

District of Ucluelet Coastal Flood Mapping Appendix C: Coastal Flood Hazard Map Atlas Map Series 2/4: Coastal Storm Flood Planning Support



26 June 2020

ebbwater
CONSULTING

 CASCADIA COAST
RESEARCH LTD.

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Introduction

This Coastal Flood Hazard Map Atlas (map atlas) is Appendix D of the District of Ucluelet (DOU) Coastal Flood Mapping report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2020). It contains a collection of maps which show coastal flood hazards affecting the DOU. This information will in turn be used to inform and update policy and planning instruments, such as flood construction levels (FCLs) and the Official Community Plan (OCP) with the goal of reducing community risk to flooding. This work generally followed the approach set out in the professional practice guidelines in BC (EGBC 2017, 2018).

Overview of Maps

For coastal storm flood hazard, modelling results were produced for 20 scenarios. Flood maps were produced to show water depths and extents for selected scenarios. We assessed and mapped the coastal flood hazard for 6.67% and 0.5% Annual Exceedance Probability (AEP) floods (15- and 200- year indicative return period, respectively). We considered these two AEP floods for three relative sea level rise scenarios (0 m, 1 m, and 2 m RSLR). Based on the 0.5% AEP flood (plus 0.6 m freeboard), we also produced Sea Level Rise Planning Areas and FCLs for the near future and future (i.e., 0.5 m and 1 m RSLR) scenarios to support policy and planning.

For tsunami flood hazard, modelling results were produced for 24 scenarios based on the Cascadia Subduction Zone (CSZ) fault. Flood maps were produced to focus on the splay faulting rupture A and buried rupture earthquake rupture models. RSLR scenarios of 0 m, 1 m, and 2 m were also included. Based on the tsunami flood hazard maps, we also produced a range of tsunami flood planning level maps, with and without a safety factor. A tsunami flood hazard vulnerability zones map was also produced to support planning. The tsunami flood planning support maps were completed for the future (1 m RSLR) scenario.

Table 1 summarizes the 4 map series that comprise this map atlas. The map series in this file is highlighted.

Table 1: Summary of Atlas Maps.

Map Type	Map Series	Map No.	Map Title	Scenarios Details
Coastal Storm	1	1	Flood Depth – Frequent Event (Present-Day)	6.67% AEP, 0 m RSLR, no freeboard
		2	Flood Depth – Frequent Event (Future)	6.67% AEP, 1 m RSLR, no freeboard
		3	Flood Depth – Frequent Event (Far Future)	6.67% AEP, 2 m RSLR, no freeboard
		4	Flood Depth – Rare Event (Present-Day)	0.5% AEP, 0 m RSLR, no freeboard
		5	Flood Depth – Rare Event (Future)	0.5% AEP, 1 m RSLR, no freeboard
		6	Flood Depth – Rare Event (Far Future)	0.5% AEP, 2 m RSLR, no freeboard
		7	Flood Extent – Frequent Event (Present-Day, Future, Far Future)	6.67% AEP, for 0 m, 1 m, and 2 m RSLR, no freeboard

Map Type	Map Series	Map No.	Map Title	Scenarios Details
		8	Flood Extent – Rare Event (Present-Day, Future, Far Future)	0.5% AEP, for 0 m, 1 m, and 2 m RSLR, no freeboard
Coastal Storm Flood Planning Support	2	1	Sea Level Rise Planning Areas – Rare Event (Near Future and Future)	0.5% AEP, 0.5 m and 1 m RSLR, with 0.6 m freeboard
		2	Flood Construction Level – Zones for Rare Event (Near Future)	0.5% AEP, 0.5 m RSLR, with 0.6 m freeboard
		3	Flood Construction Level – Zones for Rare Event (Future)	0.5% AEP, 1 m RSLR, with 0.6 m freeboard
		4	Flood Construction Level – Zones with Contours for Rare Event (Near Future)	0.5% AEP, 0.5 m RSLR, with 0.6 m freeboard
		5	Flood Construction Level – Zones with Contours for Rare Event (Future)	0.5% AEP, 1 m RSLR, with 0.6 m freeboard
Tsunami Flood Hazard	3	1	Flood Depth – Splay Faulting Rupture (Present-Day)	G2018-S-A model, 0 m RSLR
		2	Flood Depth – Splay Faulting Rupture (Future)	G2018-S-A model, 1 m RSLR
		3	Flood Depth – Splay Faulting Rupture (Far Future)	G2018-S-A model, 2 m RSLR
		4	Flood Depth – Buried Rupture (Future)	W2003 model, 1 m RSLR
		5	Flood Extent – Splay Faulting Rupture (Present-Day, Future, Far Future)	G2018-S-A model, for 0 m, 1 m, and 2 m RSLR
		6	Flood Extent – Splay Faulting and Buried Ruptures (Present-Day)	G2018-S-A and W2003 models, 0 m RSLR
		7	Flood Extent – Splay Faulting and Buried Ruptures (Future)	G2018-S-A and W2003 models, 1 m RSLR
		8	Flood Extent – Splay Faulting and Buried Ruptures (Far Future)	G2018-S-A and W2003 models, 2 m RSLR
Tsunami Flood Planning Support	4	1	Tsunami Flood Planning Level – Buried Rupture (No Safety Factor)	W2003 model, 1 m RSLR
		2	Tsunami Flood Planning Level – Splay Faulting Rupture (No Safety Factor)	G2018-S-A model, 1 m RSLR
		3	Tsunami Flood Planning Level – Buried Rupture (Safety Factor)	W2003 model, 50% safety factor, 1 m RSLR
		4	Tsunami Flood Planning Level – Splay Faulting Rupture (Safety Factor)	G2018-S-A model, 50% safety factor, 1 m RSLR.
		5	Tsunami Flood Planning Level – Scenario Comparisons	W2003 and G2018-S-A with and without safety factor, 1 m RSLR
		6	Tsunami Flood Hazard Vulnerability Zones – Splay Faulting Rupture (Future)	G2018-S-A model, 1 m RSLR

Map 1 – Notes for Map User

1. This map is designed to accompany the District of Ucluelet Coastal Flood Mapping report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2020) and is intended for the purposes set out in that report only. See the report for further details on the methodology, results, and limitations.

2. Flood water levels were developed using a 0.5% annual exceedance probability (AEP) flood and 0.5 m and 1.0 m relative sea level rise (RSLR). These values represent the extents of the Sea Level Rise Planning Areas.

3. The RSLR values are based on guidelines from Ausenco Sandwell (2011) for the years 2050 and 2100. RSLR values are subject to change and may need to be reassessed in future.

4. A 0.6 m freeboard allowance has been included in water levels in accordance with Ausenco Sandwell (2011).

5. The Sea Level Rise Planning Area is defined by the seaward side of the relevant RSLR extent.

6. The SLR Planning Areas apply within the mainland District of Ucluelet (DOU) and Francis Island only.

7. Application of the Sea Level Rise Planning Areas presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.

Limitations:

1. The accuracy of the presented Sea Level Rise Planning Areas is limited by available data and modelling approaches. The extents are based on 1D cross-shore transects. These have been simplified by

merging areas of FCL zones. These FCL zone extents were used as the basis for the SLR Planning Areas. Please refer to the report for a detailed discussion of limitations.

2. The accuracy of the flood hazard extent is limited by the accuracy of the base mapping data and surveys. The floodplain limits were not established on the ground by legal survey.

3. This map was produced by Ebbwater Consulting Inc. using generally accepted best practice and guidelines for the Province of British Columbia. However, flooding may still occur outside the defined flood hazard area, and Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. do not assume any liability by reason of the failure to delineate flood hazard areas on this map.

4. The water depths shown on this map are to provide an assessment of current and future flooding to help inform decisions on future land use policy. Under the provisions of the Local Government Act 2004, these flood extents only take effect when adopted by bylaw or implemented via another planning tool (such as a development permit area). They therefore do not currently have any legal or planning standing.

Data Sources:

1. Flood Construction Reference Plane (FCRP) values were provided by Cascadia Coast Research Ltd.
2. Water depths were interpolated from a limited number of transects and are relative to onshore topography.

3. Digital Elevation Model (DEM) was created based on LiDAR data surveyed in 2015 and obtained from the DOU.

4. Mapping Templates and Land Parcels were received from the DOU.

5. Base layer is based on CARTO's Positron, created using derivatives of OpenStreetMap data - openstreetmap.org (© OpenStreetMap contributors; cartography license CC BY-SA).

Map 1 – References

1. Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. (2020). District of Ucluelet Coastal Flood Mapping (Final Report).
2. Ausenco Sandwell (2011). Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use. Prepared for the British Columbia Ministry of Environment.

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3. The RSLR values are based on guidelines from Ausenco Sandwell (2011) for the years 2050 and 2100. RSLR values are subject to change and may need to be reassessed in future.
4. A 0.6 m freeboard allowance has been included in water levels in accordance with Ausenco Sandwell (2011).
5. The Sea Level Rise Planning Area is defined by the seaward side of the relevant RSLR extent.
6. The SLR Planning Areas apply within the mainland District of Ucluelet (DOU) and Francis Island only.
7. Application of the Sea Level Rise Planning Areas presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.

Limitations

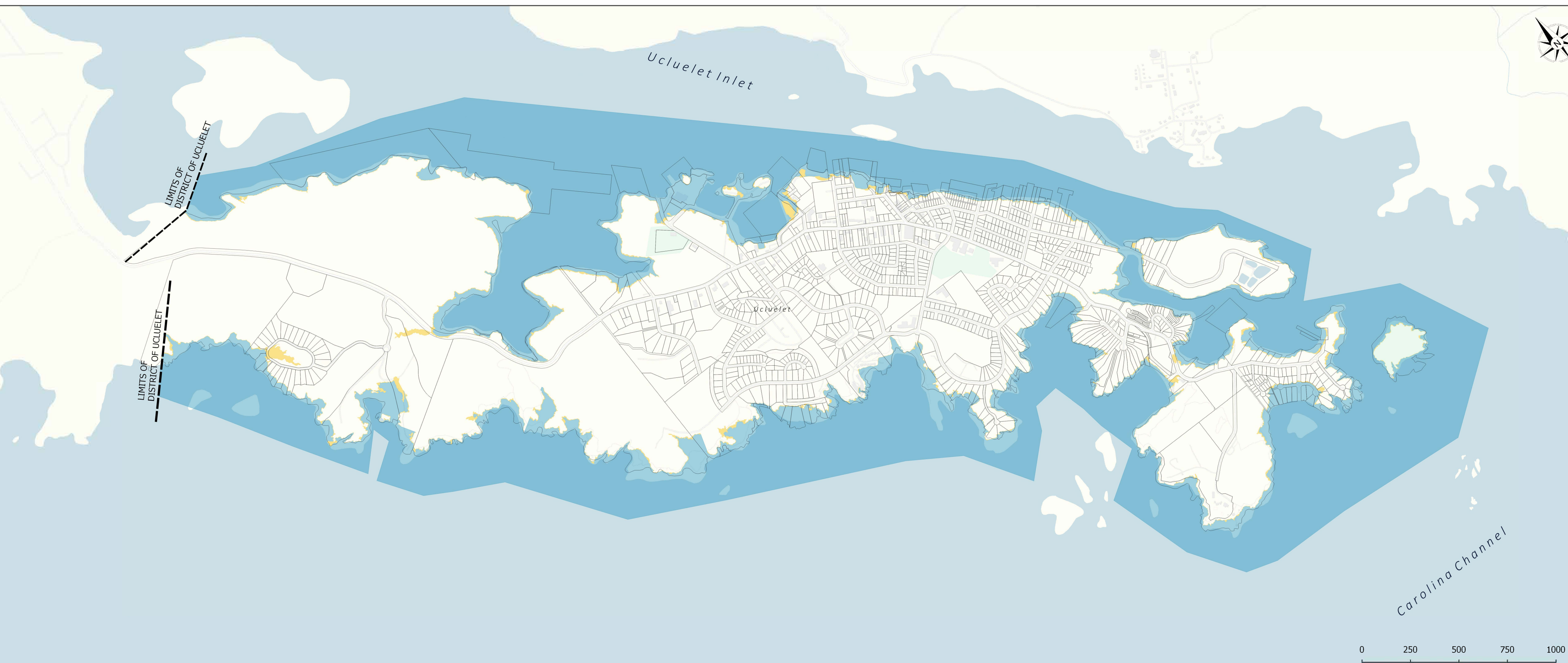
1. The accuracy of the presented Sea Level Rise Planning Areas is limited by available data and modelling approaches. The extents are based on 1D cross-shore transects. These have been simplified by merging areas of FCL zones. These FCL zone extents were used as the basis for the SLR Planning Areas. Please refer to the report for a detailed discussion of limitations.
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References

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DISTRICT OF
UCLUELET



**Coastal
Flood Mapping**

Coastal Storm

**Coastal Storm Flood
Planning Support Map 1/5**
Sea Level Rise Planning Areas –
Rare Event (Near Future and Future)
0.5% AEP, 0.5 and 1 m RSLR, with
freeboard

Land Parcels

Sea Level Rise Planning Areas
0.5 m RSLR
1.0 m RSLR

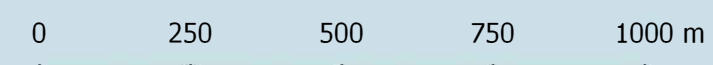
Stamp provided
in original
version

Date Created:
June 26, 2020

Map Scale:
1:12,500

Coordinate System:
NAD83, UTM 10N

Vertical Datum:
CGVD 2013



Maps 2 and 3 – Notes for Map User

1. This map is designed to accompany the District of Ucluelet Coastal Flood Mapping report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2020) and is intended for the purposes set out in that report only. See the report for further details on the methodology, results, and limitations.
2. Flood water levels were developed using a 0.5% AEP flood and 0.5 m and 1 m Relative Sea Level Rise (RSLR) to represent near-future and future flood levels. This is based on guidelines from Ausenco Sandwell (2011). RSLR values are subject to change and may need to be reassessed in future.
3. A 0.6 m freeboard allowance is included in flood construction levels (FCLs) in accordance with Ausenco Sandwell (2011).
4. The Flood Construction Levels (FCLs) have been divided into zones based on similar flood level values (FCL values are given relative to CGVD2013).
5. The coloured FCL Zone polygons show flood hazard extent areas as defined by the indicated FCL.
6. FCLs apply within the mainland District of Ucluelet (DOU) and Francis Island only.
7. The FCLs Zones represent a specific planning level as defined by Ausenco Sandwell (2011). This map should not be interpreted to mean that flooding will be limited to the FCLs indicated for each zone on the map.

8. Application of the FCLs presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.

9. The extreme variability of the western (outer) coastline means that care must be taken in interpreting these FCLs for specific sites. Exposed areas with steep frontages are subject to more wave runup and could experience higher flood levels.

Limitations

1. The accuracy of the presented FCLs is limited by available data and modelling approaches. The FCLs are based on 1D cross-shore transects. These have been simplified by merging areas of similar transects into FCL zones. Please refer to the report for a detailed discussion of limitations.
2. The accuracy of the flood hazard extent is limited by the accuracy of the base surveys and mapping data. The flood hazard extents were not established on the ground by legal survey.
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5. Base map and parcel layers were provided by different data owners and are subject to differences.

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Limitations

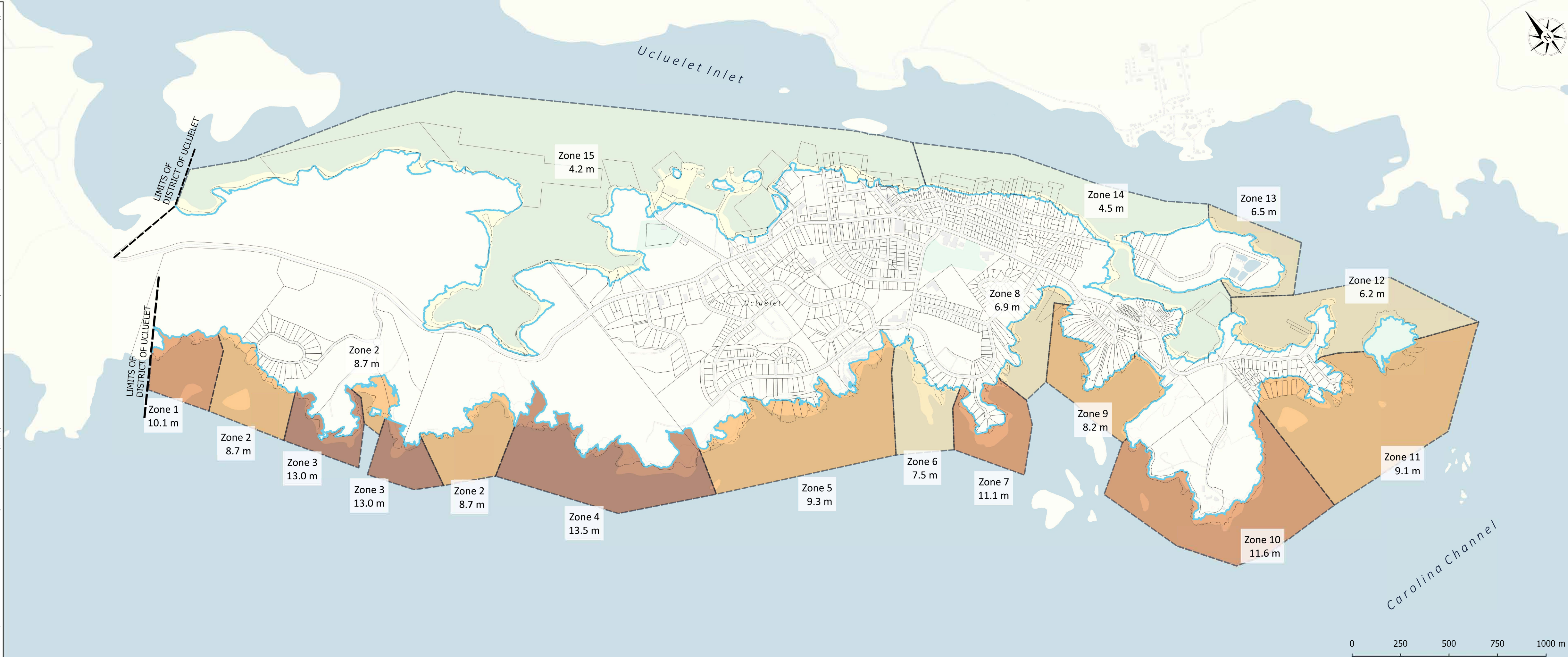
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4. The flood extents and levels shown on this map are to provide an assessment of current and future flooding to help inform decisions on future land use policy. Under the provisions of the Local Government Act 2004, these flood extents only take effect when adopted by bylaw or implemented via another planning tool (such as a development permit area). They therefore do not currently have any legal or planning standing.
5. Base map and parcel layers were provided by different data owners and are subject to differences.

Data Sources

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References

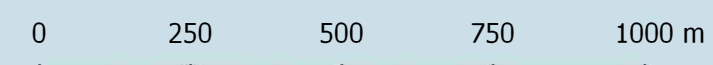
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2. Ausenco Sandwell (2011). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use. Prepared for the British Columbia Ministry of Environment.



Coastal Storm Flood Planning Support Map 2/5
Flood Construction Level – Zones for Rare Event (Near Future)
0.5% AEP, 0.5 m RSLR, with 0.6 m freeboard

- Land Parcels
- Flood Construction Level (CGVD 2013, m)**
 - 4.0 - 6.0
 - 6.0 - 8.0
 - 8.0 - 10.0
 - 10.0 - 12.0
 - 12.0 +
- Flood Hazard Boundary

Stamp provided in original version	Date Created: June 26, 2020
	Map Scale: 1:12,500
	Coordinate System: NAD83, UTM 10N
	Vertical Datum: CGVD 2013



Notes to Users

1. This map is designed to accompany the District of Ucluelet Coastal Flood Mapping report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2020) and is intended for the purposes set out in that report only. See the report for further details on the methodology, results, and limitations.
2. Flood water levels were developed using a 0.5% AEP flood and 1.0 m Relative Sea Level Rise (RSLR) to represent future flood levels. This is based on guidelines from Ausenco Sandwell (2011). RSLR values are subject to change and may need to be reassessed in future.
3. A 0.6 m freeboard allowance is included in flood construction levels (FCLs) in accordance with Ausenco Sandwell (2011).
4. The Flood Construction Levels (FCLs) have been divided into zones based on similar flood level values (FCL values are given relative to CGVD2013).
5. The coloured FCL Zone polygons show flood hazard extent areas as defined by the indicated FCL.
6. FCLs apply within the mainland District of Ucluelet (DOU) and Francis Island only.
7. The FCLs Zones represent a specific planning level as defined by Ausenco Sandwell (2011). This map should not be interpreted to mean that flooding will be limited to the FCLs indicated for each zone on the map.
8. Application of the FCLs presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.
9. The extreme variability of the western (outer) coastline means that care must be taken in interpreting these FCLs for specific sites. Exposed areas with steep frontages are subject to more wave runup and could experience higher flood levels.

Limitations

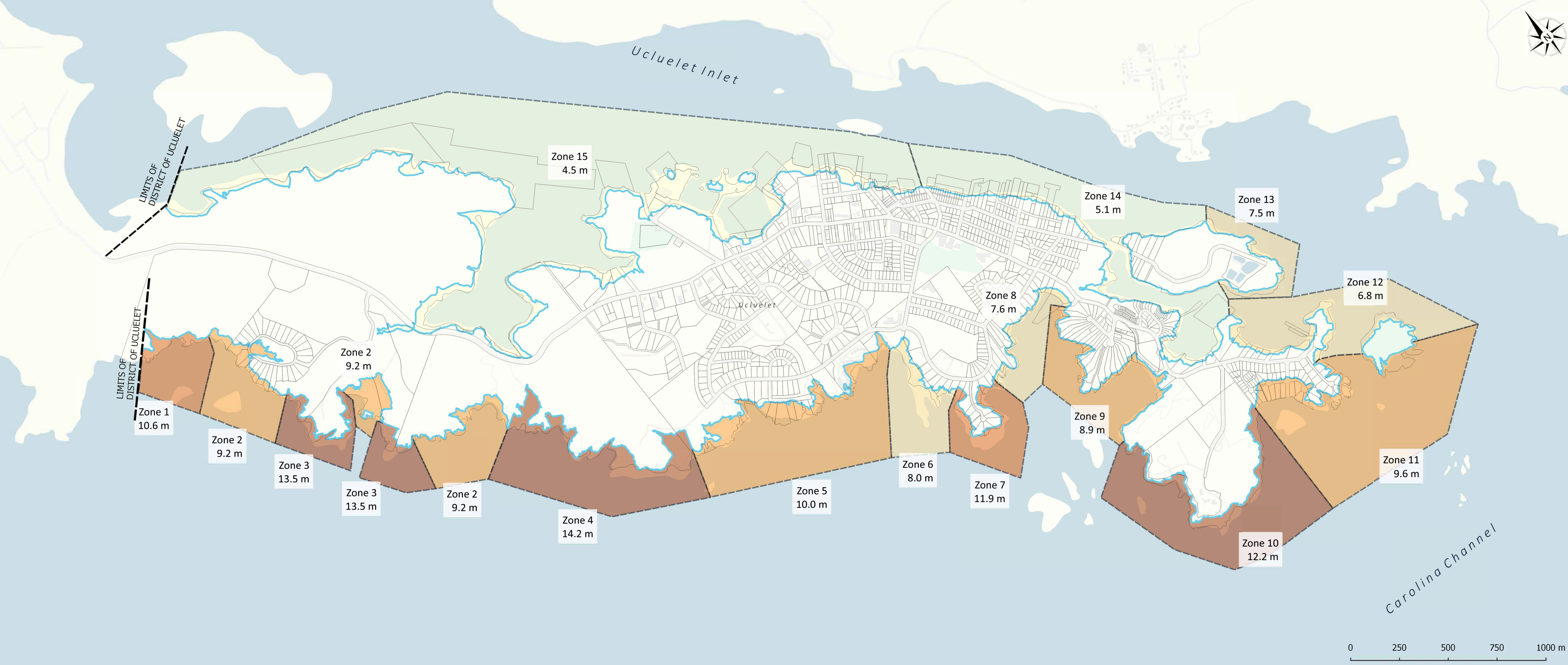
1. The accuracy of the presented FCLs is limited by available data and modelling approaches. The FCLs are based on 1D cross-shore transects. These have been simplified by merging areas of similar transects into FCL zones. Please refer to the report for a detailed discussion of limitations.
2. The accuracy of the flood hazard extent is limited by the accuracy of the base surveys and mapping data. The flood hazard extents were not established on the ground by legal survey.
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5. Base map and parcel layers were provided by different data owners and are subject to differences.

Data Sources

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2. Water depths were interpolated from a limited number of transects and are relative to onshore topography.
3. Digital Elevation Model (DEM) was created based on LiDAR data surveyed in 2015 and obtained from the DOU.
4. Mapping Templates and Land Parcels were received from the DOU.
5. Base layer is based on CARTO's Positron, created using derivatives of OpenStreetMap data - openstreetmap.org (© OpenStreetMap contributors; cartography license CC BY-SA).

References

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DISTRICT OF UCLUELET

Coastal Flood Mapping
Coastal Storm

Coastal Storm Flood Planning Support Map 3/5
Flood Construction Level – Zones for Rare Event (Future)
0.5% AEP, 1 m RSLR, with 0.6 m freeboard

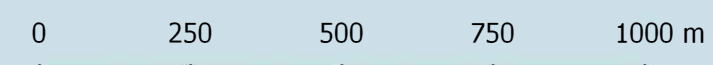
Land Parcels

Flood Construction Level (CGVD 2013, m)

- 4.0 - 6.0
- 6.0 - 8.0
- 8.0 - 10.0
- 10.0 - 12.0
- 12.0 +

Flood Hazard Boundary

Stamp provided in original version	Date Created: June 26, 2020
	Map Scale: 1:12,500
	Coordinate System: NAD83, UTM 10N
	Vertical Datum: CGVD 2013



Maps 4 and 5 – Notes for Map User

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2. Flood water levels were developed using a 0.5% AEP flood and 1.0 m Relative Sea Level Rise (RSLR) to represent future flood levels. This is based on guidelines from Ausenco Sandwell (2011). RSLR values are subject to change and may need to be reassessed in future.

3. A 0.6 m freeboard allowance is included in flood construction levels (FCLs) in accordance with Ausenco Sandwell (2011).

4. The Flood Construction Level (FCLs) have been divided into zones based on similar flood level values (FCL values are given relative to CGVD2013).

5. The coloured FCL Zones polygons show flood hazard extent areas as defined by the indicated FCL.

6. The FCLs Zones represent a specific planning level as defined by Ausenco Sandwell (2011). This map should not be interpreted to mean that flooding will be limited to the FCLs indicated for each zone on the map.

7. FCLs apply within the mainland District of Ucluelet (DOU) and Francis Island only.

8. This map was produced following the Coastal Floodplain Mapping Guidelines (KWL 2011) and the Professional Practice Guidelines (APEGBC 2017).

9. Application of the FCLs presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.

10. The extreme variability of the western (outer) coastline means that care must be taken in interpreting these FCLs for specific sites. Exposed areas with steep frontages are subject to more wave runup and could experience higher flood levels.

Limitation

1. The accuracy of the presented FCLs is limited by available data and modelling approaches. The FCLs are based on 1D cross-shore transects. These have been simplified by merging areas of similar transects into FCL zones. Please refer to the report for a detailed discussion of limitations.

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2. Water depths were interpolated from a limited number of transects and are relative to onshore topography.

3. Digital Elevation Model (DEM) was created based on LiDAR data surveyed in 2015 and obtained from the DOU.

4. Mapping Templates and Land Parcels were received from the DOU.

5. Base layer is based on CARTO's Positron, created using derivatives of OpenStreetMap data - openstreetmap.org (© OpenStreetMap contributors; cartography license CC BY-SA).

Maps 4 and 5 – References

1. Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. (2020). District of Ucluelet Coastal Flood Mapping (Final Report).

2. Ausenco Sandwell (2011). Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use. Prepared for the British Columbia Ministry of Environment.

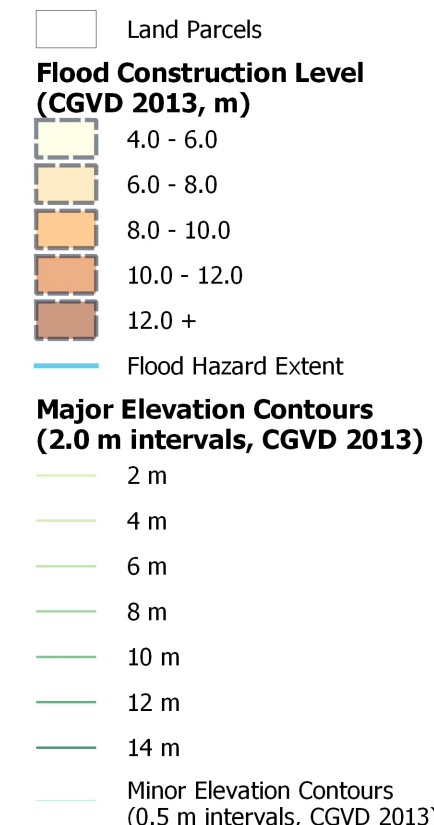


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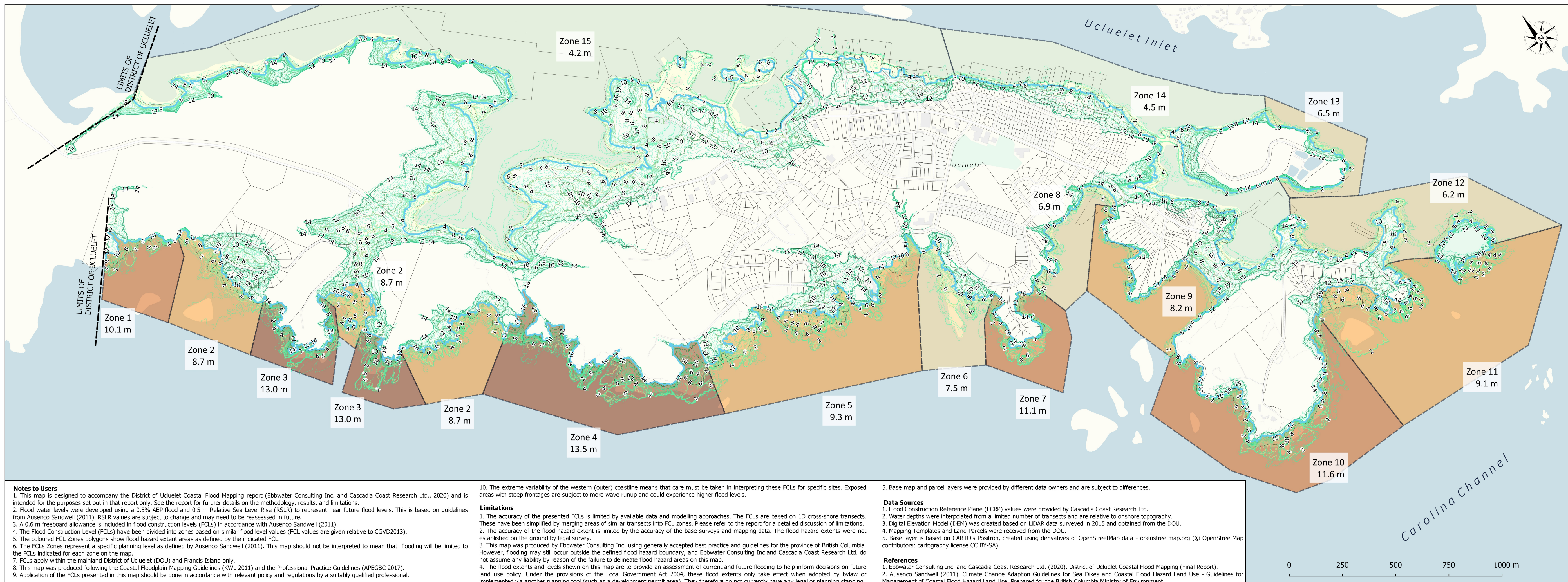


**Coastal Storm Planning Support
Map 4/5**

**Flood Construction Level – Zones and
Contours for Rare Event (Near Future)
0.5% AEP, 0.5 m RSLR, with 0.6 m freeboard**



Stamp provided in original version	Date Created: June 26, 2020
	Map Scale: 1:10,000
	Coordinate System: NAD83, UTM 10N
	Vertical Datum: CGVD 2013



Notes to Users

- This map is designed to accompany the District of Ucluelet Coastal Flood Mapping report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2020) and is intended for the purposes set out in that report only. See the report for further details on the methodology, results, and limitations.
- Flood water levels were developed using a 0.5% AEP flood and 0.5 m Relative Sea Level Rise (RSLR) to represent near future flood levels. This is based on guidelines from Ausenco Sandwell (2011). RSLR values are subject to change and may need to be reassessed in future.
- A 0.6 m freeboard allowance is included in flood construction levels (FCLs) in accordance with Ausenco Sandwell (2011).
- The Flood Construction Level (FCLs) have been divided into zones based on similar flood level values (FCL values are given relative to CGVD2013).
- The coloured FCL Zones polygons show flood hazard extent areas as defined by the indicated FCL.
- The FCLs Zones represent a specific planning level as defined by Ausenco Sandwell (2011). This map should not be interpreted to mean that flooding will be limited to the FCLs indicated for each zone on the map.
- FCLs apply within the mainland District of Ucluelet (DOU) and Francis Island only.
- This map was produced following the Coastal Floodplain Mapping Guidelines (KWL 2011) and the Professional Practice Guidelines (APEGBC 2017).
- Application of the FCLs presented in this map should be done in accordance with relevant policy and regulations by a suitably qualified professional.

10. The extreme variability of the western (outer) coastline means that care must be taken in interpreting these FCLs for specific sites. Exposed areas with steep frontages are subject to more wave runup and could experience higher flood levels.

Limitations

- The accuracy of the presented FCLs is limited by available data and modelling approaches. The FCLs are based on 1D cross-shore transects. These have been simplified by merging areas of similar transects into FCL zones. Please refer to the report for a detailed discussion of limitations.
- The accuracy of the flood hazard extent is limited by the accuracy of the base surveys and mapping data. The flood hazard extents were not established on the ground by legal survey.
- This map was produced by Ebbwater Consulting Inc. using generally accepted best practice and guidelines for the province of British Columbia. However, flooding may still occur outside the defined flood hazard boundary, and Ebbwater Consulting Inc. and Cascadia Coast Research Ltd. do not assume any liability by reason of the failure to delineate flood hazard areas on this map.
- The flood extents and levels shown on this map are to provide an assessment of current and future flooding to help inform decisions on future land use policy. Under the provisions of the Local Government Act 2004, these flood extents only take effect when adopted by bylaw or implemented via another planning tool (such as a development permit area). They therefore do not currently have any legal or planning standing.

5. Base map and parcel layers were provided by different data owners and are subject to differences.

Data Sources

- Flood Construction Reference Plane (FCRP) values were provided by Cascadia Coast Research Ltd.
- Water depths were interpolated from a limited number of transects and are relative to onshore topography.
- Digital Elevation Model (DEM) was created based on LIDAR data surveyed in 2015 and obtained from the DOU.
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**Coastal
Flood Mapping**

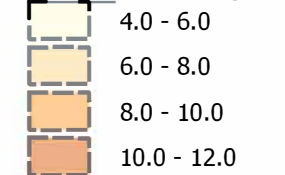
Coastal Storm

**Coastal Storm Flood
Planning Support Map 5/5**

**Flood Construction Level – Zones and
Contours for Rare Event (Future)
0.5% AEP, 1.0 m RSLR, with 0.6 m freeboard**

Land Parcels

**Flood Construction Level
(CGVD 2013, m)**



Flood Hazard Extent

**Major Elevation Contours
(2.0 m intervals, CGVD 2013)**



Minor Elevation Contours
(0.5 m intervals, CGVD 2013)

Stamp provided
in original
version

Date Created:
June 26, 2020

Map Scale:
1:10,000

Coordinate System:
NAD83, UTM 10N

Vertical Datum:
CGVD 2013



Notes to Users

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Limitations

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