Merritt
FLOURISH UNDER THE SUN

# FINAL REPORT

## Flood Mitigation Plan

Project Number: 2021-2385-02
November 2022

Associated Engineering

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# EXECUTIVE SUMMARY

The **City of Merritt** (the City) is located within the Thompson Nicola Regional District (TNRD) in the southern interior region of British Columbia. Listed alphabetically, the study area is encompassed by the traditional territories of the Nlaka'pamux (Thompson), the Secwépemc (Shuswap), and the Syilx (Okanagan) Nations. The City is situated at the confluence of the Coldwater and Nicola Rivers. Both rivers flow through the administrative boundary of the City and pose a significant flood risk.

A severe flood occurred on November 15, 2021, when an atmospheric river event (the AR event) resulted in extreme flows in the Coldwater River. The AR event caused extensive flooding and destruction in Merritt; homes, parks, roads, municipal water, wastewater and stormwater infrastructure, electrical infrastructure, and gas infrastructure experienced severe damage, and the entire City had to be evacuated due to failures of critical infrastructure.

Although the City has some existing dikes, these flood defences did not protect the City against the magnitude of flow in the AR event. Floodplain mapping completed following the AR event shows that a 200-year flood could pose an even greater risk to the City. As such, the City of Merritt requires a comprehensive plan to mitigate the risks of future flooding to the City and its residents.

Although the initial response focussed on the emergency flood response and recovery due to the AR flood event on the Coldwater River, it is important to note that the Nicola River also has a history of flood-related problems. The Nicola River was not affected by the AR event, but as recently as 2017 and 2018 there have been freshet events in the Nicola River that caused flooding issues in the City. Therefore, a comprehensive flood mitigation plan for the City of Merritt must consider flooding on both the Coldwater and Nicola Rivers.

**Associated Engineering (B.C.) Ltd.** (Associated) was retained by the City to provide hydrotechnical engineering services during the emergency flood response after the AR event. Associated continued to support Merritt with flood recovery efforts, which included the development of a flood mitigation plan and assistance with funding. The main project scope of this report is to:

- prepare conceptual options for a comprehensive flood mitigation plan that will protect the City against riverine flooding (including climate-change impacts); and
- refine the options into a single preferred option that could be used to secure funding for the various stages of project implementation, from design and permitting through to construction.

To complete the project scope Associated worked on preliminary investigations, including hydrology and climate change assessments, hydraulic modelling of the rivers, environmental overview, archaeological overview, and contaminated sites assessments.

Community engagement was also completed that included two open house events, online public survey, and presentations. This work supplemented pre planning activities carried out by the City that involved online engagement through social media and the City's website. This engagement will continue as the project continues into detailed design and construction phases of the flood recovery effort.

First Nations engagement has been initiated and will be ongoing for the project. Pre-planning engagement work has been done, but the City acknowledges that there is still work to do and is committed to completing post-planning and detailed design engagement.

Flood mitigation planning includes consideration of non-structural and structural measures. Non-structural measures include things like planning, public awareness, and monitoring. Structural measures are infrastructure improvements such as diking and conveyance improvements. There are various types of dike structures and each type can be considered for various situations. For example, where there is adequate space available an embankment dike is typically used. Alternatively, where there is limited space available a narrow dike can be considered. In addition to these options the alignment of dikes can be waterside (on the river bank) or setback (offset from river bank). Flood mitigation planning in the City considered structural measures and managed retreat areas that allow room-for-the-river where feasible.

The flood mitigation plan for Merritt developed seven conceptual arrangements:

- Option 1: Do Nothing/Status-Quo
- Option 2: Full Floodplain Retreat
- Option 3: Waterside Diking
- Option 4a, 4b, 4c: Combination Diking (combinations of waterside and setback diking)
- Option 5: Combination Diking (this is the preferred option)

Each of the conceptual options were 'built' in the hydraulic model and tested for effectiveness of flood mitigation. Once the hydraulic results were complete, the required infrastructure was summarized for each conceptual option and an opinion of probable cost was developed (Class D). The costs were one of the evaluation criteria to compare options.

To identify the optimal and preferred option, the implicit and explicit requirements and criteria of the City must first be understood. Through discussion with the City, the public and First Nations engagement, and Associated's technical expertise, the following project objective criteria were identified for the flood mitigation plan (listed below). Note that some project objective criteria are important to multiple categories for different reasons and some are mutually exclusive. Associated consulted with the City to fundamentally understand the criteria set out by the City and population of Merritt, and to consider all criteria justly in the options analysis methods that were employed in the selection of a preferred design.

**Economic:**

- **Low Capital Cost** – the ideal design shall minimize the upfront expense of acquiring and constructing the flood mitigation infrastructure.
- **Low O&M Costs** – the ideal design shall minimize the long-term costs associated with operating and maintaining the flood mitigation infrastructure.
- **Limited Property Impacts** – the ideal design shall consider the implications of the affected properties on the City's tax base and planned future land use.

**Recreational and Cultural:**

- **Maintain River Access** – the ideal design shall allow river access for swimming, fishing, observing nature, and other recreational pastimes.
- **Limited Property Impacts** – the ideal design shall minimize the number of properties impacted.

- **Create Active Transportation Corridor** – the ideal design shall extend the existing active transportation corridor (ATC) to create a continuous trail network along the riverbanks.
- **Reduce the Risk of Future Flooding** – the ideal design shall minimize the number of people directly affected by or without essential services as a result of a future high flow event.

**Environmental:**

- **Room-for-the-River** – the ideal design shall allow the river to maintain natural conditions.
- **Environmental Impacts** – the ideal design shall create a net positive impact on the environment; negative impacts shall be excluded from the design where possible.
- **Maintain River Access** – the ideal design shall provide aquatic and riparian habitat access for wildlife.

**Technical:**

- **Provide Robust Flood Mitigation** – the ideal design shall be effective for many years in the face of climate change.
- **Reduce the Risk of Future Flooding** – the ideal design shall protect the City of Merritt in all locations where a breach of the river banks could cause widespread flooding and damage.
- **Ease of Implementation** – the ideal design shall use methods that are commonplace for design and construction. The design shall consider the use, alteration, or removal of existing infrastructure.
- **Room-for-the-River** – the ideal design shall increase the river's capability to manage high flow conditions with the natural floodplain.

An options analysis was completed that included a critical area workshop and multi-criteria analysis (MCA). An MCA is a numerical decision-making tool that considers the relative importance of the project objectives and the performance of each conceptual option with respect to specific performance criteria. MCA's are robust ways to remove bias from decision-making in engineering assessments; however, they are limited by the performance criteria they are built upon and may not consider all the nuances and social implications of each concept as well as more qualitative approaches. An MCA was developed for the project to provide quantitative assessment of all flood mitigation conceptual options.

Through all of the work completed, the City and Associated selected Option 5 as the preferred option. This recommendation was based on the outcome of the options analysis, consultation with the City, feedback from the public, and Associated's professional engineering judgement. Option 5 is a combination of other options and it was developed after the preceding options were developed and evaluated. It is noted that the flood mitigation plan can still be adjusted and details will need to be developed during the design and permitting stage of the project. The opinion of probable cost for Option 5 is $167,677,000, which includes a 30% general contingency amount.

Associated recommends that the City of Merritt proceeds with Option 5 from the flood mitigation plan and requests $167,677,000 in funding from available grant programs or directly from the Provincial and Federal governments. This recommendation is supported by the results of the MCA, the City's preferences discussed during the critical areas workshop, and Associated's engineering judgement. The assessments completed by Associated indicate that this option performs particularly well due to its protection of many properties (and homeowners) and its protection and cultivation of public space and future development.

Next steps of the project include seeking and securing program funding, engagement, refining the plan, engineering design, regulatory approvals, and property acquisitions. The current roadblock to next steps is program funding. The City needs financial support to implement the flood mitigation plan. This is an important hurdle to overcome because the City is still managing recovery work and there are still people greatly affected from the AR event.

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# 1 INTRODUCTION

## 1.1 Project Context

The **City of Merritt** (the City) is located within the Thompson Nicola Regional District (TNRD) in the southern interior region of British Columbia (**Figure 1-1**). Listed alphabetically, the study area is encompassed by the traditional territories of the Nlaka'pamux (Thompson), the Secwépemc (Shuswap), and the Syilx (Okanagan) Nations.

The City is situated at the confluence of the Coldwater and Nicola Rivers. Both rivers flow through the administrative boundary of the City and pose a significant flood risk to the City's 7,000 residents (Statistics Canada, 2022). A severe flood occurred on November 15, 2021, when an atmospheric river event (the AR event) resulted in extreme flows in the Coldwater River. The AR event caused extensive flooding and destruction in Merritt; homes, parks, roads, municipal water, wastewater and stormwater infrastructure, electrical infrastructure, and gas infrastructure experienced severe damage, and the entire City had to be evacuated due to failures of critical infrastructure (City of Merritt, 2021).

Flood damage along Pine Street area and vehicle submerged in Coldwater River avulsion.

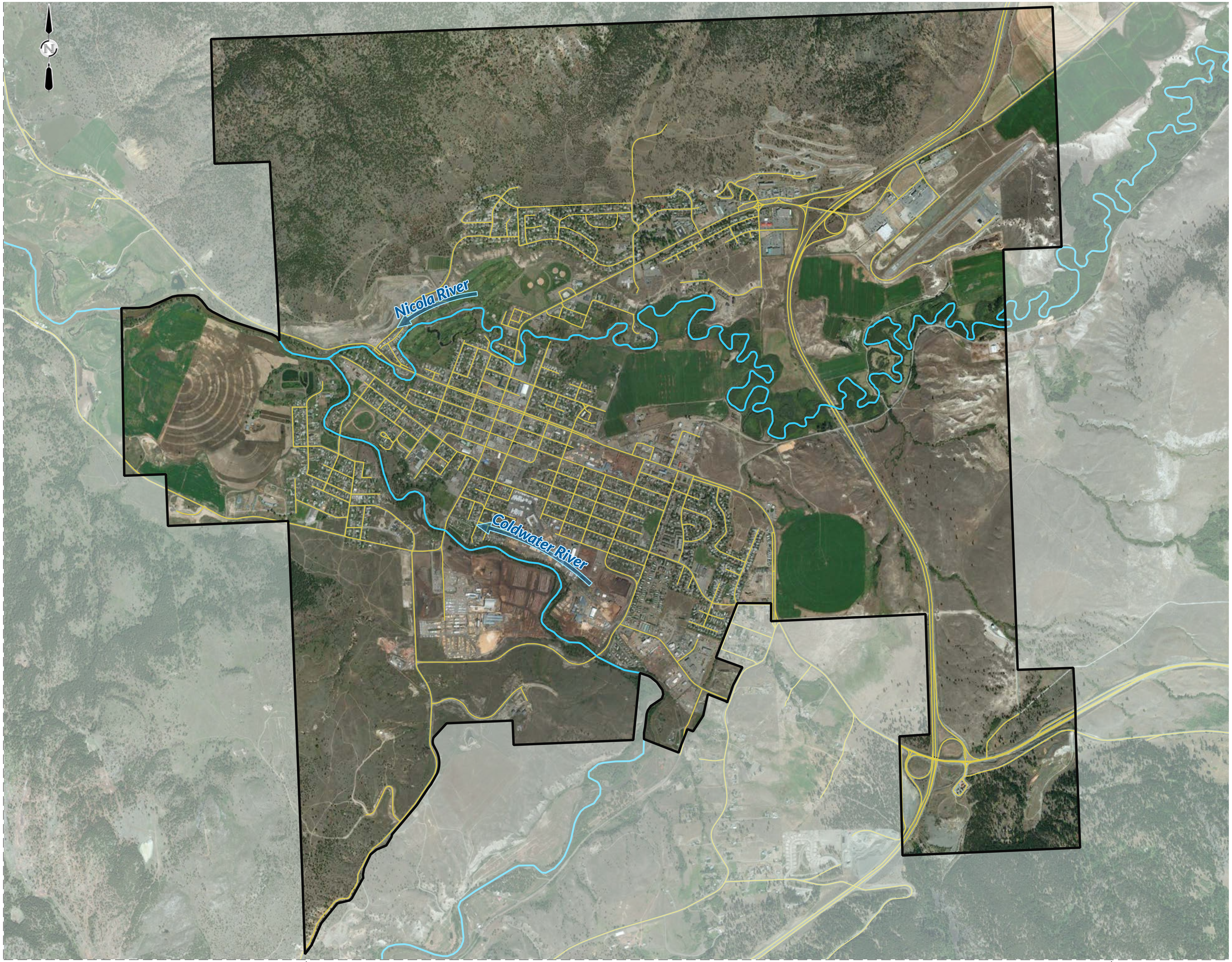
Although the City has some existing dikes, these flood defences did not protect the City against the magnitude of flow in the AR event. Floodplain mapping completed by BGC Engineering Inc. following the AR event shows that a 200-year flood could pose an even greater risk to the City (BGC Engineering Inc., 2022b). As such, the City of Merritt requires a comprehensive plan to mitigate the risks of future flooding to the City and its residents.

Although the recent focus has been the emergency flood response and recovery due to the AR flood event on the Coldwater River, it is important to note that the Nicola River also has a history of flood-related problems. The Nicola River was not affected by the AR event, but as recently as 2017 and 2018 there have been freshet events in the Nicola River that caused flooding issues in the City. Therefore, a comprehensive flood mitigation plan for the City of Merritt must consider flooding on both the Coldwater and Nicola Rivers.

## 1.2 Project Scope

**Associated Engineering (B.C.) Ltd.** (Associated) was retained by the City of Merritt to provide hydrotechnical engineering services during the emergency flood response after the AR event. Associated continued to support Merritt with flood recovery efforts, which included the development of a flood mitigation plan and assistance with a funding application. The main project scope of this report is to:

- prepare conceptual options for a comprehensive flood mitigation plan that will protect the City against riverine flooding (including climate-change impacts); and
- refine the options into a single preferred option that could be used to secure funding for the various stages of project implementation, from design and permitting through to construction.

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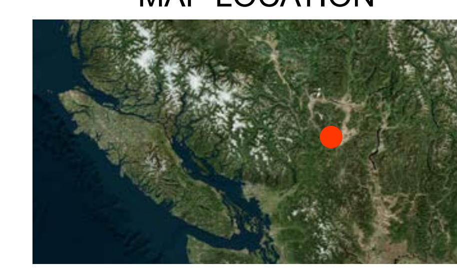
## LEGEND

CITY BOUNDARY
WATERCOURSE
ROADS

0 300 600 900 1,200 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



Merritt
FLOURISH UNDER THE SUN

FIGURE 1-1 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
LOCATION PLAN

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Associated prepared seven options for consideration, which included a 'do nothing/status-quo' option, a complete buyout of the floodplain, as well as several alternatives that comprised combinations of setback diking and waterside diking. This report describes the suite of options that were presented to the City as well as the engineering, various assessments, and cost estimates that were completed by Associated to inform and evaluate the options. A preferred option was finalized in consultation with the City after both public and First Nations engagement was completed.

Aerial view of Pine Street and Coldwater River avulsion after the river was moved back to its original channel.

The preferred option includes structural flood mitigation measures, floodplain retreat areas, and is intended to maximize flood resilience while minimizing the impacts to the City and its residents. Essentially, the preferred option is intended to be the most cost-effective solution that also balances social, environmental, economic, and technical concerns. It is expected that this preferred option will be further refined in future stages of the project.

## 1.3 Next Steps

The City is seeking financial support to implement the conceptual flood mitigation plan. Although the City meets the applicant eligibility criteria for the federal government's Disaster Mitigation and Adaptation Fund (DMAF) and had planned to submit the comprehensive flood mitigation plan in July 2022, the intake has been postponed indefinitely by Infrastructure Canada. The City is currently communicating with the Minister of Intergovernmental Affairs, Infrastructure and Communities to secure alternative sources of funding to allow the City to move forward with the implementation of the flood mitigation plan.

As noted above, the flood mitigation plan presented in this report is conceptual. Further investigation will be required during preliminary and detailed design to investigate geotechnical and groundwater conditions, confirm hydraulic/hydrologic details and design criteria, assess environmental and archaeological impacts, refine alignments of dikes and impacts to property, and confirm constructability details.

# 2 BACKGROUND

Associated gathered background data from various sources to inform the conceptual flood mitigation plan. This background information included historical data, such as previous flood hazard assessments completed for Merritt, which provided context for the flood mitigation plan as well as specific technical inputs that enabled the development and refinement of the conceptual design options.

## 2.1 Pre-November 2021

### 2.1.1 1989 Floodplain Mapping

The BC Ministry of Environment completed floodplain mapping of the City of Merritt in 1989. The floodplain mapping extents show floodwater impacting development areas primarily on the west end of the City, near the confluence of the Coldwater and Nicola Rivers. For reference purposes, the 200-year flow was 212 $m^3/s$ in the 1989 study.

### 2.1.2 Past Reports

There have been past reports completed on hydrology, flooding, and fisheries topics for the Coldwater and Nicola Rivers. These past reports are not detailed in this report. However, it is important to note that there is a history of water management and flooding in Merritt.

A pre-design study of diking systems on the Coldwater River was completed in 1999 (Hydroconsult EN3 Services Ltd., 1999). Hydroconsult (1999) noted that there had been numerous flood events prior to 1999 and a severe flood event in 1991, which was due, in part, to an ice jam. The authors noted that some areas of Merritt are particularly vulnerable to flooding, and they developed recommendations for flood mitigation.

BGC Engineering Inc. completed flood mapping (BGC Engineering Inc., 2021b) and flood hazard assessment (BGC Engineering Inc., 2021a) of the Coldwater and Nicola Rivers in 2021 for the Fraser Basin Council and the City of Merritt. These were important updates since the 1989 Floodplain Mapping. The flood inundation extents generally cover more area than the 1989 floodplain maps, particularly near the confluence of the Coldwater and Nicola Rivers. For reference purposes, the 200-year flow used in the model was 185 $m^3/s$, which included an upward scaling allowance of 20% for climate change. This flow was smaller than the 1989 floodplain mapping estimate.

### 2.1.3 Existing Dikes

At present, there are four Provincially registered Dikes within the City of Merritt:

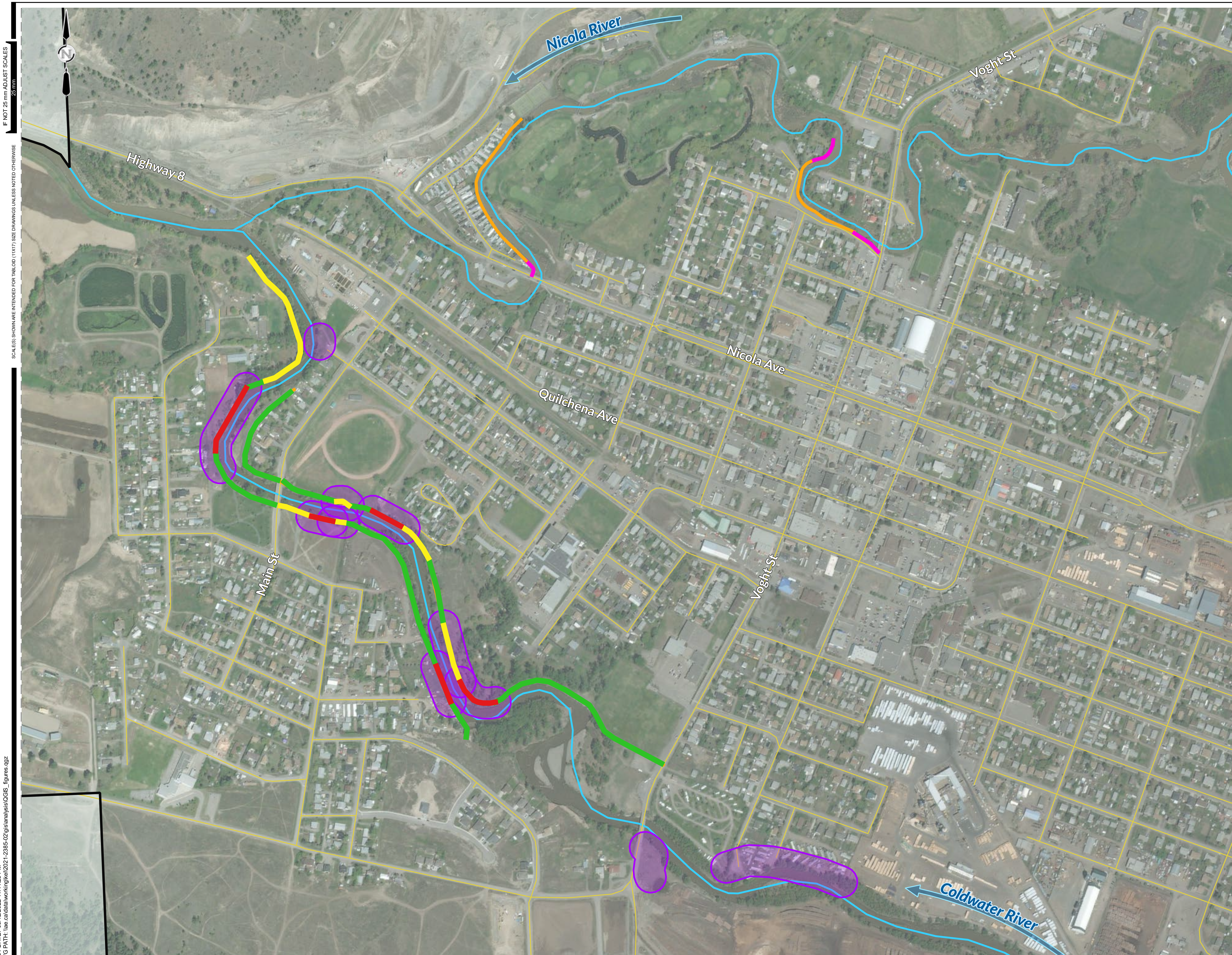
*Coldwater River*

- Dike #129 Left Bank (Colettville) – 1.28 km length
- Dike #130 Right Bank Dike (Coldwater River) – 1.20 km length

*Nicola River*

- Dike #180 Moyes Dike – 0.37 km length
- Dike #329 Chapman/Voght – 0.34 km length

These dikes are shown on **Figure 2-1**. Associated is aware that other unregistered dikes exist, particularly along the Nicola River; however, the locations and precise lengths of these dikes are not mapped by Associated.

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## LEGEND

- CITY BOUNDARY
- WATERCOURSE
- ROADS

NICOLA DIKES
- DIKE CREST
- BANK PROTECTION

COLDWATER DIKE REPAIR PRIORITY
- HIGH
- MEDIUM
- LOW
- EMERGENCY WORK AREAS

0 100 200 300 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION

Merritt
FLOURISH UNDER THE SUN

FIGURE 2-1 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
EXISTING AND EMERGENCY DIKES

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## 2.2 November 2021 Flood Event

The AR event generated intense rainfall in Southwest BC, including over the Coldwater River watershed. This resulted in extreme streamflow, extensive overland flooding, and physical damages in the City of Merritt. Preliminary information from the Water Survey of Canada (WSC) Station 08LG010 (*Coldwater River at Merritt*)[1] indicated that the peak flow had exceeded 400 $m^3/s$. This estimate has been subsequently reduced and the WSC has recently completed the final quality-controlled estimate of 320 $m^3/s$. This flow rate was still under review by WSC and was not available at the time of writing the draft report. The WSC real time data for station 08LG010 is shown in **Figure 2-2**. The AR event is recognized as the flood of record in the Coldwater River.

Within 17 days, there were three flow peaks in the Coldwater River. The first peak is described above, and the second and third peaks were also generated by subsequent AR's falling over the watershed and were notable in magnitude. For reference, prior to November 2021 the highest recorded flow in the Coldwater at WSC Station 08LG010 over a 66-year period was 129 $m^3/s$.

- November 15, 2021 – uncertainty in peak flow rate (WSC published preliminary real-time data ranging from 222 $m^3/s$, 259 $m^3/s$, to over 400 $m^3/s$ – the final estimated flow rate from WSC is 320 $m^3/s$)
- November 28, 2021 – 118 $m^3/s$
- December 02, 2021 – 116 $m^3/s$

As noted above, the AR event caused extensive damage and loss within the City. The destruction occurred due to the Coldwater River overtopping its banks, breaching dikes, and inundating developed areas in the City.

Merritt Fire Department and Canadian Armed Forces working together installing HESCO baskets.

Some of the notable events included the following:

- Inoperability of the wastewater treatment plant and overtopping of the infiltration ponds.
- Voght Street Bridge collapse.
- Significant physical damages to private properties and homes.
- Damage and deposition of river materials on roads, boulevards, sidewalks, and in stormwater and sanitary sewer systems.
- River channel avulsion through the left bank dike downstream of the Main Street bridge, which directed flow through Pine Street development area, and exposed the FortisBC gas main that supplies the City.
- Various bank and dike failures that allowed flood water to flow overland into parts of the City.
- Bank erosion and lateral migration of the river channel that caused loss of land.
- Evacuation order for the entire City population due to loss of services and health and safety risks from the AR event.

There was extensive effort and work put into emergency response activities. Merritt was fortunate to have assistance from neighbouring communities who provided operational and water utility expertise, as well as support from the

[1] This WSC Station is located at the Main Street Bridge crossing on the Coldwater River in the City of Merritt.

Canadian Armed Forces. These resource sharing activities provided humanitarian aid when the City of Merritt was in great need. An emergency operations centre (EOC) was activated and over time this evolved into a recovery operations (ROC) team that is still managing recovery activities for the City. At the time of writing this report over nine months since the AR event, recovery and restoration efforts are still ongoing.

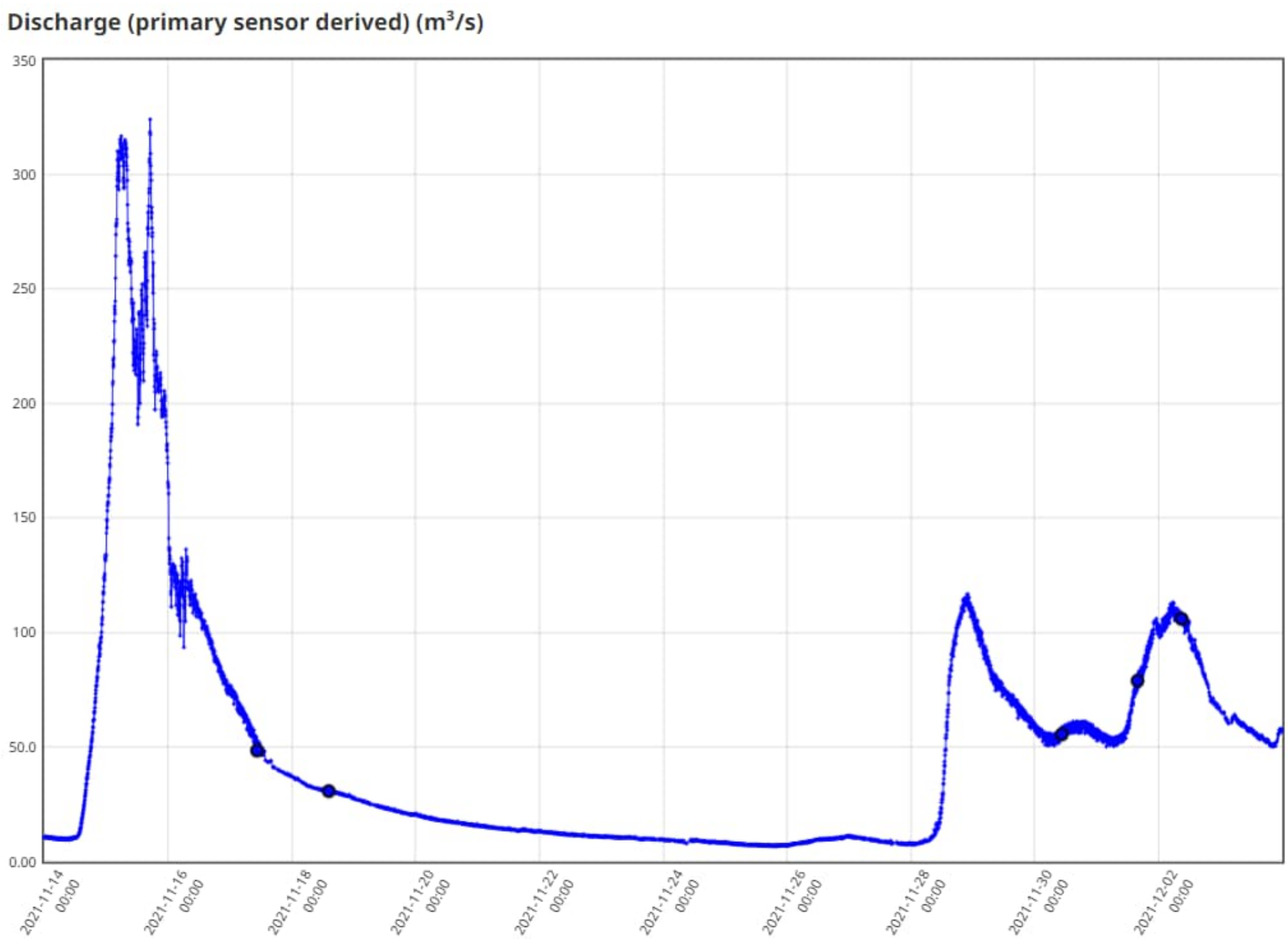



**Figure 2-2**
**Discharge at Water Survey of Canada (WSC) Station 08LG010 (*Coldwater River at Merritt*)**

## 2.3 Post-November 2021

### 2.3.1 Emergency Response and Mitigation Measures

Associated supported the City with emergency hydrotechnical engineering services, completed rapid inspections and assessments, provided emergency recommendations, and oversaw construction activities of channel dredging, dike repairs, bank armouring, HESCO basket installations, and in-stream works. Emergency repairs and bank/dike improvements were constructed following the AR event according to the most urgent areas identified by Associated's rapid dike inspection. These repairs largely consisted of earthworks and riprap placement. In some locations there was substantial sediment removal, river realignment, and the construction of temporary berms. The dikes, conditions, and work areas are shown in **Figure 2-1**.


Temporary reconstruction of dike and bank protection at avulsion downstream of Main Street Bridge.

Due to the emergency nature of the repairs, the integrity of the present diking system cannot be relied upon as permanent flood mitigation works for the City. Consequently, for the purposes of the conceptual flood mitigation options, the existing dikes were not considered to contribute to the new design; however, they may be incorporated later in the detailed design phase. Other post-event response work that is still being engineered will also be incorporated (e.g., Middlesborough Bridge replacement).

### 2.3.2 2022 Floodplain Mapping

After the AR event, BGC completed a flood-frequency analysis (BGC Engineering Inc., 2022a) to re-evaluate design flow rates for the Coldwater and Nicola rivers and updated the floodplain and hazard mapping (BGC Engineering Inc., 2022b). BGC estimated the peak of the flood to be approximately 400 $m^3/s$ (BGC Engineering Inc., 2022a), which was based on hydraulic modelling and a survey of high-water marks from the AR event. Based on this assessment, BGC revised their 200-year flow estimate on the Coldwater River to 445 $m^3/s$ excluding climate change. With the inclusion of climate change (64% upward scaling), they estimated a 200-year flow of 730 $m^3/s$ which is a large increase in flow compared to the previous estimate (185 $m^3/s$). Additional information on hydrology is included in **Section 3.1**.

The 2022 floodplain modelling shows a significant portion of the City is susceptible to flooding and underscores the need for a new comprehensive flood mitigation plan. The AR event showed that there are significant flood risks in Merritt. The entire City was evacuated for health and safety reasons with the loss of vital services. There were no fatalities due to the flood, but considering the magnitude of the event and its timing occurring in the middle of the night, this result could have been worse.

## 2.4 Additional Data

In addition to the background data noted above, the following technical sources were also consulted as Associated's team developed the conceptual flood mitigation options:

- Pre- and post-flood aerial imagery provided by the City of Merritt.
- Hydraulic modelling provided by BGC (see **Section 1** for additional information).
- Pre- and post-flood bathymetry within the project area, collected by Ecoscape Environmental Consultants.
- Post-flood LiDAR provided by the City of Merritt (via the Province of BC).
- GIS data provided by the City of Merritt, including cadastres, building footprints, roads, and utilities.
- 2021 Property Assessment data and estimated post-flood recovery costs by the City of Merritt.
- Post-flood condition assessments provided by the City of Merritt.

# 3 PRELIMINARY INVESTIGATIONS

## 3.1 Hydrological and Climate Change Assessment

The purpose of the hydrologic assessment was to determine appropriate design peak flow estimates and hydrographs for the Coldwater and Nicola Rivers to support the subsequent conceptual design modelling presented in **Section 4**. Because future climate change has the potential to significantly change the hydrological characteristics of the Coldwater and Nicola River watersheds, the design peak flow estimates used for the hydraulic modelling incorporated a climate change factor to ensure the proposed flood mitigation plan will be resilient against future climate change. This hydrologic assessment is considered preliminary and additional refinement is expected during preliminary and detailed design; particularly if/when the WSC updates hydrometric data at Station 08LG010.

### 3.1.1 Watershed Overview

Merritt is situated at the confluence of the Coldwater and Nicola Rivers. **Figure 3-1** provides an overview map of the two watersheds.

The Coldwater River at the confluence has an approximate drainage area of 914 $km^2$. The headwaters of the Coldwater River start around the Coquihalla Summit, specifically Zopkios Peak at an elevation of 1,921 m. This area is in the Cascade Mountains. The Coldwater River is a natural system and the watershed land cover is primarily forested. There are a few small dams in the upland area of the watershed. Flooding on the Coldwater is typically mixed regime: high flows can occur in May-June due to snowmelt (i.e., freshet) and high flows can also occur in November-December due to high rainfall or rain-on-snow events.

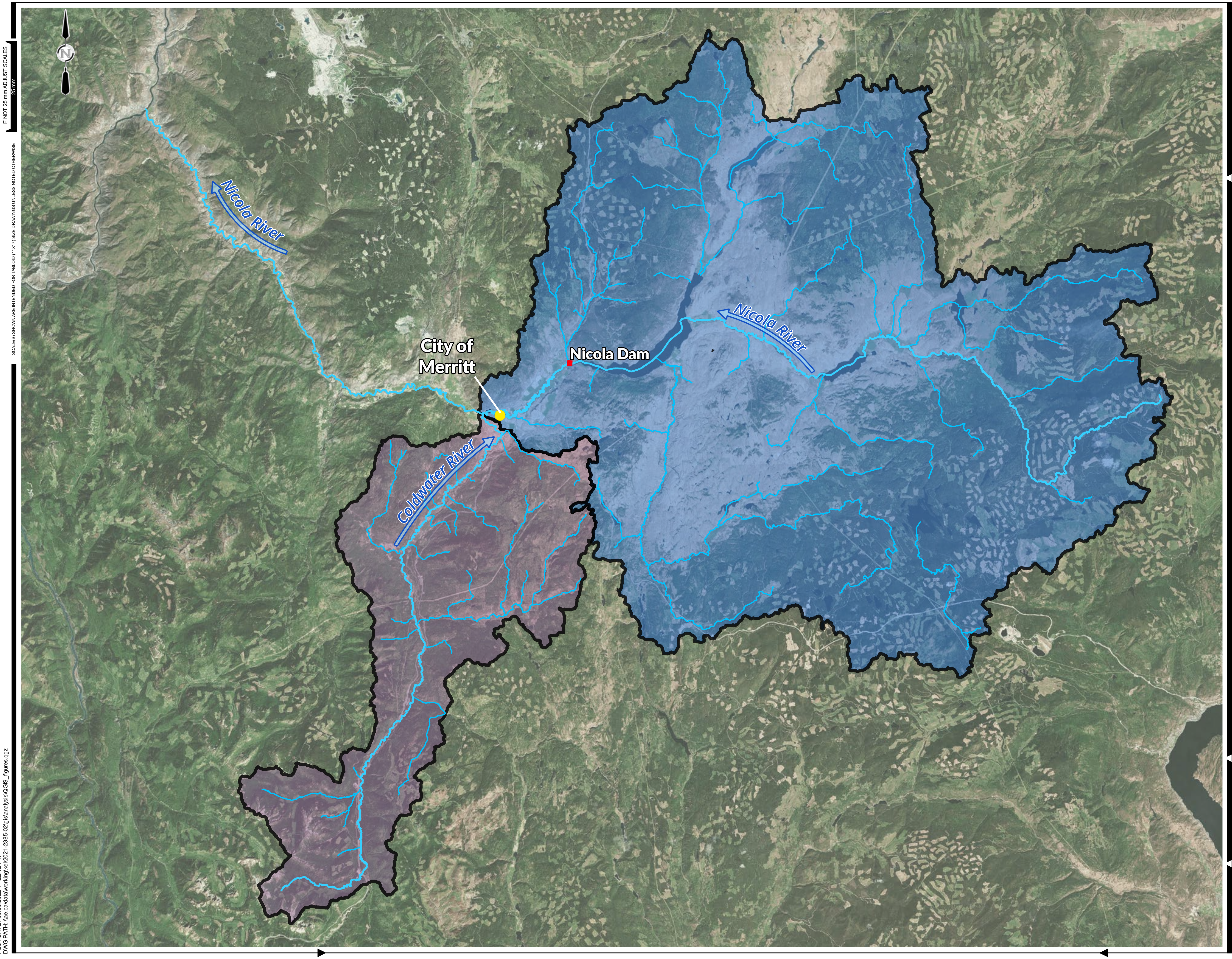
The Nicola River at the confluence has a drainage area of approximately 3,331 $km^2$. The headwaters of the Nicola River are on the Thompson Plateau. The Nicola River is a regulated system with the presence of Nicola Lake and the Nicola Dam situated 27.5 km upstream of the confluence. The land cover is primarily forested. There are two creeks (Clapperton and Hamilton) that flow into the Nicola River downstream of the Nicola Dam. The Nicola River watershed is snowmelt-dominated and the highest flows tend to occur in May-June.

### 3.1.2 Climate Change Assessment

The Pacific Climate Impacts Consortium (PCIC) publishes the 'Plan2Adapt' tool that summarizes project future climate change projections through all regions of BC. The Thompson-Nicola Regional District was selected to describe future climate change considerations. Based on the Representative Concentration Pathway 8.5 (RCP 8.5) future climate scenario up to the 2080's time period (2070-2099), the average annual temperature is projected to increase 5°C in the region. There will also be less winter precipitation, more summer precipitation, and less snow. These changes will have hydrological effects, and this must be considered in the design flows for the flood mitigation plan. The following impacts could be realized in the region:

- Alteration to the hydrologic regime, such as earlier snowmelt.

Road structure damage along Canford Avenue.

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## LEGEND

- CITY OF MERRITT
- NICOLA RIVER WATERSHED
- COLDWATER RIVER WATERSHED
- WATERCOURSE
- NICOLA DAM

0 5 10 15 20 km

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION

Merritt
FLOURISH UNDER THE SUN

FIGURE 3-1 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
WATERSHED OVERVIEW

| | |
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- Higher intensity precipitation events.
- Possible change from snowmelt-dominated flooding to rainfall-dominated flooding.
- Potential for increased runoff and more frequent flooding.

**Table 3-1**
**PCIC Projected Climate Change Variables to the 2080's Time Period (2070-2099)**

| Climate Variable | Season | Projected Change from 1961-1990 Baseline | |
|---|---|---|---|
| | | Ensemble Median | Range (10th to 90th) Percentile) |
| Temperature (°C) | Annual | +5 | +3.7 to +6.6 |
| Precipitation (%) | Annual | +8.4 | +1.1 to +16 |
| | Summer | -8.6 | -33 to +12 |
| | Winter | +11 | -2.2 to +16 |
| Precipitation as Snow (%) | Annual | -44 | -49 to -39 |
| | Winter | -34 | -40 to -24 |
| | Spring | -68 | -77 to -57 |

### 3.1.3 Design Criteria

The Coldwater River AR event was initially selected by Associated for use as the design criterion as a flood of record. However, there was still hydrological uncertainty on the magnitude of the AR event when the project work was completed for the draft report. Therefore, Associated adopted a reasonably conservative approach for the Coldwater River design flow and this is described below. There is flexibility in the flood mitigation plan and the hydrological design criteria can be updated during the detailed design phase of the project now that the WSC has finalized the flow rate estimate.

The design flow criteria for the conceptual flood mitigation plan is the 200-year flow (0.5% Annual Exceedance Probability, AEP). Although risk-based approaches are now being considered, the 200-year flow was adopted because it is a generally accepted standard approach for flood management in BC. Associated analyzed available WSC data and referenced work completed by BGC (BGC Engineering Inc., 2022a) to select design flows on both rivers.

### 3.1.4 Coldwater River Design Flow

As noted above, WSC Station 08LG010 is conveniently located in Merritt and is applicable for flood analysis and design flow estimation. The station has 66 years of record, which is discontinuous between 1911 and 2022 (**Figure 3-2**). Instantaneous measurements commenced at the station in 2005. There have been three measured flood events that exceeded 120 $m^3/s$ in the Coldwater River (1980, 2006, and 2017).

BGC completed the revised flood frequency analysis on the Coldwater River in support of floodplain mapping (BGC Engineering Inc., 2022a). The hydrologic analysis was revised to a Dual Maximum Series (DMS). This accounts for the fact that the Coldwater River has the two separate flood mechanisms discussed above: spring flooding driven by snowmelt and fall flooding driven by rainfall. From there, BGC employed two different approaches to estimate the 200-year flow: a standard approach, assuming a GEV distribution, and a combined approach using an ensemble of distributions. This resulted in a range of 200-year flow estimates (before climate adjustments):

- 295 m$^3$/s – standard approach
- 325 m$^3$/s – combined approach excluding BGC's estimate of the AR event
- 445 m$^3$/s – combined approach including BGC's estimate of the AR event

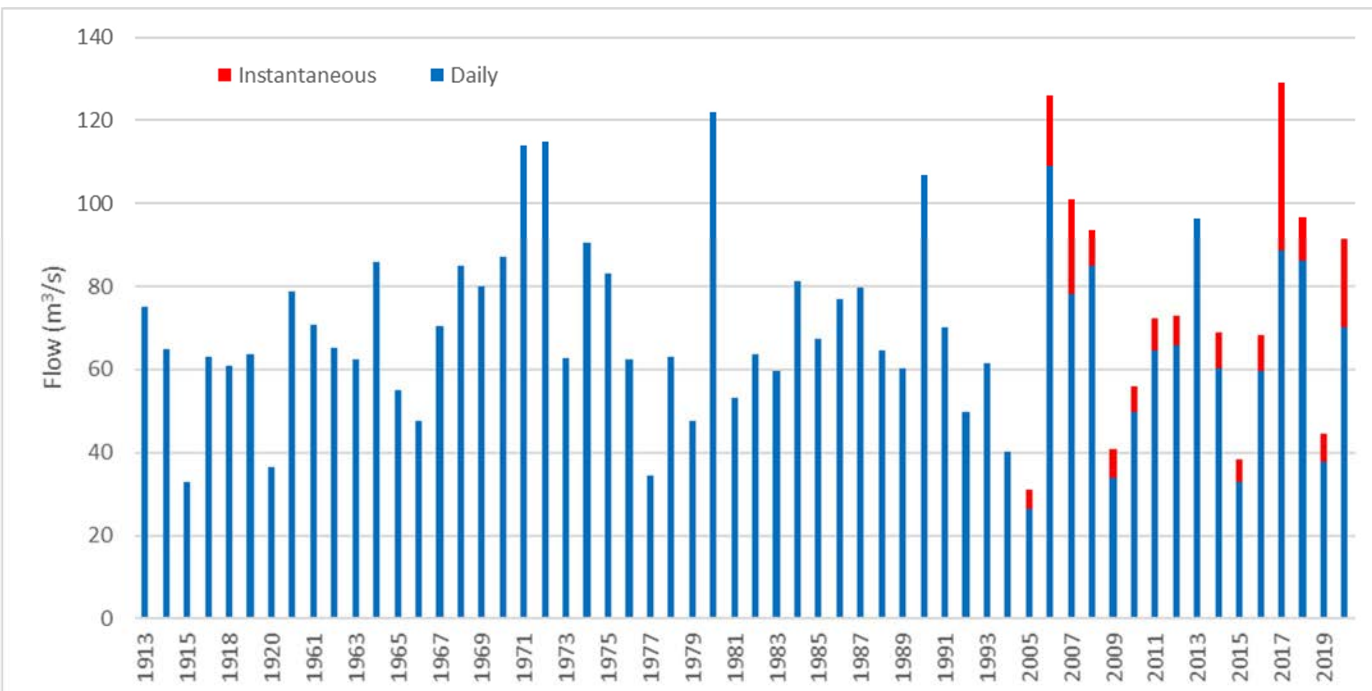



**Figure 3-2**
**WSC Station 08LG010 Time Series of Maximum Daily and Peak Instantaneous Flows**

BGC's analysis also incorporates a climate change scaling factor to account for the expected influence of climate change on the peak flow. Their analysis was based on the PCIC's Variable Infiltration Capacity (VIC) model data (BGC Engineering Inc., 2022a). With climate adjustment, BGC's largest 200-year flow estimate was increased to 730 m$^3$/s and this represents a 64% upward scaling factor.

After reviewing the methodology and results, Associated selected the result of the combined approach excluding BGC's estimate of the AR event (325 m$^3$/s). This was because there was still uncertainty in the magnitude of the AR event and it was therefore excluded. Climate change adaptation is required for flood mitigation in Merritt. Therefore, the 64% upward scaling factor was included and the Coldwater River design flow result is 533 m$^3$/s.

In the interim, Associated considers this to be a conservative estimate of the peak flow rate and appropriate for the conceptual flood mitigation plan. This design flow could be updated now that the WSC established the flood of record from the AR event.

### 3.1.5 Nicola River Design Flow

WSC Station 08LG065 is located downstream of Nicola Dam and is applicable for flood analysis and design flow estimation. The station has 40 years of record, which is continuous since 1983 (**Figure 3-3**). The highest measured flow of 78.3 $m^3$/s occurred in 2018. Clapperton and Hamilton Creeks are tributaries draining into the Nicola River between the dam and the City.

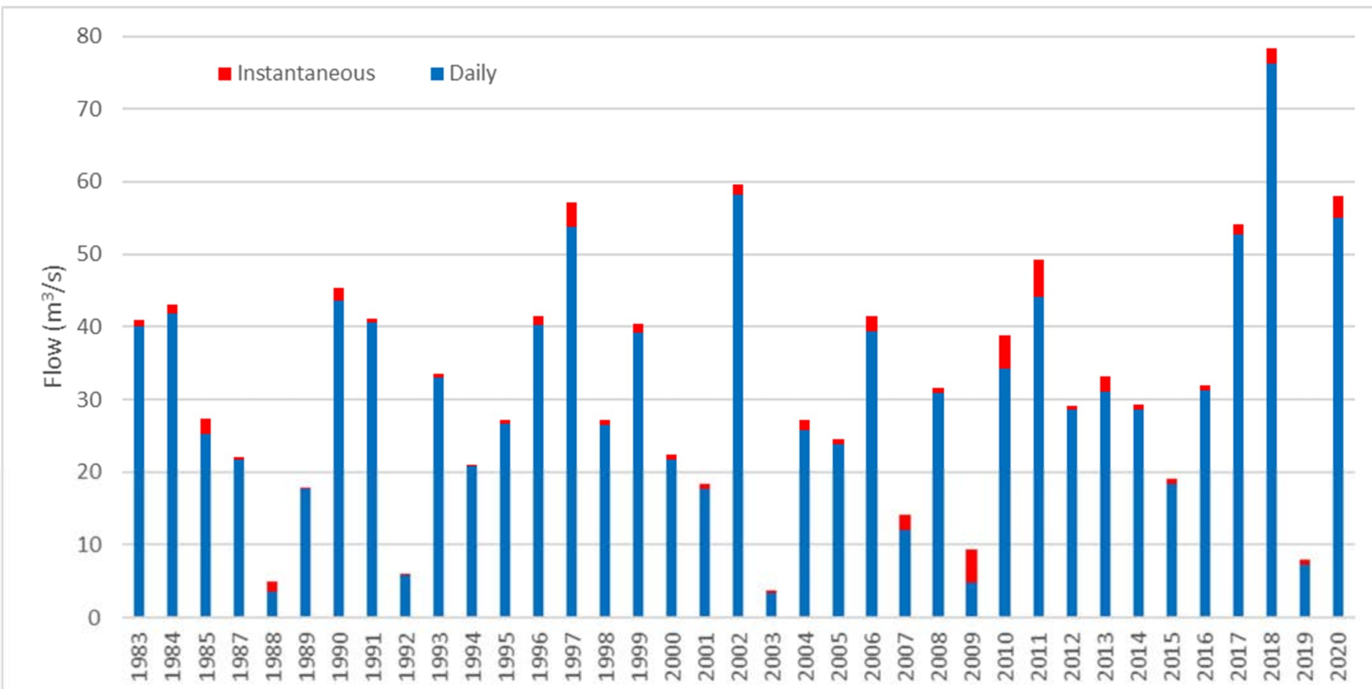



**Figure 3-3**
**WSC Station 08LG065 Time Series of Maximum Daily and Peak Instantaneous Flows**

Due to the anthropogenic influence of Nicola Dam controlling most of the flow in the Nicola River, the estimate of flooding that the City could experience on the Nicola River has to account for the operations of the dam as well as the potential flows due to extreme events.

The reported maximum possible outflow from normal dam operations (without spilling) is 130 $m^3$/s (BGC Engineering Inc., 2021a). This outflow could be generated from opening the two radial gates on the dam. As noted above, the highest recorded outflow is 78.3 $m^3$/s.

Associated completed statistical analysis on the WSC Station 08LG065 peak instantaneous flow data. Unreasonably low outlier years were removed from the data. The Log Pearson III distribution was chosen because it had good fit with the data (**Figure 3-4**). The 200-year flow estimate was 93.4 $m^3$/s without consideration of climate change. By adding a 20% upward scaling factor for climate change recommended by Engineers and Geoscientists BC (EGBC, 2018), the 200-year flow estimate increased to 112.1 $m^3/s$. This flow is less than the maximum possible outflow from the dam (130 $m^3/s$).

Inflow from Clapperton and Hamilton Creeks also needs to be considered. These creeks do not have hydrometric data that can be statistically analyzed. Likewise, the joint probability of high flows on the Nicola River and high flows in these creeks cannot be analyzed, but there is a likelihood for the high flows to be synchronized. Clapperton Creek watershed is larger than Hamilton Creek watershed (232 $km^2$ compared to 55 $km^2$). Associated recently completed a bridge replacement project for the Ministry of Transportation and Infrastructure (MoTI) and this work included regional study of hydrology. The 200-year flow estimate for Clapperton Creek was 11.4 $m^3/s$. Applying the same method for Hamilton Creek, the 200-year flow estimate is 3.7 $m^3/s$. By adding a 20% upward scaling factor for climate change to these estimates the total additional flow is 18 $m^3/s$. When this is added to the 200-year flow for WSC Station 08LG065 (112.1 $m^3/s$), the total flow is 130.1 $m^3/s$. This is the same flow rate as the maximum possible dam outflow and it was therefore chosen as the design flow for the Nicola River. Like the Coldwater River, the design flow for the Nicola River can be updated during the design phase of the project.

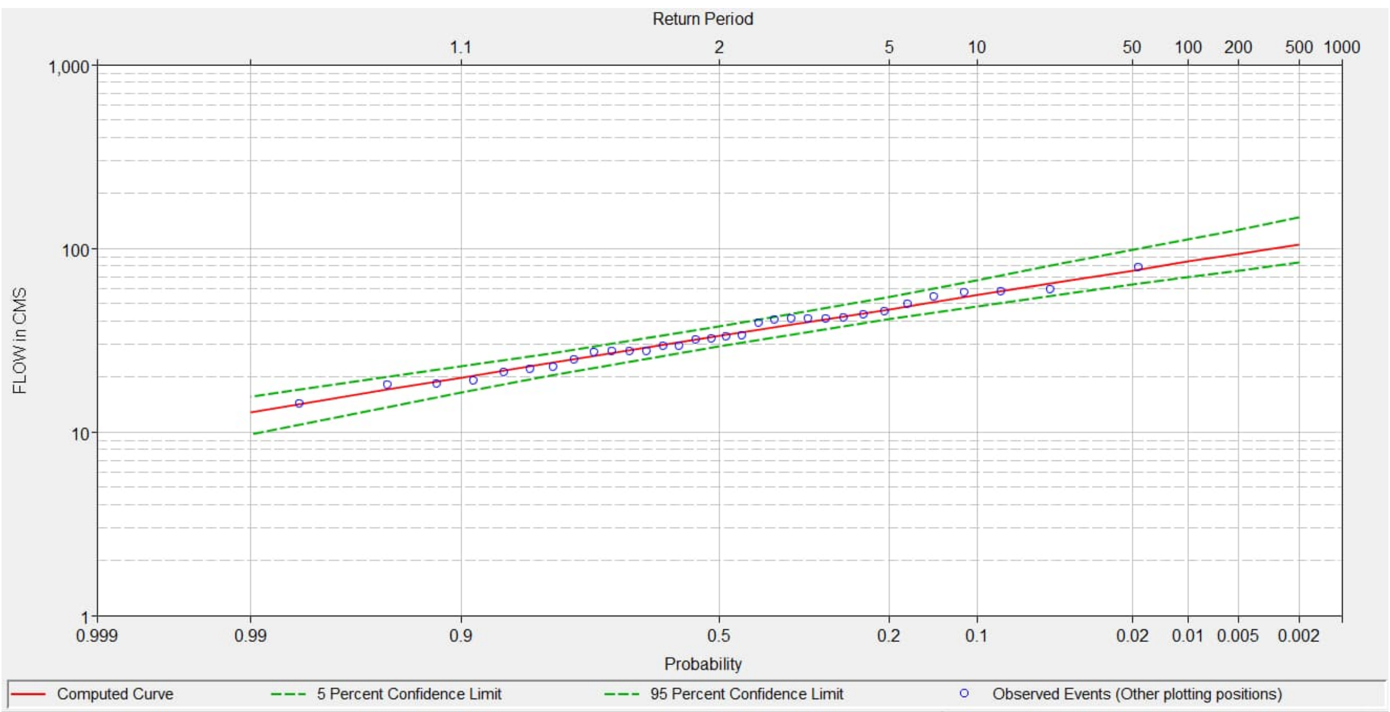



**Figure 3-4**
**WSC Station 08LG065 Frequency Analysis Chart**

### 3.1.6 Design Flow Summary and Hydrographs

Table 3-2 summarizes the 200-year design flow estimates adopted by Associated for the purposes of hydraulic modelling and testing of flood mitigation options.

**Table 3-2:**
**Design Flow Rates on Coldwater and Nicola Rivers in Merritt**

| Coldwater River | Nicola River |
| --- | --- |
| **533 $m^3/s$** | **130 $m^3/s$** |

There are several approaches to determining a design hydrograph for modelling purposes. Previous flood events can be reviewed to create a real or synthetic hydrograph that resembles the expected rise and fall of flow for the duration of the design event (like the hydrograph shown in **Figure 2-2**). However, to develop and test flood mitigation options, Associated adopted synthetic hydrographs and simulated steady conditions in the 2D models. This was the same method used by BGC for the purposes of floodplain mapping. Hydrographs for both rivers start at zero, then ramp up quickly to the peak design flow, and then are held at the peak flow rate until a steady state is achieved. This approach is suitable for a conceptual design exercise where the primary goal is to confirm the flood inundation extents of the flood mitigation options and the key output parameters (such as maximum water surface elevations and velocities) can be estimated without requiring lengthy model simulations. One of the limitations of this approach is that this type of hydrograph cannot be used to determine the length of flooding or expected recovery time after a flood. Alternative hydrographs can be developed and applied as necessary during the design phase of the project.

## 3.2 Environmental Overview Assessment

To provide a baseline of the environmental values in the project area, Associated carried out an Environmental Overview Assessment (EOA) for the Project Area. Specifically, an EOA identifies regulatory limitations; aquatic values including fish and fish habitat and groundwater resources; ecosystem and vegetation values, including rare ecological communities and rare plants; and wildlife and wildlife habitat values, including species at risk. The EOA provides high-level design and construction recommendations to avoid, minimize, or mitigate these potential environmental effects. The EOA report has been prepared in accordance with the DMAF Application's Guide (Infrastructure Canada, 2021), and the information provided is driven by the requirements of the DMAF Full Application.

As part of the EOA scope of work, Associated conducted an environmental site assessment to assess the environmental conditions in the Project Area. To support the field assessment component of the EOA, Associated also carried out a background information review to identify environmentally-sensitive features and high value habitat in the Project Area as well as the Regional Area to assess potential environmental effects of the project and regulatory limitations.

The results of the EOA identified the following environmental values in the Project Area that should be considered during design and construction:

- Fish and fish habitat in the Coldwater and Nicola Rivers;
- Sensitive oxbow riparian and aquatic habitat;
- Sensitive mature cottonwood forests along Coldwater and Nicola Rivers (i.e., Lewis' woodpecker critical habitat);
- Listed ecological community on the Coldwater River;
- Existing groundwater wells;

- Removal of buildings and other structures in the habitat compensation areas; and
- Altered hydrology in the regional area.

Old vehicles in Coldwater River following the AR event, which were removed during emergency response.

Based on the results of the EOA, Associated provides the following recommendations once designs have been finalised:

1. Retain a Qualified Environmental Professional (QEP) to conduct additional site-specific assessments (i.e., fish habitat assessments) prior to permitting, where required.
2. Prepare an Environmental Management Plan (EMP) that describes site-specific mitigation measures, including seasonal time sensitivities. The EMP should include a Spill Contingency Plan, a Weed Management Plan, a Riparian Management Plan, and a Fisheries Compensation and Enhancement Plan.
3. Apply for permits and approvals that may be required depending on the proposed works;
4. Retain a QEP to conduct pre-construction surveys and monitor construction activity, with the authority to stop construction if activities contravene mitigation recommendations or have the potential to harm the natural environment. The QEP will assist the contractor in implementing the protection measures detailed in the EMP.

The full EOA report can be found in **Appendix A**.

## 3.3 Archaeological Overview Assessment

Ursus Heritage Consulting Ltd. was retained by Associated to conduct an archaeological overview assessment (AOA) for the proposed study area. AOAs are assessments that compile existing knowledge of known archeological sites and historical First Nations land use to identify highly probable areas where further studies may be required to identify areas with high archeological potential. The AOA can also inform future fieldwork and archaeological site testing strategies, support land-use decisions, and identify risks for proposed developments impacting sites. This report presents the results of the AOA. The objectives of the AOA were to:

- Conduct background research for the project area;
- Identify and evaluate any areas of archaeological potential within the proposed project areas, and;
- Provide recommendations regarding the need and appropriate scope of further archaeological examination, including conducting an Archaeological Impact Assessment (AIA) level study.

The AOA was undertaken in accordance with the British Columbia Archaeological Impact Assessment Guidelines (Archaeology Branch, 1989) issued by the Archaeology Branch at the Ministry of Forests, Lands, Natural Resource Operations, and Rural Development (MFLNRORD) and Archaeological Overview Assessments as General Land Use Planning Tools – Provincial Standards and Guidelines (2009).

The assessment described in the AOA is concerned with the identification of areas of archaeological potential. An archaeological site is any location that contains the remains of past human activity. Examples of archaeological sites include habitation sites, stone tool manufacturing and maintenance sites, burials, fish weirs, rock art, culturally modified trees (CMTs), and trails. The current AOA is not concerned with identifying traditional use sites, as the identification of traditional use sites is beyond the scope of the current research project and more appropriately addressed in Traditional Use and Traditional Knowledge Studies (TUS/TKS).

Potential within the study area was calculated using the above methodology and particular attention was paid to previously recorded archaeological sites and their settings, slope, hydrology, and environment. In total, there were 22 recorded archeological sites found within 200 meters of the Project Area. These sites and the other variables contributed to the assessment of potential which found a total of 273 hectares of archaeological potential for the study area.

The detailed AOA report for the proposed Merritt flood mitigation can be found in **Appendix B**.

## 3.4 Contaminated Sites Assessment

To identify the presence of the potential for contaminated materials on site, a Limited Phase I Overview Assessment (Limited OA) was completed. The OA was completed on the construction footprint of the proposed potential flood mitigation infrastructure (Project Footprint) to support the DMAF application. The Limited OA report has been prepared in accordance with the DMAF Application Guide (Infrastructure Canada, 2021), and the information provided is driven by the requirements of the DMAF Full Application.

Road damage, exposed and damaged utilities, and property damage along Pine Street.

The Limited OA was conducted in general accordance with the requirements of the *BC Contaminated Sites Regulation* (CSR) (B.C. Reg. 375/96) of the Environmental Management Act (S.B.C. 2003, c. 53) and followed the general protocols defined in the Canadian Standards Association (CSA) Z768-01 (R2022) – Phase I Environmental Site Assessment standard (CSA 2022).

The objective of the Limited OA was to determine if areas of potential environmental concern (APECs) and potential contaminants of concern (PCOCs) exist on or near the Project Footprint. The potential risk level of soil, vapour, and/or groundwater contamination was qualitatively assessed based on the past, current, or intended land use(s) at the Project Footprint and adjacent properties. The results of the Limited OA will be used to identify properties at or near the Project Footprint that may present health and safety risks during the construction phase of the Project and/or areas that may require soil or groundwater management during construction activities.

The Limited OA findings indicate a moderate to high potential[2] that current and historical activities at the Project Footprint have resulted in contamination of soil, soil vapour, and/or groundwater at the Project Footprint relative to

[2] High potential means there is either physical or visual/olfactory evidence or very recent factual evidence of contamination on site. Moderate potential means there is evidence of past or current land uses or infrastructure with potential to release contaminant(s) into the environment. Low potential means there is little or no evidence of sources of contamination.

the industry standards. Subsequently, 10 APECs were identified within the Project Footprint and an additional 10 were identified in the surrounding area.

The next steps related to contaminated sites investigations as the project proceeds include the following:

- To confirm or refute potential contamination at the Project Footprint, further investigation (i.e., Phase II ESA) of the APECs within and near the Project Footprint is recommended.
- Prior to any development and/or major ground disturbance on the site, the groundwater monitoring wells within the Project Footprint should be decommissioned according to established guidelines as described in the *Groundwater Protection Regulation* (B.C. Reg. 39/2016) and *Water Sustainability Regulation* (B.C. Reg. 36/2016) of the *Water Sustainability Act* (S.B.C. 2014, c.15).
- If potentially contaminated soil or heating oil tanks are observed during building demolition and/or development activities, an environmental consultant should be notified to determine the proper management and disposal.
- Due to the age of the buildings within the Project Footprint managed retreat areas (i.e., built prior to 1990), hazardous building materials (HBMs) may be present. A qualified HBM assessor should be consulted prior to any disturbance of building materials (e.g., demolition or renovation) to ensure worker safety and compliance with the BC Occupational Health and Safety Regulation and the Workers Compensation Act.

Details of the Limited Phase I Overview Assessment are found in the report in **Appendix C**.

# 4 HYDRAULIC MODELLING

Two-dimensional (2D) hydraulic modelling was used to analyze the conceptual flood mitigation design concepts for the City of Merritt. Hydraulic modelling allows Associated to evaluate the technical performance of the various flood mitigation options by evaluating the model velocities, depths, and water surface profiles under various scenarios.

## 4.1 Base Model

The base hydraulic model used to simulate the flood mitigation design concepts was developed by BGC. Associated received the 2D HEC-RAS (Hydrologic Engineering Centre River Analysis System) model from BGC on May 4, 2022, with a summary document highlighting key points of the model setup (BGC Engineering Inc., 2022b).

Associated completed a high-level review of the model setup, including terrain, hydraulic structures, 2D flow area/mesh, boundary conditions, and computational settings (such as time step and flow equations) to confirm that the base model was suitable for use to simulate flood mitigation concepts. Associated made minor adjustments to the model as required and then applied the design flows provided in **Table 3-2** to finalize the existing conditions model. The existing conditions model represents the flood impacts of a 'do nothing/status-quo' scenario. Further technical details on the model setup are included in **Appendix D**. The model extent is shown in **Figure 4-1**.

## 4.2 Conceptual Flood Mitigation Options

Associated prepared separate models representing each of the conceptual flood mitigation options to evaluate the concepts. Associated modified the base terrain to represent the various structural flood mitigation measures included in each option (i.e., waterside vs. setback diking). For the purposes of conceptual modelling, a standard cross-section was used for each proposed each proposed structure:

- Earthen dikes (5 m wide crest with 2:1 side slopes), and
- Sheet pile walls (2 m wide).

To best represent the proposed mitigation measures, an iterative process was used to set the dike heights approximately 0.6 m above the simulated water surface elevation. This assumes 0.6 m of freeboard would be required, which is the typical freeboard used in BC for daily flow rates. The design freeboard should be reviewed during the detailed design phase of the project.

Associated ran the design flood event for each scenario and then used the results of the model to evaluate several key components of the conceptual flood mitigation plan, including (but not limited to):

- the required footprint of the proposed dikes and physical constraints on properties,
- the capacity of existing bridges (based on the simulated water surface elevation),
- the impact of diking on river hydraulics, and
- the need for bank protection (based on water velocities).

Associated also used the proposed diking lengths and heights from the models to prepare high level cost estimates for each of the options.


Associated Engineering

BEST MANAGED COMPANIES
Platinum member

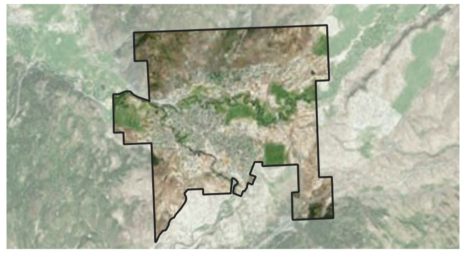
## LEGEND

- MODEL EXTENTS
- WATERCOURSE
- ROADS

0 250 500 750 1,000 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



Merritt
FLOURISH UNDER THE SUN

FIGURE 4-1 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
MODEL EXTENTS

| | |
|---|---|
| **AE PROJECT No.** | 20212385-02 |
| **SCALE** | AS SHOWN |
| **APPROVED** | G. CAHILL |
| **DATE** | 20220809 |
| **REV** | A |
| **DESCRIPTION** | ISSUED FOR DRAFT |

IF NOT 25 mm ADJUST SCALES

SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

PLOT DATE: 08/05/2022 11:53:33 PM

## 4.3 Model Limitations

Hydraulic models are an engineering tool used to assess flood extents and impacts. While hydraulic models are a powerful tool in river engineering studies, the modeller must understand the limitations. The hydraulic model utilized available data to simulate the technical performance of the flood mitigation concepts. However, there were some limitations to the modelling process, including input data and design conditions modelled, as follows:

- **River Bathymetry** – The model used digital elevation model of the riverbed that was generated from the Ecoscape bathymetric survey. The spatial scope of the bathymetric survey was limited to selective cross sections and there are spatial gaps between cross sections. Due to spatial gaps there could be detail missing of the riverbed that was not captured when the digital elevation model was generated. Furthermore, rivers are dynamic and riverbeds/banks can change over time due to flow conditions. More detailed river bathymetry surveying should be considered at the detailed design phase of the project.
- **Sediment Transport** – The model assumes stable bed conditions. No sediment transport, mobilization or deposition modelling has been included in the model. While these complex processes were not considered to be within the scope of the current project, this may be a valuable component to add into future models to better understand the impacts of a large flood event on fluvial morphology.
- **Debris Floods/Flows** – The model has been developed assuming clearwater flood conditions. Debris floods/flows are considered unlikely to occur in the project areas (particularly for the Nicola River), have not been modelled, and their impact on water elevations has not been tested.

Aerial view of Coldwater River facing upstream near Chapman Street (left) and Fir Road (right), where channel avulsion occurred. The Middlesborough Bridge is visible upstream.

# 5 COMMUNITY & FIRST NATIONS PARTNER ENGAGEMENT

## 5.1 Community Engagement

The City recognises that it is the community residents who have been impacted the most from the flood event within the City confines. Either through impact on their properties, employment, lifestyle, or the city-wide evacuation all the residents have been impacted from the flood event and the recovery process in some way. It is for this reason that the City is committed to ensuring that a sound, dependable, and inclusive community engagement process is in place.

### 5.1.1 Proposed Community Engagement Framework

The City will strive to maintain open and transparent communication with residents and the community. Our engagement objective is to ensure that the community is heard and that concerns are addressed wherever possible. The first phase of engagement has been completed prior or during the creation of this Flood Mitigation Plan, while the remaining three phases will be undertaken at various steps throughout the project. A description of each phase of engagement is as follows:

1. **Pre-planning engagement** – During this phase of engagement, the City engaged with the community through open houses, the City website, and social media. The City hired a consultant (Centre for Crisis and Risk Communications) in January 2022 to support their communication efforts concerning the November flood event An open house and Council meeting were held on June 28th 2022 to present the initial options for flood mitigation. The City also engaged residents in a public survey to better understand what aspects of the Coldwater and Nicola River systems and flood mitigation were most important to them.

2. **Post-plan engagement** –the City will make this Flood Mitigation Plan and all appendices public and available to the community. The City will provide a contact person for residents to reach out to if they have any concerns or want clarification. If necessary, any portion of this plan, including this engagement framework, will be amended based on community feedback and guidance.

   While undertaking this phase of engagement, the City will continue to work with the Provincial and Federal Government to identify funding sources to pay for the costs of implementing this plan. If funding is identified for portions of the plan that are deemed priority, any directly impacted property owners will be contacted on an individual basis prior to the funding application being submitted.

3. **Detailed design engagement** – When the City has received sufficient funds to proceed with detailed project design and engineering, the City will arrange for a mechanism for public input, which may include an open house, an info night, a feedback form, or some other mechanism, depending on the scope of the project. The residents will have a period following this meeting to ask questions and provide feedback. City property owners who have properties that may be directly affected or changed will be contacted on an individual basis to discuss options and to minimize impacts to the property where possible. To facilitate this process the City will assign a point of contact for residents to reach out to if they require further information.

4. **Project Construction Engagement** – Since construction activities for this project are likely to span the course of multiple years, this will likely be the longest phase of engagement. The City will appoint a single point of contact for all inquiries from residents regarding this project and project updates will provided through the City website and social media. At the conclusion of the project, a report will be prepared detailing the steps that were taken to

meet the project objectives identified during the second phase of this plan. Throughout the construction process, the City is committed to maintaining open communication with all the residents of the City of Merritt.

### 5.1.2 Pre-Planning Community Engagement Feedback

A variety of communication techniques were deployed to keep the residents informed on flood response, recovery, and planning initiatives. The City has directed the activities described below as part of the pre-planning community engagement process.

#### 5.1.2.1 Online Information

The City has been actively using online resources to update the City residents since the flood event in November 2021. **Table 5-1** outlines the online portals the City maintains as information portals during the flood event and recovery.

**Table 5-1 Online Resources Used by the City of Merritt During Flood Recovery**

| Online Resource | Resource Location | Purpose and Details |
|---|---|---|
| City website | https://www.merritt.ca/ | • All Council meeting minutes and social media links noted |
| Recovery and Support website | https://home.merritt.ca/ | • Deployed in Feb 2022 to focus flood information away from the City's main website.<br>• FAQ about flood related topics<br>• Update on evacuation Orders<br>• News Updates<br>• Links for support<br>• Recovery information related to debris collection and flood zone development<br>• Information and contacts for mental and physical health, financial assistance, cleanup and rebuild, contractor services |
| Facebook Page | https://www.facebook.com/groups/3082982508591319 | • Deployed in Feb 2022<br>• Public group operated by the Recovery Operations Team of the City of Merritt. It is intended to provide updated information to |

| | | |
|---|---|---|
| | | those who have been and continue to be impacted by the Flood.<br>• Public Group with 93 members (July 24, 2022)<br>• Postings by the City of Merritt and member individuals updating the public with the newest flood-related information.<br>• Recovery Operations team respond to questions posed by the public. |
| Twitter Account | https://twitter.com/CityofMerritt | • General City Twitter account that was used to update the population on flood related information.<br>• 1180 followers (June 24, 2022) that has 2147 tweets |
| YouTube Channel | https://www.youtube.com/c/<br>CityofMerrittMeetings/channels | • Monthly live Recovery Public Information Sessions with key members of the flood response team.<br>• Public were able to submit questions prior to the event to receive answers from the relevant City personnel.<br>• Also housed recordings from City personnel that addressed specific component of the flood recovery.<br>• Recordings of live Committee as a Whole and Council meetings where flood information was conveyed to the City. |

The public engaged with these various online resources based on their information needs and timing. Typically, during emergencies people will engage with social media platforms because social media is readily available and can provide up-to-date information. There is also a vast number of people who are comfortable using and engaging on these social media platforms. Citizens also utilise the features in the platforms to ask questions and, when managed effectively, can receive timely responses and directions. The value of the social media platforms extended beyond the initial emergency response and became a regular source of information for many as the City entered the recovery stage. Various usage statistics of the online resources are noted in **Table 5-2**.

**Table 5-2**
**Significant Online Resources Usage Statistics**

<table>
<tr><th>Online Resource</th><th>Usage Statistics[3]</th></tr>
<tr><td>YouTube</td><td>
<ul>
<li>137 Subscribers to Meeting minutes</li>
<li>212 views of Flood Mitigation Planning presentation to Committee of the Whole</li>
<li>Monthly flood related updates that saw usage as follows:</li>
</ul>
<table>
<tr><th>Meeting Date</th><th>Views</th></tr>
<tr><td>Apr 7, 2022</td><td>125</td></tr>
<tr><td>Mar 3, 2022</td><td>220</td></tr>
<tr><td>Feb 10, 2022</td><td>485</td></tr>
<tr><td>Jan 27, 2022</td><td>181</td></tr>
<tr><td>Dec 14, 2021</td><td>392</td></tr>
<tr><td>Nov 27, 2021</td><td>2545</td></tr>
<tr><td>Nov 24, 2021</td><td>5836</td></tr>
</table>
</td></tr>
<tr><td>Merritt Home and Recovery Facebook Page</td><td>
<ul>
<li>75 posts since its creation on Feb 2, 2022</li>
<li>6 specific posts related to 2 open houses and public survey related to Flood Management Plan sessions</li>
</ul>
</td></tr>
<tr><td>Recovery and Support website</td><td>
<ul>
<li>Content noted Committee of the Whole presentation, Open House meetings, and public survey announcement</li>
<li>Monthly flood related updates that saw usage as follows:</li>
</ul>
<table>
<tr><th>Month</th><th>Unique Visitors</th><th>Number of Visits</th></tr>
<tr><td>Aug 2022</td><td>14</td><td>18</td></tr>
<tr><td>July 2022</td><td>501</td><td>1017</td></tr>
<tr><td>June 2022</td><td>529</td><td>1316</td></tr>
<tr><td>May 2022</td><td>1357</td><td>2264</td></tr>
<tr><td>April 2022</td><td>1405</td><td>2242</td></tr>
<tr><td>March 2022</td><td>628</td><td>1263</td></tr>
<tr><td>Feb 2022</td><td>295</td><td>522</td></tr>
</table>
</td></tr>
</table>

#### 5.1.2.2 Public Survey

During the flood mitigation planning project, public input was sought on a variety of flood-related topics using a SurveyMonkey poll. The poll was active from April 22 to July 3 and was intended to provide the project team insights

[3] Usage as of Aug 2, 2022

that would help guide proposing of conceptual flood mitigation measures. A total of 315 responses were received and the results of the survey are noted in **Appendix E**. **Figure 5-1** shows one of the many invitations for feedback for the survey. This notice was a Facebook posting on May 5, 2022 but also included QR codes on Open House poster boards and social media postings.


**Figure 5-1: Public Survey Notice**

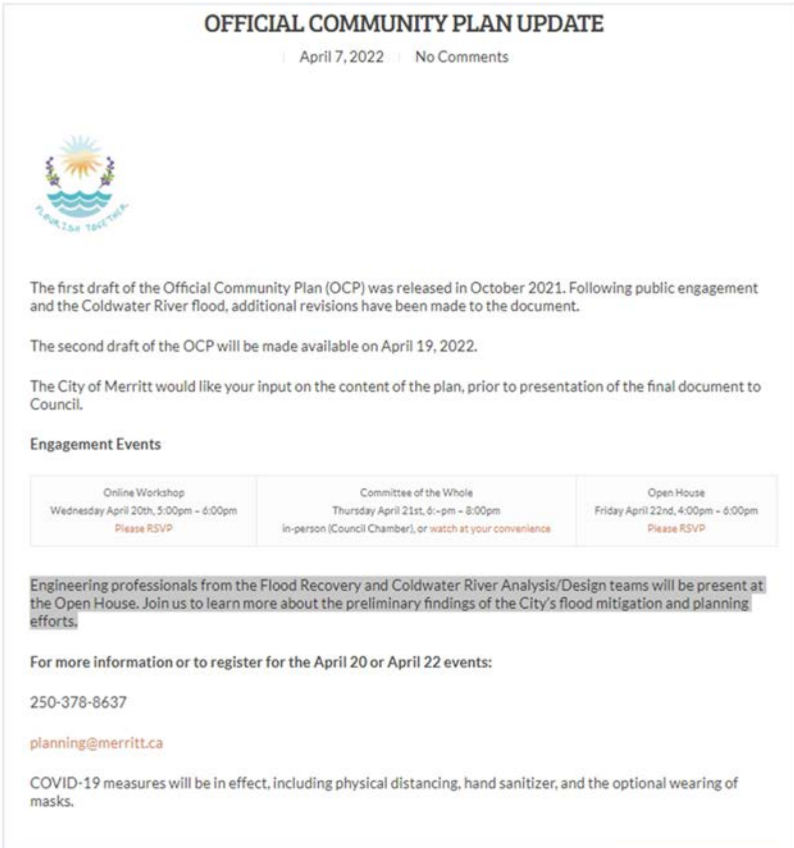
(https://www.facebook.com/groups/3082982508591319)

The survey helped guide Associated in how the residents viewed components of the flood mitigation planning measures. Notable takeaways from the survey included the following:

- **84%** of respondents noted having access to the Coldwater and Nicola rivers was important to them.
- **92%** of the respondents used the existing dike features as some form of recreation or transportation.
- The river systems were used by **93%** of the respondents for recreational purposes.
- **43%** of the respondents noted wildlife habitat as their highest value natural feature on the rivers.

#### 5.1.2.3 Open House #1

Public Engagement also occurred early in the project by presenting some of the initial findings at the public review session of the Official Community Plan (OCP) on April 22, 2022. The session allowed Associated to outline the project and funding timeline as well as to outline the various flood mitigation measures that were being used in the engineering tasks. Attendance at the session was limited, with 18 individuals based using the event sign-in sheets.



OFFICIAL COMMUNITY PLAN UPDATE

April 7, 2022 | No Comments

The first draft of the Official Community Plan (OCP) was released in October 2021. Following public engagement and the Coldwater River flood, additional revisions have been made to the document.

The second draft of the OCP will be made available on April 19, 2022.

The City of Merritt would like your input on the content of the plan, prior to presentation of the final document to Council.

**Engagement Events**

| Online Workshop | Committee of the Whole | Open House |
|---|---|---|
| Wednesday April 20th, 5:00pm - 6:00pm<br>Please RSVP | Thursday April 21st, 6:-pm - 8:00pm<br>in-person (Council Chamber), or watch at your convenience | Friday April 22nd, 4:00pm - 6:00pm<br>Please RSVP |

Engineering professionals from the Flood Recovery and Coldwater River Analysis/Design teams will be present at the Open House. Join us to learn more about the preliminary findings of the City's flood mitigation and planning efforts.

**For more information or to register for the April 20 or April 22 events:**

250-378-8637

planning@merritt.ca

COVID-19 measures will be in effect, including physical distancing, hand sanitizer, and the optional wearing of masks.

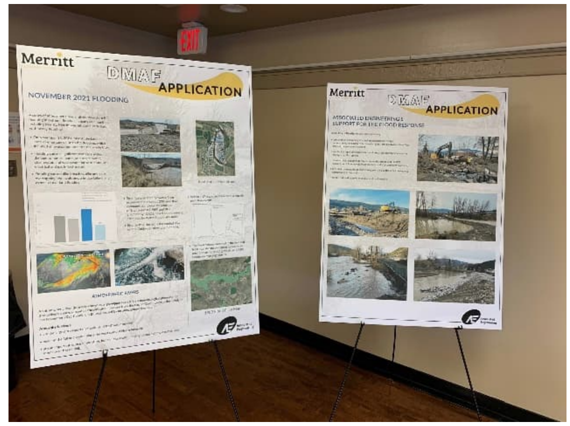



**Figure 5-2 Open House #1 Information**

### 5.1.2.4 Committee of the Whole Presentation

On June 29, 2022 Associated presented preliminary information from the flood mitigation plan to the City's Committee of the Whole. As with all City Council meetings, the session had a live feed to the City's YouTube channel that was also open to the public. The 45-minute presentation reviewed all aspects of Associated's flood mitigation planning project and the presentation was also posted to the City's Recovery and Support website and at the time of writing this report it has been viewed over 220 times[4].

[4] https://www.youtube.com/watch?v=VSZI_xLvvPA

### 5.1.2.5 Open House #2

Following the Committee of the Whole presentation on June 29, 2022, an open house was set up by the City at the Merritt Civic Center where the representatives from Associated, City, Red Cross, Emergency Management BC, the City Support Center, and the Provincial Government were available to answer questions from citizens. There were an estimated 150 attendees at the event. Associated presented 11 poster boards displaying the following information:

- 6 conceptual flood mitigation options that were modeled using various flood mitigation measures
- Summary table that outlined the respective costs of the 6 options
- Structural flood mitigation measures (i.e., dike types and footprint)
- Public survey results
- Environmental and archeological features
- Sedimentation and dredging limitations

**Figure 5-3 Open House #2 Session**

## 5.2 First Nations Engagement Activities

First Nations engagement is guided by the City of Merritt's OCP where the following objective is noted.

> *"We will work to earn the trust and confidence of First Nations communities, residents, businesses, and community organizations by acting with integrity, acknowledging our shortcomings, and inviting meaningful participation"* – City of Merritt Official Community Plan

The City of Merritt is aware of the Indigenous rights to the territories and land base that is within the proposed Flood Mitigation Plan. The City in good faith has followed engagement concepts in our community involvement strategies from the beginning. Collectively, all our communities have been affected which alone has encouraged that we move together to mitigate flood damages now and into the future.

The City of Merritt, by consulting with Indigenous communities, has intended to meet Free, Prior and Informed Consent (FPIC) as a specific right pertaining to Indigenous peoples. This right is recognised within the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). This right does allow the Indigenous Communities to give or withhold consent to a project that may affect them or their territories.

FPIC enables communities to negotiate the conditions under which the project will be designed, implemented, monitored and evaluated. These intentions are embedded within the universal right to a self-determination for Indigenous Nations.

It is with these parameters that the City of Merritt strives to be guided.

### 5.2.1 Proposed First Nations Engagement Framework

The Nicola Valley is the traditional, ancestral and unceded territory of the Nleʔkepmx and Syilx Nations, including the Shackan, Nooaitch, Lower Nicola, Coldwater and Upper Nicola Bands. The City is committed to engage with each of these Communities through four successive rounds of engagement. The engagement objective is to ensure that each community is heard, that concerns are addressed and guidance is implemented wherever possible. We acknowledge the Nleʔkepmx and Syilx Nations and their connection to this land, and we aim to incorporate their collective knowledge, values and traditions regarding environmental management and stewardship practices.

The first phase of engagement has been completed as part of the creation of this Flood Mitigation Plan, while the remaining three phases will be undertaken at various steps throughout the project. A description of each phase of engagement is as follows:

1. **Pre-planning engagement** – During this phase of engagement, the City engaged in high level conversations with the Chiefs of each community, community leaders and staff, and the Nicola Watershed Governance Partnership, to identify issues that the Flood Mitigation Plan must address and values that it must incorporate. The City also sought preliminary feedback from of each community on what future phases of engagement should look like. The First Nations were also formally invited to the two open house sessions as part of the FMP plan development.

2. **Post-plan engagement** – Moving forward, the City intends to circulate this Flood Mitigation Plan and all appendices to the Chief and Council of each community, along with administrative and technical staff that have been identified for each community. The City will set up individual meetings with each Band to review the

proposed plan and engagement framework to ensure that we accurately heard and implemented the recommendations that were collected during Pre-planning engagement. If necessary, any portion of this plan, including this engagement framework, will be amended based on community feedback and guidance.

A list of specific project objectives provided by the communities will be compiled, which will form an important basis for detailed project design, and which will also set the framework for measuring success and reporting to the communities throughout the construction process through to project completion.

While undertaking this phase of engagement, the City will continue to work with the Provincial and Federal Government to identify funding sources to pay for the costs of implementing this plan. At the conclusion of this phase of engagement, if any community wishes to provide formal support for this project, they will be invited to provide a letter of support.

3. **Detailed design engagement** – When the City has received sufficient funds to proceed with detailed project design and engineering, the City will invite the Communities to appoint two or more technical experts from First Nations communities to form part of the City's engineering and design team. The goal of this team will be to design and engineer specific flood mitigation solutions consistent with this Flood Mitigation Plan, with an aim towards maximizing protection of the community, environmental and recreational benefits and preserving cultural values, while mitigating for downstream effects, private property impacts and project costs. This team will also be responsible for ensuring that detailed project design meets the objectives identified during the second phase of engagement.

   The detailed design component of this project will include obtaining the regulatory approvals required to carry out various mitigative measures prescribed in the Plan. Specifically, Fisheries and Oceans Canada approvals will be required for measures affecting fish or fish habitat. The regulator has a policy in place for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the Fisheries Act' (the Policy). It provides guidance on undertaking effective measures to offset death of fish and the harmful alteration, disruption or destruction of fish habitat, consistent with the fish and fish habitat protection provisions of the *Fisheries Act*. The City intends to engage with First Nations to identify areas in and around the prescribed works that would be suitable offsetting endeavors to meet any compensation related regulatory requirements.

   When the draft detailed design work has been completed, the City will set up an engagement event within each, or collectively, with the Communities in their agreed assembly area, where the detailed project design and proposed construction schedule will be reviewed and discussed. This engagement will be technical in nature, though all community leadership will be invited to attend in addition to technical staff. The Communities will have a period following this meeting to review the plans, ask questions, and provide feedback prior to plan finalization. This engagement will run parallel to engagement opportunities for City of Merritt residents.

4. **Project Construction Engagement** – Since construction activities for this project are likely to span the course of multiple years, this will likely be the longest phase of engagement. The City will appoint a single point of contact for all inquiries from First Nations regarding this project and a system of monthly project updates will be established. At the conclusion of the project, a report will be prepared detailing the steps that were taken to meet the project objectives identified during the second phase of engagement. Throughout the construction process, the City is committed to retaining local Indigenous environmental and cultural monitors to support all construction activities.

### 5.2.2 Pre-planning Engagement Feedback

The City's pre-planning engagement activities consisted of phone conversations with each Chief, participation from Chiefs, Band staff and First Nations Service Organizations during bi-weekly recovery meetings with indigenous Communities, and two presentations to the Nicola Watershed Governance Partnership team. The City of Merritt specifically acknowledges that none of these activities were aimed at satisfying any potential consultation requirements, though the feedback received through pre-planning engagement has been incorporated throughout this Flood Mitigation Plan and forms the basis the proposed engagement framework. Through these engagement activities, the Communities have provided the City with the following guidance, which has been aggregated and paraphrased:

1. Any work that the City of Merritt does must protect and potentially enhance environmental factors, especially fish values. There is a collective desire to see the floodplain, or at least portions of the floodplain, return to a more natural state. This was highlighted in nearly every engagement conversation.

   > "*The flood mitigation work done in the City of Merritt will impact the Coldwater Band. In addition to high flow scenarios, any design for flood mitigation must also consider the regularly occurring summer drought conditions on the Coldwater River. Fish need deeper pools and cooler water to survive. We support flood mitigation in Merritt, so long as there is an emphasis on the protection of the environment, and particularly, fish values.*" – Chief Lee Spahan, Coldwater Indian Band

2. The issues facing both the Coldwater and Nicola Watersheds are diverse and a wholistic approach to the watershed must be taken. As a result, engagement for this project cannot just be token. The Bands must be part of the process of developing solutions. - Representatives from the Nicola Watershed Governance Partnership raised this issue, as well as Chief Marcel Shackelly (Nooaitch Indian Band) and Chief Lee Spahan.

3. Flood protection along the Nicola River through Merritt reduces flood risk for the Upper Nicola Indian Band at Nicola Lake.

   If the City of Merritt is capable of receiving higher flows through the Nicola Lake dam, the lake levels won't rise as high and the Province won't need to balance flooding in Merritt against flooding in Upper Nicola during freshet season. – Chief Harvey McLeod, Upper Nicola Indian Band

4. Downstream effects must be mitigated as part of this project. In particular, the project must not increase the velocity of the river as it leaves the City. – Chief Stuart Jackson, Lower Nicola Indian Band

5. The City of Merritt is a regional hub for the Bands, especially during emergencies, so seeing it protected is important.

   > "*When the City of Merritt went down, we lost a second home. We felt displaced, again. As a Chief, I support the City of Merritt*" – Chief Arnold Lampreau, Shackan

6. There is a desire for the City of Merritt to explore options regarding the possibility of re-locating the City's Wastewater Treatment Plant. As a result of damage to the City's rapid infiltration basins, the City discharged processed effluent into the Coldwater River for nearly a year.

# 6 FLOOD RISK MITIGATION OPTIONS

## 6.1 Flood Mitigation Planning Measures

A comprehensive flood mitigation plan usually includes both structural and non-structural measures. Non-structural measures reduce exposure and vulnerability to floods, often by a combination of hazard and risk assessments, land use planning, public awareness, and emergency planning and warning systems (NHC, 2021a). Structural measures reduce harm by physically modifying landscapes to reduce the impact of flooding.

Non-structural flood mitigation measures include (but are not limited to) the following:

- **Land Use Planning**, which includes policies and/or bylaws on flood construction levels, setback distances, zoning, and spatial restrictions on land development.
- **Public Awareness and Education**, which informs the public about flood hazards and what to do in an emergency.
- **Monitoring and Early Warning**, which is the purpose of the BC River Forecast Centre.
- **Emergency Planning**, involves the development, continual updating, and testing of emergency plans.
- **Risk-Receptor Relocation**, which reduces the exposure to the flood hazard by relocating the people and/or structures outside the floodplain.

Structural flood mitigation measures include (but are not limited to) the following:

- **Flow Reduction Measures**, which lower the flood hazard by reducing the maximum flow through the area of interest at any given time (e.g., upstream storage).
- **Conveyance Improvements**, which reduce water levels within the area of interest, without reducing the river's flow rate (e.g., dredging, channelization, and diversion).
- **Flood Barriers**, which mitigate the risk of the flood hazard through engineered solutions (e.g., setback or waterside diking).

Land use planning can be updated by the City with new floodplain maps and flood risk assessment information. Public awareness and education can also be considered through updated land use planning procedures. The City of Merritt can consider taking on more emergency flood planning based on experience from the AR event.

Emergency response activities included construction works extending beyond normal hours.

Flow reduction measures, such as upstream storage, were not considered for the City of Merritt. Upstream storage on the Coldwater River was not considered due to the immense storage volumes that would be required to reduce the flow rate during floods. Upstream storage already exists on the Nicola River at the Nicola Dam; however, the dam is not solely intended as a flood mitigation measure for the City of Merritt and its operating rules cannot be modified at the expense of the dam's other interests.

Conveyance improvements were considered for the City but are not adequate as a standalone solution. Generally, conveyance improvements are achieved though channel clearing and maintenance, replacement of undersized structures or removal of flow constrictions, river training, or dredging. River characteristics are dynamic, and any proposed conveyance improvement options need to be evaluated to determine how effective they will be in meeting the objectives and for what timeframe the modifications will function. Performing instream works can also have significant environmental impacts on the site as well as upstream and downstream of the works. Regulators have traditionally discouraged instream operations that would result in adverse environmental impacts.

Dredging tends to be popular among residents (based on public survey commentary), as it is thought to have fewer property impacts; however, a comparison of the pre- and post-event bathymetry gathered for the City of Merritt revealed that there was no widespread channel deposition within the City following the AR event. Therefore, it is not expected that dredging would significantly improve conveyance capacity.

The flood mitigation options of risk-receptor relocation and direct defence form the primary basis of the proposed options discussed in **Section 6.3**. Risk-receptor relocation can be unpopular when people have deep connection and value their home and land. However, given the proximity of many properties to the rivers in Merritt, the construction of any structural flood mitigation works will require some relocation. Additional information on flood mitigation structures is provided in the following section.

## 6.2 Types of Flood Mitigation Structures

The *Dike Maintenance Act* (1996) defines a "dike" as an embankment, wall, fill, piling, pump, gate, floodbox, pipe, sluice, culvert, canal, ditch, drain or any other thing that is constructed, assembled, or installed to prevent the flooding of land. flood mitigation structures (i.e., dikes) are common flood mitigation methods used in BC. Because so much of the City resides within floodplains of the Coldwater and Nicola Rivers, diking can protect land and property that would otherwise flood without requiring the relocation of a significant number of properties.

Traditional earthen dikes can require a significant footprint, depending on the location of the dike (waterside vs. setback) and its required height. **Figure 6-1** illustrates the relationship of a standard earthen dike footprint to its height. This illustration assumes a side slope of 2 (horizontal) to 1 (vertical), but flatter slopes and wider dikes may be required is some conditions. A 2 m high dike will be at least 12 m wide based on this sketch. For every 1 m that is added in elevation, the dike will increase 4 m in width. There will be some areas in Merritt that require a wide are to accommodate construction of a dike structure. In addition, the Province typically requires a 7.5 m right-of-way behind a dike structure to allow for inspection and maintenance activities.

Structural flood mitigation dikes introduce a barrier to natural overland flow paths. As a result, surface water can be impounded on the land side of the dikes. If there is a situation when riverine flooding is occurring at the same time as a storm event, surface flooding in the City may still result due to rainfall, seepage, or groundwater. Therefore, outfalls and pump stations are used to convey water from the land side area to the river. The four types of dikes considered for the City of Merritt are described below. The stormwater impacts and potential outfall improvement requirements are described in **Section 6.2.7**.

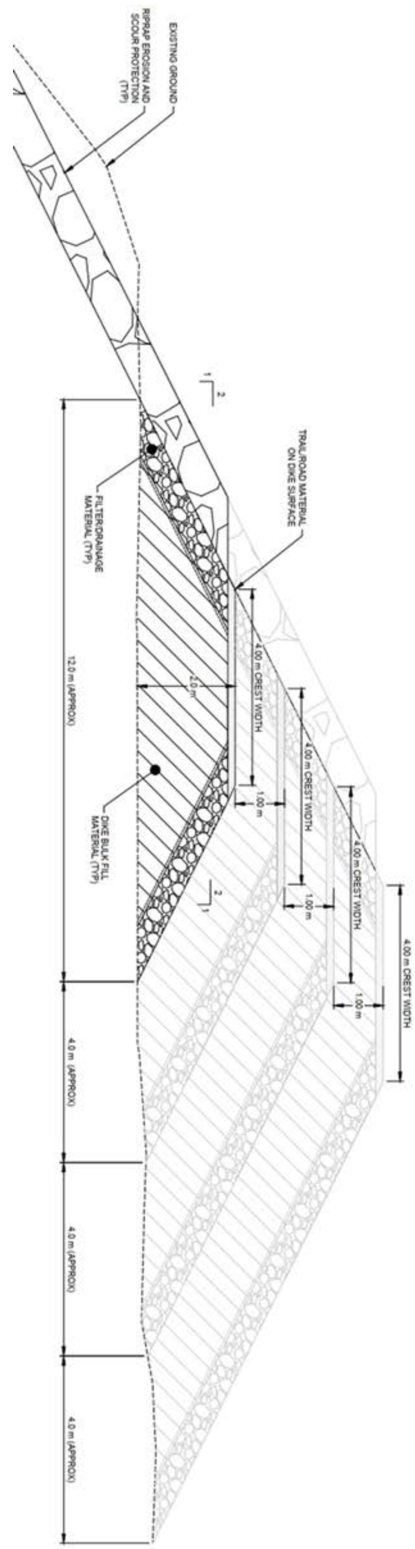



**Figure 6-1: Earthen Dike Footprint Based on Variation in Height**

### 6.2.1 Waterside Dikes

Waterside dikes are built immediately next to a river and serve as a vertical extension of the existing riverbank (see **Figure 6-2**). The height of the dike and the size and thickness of riprap on the water side of the dike depend on flow hydraulics against the surface of the dike. Waterside dikes are a common form of dike structure because it is logical to build a dike on a riverbank. Typically, this type of diking affects fewer properties compared to setback diking; however, properties within the dike footprint can still require acquisition or right-of-way. Waterside dikes can be used as part of an Active Transportation Corridor along the river because there is a wide, flat crest that can dovetail as a pathway.

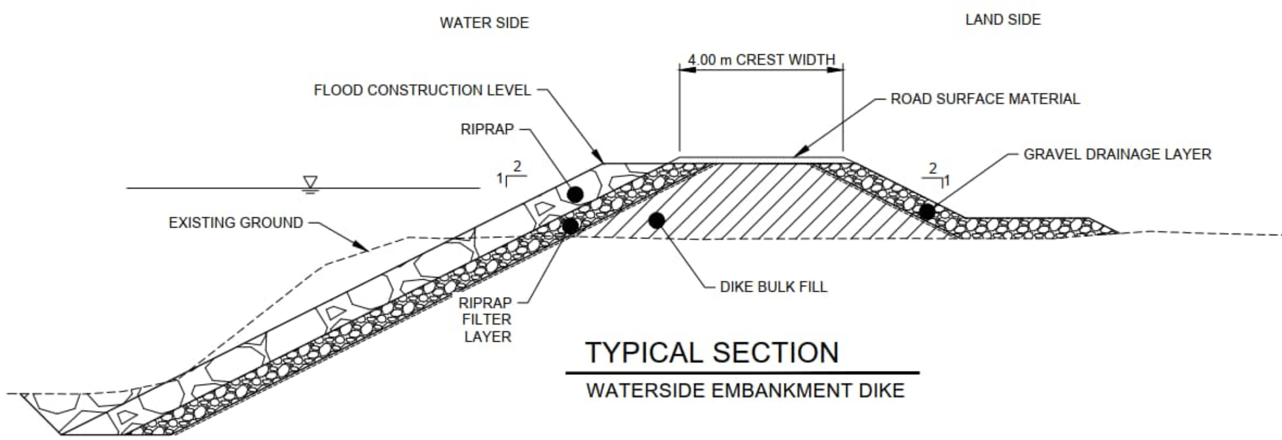



**Figure 6-2**
**Waterside Dike Section**

### 6.2.2 Setback Dikes

Setback dikes are like waterside dikes but are built away from the riverbank. Setback dikes provide additional space for the river and often include natural floodplains and habitat area (**Figure 6-3**). Providing additional floodplain areas helps reduce water surface elevations and velocities. Usually no riprap erosion protection is needed on a setback dike due to lower water velocities. Any properties on the water side of the dike as well as those under the dike footprint would be acquired or require a right-of-way. The water side land can be made accessible during non-flood times for undeveloped recreational use. Similarly, setback dikes can also be used as part of an ATC near the river.

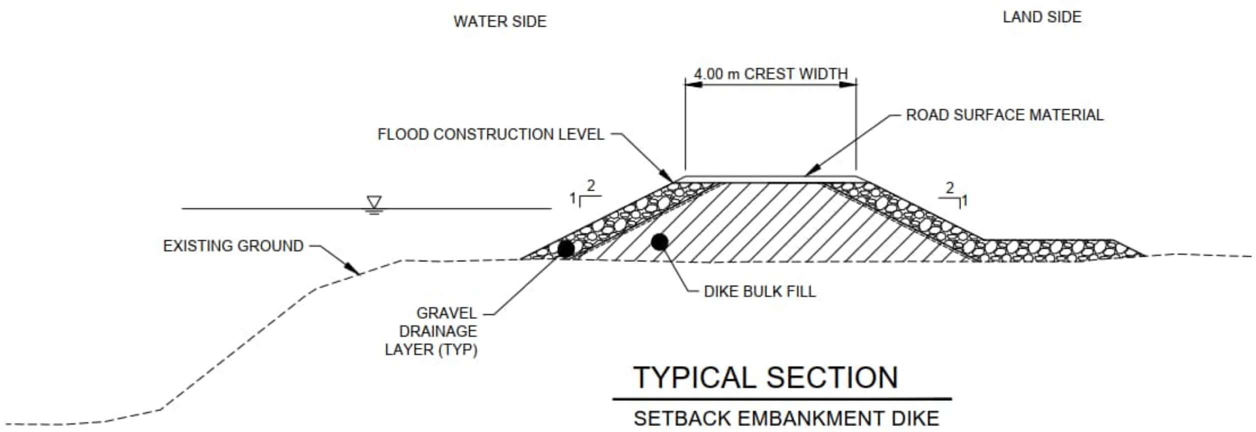



**Figure 6-3**
**Setback Dike Section**

### 6.2.3 Narrow Dikes

Narrow dikes can provide continuity of a diking system in areas where the acquisition of land or the desired dike alignment is impractical. Narrow dikes are typically wall structures, such as sheet pile walls. Sheet piles have a much smaller footprint compared to embankment dikes, as shown in **Figure 6-4**. However, they can be more difficult and expensive to construct. Narrow dikes do not typically accommodate the same ATC benefit as embankment dikes and can even cut off river access in some situations. Further to this, the aesthetics of sheet pile walls along a natural river system may not be desirable to some people.

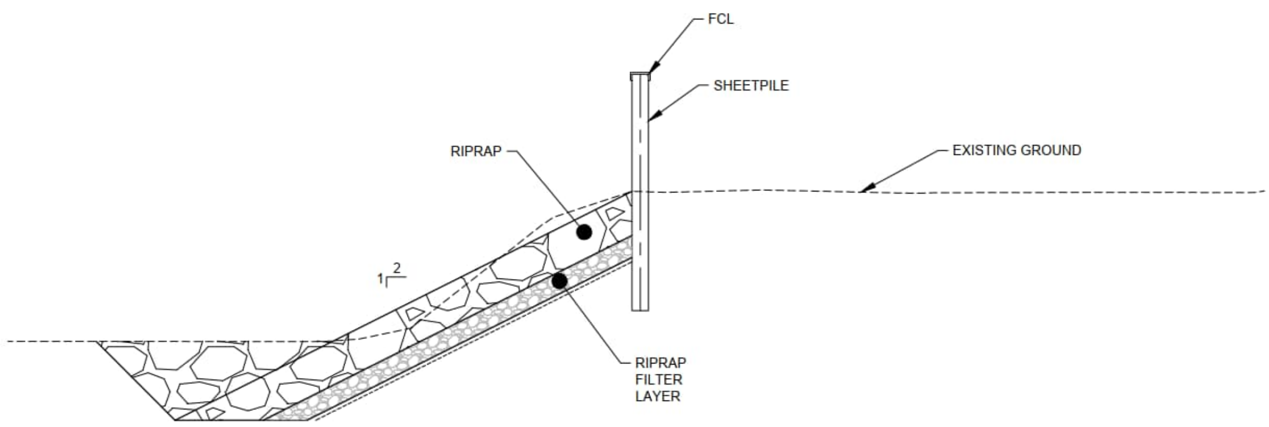



**Figure 6-4**
**Narrow Dike (Sheet Pile Wall) Section**

### 6.2.4 Road Raising

Road raising can be considered as a flood mitigation structure where setback or waterside dikes coincide with an existing (or proposed) road. In this case the roadway will also serve as a dike. This concept is sometimes referred to as an overwide dike.

When roads are raised vertically, the profile changes can often lead to elevation and grading challenges with nearby intersections and driveways. If the required elevation increase is significant, the technical challenges can be too great to overcome and road raising will be impractical.

### 6.2.5 Channel Dredging

As noted above, respondents to the public survey had many comments about channel dredging and many citizens felt it was necessary and the best option to consider. While dredging can be selectively used to improve channel capacity and remove blockage areas, Associated has not considered widespread application of this method in the flood mitigation plan.

Channel dredging is considered a temporary solution and will require ongoing maintenance if to be effective (particularly on Coldwater River with a high sediment load). Furthermore, channel dredging is not a dike structure under the *Dike Maintenance Act* and cannot be relied upon for flood mitigation in the City. Lastly, there can be adverse environmental impacts associated with dredging and regulatory agencies may not support ongoing channel maintenance in the rivers considering the aquatic values and groundwater resources.

### 6.2.6 Bridge Replacement

Bridge structures are not considered dikes. However, bridge replacement may be necessary if existing bridge structures are undersized for the design flood. Bridge crossings can be hydraulic control points and constrict flow, which can lead to overland flooding and erosion/scour damage. Based on Associated's hydraulic modelling, three bridges have been identified with hydraulic capacity limitations:

- Main Street Bridge over Coldwater River
- Voght Street Bridge over Nicola River
- Highway Bridge over Nicola River (owned by MoTI)

Collapsed span of Middlesborough Bridge.

### 6.2.7 Stormwater System Improvements

The flood mitigation plan focuses on protecting the City from riverine flooding. However, a consequence of constructing dikes is the interruption of natural overland flow paths to watercourses. The effect of a rainfall event during a flood event must be considered as stormwater cannot naturally flow into the river when water levels are high. During these times, pumping is generally required to convey stormwater out of the protected area and into the adjacent river. Stormwater outfalls that pass through a dike must be protected with backwater prevention valves (or gates) to prevent flood water from flowing into the protected area.

To address these factors, Associated has assessed the expected impacts to the City's major drainage network from the proposed flood mitigation scenarios. Stormwater improvements are proposed to maintain the functionality of the system during normal river levels (gravity outfalls through the dike) and flood events (pumping).

#### 6.2.7.1 Existing Conditions

Associated reviewed the City's Integrated Stormwater Management Plan (ISMP) (Associated Engineering (B.C.) Ltd., 2014) and the GIS data provided by the City to assess the existing conditions. No pipe or manhole invert elevations were available in the data reviewed. Associated also met with the City to discuss the existing stormwater network's functionality. From this, the following conclusions were made:

- Some areas flood regularly due to undersized stormwater infrastructure.
- When Nicola River levels are high, water flows into the stormwater system as the existing outfalls are not protected with backflow prevention.
- Overland flow routes are likely to be impacted by dike alignments and could further overwhelm stormwater pipe network.
- The current location and elevations of outlets are often below the elevation required to discharge during flood events.

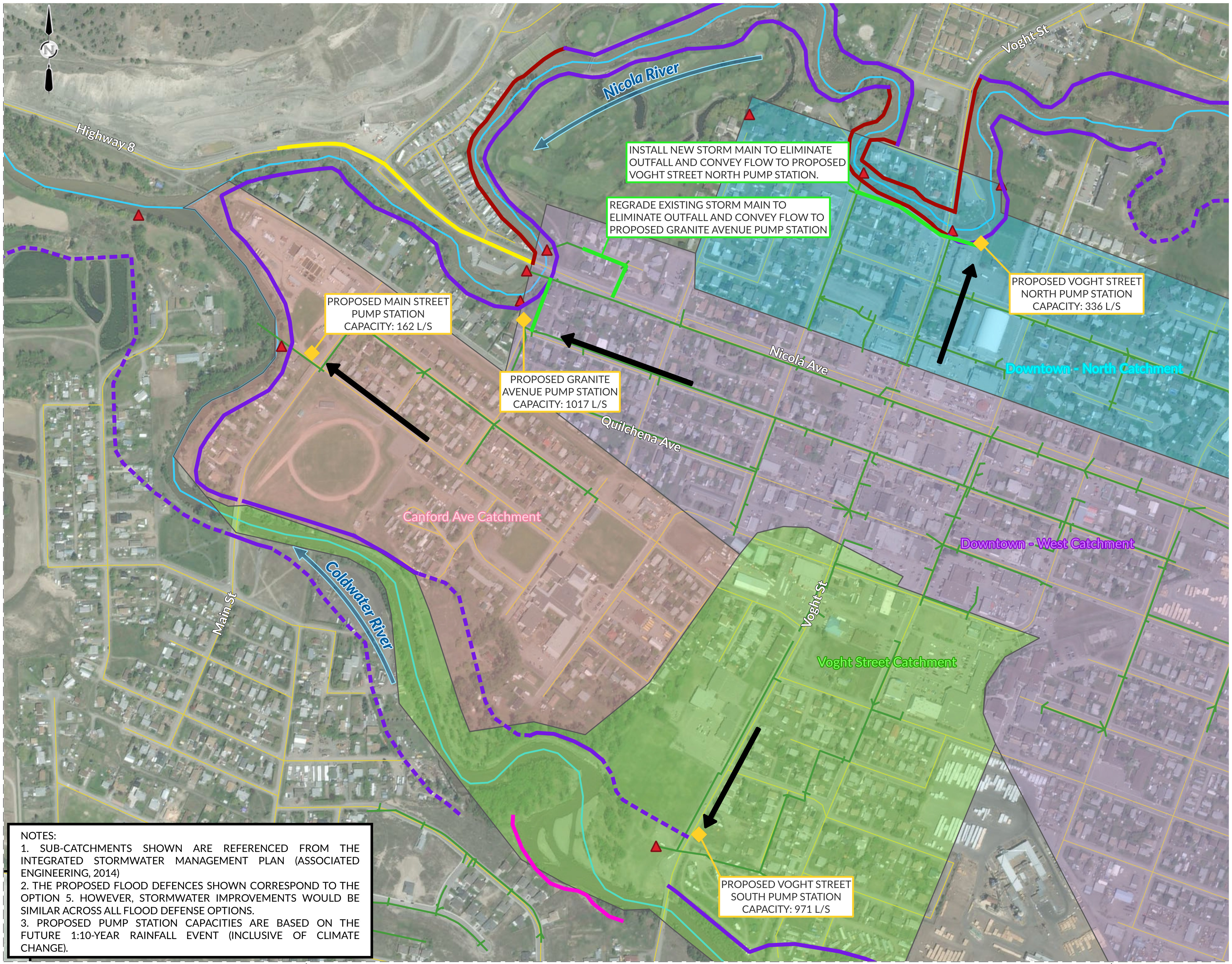
The existing stormwater network and catchment areas are shown on **Figure 6-5**.

#### 6.2.7.2 Proposed Stormwater Alterations

The downtown core of Merritt is surrounded by the Coldwater and Nicola Rivers, with the surface graded generally towards the confluence. In a future state with dike systems in place there is no overland flow route for surface water to reach either river. Flow must be conveyed through the dikes either by gravity when river levels are sufficiently low to permit drainage or by pumping when river levels are elevated.

The City between the rivers is divided into four main catchments based on overland flow routes and stormwater infrastructure (Associated Engineering (B.C.) Ltd., 2014). Conceptually, stormwater alterations would allow for a single gravity outfall and pump station to service each of the four catchments. In several cases, pipe upgrades would be required to redirect flow and eliminate excess outfalls, which is recommended to reduce the total number of penetrations through the dike, as well as the number of pump stations required.

**Figure 6-5** presents the four proposed conceptual pump station locations and conveyance alterations required to combine the sub-catchment outfalls at a single location. Those outlets are at Voght Street (north), Granite Avenue, Main Street, and Voght Street (South). Each pump station would include a gravity outfall with backflow prevention, and separate pump outlet pipes to discharge to the river. The pumping capacities shown are based on the resulting flow rates from the future 10-year rainfall event, as reported in the ISMP (Associated Engineering (B.C.) Ltd., 2014). These proposed capacities include a 41% increase to account for future climate conditions at year 100 (assuming an approximate design life of 75 years for new infrastructure). The percent increase was calculated using the temperature scaling method as outlined in *CSA Plus 4013:2019*, *Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners* (2019). This method is endorsed by Environment and Climate Change Canada. A mean temperature increase of 5.1 °C was assumed following a review of RCP 8.5 climate data projections at the location of the City of Merritt.




NOTES:
1. SUB-CATCHMENTS SHOWN ARE REFERENCED FROM THE INTEGRATED STORMWATER MANAGEMENT PLAN (ASSOCIATED ENGINEERING, 2014)
2. THE PROPOSED FLOOD DEFENCES SHOWN CORRESPOND TO THE OPTION 5. HOWEVER, STORMWATER IMPROVEMENTS WOULD BE SIMILAR ACROSS ALL FLOOD DEFENSE OPTIONS.
3. PROPOSED PUMP STATION CAPACITIES ARE BASED ON THE FUTURE 1:10-YEAR RAINFALL EVENT (INCLUSIVE OF CLIMATE CHANGE).

Associated Engineering

BEST MANAGED COMPANIES Platinum member

## LEGEND

- WATERCOURSE
- DRAINAGE DIRECTION

**EXISTING INFRASTRUCTURE**
- ROADS
- STORM MAINS
- EXISTING OUTFALL

**PROPOSED ALTERATIONS**
- PIPE UPGRADES
- PUMP STATION

**OPTION 5 FLOOD DEFENSES**
- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

0 100 200 300 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION

Merritt
FLOURISH UNDER THE SUN

FIGURE 6-5 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
PROPOSED STORM SEWER ALTERATIONS

| | |
|---|---|
| AE PROJECT No. | 20212385-02 |
| SCALE | 1:6000 |
| APPROVED | C. DUNCAN |
| DATE | 20220811 |
| REV | A |
| DESCRIPTION | ISSUED FOR DRAFT |

#### 6.2.7.3 Groundwater

A groundwater assessment has not been completed as part of this conceptual flood mitigation plan. However, the City of Merritt is located on an unconfined aquifer which is hydraulically connected to the Nicola and Coldwater Rivers. As such, groundwater flooding poses risk to the dike-protected area. A groundwater risk assessment could be completed during the design phase to assess the potential impact of groundwater flooding to the City, and to develop mitigation options for dealing with groundwater flooding. Groundwater solutions (e.g., interception wells and pumping) may be combined with the overall stormwater pumping scheme as a combined system.

## 6.3 Proposed Flood Mitigation Options

Associated prepared seven flood mitigation options that were presented to the City for review:

- Option 1: Do Nothing/Status-Quo
- Option 2: Full Floodplain Retreat
- Option 3: Waterside Diking
- Option 4a, 4b, 4c: Combination Diking (combinations of waterside and setback diking)
- Option 5: Combination Diking (this is the preferred option)

Options 3, 4, and 5 include the stormwater system alterations that were described above. It is important to note that the flood mitigation options for the City of Merritt are only concept-level and have been prepared for planning purposes. Design has not been completed and further details and refinement will be completed at later phases of the project. Each of the options is described below.

### 6.3.1 Option 1: Do Nothing/Status-Quo

The first option, the “do nothing/status-quo” option, is intended to provide information on the flood hazard risks and expected costs associated with future flooding if the City does not implement any flood mitigation measures. This type of approach can be feasible in cases where the flood risks are low, and/or the cost-benefit ratio of flood mitigation measures are high. However, Associated has determined that there are significant costs associated with this option due to the large area of the City that falls within the floodplain and is prone to damage, and from the amount of restoration work required following a flood (as experienced following the AR event). This option also has inevitable environmental impacts, as there will be river channel changes, erosion, scour, loss of riparian vegetation, and it exposes many non-aquatic environments to the influences of water. Option 1 is illustrated in **Figure 6-6**.

### 6.3.2 Option 2: Full Floodplain Retreat

The second option is a complete retreat from the floodplain. This involves a large-scale managed retreat and removal/relocation of all structures (i.e., risk receptors) within the flood extent to safe ground, outside of the floodplain. This type of “room-for-river” approach allows for floodplain reconnection in areas that have been developed close to the river channel. Because Merritt developed primarily along the Coldwater and Nicola riverbanks, this type of mitigation option would be costly, difficult to implement, cause significant social disruption to the community, and be prohibitive to any future development and economic activities in the City. Significant demolition and restoration are required for this option, which would be costly and time-consuming to implement. Additionally, construction services and land could be in high-demand outside of the floodplain which could impact the feasibility of relocation people and businesses.

One of the benefits to this type of option is that little to no maintenance are required following successful implementation, as the river would no longer impact homes or surrounding infrastructure. Retreating from floodplain areas creates the environmental benefits of giving the river room to migrate, be unimpeded by anthropogenic structures, and creating more valuable habitat. Option 2 is illustrated in **Figure 6-7**.

### 6.3.3 Option 3: Waterside Diking

The third option provides flood mitigation using primarily waterside diking along the banks of the Coldwater and Nicola Rivers. Where construction, cost, environmental, or space constraints made waterside diking impractical, narrow dikes or setback dikes are used instead of traditional earthen dikes. For example, setback diking is proposed at the upstream end of the Coldwater River to avoid impacts to Godey Creek, and narrow dikes are proposed near the Voght Street Bridge where utilities, infrastructure, and existing topography make waterside dikes impractical.

This option is intended to minimize the property acquisition required for the construction of flood mitigation works. In this option there is no managed retreat apart from the property acquisition required to accommodate the footprint of dike structures. However, there are some notable environmental impacts to this option. Waterside diking will isolate valuable oxbow habitats along the Nicola River and will limit the riparian habitat. There are also significant infrastructure costs associated with this option. Restricting the flowing area of the river results in higher water surface elevations and velocities. As a result, Associated expects bridge replacements would be required for Main Street, Nicola Avenue, and Voght Street Bridges. Option 3 is illustrated in **Figure 6-8**.

### 6.3.4 Option 4a, 4b, 4c: Combination Setback/Waterside Diking

Options 4a, 4b, and 4c consist of various combinations of setback and waterside diking. The alignments are determined primarily based on existing natural and developed features that the City expressed interest in protecting. The options vary in the following locations:

Coldwater River:

- Upstream of Houston Street Bridge
- Upstream of Middlesborough Bridge
- Around the Mainstreet Bridge

Nicola River:

- Along Nicola Avenue
- Around the Vought Street Bridge
- Near Conklin Avenue

Along the Coldwater River these options have waterside diking opposite the Tolko property, setback diking in the reach between the Main Street and Middlesborough bridges, setback diking along Pine Street protecting the wastewater infiltration ponds, and waterside diking on the east side of the confluence.

Along the Nicola River, these options have diking along the oxbows at the upstream end of the protected area and setback diking along the south side of the golf course, with the area bounded by waterside diking on the downstream left bank.

Replacements for Main Street, Nicola Avenue, and Voght Street Bridges would be required in all options. These options employ varying extents of setback diking which effectively provides room-for-the-river. This approach will increase the riparian habitat along rivers and allows for some land to be restored back to a natural floodplain condition. There are some differences between these options that are described below. Each of these options was developed to evaluate the difference in river hydraulics and flood mitigation performance.

#### 6.3.4.1 Option 4a

Option 4a includes road raising as a setback dike upstream of Houston Street. A setback dike is placed behind the Claybanks RV Park upstream of Middlesborough Bridge. Voght Park and areas of Main and Pine Streets are unprotected and would be flooded during an event. Narrow diking is used on the south and east sides of the Voght Street Bridge crossing, and a setback dike is placed along First Avenue to widen the opening for the river through this bend. A setback dike extends behind the oxbow along Conklin Avenue. Option 4a is illustrated in **Figure 6-9**.

#### 6.3.4.2 Option 4b

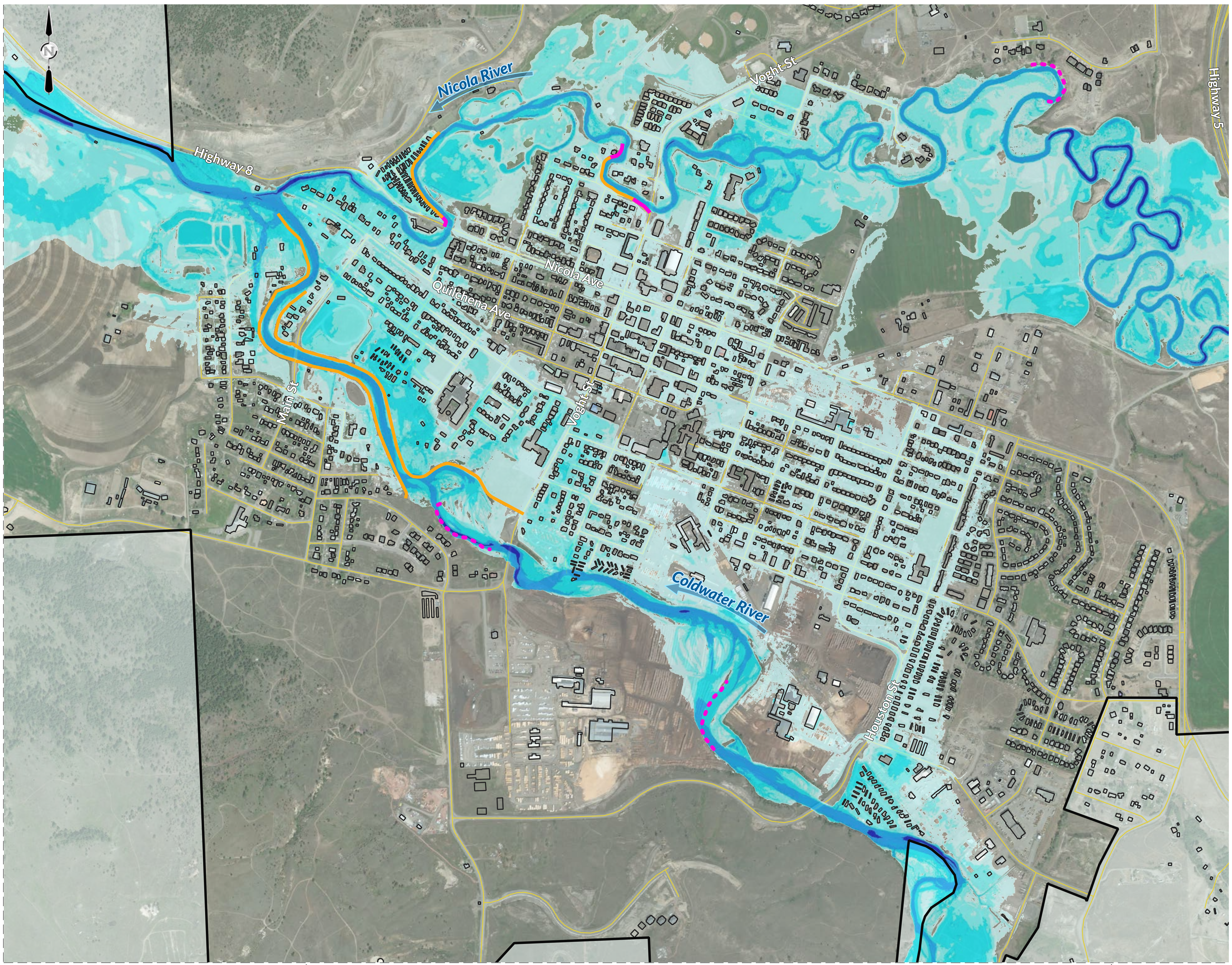
Option 4b includes a setback dike placed behind the Riverside Mobile Home Park and along the water upstream of Houston Street to protecting the industrial properties. A setback dike is placed through the Claybanks RV Park upstream of Middlesborough Bridge, allowing a portion of the property to continue to be used. Voght Park and areas of Main and Pine Streets are unprotected and would be flooded during an event; the Main Street properties on the inside of the bend are protected by waterside dikes and road raising. Road raising along Nicola Avenue bounds the flooding through the golf course on the downstream side. Narrow diking is used on both the inside and outside of the bend at the Voght Street Bridge crossing as well as along the road upstream of the bridge. A setback dike extends behind the oxbow along Conklin Avenue. Option 4b is illustrated in **Figure 6-10**.

#### 6.3.4.3 Option 4c

In this option, a waterside dike runs upstream of the Houston Street Bridge, protecting the Riverside Mobile Home Park and the industrial properties. Upstream of the Middlesborough Bridge, a waterside dike protects the Claybanks RV Park such that most of the property may continue to be used. A waterside dike follows the right bank of the river under the Main Street Bridge to the confluence. There is no road raising along Nicola Avenue. Narrow diking is used on both the inside and outside of the bend at the Voght Street Bridge crossing as well as along the road upstream of the bridge. A waterside dike follows the oxbow upstream of the Voght Street Bridge but does not extend back to Conklin Avenue. Option 4c is illustrated in **Figure 6-11**.

### 6.3.5 Option 5

Option 5 is the preferred flood mitigation option and is recommended for the flood mitigation plan in the City of Merritt. This option is a combination of options described above and it was developed after the preceding options were developed and evaluated. Associated reviewed critical areas with the City (refer to **Section 7.3**) and Option 5 was developed following this review. Like all the Option 4's, this option is still structural flood mitigation using combinations of setback and waterside diking. Option 5 is illustrated in **Figure 6-12**. This recommendation was based on the outcome of the options analysis (**Section 1**), consultation with the City, feedback from the public, and Associated's professional engineering judgement.




**LEGEND**

- CITY BOUNDARY
- ROADS
- BUILDING FOOTPRINT
- PROPOSED BANK PROTECTION

**EXISTING FLOOD PROTECTION WORKS**

- BANK PROTECTION
- DIKE (CREST)

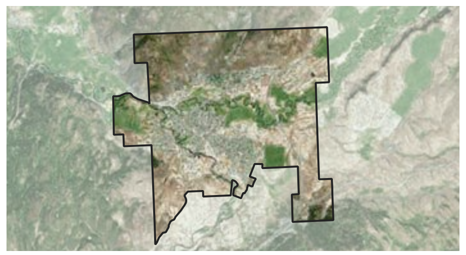
**INUNDATION DEPTH (m)**

- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

**MAP LOCATION**



Merritt
FLOURISH UNDER THE SUN

FIGURE 6-6 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 1: STATUS QUO

| | |
|---|---|
| AE PROJECT No. | 20212385-02 |
| SCALE | AS SHOWN |
| APPROVED | G. CAHILL |
| DATE | 20220817 |
| REV | A |
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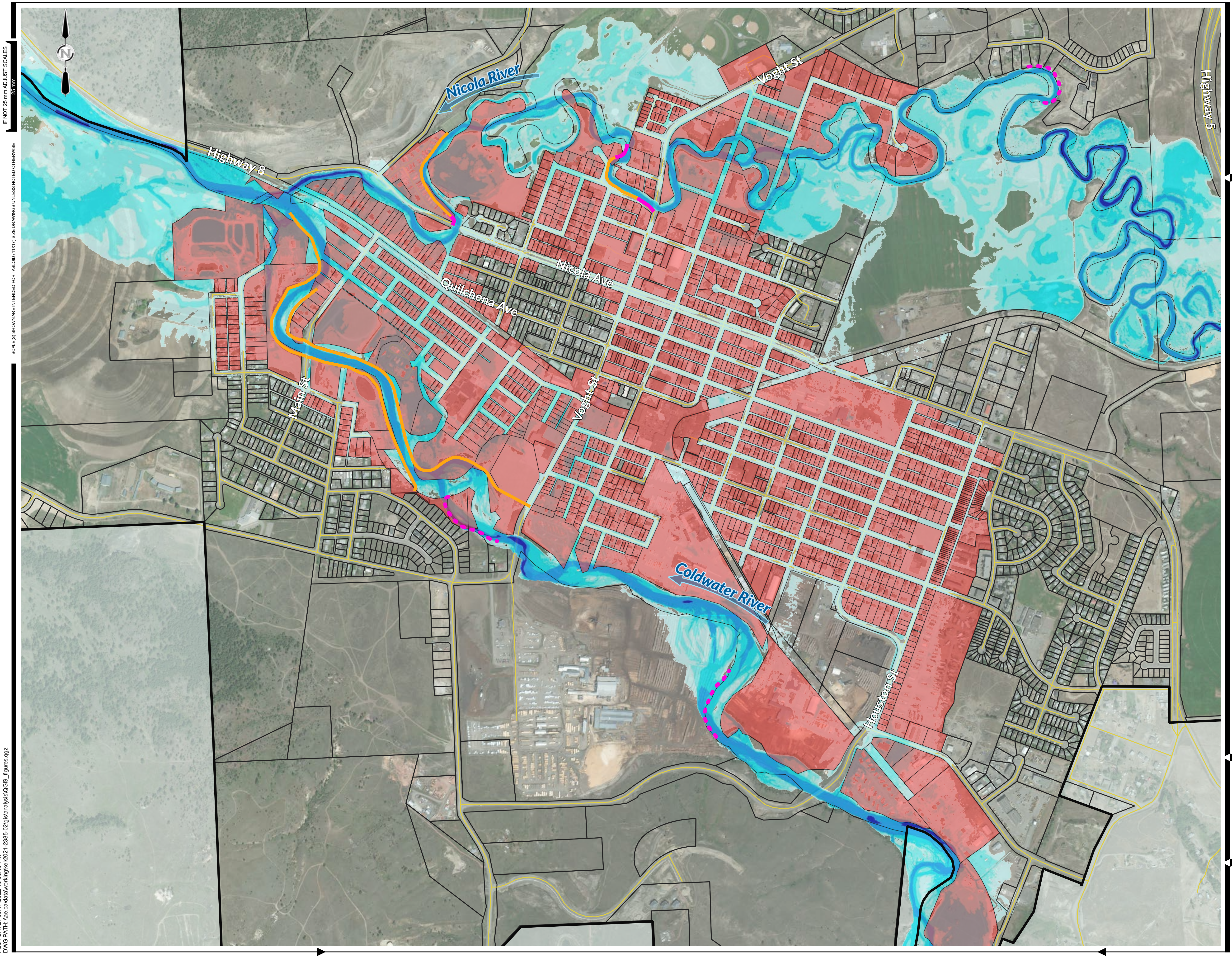



**LEGEND**

- CITY BOUNDARY
- ROADS
- MANAGED RETREAT AREAS
- PROPERTY BOUNDARIES
- PROPOSED BANK PROTECTION

**EXISTING FLOOD PROTECTION WORKS**

- BANK PROTECTION
- DIKE (CREST)

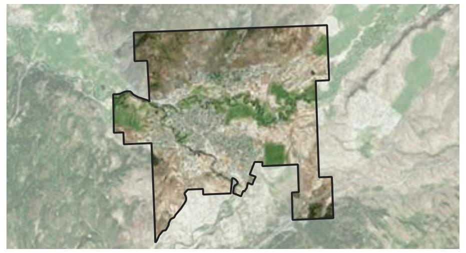
**INUNDATION DEPTH (m)**

- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



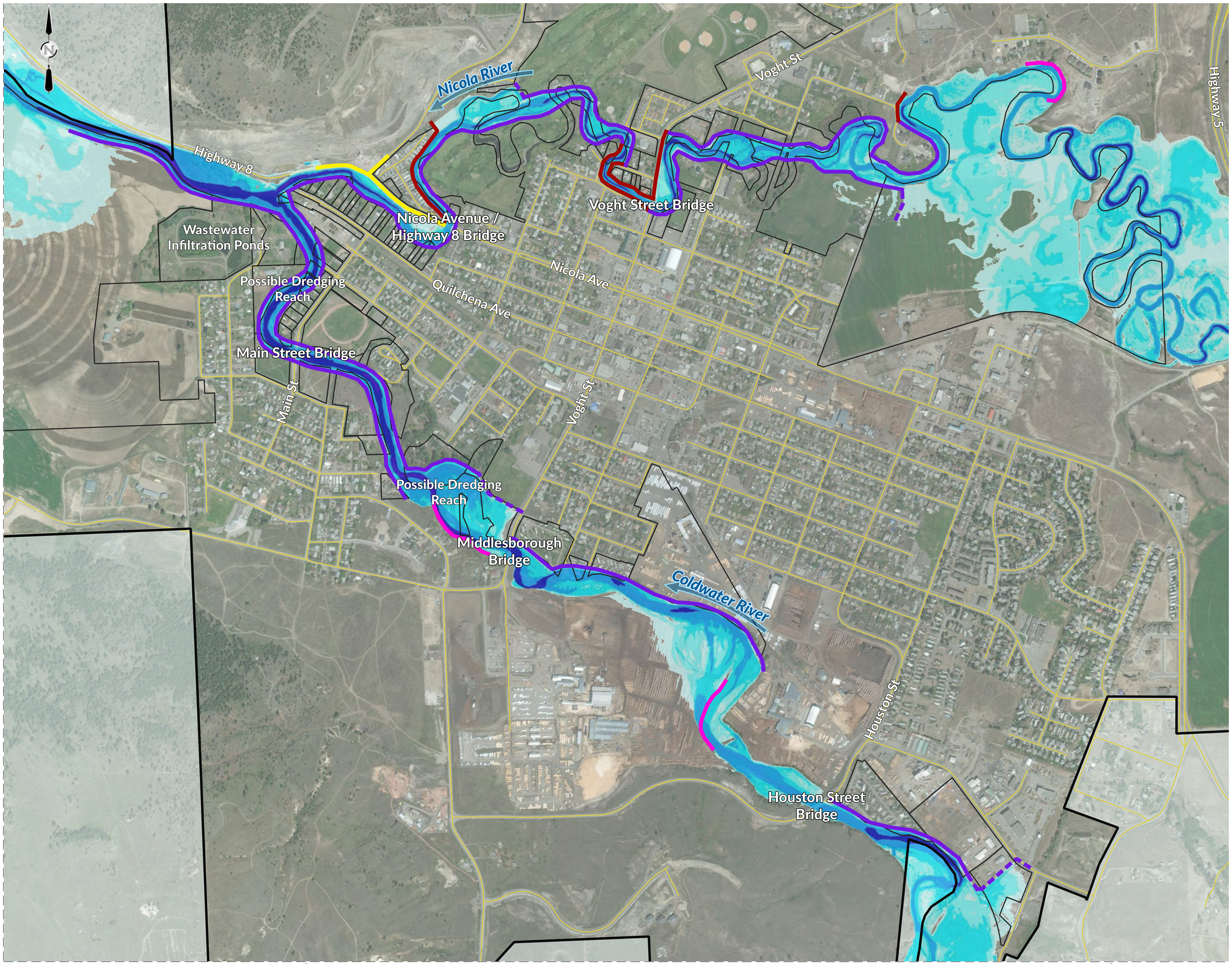
Merritt
FLOURISH UNDER THE SUN

FIGURE 6-7 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 2: FULL FLOODPLAIN RETREAT

| | |
|---|---|
| **AE PROJECT No.** | 20212385-02 |
| **SCALE** | AS SHOWN |
| **APPROVED** | G. CAHILL |
| **DATE** | 20220817 |
| **REV** | A |
| **DESCRIPTION** | ISSUED FOR DRAFT |

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## LEGEND

- CITY BOUNDARY
- AFFECTED PROPERTIES
- ROADS

**OPTIONS**

- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

**INUNDATION DEPTH (m)**

- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION

Merritt
FLOURISH UNDER THE SUN

FIGURE 6-8 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 3: WATERSIDE DIKING

| | |
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| AE PROJECT No. | 20212385-02 |
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| REV | A |
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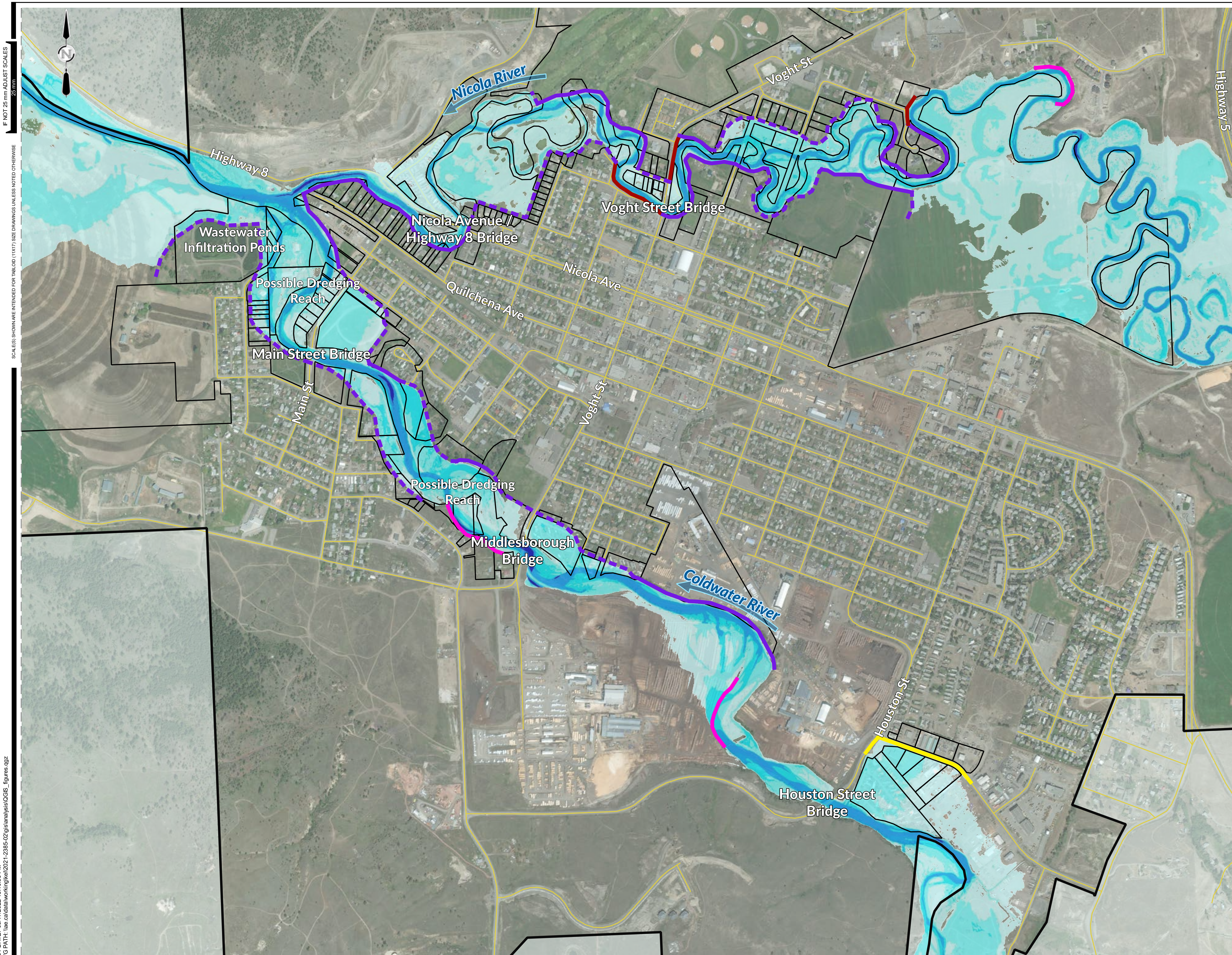


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## LEGEND

- CITY BOUNDARY
- AFFECTED PROPERTIES
- ROADS

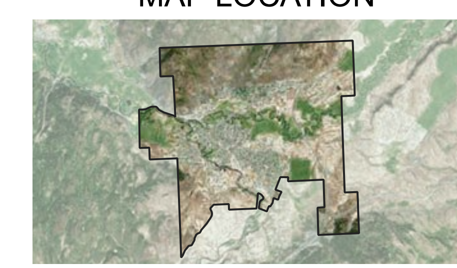
OPTIONS
- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

INUNDATION DEPTH (m)
- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



Merritt
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FIGURE 6-9 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 4a: COMBINATION DIKING

| | |
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| APPROVED | G. CAHILL |
| DATE | 20220817 |
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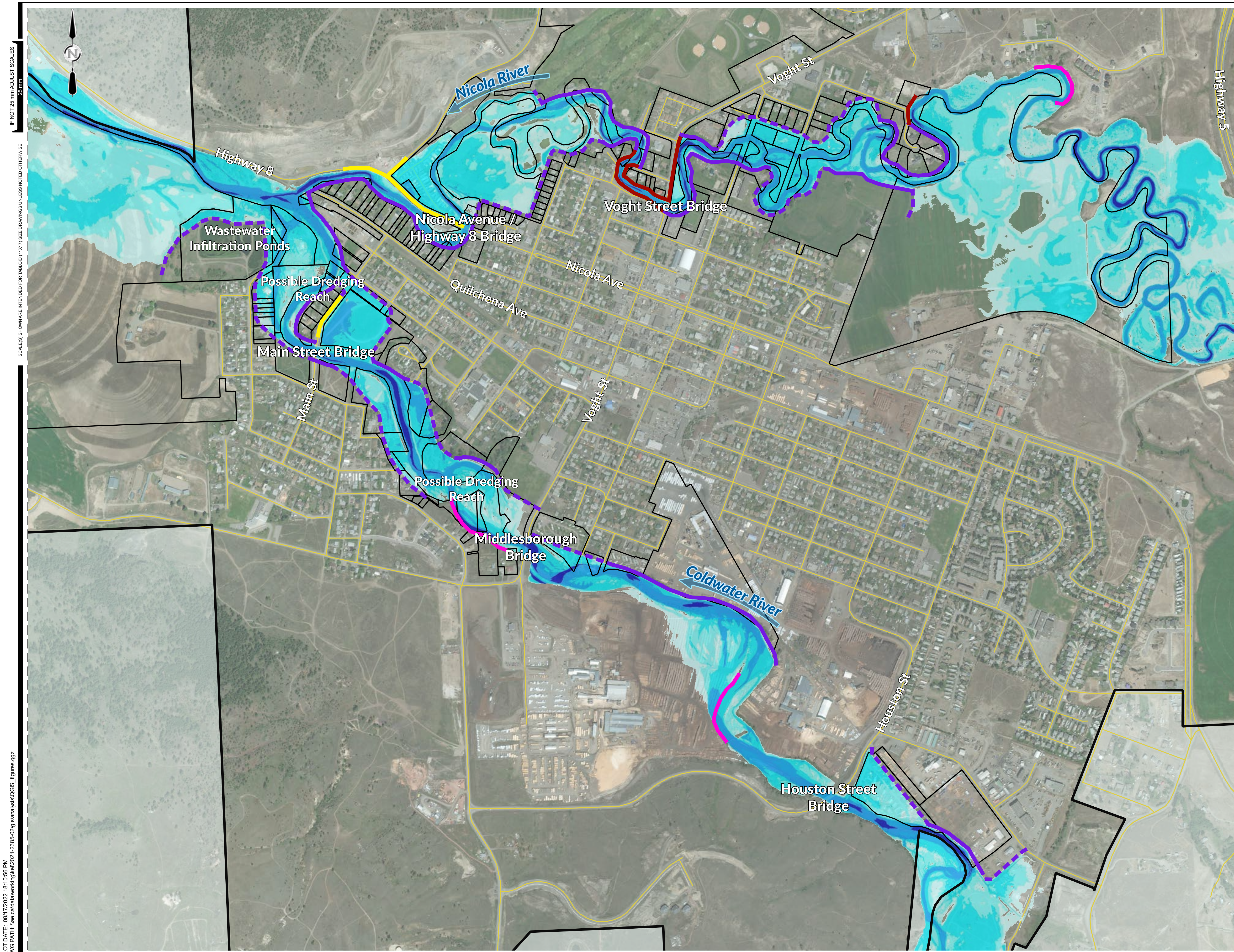


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## LEGEND

- CITY BOUNDARY
- AFFECTED PROPERTIES
- ROADS

OPTIONS

- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

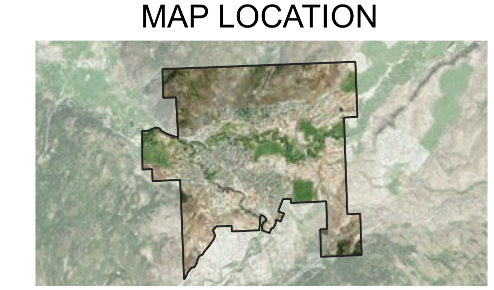
INUNDATION DEPTH (m)

- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



Merritt
FLOURISH UNDER THE SUN

FIGURE 6-10 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 4b: COMBINATION DIKING

| | |
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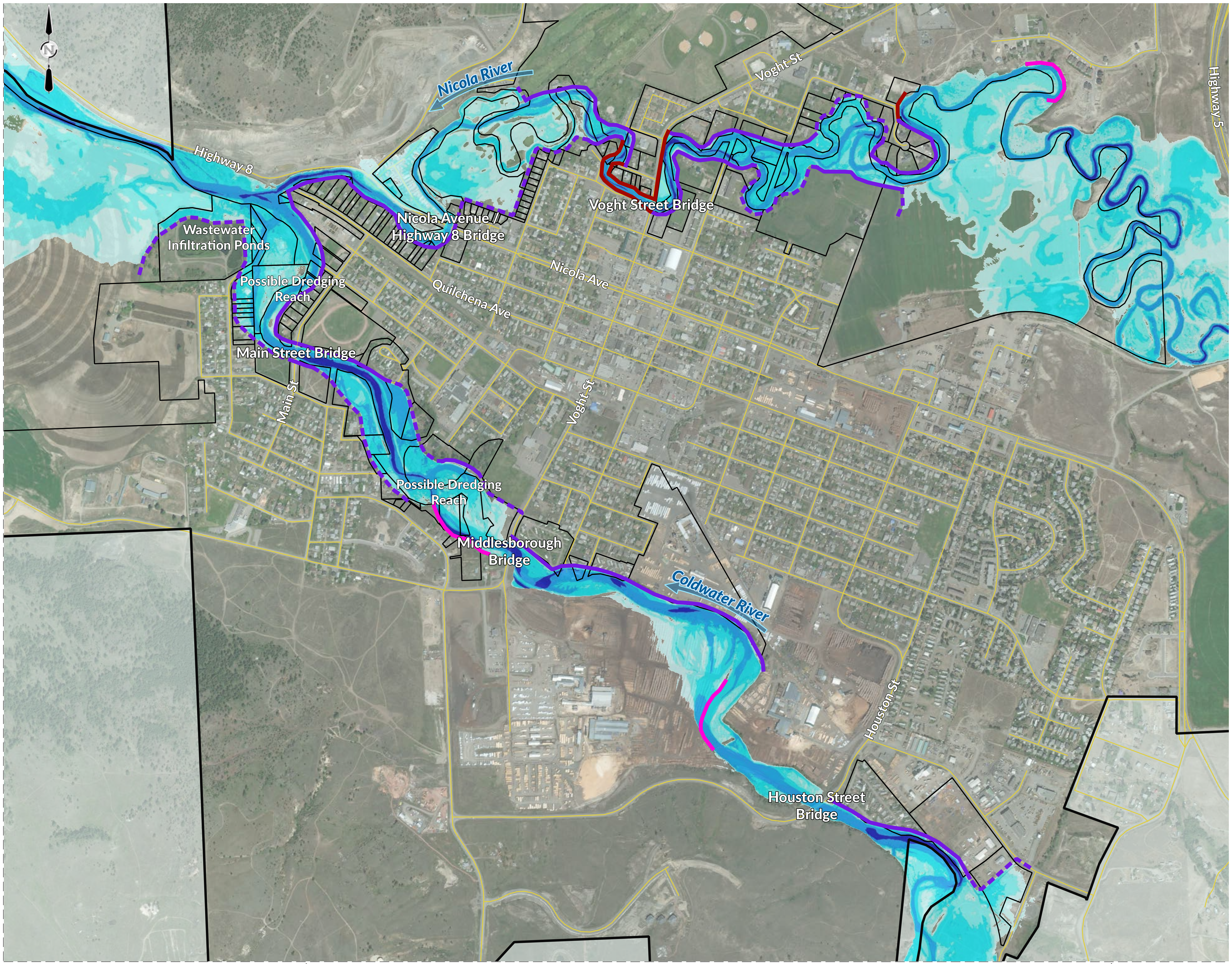


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## LEGEND

- CITY BOUNDARY
- AFFECTED PROPERTIES
- ROADS

OPTIONS

- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

INUNDATION DEPTH (m)

- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION

Merritt
FLOURISH UNDER THE SUN

FIGURE 6-11 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 4c: COMBINATION DIKING

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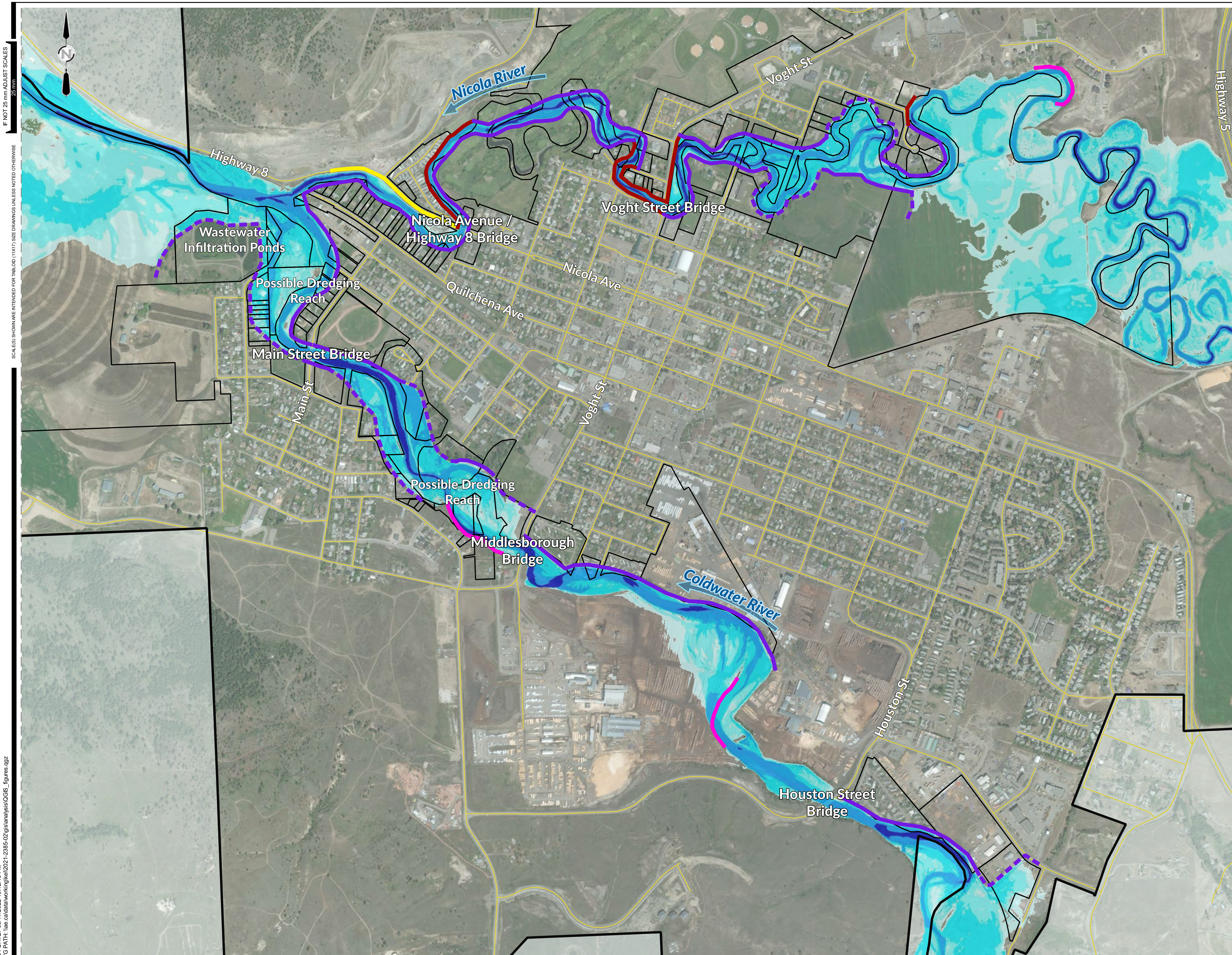


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## LEGEND

- CITY BOUNDARY
- AFFECTED PROPERTIES
- ROADS

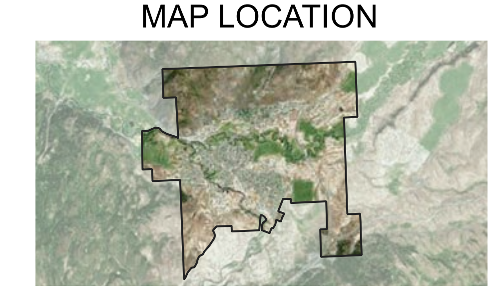
OPTIONS
- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

INUNDATION DEPTH (m)
- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



Merritt
FLOURISH UNDER THE SUN

FIGURE 6-12 DRAFT

CITY OF MERRITT

FLOOD MITIGATION PLAN
FLOOD MITIGATION CONCEPTS
OPTION 5: MODIFIED COMBINATION DIKING

| | |
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| AE PROJECT No. | 20212385-02 |
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| APPROVED | G. CAHILL |
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# 7 OPTIONS ANALYSIS

## 7.1 Objectives

To identify the optimal and preferred option, the implicit and explicit requirements and criteria of the City must first be understood. Through discussion with the City, the public and First Nations engagement, and Associated's technical expertise, the following project objective criteria were identified for the flood mitigation plan:

### Economic:

- **Low Capital Cost** – the ideal design shall minimize the upfront expense of acquiring and constructing the flood mitigation infrastructure.
- **Low O&M Costs** – the ideal design shall minimize the long-term costs associated with operating and maintaining the flood mitigation infrastructure.
- **Limited Property Impacts** – the ideal design shall consider the implications of the affected properties on the City's tax base and planned future land use.

### Recreational and Cultural:

- **Maintain River Access** – the ideal design shall allow river access for swimming, fishing, observing nature, and other recreational pastimes.
- **Limited Property Impacts** – the ideal design shall minimize the number of properties impacted.
- **Create Active Transportation Corridor** – the ideal design shall extend the existing ATC to create a continuous trail network along the riverbanks.
- **Reduce the Risk of Future Flooding** – the ideal design shall minimize the number of people directly affected by or without essential services as a result of a future high flow event.

### Environmental:

- **Room-for-the-River** – the ideal design shall allow the river to maintain natural conditions.
- **Environmental Impacts** – the ideal design shall create a net positive impact on the environment; negative impacts shall be excluded from the design where possible.
- **Maintain River Access** – the ideal design shall provide aquatic and riparian habitat access for wildlife.

### Technical:

- **Provide Robust Flood Mitigation** – the ideal design shall be effective for many years in the face of climate change.
- **Reduce the Risk of Future Flooding** – the ideal design shall protect the City of Merritt in all locations where a breach of the river banks could cause widespread flooding and damage.
- **Ease of Implementation** – the ideal design shall use methods that are commonplace for design and construction. The design shall consider the use, alteration, or removal of existing infrastructure.
- **Room-for-the-River** – the ideal design shall increase the river's capability to manage high flow conditions with the natural floodplain.

Note that some project objective criteria are important to multiple categories for different reasons and some are mutually exclusive. Associated consulted with the City to fundamentally understand the criteria set out by the City and population of Merritt, and to consider all criteria justly in the options analysis methods that were employed in the selection of a preferred design. These methods are described below.

## 7.2 Class 'D' Opinion of Probable Cost

Associated prepared Class 'D' opinions of probable cost for each flood defence option to support the economic aspect of the options analysis. The estimation sheets are provided in **Appendix F** and the total costs are summarized in **Table 7-1**. Due to the conceptual nature of the flood mitigation plan and understanding that there exist unknown variables beyond the scope of this project, the estimates presented herein include a contingency allowance of 30% of the total estimated capital costs. Associated has no control over the actual cost of labour and materials, the bidder's method of determining prices, or market conditions. The opinions of probable cost of construction are made based on experience and best judgment based on the scope of work proposed in the flood mitigation plan conceptual options.

**Table 7-1:**
**Opinion of Probable Cost for Each Option**

| Option | Opinion of Probable Cost (Including 30% General Contingency) |
|---|---|
| Option 1 – Status Quo | $579,150,000 |
| Option 2 – Full Floodplain Retreat | $763,399,000 |
| Option 3 – Waterside Diking | $183,669,000 |
| Option 4a – Combination Diking | $161,896,000 |
| Option 4b – Combination Diking | $172,761,000 |
| Option 4c – Combination Diking | $167,799,000 |
| Option 5 – Combination Diking (Preferred Option)[5] | $167,677,000 |

General considerations, assumptions, and limitations of the Class 'D' opinions of probable cost are as follows:

- Unit rates and lump sums were estimated based on historical BC bid prices for similar projects, with inclusion of inflation using Canadian Consumer Price Index data (Statistics Canada) to bring rates to 2022 dollars. Consideration was made for material availability in Merritt, and where deemed applicable, an addition of 10% was included in the unit rate to account for the more rural location of Merritt compared to major centres (e.g., for specialty contractor work).
- General items (e.g., mobilization/demobilization, temporary facilities, restoration, etc.) were estimated as a percentage of the construction cost or lump sum, as applicable.

[5] See **Section 0** for the development of this Option

- Engineering fees for detailed design and construction services were included as 15% of the total physical construction costs (e.g., not applied to pre-construction, general, or demolition items). Additional allowances for environmental and geotechnical investigations, topographic survey, permitting, and consultation have been included separately.
- A general construction contingency allowance of 30% was added to total construction costs.
- Costs exclude any applicable taxes.

Specific considerations, assumptions, and limitations of the Class 'D' opinions of probable cost are as follows:

- **Pre-Construction / Other**
    - Program Management costs have been included over an assumed program period of 4 years for the City to manage (or retain a consultant to manage) the implementation of the flood mitigation plan.
    - A lump-sum for relocation and/or protection of the FortisBC gas main has been included, as it will likely be impacted by the installation of proposed flood mitigation works.
    - Dredging costs have been included in the Middlesborough and Main Street areas by assuming a 1m average dredging depth over 21,000 and 17,000 $m^2$, respectively.
    - Damage costs to unprotected structures affected by the design flood is an estimate of structural and property damages to buildings within the flood inundation zone. It applies to Option 1. The total sum is an aggregate of damages to each structure based on depth-damage curves associated with varying flood depths and building types. Depth-damage curves were referenced from the Provincial Flood Damage Assessment Study (IBI Group, 2015) which reports detailed data from the 2013 floods in Alberta.
    - Damage costs to unprotected city infrastructure includes the estimated municipal damages, initial flood response costs, and recovery center costs during the AR event (as provided by the City of Merritt). It applies to Option 1.
    - Property acquisition costs were estimated based on the fraction of the property that would be unusable, and whether the primary structure appeared to be impacted. Property values were based on the pre-flood 2021 BC Assessment values for land and building.
- **Removals and Site Demolition**
    - Hazardous building assessments and demolitions, removal, and restoration were quantified based on the total number of structures to be demolished for each option, whether for floodplain restoration or flood mitigation construction.
    - Overhead utility pole relocations were counted based on conflict with proposed dike footprints or raising required at river crossings. Removals in floodplain restoration areas were not accounted for as this is assumed to be a salvage activity at no cost to the City.
- **Structural Flood Mitigation**
    - All structural flood mitigation estimates have been combined into cost per lineal metre of defense. The unit rates are inclusive of clearing, subgrade preparation, aggregates and dike fill, geotextile, bedding, riprap, and planting.
    - Bank height for riprap line items refers to the vertical distance between the channel bed and the top elevation of the defence (e.g., Flood Construction Level) or bank.
    - Dike height for the embankment height item refers to the vertical distance between existing grade and the top elevation of the dike.
    - Sheetpile dike embedment has been assumed at a 2:1 ratio to the stickup height (e.g., a 2 m sheet pile stickup height includes 4 m embedment depth for a total sheetpile length of 6 m).

- **Bridges**
  - Bridge replacement costs were included to account for required bridge deck raising to meet the design flood elevation. A value of $10,000 per m² of bridge deck was used as an approximation for structure replacement.
- **Roadworks**
  - Estimated costs for road raising are inclusive of fill material, full pavement structure, sidewalks, driveway tie-ins, and utility raising/extensions as required.
  - Road raising is for structural flood mitigation, except where designated as 'bridge approach raise', which is to accommodate bridge deck replacement and raising.
- **Habitat Restoration**
  - Habitat restoration has been quantified based on the estimated footprint of flood defence construction. Any impacts to aquatic impact have been estimated to require habitat compensation at a 2:1 area ratio. Terrestrial impacts have been estimated at a 1:1 compensation area ratio.
- **Stormwater**
  - Each of the four pump station estimates are inclusive of all structural, civil, electrical, and mechanical works. Stormwater main upgrades directly connected to the pump stations are also included. Widespread capacity improvements of the stormwater system (e.g., as proposed in the 2014 ISMP) are not accounted for.

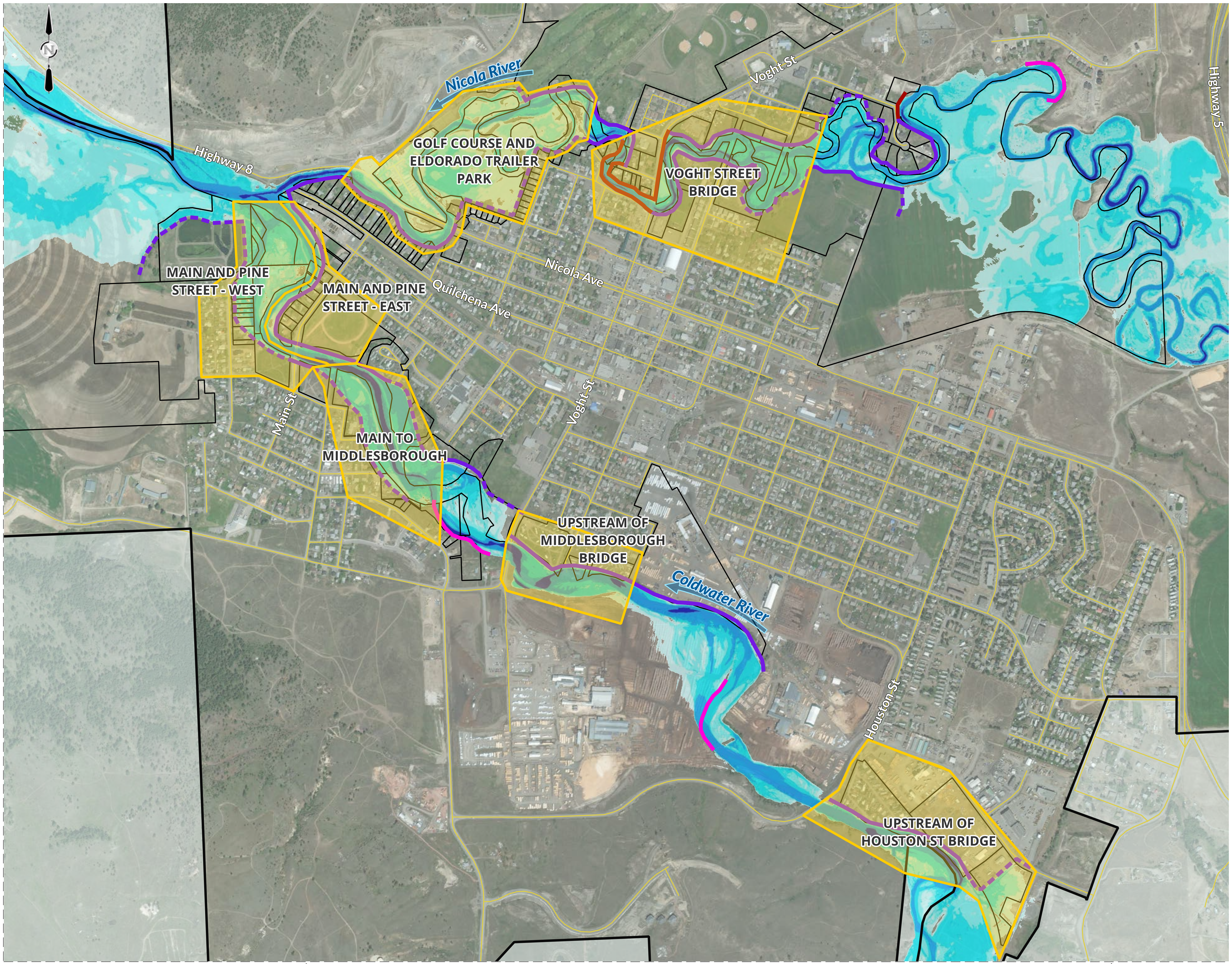
## 7.3 Critical Area Workshop

FortisBC gas main supplying entire City of Merritt exposed in Coldwater River avulsion channel.

Prior to development of Option 5, Associated identified seven areas that presented challenges throughout the planning stage and in public consultation at the Open House. These areas, shown in **Figure 7-1**, were presented to the City with their associated costs, impacted properties, river hydraulics, and quantitative impacts during a project team workshop on July 15, 2022.

The workshop cultivated a discussion to assess the benefits of each option at a smaller scale. Doing so allowed the City to provide insight to key and culturally significant properties that are not clearly defined by other means, as well as to bring forward the City's knowledge about critical and recreational infrastructure, and unique situations that are not represented in the data available to Associated. Some key topics discussed during this meeting included:

- The actual post-flood condition of riverside homes and properties, and their likely willingness to move.
- The impact of the dike alignments on homes, businesses, and a future multi-family development.
- The fire response time to certain properties that would be increased due to proposed alignments.
- The potential development of future parkland that could proceed knowing it would be protected.
- The potential that certain properties outside of City limits erect their own flood mitigation.

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LEGEND

- CRITICAL AREAS
- CITY BOUNDARY
- ROADS

OPTIONS

- WATERSIDE DIKE
- ROAD RAISING
- SHEETPILE WALL
- SETBACK DIKE
- BANK PROTECTION

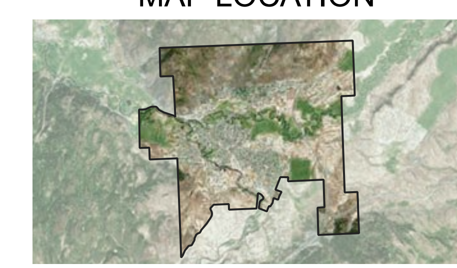
INUNDATION DEPTH (m)

- <=0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

0 200 400 600 m

Coordinate System: NAD 1983 CSRS UTM Zone 10N
Units: METERS

MAP LOCATION



Merritt
FLOURISH UNDER THE SUN

FIGURE 7-1

CITY OF MERRITT

DRAFT

FLOOD MITIGATION PLAN
CRITICAL AREAS OVERVIEW
OPTION 4c UNDER CRITICAL AREAS

| | |
|---|---|
| AE PROJECT No. | 20212385-02 |
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| APPROVED | G. CAHILL |
| DATE | 20220809 |
| REV | A |
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SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

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The purpose of the workshop was to select preferred flood mitigation alignments within each critical area, based on the project objective criteria outlined above and with the additional information provided by the City throughout the discussion. Selecting a preferred alignment by area removed some of the bias that could be introduced by individuals who place higher value on certain areas if the selection were done at the full City-wide scale.

In general, the preferred alignments from those presented in the workshop meeting was Option 4c. This option was selected as the preferred choice in six of the seven areas discussed based on the properties it protects, its potential for a continuous ATC, and its overall cost. In the seventh area, Option 4c was noted not to provide enough protection to the recreational and mental health values of the golf course or to the 57 units located within the Eldorado Trailer Park. In this location, Option 3 was likely the preferred alignment, though there was additional discussion about which parts, if any, of the golf course could be sacrificed to overland flooding.

## 7.4 Development of Option 5

Based on the feedback received in the Critical Area Workshop, Option 4c was preferred in most locations, but did not provide adequate protection for some of the culturally significant properties discussed. In response to this, Associated developed Option 5 by adapting Option 4c:

- Adding a narrow dike along the Nicola River as well as raising a portion of Nicola Avenue northwest of the Nicola River is proposed to protect the Eldorado Trailer Park community.
- Waterside diking is proposed to protect the full length of the golf course. This will isolate the oxbow features from the main river, but these features have been previously separated from the river during development.

The resulting Option 5 is shown in **Figure 6-12**.

## 7.5 Multi-Criteria Analysis

A multi-criteria analysis (MCA) is a numerical decision-making tool that considers the relative importance of the project objectives and the performance of each conceptual option with respect to specific performance criteria. MCA's are robust ways to remove bias from decision-making in engineering assessments; however, they are limited by the performance criteria they are built upon and may not consider all the nuances and social implications of each concept as well as more qualitative approaches. An MCA was developed for the project to provide quantitative assessment of all flood mitigation options and recommendation of the preferred option, in addition to the qualitative result that came out of the critical area workshop. The MCA is included in **Appendix G** and its procedure are described below.

### 7.5.1 Weighting Methodology

The MCA was used to assess the flood mitigation options according to the relative importance of the project objectives outlined in **Section 7.1**. Associated used feedback from the public consultations to assign an importance ranking to each of the project objectives on a scale of one to ten. These importance rankings were presented and discussed with the City to confirm the importance of the various project objectives.

The performance criteria were considered individually to assess how they contribute to each project objective. This contribution was ranked according to the scale shown in **Table 7-2**.

**Table 7-2**
**Criteria Contribution Factor**

| | |
|---|---|
| -3 | Very detrimental to achieving the project objective |
| -2 | Somewhat detrimental to achieving the project objective |
| -1 | A little bit detrimental to achieving the project objective |
| 0 | No impact; irrelevant to project objective |
| 1 | A little bit beneficial to achieving the project objective |
| 2 | Somewhat beneficial to achieving the project objective |
| 3 | Very beneficial, main contributor to achieving the project objective |

The performance criteria were broken down into the following themes:

- **Technical:** Is the proposed solution technically sound and does it effectively reduce the flood risk for the City? Objectives within this theme include operational-robustness, design risk, sustainability, and climate-change adaptability.
- **Construction:** Is the proposed solution feasible to construct and does it consider the potential conflicts it could face? Objectives within this theme include construction risk, constructability, and interferences with existing infrastructure.
- **Environmental:** Is the proposed solution environmentally friendly and sustainable? Objectives within this theme include mitigating environmental damage, protecting and enhancing landscape character and visual amenity, preservation of historic and cultural resources, and minimizing anticipated regulatory risk.
- **Land Use:** Is the proposed solution impacting a significant area? Objectives within this theme include minimizing property impacts, preserving future development plans and maximizing future opportunities, preserving, or creating public spaces, and minimizing risk due to land acquisition.
- **Economic:** Is the proposed solution cost-effective? Objectives within this theme include minimizing capital cost, minimizing operations and maintenance costs, maximizing potential for economic development, and minimizing economic risk.

A weight was assigned to each theme so that the overall performance was not skewed in favour of themes with more criteria. Weights for each theme were assigned based on the aforementioned consultation with the City.

The final weight for each performance criteria considers the objective importance of each of the individual performance criteria as well as the overall importance of its theme (e.g., technical, economic, etc.). This calculation is:

$$Performance\ Criteria\ Weight = \frac{\sum_{Project\ Objective}(Contribution\ Factor * Objective\ Importance)}{\sum_{Criterion\ within\ Theme}(Contribution\ Factor * Objective\ Importance)}$$

A negative performance criteria weight means that more of that criterion results in a worse overall performance (e.g., more risk, higher cost, or more property impacts). A performance criterion can have both positive and negative impacts on the different project objectives. When this occurs, the criteria weight is based on the net impact of the contributing factors and their respective importance to the project objectives.

### 7.5.2 Scoring Methodology

Each conceptual design option was scored individually in the MCA against the performance criteria using a scoring system that is the same for all conceptual flood mitigation options. The score assigned to each performance criteria is considered with the weight determined in **Section 7.5.1** to determine an overall performance score for that option. Because the impact of the criteria has already been accounted for, the scoring system shown in **Table 7-3** only needs to determine whether there is more or less of that criterion. For example, a score of 4 indicates more protection for the flood mitigation criteria, and more risk for the risk criteria.

**Table 7-3**
**Criteria Scoring System**

| | |
|---|---|
| **4** | This option is ranked high for this criterion |
| **3** | Moderate rank |
| **2** | Low rank |
| **1** | This option is ranked very low for this criterion |

## 7.6 Results of MCA

It is important to note that the results of an MCA are relative and have no numerical significance outside the context of the MCA. Because scoring is done with scales and not quantifiable metrics, the values determined through this method cannot indicate how an option performs relative to anything other than another option analyzed by the same method. That said, the MCA provides a valuable high-level and unbiased assessment of each proposed option. The relative scores of all conceptual design options are shown in **Table 7-4.**

**Table 7-4**
**Overall Option Performance Scores**

| | | |
|---|---|---|
| **Preferred** | **Option 5** | **0.736** |
| | Option 4c | 0.634 |
| | Option 3 | 0.314 |
| | Option 4a | 0.299 |
| | Option 4b | 0.095 |
| | Option 1 | 0.090 |
| | Option 2 | 0.016 |

These scores suggest that structural flood mitigation is the logical course of action for flood mitigation in the City, and that Option 5 is the best performing of these options. Option 4b is ranked notably lower than all the other structural flood mitigation options because of the implications of preserving some of the main street properties in the isolated piece of land. With this exception aside, a large difference in performance is noted between the structural flood mitigation options and the non-structural mitigation Options 1 and 2.

# 8 RECOMMENDATIONS AND NEXT STEPS

## 8.1 Recommendations

Associated recommends that the City of Merritt proceeds with Option 5 from the flood mitigation plan and requests $167,677,000 in funding from available grant programs or directly from the Provincial and Federal governments. This recommendation is supported by the results of the MCA, the City's preferences discussed during the critical areas workshop, and Associated's engineering judgement. The assessments completed by Associated indicate that this option performs particularly well due to its protection of many properties (and homeowners) and its protection and cultivation of public space and future development. The cost for this option is the second lowest of all the structural flood mitigation options considered and it offers almost all the benefits of other more expensive options, such as (but not limited to) limited property acquisitions, protection of Nicola River oxbows, minimal conflicts with existing infrastructure, and protection of the City golf course.

The design flows for the Coldwater and Nicola Rivers need to be confirmed and/or refined. The WSC data for the Coldwater River should be analyzed once it is available. It is recommended that hydrological modelling is considered for the Coldwater River to analyze physical watershed characteristics and runoff generation processes. Hydrological modelling can be used to evaluate watershed runoff of extreme events, and this is a key element for the design of structural flood mitigation measures in Merritt.

Associated recommends that refinement of the Option 5 concept is completed once program funding is obtained by the City. There are going to be many details that need to be evaluated and designed as the project moves forward to implementation. At the very least, preliminary design needs to be completed prior to acquisition of property (buyout or right-of-way) to confirm dike alignments and footprints. Lastly, a meeting with the Deputy Inspector of Dikes is recommended to review the Option 5 recommendation and the design criteria for flood mitigation in Merritt.

## 8.2 Next Steps

The current roadblock to next steps is program funding. The City needs financial support to implement the flood mitigation plan. This is an important hurdle to overcome because the City is still managing recovery work and there are still people greatly affected from the AR event.

Coldwater River avulsion channel on Pine Street and substantial damage to property.

The City of Merritt will need $167,677,000 to implement Option 5 and it is recognized that this is not a small request, nor is it funding that can be spent in a short period of time. There will be numerous stages and phasing of work required.

A high-level overview of the possible sequence and estimated duration for the project stages is shown in the Gantt chart in **Figure 8-1**. The main tasks include refinement of Option 5, further engagement activities, acquisition of property (buyouts and right-of-ways), and then engineering, environmental, and construction details. It is important to note that following engineering design and environmental review there will be Provincial and Federal permitting review periods, which are assumed to be 8 months in duration in the Gantt Chart. This is a preliminary project schedule and it can be refined as the project progresses. Associated has assumed that the project could be divided into four broad work packages. Therefore, there are four periods of engineering design, environmental review, regulatory permitting, and construction. Due to the size of the proposed flood mitigation plan, the schedule could be extended over a five-year period rather than four years. The division of work packages would likely be based on geography, so design and construction would focus on specific areas in Merritt for each work package. The main tasks are discussed in the following sections.

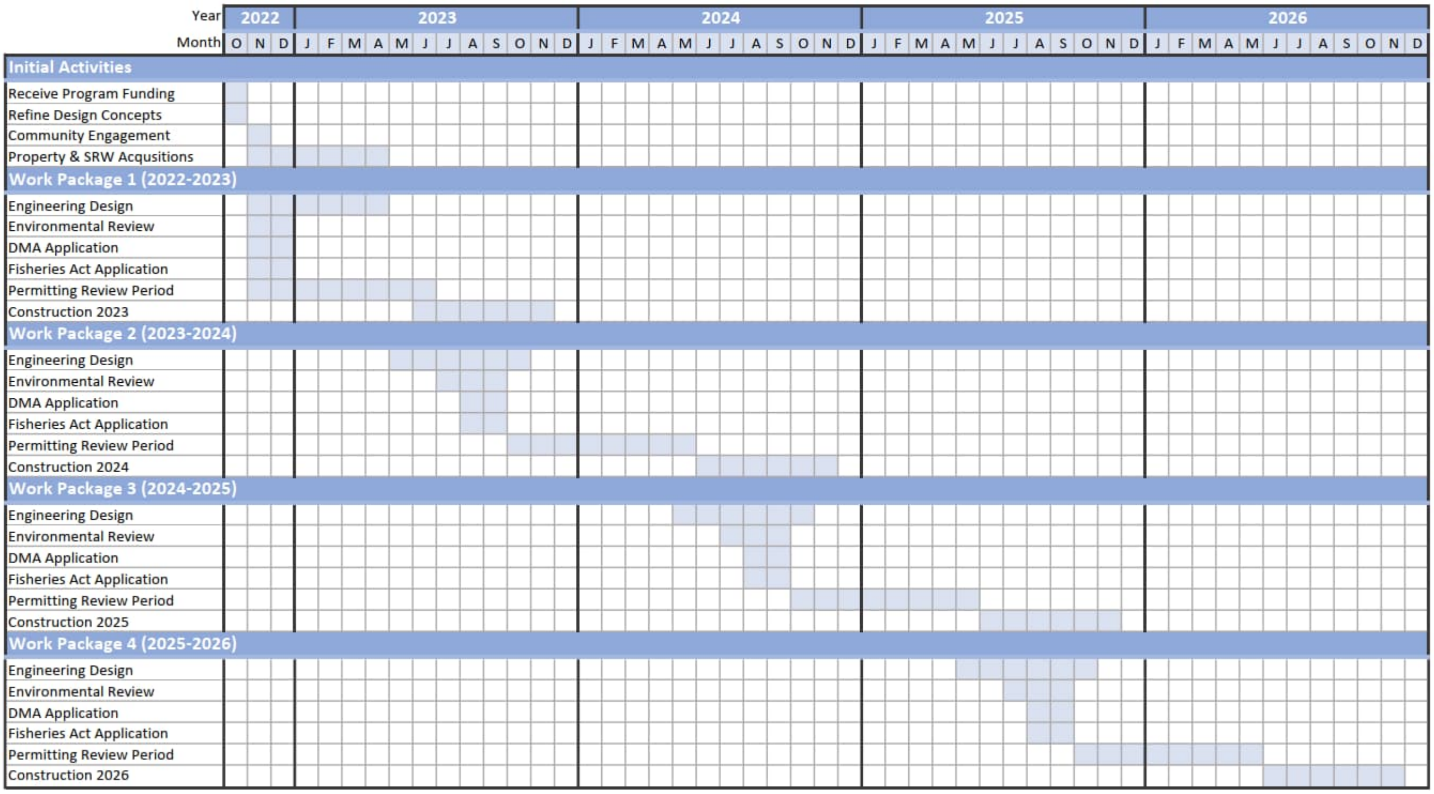


**Figure 8-1**
**Conceptual Project Schedule Gantt Chart**

### 8.2.1 Funding Application

Due to the postponement of the DMAF funding, the City is looking for alternate funding sources to proceed with the immediate work needed to proceed with implementation. This item is on the critical path. Without funding confirmed for the project, proceeding with property acquisitions and engineering design would be a financial risk. The City has already been in communication with different levels of government and this flood mitigation plan report should support further discussion.

### 8.2.2 Plan Refinement

Refining Option 5 has already been discussed. This is an important task because it will confirm dike alignments and extents for the City to begin working with individual property owners. Plan refinement could also identify opportunities and constraints to improve the design of Option and potentially lower costs. This includes confirming the design criteria and finalizing the design flow rate for both river systems.

### 8.2.3 Community and First Nations Engagement

Both the community and First Nations engagement processes are following a four-stage engagement process. With the completion of the first stage of the process the City recognises and are committed to the ongoing engagement through to the construction phase of the project. To date the City has utilised a variety of engagement approaches from online surveys to face to face open houses. This variety of approaches will continue for the project as additional parties such as regulatory agencies outline their requirements for the project to proceed. As the design moves from the conceptual to more detailed design, more information on the impacts of the mitigative measures will be outlined leading to more specific engagement with affected parties.

### 8.2.4 Property Acquisitions

Buyout and right-of-ways are going to be required for implementation. The City of Merritt has been in discussion with the City of Grand Forks, who also had a historically large flood event and worked with Associated to develop a plan that included property acquisition to allow room-for-the-river. Grand Forks completed a voluntary buyout program and it was generally considered successful. Merritt could consider the learnings from Grand Forks buyout program and move forward with a similar program. It is recommended that the City of Merritt seek legal advice on this matter.

Right-of-ways will also be required where properties do not require full buyout. These can be negotiated directly with the property owner as required.

### 8.2.5 Regulatory Approvals

Regulatory review and approval is a critical and necessary part of the project. The project work is governed by federal and provincial laws and regulations, as well as some municipal bylaws. **Table 8-1** provides a summary of the key Acts and Regulations applicable to the project and EOA process (**Appendix A**), including potential authorizations required for the project. The final list of regulatory considerations will be done during the environmental review (which would include further archaeological and contaminated sites work, as required).

**Table 8-1**
**Regulatory Framework Relevant to the Project (Partial List)**

| Legislation | Relevant Section | Project Component | Approval / Authorization / Permit Requirements |
|---|---|---|---|
| **Federal** | | | |
| *Fisheries Act* (RSC 1985, c. F-14) | This Act protects fish and fish habitat. Subsection 35 (1) states that “no person shall carry on any work, undertaking or activity that results in the harmful alteration, disruption or destruction (HADD) of fish habitat.” Subsection 36 (3) stipulates that “no person shall deposit or permit the deposit of | Two fish-bearing waterbodies will be affected by the project: Coldwater River and Nicola River. Other watercourses that may or may not be fish-bearing include Godey Creek, an unnamed tributary of Godey Creek, | Project works that involve temporary or permanent disturbance below the high-water mark will affect fish habitat through habitat disturbances and losses and could, without appropriate mitigation, introduce deleterious substances that could affect water quality. |

| Legislation | Relevant Section | Project Component | Approval / Authorization / Permit Requirements |
|---|---|---|---|
| | a deleterious substance of any type in water frequented by fish…" | three oxbows, and two side channels. | Streamside dikes and bank armouring will require a ***Fisheries Act* Request for Review** from Fisheries and Oceans Canada (DFO). |
| *Species at Risk Act* (SARA) (SC 2002, c.29) | SARA protects federally listed species at risk,[6] their residences, and critical habitat. Under Sections 32 and 33 of SARA, it is an offence to kill, harm, harass, capture or take a federally listed species that is endangered or threatened, and damage or destroy the residence of one or more individuals of a listed endangered or threatened species or of a listed extirpated species if a recovery strategy has recommended its reintroduction. | There are 35 species at risk with the potential to occur in the Project Area. | If the project may negatively affect a listed species or its critical habitat, **SARA permits** may be issued, or agreements may be entered to authorize certain activities that would otherwise contravene the general or critical habitat prohibitions, if certain conditions are met*.<br><br>A site-specific Environmental Management Plan will include mitigation measures to minimise potential impacts on species at risk. |
| *Migratory Birds Convention Act, 1994* (SC 1994, c. 22) | This Act protects migratory birds and their nests from indiscriminate harvesting and destruction. | Project works will likely involve removal and disturbance of vegetation, habitat potentially used by migratory birds for stop-over, staging, breeding and summer foraging. | None required.<br><br>Where vegetation clearing cannot occur during the least-risk timing window for migratory birds in the Merritt Region (mid-August to early-April) (Environment and Climate Change Canada 2018), clearing should be preceded by a nest survey to ensure nests and young will not be affected. |
| **Provincial** | | | |
| *Water Sustainability Act* (WSA) | This Act protects the quality of water, fish and wildlife habitat, and the rights of licensed water users. Under Section 11 of the WSA, any activities that result | Project works that include instream works, including streamside dikes and bank | **Section 11 Approvals** will be required for bank armouring and streamside dikes, if work is |

[6] Species at risk means an extirpated, endangered or threatened species or a species of special concern.

| Legislation | Relevant Section | Project Component | Approval / Authorization / Permit Requirements |
|---|---|---|---|
| (SBC 2014, c.15) | in "changes in or about a stream" require Notification or Approval. | armouring, will trigger the WSA. | planned below the high-water mark.<br><br>**Section 11 Notifications** may be required for setback dikes. |
| *BC Wildlife Act* (RSBC 1996, c.488) and *Wildlife Amendment Act* (Bill 51-2004) | This Act protects wildlife species. The Act permits certain activities (e.g., wildlife salvage) and makes it an offence to kill, harm, harass or capture an animal identified as at risk. | Vegetation clearing, and grubbing has potential to harm or kill wildlife. Instream works has potential to harm fish. | Vegetation clearing, and grubbing should be preceded by surveys for wildlife and wildlife habitat in the Project Area.<br><br>Following instream work isolation, a fish salvage should be undertaken to ensure no fish are present in the isolated work area.<br><br>A **Scientific Fish Collection Permit** under the *Wildlife Act* will be required for fish salvage.<br><br>A **General Permit** under the *Wildlife Act* will be required for any trapping and relocations anticipated for this project, particularly for the salvage of amphibians and reptiles residing in open water or oxbow habitats directly affected, as well as those encountered incidentally during site preparation and construction. |
| *Weed Control Act* (RSBC 1996, c. 487) | This Act provides guidelines for noxious weed prevention and management, stating that it is the responsibility of the landowner to manage and prevent spread of noxious weeds. | Noxious weeds may be present in the Project Footprint. | None required.<br><br>A site-specific Weed Management Plan should be prepared as part of the Environmental Management Plan in advance of construction. |
| *Riparian Areas Protection Regulation* (RAPR) | This Regulation protects riparian areas in local governments. The Regulation protects riparian areas during | The Project Area is within the riparian assessment area. | A **RAPR Assessment** may be required as it is triggered by the City's bylaws and Development Permit Areas. The City may |

| Legislation | Relevant Section | Project Component | Approval / Authorization / Permit Requirements |
|---|---|---|---|
| (BC Reg. 178/2019) | residential, commercial, and industrial development by ensuring a Qualified Environmental Professional (QEP) conducts a Riparian Areas Protection Regulation (RAPR) Assessment. | | choose not to enact their permit process. |
| **Municipal** | | | |
| *Local Government Act* ([RSBC 2015] c. 1) | City of Merritt Official Community Plan Bylaw No. 2116, 2011 | The Project Area overlaps with Development Permit No. 6 – Environmentally Sensitive Areas | A **Development Permit** may be required. The City may choose not to enact their permit process. |

### 8.2.6 Engineering Design

Engineering design is required to review and finalize all components, locations, and dimensions of the structural flood mitigation works before the City can proceed with tendering the project work packages for construction. The project will be constructed over multiple seasons due to its large scale and the comparatively short construction window for instream work. A phased approach will be considered in the design. There are many activities that need to be completed early in the design cycle, such as land and bathymetric surveying, geotechnical investigations, and confirmation of all design criteria. Associated can review all the engineering design requirements with the City.

# CLOSURE

This report was prepared for the City of Merritt to develop a comprehensive flood mitigation plan and seek funding to implement the next steps of the project. The services provided by Associated Engineering (B.C.) Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,

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