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Technical Memorandum #5

DATE: April 23, 2021

TO: Robyn Holme, RPP, MCIP
Comox Valley Regional District

FROM: Eric Morris, M.A.Sc., P.Eng.

RE: **COASTAL FLOOD MAPPING PROJECT**
Technical Memorandum #5 – Coastal and Fluvial Mapping Products
Our File 2623.014-300

1. Introduction

Kerr Wood Leidal Associates Ltd. (KWL) has been retained by the Comox Valley Regional District (CVRD) to provide consulting engineering services for the preparation of coastal floodplain mapping. The coastal floodplain mapping includes the anticipated effects of sea level rise and will be used by the CVRD for land use planning, emergency planning and risk assessment.

This technical memorandum (#5) describes the flood mapping products prepared for this project and provides information regarding how they were developed, their intended uses and their limitations. Other technical memoranda document the remaining project components.

1.1 Project Scope

The main project tasks include:

1. Conducting a mapping workshop to discuss mapping objectives and deliverables.
2. Collection and integration of topographic and bathymetric mapping from a variety of sources including bathymetric data collected in the Oyster River as part of the project scope, bathymetric data in the sea obtained from the Canadian Hydrographic Service and topographic data in upland and intertidal areas obtained from GeoBC and other sources.
3. Hydrologic and hydraulic modelling of the Oyster River downstream of Highway 19 to its mouth at the Strait of Georgia and the lower reaches of the Courtenay River, Puntledge River (downstream of the BC Hydro Powerhouse) and Tsolum River (downstream of the Piercy Road Bridge/North Courtenay Connector). Modelling was conducted for floods having annual exceedance probabilities (AEP) ranging from 10% to 0.2% and included the anticipated effects of climate change.
4. Hydraulic modelling of coastal water levels (tide plus storm surge) and wave effects in deep and shallow water to determine wave heights in the surf zone and the maximum elevation of wave run-up for storm events with AEPs ranging from 10% to 0.2% and sea levels ranging from current conditions to a projected scenario with two metres of sea level rise (to Year 2200).
5. A desktop geomorphologic assessment of the Lower Oyster River and shoreline to identify areas that may be non-erodible or exceptionally vulnerable to erosion.

6. Determination of flood levels for the Oyster River, the lower Courtenay/Puntledge/Tsolum River system and coastal areas.
7. Preparation of 1:4000 scale regulatory floodplain maps which show flood levels and floodplain extents and digital mapping for flood levels, setbacks, inundation depths, wave heights and climate change planning areas.

A series of reports and memoranda are provided to describe data sources, analysis approaches, assumptions, and study findings:

1. Technical Memorandum #1 – Coastal and River Base Map Development
2. Technical Memorandum #2 – Fluvial and Coastal Geomorphology
3. Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions
4. Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions
5. Technical Memorandum #4 – Coastal Modelling
6. Technical Memorandum #5 – Coastal and Fluvial Mapping Products
7. Final Report – Coastal Flood Mapping Project
8. Coastal and Fluvial Models User Guide

This is Technical Memorandum #5, which describes the flood mapping products prepared for this project and provides information regarding how they were developed, their intended uses and their limitations. Plotted samples of the mapping in localized areas are provided in Appendix A.

The mapping products have been developed to support the management of land use within floodplain areas and emergency management. The flood mapping products are:

1. Digital base mapping including topographic and bathymetric data sets.
2. Regulatory floodplain mapping consisting of a set of floodplain maps at 1:4000 scale on 11”X17” paper which were prepared in general conformance with the Province of BC’s *Flood Hazard Area Land Use Management Guidelines* (FLNR, 2018), herein referred to as the ‘provincial guidelines’.
3. Raster and GIS contour (polyline) files showing:
   - Maximum water levels for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum water levels are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total;
   - Maximum water depths for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum water depths are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total;
   - Maximum flow velocities for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum flow velocities are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total;

- Flood hazard rating (the product of water depth and velocity) for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Flood hazard ratings are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total;
- Maximum wave heights in the coastal floodplain for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%); 20 scenarios total;
- Climate change planning areas; and
- Coastal setbacks based on the provincial guidelines (FLNR, 2018).

1.2 Glossary and Abbreviations

AEP = Annual Exceedance Probability. Probability of an event (e.g., flood event) of equal or greater magnitude occurring in a given year. The AEP is the inverse of the Return Period.

Astronomical Tide = Tide caused by forces of the sun and the moon.

Bathymetric = Survey to establish elevations of underwater river channel bed or ocean bed surfaces.

CGVD2013 = Canadian Geodetic Vertical Datum 2013, updated vertical datum used for mapping in this study.

Designated Storm = A storm, which may occur in any given year, of such a magnitude as to equal a storm having the designated annual exceedance probability (AEP). The Designated Storm has several phenomena associated with it that define components of the flood level, including storm surge and wave run-up for the storm. These include:

- A time series of atmospheric pressure during the passage of the storm over the area in question;
- A time series of wind speed and direction during the passage of the storm over the area in question; and
- A time series of wave conditions, including wave heights, periods, and directions during the passage of the storm in question.

Flood Hazard Maps = Engineering maps that display the results of hydrologic and hydraulic investigations (including water level, water depth, and velocity) and show areas that could be flooded under different scenarios. These maps are used for planning purposes related to land use planning, emergency management, and flood mitigation. Note that this is the working definition for this project and other projects or organizations may have a different definition.

Flood Level = The maximum elevation of the water surface in a given flood scenario including freeboard.

Freeboard	=	A vertical distance added to the actual calculated flood level to accommodate uncertainties in flood levels. Such uncertainties include uncertainties in hydrological analysis, hydraulic modelling, and wave modelling, climate change projections, local river hydraulic effects such as waves and surges, and, to some extent, river, delta, and coastal geomorphic changes which could influence flood levels. The freeboard allowance does not accommodate uncertainties in flood levels related to significant changes in river channel shape/location or shoreline characteristics.
HHWLT	=	Higher High Water, Large Tide, the average of the highest annual tides over the 18.6-year tidal cycle.
Inundation Maps	=	Topographic maps showing the extent of floodwater in plan, for the specific Designated Storm.
LiDAR	=	Light Detection and Ranging. A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. LiDAR collected at a regional scale is usually collected by aircraft.
Maximum Water Level	=	The calculated maximum water surface elevations for the specific design flood magnitudes derived using hydraulic modelling software.
MKP File Format	=	Model Key Point file format. A “thinned out”, generalised subset of the original x,y,z data points used to represent the minimum number of points required to determine the shape of the ground. MKP files are generated to reduce file sizes and make data handling more manageable.
NAD83 (CSRS)	=	The North American Datum of 1983 (NAD 83) is the horizontal and geometric control datum for the United States, Canada, Mexico, and Central America. The CSRS (Canadian Spatial Reference System) is the improved realization of NAD83 for Canada. The datum provides a common point of reference to define horizontal coordinates across the entire country.
Regulatory Floodplain Mapping	=	Maps used for regulatory purposes, such as developing floodplain bylaws and informing official community plans. For the Coastal Flood Mapping Project, the regulatory mapping is based on inundation mapping for the 0.5% AEP Designated Storm incremented by a freeboard allowance to establish the Flood Level and floodplain limits.
Return Period	=	An estimate of the average interval of time between events of a certain intensity or size. The inverse of the Annual Exceedance Probability.
SLR	=	Sea Level Rise.
Storm Surge	=	Increase in water level caused by low atmospheric pressure and winds.
TIN File Format	=	Triangular Irregular Network File Format. Vector-based digital geographic data used to represent surface morphology constructed by triangulating a set of points. The points are connected with a series of edges to form a network of triangles. There are different methods of interpolation to form these triangles, the Delaunay triangulation method being the most common.

Topographic Plateau	=	A topographic feature with a flat or mild slope inland of a steeper foreshore slope. Wave runup calculations for topographic plateaus are handled in a different manner from continuously rising slopes because the extent of inundation is governed by "bore dominated" overland flow rather than the momentum present in the waves.
UTM10	=	Universal Transverse Mercator map projection for Zone 10. Map projections are used to project the spherical surface of the earth on a flat plane and involve some distortion, therefore its' important to know what map projection is used. In the UTM system, the earth is divided into a series of zones along lines of longitude; the coast of BC is in Zones 8, 9, and 10.
Wave Runup	=	The maximum vertical extent of wave uprush on a beach or structure above the still water level. The wave runup includes the wave setup.
Wave Setup	=	An increase in mean water level in the breaking wave or "surf" zone due to the effect of transferring wave-related momentum to a local increase in the water level.

1.3 References

The following references were used for the preparation of this memorandum:

1. Ausenco Sandwell. (2011). *Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use*.
2. Australian Institute of Disaster Resilience (AIDR). (2017). *Australian Disaster Resilience Guideline 7-3 Flood Hazard*.
3. British Columbia Ministry of Forests, Land and Natural Resource Operations (FLNR). (2018). Flood Hazard Area Land Use Management Guidelines.
4. Engineers and Geoscientists British Columbia (EGBC). (2017). *Flood Mapping in BC – EGBC Professional Practice Guidelines V 1.0*.
5. Fraser Basin Council. (2004). *Floodplain Mapping Guidelines and Specifications*.
6. Goda. (2010). *Random Seas and Design of Maritime Structures – Advanced Series on Ocean Engineering – Volume 88 – 3rd Edition*. World Scientific.
7. Kerr Wood Leidal Associates Ltd. (2011*). Coastal Floodplain Mapping – Guidelines and Specifications*.
8. Kerr Wood Leidal Associates Ltd. (2013). *City of Courtenay, Integrated Flood Management Study, Hydrodynamic Model Development and Flood Management Options Evaluation*.
9. Natural Resources Canada. (2018). *Federal Flood Mapping Framework Version 2.0*.

1.4 Professional Assurance Statements

In accordance with the Engineers and Geoscientists British Columbia (EGBC) Flood Mapping in BC Professional Practice Guidelines, signed and sealed assurance statements have been provided to confirm that, with respect to the specific professional activity carried out, the appropriate requirements have been met (EGBC, 2017). A copy of the assurance statements for the coastal floodplain mapping and river floodplain mapping have been included in Appendix C.

2. Development of Mapping Products

2.1 Mapping Product Overview

This section provides an overview of the development of the mapping products prepared as part of the Coastal Flood Mapping Project. A table is provided for each mapping product which summarizes file names and formats, datums, how the mapping products were developed and notes and limitations.

The mapping products are expected to be used for a variety of purposes including planning, emergency management, public engagement, hazard assessment and supporting risk assessment and development of sea level rise adaptation plans. The mapping products, typical audiences and potential uses are summarized in Table 1.

Table 1: Mapping Products and Typical Uses

Mapping Product	Typical Audience	Potential Uses
• Base Mapping (Section 3.1)	• Planning and GIS staff	• Preparation of various types of geographic mapping. • Future river and coastal modelling work.
• Regulatory Floodplain Mapping (Section 3.2)	• Planning staff • Engineering staff • Emergency managers • Building inspectors • Building department • Consultants • Public	• Land use management in floodplains. • Supporting floodplain bylaws. • Emergency management.
• Maximum Water Level Mapping (Section 3.3) • Maximum Water Depth Mapping (Section 3.4) • Maximum Flow Velocity Mapping (Section 3.5) • Flood Hazard Rating Mapping (Section 3.6) • Maximum Wave Heights in the Coastal Floodplain Mapping (Section 3.7)	• Planning staff • Engineering staff • Emergency managers • Building inspectors • Building department • Consultants	• Hazard assessment. • Supporting risk assessment. • Supporting development of sea level rise adaptation plans. • Supporting emergency preparedness and emergency response planning.
• Climate Change Planning Area Mapping (Section 3.8)	• Planning staff • Building inspectors • Building department	• Land use management in floodplains. • Supporting development of sea level rise adaptation plans.
• Setback Mapping (Section 3.9)	• Planning staff • Building inspectors • Building department • Public	• Land use management in floodplains. • Supporting floodplain bylaws.

Pertinent details for each of the above-noted map products are provided in Section 3.

2.2 Study Area

Mapping has been prepared for the following areas:

- The Oyster River downstream of Highway 19 to its mouth at the Strait of Georgia;
- The lower reaches of the Courtenay River, Puntledge River (downstream of BC Hydro Powerhouse) and Tsolum River (downstream of Piercy Road Bridge/North Courtenay Connector);
- The entire shoreline of Vancouver Island within the CVRD from Deep Bay in the south to the Oyster River in the north. A small portion of the shoreline north of the Oyster River within the Strathcona Regional District is included in the mapping to provide coverage of the entire Oyster River floodplain; and
- The entire shoreline of Denman and Hornby Islands, Sandy Island and Chrome Island.

Setback mapping has been prepared for coastal areas only. For the purpose of the setback mapping, the boundary between the "coast" and the "river" has been defined as follows:

- For the Oyster River, the Regent Road Bridge;
- For the Courtenay River, the 17th Street Bridge and Comox Road;
- For Black Creek, Miracle Beach Road;
- For the Trent River, Highway 19A (Old Island Highway);
- For Hart Creek, Highway 19A (Old Island Highway); and
- For the Tsable River, Highway 19A (Old Island Highway).

2.3 Digital Flood Hazard Mapping Products

Due to the large amount of mapping generated, and the challenges of viewing the mapping in a hardcopy or portable document format, some of the mapping products have been provided only in a digital format which is viewable in Geographic Information System software (ArcGIS). Having the mapping available in a digital format will allow the mapping to be viewed in a variety of ways depending on the intended use and objectives. For example, flood inundation levels for various AEP and SLR scenarios could be viewed individually or in combination when overlaid on an orthophoto for use in risk assessment. Plotted samples of the mapping in localized areas are provided in Appendix A as follows:

- Figure 1A: Little River Area – Regulatory Floodplain Mapping (provided in Adobe Portable Document Format (PDF));
- Figure 2A: Oyster River Area – Regulatory Floodplain Mapping (provided also in PDF);
- Figure 3A: Little River Area - Maximum Water Levels for a Wind Storm and Extreme Static Water Level with an AEP of 0.5% for the Four Different Sea Level Rise Scenarios (0 m, 0.5 m, 1.0 m, and 2.0 m);
- Figure 4A: Oyster River Area - Maximum Water Levels for a Wind Storm and Extreme Static Water Level with an AEP of 0.5% for the Four Different Climate Scenarios (0 m SLR, 0.5 m SLR + 15% Increase in River Flow, 1.0 m SLR + 15% Increase in River Flow, and 2.0 m SLR + 30% Increase in River Flow);

- Figure 5A: Little River Area - Maximum Water Depths for the 1.0 m Sea Level Rise Scenario for Extreme Static Water Levels and Wind Storms with an AEP of 0.5%;
- Figure 6A: Oyster River Area – Maximum Water Depths for the 1.0 m Sea Level Rise + 15% Increase in River Flow Scenario for Extreme Static Water Levels and Wind Storms with an AEP of 0.5%;
- Figure 7A: An Area Upstream of Oyster River Bridge – Maximum Flow Velocity for AEP 0.5% for 1.0 m of Sea Level Rise + 15% Increase in River Flow;
- Figure 8A: An Area Upstream of Oyster River Bridge – Flood hazard Rating for AEP 0.5% for 1.0 m Sea Level Rise + 15% Increase in River Flow;
- Figure 9A: Little River Area – Maximum Wave Heights in the Coastal Floodplain for a Water Level and AEP of 0.5% and 1.0 m of Sea Level Rise;
- Figure 10A: Little River Area – Climate Change Planning Areas; and
- Figure 11A: Little River Area – Setbacks.

3. Technical Details for Map Products

This section includes a table for each mapping product which summarizes file names and formats, datums, how the mapping products were developed and notes and limitations.

3.1 Base Mapping

The base mapping product deliverables are described in Table 2.

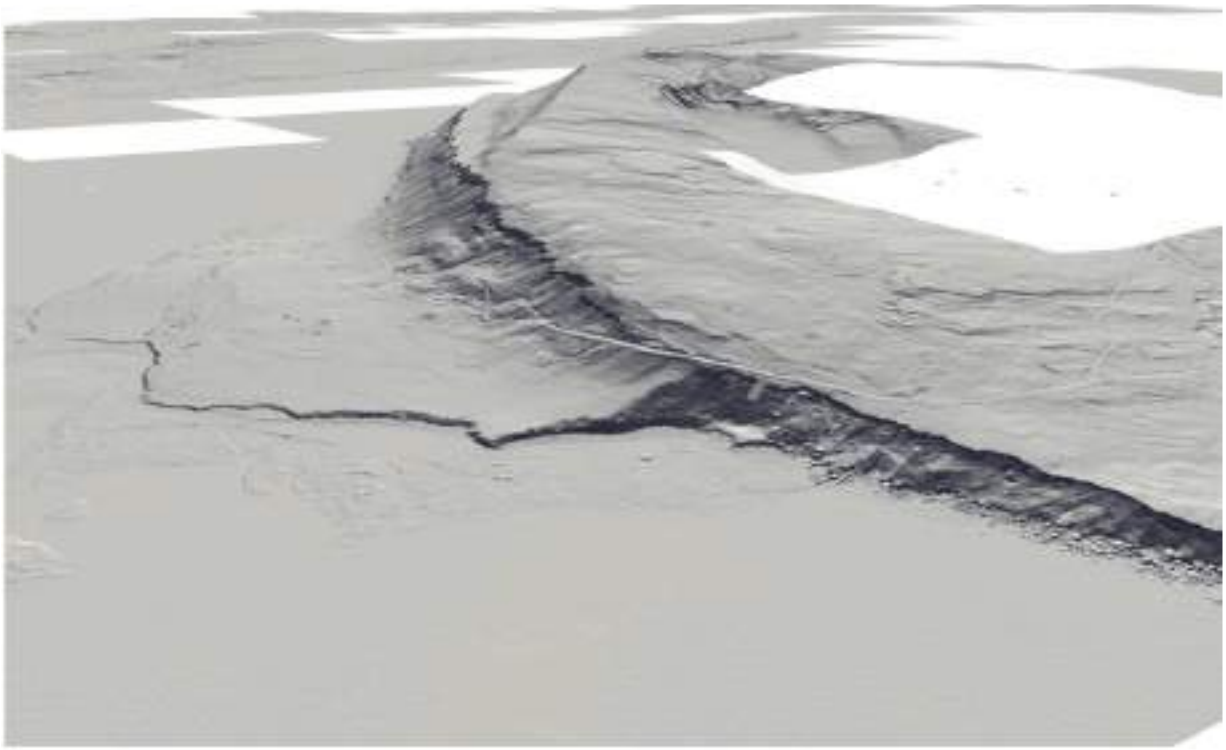
Table 2: Base Mapping Products

Description
1. Processed GeoBC LiDAR: LiDAR topography for the study area collected in 2018/2019 obtained from GeoBC and processed by KWL**. It should be noted that the ocean water surface has not been removed from the dataset.**
2. Oyster River Bathymetric Survey: Bathymetric survey data for the Oyster River collected in 2019. Cross-sections were collected in the upper river and 2D survey was done in the lower river.
3. Bathymetric Digital Elevation Model (DEM): DEM prepared by integrating various CHS bathymetric data sets. This base mapping was used for deep water wave modelling.
4. Shoreline Transects: Cross sections through the shoreline at various locations (transects) prepared by integrating the GeoBC LiDAR and the Bathymetric DEM. These transects were used for the nearshore wave modelling. Transect location coordinates are also included.
5. Oyster River Alluvial Fan Boundary: Boundary of the Oyster River Alluvial Fan as per Technical Memorandum #2 – Fluvial and Coastal Geomorphology.
6. Normal Water Surface Boundary: As shown on the regulatory mapping. Equal to an elevation on 2.3 m CGVD2013 (nominally higher-high water level large-tide at Little River)
The mapping used to develop the model of the Courtenay River system was prepared under a separate project; reference should be made to the KWL memorandum *City of Courtenay, Integrated Flood Management Study, Hydrodynamic Model Development and Flood Management Options Evaluation, November 29, 2013* prepared for McElhanney Engineering for further details on the base mapping used for model development (KWL, 2013).

File Names and Formats	
1. Processed GeoBC LiDAR: Model Key Points (*.dxf and *.xyz) and Rasters (*.tif) 2. Oyster River Bathymetric Survey: OysterRiverBathymetricSurvey.zip 3. Bathymetric DEM: 2019-1127_CCR_DataRequest_Combine_10m_Extract.csar.txt, 2019-1127_CCR_Metadata.docx (metadata) 4. Shoreline Transects: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *CoastalTransects* (polyline)] 5. Oyster River Alluvial Fan Boundary: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *OysterRiverAlluvialFanBound* (polyline)] 6. Normal Water Surface Boundary: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *NormalWaterSurfaceBound* (polygon)] 7. Coastal Zone Boundary: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *CoastalZone* (polyline)]	
Datum	
Processed GeoBC LiDAR, Oyster River Model Base Mapping, Shoreline Transects, Upper Oyster River Cross Sections from Bathymetric Survey, Normal Water Surface Boundary: *Horizontal Datum: NAD83(CSRS), UTM Zone 10* *Vertical Datum: CGVD2013* Bathymetric DEM: *Horizontal Datum: NAD83(CSRS), UTM Zone 10* *Vertical Datum: Low Water Datum* Oyster River Alluvial Fan Boundary *Horizontal Datum: NAD83(CSRS), UTM Zone 10* *Vertical Datum: N/A*	
Quality Control	
Mapping prepared by:	Ryan Taylor, GISP
Mapping checked by:	Eric Morris, P.Eng.
Mapping Product Development	
Refer to Technical Memorandum #1 – Coastal and River Base Map Development. The various topographic and bathymetric data sources used for the project base mapping, with the exception of the Bathymetric DEM, were collected in or adjusted to the project datum (CGVD2013)	
Notes and Limitations	
The following limitations should be considered when interpreting and using the maps: 1. Multiple data sources with different datums were integrated to create the base mapping. Some approximations were made when shifting the base mapping to a common datum and vertical errors of as much as approximately 4 cm related to conversion are present in the Shoreline Transects. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for details related to the datum shifts made during base mapping integration. 2. The LiDAR data sets used to create the base mapping were collected in 2016, 2018 and 2019. Changes in topography due to land development and erosion which affect the accuracy of this base mapping can be expected in the future and this should be considered when using the mapping. 3. Refer to Technical Memorandum #2 – Fluvial and Coastal Geomorphology for details regarding the development of the Oyster River Alluvial Fan Boundary mapping. The mapped extent of the fan has been truncated at the study area boundary at the northern end. The southern extent of the fan and the apex of the fan (upriver extent) have been determined through desktop study and should be considered approximate.	

Sample

Processed GeoBC LiDAR (Hillshade) – Southwest Hornby Island



3.2 Regulatory Floodplain Mapping

The regulatory floodplain mapping product deliverables are described in Table 3. Example regulatory floodplain maps showing the Little River area (Map #33) and the Oyster River Area (Map #4) are provided in Figure 1A and 2A in Appendix A.

Table 3: Regulatory Floodplain Mapping Products

Description
Set of 163 regulatory floodplain maps at 1:4000 scale on 11"X17" paper. The regulatory floodplain maps show: • Floodplain Limits • Flood Levels (labelled) • River Flood Elevation Contour The maps also include a "hillshade" background generated from the LiDAR that gives an indication of the topography, and road and parcel boundaries. The maps were prepared in general conformance with the provincial guidelines (FLNR, 2018).
File Names and Formats
Regulatory Coastal Flood Maps.pdf (Adobe Portable Document Format) List of geodatabase files: RegCoastalFloodExtents.gdb [ArcGIS File Geodatabase Feature Class including features for flood extents (polygon)] RegCoastalFloodLimit.gdb [ArcGIS File Geodatabase Feature Class including features for Floodplain Limit (polyline)] RegCoastalFloodContours.gdb [ArcGIS File Geodatabase Feature Class including features for River Flood Elevation Contours (polylines)] RegCoastalZones.gdb [ArcGIS File Geodatabase Feature Class including features for Coastal Zone Boundaries (polylines)]
Datum
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013
Notes on Map Data, Data Sources and Dates:
The following additional mapping data is shown on the regulatory floodplain mapping: 1. Cadastral information supplied by ParcelMap BC / Land Title and Survey Authority of British Columbia (accessed September 30, 2020). 2. Property addressing and landmarks supplied by Comox Valley Regional District (accessed April 9, 2020). 3. Hydrology features supplied by National Hydrology Network (accessed June 29, 2017). 4. Parks, Ecological Reserves and Protected areas supplied by DataBC and Comox Valley Regional District (accessed May 16, 2019). 5. Road features supplied by Digital Road Atlas (accessed March 4, 2020). 6. Building footprints in the City of Courtenay supplied by the City of Courtenay (accessed June 4, 2020). 7. Building footprints outside the City of Courtenay derived from 2018 Orthophoto (CVRD). 8. Topography collected by LiDAR. Sources and dates as follows: • South of Oyster River: GeoBC (2018/2019) • North of Oyster River: Strathcona Regional District (2016)

Contour Intervals	
• 0.5 m water level intervals for Water Levels < 8.0 m Elevation • 1.0 m water level intervals for Water Levels > 8.0 m Elevation	
Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.
Mapping Product Development	

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions; and,
- Technical Memorandum #4 – Coastal Modelling.

Coastal Floodplain Mapping

For the coastal floodplain mapping, the flood levels have been established using the “probabilistic method” in the provincial guidelines (FLNR, 2018) as the sum of:

- The 0.5% AEP extreme static water level as determined by probabilistic analysis of tides and storm surge;
- Allowance for future Sea Level Rise to the year 2100 (+1.0 m);
- Allowance for regional land uplift, or subsidence to the year 2100;
- Estimated wave effects in the Designated Storm with a 0.5% AEP; and
- A freeboard of 0.6 metres.

For the special case of topographic plateaus, the flood level has been established as the elevation of the seaward crest of the plateau plus freeboard, or the maximum elevation of the overland flooding zone plus freeboard, whichever is greater.

Flood levels have been established based on one-dimensional modelling in which wave effects are calculated at discrete locations (transects) along the shoreline. In this modelling approach, the shoreline is divided into a series of “coastal zones” with similar topography, bathymetry, and wave exposure. A single transect location is then defined within each coastal zone. The transect location is selected to be representative of the topography, bathymetry, and wave exposure of the zone. The one-dimensional modelling results have been converted into two-dimensional mapping as follows:

- Each coastal zone is assigned a flood level based on the flood level calculated at the representative transect. This approach, relative to interpolation of flood levels between transects, allows for explicit definition of the flood level selected for a given area;
- Inland coastal zone boundaries are mapped to ensure that the floodplains within each coastal zone are contiguous with the sea. In practice, this means that the zone boundaries follow the topography so that flooded areas are connected to the source of flooding.

Some examples of coastal zones and coastal zone boundaries are provided in Figure 1B of Appendix B; the examples are described as follows:

Example A – Coastal Zone 11: This is an example of a coastal zone where the zone boundaries have been dictated mostly by topography since the offshore wave conditions are reasonably uniform along this stretch of shoreline. The boundaries have been placed at a road right-of-way to the west and a property boundary to the east. The zone boundaries extend inland beyond the floodplain limit.

Example B – Coastal Zone 4: This is an example of a coastal zone where the inland alignment of the western zone boundary has been selected such that the flooding from adjacent Coastal Zone 3 is contiguous with the sea. The zone boundary has been selected to follow road rights-of-way and property boundaries.

Example C – Coastal Zones 95, 96 and 97: This is an example of a series of coastal zones where the zone boundaries have been dictated by both topography and wave exposure. Coastal Zone 95 is more sheltered from waves than the other two zones and has the flattest topography. Coastal Zone 97 has the steepest shoreline topography. As with the other examples, the zone boundaries have been selected to follow road rights-of-way and property boundaries.

Some limitations with respect to the coastal modelling and mapping approach are as follows:

- The modelling and mapping have been performed at a regional scale, and do not resolve small-scale variations in shoreline topography. Flood levels calculated at locations other than the transect locations may differ from those depicted in the mapping.
- The modelling and mapping techniques do not account for wave overtopping and the relative conveyance capacity and storage volume of inland water courses and drainage systems. Instead, inland areas are assumed to flood to the flood level of the coastal zone. As a result, the inland flood levels and floodplain limits associated with coastal flooding depicted in the mapping are considered to be conservative values.

River Floodplain Mapping

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the flood levels have been established as 0.5% AEP modelled flood profile plus 0.6 m of freeboard based on the following:

- 0.5% AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- An allowance of +15% added to the peak instantaneous flow to account for projected climate change impacts to the year 2100;
- The 0.5% AEP extreme static water level plus allowance for Sea Level Rise to the year 2100 at the estuary (+1.0 m); and
- A freeboard of 0.6 metres.

Oyster River flood levels have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. The flood levels and floodplain limits depicted in the mapping are the maximum values of the two scenarios. The location and size of the hypothetical dike breach is based on recommendations provided in the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004). In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flood levels have been modelled for two scenarios: existing conditions and a scenario with additional proposed flood protection works in place. The proposed flood protection alignment is based on the Flood Protection Option 2 ring dike presented in the City of Courtenay Integrated Flood Management Strategy (KWL, 2013). The flood levels and floodplain limits depicted on the map are the maximum values of the two scenarios.

The river mapping was created as follows:

- For the Lower Oyster River, the two-dimensional output from the river modelling software package (HEC-RAS) was imported into GIS software and the freeboard allowance was added. In order to confirm that the flood extents with the freeboard allowance added were reasonable from a hydraulic perspective, a model run was conducted at a higher flow level which resulted in a river flood level which approximately matched the level with freeboard; the floodplain limits obtained from both techniques where then compared to confirm they are similar;
- For the Upper Oyster River, the flood extent in the 1D model area was created using the following procedure:
    1. Visually delineated the full width of the valley bottom based on the topography showing the location higher ground.
    2. Manually created a flood contour polyline at each cross-section location, extending the full width of the valley.
    3. Assigned the 1D modelled water level plus freeboard value to each polyline.
    4. Created a flood level surface raster from the polyline locations with elevations.
    5. Created 0.5 m flood contour isolines throughout the surface.
    6. Intersected flood level raster with topography raster to create a flooded areas with freeboard polygon.
    7. Visually reviewed flood polygon and noted locations of what appear to be backwatered low spots separated by high ground from the river. Revised the alignment of the 0.5 m flood contour polylines to reflect the backwatering condition (by extending 0.5 m polylines from the location where the backwatered area is connected to main channel up and around the backwatered area).
    8. Repeated Steps 3, 4, and 5 with updated 0.5 m flood contour isolines to create the updated flooded raster with lower water levels in the backwatered areas.
    9. Intersected the updated flood level raster with the topography raster to create an updated flooded areas with freeboard raster. Removed floodplain flooded areas that are disconnected from the river flooded area (isolated pools of water).
    10. From the raster created in Step 9, generated 1m flood contours with freeboard.
- For the Courtenay River system, the one-dimensional/two-dimensional maximum water level output from the river modelling software package (MIKE Flood) developed in 2013 for the City of Courtenay Integrated Flood Management Study (KWL, 2013) was imported into GIS software, adjusted to CVGD 2013 datum and then the freeboard allowance was added.

Post-Processing and Mapping Integration

The flood extents and limits were post-processed to remove small “islands” within the floodplain and flooded areas that are disconnected from the coastal and river flooded areas. Islands were removed using an algorithm based on the elevation of the island above the flood level and the size of the island. Any islands that are less than 3 m above the surrounding flood level on average or are less than 1000 m^2 in area were removed and the area is depicted as flooded.

Once the coastal and river floodplain limit lines, floodplain surfaces and extents were established, the datasets were merged using GIS software to create seamless floodplain mapping in coastal and river areas. This involved selecting the governing (highest) flood levels in areas where the coastal and river modelling overlap.

Water level contours (isolines) have been smoothed based on engineering judgement.

Notes and Limitations

The following limitations should be considered when interpreting and using the maps:

1. Regulatory floodplain maps are administrative tools which depict the estimated flood levels and floodplain limits for a designated storm and flood events within the map area. Flooding may occur to levels above the estimated flood levels and outside the estimated floodplain limits. The local government does not assume any liability for the accuracy of the estimated flood levels and floodplain limits shown on this map. A site-specific analysis should be conducted to assess the potential for flooding in areas outside/near the mapped floodplain limits.
2. The flood levels and floodplain limits depicted on this map have been developed using a methodology which is consistent with the BC Flood Hazard Area Land Use Management Guides (FLNR, 2018 - the "provincial guidelines") for the development of flood construction levels, the Federal Flood Mapping Framework (NRC, 2018) including relevant guidelines, the Engineers and Geoscientists BC Flood Mapping Guidelines (EGBC, 2017) and the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004).
3. The flood levels and floodplain limits correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum flood levels may occur in different areas at different times).
4. River flood levels are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions. The river flooding events depicted on this map have a statistical annual exceedance probability of 0.5% (the flood which is estimated to be equalled or exceeded on average once every 200 years) and occur at an ocean still water level with an annual exceedance probability of 0.5%. River flows have been increased by 15% over current (2020) extreme values to account for projected climate change impacts and ocean still water levels have been increased by 1.0 m over current extreme static water levels to account for the effects of sea level rise. River flood levels and floodplain limits include a freeboard allowance of 0.6 m.
5. The accuracy of the location of the floodplain limit as shown on this map is limited by the accuracy of the base topography and the scale at which the map is produced. The floodplain limits are not established on the ground by legal survey. Existing ground elevations, building and floodproofing elevations should be based on field survey using established benchmarks. The legal boundaries shown on this map are based on cadastral information and are for illustration only. A site-specific legal survey is required to reconcile property locations.
6. This flood map does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The map does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Flood levels and floodplain limits are not delineated for side streams or tributaries. Flood levels and floodplain limits due to tsunami are not depicted on the map.
7. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Sample


Normal Water Surface
Park, Ecological Reserve, Protected Area
Building Footprint (Approximate)
Flood Extents
Coastal Zone Limit
Avontee Rd
Coral Rd
Bates Rd
Mariner Rd
Fern Rd

3.3 Maximum Water Level Mapping

The maximum water level mapping deliverables are described in Table 4.

Table 4: Maximum Water Level Mapping

Description	
Maximum water level raster and polyline contours and point file of the Limit of the Wave Action Zone for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum water levels are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. **No freeboard allowance is included**.	
File Names and Formats	
List of geodatabase files: MaxWL_Raster.gdb [ArcGIS file geodatabase of maximum water levels (raster)] MaxWL_Contours.gdb [ArcGIS file geodatabase of maximum water level contours (polyline)] MaxWL_Extents.gdb [ArcGIS file geodatabase of maximum water level flood extents (polygon)] MaxWL_LoWAZ.gdb [ArcGIS file geodatabase of limit of wave action zone (points)]	
Feature classes of geodatabases follow the scenario naming convention of A_XXYYY_Z where A is the geodatabase name and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing water levels along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and extents must be considered because the no-breach results will generally have higher water levels within the diked river corridor.	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013	
Contour Intervals	
• 0.5 m intervals for Water Levels < 8.0 m Elevation • 1.0 m intervals for Water Levels > 8.0 m Elevation	
Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.

Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions; and,
- Technical Memorandum #4 – Coastal Modelling.

For coastal mapping, the water level is calculated as the sum of:

- The appropriate annual exceedance probability extreme water static level as determined by probabilistic analyses of tides and storm surge;
- Allowance for future SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200);
- Allowance for regional land uplift, or subsidence; and,
- Estimated wave effects with an annual exceedance probability matching the annual exceedance probability of the extreme water level.

In the special case of topographic plateaus, the Limit of the Wave Action Zone is also provided in the mapping as a point. The limit of the Wave Action Zone is the location (distance along transect) of the transition between impulsive wave run-up on the foreshore and the overland flow on the topographic plateau.

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the water levels have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River flood levels have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. The flood levels and floodplain limit mapping is provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004). In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flood levels have been modelled for existing conditions.

Refer to the Section 3.2, Regulatory Floodplain Mapping, for information on how the coastal and river model results were converted into two-dimensional mapping, post-processed and merged. Note, however, the following differences regarding how the maximum water level mapping has been processed:

- The Maximum Water Level Mapping as described in this section **does not include a freeboard allowance;**

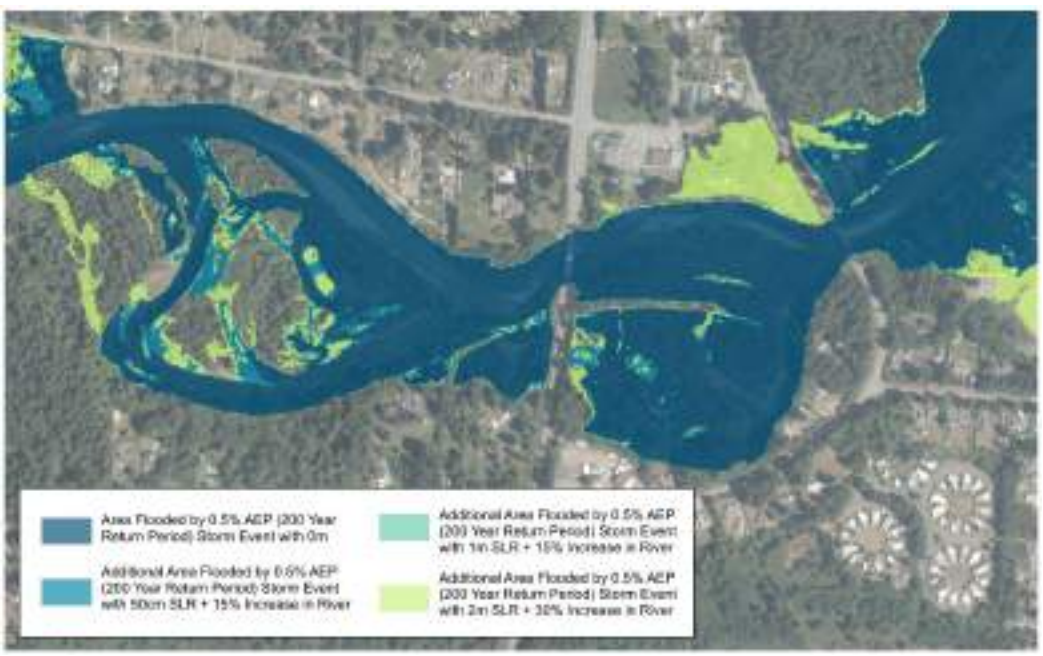
- "Islands" within the floodplain have not been removed from the raster dataset but have been removed from the "limit" polyline using the same techniques used for post-processing the regulatory floodplain mapping; and
- Water level contours have not been smoothed.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum water level mapping depicts the estimated water levels for various flood events within the map area **WITHOUT freeboard allowance**. Flooding may occur to levels above the estimated water levels. The local government does not assume any liability for the accuracy of the estimated water levels.
2. The water levels correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum water levels may occur in different areas at different times).
3. River water levels are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. The accuracy of the location of the flood limits as shown in the mapping is limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
5. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Water levels are not delineated for side streams or tributaries. Water levels due to tsunami are not depicted in the mapping.
6. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Sample



3.4 Maximum Water Depth Mapping

The maximum water depth mapping deliverables are described in Table 5.

Table 5: Maximum Water Depth Mapping

Description
Raster GIS layer and polyline contours showing maximum water depths for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum water depths are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. **No freeboard allowance is included**.
File Names and Formats
List of geodatabase files: MaxDepth_Raster.gdb [ArcGIS file geodatabase of maximum water depths (raster)] MaxDepth_Contours.gdb [ArcGIS file geodatabase of maximum water depth contours (polyline)] MaxDepth_Extents.gdb [ArcGIS file geodatabase of maximum water depth flood extents (polygon)] Feature classes of geodatabases follow the scenario naming convention of A_XXYYY_Z where A is the geodatabase name and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing water depths along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and limits must be considered because the no-breach results will generally have higher water depths within the diked river corridor.
Datum
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A
Contours
Contour intervals have been selected to provide higher resolution in shallow water areas and to provide a distinction between nuisance flooding events (nominally < 0.3 m water depth) and more damaging and hazardous flooding events. Contours are provided for the following depths: 0.1 m, 0.3 m, 1 m, 2 m, 3 m. Contours for water depths greater than 3 m are not provided because water depths greater than 3 m are outside the coastal floodplain (i.e., they are flooded under existing conditions).

Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions; and,
- Technical Memorandum #4 – Coastal Modelling.

For coastal flood hazard mapping, the maximum water depths are depicted as the extreme static water level plus an allowance for future SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200); and an allowance for regional land uplift, or subsidence as appropriate minus the ground surface elevation at any point. Water depths do not include wave effects, including wave setup. Water depths are not depicted for overland flow/flooding due to waves.

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the water depths have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and,
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River water depths have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. Water depths are provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the 2004 Fraser Basin Council Floodplain Mapping Guidelines and Specifications. In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River water depths have been modelled for existing conditions.

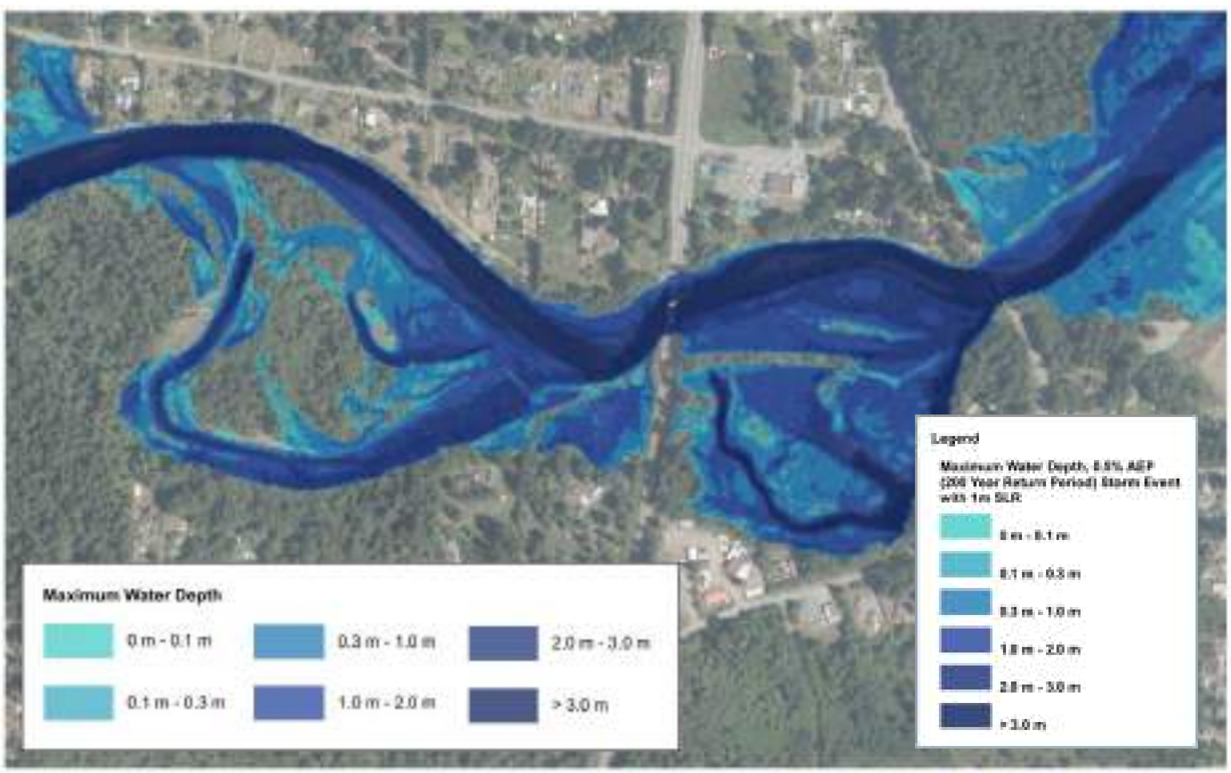
Refer to the Section 3.3, Maximum Water Level Mapping, for information on how the coastal and river model results were converted into mapping and merged. Note that the Maximum Water Depth Mapping as described in this section **does not include a freeboard allowance**.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum water depth mapping depicts the estimated water depths for various flood events within the map area **WITHOUT freeboard allowance**. Flooding may occur to depths greater than the estimated water depths. The local government does not assume any liability for the accuracy of the estimated water depths.
2. The water depths correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum water depths may occur in different areas at different times).
3. River water depths are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. The accuracy of the location of the flood limits as shown in the mapping are limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
5. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Water depths are not delineated for side streams or tributaries. Water depths due to tsunami are not depicted in the mapping.
6. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Sample



3.5 Maximum Flow Velocity Mapping

The maximum flow velocity mapping deliverables are described in Table 6.

Table 6: Maximum Flow Velocity Mapping

Description
Raster GIS layer and polyline contours showing maximum flow velocities for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum flow velocities are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. Maximum flow velocity mapping is provided only for the Oyster River and the Courtenay River System.
File Names and Formats
List of geodatabase files: MaxVelocity_Raster.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River maximum flow velocity (raster)] MaxVelocity_Contours.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River maximum flow velocity contours (polyline)] MaxVelocity_Extents.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River maximum flow velocity extents (polygon)] Feature classes of geodatabases follow the scenario naming convention of A_B_XXYYY_Z where A is the geodatabase name, B indicates the Oyster or Courtenay River and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing flow velocities along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and limits must be considered because the no-breach results will generally have higher velocities within the diked river corridor.
Datum
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A

Contours	
Contours are provided at regular 0.5 m/s intervals as follows: 0.5 m/s, 1.0 m/s, 1.5 m/s, 2.0 m/s, 2.5 m/s, 3.0 m/s, 3.5 m/s, 4.0 m/s, 4.5 m/s, 5.0 m/s.	
Quality Control	
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.
Mapping Product Development	

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions.

The flow velocities have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and,
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River flow velocities have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. Flow velocities are provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the 2004 Fraser Basin Council Floodplain Mapping Guidelines and Specifications. In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flow velocities have been modelled for existing conditions.

Maximum flow velocity mapping is only provided for areas in which 2-dimensional modelling has been performed (i.e., the Lower Oyster River and the Courtenay River). Refer to the river modelling memorandum listed above for tabular maximum velocity data in areas where 1-Dimensional modelling has been performed.

The flow velocities correspond to the maximum for the entire storm event modelled across the full tidal range so may not correspond to the flow velocity at the maximum water level (i.e.: may occur during periods of high river flow and low tide) and may not be contemporaneous across the mapping (i.e.: maximum velocities in different areas may occur at different times).

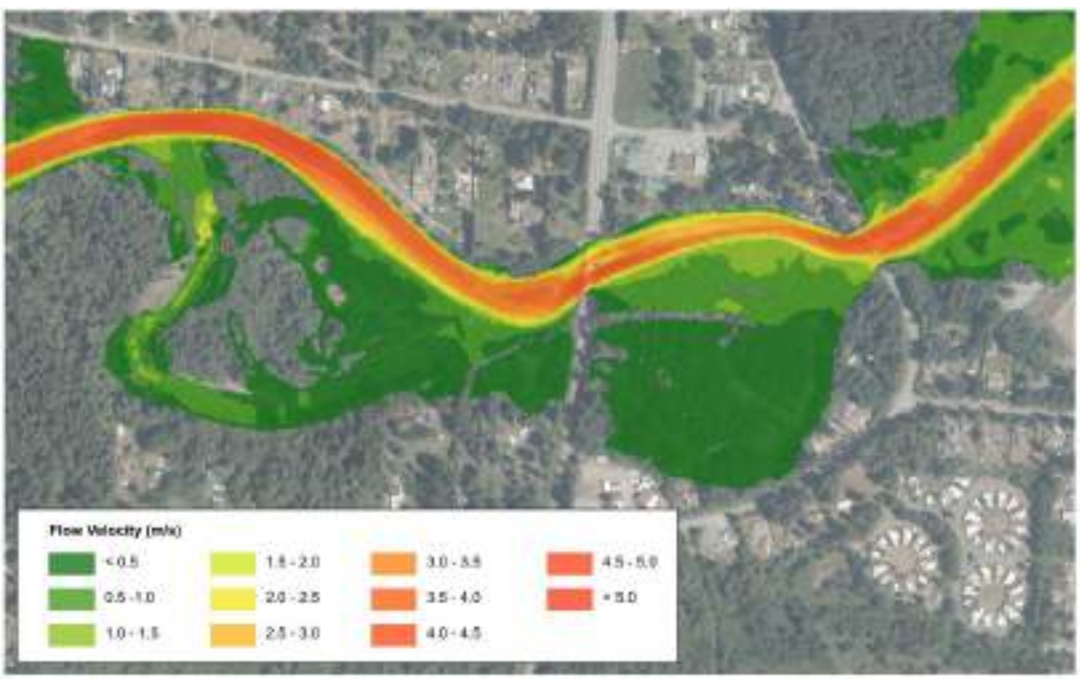
Refer to the Section 3.3 Maximum Water Level Mapping, for information on how the river model results were converted into mapping. Flow velocity is a direct output from the modeling software and the data was handled using similar techniques.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum flow velocity mapping depicts the estimated flow velocities for various flood events within the map area. Flow velocities greater than the estimated values may occur. The local government does not assume any liability for the accuracy of the estimated flow velocities.
2. The flow velocities correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum flow velocities may occur in different areas at different times).
3. River flow velocities are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. Flow velocities shown in coastal areas are for river flow in isolation and effects of tidal and wave induced currents are not included.
5. The accuracy of the location of the flood limits as shown in the mapping are limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
6. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Flow velocities are not delineated for side streams or tributaries.
7. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Sample



3.6 Flood Hazard Rating Mapping

The flood hazard rating mapping deliverables are described in Table 7.

Table 7: Flood Hazard Rating Mapping

Description
Raster GIS layer and contour polylines showing flood hazard rating (the product of water depth and velocity) for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Flood hazard ratings are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. Flood hazard rating mapping is provided only for the Oyster River and the Courtenay River System.
File Names and Formats
List of geodatabase files: HR_Raster.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River flood hazard rating (raster)] HR_Contours.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River flood hazard rating contours (polyline)] HR_Extents.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River flood hazard extents (polygon). Note that the hazard map extent excludes the Courtenay River areas that were modelled in 1D (upper end of Puntledge River including adjacent floodplain, and top of bank to top of bank for all other rivers).] Feature classes of geodatabases follow the scenario naming convention of A_B_XXYYY_Z where A is the geodatabase name, B indicates the Oyster or Courtenay River and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing flood hazard ratings along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and limits must be considered because the no-breach results will generally have higher flood hazard ratings within the diked river corridor.
Datum
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A

Contours	
Contour intervals have been selected to correspond to the hazard vulnerability classifications in the Australian flood hazard guidelines (AIDR, 2017) as follows: 0.3 m^2/s, 0.6 m^2/s, 1.0 m^2/s, 2.0 m^2/s, 4.0 m^2/s. It should be noted that the Australian flood hazard guidelines provide upper-bound water depths and velocities for each hazard classification and therefore cross-referencing with the depth and velocity mapping is required to perform a complete assessment.	
Quality Control	
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.
Mapping Product Development	

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions.

The flood hazard rating is the product of depth and velocity calculated using the hydraulic model output (AIDR, 2017).

The flood hazard ratings have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and,
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River flood hazard ratings have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. Flood hazard ratings are provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the 2004 Fraser Basin Council Floodplain Mapping Guidelines and Specifications. In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flood hazard ratings have been modelled for existing conditions.

Flood hazard rating mapping is only provided for areas in which 2-dimensional modelling has been performed (i.e., the Lower Oyster River and the Courtenay River.

The hydraulic model calculates the product of depth and velocity within each grid cell for each time step and the maximum value of the modelled depth-velocity product time series is then selected as the maximum flood hazard rating and plotted for mapping. Given that the depth-velocity product values are calculated at each time step throughout the modelled flood duration, the flood hazard rating may not necessarily occur at the time of maximum water depth or maximum flow velocity and may not be contemporaneous across the mapping (i.e.: maximum hazard ratings in different areas may occur at different times) The flood hazard rating data can be used for future quantitative flood risk and vulnerability assessments, multi-zone planning approaches (e.g., floodway and flood fringe) and for emergency preparedness planning.

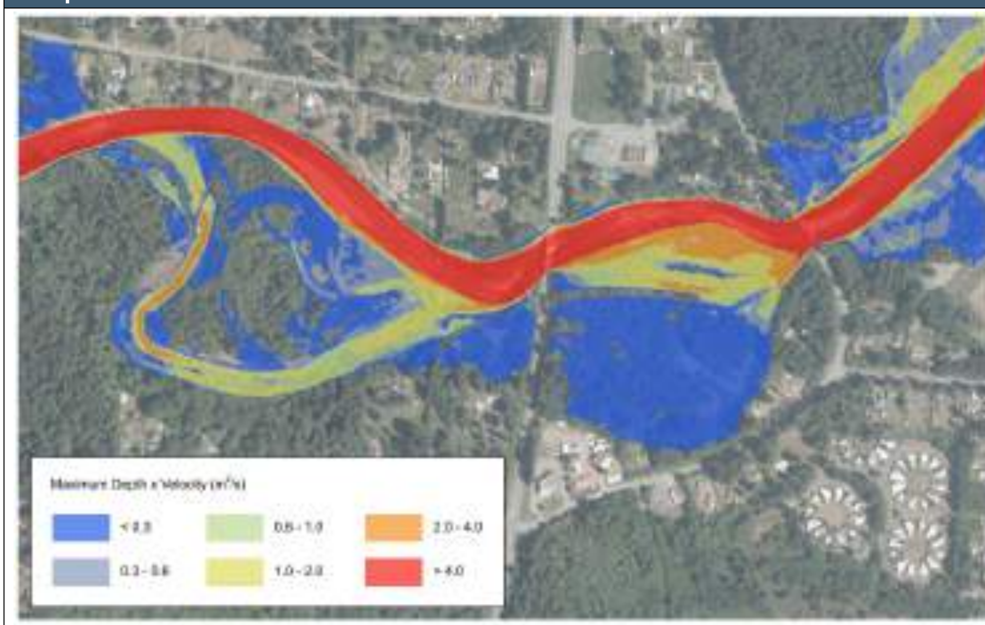
Refer to the Section 3.3 Maximum Water Level Mapping, for information on how the river model results were converted into mapping; the flood hazard data was handled using similar techniques.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum flood hazard rating mapping depicts the estimated flood hazard rating for various flood events within the map area where 2D modelling was performed. Flood hazard ratings greater than the estimated values may occur. The local government does not assume any liability for the accuracy of the estimated flood hazard ratings.
2. The flood hazard ratings correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum flood hazard ratings may occur in different areas at different times).
3. River flood hazard ratings are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. Flood hazard ratings shown in coastal areas are for river flow in isolation and effects of tidal and wave induced currents are not included.
5. The accuracy of the location of the flood limits as shown in the mapping are limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
6. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Flood hazard ratings are not delineated for side streams or tributaries.
7. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Sample



3.7 Maximum Wave Heights in the Coastal Floodplain Mapping

The maximum wave heights in the coastal floodplain mapping deliverables are described in Table 8.

Table 8: Maximum Wave Heights in Coastal Floodplain Mapping

Description	
Polyline contours of significant wave height in the coastal floodplain for 4 SLR scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5% and 0.2%); 20 scenarios total. Maximum Wave Height in the Coastal Floodplain Mapping is provided for coastal areas only.	
File Names and Formats	
List of geodatabase files: MaxWV_Contours.gdb [ArcGIS file geodatabase of maximum wave height contours (polyline)] Feature class of geodatabase follows the scenario naming convention of MaxWV_XXYYY where XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2%	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A	
Contour Intervals	
Various. Wave heights have been calculated for water depths at nominal 0.1 m increments which results in variable intervals between wave height contours.	
Quality Control	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Mapping Product Development	
Refer to: • Technical Memorandum #4 – Coastal Modelling Wave height contours have been provided in the coastal floodplain, which is the flooded area shoreward of the existing normal highest tide (higher-high water large tide, HHWLT). Wave heights are not depicted for overland flooding areas at topographic plateaus. The water levels used for the modelling of the maximum wave heights in the coastal floodplain are the extreme static water level plus an allowance for future SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200); and an allowance for regional land uplift, or subsidence as appropriate. Wave heights in the floodplain have been estimated based on the formulas developed by Goda (Goda, 2010). These formulas account for the effects of wave shoaling and breaking on wave heights.	

The maximum wave heights in the coastal floodplain have been calculated using one-dimensional modelling techniques using the same transects used for wave effect (nearshore wave) modelling. The calculated wave heights are only considered to be accurate on the transect and have been extrapolated to other areas within each coastal zone using an algorithm based on water depth. In this algorithm, each water depth contour (at nominal 0.1 m increments) is assigned a wave height based on the value of the wave height on the transect where the water depth contour crosses the transect. In cases where a water depth contour crosses a transect several times, the water depth contour is conservatively assigned a wave height at the most seaward crossing location on the transect.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum wave heights in the coastal floodplain mapping depicts the estimated wave heights for various flood events within the map area. Wave heights greater than the estimated values may occur. The local government does not assume any liability for the accuracy of the wave heights.
2. As noted in Goda (2010), a feature of the formulas is a prediction of wave heights at the shoreline where the water depth, as per the water depth mapping, is zero. To quote Goda: *The presence of finite wave heights there (at the shoreline) is due to the increase in actual water depth due to wave setup and surf beats. The motion of water around the shoreline, however, is more intensive than that of ordinary wave motion corresponding to the height estimated because of the up-rushing and down-rushing surging motion of water there. Therefore, the estimated wave height at [the shoreline] should be regarded as an apparent one which does not adequately represent the magnitude of the wave action*. The estimated wave heights in the mapping should therefore not be used for design of coastal structures or other works and are considered to be suitable only for hazard assessment or other uses where an indication of relative wave action is needed.
3. Wave heights are maximum significant wave heights as per Goda ($H_{1/3}$) corresponding to the peak of the storm event for the ensemble of storm directions modelled and may not be contemporaneous across the mapping (i.e., maximum wave heights may occur in different areas at different times).
4. The accuracy of the wave heights as shown on the mapping is limited by the base topography and the 1D to 2D conversion algorithm as described in “Mapping Product Development”.
5. The wave height in the coastal floodplain modelling and mapping have been prepared at a regional scale, and do not resolve small-scale variations in shoreline exposure, topography, and bathymetry. Wave heights in the coastal floodplain have been calculated based on one-dimensional modelling in which the shoreline is divided into "Coastal Zones" and wave heights are calculated at discrete locations (transects) within each Coastal Zone. When preparing two-dimensional mapping based on the coastal model results, it is assumed that the results at these transect locations are representative of the adjacent locations within the zone and wave heights are proportional to water depth. Wave heights calculated at locations other than the transect locations may differ from those depicted on the map due to the effects of refraction, diffraction, and varying bathymetry which are not accounted for in the one-dimensional modelling.
6. Wave heights as a result of tsunami are not included.
7. Users must note the dates of base mapping, ground or bathymetric surveys and issue of mapping relevant to dates of development in the map area. Changes within the floodplain or in offshore areas will affect wave heights and render site-specific map information obsolete.

Sample


Wave Height (m)
Coastal Zone Limit
< 0.6
0.6 - 1.1
1.1 - 1.6
1.6 - 2.1
2.1 - 2.7
2.7 - 3.5
3.5 - 4.6
> 4.6

3.8 Climate Change Planning Area Mapping

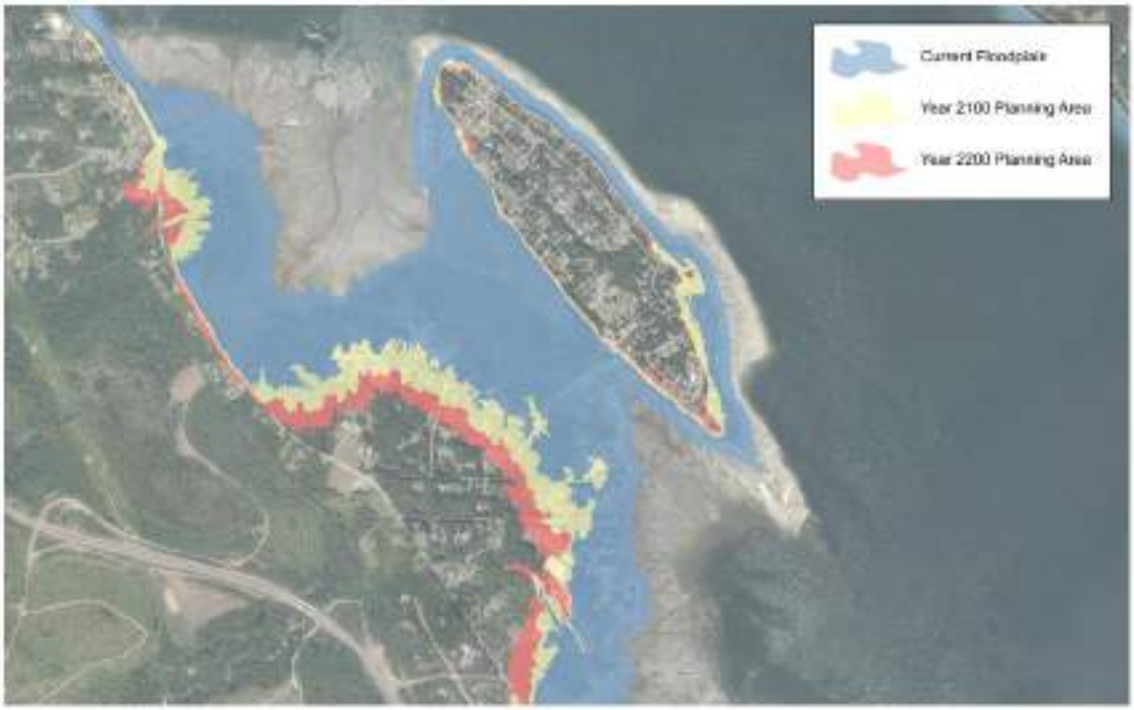
The climate change planning area mapping deliverables are described in Table 9.

Table 9: Climate Change Planning Area Mapping

Description	
Year 2100 and year 2200 Sea Level Rise Planning Areas as defined in the provincial guidelines (FLNR, 2018). Areas exposed to flood hazards from the Oyster and Courtenay River systems within the study area are also included in the mapping. A freeboard allowance is included.	
File Names and Formats	
List of geodatabase file(s): Planning.gdb [ArcGIS file geodatabase of sea level rise planning areas (polygon)] Feature classes of geodatabase includes the following: Year 2100 Climate Change Planning Area: AdmClimateChangePlanningArea_2100 Year 2200 Climate Change Planning Area: AdmClimateChangePlanningArea_2200	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013	
Contour Intervals	
Not applicable.	
Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.
Mapping Product Development	
Refer to: • Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions; • Technical Memorandum #3B – Courtenay River Modelling – Hydrology and Model Assumptions; and, • Technical Memorandum #4 – Coastal Modelling. The Year 2100 Climate Change Planning Area is depicted as the area between the existing floodplain limit and the Year 2100 floodplain limit. The Year 2200 Climate Change Planning Area is depicted as the area between the Year 2100 floodplain limit and the Year 2200 floodplain limit. The extents of the Climate Change Planning Areas in coastal areas are dictated by sea level rise, while the extents of the Climate Change Planning Areas bordering rivers are dictated by increases in river flow. For coastal areas, the Year 2100 scenario includes a 1 m SLR allowance, and the Year 2200 scenario includes a 2 m SLR allowance as per the provincial guidelines (FLNR, 2018). The floodplain limit is the elevation of the wave runup, $R_{2\%}$, and is calculated as the sum of:	

• The 0.5% AEP extreme static water level as determined by probabilistic analyses of tides and storm surge; • Allowance for future SLR (1 m for year 2100 and 2 m for year 2200); • Allowance for regional land uplift, or subsidence; • Estimated wave effects with a 0.5% AEP; and • A freeboard of 0.6 metres. As with the regulatory floodplain mapping, for the special case of topographic plateaus, the flood level has been established as the elevation of the seaward crest of the plateau plus freeboard, or the maximum elevation of the overland flooding zone plus freeboard, whichever is greater. For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the flood levels have been established as 0.5% AEP modelled flood profile plus 0.6 m of freeboard based on the following: • 0.5% AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada; • An allowance added to the peak instantaneous flow to account for projected climate change impacts (+15% for Year 2100 and +30% for Year 2200); • The 0.5% AEP extreme static ocean level plus allowance for Sea Level Rise (1 m for Year 2100 and 2 m for Year 2200); and, • A freeboard of 0.6 metres. Oyster River flood levels have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. The flood levels and floodplain limits depicted in the mapping are the maximum values of the two scenarios. The location and size of the hypothetical dike breach is based on recommendations provided in the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004). In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road. For the Year 2100 Climate Change Planning Area boundary, Courtenay River flood levels have been modelled for two scenarios: existing conditions and a scenario with additional proposed flood protection works in place. The proposed flood protection alignment is based on the Flood Protection Option 2 ring dike presented in the City of Courtenay Integrated Flood Management Strategy, 2013. The flood levels and floodplain limits depicted on the map are the maximum values of the two scenarios. For the existing and Year 2200 Climate Change Planning Area boundaries, Courtenay River flood levels have been modelled for existing conditions without flood protection works in place. • Refer to the Section 3.2, Regulatory Floodplain Mapping, for information on how the coastal and river model results were converted into two-dimensional mapping and merged.
Notes and Limitations
1. Refer to Table 3 - Regulatory Floodplain Mapping Products for relevant notes and limitations.

Sample


Current Floodplain
Year 2100 Planning Area
Year 2200 Planning Area

3.9 Setback Mapping

The setback mapping deliverable is described in Table 10.

Table 10: Setback Mapping

Description	
Coastal Setback polyline based on the provincial guidelines (FLNR, 2018). River Setbacks are not depicted. Potential Setback Reduction or Increase polyline which is intended to serve as a screening tool when making land use planning decisions. Field investigations by qualified professionals should be conducted to confirm local conditions and setback requirements.	
File Names and Formats	
List of geodatabase file(s): Coastal_Setbacks.gdb [ArcGIS file geodatabase of coastal setbacks (polyline)]	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013	
Contour Intervals	
Not applicable.	
Quality Control	
Mapping prepared by:	Jamie Rodstrom, EIT
Mapping checked by:	Eric Morris, P.Eng.
Mapping Product Development	
Refer to: • Technical Memorandum #2 – Fluvial and Coastal Geomorphology • Technical Memorandum #4 – Coastal Modelling. Coastal setbacks have been defined for the same sea level rise and storm scenario as depicted in the regulatory floodplain mapping: 1 m of SLR and 0.5% AEP water level and storm event. Setbacks are depicted as the greater of 15 m from the future estimated natural boundary of the sea with 1 m of SLR, or landward of the location where the natural ground elevation contour is equivalent to the floodplain limit with 1 m of SLR. A freeboard allowance of 0.6 m is included when estimating the floodplain limit with 1 m of SLR. For the special case of topographic plateaus, the floodplain limit has been established as the elevation of the seaward crest of the plateau plus freeboard, or the elevation of the shoreward extent of overland flooding plus freeboard, whichever is greater. The location of the future estimated natural boundary of the sea with 1 m of SLR is estimated as the elevation of the wave runup exceeded by 50% of the waves ($R_{50\%} = R_{2\%}/2.2$) for the 0.5% AEP storm event (Ausenco Sandwell, 2011). For areas with coastal bluffs that are steeper than 3 (Horizontal) to 1 (Vertical) and have a height in excess of 3 m, setbacks have been determined with the following criteria, illustrated in Figure 2B of Appendix B: • If the future estimated natural boundary is located at least 15 m seaward of the toe of the bluff, then no special bluff setback has been defined and the setback is defined as per above. • If the future estimated natural boundary is located 15m or less seaward of the toe of the bluff, then the setback from the future estimated natural boundary has been located at a horizontal distance of 3 times the height of the bluff, measured from 15 m landwards from the location of the future estimated natural boundary.	

Lengths of shoreline which may warrant a reduction or increase in setbacks have been identified in the mapping. Potential extraordinarily erodible or eroding areas have been identified as locations where setbacks could be increased while potential non-erodible areas have been identified as locations where setbacks could be reduced.

Refer to Technical Memorandum #2 – Fluvial and Coastal Geomorphology for further information.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The setback mapping has been performed entirely as a desktop exercise based on provincial guidelines for setback mapping (FLNR, 2018). No field investigations have been conducted to confirm local site conditions or the adequacy of the setbacks depicted in the mapping; larger setbacks may be needed due to local erosion hazards. Terrestrial cliff and slope stability hazards have not been reviewed when preparing the setback mapping. Field investigations by qualified professionals should be conducted to confirm local conditions and setback requirements.
2. The shoreline erodibility assessment which supported the identification of lengths of shoreline which may warrant potential setback increase or reduction was entirely a desktop exercise and relied on the interpretation of orthophotos, mapping and reports by others that provided only partial coverage of the study area. As such, the results should be viewed as indicative only. The assessment is intended to serve as a potential screening tool when making land use planning decisions. Field investigations by qualified professionals should be conducted to confirm local conditions and setback requirements.
3. Setbacks have not been defined for tsunami hazards.
4. Refer to Table 3 - Regulatory Floodplain Mapping Products for additional relevant notes and limitations.

Sample

4. Closing

We trust that this summary of the mapping products prepared for the Coastal Flood Mapping Project provides the Comox Valley Regional District with the information required. If you have any questions, please contact the undersigned at (250) 595-4223.

KERR WOOD LEIDAL ASSOCIATES LTD.

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(Coastal mapping)*

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Principal, Senior Water Resources Engineer

EM/em/aah

Encl.: Appendix A: Digital Mapping Product Samples
Appendix B: Figures
Appendix C: Flood Mapping Assurance Statements

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
0	April 23, 2021	Final	Final	EM

OQM CERTIFIED

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Appendix A

Digital Mapping Product Samples

Figure 1A - Regulatory Map for Little River Area

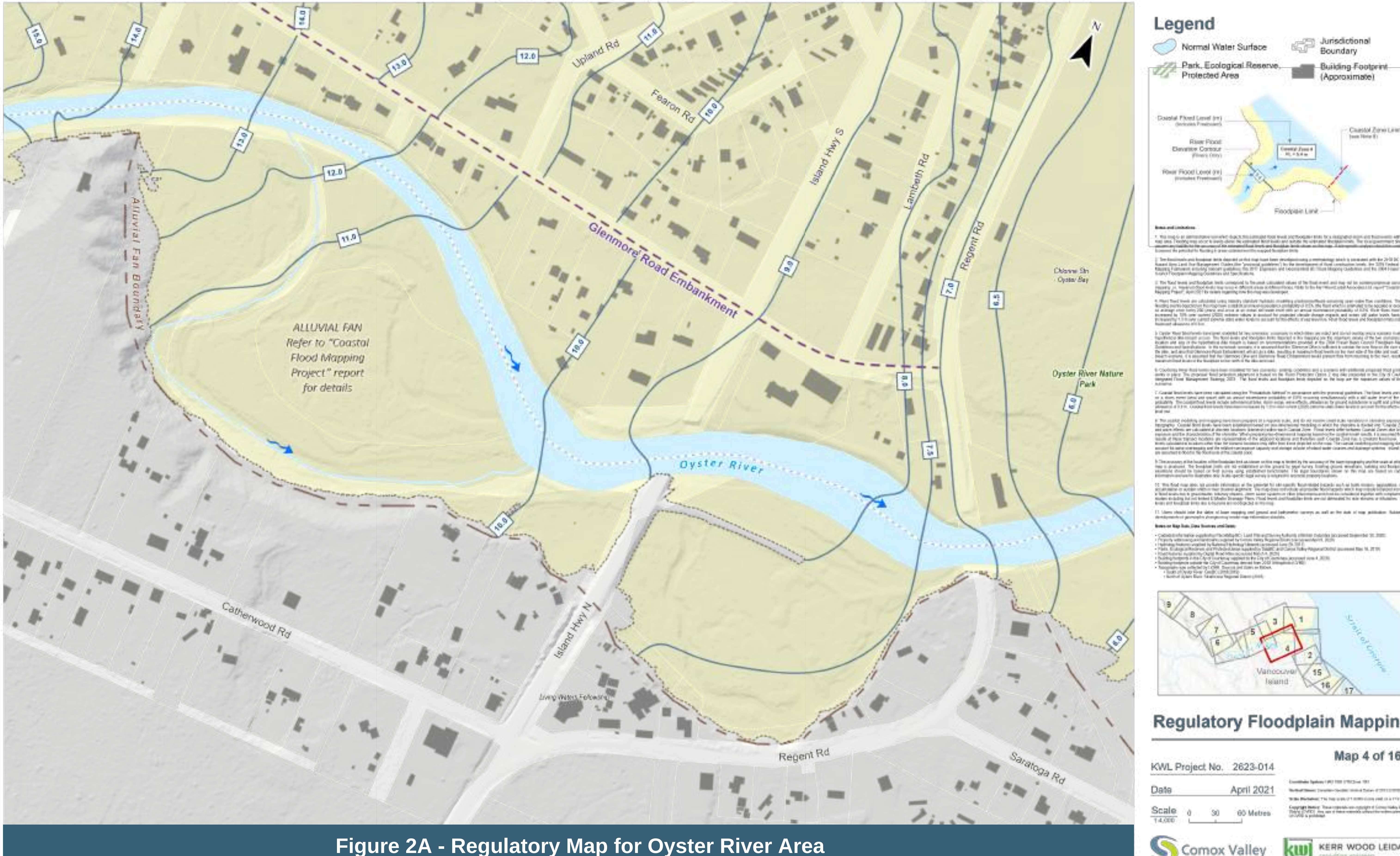


Figure 2A - Regulatory Map for Oyster River Area

Comox Valley Regional District

Coastal Flood Mapping Project

KERR WOOD LEIDAL consulting engineers

Project No.	2623-014
Date	April 2021
Scale	1:4,500
0 25 50	100 Meters

Little River Area - Maximum Water Levels for 0.5% AEP Storm with 0 m, 0.5 m, 1.0 m and 2.0 m Sea Level Rise

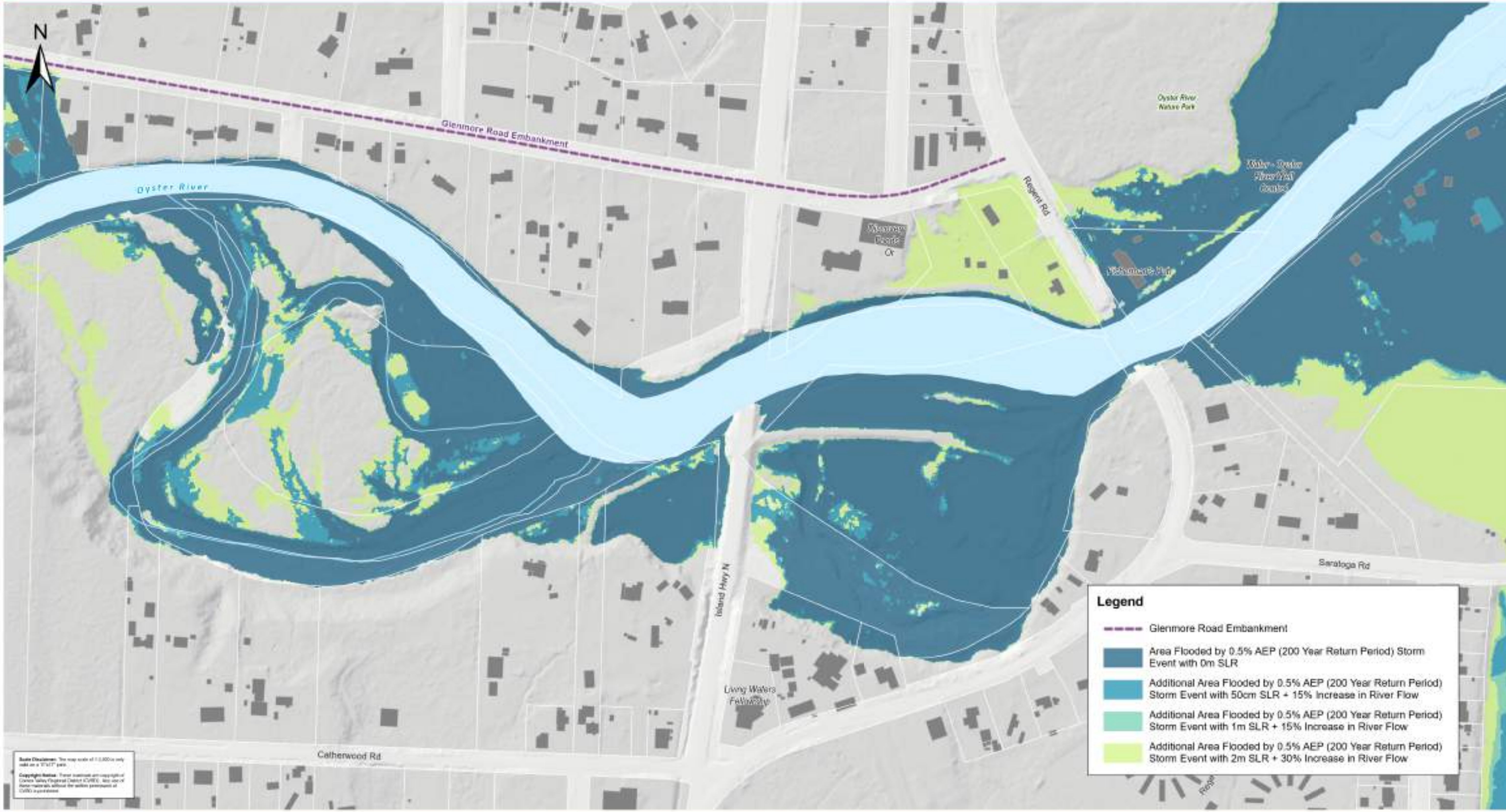
Figure 3A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples_WL_Depth_Setback.aprx Date Saved: 4/22/2021 11:10 AM | Author: TSoh

Comox Valley Regional District

Coastal Flood Mapping Project

KERR WOOD LEIDAL
consulting engineers



Project No.	2623-014
Date	April 2021
Scale	1:3,500
0 20 40	80 Metres

Oyster River Area - Maximum Water Levels for 0.5% AEP Storm for Four Different Climate Scenarios

Figure 4A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples_WL_Depth_Setback.aprx Date Saved: 4/22/2021 1:48 AM | Author: TSoh

Comox Valley Regional District

Coastal Flood Mapping Project

KERR WOOD LEIDAL consulting engineers

Project No.	2623-014
Date	April 2021
Scale	1:4,500

0 25 50 100 Metres

Little River Area - Maximum Water Depths for 0.5% AEP Storm with 1.0 m Sea Level Rise

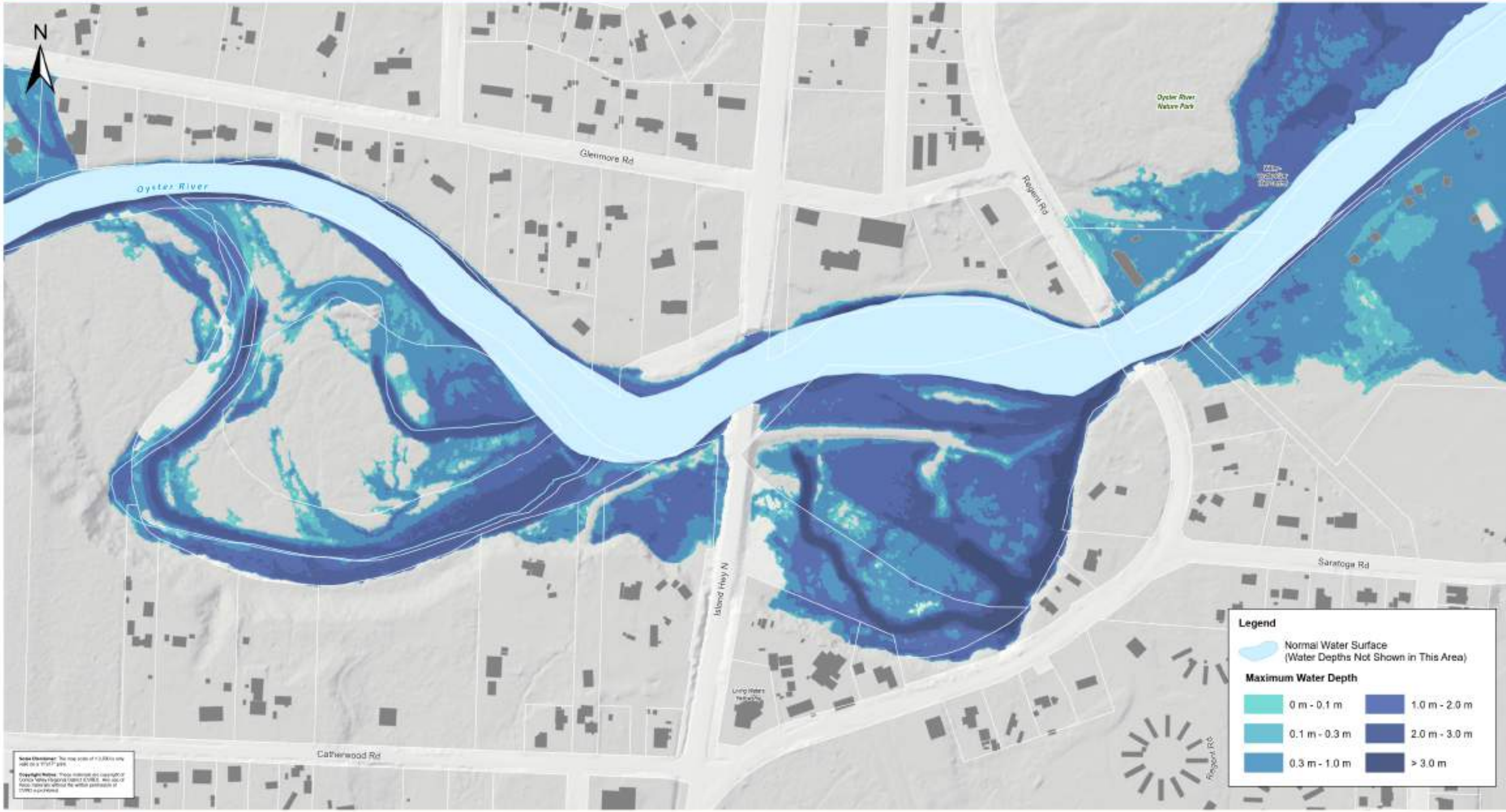
Figure 5A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples_WL_Depth_Setback.aprx Date Saved: 4/22/2021 9:24 PM | Author: TSoh

Comox Valley Regional District

Coastal Flood Mapping Project

KERR WOOD LEIDAL consulting engineers



Project No.	2623-014
Date	April 2021
Scale	1:3,500

0 20 40 80 Metres

Oyster River Area - Maximum Water Depths for 0.5% AEP Storm with 1.0 m Sea Level Rise + 15% Increase in River Flow

Figure 6A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples.aprx Date Saved: 4/22/2021 10:04 AM | Author: TSuh

Project No. 2623-014
Date April 2021
Scale 1:3,500
0 20 40 80 Metres

Oyster River Area - Maximum Flow Velocity for AEP 0.5% for 1 m Sea Level Rise + 15% Increase in River Flow

Figure 7A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples.aprx Date Saved: 4/22/2021 11:21 AM | Author: TSoh

Comox Valley Regional District

Coastal Flood Mapping Project

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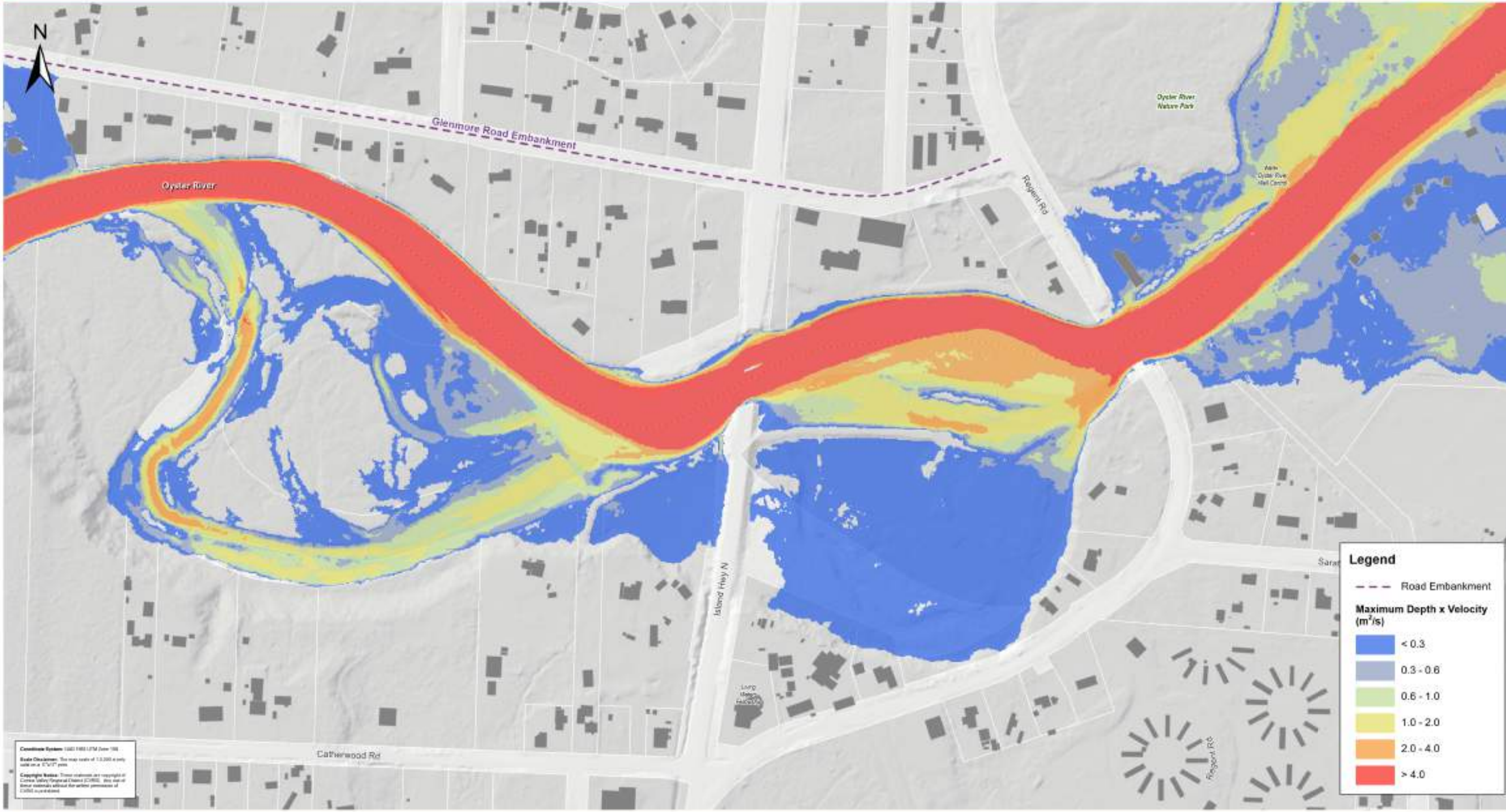

Project No. 2623-014

Date April 2021

Scale 1:3,500

0 20 40 80 Metres

Oyster River Area - Flood Hazard Rating for AEP 0.5% for 1 m Sea Level Rise +15% Increase in River Flow

Figure 8A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples.aprx Date Saved: 4/22/2021 3:13 PM | Author: MScruton

Comox Valley Regional District
Coastal Flood Mapping Project

KERR WOOD LEIDAL
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Project No.	2623-014
Date	April 2021
Scale	1:5,000

0 25 50 100 Metres

Maximum Wave Heights in the Coastal Floodplain for AEP of 0.5% and 1.0 m of Sea Level Rise

Figure 9A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples.aprx Date Saved: 4/22/2021 11:21 AM | Author: TSoh

Comox Valley Regional District
Coastal Flood Mapping Project

KERR WOOD LEIDAL
consulting engineers

Project No.	2623-014
Date	April 2021
Scale	1:4,500

0 25 50 100 Metres

Little River Area – Climate Change Planning Areas

Figure 10A

Path: Z:\2000-2999\2600-2699\2623-014\430-GIS\Pro Projects\2623014_Rp_RepresentativeExamples\2623014_Rp_RepresentativeExamples_WL_Depth_Setback.aprx Date Saved: 4/22/2021 12:50 PM | Author: TSoh

Comox Valley Regional District
Coastal Flood Mapping Project

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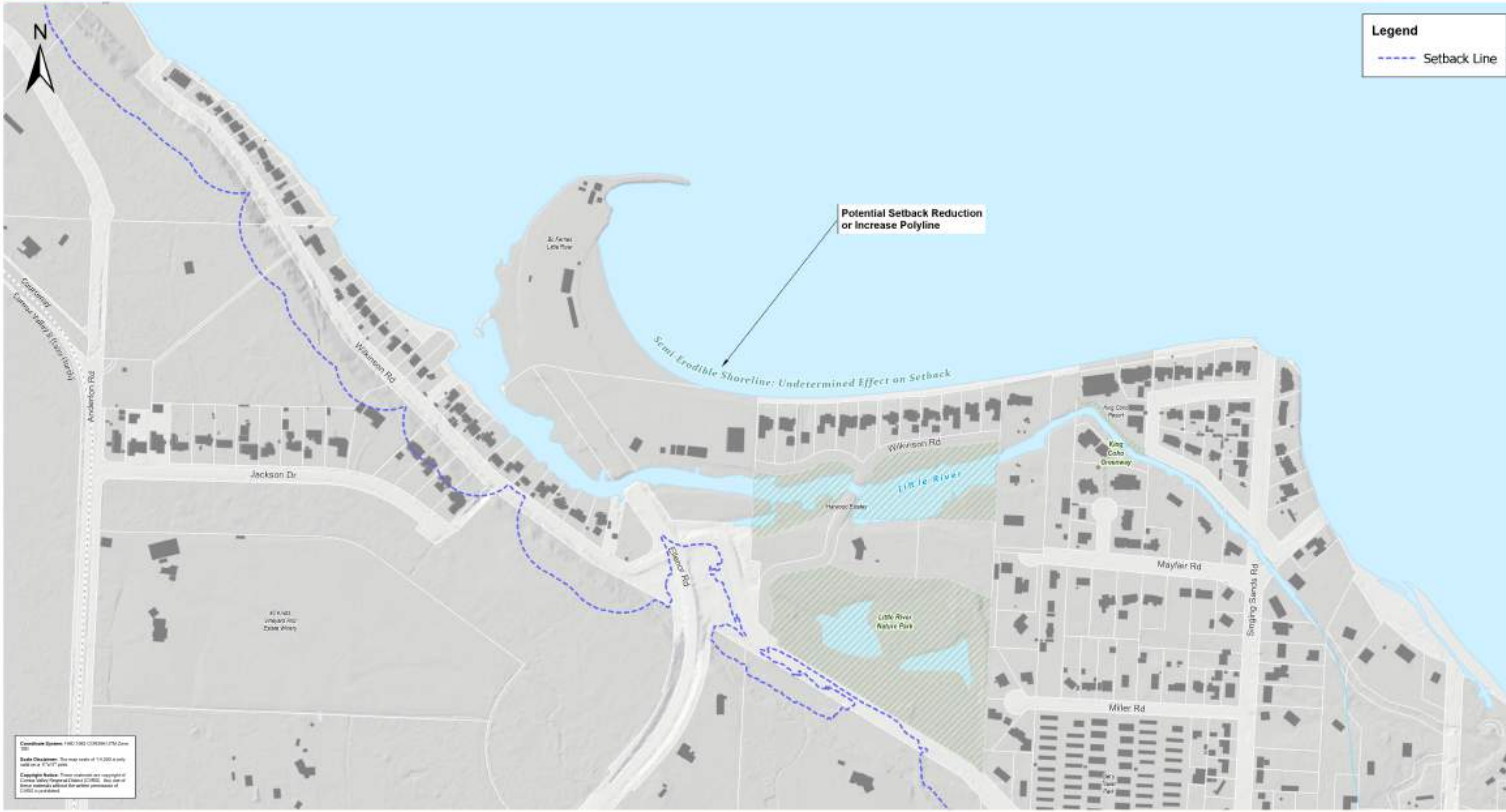

Project No.	2623-014
Date	April 2021
Scale	1:4,500

0 25 50 100 Metres

Little River Area - Setbacks

Figure 11A

KERR WOOD LEIDAL
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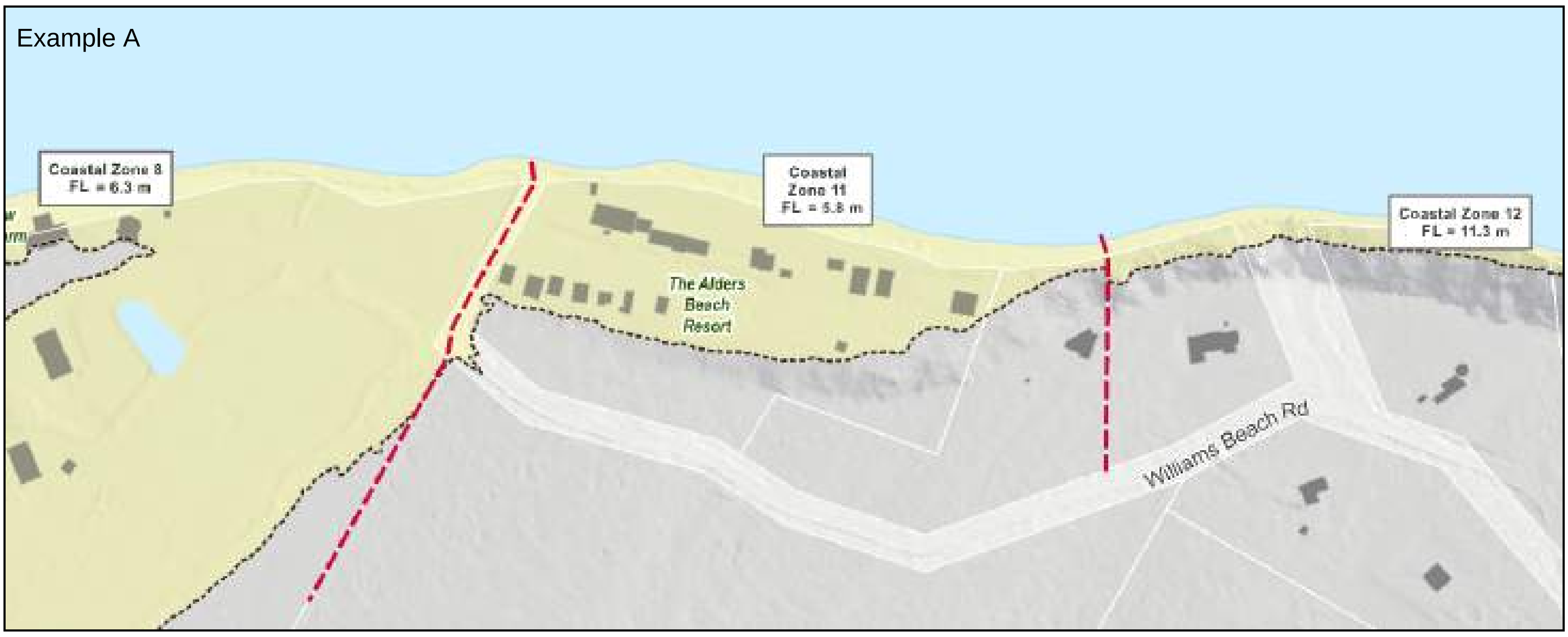
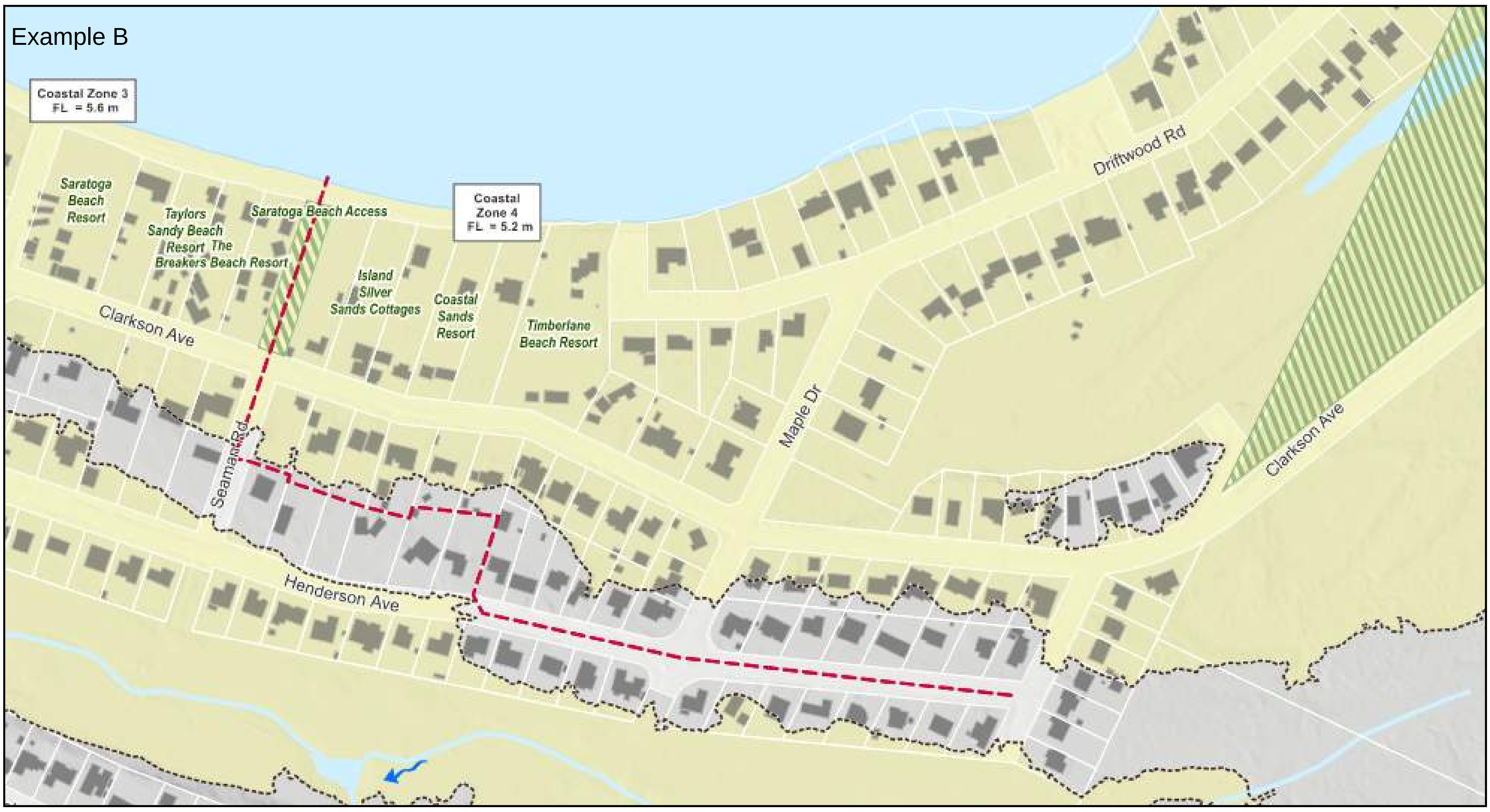
Appendix B

Figures

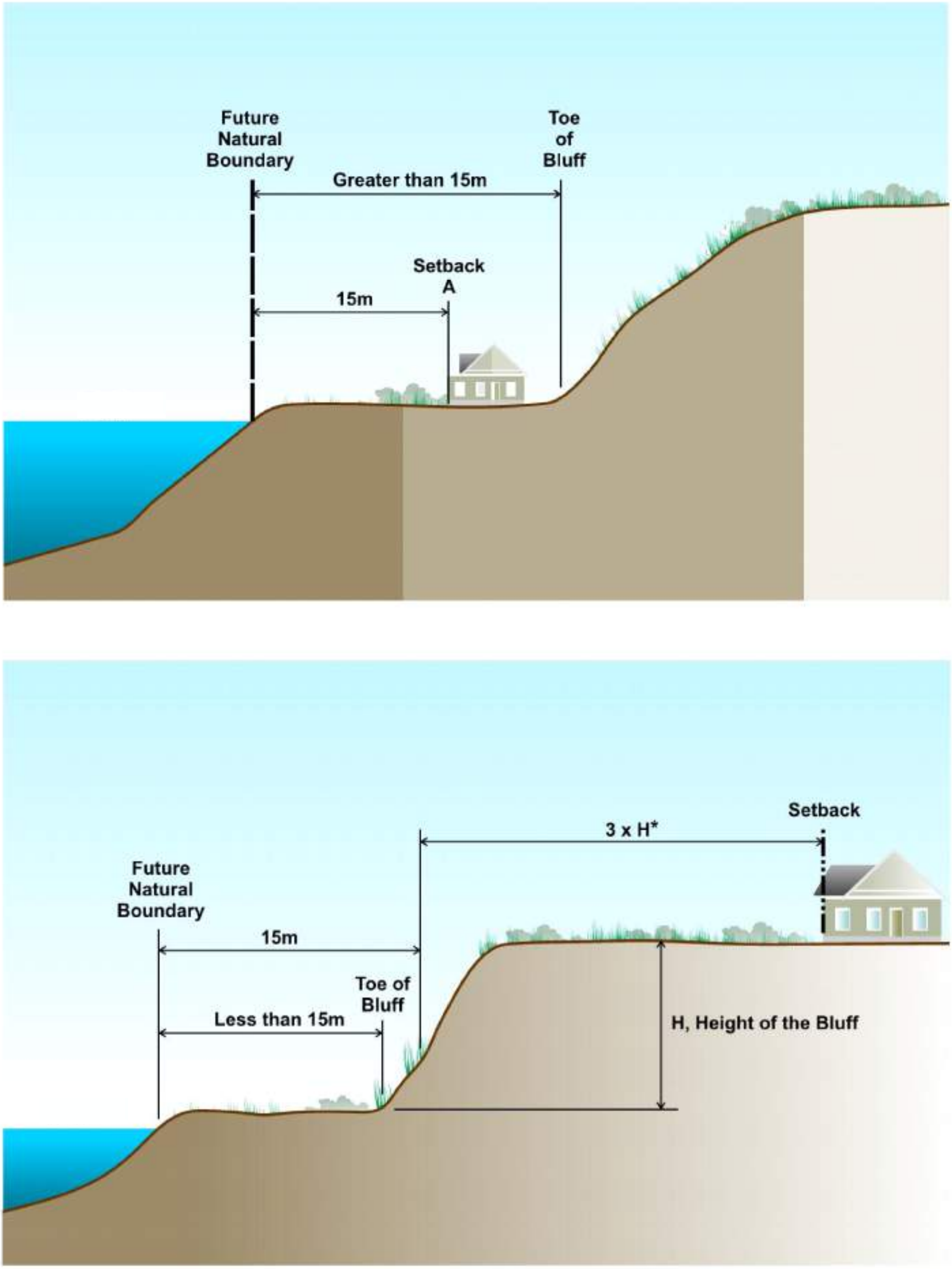
Example A



Example B



Example C



Project No.	2623-014
Date	April 2021
Scale	N/A

Setbacks for Coastal Bluffs

Figure 2B

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Appendix C

Flood Mapping Assurance Statements

APPENDIX A: FLOOD MAPPING ASSURANCE STATEMENT

To: The Client

Date: April 23, 2021

Comox Valley Regional District

Name (print)

770 Harmston Ave

Courtenay, BC V9N 2X6

Address (print)

Flood Mapping Project:

Coastal Flood Mapping Project - Courtenay-Tsolum-Puntledge River

The undersigned hereby gives assurance that he/she is an APEGBC registered professional and the Qualified Professional for the project identified above.

I have signed, sealed and dated the attached report in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*. The report supports and accurately reflects the assurances made in this Assurance Statement.

I have completed the following activities:

(Check the applicable items)

	Activity
X	Reviewed the relevant provincial legislation and local government regulations, policies, and floodplain bylaws
X	Reviewed available and relevant background information, documentation and data
X	Visited the site and reviewed the conditions in the field that may be relevant
X	Considered the need for, and scale of, investigations that address future land use changes and climate change
X	Developed and executed the flood mapping in accordance with the criteria established by the client
X	Addressed any significant comments arising from internal or peer reviews
X	Prepared a flood mapping report along with the accompanying digital information

I hereby give assurance that the attached flood mapping report and supporting digital documentation have been produced in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*.

Craig Sutherland, P. Eng.

Name (print)

Signature

April 23, 2021

Date

3045 Douglas St

Address (print)

Victoria, BC, V8T 4N2

250-595-4223

Telephone

info@kwl.ca

(email)

If the APEGBC Qualified Professional is a member of a firm, complete the following:

I am a member of the firm Kerr Wood Leidal Associates Ltd. (Print name of firm), and I sign this letter on behalf of the firm.

APPENDIX A: FLOOD MAPPING ASSURANCE STATEMENT

To: The Client Date: April 23, 2021

Comox Valley Regional District
Name (print)

770 Harmston Ave
Courtenay, BC V9N 2X6
Address (print)

Flood Mapping Project:
Coastal Flood Mapping Project - Oyster River

The undersigned hereby gives assurance that he/she is an APEGBC registered professional and the Qualified Professional for the project identified above.

I have signed, sealed and dated the attached report in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*. The report supports and accurately reflects the assurances made in this Assurance Statement.

I have completed the following activities:

(Check the applicable items)

	Activity
X	Reviewed the relevant provincial legislation and local government regulations, policies, and floodplain bylaws
X	Reviewed available and relevant background information, documentation and data
	Visited the site and reviewed the conditions in the field that may be relevant
X	Considered the need for, and scale of, investigations that address future land use changes and climate change
X	Developed and executed the flood mapping in accordance with the criteria established by the client
X	Addressed any significant comments arising from internal or peer reviews
X	Prepared a flood mapping report along with the accompanying digital information

I hereby give assurance that the attached flood mapping report and supporting digital documentation have been produced in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*.

Dave Zabil, P. Eng.
Name (print)

Signature

April 23, 2021
Date

202 - 3334 30 Avenue
Address (print)
Vernon, BC, V1T 2C8

PROFESSIONAL
PROVINCE
23 Apr 2021
D. ZABIL
#27382
BRITISH COLUMBIA
ENGINEER

250-503-5816
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dzabil@kwl.ca
(email)

If the APEGBC Qualified Professional is a member of a firm, complete the following:

I am a member of the firm Kerr Wood Leidal Associates Ltd. (Print name of firm), and I sign this letter on behalf of the firm.

APPENDIX A: FLOOD MAPPING ASSURANCE STATEMENT

To: The Client

Date: April 23, 2021

Comox Valley Regional District

Name (print)

770 Harmston Ave

Courtenay, BC V9N 2X6

Address (print)

Flood Mapping Project:

Coastal Flood Mapping Project - Coastal

The undersigned hereby gives assurance that he/she is an APEGBC registered professional and the Qualified Professional for the project identified above.

I have signed, sealed and dated the attached report in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*. The report supports and accurately reflects the assurances made in this Assurance Statement.

I have completed the following activities:

(Check the applicable items)

	Activity
X	Reviewed the relevant provincial legislation and local government regulations, policies, and floodplain bylaws
X	Reviewed available and relevant background information, documentation and data
	Visited the site and reviewed the conditions in the field that may be relevant
X	Considered the need for, and scale of, investigations that address future land use changes and climate change
X	Developed and executed the flood mapping in accordance with the criteria established by the client
X	Addressed any significant comments arising from internal or peer reviews
X	Prepared a flood mapping report along with the accompanying digital information

I hereby give assurance that the attached flood mapping report and supporting digital documentation have been produced in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*.

Max Scruton, P. Eng.

Name (print)

Signature

April 23, 2021

Date

200-4185A Still Creek Dr

Address (print)

Burnaby, BC, V5C 6G9

604-294-2088

Telephone

info@kwl.ca

(email)

If the APEGBC Qualified Professional is a member of a firm, complete the following:

I am a member of the firm Kerr Wood Leidal Associates Ltd. (Print name of firm), and I sign this letter on behalf of the firm.