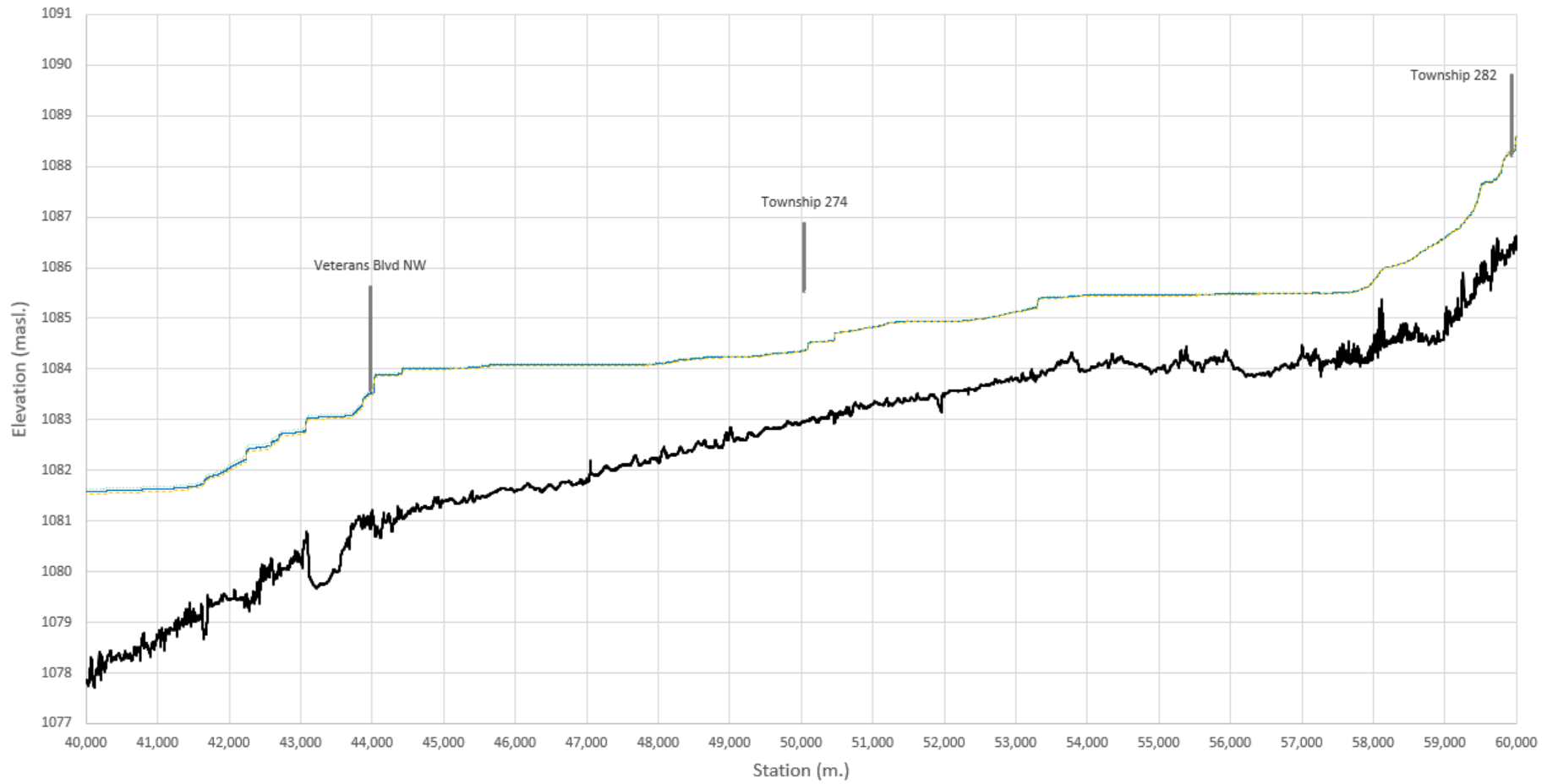
Nose Creek Station 20,000-40,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

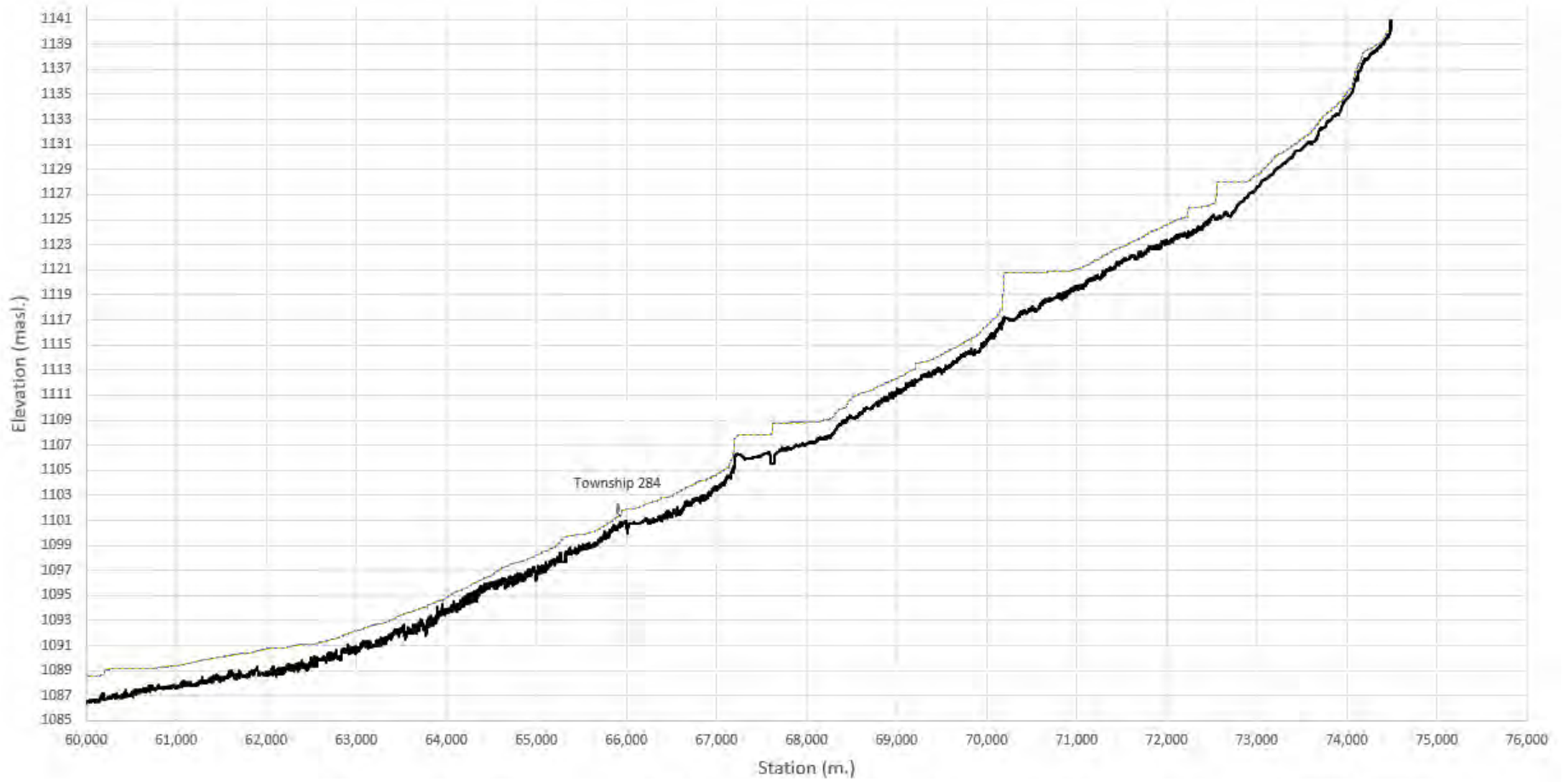
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — Very High WSEL Very High WSEL (+10%) - - - Very High WSEL (-10%) — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

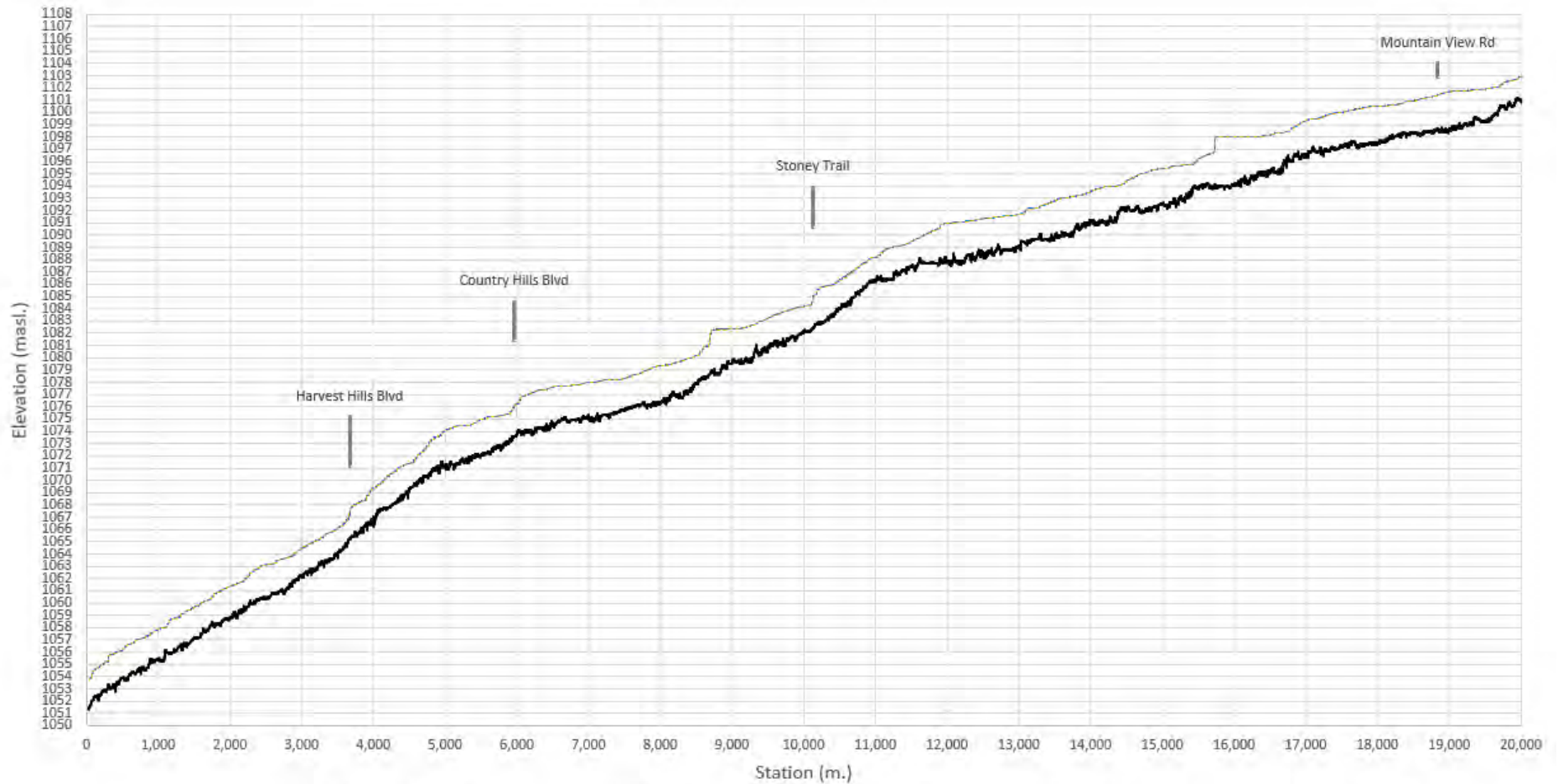
Nose Creek Station 60,000-76,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

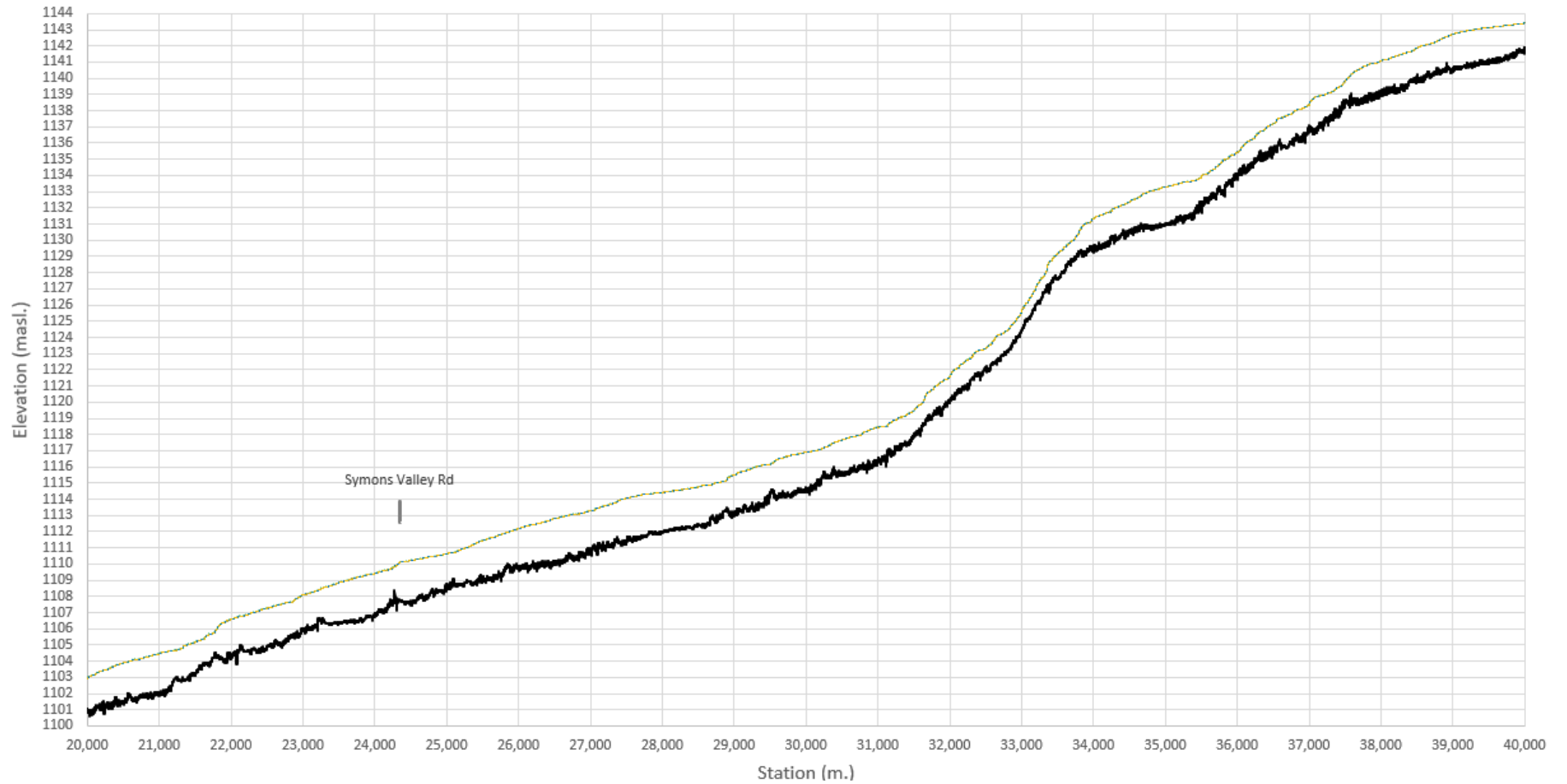
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

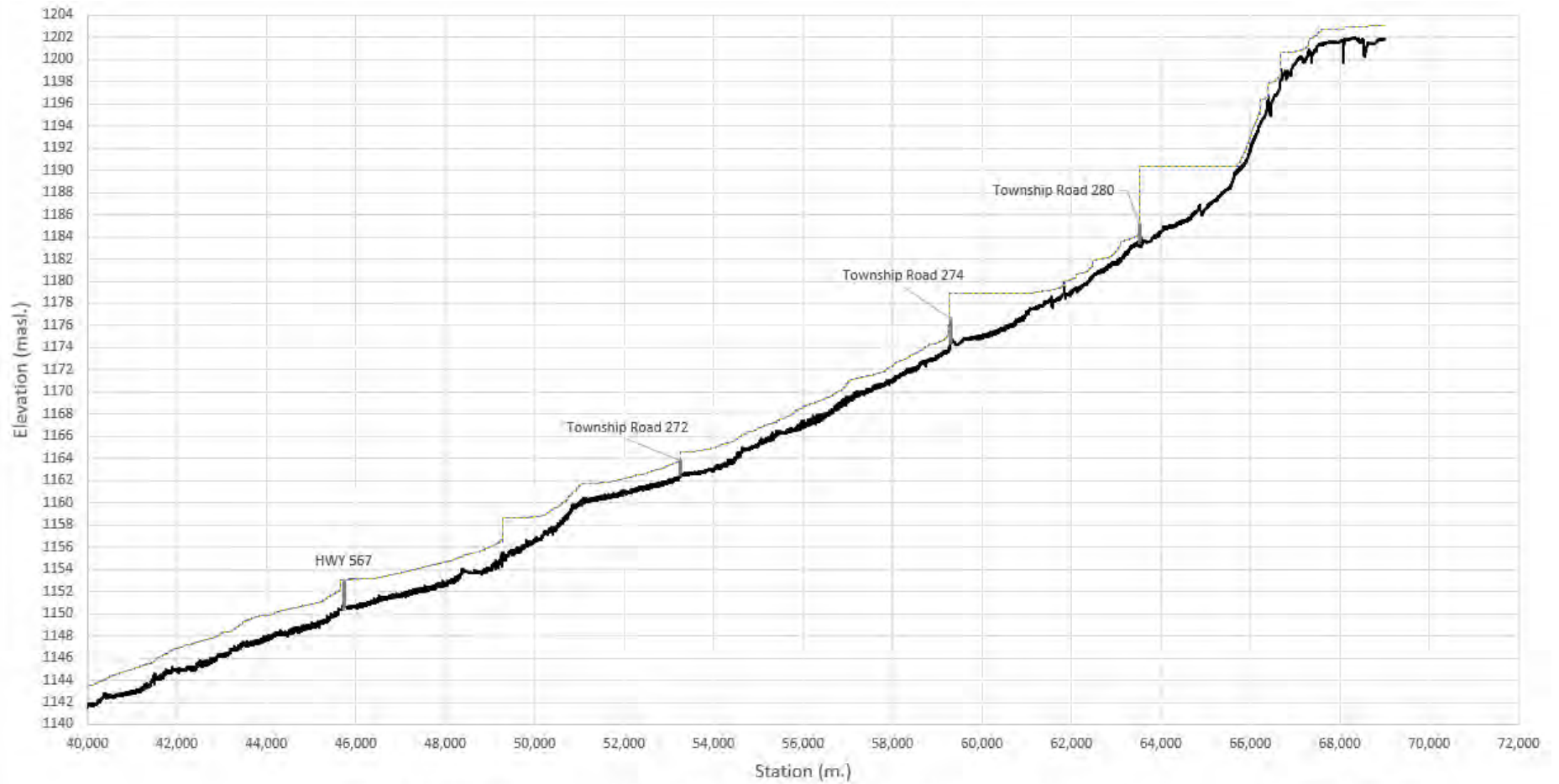
West Nose Creek Station 20,000-40,000 m



— Channel Centerline Bed — Very High WSEL Very High WSEL (+10%) - - - Very High WSEL (-10%) — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-60,000 m

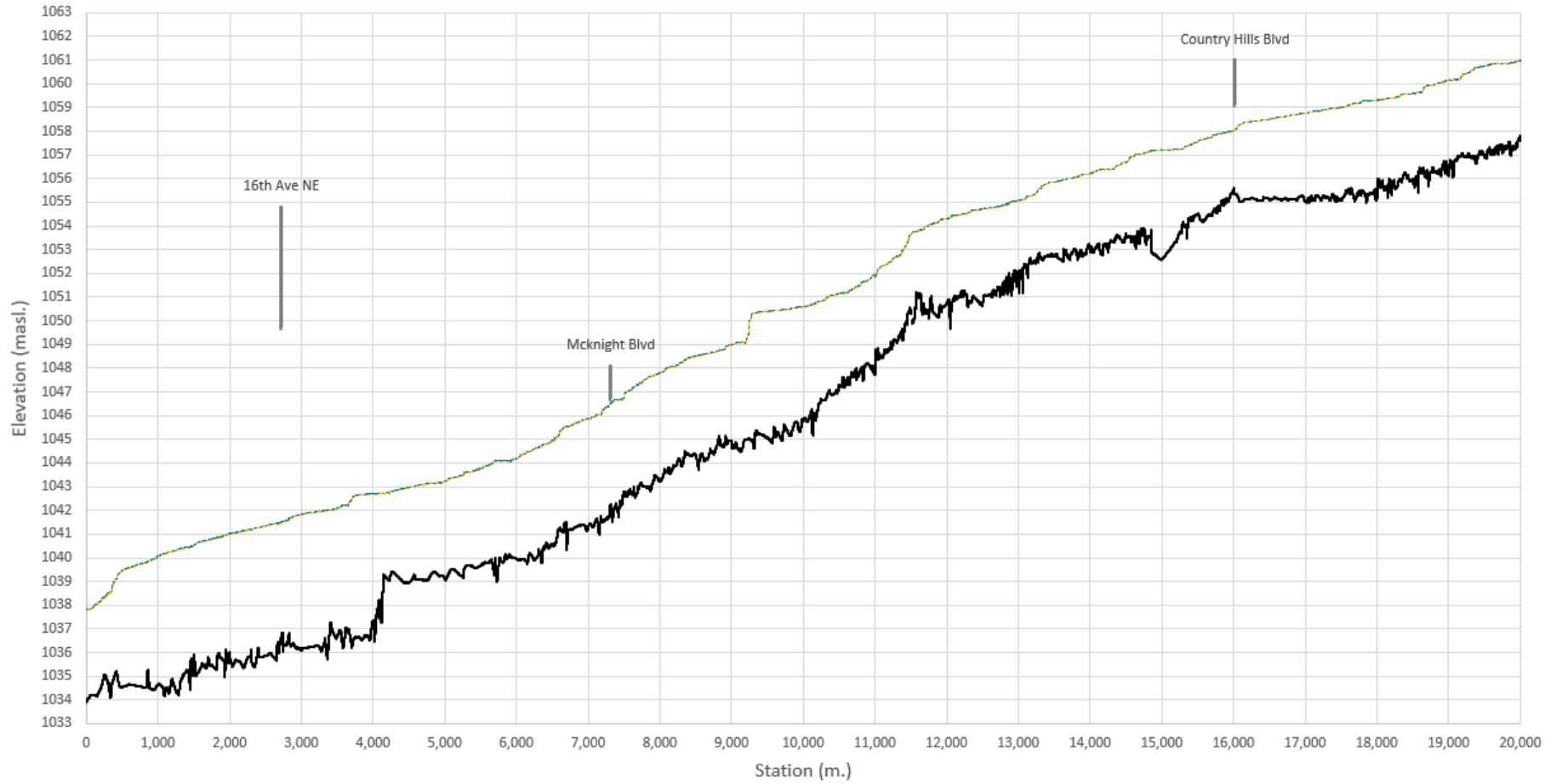


Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

Sensitivity Floodplain Roughness +/- 10% Simulated Water Level Profiles

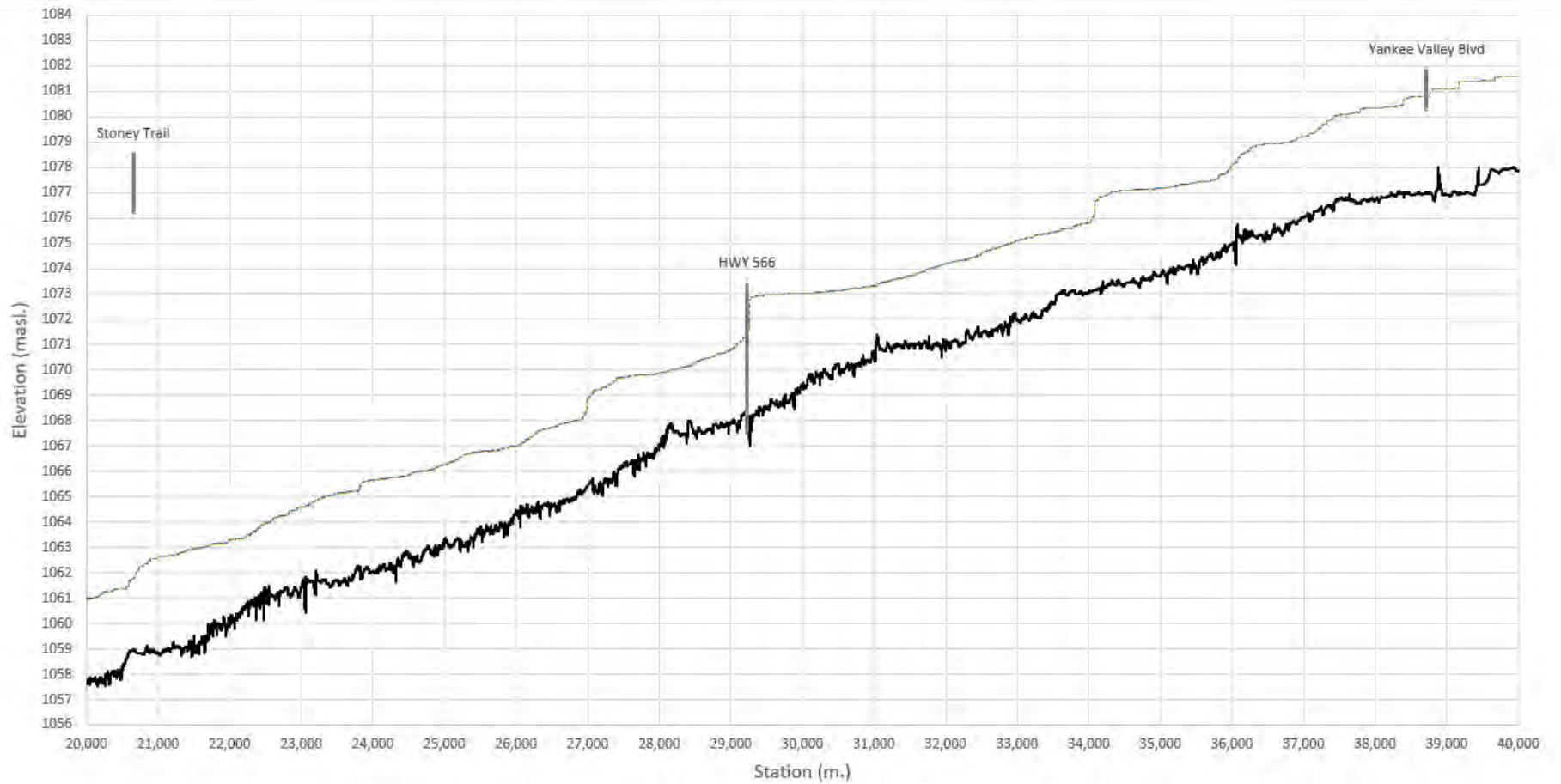
Nose Creek Station 0-20,000 m



— Channel Centerline Bed — Very High WSEL Very High WSEL (+10%) - - - Very High WSEL (-10%) — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

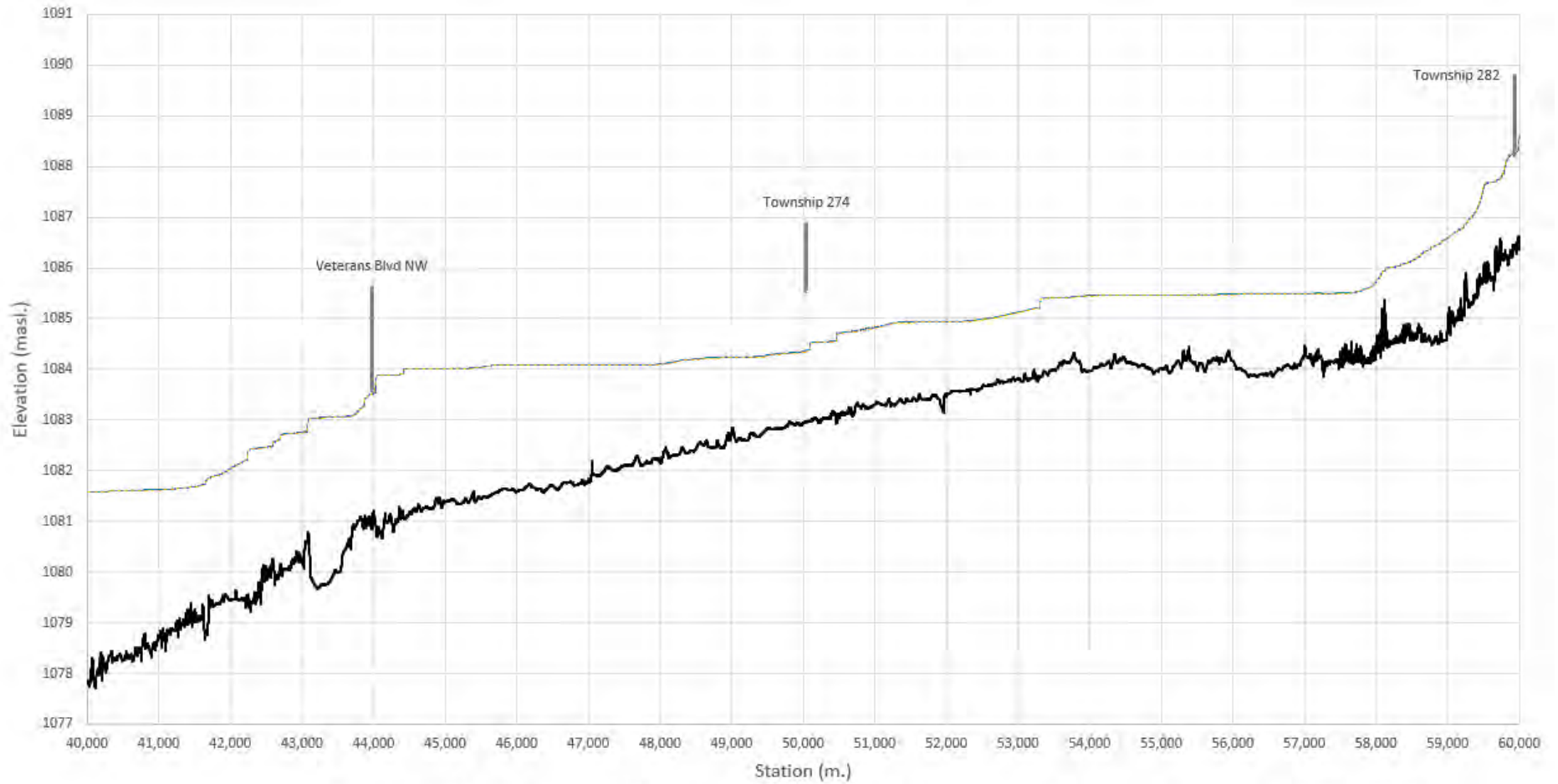
Nose Creek Station 20,000-40,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

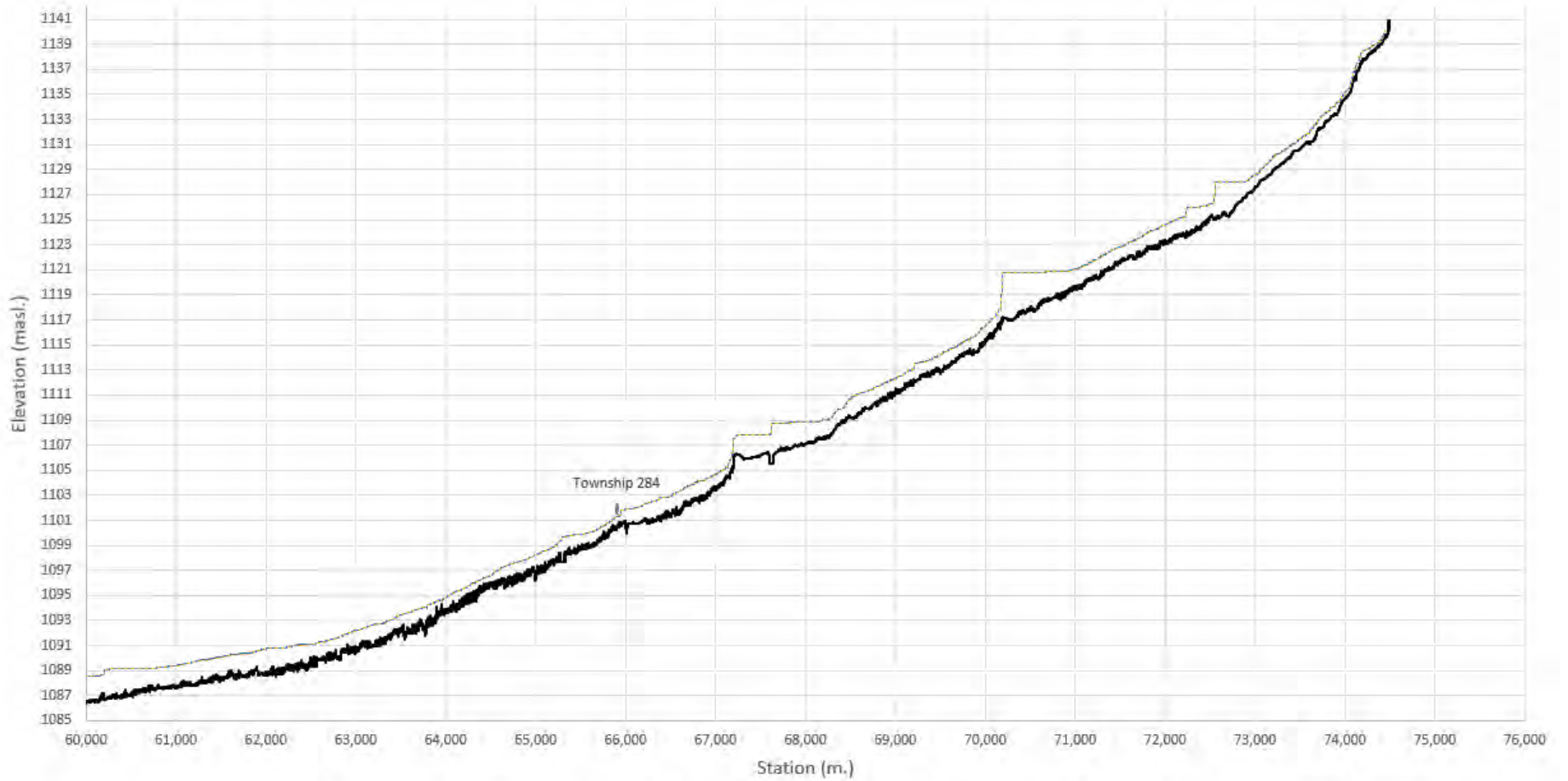
Nose Creek Station 40,000-60,000 m



— Channel Centerline Bed — Very High WSEL Very High WSEL (+10%) - - - Very High WSEL (-10%) — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

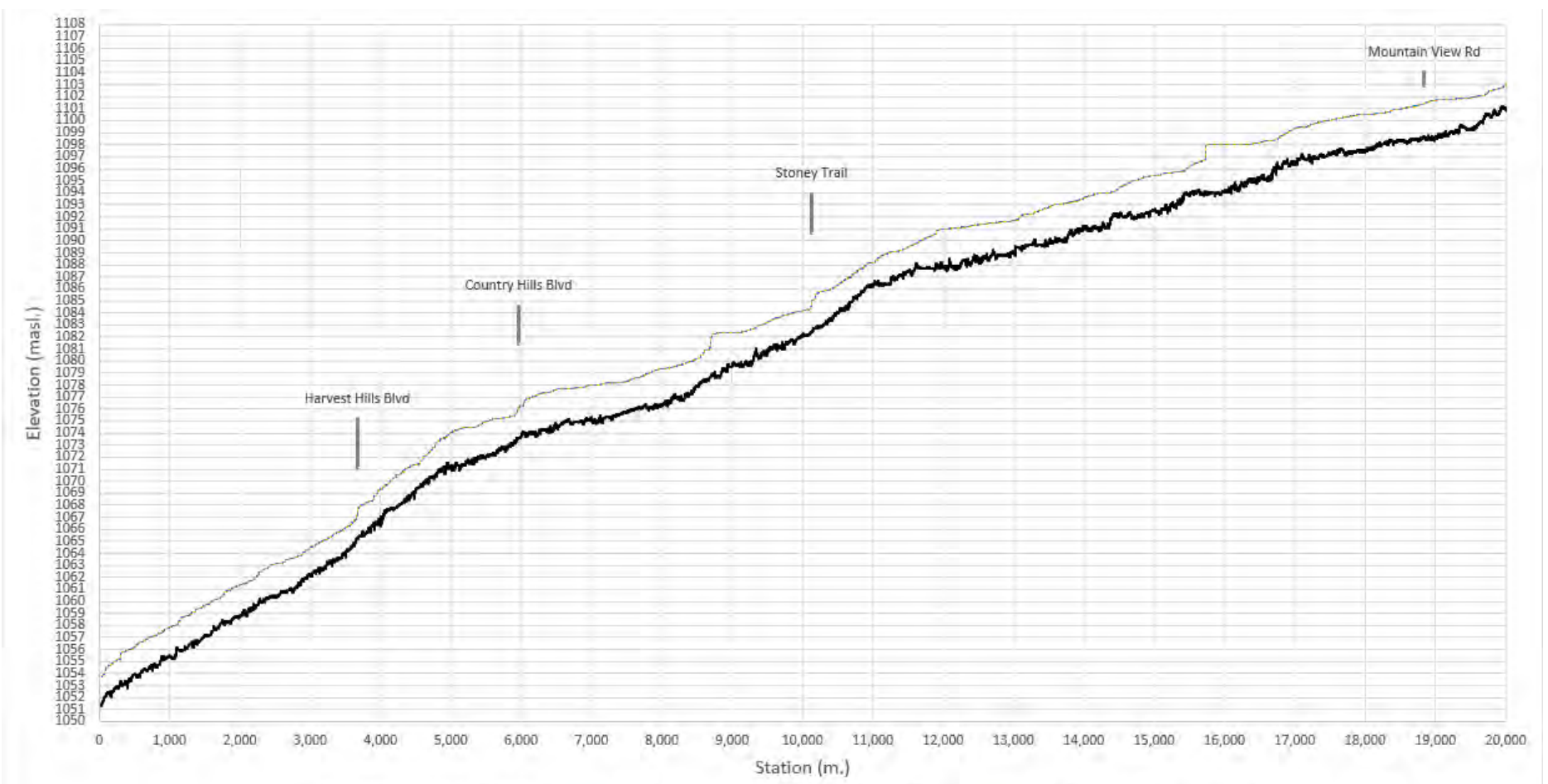
Nose Creek Station 60,000-76,000 m



— Channel Centerline Bed — Very High WSEL Very High WSEL (+10%) - - - Very High WSEL (-10%) — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

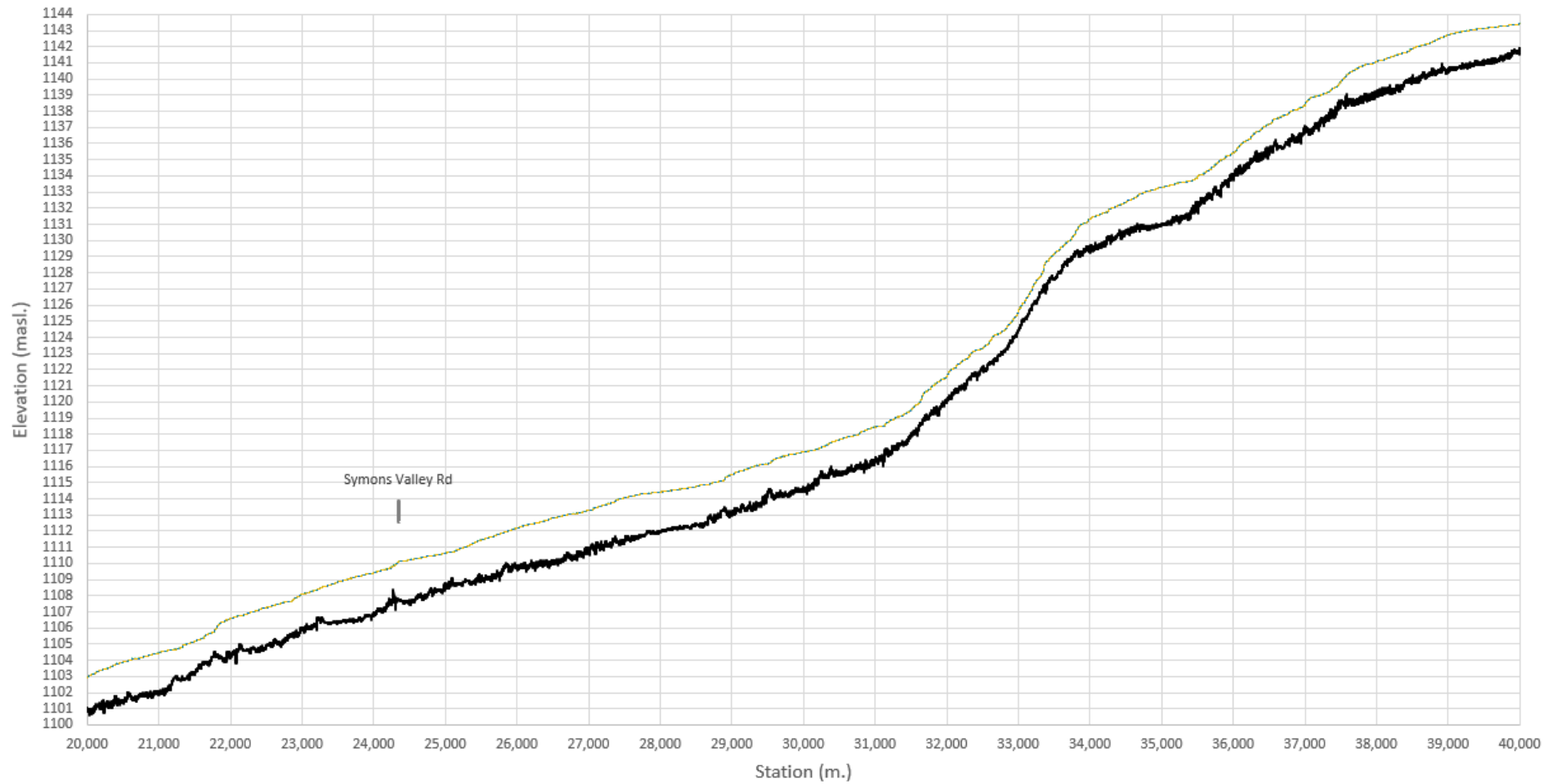
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

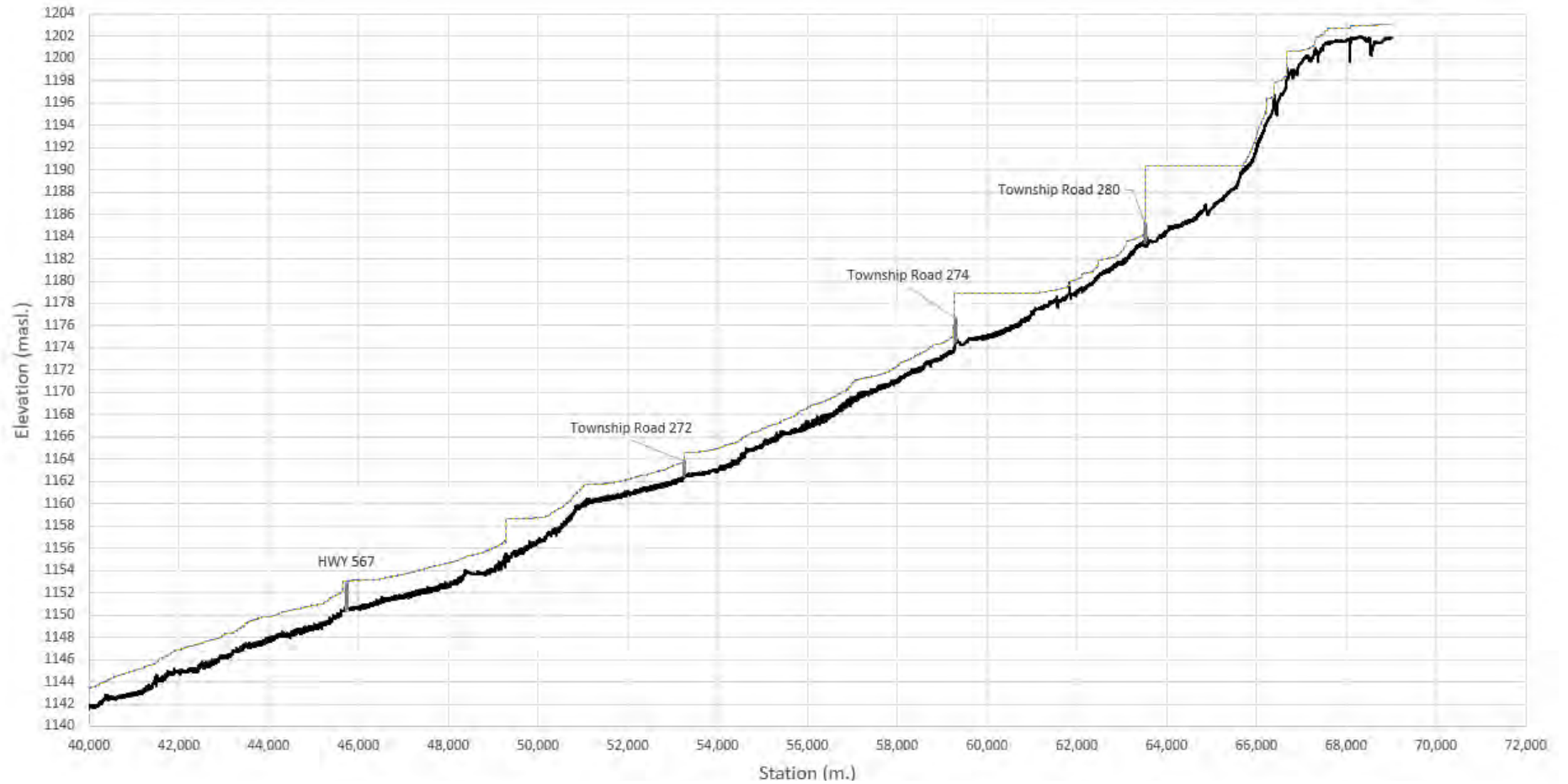
West Nose Creek Station 20,000-40,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m

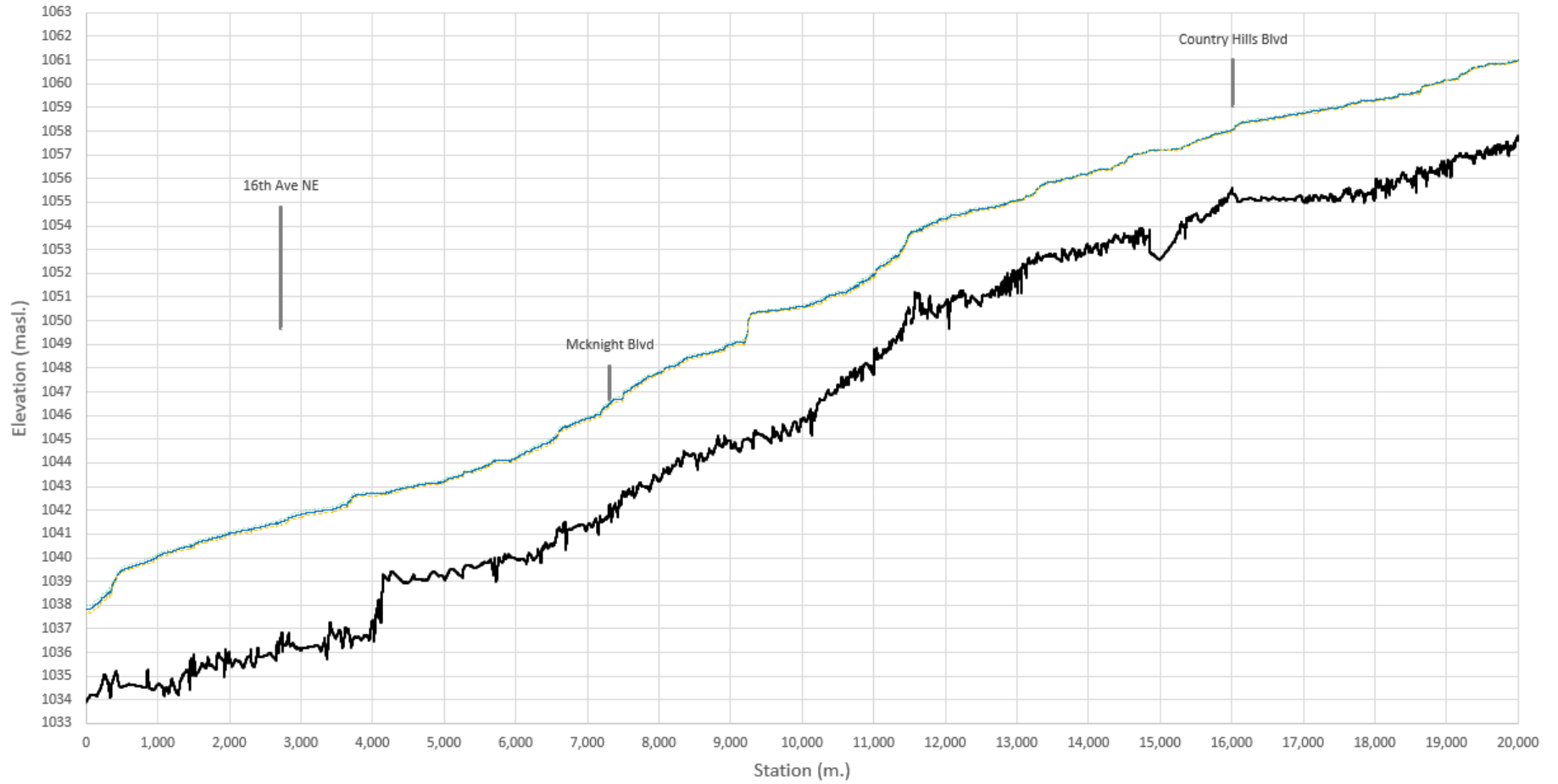


Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

Sensitivity Channel and Floodplain Roughness +/- 10% Simulated Water Level Profiles

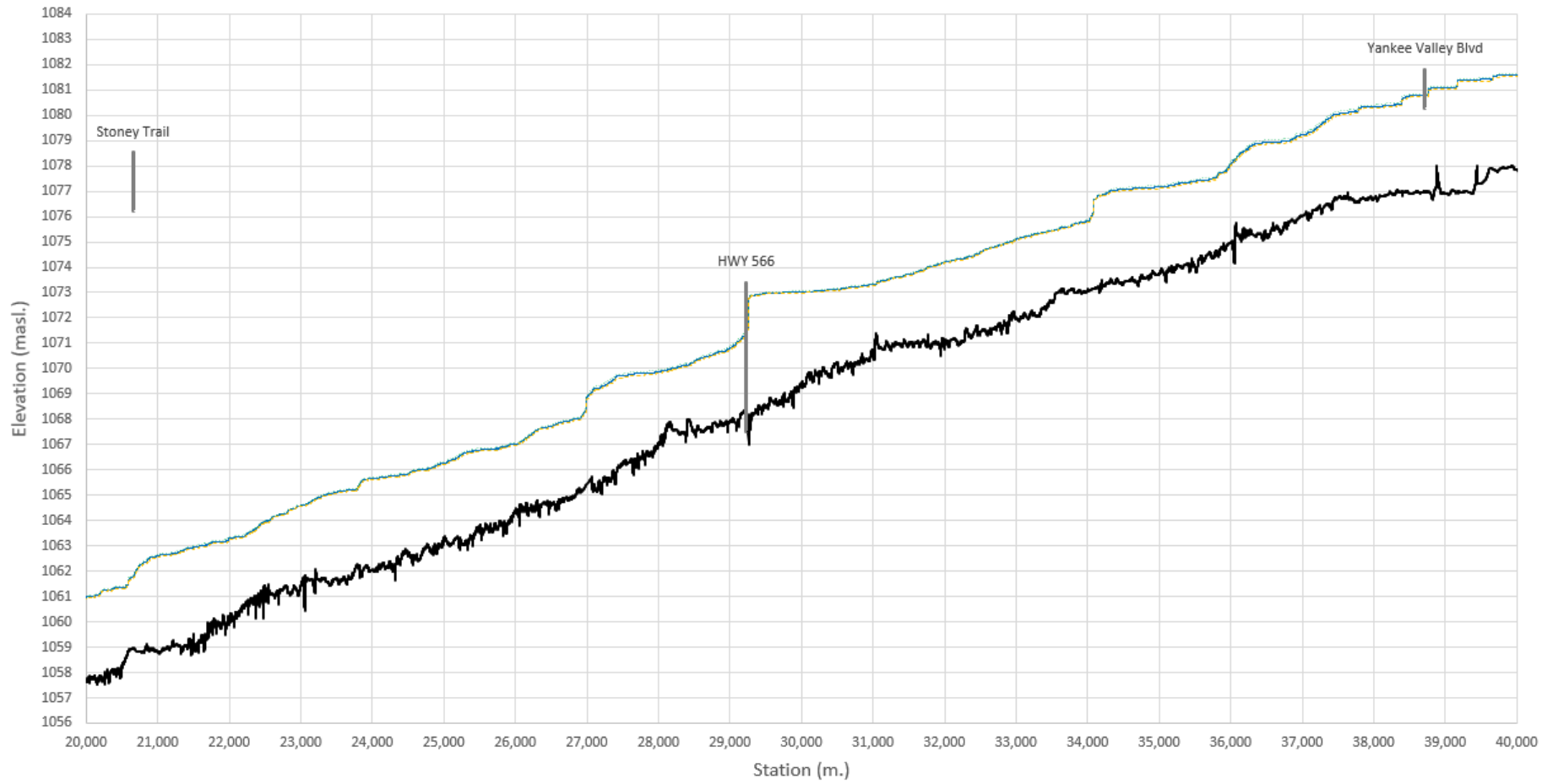
Nose Creek Station 0-20,000 m



— Channel Centerline Bed — Very High WSEL Very High WSEL (+10%) - - - Very High WSEL (-10%) — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

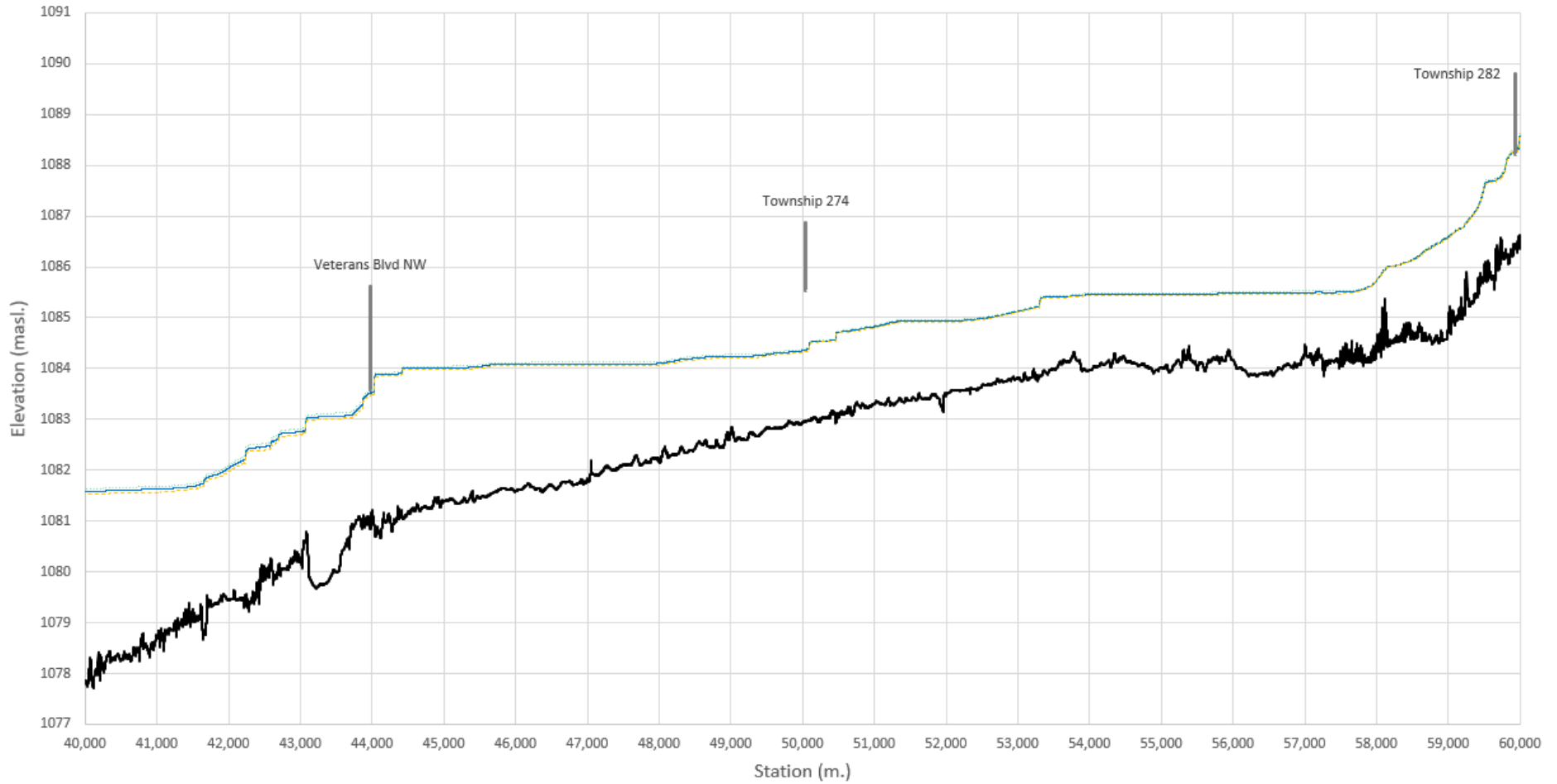
Nose Creek Station 20,000-40,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

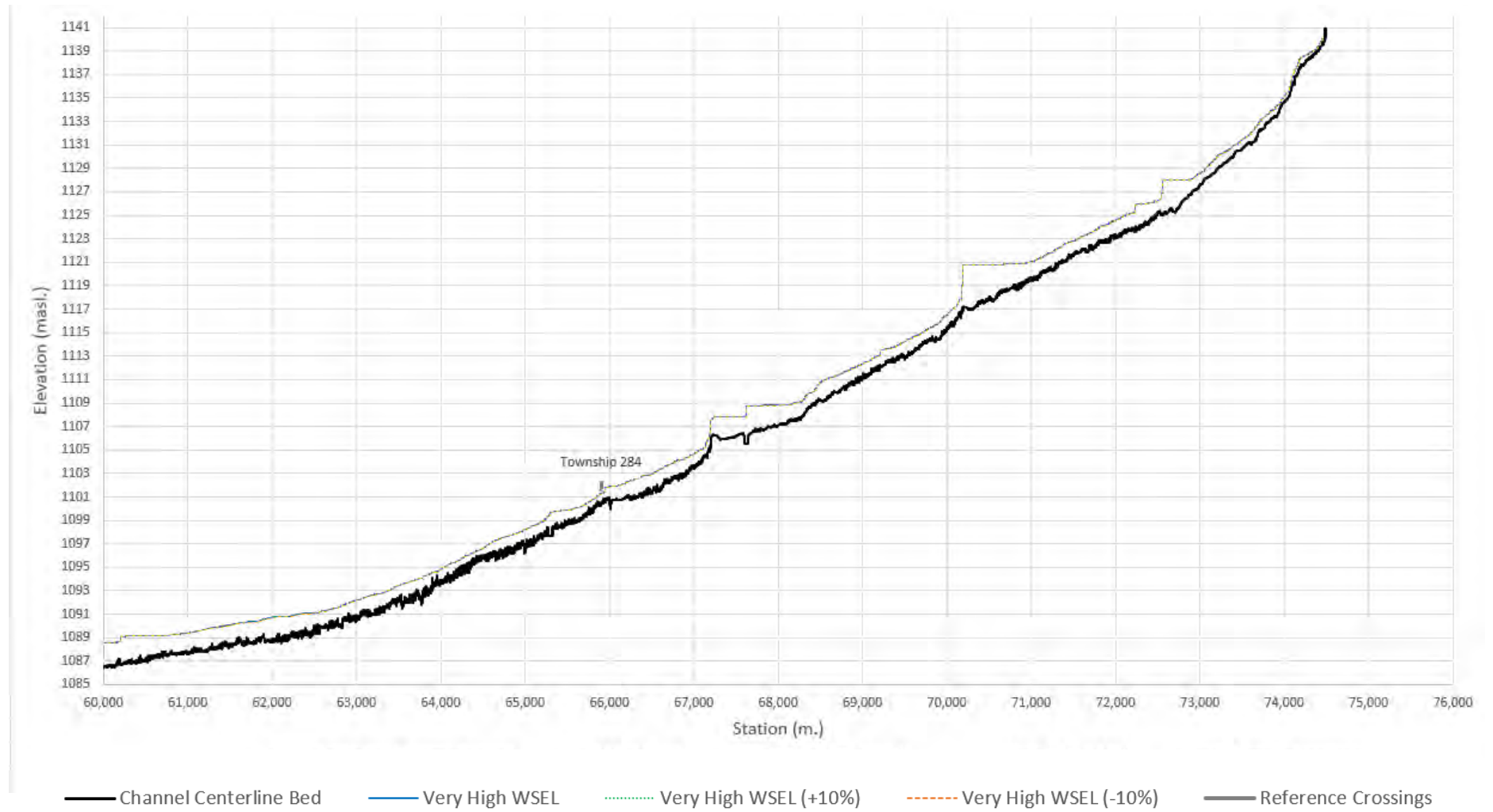
Nose Creek Station 40,000-60,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

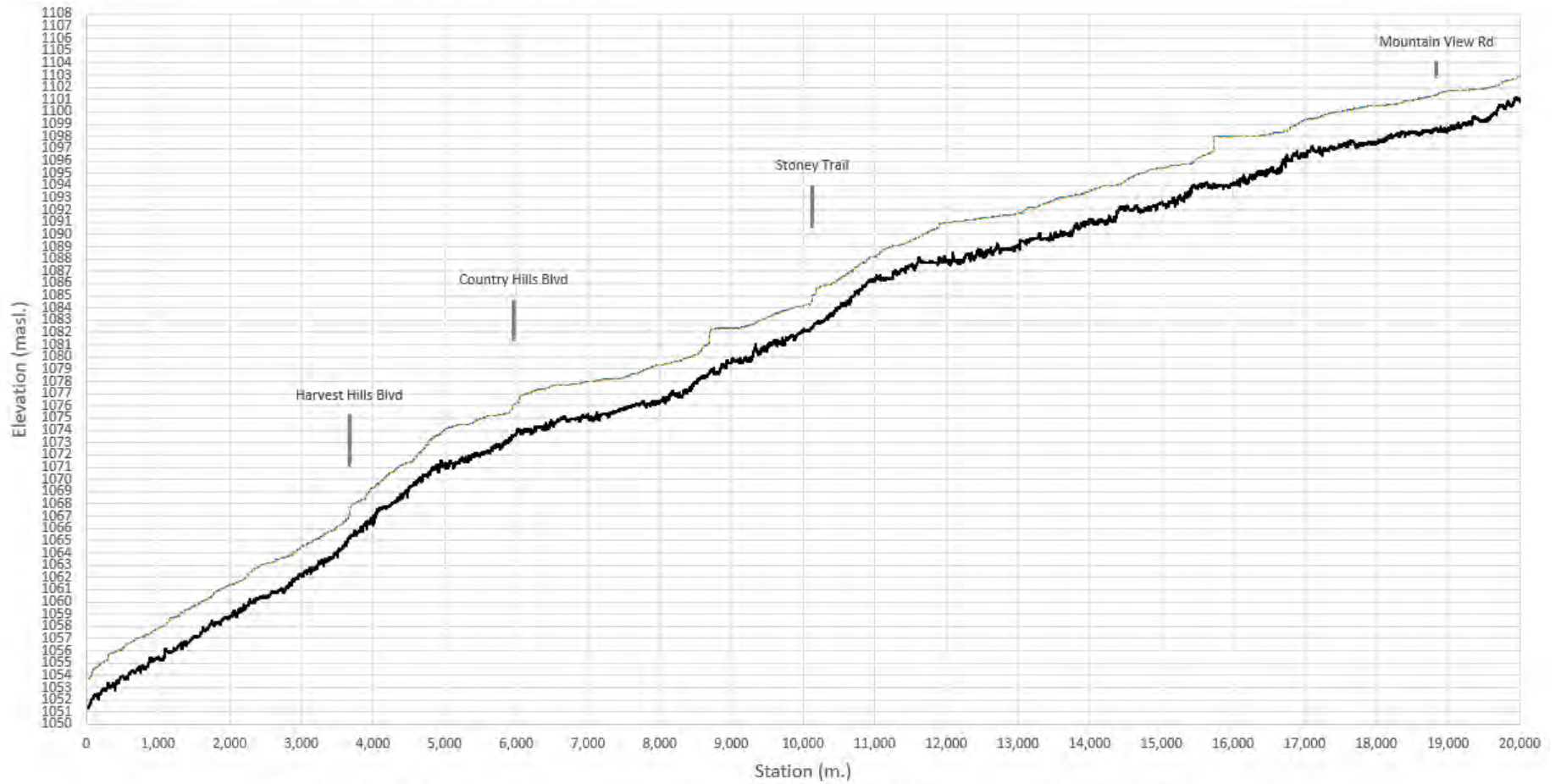
Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

Nose Creek Station 60,000-76,000 m



Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

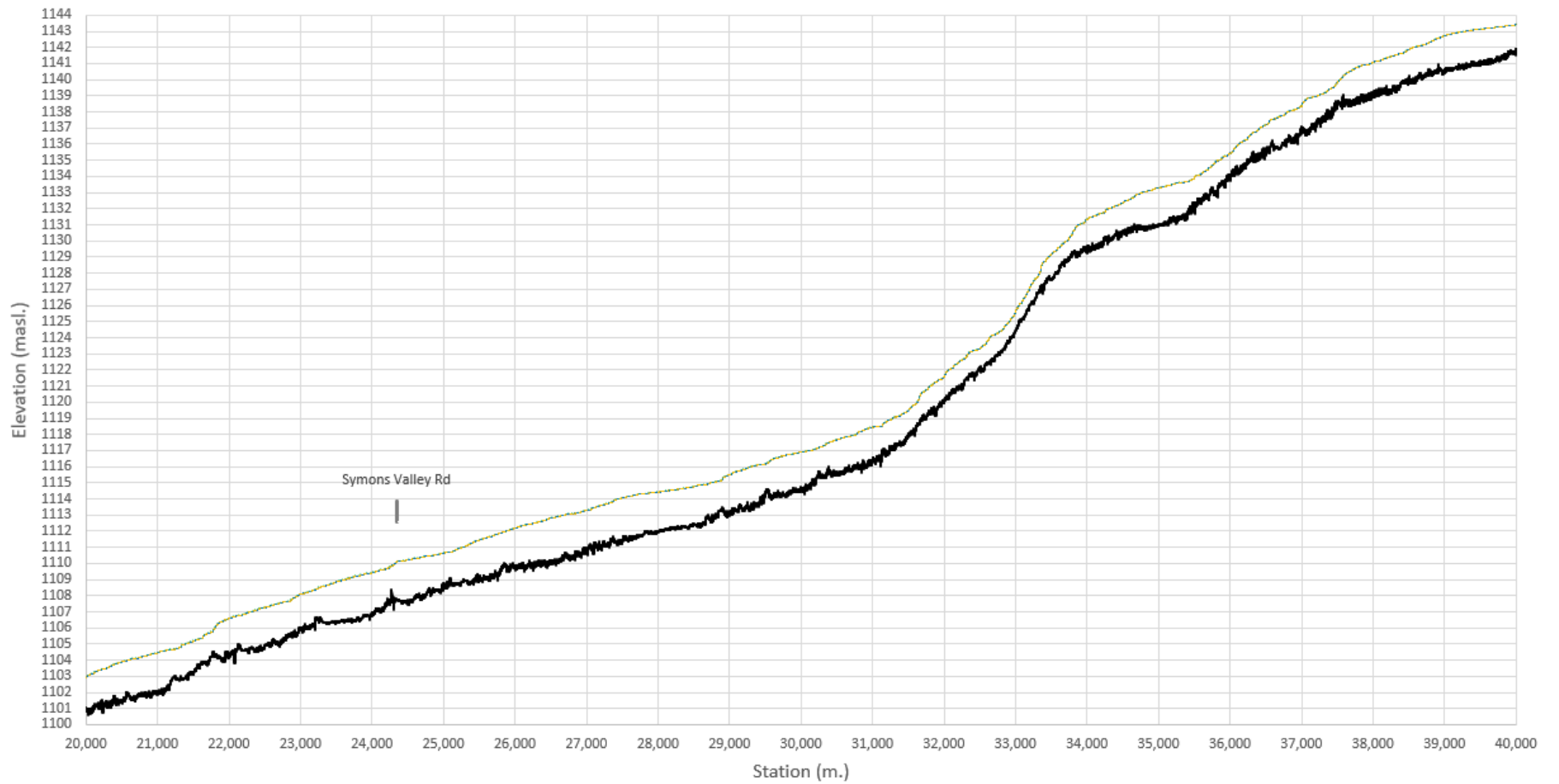
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

West Nose Creek Station 20,000-40,000 m



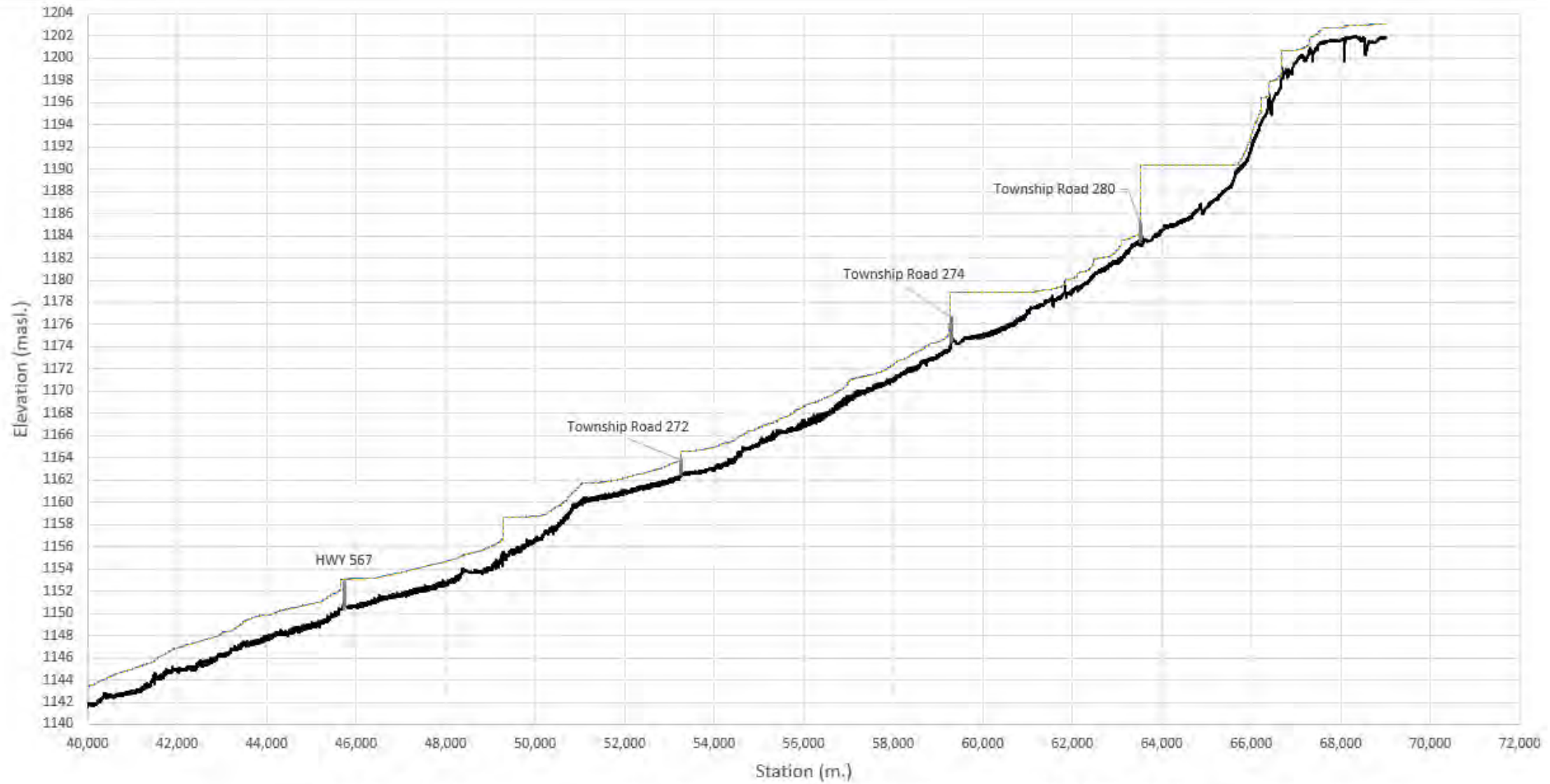
Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-76,000 m



Channel Centerline Bed
 Very High WSEL
 Very High WSEL (+10%)
 Very High WSEL (-10%)
 Reference Crossings

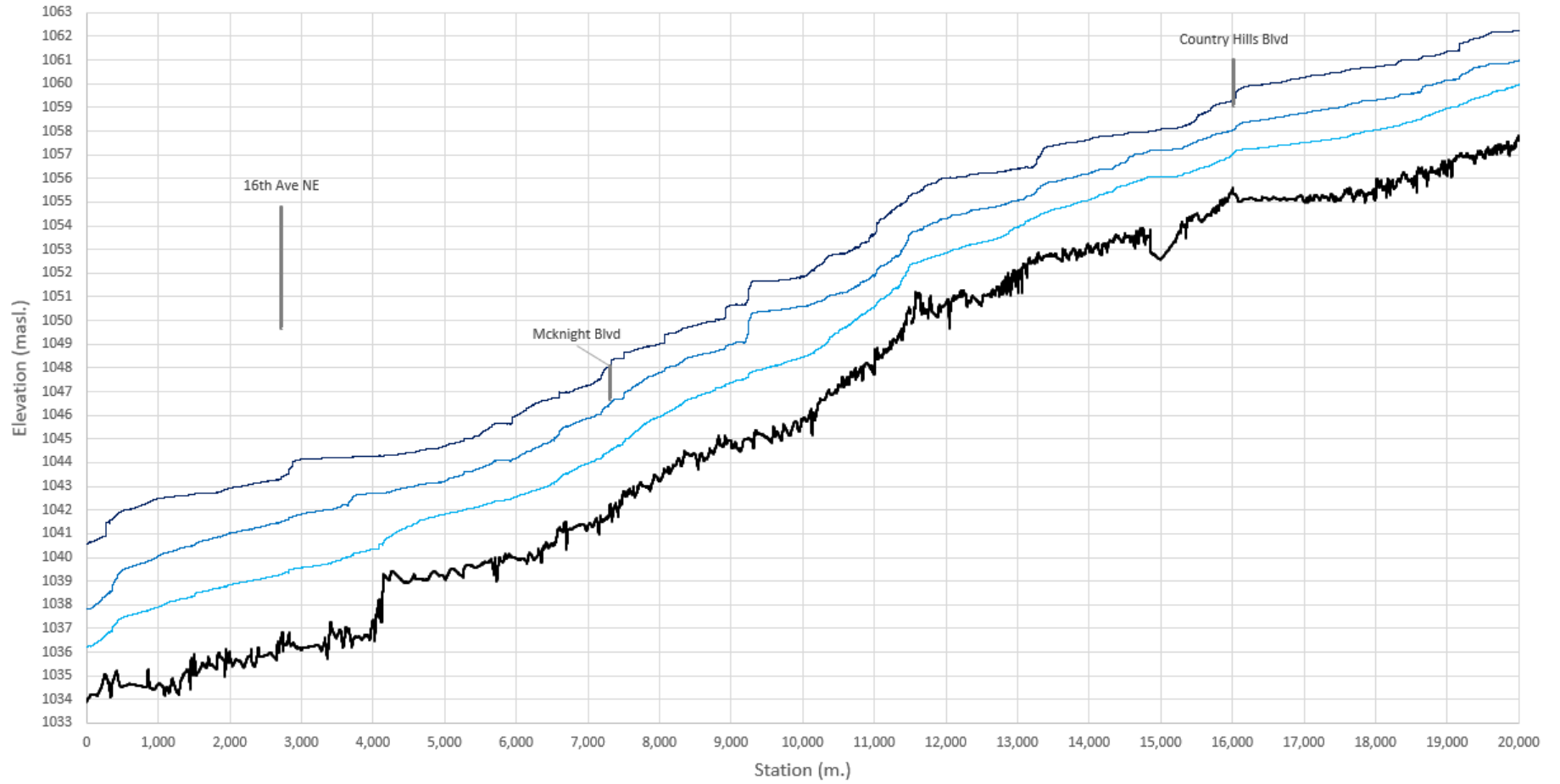
Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

Appendix G

Infrequent Flood Simulated Channel Profiles

Flood Scenario Simulated Water Level Profiles

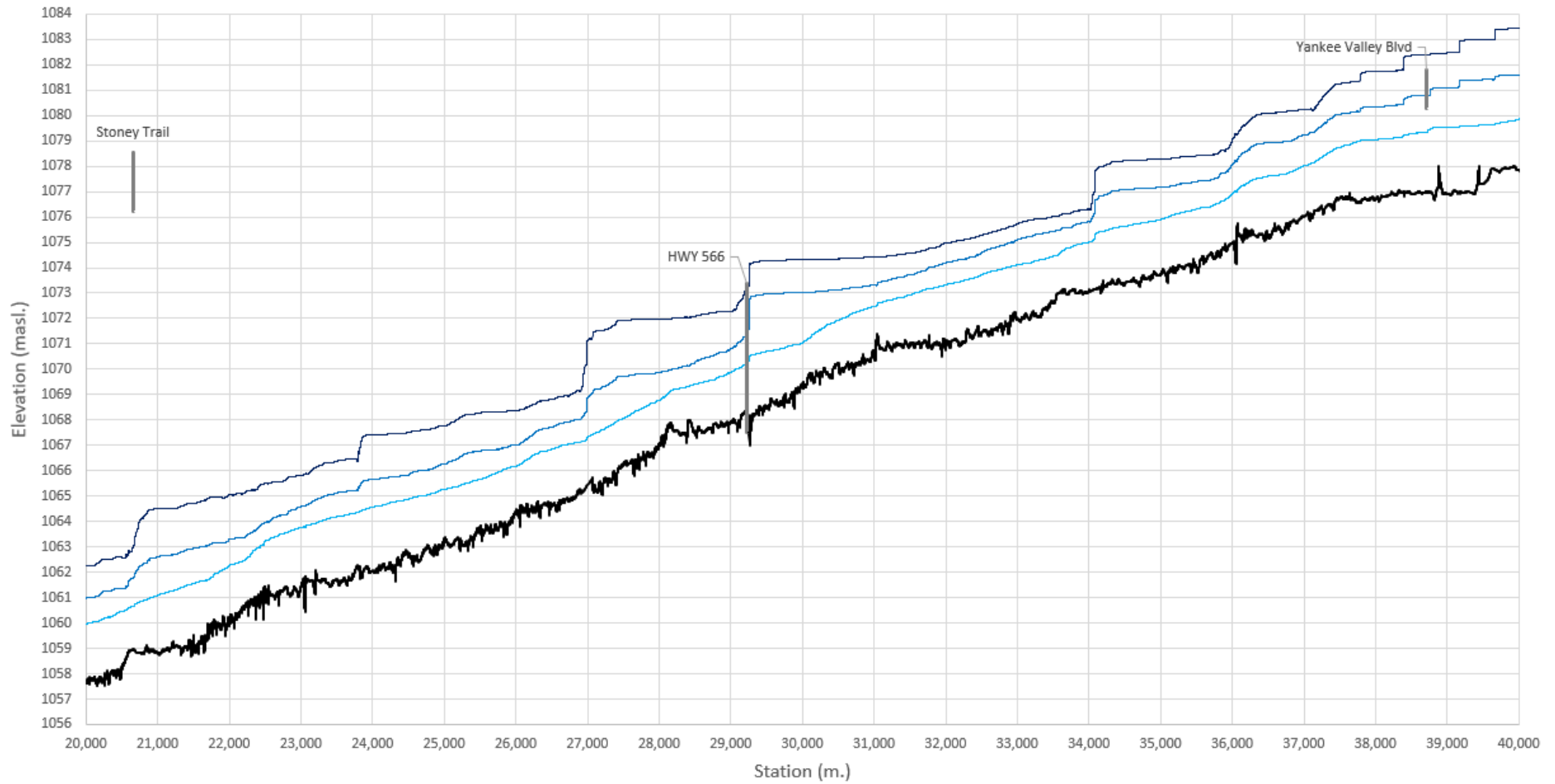
Nose Creek Station 0-20,000 m



— Channel Centerline Bed — High WSEL — Very High WSEL — Extreme WSEL — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

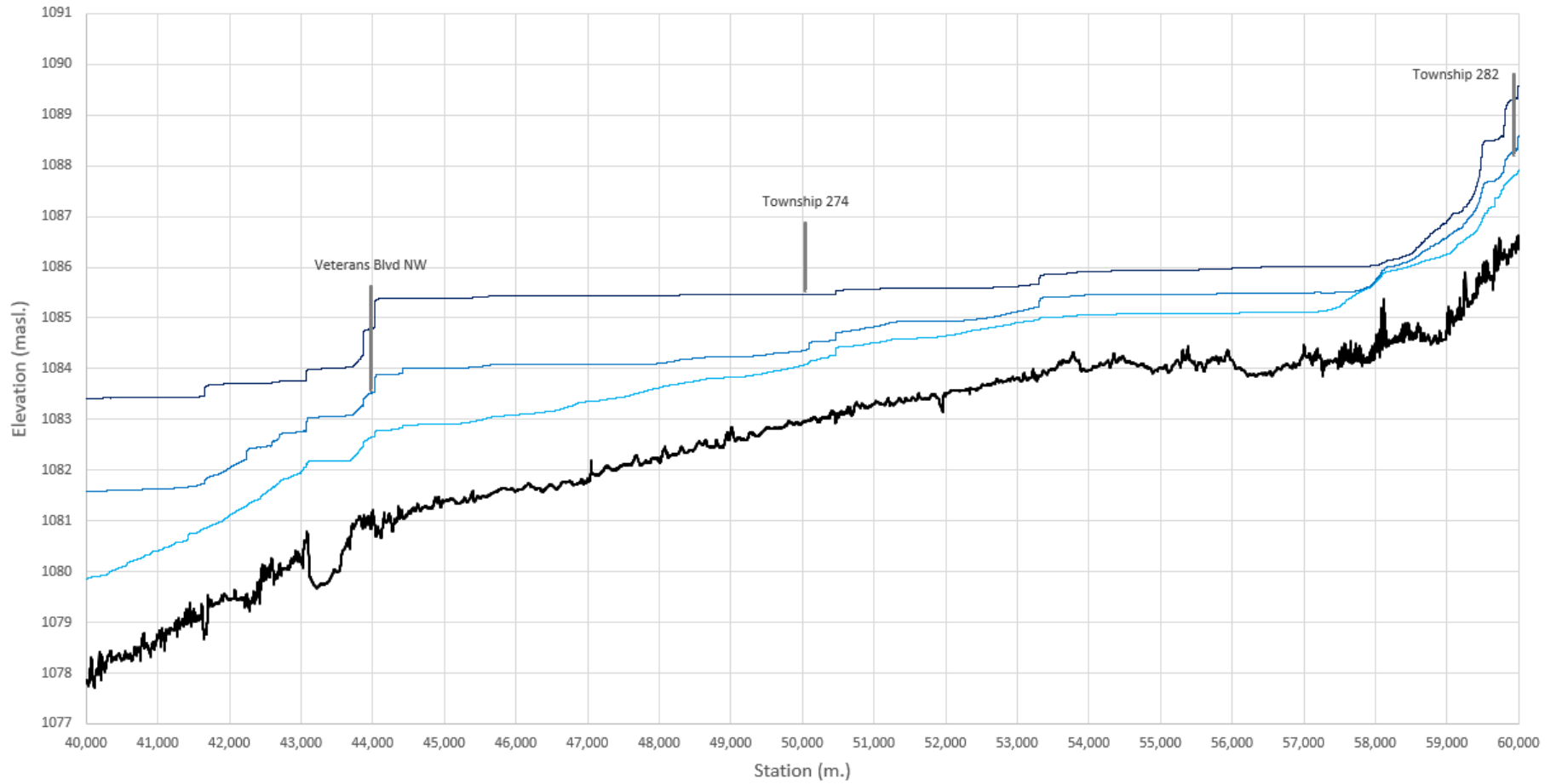
Nose Creek Station 20,000-40,000 m



— Channel Centerline Bed — High WSEL — Very High WSEL — Extreme WSEL — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

Nose Creek Station 40,000-60,000 m



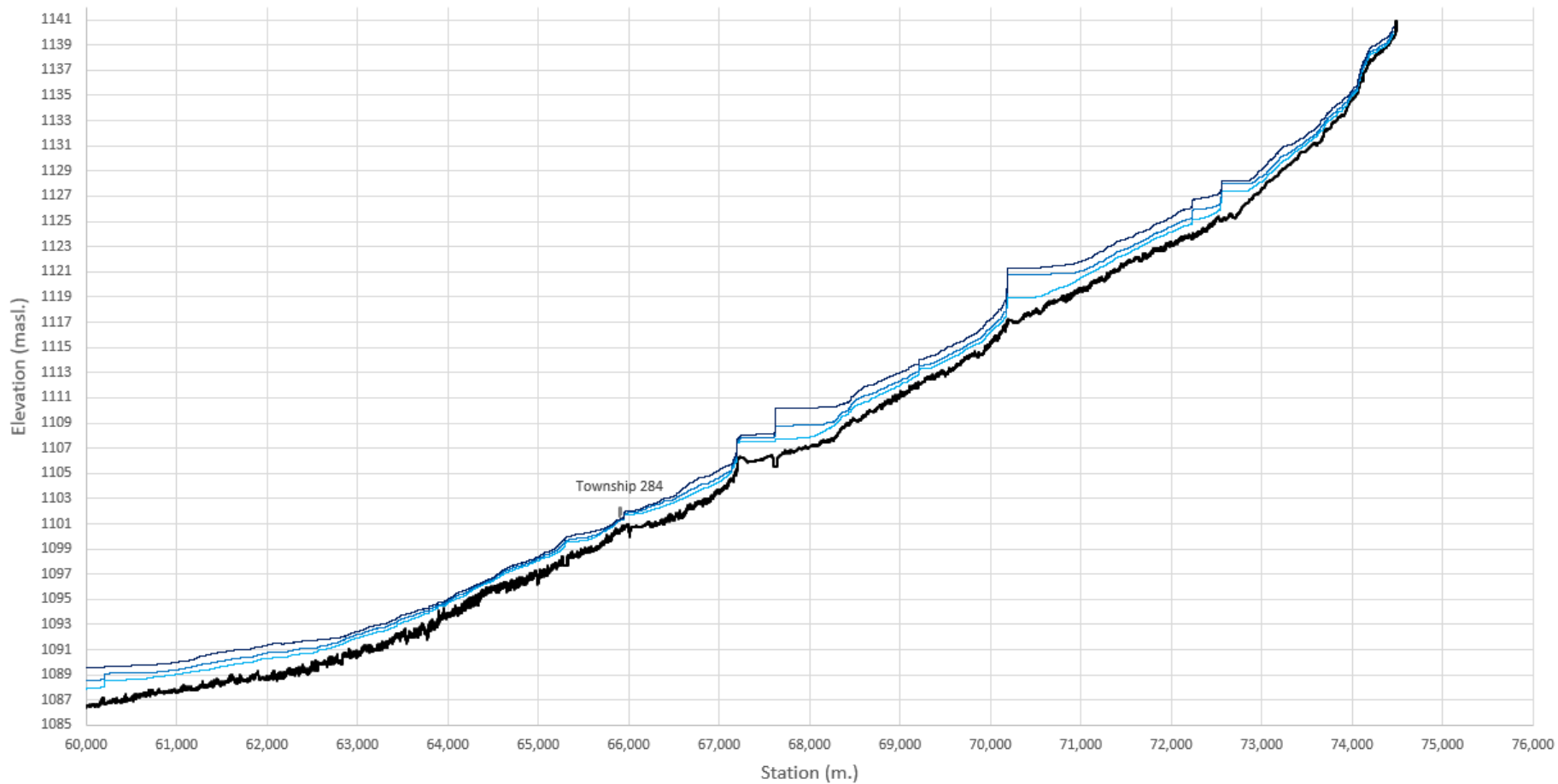
— Channel Centerline Bed — High WSEL — Very High WSEL — Extreme WSEL — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

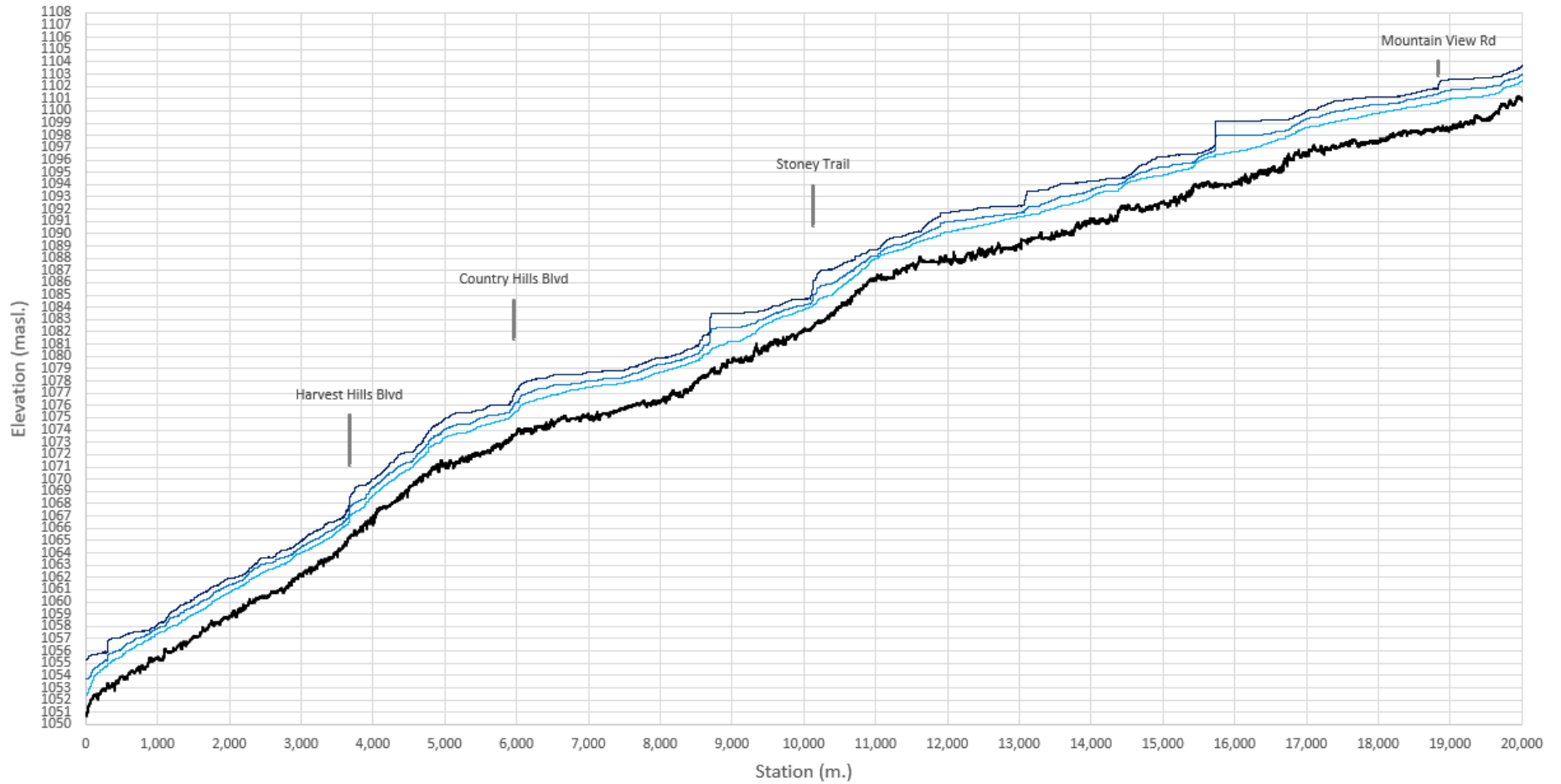
Nose Creek Station 60,000-76,000 m



— Channel Centerline Bed — High WSEL — Very High WSEL — Extreme WSEL — Reference Crossings

Reference crossing represent both bridge and culvert crossings.
Bridge crossings are represented by the high chord and low chord.
Culverts are represented by the obvert and invert.

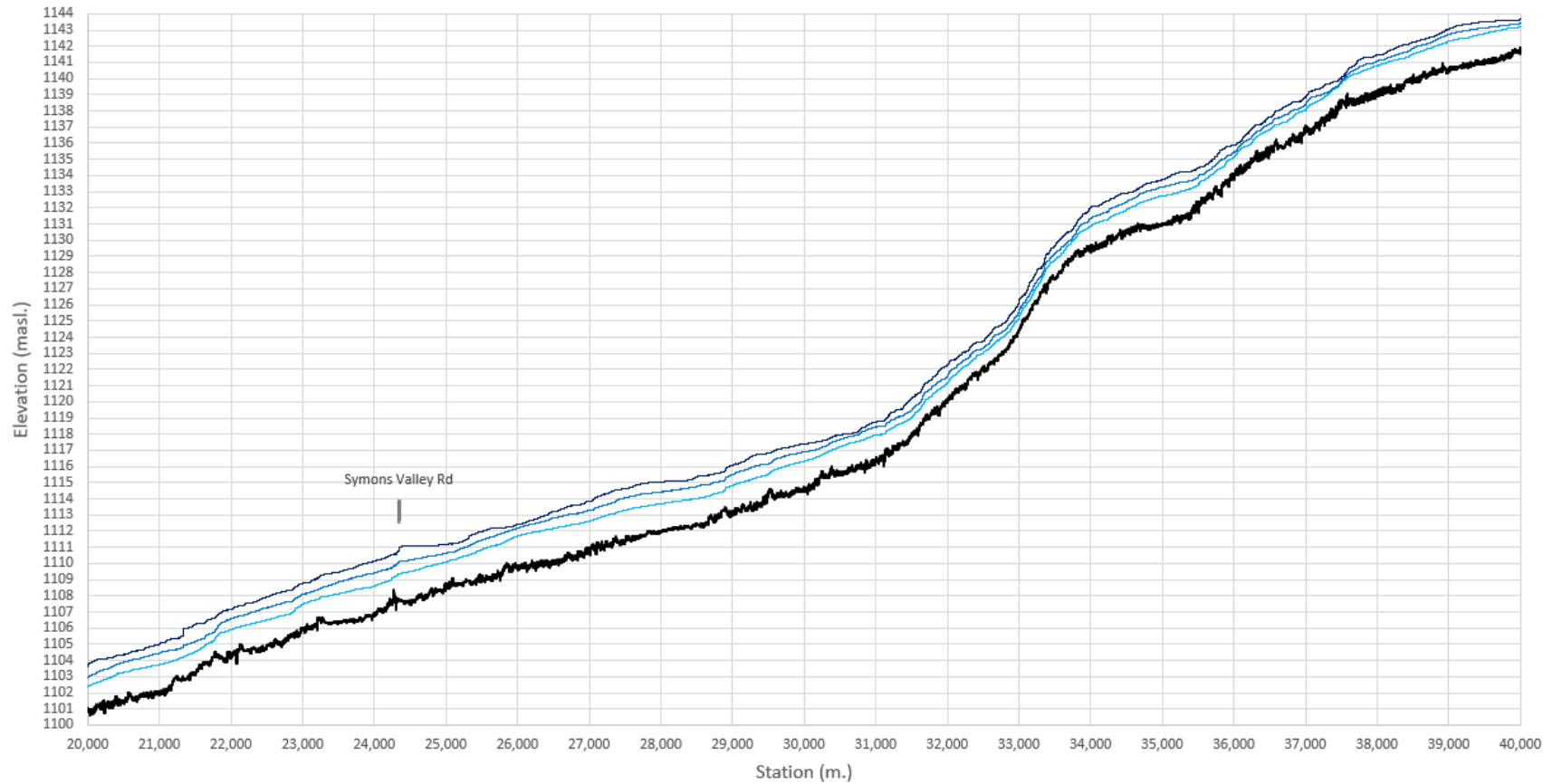
West Nose Creek Station 0-20,000 m



Channel Centerline Bed
 High WSEL
 Very High WSEL
 Extreme WSEL
 Reference Crossings

Reference crossing represent both bridge and culvert crossings.
 Bridge crossings are represented by the high chord and low chord.
 Culverts are represented by the obvert and invert.

West Nose Creek Station 20,000-40,000 m



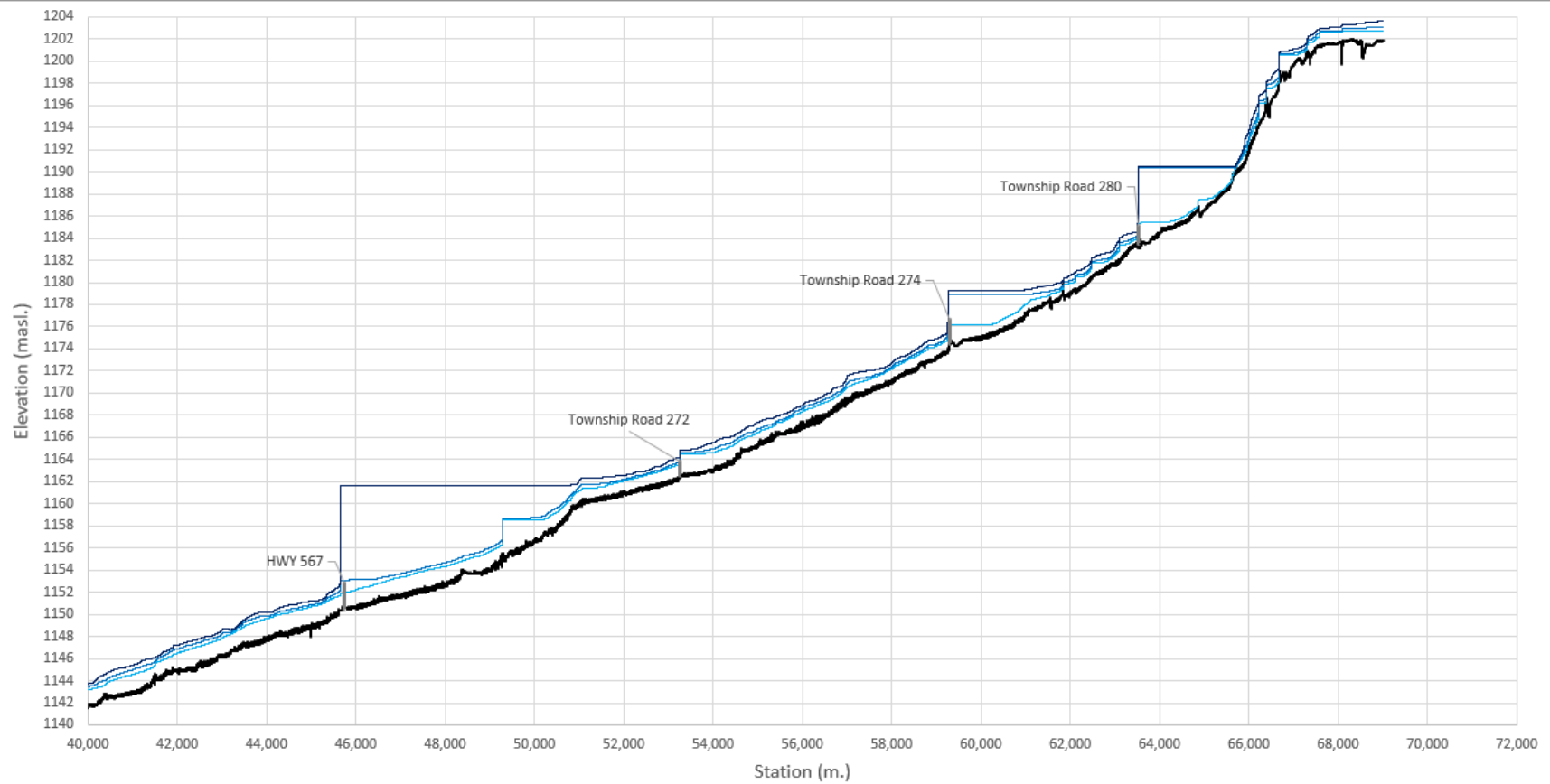
— Channel Centerline Bed — High WSEL — Very High WSEL — Extreme WSEL — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

West Nose Creek Station 40,000-72,000 m



— Channel Centerline Bed — High WSEL — Very High WSEL — Extreme WSEL — Reference Crossings

Reference crossing represent both bridge and culvert crossings.

Bridge crossings are represented by the high chord and low chord.

Culverts are represented by the obvert and invert.

Appendix H

HEC-RAS Model Summary Table

Scenario		Model Project File	Model Plan File	Model Geometry File	Model Flow File	Result File Name ¹
Calibration	LF1	NC_2D_HECRAS _01302024_Submittal	NC_2D_LF1_SWE	NOSECREEK_2D_GEOMETRY	2D_LF1_wt_rst	2D_LF1_SWE
	LF2		NC_2D_LF2_SWE	NOSECREEK_2D_GEOMETRY	2D_LF2_wt_rst	2D_LF2_SWE
	MF1		NC_2D_MF1_SWE	NOSECREEK_2D_GEOMETRY	2D_MF1_wt_rst	2D_HF1_SWE
	MF2		NC_2D_MF2_SWE	NOSECREEK_2D_GEOMETRY	2D_MF2_wt_rst	2D_HF2_SWE
	MF3		NC_2D_MF3_SWE	NOSECREEK_2D_GEOMETRY	2D_MF3_wt_rst	2D_HF3_SWE
Infrequent Flood Event	High Flow		NC_2D_HF_SWE	NOSECREEK_2D_GEOMETRY_FLOOD_SCENARIO	2D_HF_wt_rst	NC_2D_10yr_SWE
	Very High Flow		NC_2D_VHF_SWE	NOSECREEK_2D_GEOMETRY_FLOOD_SCENARIO	2D_VHF_wt_rst	NC_2D_100yr_SWE
	Extreme Flow		NC_2D_EF_SWE	NOSECREEK_2D_GEOMETRY_FLOOD_SCENARIO	2D_EF_wt_rst	NC_2D_1000yr_SWE
Sensitivity	Main Channel "A" (+10%)		NC_2D_VHF_SWE_A+10%	NOSECREEK_2D_GEOMETRY_FS_A+10%	2D_VHF_wt_rst	NC_2D_100yr_SWE_+10%_CHNL
	Main Channel "A" (-10%)		NC_2D_VHF_SWE_A-10%	NOSECREEK_2D_GEOMETRY_FS_A-10%	2D_VHF_wt_rst	NC_2D_100yr_SWE_-10%_CHNL
	Floodplain "B" (+10%)		NC_2D_VHF_SWE_B+10%	NOSECREEK_2D_GEOMETRY_FS_B+10%	2D_VHF_wt_rst	NC_2D_100yr_SWE_+10%_FLDPN
	Floodplain "B" (-10%)	NC_2D_VHF_SWE_B-10%	NOSECREEK_2D_GEOMETRY_FS_B-10%	2D_VHF_wt_rst	NC_2D_100yr_SWE_-10%_FLDPN	
	Channel and Floodplain "C" (+10%)	NC_2D_VHF_SWE_C+10%	NOSECREEK_2D_GEOMETRY_FS_C+10%	2D_VHF_wt_rst	NC_2D_100yr_SWE_+10%	
	Channel and Floodplain "C"(-10%)	NC_2D_VHF_SWE_C-10%	NOSECREEK_2D_GEOMETRY_FS_C-10%	2D_VHF_wt_rst	NC_2D_100yr_SWE_-10%	

1. File names have not been updated in RAS-Mapper to preserve the model runs. These file names will change once the plan has been rerun.

Appendix I

NCWP Comments and Barr Responses on the Full 2D Model and Report

Round 1 of Report and Couple 1D/2D HEC-RAS Model Review

Number	Report Section Number	Author	Affiliation	Comment	Barr Response
1	Acknowledgement	Sandi Riemersma	Palliser	I suggest we remove this reference to Stakeholders in this report? Or I will update the list. Any thoughts here?	Removed.
2	Executive Summary	Sandi Riemersma Jonathan Slaney	Palliser CoC	See suggested wording in the Foreward Sounds like Sandi has some good suggestions here, but I agree that some background as to why the change was requested would be useful here. From my perspective it was because the proposed methodology	We used the edited texts from forward in here for consistency.
3	Executive Summary	Jonathan Slaney	CoC	What about the water levels taken during the bathymetric survey? These would have been during low flows for the most part. Relying on model wide calibration on so few points is unfortunate.	This was discussed during the technical team meeting on May 12, 2023. Please refer to the new scope of work dated July 6, 2023.
4	Executive Summary	Sandi Riemersma Jonathan Slaney	Palliser CoC	Could you provide some context for this maximum flow value? (e.g., Does it represent the 90th percentile point?) This is just over the 1:5 year flood.	The texts is removed as per new scope of work (not applicable anymore).
5	Executive Summary	Jonathan Slaney	CoC	My understanding was that flows as high as the 1:1000 (+400 cms) were to be run. At the very least flows equal to the 1:100 year flood (130 cms) should be able to be run. Let's confirm the workplan and discuss.	The texts is removed as per new scope of work (not applicable anymore).
6	1.1	Sandi Riemersma	Palliser	This likely belongs in the introduction as background rather than the Objectives which should be clear statements.	Moved the texts to the introduction.
7	1.1	Sandi Riemersma	Palliser	Link this to Phases III, IV and V objectives - this seems off-hand and not strategic.	Added some texts.
8	1.2.2	Sandi Riemersma	Palliser	The creek has been able to flow somewhat naturally in the confines of the golf course and the pathway network in Confluence Park; upstream encroachment limits channel movement.	Edits were made.
9	1.2.2	Jonathan Slaney	CoC	Based on historic airphoto's about 1/3 of Nose Creek has been realigned in The City of Calgary Limits. I am not sure this statement is	Texts have been replaced by Sandi's suggestion.
10	1.2.3	Sandi Riemersma	Palliser	cropland?	Yes, edit was made.
11	1.2.3	Sandi Riemersma	Palliser	It would be good to add in a reference to riparian condition (Fiera Biological 2023).	Added.
12	1.3	Sandi Riemersma	Palliser	Has Barr reviewed the GOAs flood portal? Alberta Floods Portal ; Final flood studies and maps Alberta.ca	Yes.
13	1.3	Sandi Riemersma	Palliser	NCWP TT - is there more to describe flood occurrence in Airdrie? Is there additional flood verbage that could be included for Rocky View County? Maybe not directly on the creeks, but in the greater watershed	-
14	1.3	Jonathan Slaney	CoC	Should we define what we mean by major flood? Also are we sure this is true? 2007 was a pretty big flood on Nose Creek that caused quite a few outfalls to fall into the creek	Can you please share a reference for this? We have further reviewed "Provincial Flood Damage Assessment Study – City of Airdrie: Damage Estimates, 2019" and "Provincial Flood Damage Assessment Study City of Calgary: Assessment of Flood Damages, 2015", but were not able to find citations to the 2007 flood and its magnitude in the Nose Creek watershed.
15	1.3	Sandi Riemersma	Palliser	Be sure to include figure after first reference.	Done.
16	2.3	Sandi Riemersma	Palliser	will?	Sure.
17	2.4	Xue Chen	AEPA	If the survey couldn't be done soon, an alternative approach to estimate the gauging datum is to use DEM data to locate the gauging point, and get the elevation number for that gauging point from DEM. There are also some bench marks with relative elevation marked at surrounding places that Barr could use to back calculate the gauging datum once	We will need more directions to pursue with this task. This was not included in the scope of work.
18	2.4	Jonathan Slaney	CoC	Much more flow data exists than just these three years. Also should we not qualify that this is for open season only?	During Phases I and II of the Nose Creek project, Barr standardized the flows received from the NCWP for these years, which is used as basis for this study and model calibration. Note 3 states that the data is for the open water season only.
19	2.6	Jonathan Slaney	CoC	I am not sure on the value of this section. Every project requires data management. Perhaps this section can be moved to the main report but I do not think it belongs here.	Section is removed.
20	3.1	Jonathan Slaney	CoC	I am not sure this is true. My understanding is that 2D is generally more stable than 1D models especially for unsteady flow simulations.	Correct. However, a coupled 1D/2D model is more unstable compared to a 1D model. Sentence has been modified.
21	3.1	Jonathan Slaney	CoC	My understanding of this discussion was that BARR requested the 1D/2D approach because the 1D cross sections were going to converge in the floodplain due to the heavy meandering of the creek in some locations?	It was a collective decision between Barr and NCWP, but the reason you mentioned here is correct: ~10,000 cross sections were going to converge in the floodplain due to the heavy meandering of the creek in many locations!
22	3.1	Sandi Riemersma	Palliser	The most recent?	Yes, at the time. For HEC-RAS 2D we are using V6.4.1.
23	3.1	Jonathan Slaney	CoC	The map does not seem consistent with the above table. The Brown/Orange is delineating the NC2D reach but the description in the above table for the 1D/2D area is from Airdrie to the confluence leaving a gap above airdrie. Can we make the reaches super clear.	Thanks for pointing this out. Added "above" in Table 3-1.
24	3.4	Jonathan Slaney	CoC	Can you explain the instability, the solution, and where exactly this is in the model further.	Texts have been added.
25	3.5	Jonathan Slaney	CoC	This is not consistent with the reach names in the previous tables. Can we please be consistent.	Revised.
26	3.6	Phil McMechan	CoC	Was the downstream boundary condition tested for impacts as part of the sensitivity analysis?	No, sensitivity analysis will be done only on the roughness.
27	3.6	Jonathan Slaney Phil McMechan	CoC	I'm not clear on the how the discharge for these inflows was determined for the various calibration/validation runs Agreed, my understanding was that the hydrologic model was going to be used to guide inflow points into the model? If not, how were the number and location of the inflow points decided on?	The inflow locations were identified by physical features in the terrain (e.g., tributaries). However, for the full 2D model, the hydrologic model was used to inform the inflow locations. This resulted in more inflow locations. Please see Section 4 for more details on this.
28	3.6	Jonathan Slaney	CoC	Maybe I missed it, but I could not find any information on how the various (18) inflows were determined?	A sentence is now added in Section 3.9.3.
29	3.7	Sandi Riemersma	Palliser	Reference	Model was constructed by Golder. Revised accordingly.
30	3.7	Sandi Riemersma	Palliser	Should the land cover classification developed by Fiera Biological for the riparian intactness assessment be used here, and the wetland inventory? My concern is that the AAFC data set is 2010 and that the land use/land cover has changed considerably since then. The urban footprint in Rocky View County is not well-represented if you compare the maps. From the draft HEC-RAS report, I don't think Rocky View County provided a land use layer. For the wetland roughness value in Table 36, I am uncertain if the land use layer was generated from AAFC or if the merged wetland inventory data set was used.	This has been addressed now and we are using Fiera's dataset instead of AAFC dataset.
31	3.7	Jonathan Slaney	CoC	Would there not also be varying mannings n depending on where in the catchment you are. The upper catchment likely has higher mannings n as it is a smaller creek.	You are correct and it is the case for the main channel. For floodplain we are using this distributed roughness. Edited title for Table 3-6 to clarify.
32	3.7	Jonathan Slaney	CoC	So just confirming this is for the main channel? Was it modified based on the calibration points? How was the value chosen?	Not for the main channel, this is for the floodplain (e.g., ponds). The initial values are best guesses and they (mostly main channel roughness) will be modified during the calibration process.
33	3.7	Jonathan Slaney	CoC	Much of the overbank of nose creek is a combination of grassland and shrubland. I am guessing this value is what is being used for this initial	It is correct.
34	3.7	Sandi Riemersma	Palliser	Is this the NCWP wetland inventory or AAFC (2010) data layer?	This is now based on the layer from Fiera (2023).
35	3.7	Sandi Riemersma	Palliser	Maybe title Land Cover and Use? The colours on the map are distorted and not consistent with the colours on the map...in the rural area, there are two shades of brown?	There is only one brown for croplands. The different shades are due to different colors in the background imagery used here. This image now has been updated with the Fiera layer, instead of AAFC.
36	3.8	Jonathan Slaney	CoC	Is this still true at high flow events? Seems like some bridges are pretty skewed but maybe they are high enough to not be of consequence?	Correct, since the coupled 1D/2D model was run for low flows, it was not of concern. For the new 2D model, this is no longer applicable.
37	3.9.4	Jonathan Slaney	CoC	As noted, this is a problem because the 1:100 is about 130 cms and the goal was to model up to the 1:1000 which is about 407 cms. As a general comment, I cannot imagine that Nose Creek represents an unusually unique hydraulic scenario that HECRAS would have trouble modelling and so some further explanation as to why the creek seems to be presenting such a challenge would be helpful.	This was discussed during the technical team meeting which resulted in the new scope of work for the full 2D model.
38	3.9.4	Sandi Riemersma	Palliser	What is the likelihood of flows greater than 24.5 m3/s?	We do not have the frequencies, but as per Jon's comment, it is over 1:5 year flood.
39	4.1	Sandi Riemersma	Palliser	Review utility of land cover class generated by Fiera Biological within the floodplain as part of the riparian intactness assessment; wetland	Done.
40	4.1	Sandi Riemersma Jonathan Slaney	Palliser CoC	Why 2019 to 2021? Why not use a high flow year like 2005 or 2013? This data should be available? Yes in fact 2007 was apparently an even higher flow year? I believe the entire flow record has been provided to BARR correct? Yes. all available flow data	See responses to previous comments.
41	4.1	Jonathan Slaney	CoC	bit of a confusing nomenclature	This is the actual label that CoC uses for the gauge on Nose Creek at the Mouth. We removed that based on your suggestion.
42	4.1	Jonathan Slaney	CoC	Nice work and yes this makes sense. Can you show some examples?	See Table 5-2 for item number 3.
43	4.1	Jonathan Slaney	CoC	The 50 cms event is pretty significant and equates to about a 1:20 year flood!	This is removed to reflect the new scope of work.
44	4.1	Jonathan Slaney	CoC	Can we be consistent and just call in nose creek at the mouth?	Done.
45	4.1	Jonathan Slaney	CoC	These flows are really high for low flow events? Why not use the normal summer low flow of +0.01 m3/s	In the new scope of work much lower flows are considered.
46	4.1	Sandi Riemersma	Palliser	Exploring options to survey the site again.	-
47	4.1	Sandi Riemersma	Palliser	Recommendation: Improve West Nose Creek gauging station upstream of Calgary (currently constrained to 1 m3/s.	-
48	4.1	Jonathan Slaney	CoC	I am confused, should this not be 51.30 m3/s?	this is the West Nose Creek Mouth not Nose Creek Mouth.
49	References	Sandi Riemersma	Palliser	Is this the complete reference? Does A. Deboer work for the River Engineering Branch or was this a consultant?	Worked for the River Engineering Branch - revised.

Round 1 of Full 2D HEC-RAS Model Review

Number	Author	Affiliation	Comment	Barr Response
1	Andrew Huang	CoC	My additional comments would be that I randomly looked at a few bridges, and noticed that the bridge deck is much higher than the road approaches, which don't make sense.	The increase in elevation is modeled to represent the bridge railing if deemed dense enough to restrict flow during overtopping (see tab "Bridge High Chords" for an example).
2	Andrew Huang	CoC	Another comment is the scaling of the 1000yr flow from the mouth upstream to the upstream boundary condition doesn't seem to align with AEP hydrology. At the upstream end of Calgary on Nose creek, we are down to the range of around ~100yr flows, and up in Airdre it is only around 7.5 cms which is roughly a 5yr flow, so I would say we don't have a good assessment of how well the model is running at really high flows (ex. 500yr or 1000 yr). Maybe there will be more instabilities at more locations than currently exists?	Barr utilized the 2020 hydrology flows (Golder, 2020) scaled to the flow change locations in the 2000 report (Alberta Environment, 2000) to develop flow distributions for the 1000-year event that is more comparable to the Alberta EPA mapping. For example, the flow in Airdrie has been increased to 88.4 m3/s for the 1000-year event.
3	Andrew Huang	CoC	It would be nice to have a figure and maybe a Table (including as columns: river stationing, peak flow, etc) of where all of the boundary conditions are of the incremental inflows into the model as it is not easy to pull all of that info out of the model quickly to get an overall picture.	This was included in the draft report that was submitted with the model, Appendix C.
4	Andrew Huang	CoC	It would be very helpful if the consultant can add the channel centerlines in the RAS Mapper. They can be used as Profile Lines to view	It is included in the new model delivery.
5	Andrew Huang	CoC	I wonder if after we run the model at an actual reasonably close to the 1000yr flow, perhaps we can identify areas in the model where we can make the 2D area smaller to have less overall cells (not sure how much	Barr followed same methodology as described in this comment to optimize the model domain. Sections 4.1 and 4.2 discuss the model domain and mesh.
6	AEPA	AEPA	It would be nice to have more meaningful Boundary Condition (BC) names. Currently it's difficult to locate BC in the map or geometry editor. The BC names do not specify if it's at an upstream, middle, or downstream reach. It should mention the structure (bridge, road) name for easy identification.	Upstream (on NC and WNC) and downstream (on NC) boundary conditions are clearly named in the model. Regarding other inflow names, they were assigned to be easily tracked back to the PCSWMM model.
7	AEPA	AEPA	The total precipitation on 23 July 2020 that was used as input in the PCSWMM model to generate flows is not mentioned in the draft report (section 4.6). Also, the method to estimate flow at each inflow location and it's scaling is bit unclear. What was the flow at different inflow locations after scaling? It would be better if the consultant can add more details in this section, like the total flows, flow for different return periods, drainage area ratios that were used for scaling etc.	Barr included more text in the report to address this comment. Two tables were added to identify the inflow locations and values for calibration and flood event scenarios (Appendix C and Table 4-4). Note that the hydrology assessment was not part of the scope of this work.
8	AEPA	AEPA	For event-based modeling, different rainfall intensity distributions like Chicago, SCS Type I, II etc. are commonly used. Another option is to use Intensity Duration Frequency Curves (IDF). Is there a reason why a	See comment 2 and response. The scope detailed using the PCSWMM model which was continuous rather than event based.
9	AEPA	AEPA	The consultant has not added contraction and expansion coefficients for most of the bridges in the study area. This is true for both Nose Creek (NC) and West Nose Creek (WNC). Please check all bridges and	Coefficients added to the model after discussion with USACE.
10	AEPA	AEPA	Please double check that appropriate entrance and exit loss coefficients have been added for all culverts. We were not able to check all culverts	Barr reviewed all culverts and is comfortable with the loss coefficients applied in the model.
11	AEPA	AEPA	We checked High Flow modeling method for few bridges and noticed that the 'Energy Only (Standard Step)' method is used for them. This method is ok if the Water Surface Elevation (WSE) is below the low chord of the bridge. In case if the WSE reaches the low chord of bridge or if the bridge is overtopped then the 'Pressure and or /weir' method should be used. Has the consultant checked WSE at all bridges and used the appropriate method for high flows modeling?	High flow pressure/weir methodology implemented in all bridges.
12	AEPA	AEPA	The consultant has not used channel centerline as a breakline to generate the mesh. Although it's not compulsory but the U.S Army Corps of Engineers has suggested to use breakline along the centerline of the channel to align the cells with the flow in the channel. In 2D modeling, the results are more accurate if the cells are aligned with the flow. This improves numerical accuracy and reduces errors in the model. Currently, the cells alignment is not consistent in the channel as shown in the snip below.	Barr acknowledges that a center breakline is an excellent way to represent the channel within a HEC-RAS 2D model. However, due to the high sinuosity and size of model it was determined that a refinement region would be a more efficient method of defining the channel.
13	AEPA	AEPA	The flows are not steady especially towards the end of the simulation, and they fluctuate/drop during the model simulation time on Nose Creek, especially near Airdrie. The flows are kept constant in the Boundary Condition Hydrographs, but they seem to be dropping in the results.	Barr has improved model stability particularly in the Airdrie area since this review. Note that we are using restart files to initialize the model and this may show a dip of flow at the beginning in some areas, but it was made sure that model reaches to a steady state solution at the end of simulation for the entire model domain.
14	AEPA	AEPA	The flows have not reached a steady state in the upper reaches of West Nose Creek. It seems like the simulation time is short for the model to reach a constant flow towards the end of the simulation time.	Barr has increased the simulation period to achieve a steady state solution for the entire model domain.
15	AEPA	AEPA	At all locations, the hydrographs start at a high flow, then they drop to zero, and then rise again. Ideally, the flows should start from a lower value and then gradually rise and reach a constant state towards the end of the simulation.	Barr is utilizing a restart file as an initial condition for the model runs. This high flow drop seems to be a remnant of this method. Barr will run the simulations for a sufficient period to achieve steady state solutions for the entire model domain.
16	AEPA	AEPA	We did a cursory comparison of the 1000 year flood inundation extent simulated by the HEC RAS model by Barr with the 100 year flood inundation map available on Flood Awareness Map Application (FAMA). We understand that the two return periods are different and the two model setups are different. We don't expect Barr's inundation extent to match with our maps. However, it can give us a general idea about the floodplain of the Nose and West Nose Creek, instead of the fact that Barr has used a flow which is more than four times higher than our 100 year flood. We have found that in general Barr's 1000 year flood inundation extent is less than EPA's 100 year flood inundation extent at the upstream reaches of Nose Creek and West Nose Creek (before the confluence of the two creeks). These reaches need a more careful review by the consultant. The consultant has ran the model for the 1000 year flood, however, water is contained in the main channel only and the wider floodplain is dry. It will be interesting to see what the inundation extents look like after the consultant has addressed our comments.	The reason for this was the flow scaling and distribution based on the hydrologic model developed as part of Phase II Nose Creek Model Development. Note that flood frequency analysis was not within the scope of the HEC-RAS model project. For the three flood frequency simulations (i.e., 10-year, 100-year, 1000-year), Barr is now using the two hydrology reports cited in response to Comment 2 for inflow locations and magnitudes. See tabs "10-year Inundation Extents", "100-year Inundation Extents", and "1000-year Inundation Extents" for comparison of inundation extents. The hydrology used in the FAMA simulations is unknown.

Bridge High Chords

My additional comments would be that I randomly looked at a few bridges, and noticed that the bridge deck is much higher than the road approaches, which don't make sense. See image below.

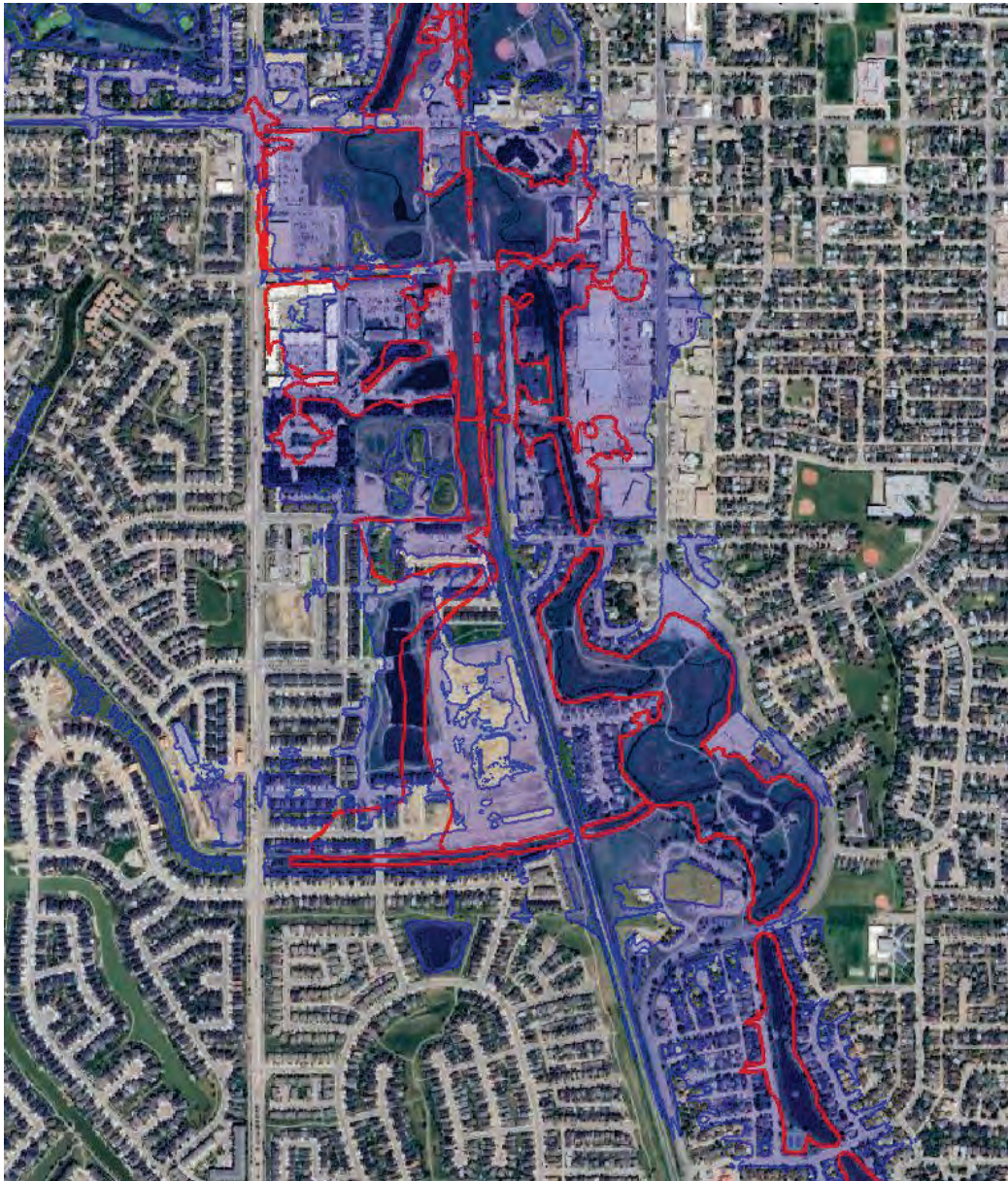
The screenshot displays a software interface for bridge data. On the left, a profile graph titled "NC 42195 US inside bridge" plots Elevation (m) on the y-axis (ranging from 1078 to 1084) against Station (m) on the x-axis (ranging from 0 to 35). The graph shows a bridge deck at approximately 1082m and a road approach at approximately 1079m. A legend indicates Ground, Bank Sta, and Current Terrain. The main window shows a 3D map view of the bridge structure with a pink circle highlighting the bridge deck area. The map view includes labels for "Nose of emb." and "NC 42195".

Barr modeled bridge railings where it was believed the would act as a hydraulic barrier, such as the concrete in the example.

The aerial view shows a bridge structure with a concrete railing. The bridge deck is significantly higher than the road approaches, which is highlighted by a pink circle. The railing is a concrete barrier. The map view includes labels for "Nose of emb." and "NC 42195".

Google

1,000-year Inundation Extents

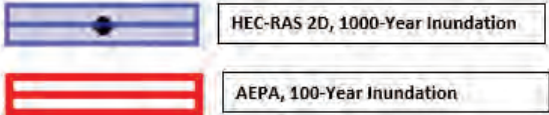
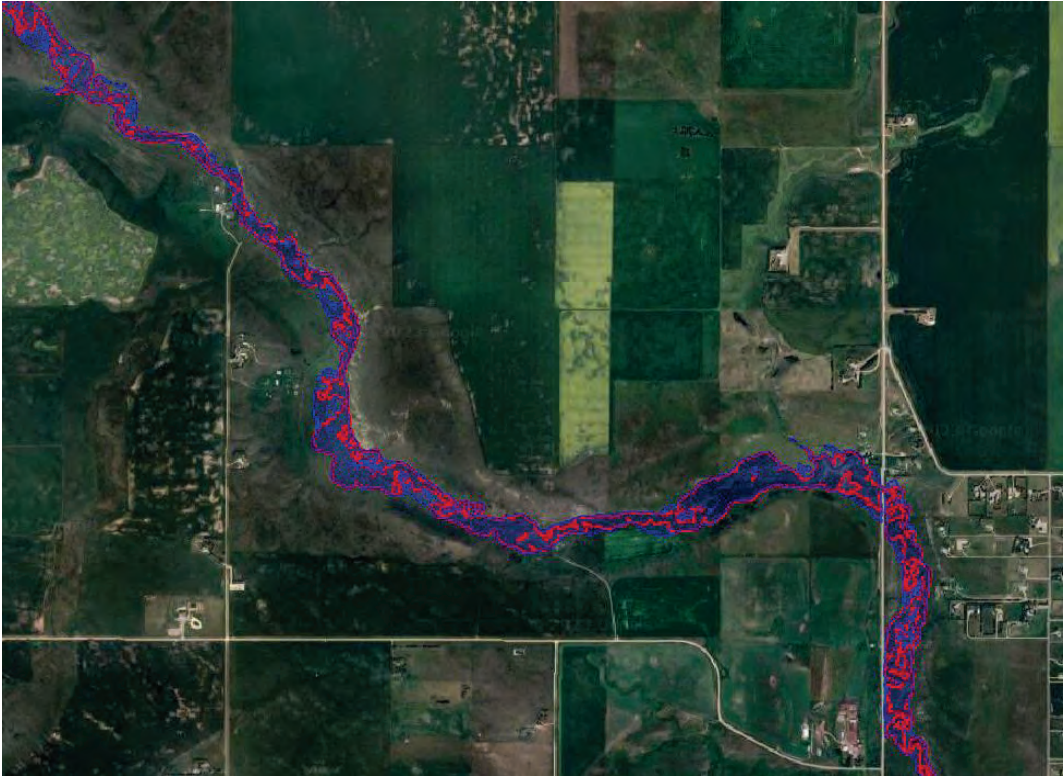


HEC-RAS 2D, 1000-Year Inundation

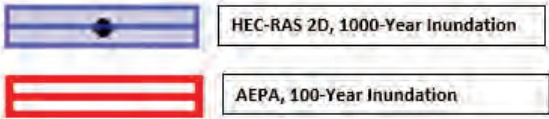
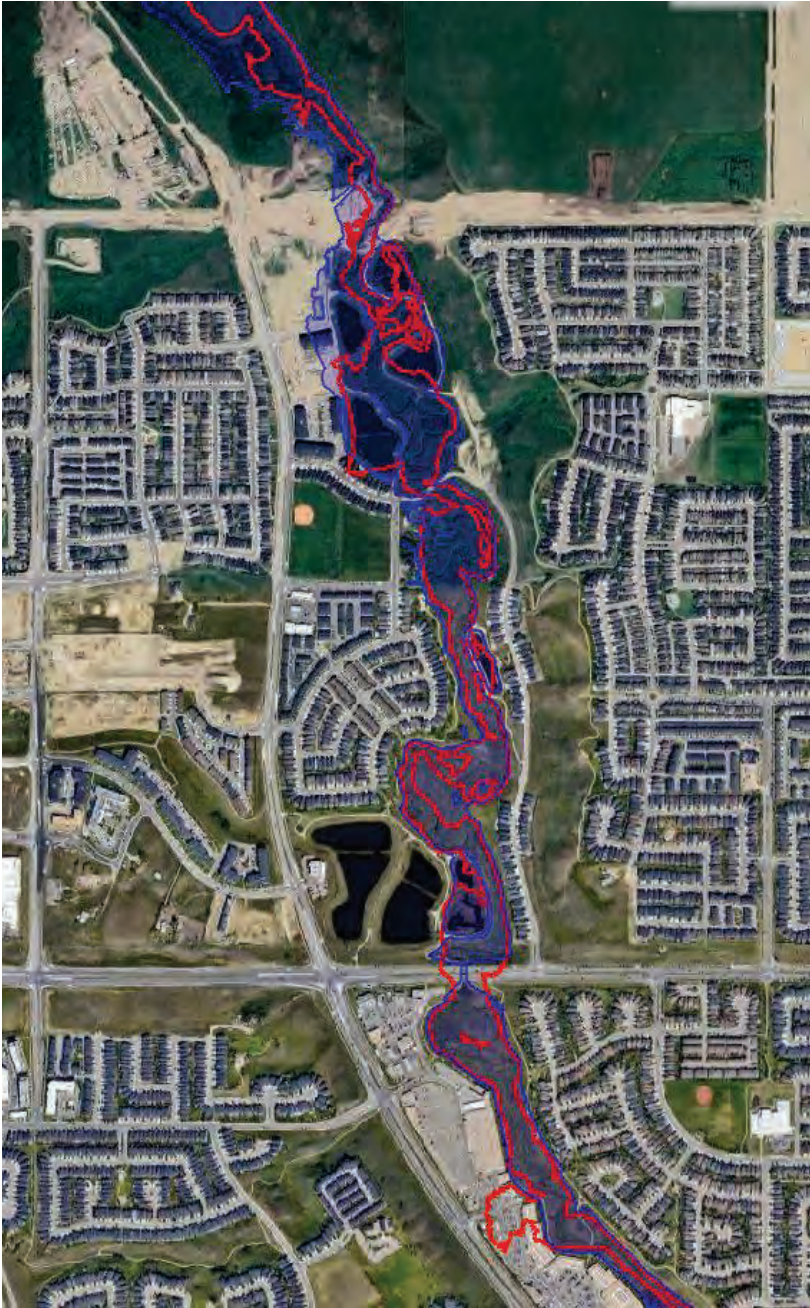


AEPA, 100-Year Inundation

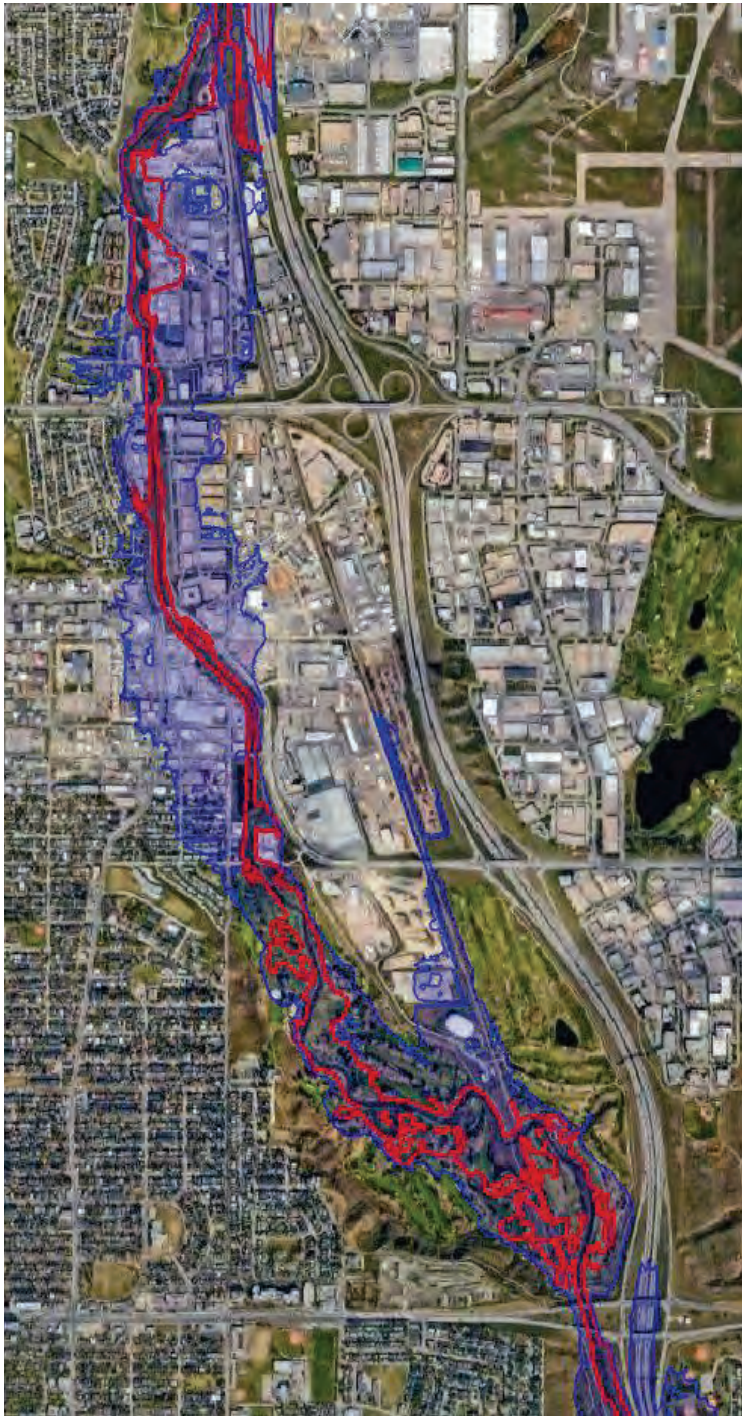
1,000-year Inundation Extents



1,000-year Inundation Extents



1,000-year Inundation Extents

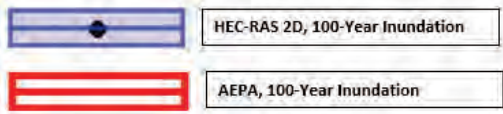
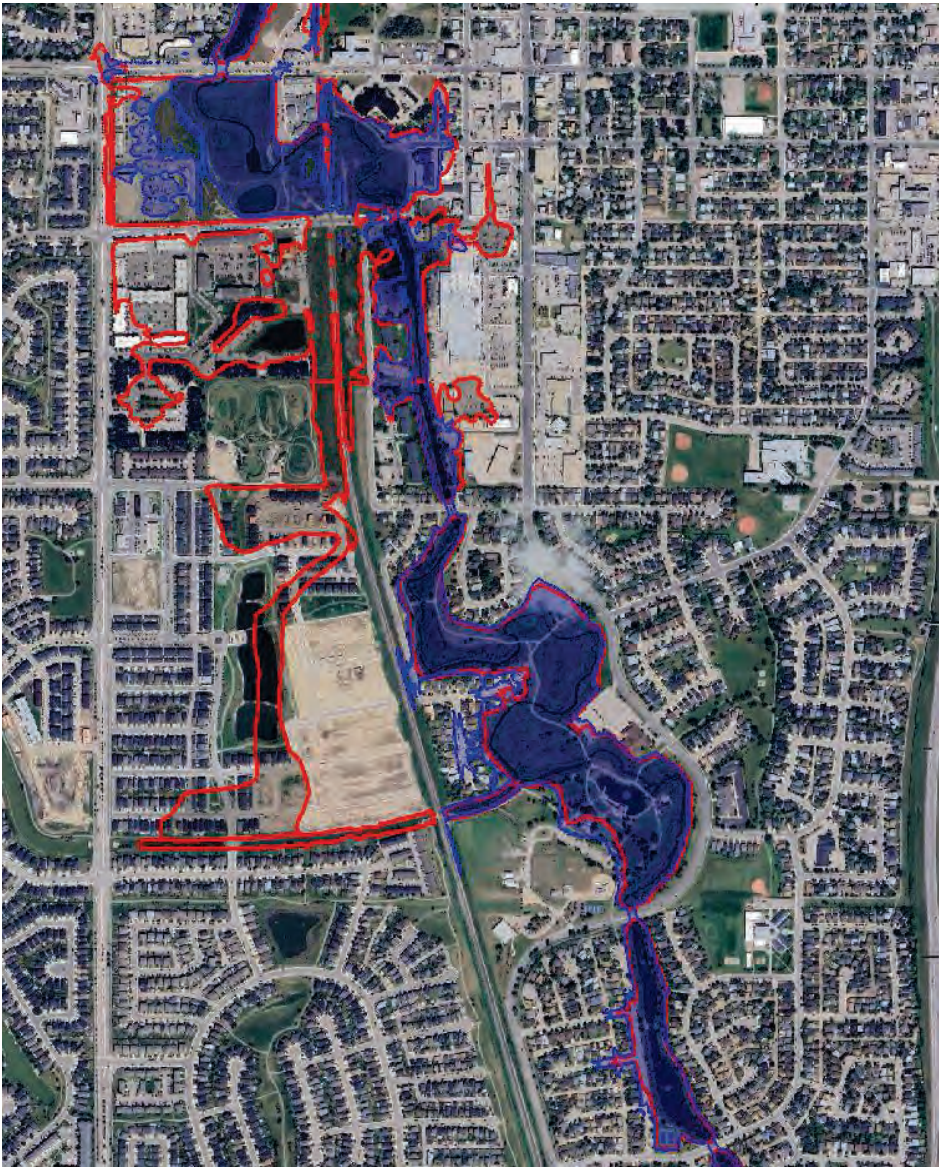


HEC-RAS 2D, 1000-Year Inundation

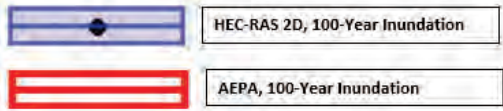


AEPA, 100-Year Inundation

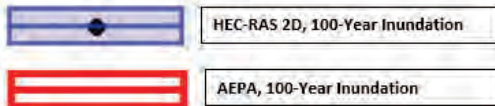
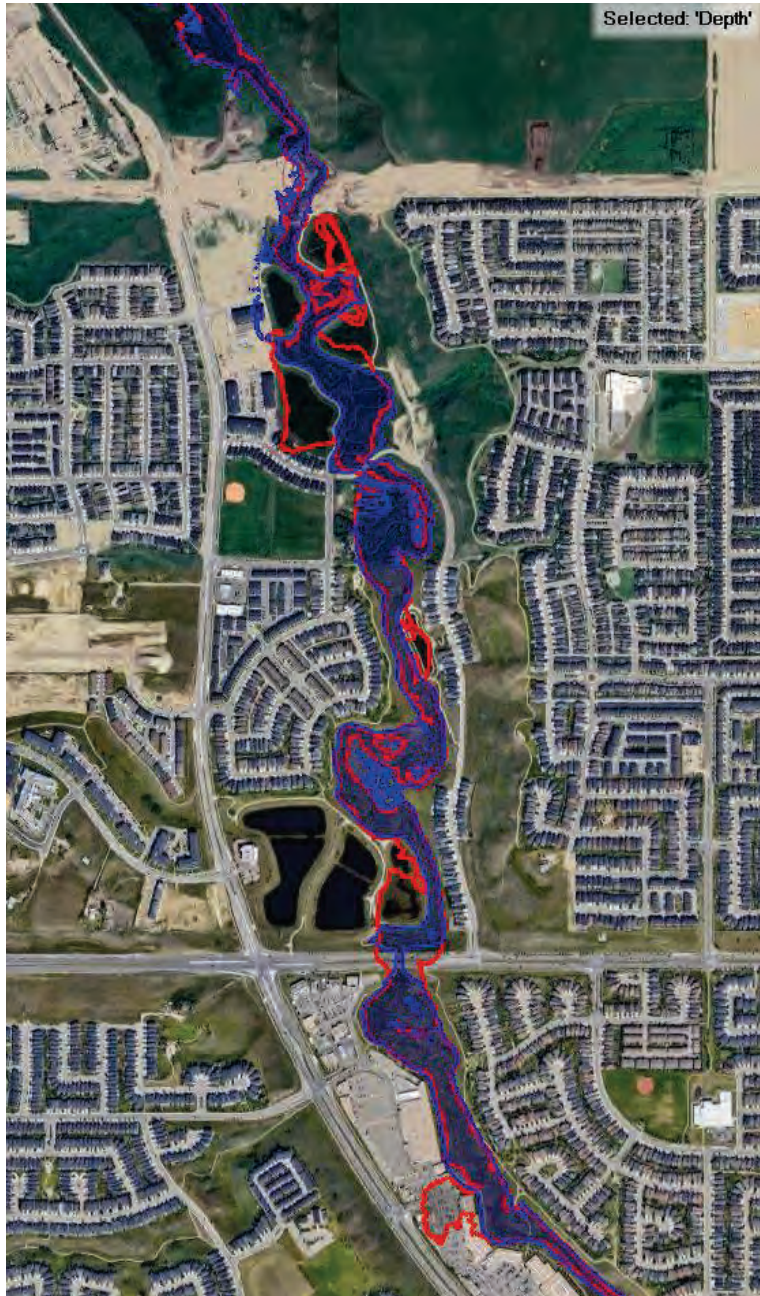
100-year Inundation Extents



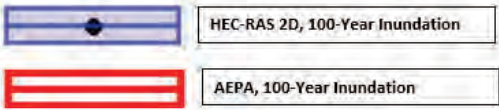
100-year Inundation Extents



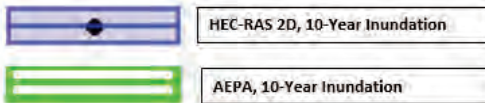
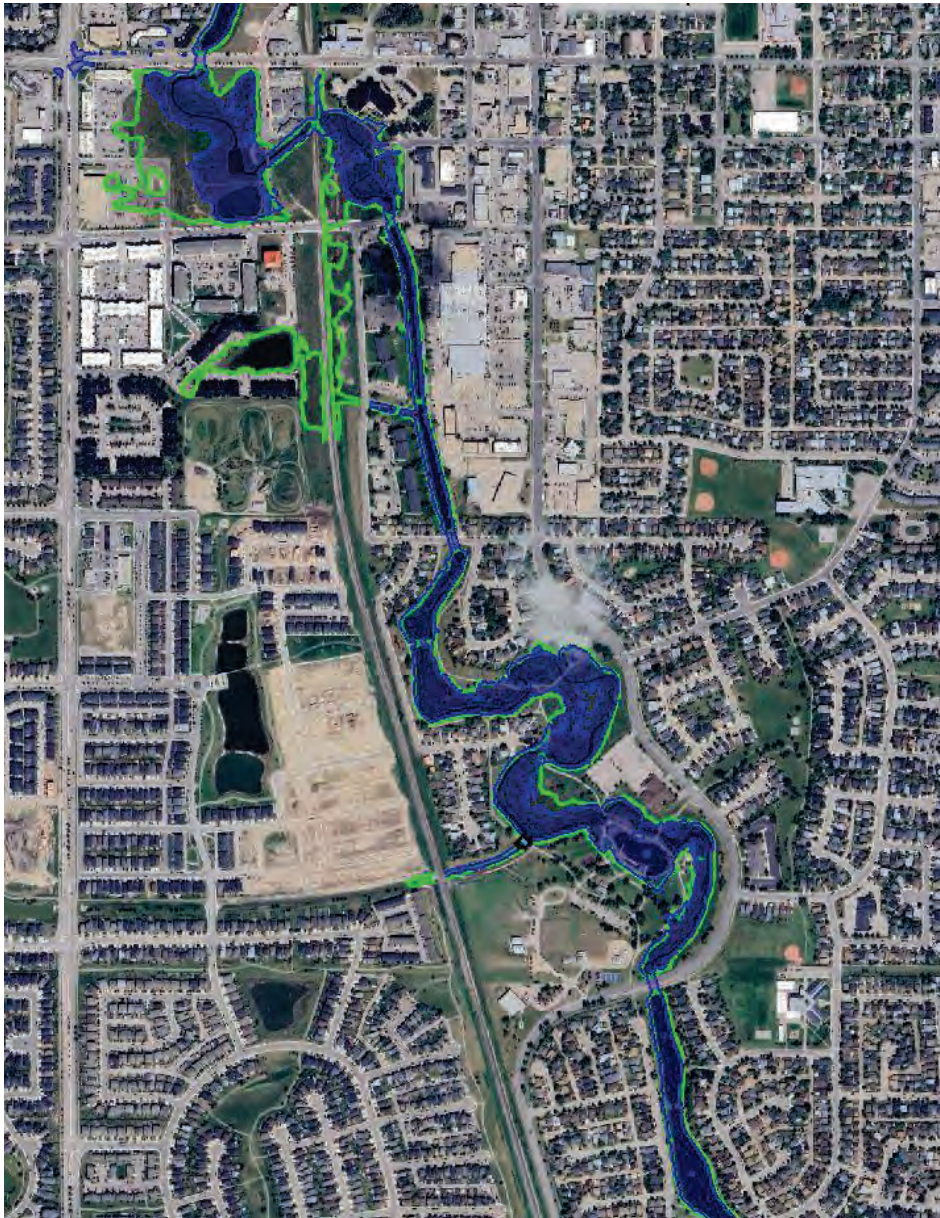
100-year Inundation Extents



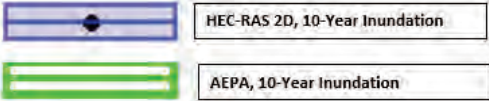
100-year Inundation Extents



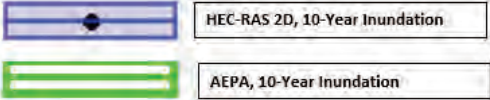
10-year Inundation Extents



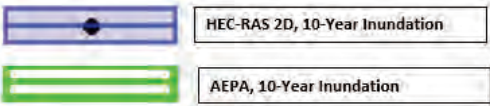
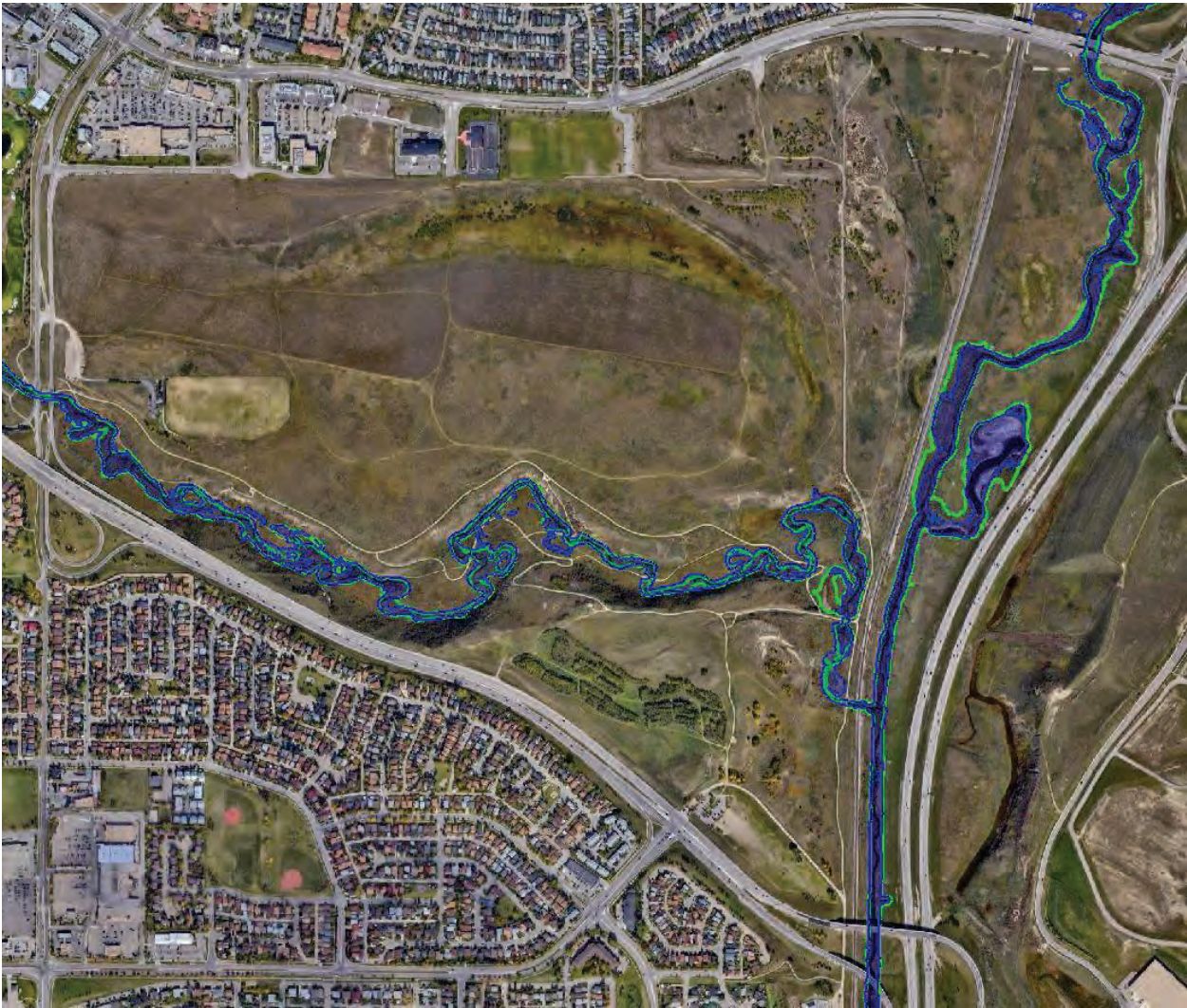
10-year Inundation Extents



10-year Inundation Extents

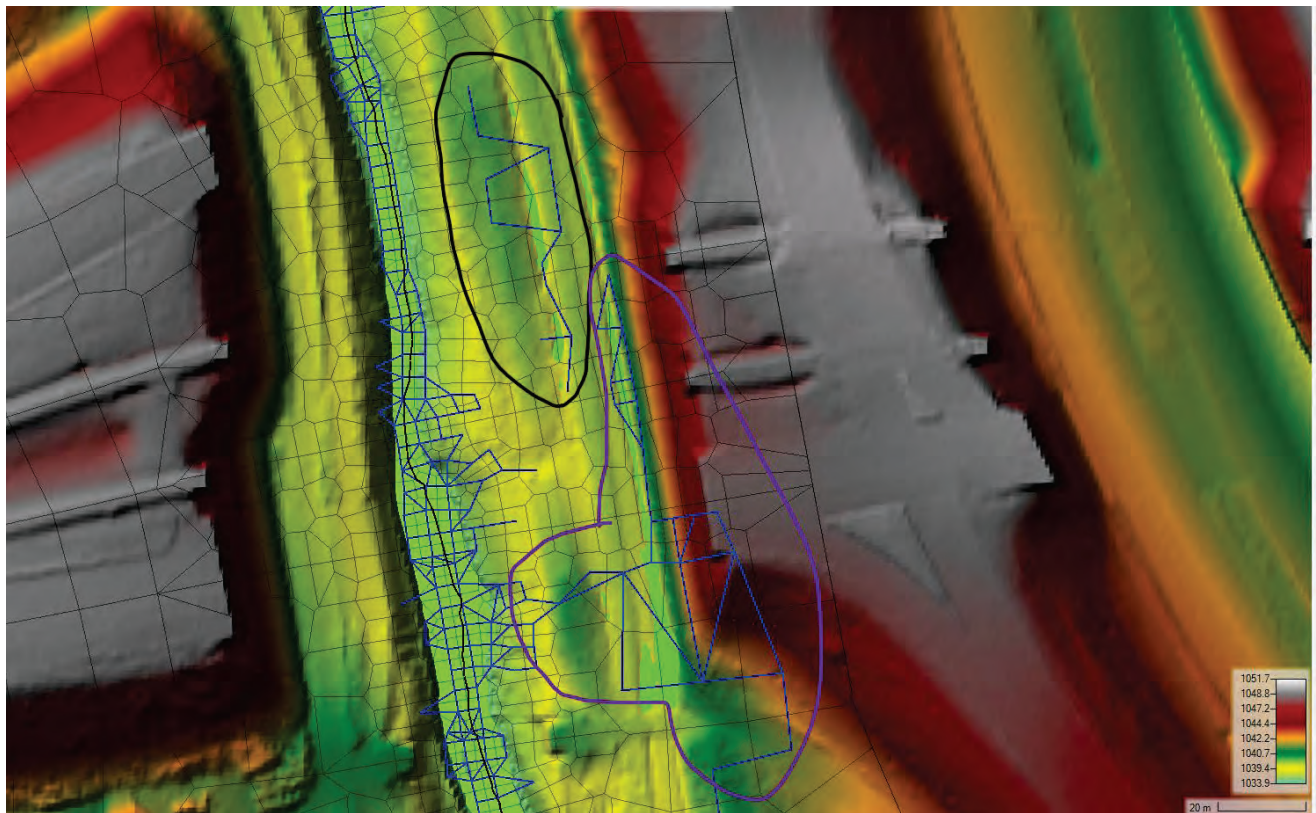


10-year Inundation Extents



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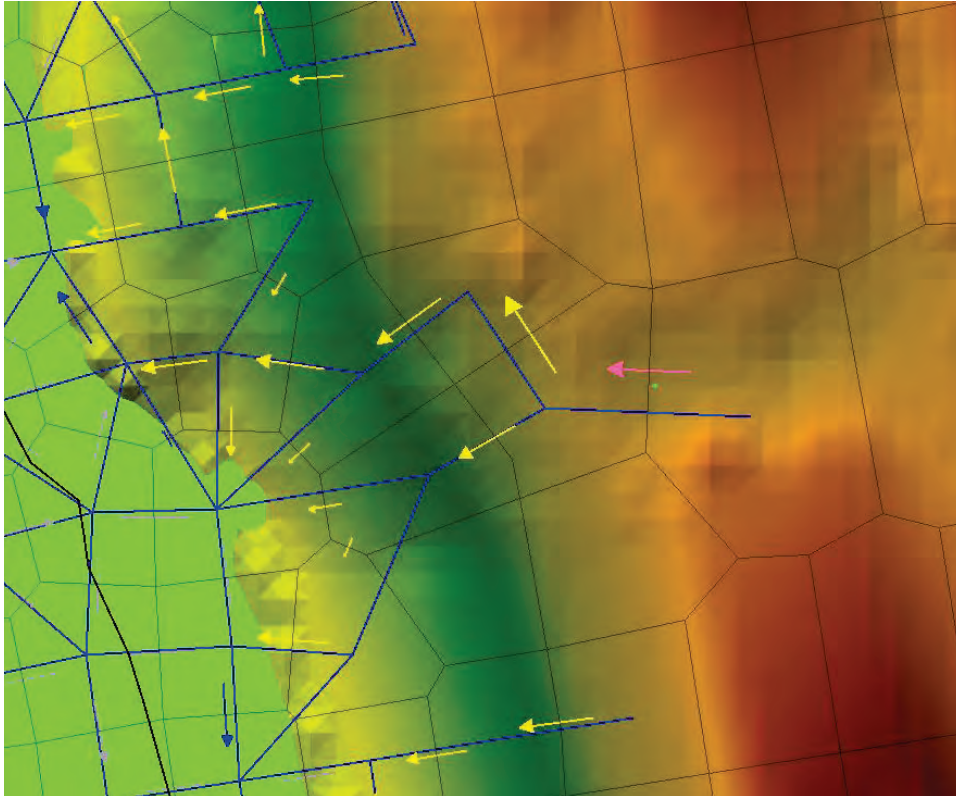
1. For the Figure below, I'm not sure I understand why there is inundation outside of the river channel. This is from the NC_2D_LF2 run (LF1 is the same) (station 11170 m of nose creek confluence to Mouth). I have turned on the 2D hydraulic connectivity lines, and the area circled in black is not connected in any way. Is this because the run that made the restart file was at a higher flow that it was inundating this area? Even the part circled in purple doesn't seem to make sense. I zoomed into the part where the connectivity occurs to the flood plain and looked at the water levels and terrain, and it doesn't seem like it should have gone across. My only thought is that it has to do with the restart file.



Response:

See response to comment #4.

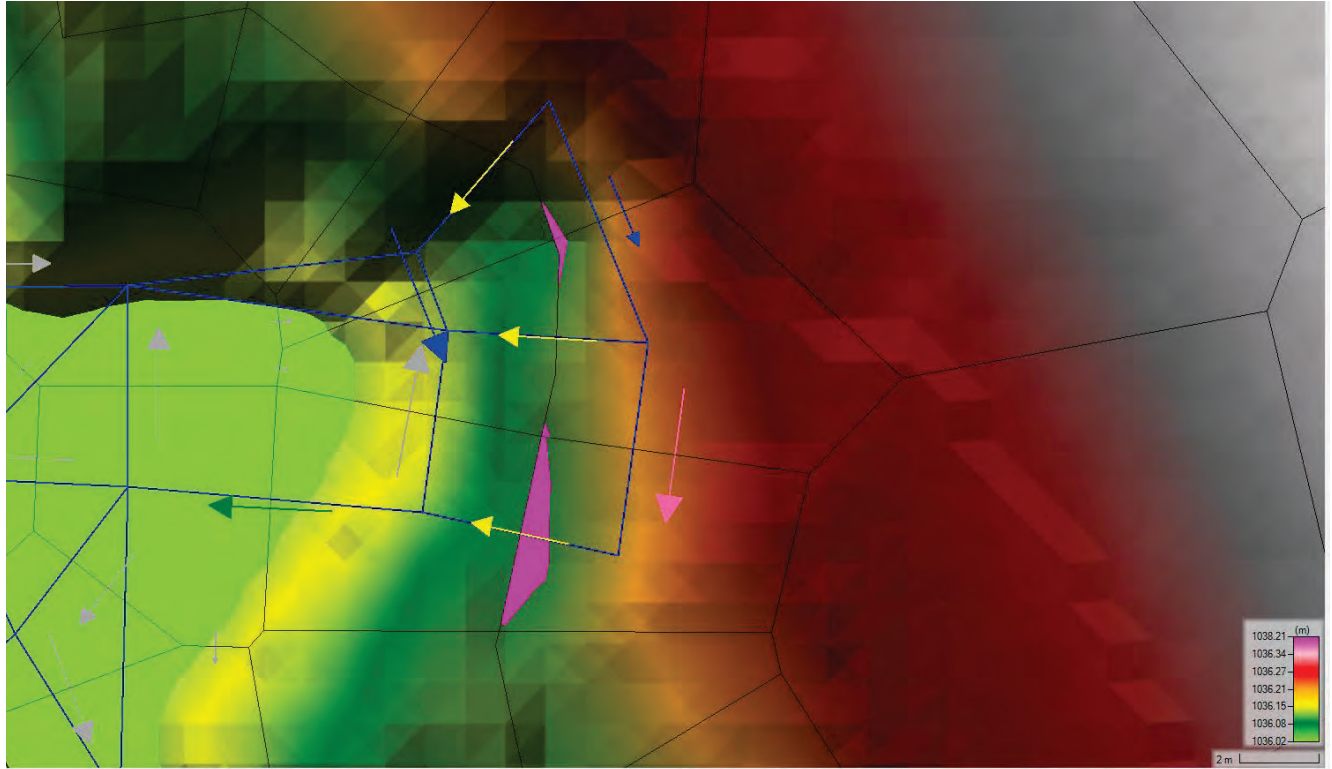
- Below is another further zoomed in image (stn 11175) showing the water surface gradient arrows, and you can see the pink arrow saying that it is flowing into the river channel and not the other way around, so it seems like that dot of water was already there at the beginning of the model run (i.e., from the restart file?). I don't want the model package to be super cluttered, but it might be beneficial to have the plans/flow files/runs that created the restart files.



Response:

See response to comment #4.

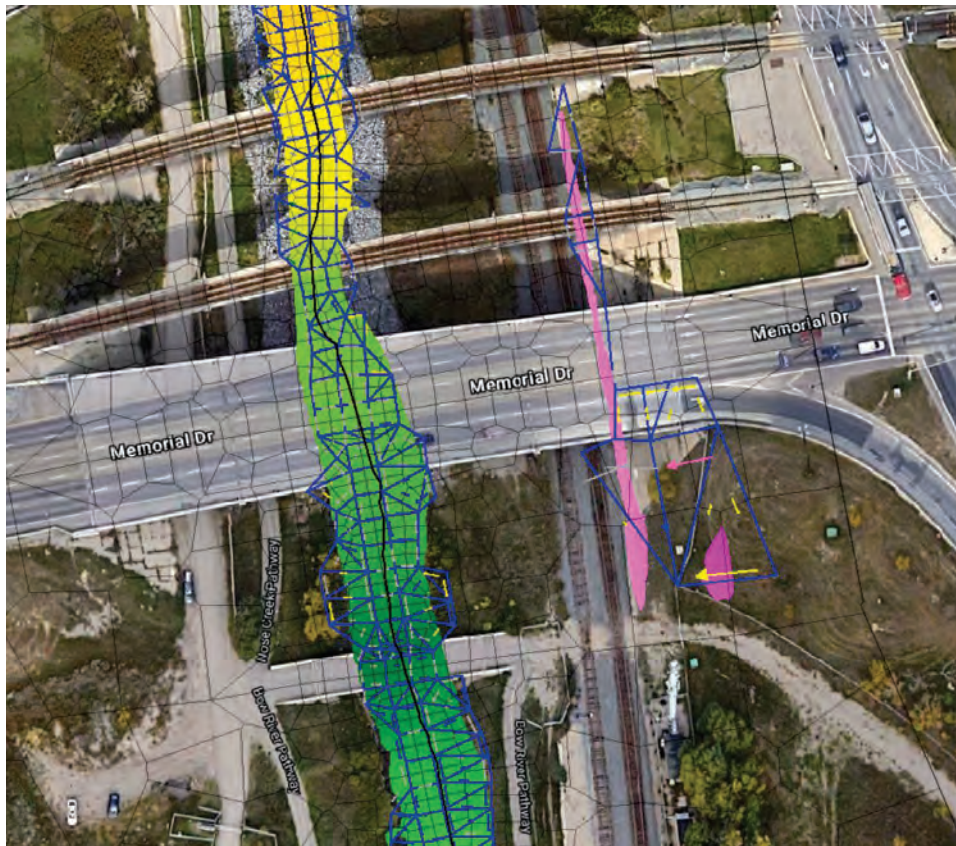
- Below is another example (nose creek confluence to mouth – station 9800) of where it seems like maybe there was water from the restart file, but in this case, it seems like the water should flow back into the river through the model run based on the terrain elevation, but it never does. Is this because the model run isn't long enough for the water to have flowed back to the river?



Response:

See response to comment #4.

- I took another step and ran the model without the restart file and extended the model run period so that it would get all the way to the mouth where at the mouth the flow is ~15 cms, and there is still flow outside of the banks that just appears and also doesn't have connection to the river from the hydraulic connectivity view. See screenshot below by memorial drive. Does Barr have any idea what is going on here? There are a few other places in the model where this happens. There is no boundary line in the area where you are adding flow from off the side of the channel or anything either. I don't know if we need to have outputs at a finer timestep perhaps to see what is happening, but there definitely shouldn't be any flow in the area in the image below at a flow of 15 cms.

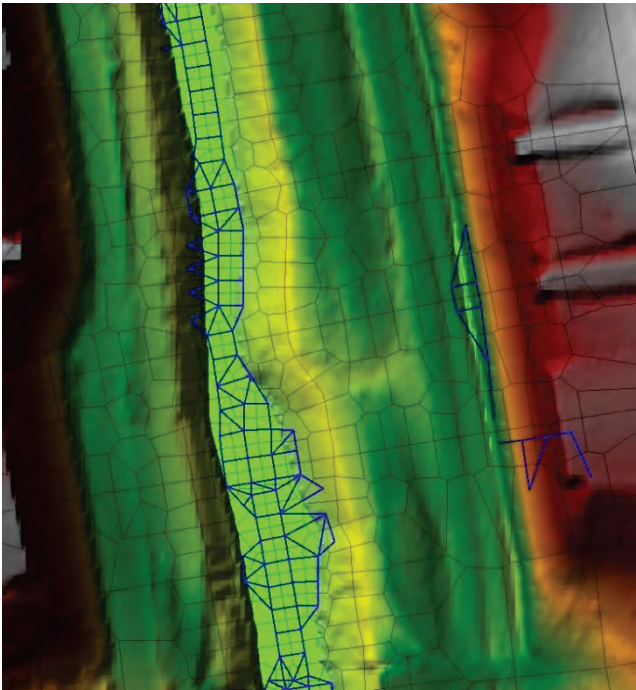


Response:

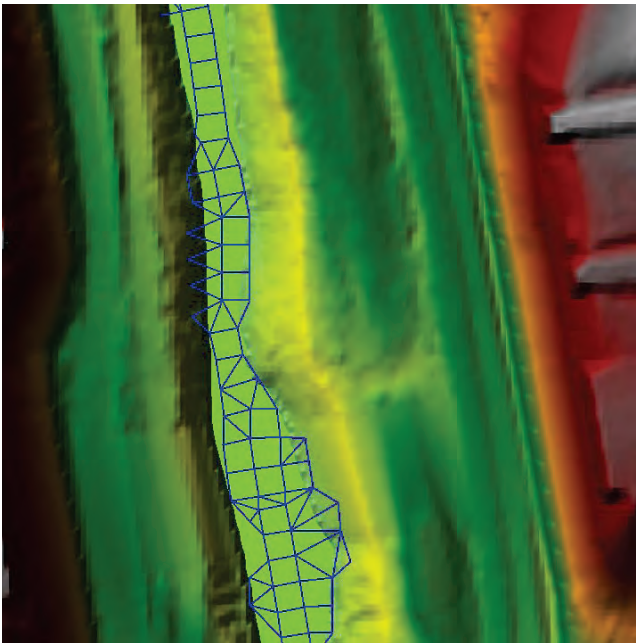
The majority of the disconnected inundation is the result of the initial conditions and restart files utilized. There are, however, approximately 10-15 locations within or connected to bridges that are not caused by initial conditions or a restart file. Barr believes that these disconnected inundation polygons are a HEC-RAS issue with plotting of inundation at bridges. As you can see in the two captures below, the first is a model with bridges, while the second is a model without bridges.

Note that this will not impact the overall model results (i.e., water levels or velocities). For any mapping exercises, cautious should be practiced for such regions and they should be removed manually.

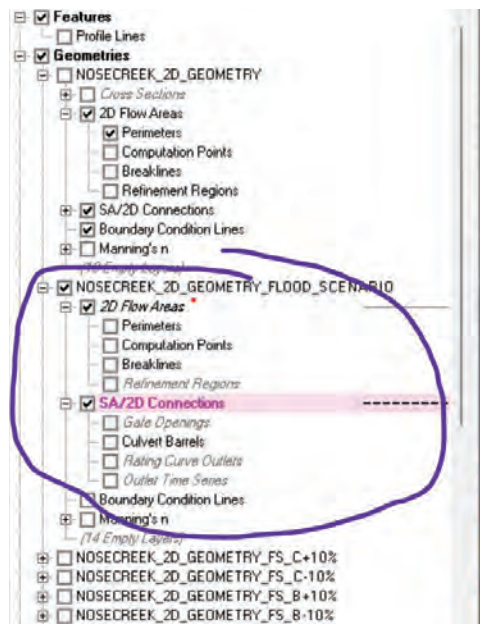
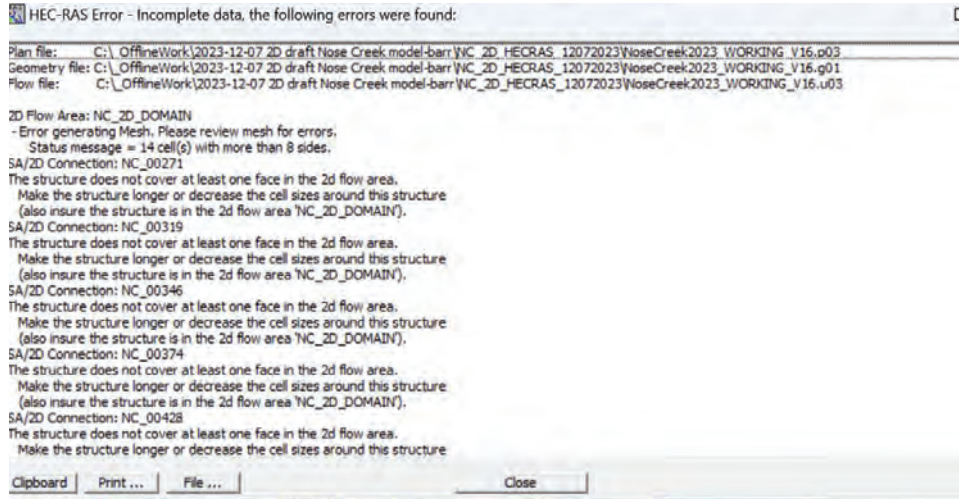
Bridges included:



Bridges removed.:



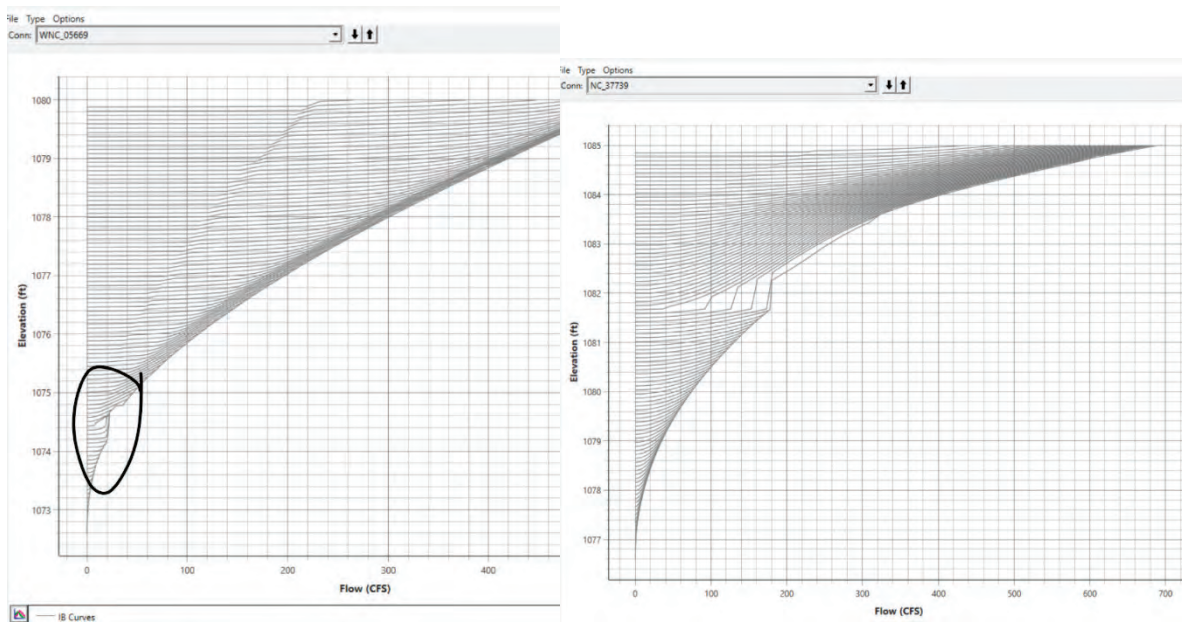
5. I tried running the 1000 yr (NC_2D_1000yr_SWE_ plan and it does not start computations. The model gives errors about cells having more than 8 sides and a lot of errors about SA/2D connections. I also noticed that there is a separate geometry for the flood scenarios. Why is there a separate geometry. How is it different from the main geometry file? It was not mentioned in the report at all. See screenshots below:



Response:

The flood scenario geometry has recomputed and will need some minor adjustments by Barr to provide a working model. These adjustments have been completed for the final package submittal. In terms of the multiple geometries, the two geometries are identical with the exception of boundary condition inflows. This was done to make the model geometry and flow file cleaner.

6. I recall the previous draft model (the one from September) there were 5 or 6 locations (at SA2D connections) where there were some instabilities. I think it was mentioned as well in this draft report that there are still a couple of locations with minor instabilities. I took a look at some of the bridge family of curves and it seems like for most of them the headwater maximum elevation in the htab parameters has been entered with a very high elevation. I wonder if using a lower max elevation could help with having more curves over a smaller flow range to maybe make the curves a bit smoother and have less discontinuities and maybe make things more stable. Or perhaps consider if the expansion/contraction coefficients should be adjusted from the typical bridge section values (0.3/0.5) you've used to something else if the transition is more gradual or abrupt. See image below for some bridge curve examples. For some reason it is showing the bridge curves with feet and cfs, but I think that is maybe a bug in version 6.4.1 and is just a labelling issue. The first image below shows a curve for a WNC bridge, the flow goes above 400 cms which is way higher than it needs to be. The second image is of NC37739 which was a connection that Barr had identified as having stability issues in the September draft model and you can see that it is not very smooth in the 100-200cms range



Response:

The right curve is at the low chord of the bridge, this transition is expected. A sensitivity analysis was conducted reducing the vertical scale of the Htab parameters, and it was found to make no significant difference to model results and 2D connection stability.

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1. We noticed there are small patches applied to the Terrain at culvert crossings/connections. It would be ideal to provide rationale. It is common to modify terrain at bridge locations to remove the bridge deck from the LiDAR. However, we are interested to know why the terrain was modified at culvert connections as well.

Response:

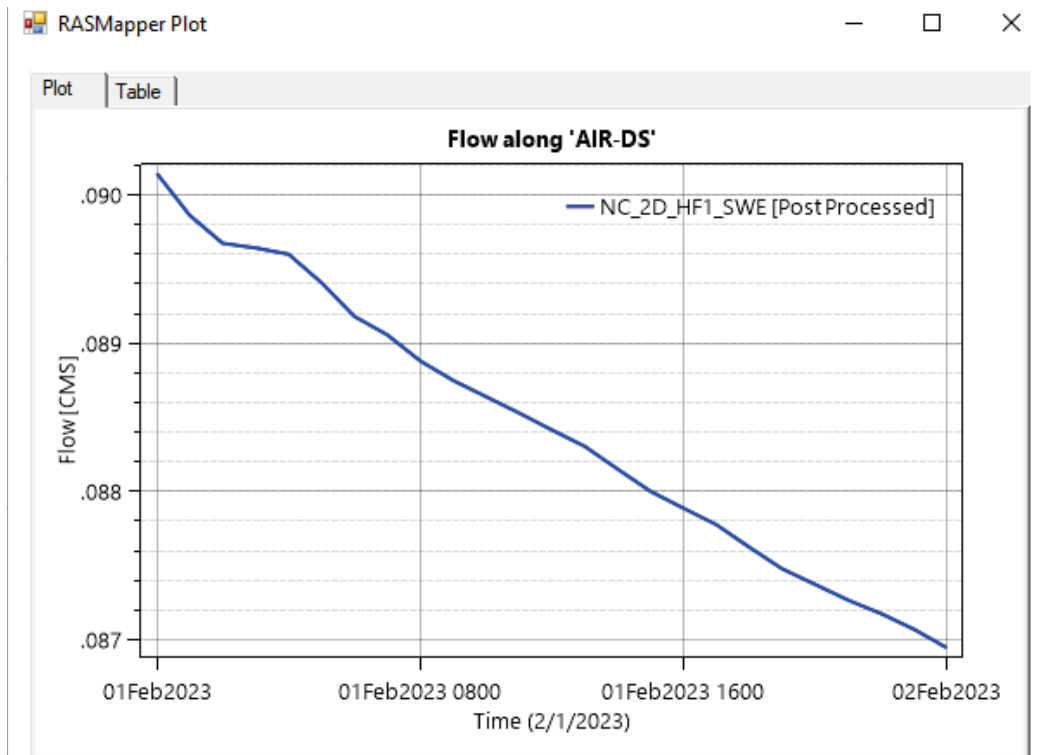
The terrain modifications were used to match terrain surface at the culvert inlet/outlet to match the surveyed values. This was done to pass low flows through the culverts and improve model stability.

2. Regarding our comment from the previous review of the model, about using channel centerline as a breakline to generate Mesh, Barr provided a response that they used refinement regions as a method to define the channel. Our understanding is that channel centerline can be used as breakline to generate Mesh for refinement regions as well. This is not compulsory but recommended by HEC-RAS developers for generating mesh. It gives a much better cell alignment within and along the channel.

Response:

Discussed with project team and only included in lower Nose Creek reach due to cell size/number optimization (this is included now in the report Section 4.2). Barr also performed a sensitivity analysis on a clipped version of the model (i.e., centerline as breakline versus refinement region) and the water level difference for the length of the clipped model was negligible.

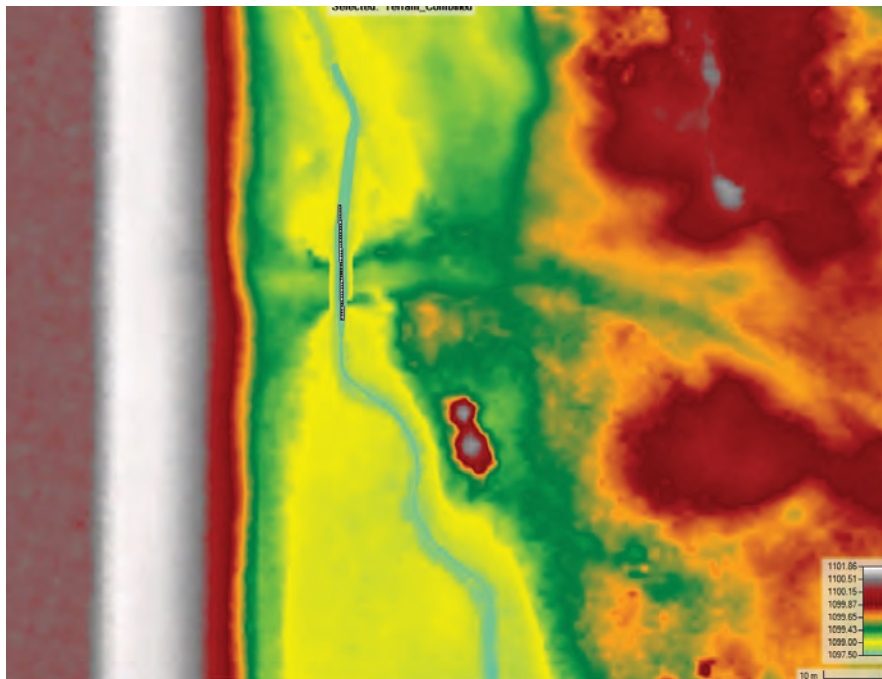
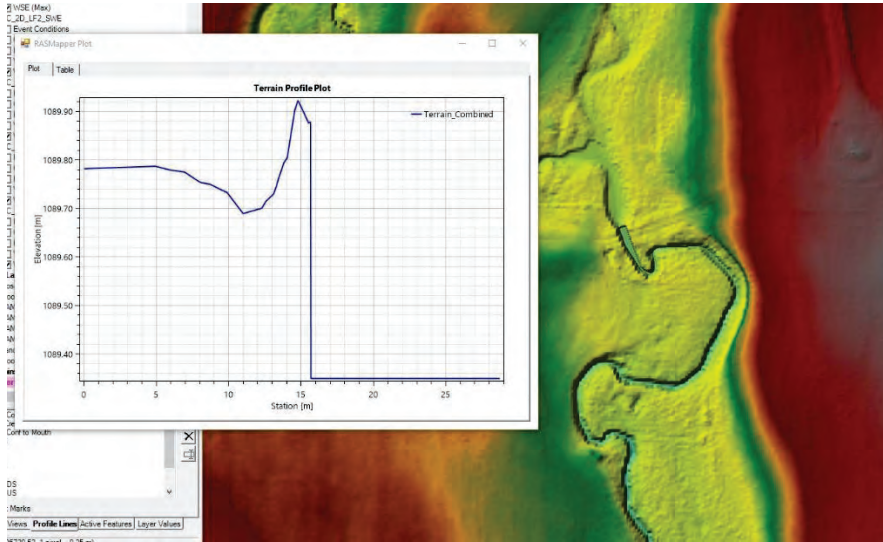
3. Please check the HF1 scenario. It seems the flow did not reach stability near AIR-DS calibration point location.



Response:

Although the flow is still decreasing, the left axis is representing a small change in flow. Additionally, this change in flow is likely not to represent any significant change in water surface. Therefore, the decision was made to accept these results given the lack of change in water levels and long simulation time. Note that future users can run the model for longer duration, if needed.

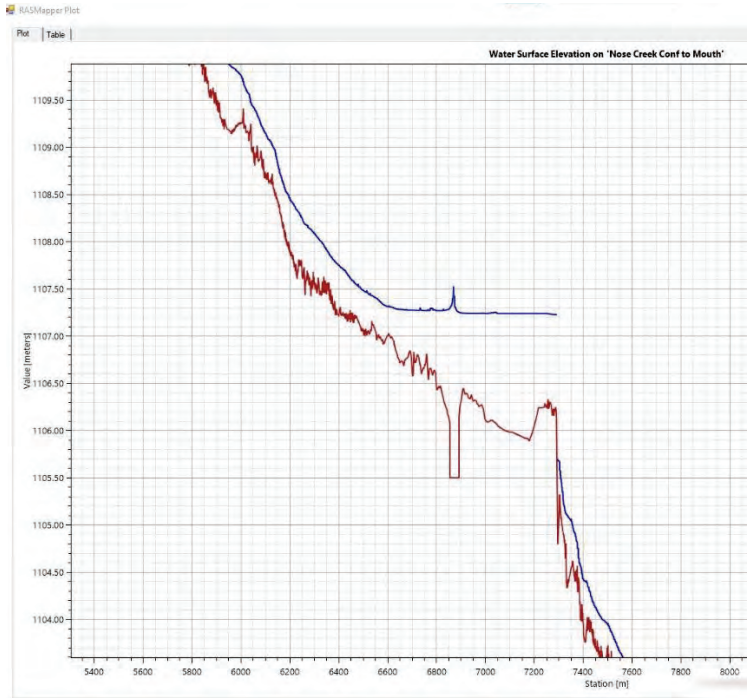
- We noticed a long patch (~100 m) of smoothed DEM surface with lower elevation was applied to the Terrain near the Effluent Storage Pond west of Crossfield, at NC 65236 culvert connection. There is a spike in elevation followed by a drop of ~0.45 m (please see the screenshot below). Is there a reason why a long patch of lower elevation was applied to the Terrain? Has it been mentioned in the report? Was the terrain modified with other similar long patches at other locations as well? It would be nice to briefly mention those in the report for better clarity.



Response:

Water was not passing through this segment of the model as described in comment 1. An artificial notch was added to pass water through this problematic area for very low flow conditions. The notch used was an attempt to resolve the issue while maintaining as much surveyed terrain as reasonable.

- If the WSE is plotted for HF2 scenario using 'Nose Creek Conf to Mouth' profile line, it shows a spike in WSE at ~6850 station (m). WSE rises by ~0.20 m and drops by ~0.25 m. It's at NC 67566 culvert connection, flows seem unstable during HF2 and HF3 scenario runs.



Response:

It is acknowledged that some instability is occurring at NC 67566. This instability does appear to spread far from this connection in the model. As this connection is in a remote area of the model it was decided that the connection could remain. However, if additional stability is required, a rating curve was developed and could be implemented in the model, as shown below.

Connection Structure Outlet Rating Curve

Outlet Rating Curve Name (32 chars max):

Stationing along structure for outlet flows:

Outlet Width:

Outlet Flow Computed as Function of Upstream:

Water Surface

Flow

Outlet Rating Curve		
	Reference WS Elev	Outlet Flow
1	1105.7	0
2	1107.25	1
3	1107.7	5
4	1108.62	15
5	1110.1	50
6		
7		
8		
9		

Plot Curve ...

GIS Coordinates

Connection Data Editor - NOSECREEK_2D_CLIPPED_RATING_CURVE

File View Options Help

Connection:

Description:

Connections

From:

To:

Weir Length:

Centerline Length:

Overflow Computation Method

Normal 2D Equation Domain Use Weir Equation

Structure Type:

Flap Gates:

NC_67566

Elevation (m)

Station (m)

Outlet RC

Legend

- Spillway
- Extend/Trim to Face Points
- HW Cell Min Elev
- TW Cell Min Elev
- Current Terrain

Round 2 of the HEC-RAS Report Review

Number	Report Section Number	Author	Affiliation	Comment	Barr Response
1	Acknowledgement	Sandi Riemersma	Palliser	Since this report strictly relates to the HEC-RAS model, acknowledging only Jon and Andy here will highlight their contribution specifically.	Agreed.
2	Executive Summary	Andrew Huang Phil McMechan	CoC	not sure if we need/want this report to detail the 1D/2D model. anyone else have thoughts? @McMechan, Phil @Slaney, Jonathan I think it's worth documenting the decision making process	No action was needed.
3	Executive Summary	Andrew Huang Andrew Huang Andrew Huang Phil McMechan	CoC	I think it may be best to not explicitly refer to using the 1:10, 1:100, 1:1000 AEP flood frequency values, as we don't want to confuse anyone of these replacing the AEP flood inundation maps, and particularly their Flood Hazard map product. Maybe we can just state the max flow values for Nose Creek at the mouth and call them "medium", "very high", and "extreme" event. @McMechan, Phil @Slaney, Jonathan what do you think? if agreed about comment above, should change wording throughout the entire document. reading through the other parts of the report, I think it may be hard to not just use the return periods. I just want to make sure others within the NCWP aren't going to take this model and ignore the AEP official flood hazard floodway info if they are doing something that needs regulatory approval relating to the water act... I agree that we should avoid using return periods. The flow values used are unlikely to correspond to the results on an updated hydrology analysis	In meeting on January 17, 2024, Barr and NCWP agreed to use "high", "very high", and "extreme" instead of 1:10, 1:100, and 1:1,000 AEP. This has been updated throughout the report.
4	Executive Summary	Sandi Riemersma	Palliser	Note EPA is the correct term now (Environment and Protected Areas)	AEP here refers to annual exceedance probability. This is noted in the list of abbreviations. I rejected your edits for this in other parts of report.
5	Executive Summary	Phil McMechan	CoC	Replace with actual flows	Done.
6	Executive Summary	Phil McMechan	CoC	Replace with actual flows	Done.
7	1	Andrew Huang	CoC	somewhere in the report it should state what version of hec-ras was used in the model development.	Added in Section 4.
8	1.2.1	Andrew Huang Sandi Riemersma	CoC Palliser	there is no AEPA, 2000 in the references. AEPA's current name has only existed for ~1 year. Should it be Alberta Environment, 2000? Were they AEP then? Alberta Environment and Parks?	Yes, Alberta Environment.
9	1.3	Andrew Huang	CoC	I think all of these AEPA, 1983 should be changed to Alberta Environment 1983? There is no AEPA 1983 in the references. they were called Alberta Environment in 1983.	Yes, Alberta Environment.
10	1.2.3	Sandi Riemersma	Palliser	Please also reference the 2013 flood in this section.	Through our review of past technical documents and online news letters, it seems that NC and WNC did not experience a major flood in 2013.
11	2.1	Andrew Huang	CoC	what is the vertical datum of the elevation data? was the Lidar and survey data all the same vertical datum? if they weren't, was one converted to the other, merged together to create the terrain surface that is in the HEC-RAS model?	Survey data collected by the Compass is in CGVD28. We have confirmed this with compass that composite surface was in the same datum.
12	3.1	Sandi Riemersma	Palliser	Format this figure to fit full page so that text is easily readable.	This is a full page map in the PDF file.
13	3.9.3	Sandi Riemersma	Palliser	Typo	Corrected.
14	4.1	Sandi Riemersma	Palliser	EPA	AEP here refers to annual exceedance probability. This is noted in the list of abbreviations.
15	4.3	Andrew Huang	CoC	please put together a table of the locations of the instabilities so users in the future can be aware and easily identify them	Table 4-3 is now added to address this comment.
16	4.6.1	Andrew Huang	CoC	not sure I understand what this is saying	There are arms of flow paths or tributaries that are inside the model domain. A minimal flow was assigned at those locations.
17	4.6.1	Phil McMechan	CoC	This is very hard to read	This map is a full page map in the PDF file. The table is also included in Appendix C.
18	4.6.2	Phil McMechan	CoC	I think a figure as to where these areas are might help me understand this (or adding them to figure 4-5)	They have already been shown in Figures 4-5 and 4-6. I references them in this sentence accordingly.
19	4.6.3	Phil McMechan	CoC	Using the 1:10, 1:100, and 1:1000 as the range where we want the model to work is the agreed upon approach, but absent a new hydrologic assessment I do think we should refer to them differently. At some point I expect AEPA will probably update the flood mapping for Nose Creek and it would be mutually beneficial for the Partners and AEPA to share this reporting with them. I anticipate they may come up with different numbers for the overall flood discharges and the distribution of flows within the modelled domain. If we call them "high, very high, and extreme flow" (or something like that) I think we can avoid conflict that may arise when comparing the results	In a meeting on January 17, 2024, Barr and NCWP agreed to use "high", "very high", and "extreme" instead of 1:10, 1:100, and 1:1,000 AEP. This has been updated throughout the report.
20	5.2	Andrew Huang Sandi Riemersma	CoC Palliser	while reviewing the model, I had noticed that the Barr had the location of the Nose Creek at mouth gauge station incorrectly identified. The actual station is further upstream. I had sent Sandi the correct coordinates. This would likely make the numbers you have for your calibration results (it would likely make the results better). Have these tables been updated to incorporate the correct location? Andy's email was forwarded to Barr on December 5 noting the correct location of the NC at mouth gauge station.	We have not received your email on December 5, Sandi. We have updated the report based on Andrew's comment.
21	5.2	Andrew Huang	CoC	I checked the model and the simulated WSE for the correct SUR_NC-M location is 1035.5 m, so the difference is -0.2 m	We updated the results and stats in the report. This helps with our calibration results.
22	5.2	Andrew Huang	CoC	the simulated WSE at the correct SUR_NC-M location is 1035.35m, so the difference is -0.2 m	We updated the results and stats in the report. This helps with our calibration results.
23	5.2	Andrew Huang Sandi Riemersma	CoC Palliser	this is not the case. you just have the location of the gauge at the incorrect location. I sent Sandi the actual location, and the numbers match up much better as I've noted in the tables above. Our past analysis, there is no backwater effect from the Bow at average bow flows. Andy's note was circulated to Barr on December 5, 2023.	We have not received your email on December 5, Sandi. We have updated the report based on Andrew's comment.
24	5.2	Andrew Huang	CoC	should we change the word "high" flow? It isn't actually very high. We get these flows almost yearly. maybe call it "Moderate" flow?	In a meeting on January 17, 2024, Barr and NCWP agreed to use "moderate" instead of "high".
25	5.3	Andrew Huang	CoC	It doesn't appear the tables have been updated to reflect the correct location of SUR_NC-M. if I look at the simulated water level at the correct location, it is 1037.18 m. this would mean the difference value should be +0.14 m (much better than -0.41 m)	We updated the results and stats in the report. This helps with our calibration results.
26	5.3	Andrew Huang	CoC	For this run, the SUR_NC-M simulated WSE is 1036.58 m at the correct location. this would mean the difference value is +0.02 m (not -0.46 m)	We updated the results and stats in the report. This helps with our calibration results.
27	5.3	Andrew Huang	CoC	correct SUR_NC-M location's simulated WSE is 1036.08 m, and difference would be -0.09 m	We updated the results and stats in the report. This helps with our calibration results.
28	5.3	Andrew Huang	CoC	same as earlier comment. you have the location of the nose creek at mouth gauge in the wrong place. calibration results are actually pretty good. There is not backwater effect from the Bow when flows are average on the Bow	We updated the results and stats in the report. This helps with our calibration results.
29	5.4	Andrew Huang	CoC	Are all of the elevation data in the same vertical datum? For the 05BH014 station, they are using CGVD2013e2010. For the City gauge data, we use CGVD28. The City still hasn't moved to CGVD2013 (as far as I know). What is the vertical datum of the Lidar data/bathymetry data? I you received Lidar data from the City, it is likely in CGVD28. Not sure what vertical datum outside of Calgary would have been... I believe differences between CGVD28 and CGVD2013 can be 10 to 15 cm in the Calgary area	Thanks for the comment and pointing out the different datum for 05BH014. We have corrected that and updated the stats. This helps with the calibration results.
30	6	Phil McMechan	CoC	Is this throughout the whole model, or at a single location? If this is a location near a hydraulic control or boundary condition it might not be a very meaningful analysis...	Throughout the whole model. We added some texts to comment on most sensitive reaches in both streams.
31	1	AEPA		It'd be ideal to clearly state the purpose of the study and the necessity of developing the model in the introduction.	Texts are added to the intro to highlight this.
32	7	AEPA		We suggest revising the section heading of "Section 7" to avoid any confusion with the Provincial Flood mapping program.	We kept the title as it refers to infrequent flood simulations, however, made changes throughout the report and now we are not referring to flood frequencies. In a meeting on January 17, 2024, Barr and NCWP agreed to use "high", "very high", and "extreme" instead of 1:10, 1:100, and 1:1,000 AEP. This has been updated throughout the report.
33	-	AEPA		We understand that the final deliverable is a 2D model instead of a 1D/2D coupled model. We suggest removing the portion of the report that indicate 1D/2D model preparation or make it concise.	See response to comment #2.
34	-	AEPA		A separate readme file containing a table of model scenarios and associated Plan and Geometry files was provided to RETS. It would be useful to include this information in the report (e.g., as an Appendix).	We included that as Appendix H to the report.
35	8	AEPA		The conclusion section is brief and may needs revisions to align with the introduction.	The reason we kept it concise was to avoid repeating the texts, especially from the Executive Summary section.
36	-	Emily Chen	AEPA	The only recommendation I'd like to make is that it'd be ideal for Barr to compile RETS's comments from last review (made on October 2nd, 2023) and this review to prepare an Appendix (called i.e. reviews and responses) to the final report as a record. Currently the responses are in a separate spreadsheet. It would be easier for reviewer to keep track of the communication if information is in one document.	We included that as Appendix I to the report.