

# District of Ucluelet Coastal Flood Mapping Appendix C: Coastal Flood Hazard Map Atlas Map Series 1/4: Coastal Storm Flood Hazard



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
<b>Coastal Storm</b>	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
<b>Coastal Storm Flood Planning Support</b>	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 and Contours for Rare Event (Near Future)	0.5% AEP, 0.5 m RSLR, with 0.6 m freeboard
		5	Flood Construction Level – Zones and Contours for Rare Event (Future)	0.5% AEP, 1 m RSLR, with 0.6 m freeboard
<b>Tsunami Flood Hazard</b>	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
<b>Tsunami Flood Planning Support</b>	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



## Notes for Map User

1. These maps are designed to accompany the District of Ucluelet Coastal Flood Mapping report (Ebbwater Consulting Inc. and Cascadia Coast Research Ltd., 2020) and are 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 and extents were developed using a 6.67% and a 0.5% Annual Exceedance Probability (AEP) flood and 0 m, 1 m, and 2 m Relative Sea Level Rise (RSLR) to represent present-day and future flood levels.

3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 0 m, 1 m, and 2 m of sea level rise approximately correspond to the years 2000, 2100, and 2200.

4. Water depths DO NOT include a freeboard allowance.

5. Flood depths and extents are presented for all areas landward of the cadastral shoreline layer (as provided by the District of Ucluelet (DOU)), including a small buffer to ensure all exposed areas are captured.

### Limitations:

1. The accuracy of the presented flood depths is limited by available data and modelling approaches. Water elevations were interpolated from 1D cross-shore transects to calculate the flood depth layer. 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 DEM. 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 and extents shown on these maps 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:

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, Shoreline layer 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](https://openstreetmap.org) (© OpenStreetMap contributors; cartography license CC BY-SA).

## References

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**Limitations**

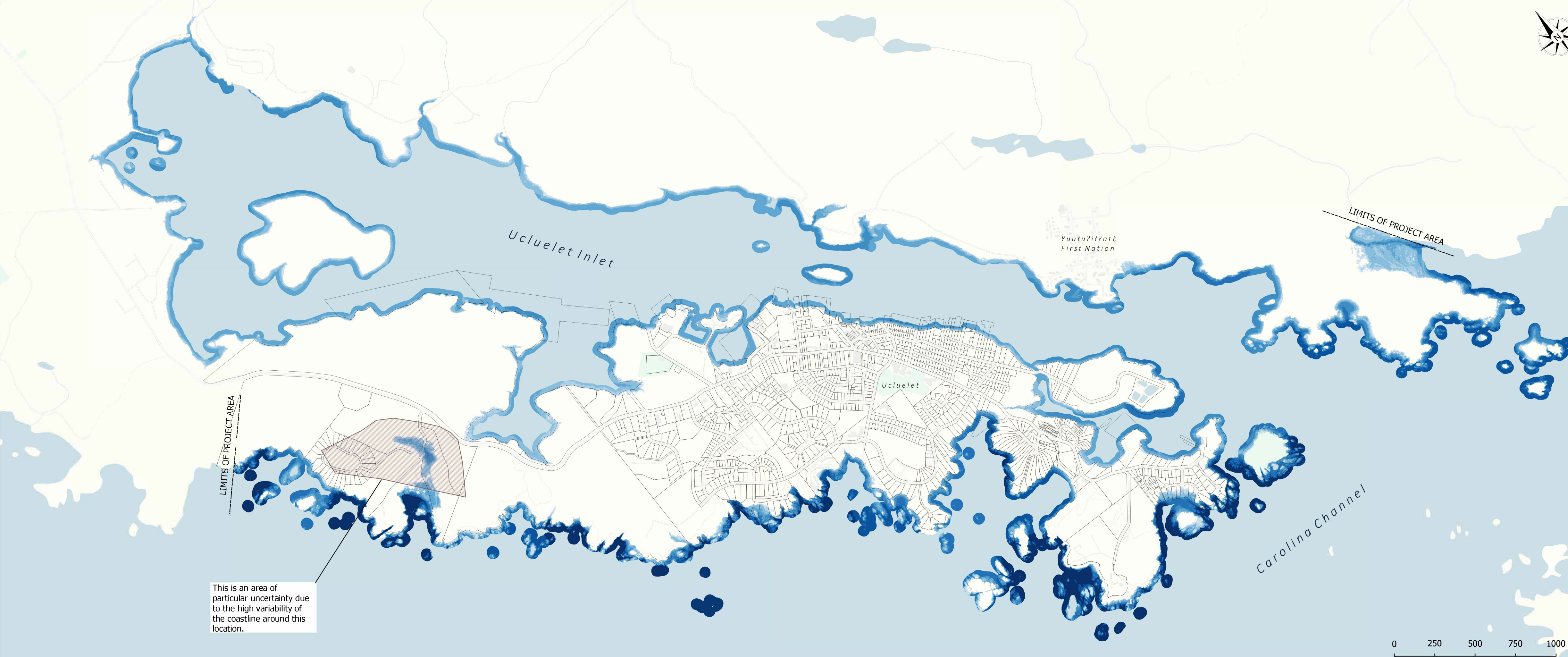
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**Coastal Storm Flood Hazard Map 1/8**  
**Flood Depth – Frequent Event (Present-Day)**  
**6.67% AEP, 0 m RSLR, no freeboard**

- Land Parcels
  - Area of High Uncertainty
- Water Depth (m) :**
- 0.0 - 0.1
  - 0.1 - 0.5
  - 0.5 - 1.0
  - 1.0 - 2.0
  - 2.0 - 3.0
  - 3.0 - 4.0
  - 4.0 - 5.0
  - 5.0 - 6.0
  - > 6.0

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	Map Scale: 1:15,000
	Coordinate System: NAD83, UTM 10N
	Vertical Datum: CGVD 2013





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2. Flood water levels were developed using a 6.67% Annual Exceedance Probability (AEP) flood and 1 m Relative Sea Level Rise (RSLR) to represent future flood levels.
3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 1 m of sea level rise approximately corresponds to the year 2100. However, this time period is subject to changes in climate projections and the response of the earth system and is likely to require reassessment in the future.
4. Water depths DO NOT include a freeboard allowance.
5. Flood depths and extents are presented for all areas landward of the cadastral shoreline layer (as provided by the District of Ucluelet (DOU)), including a small buffer to ensure all exposed areas are captured.

**Limitations**

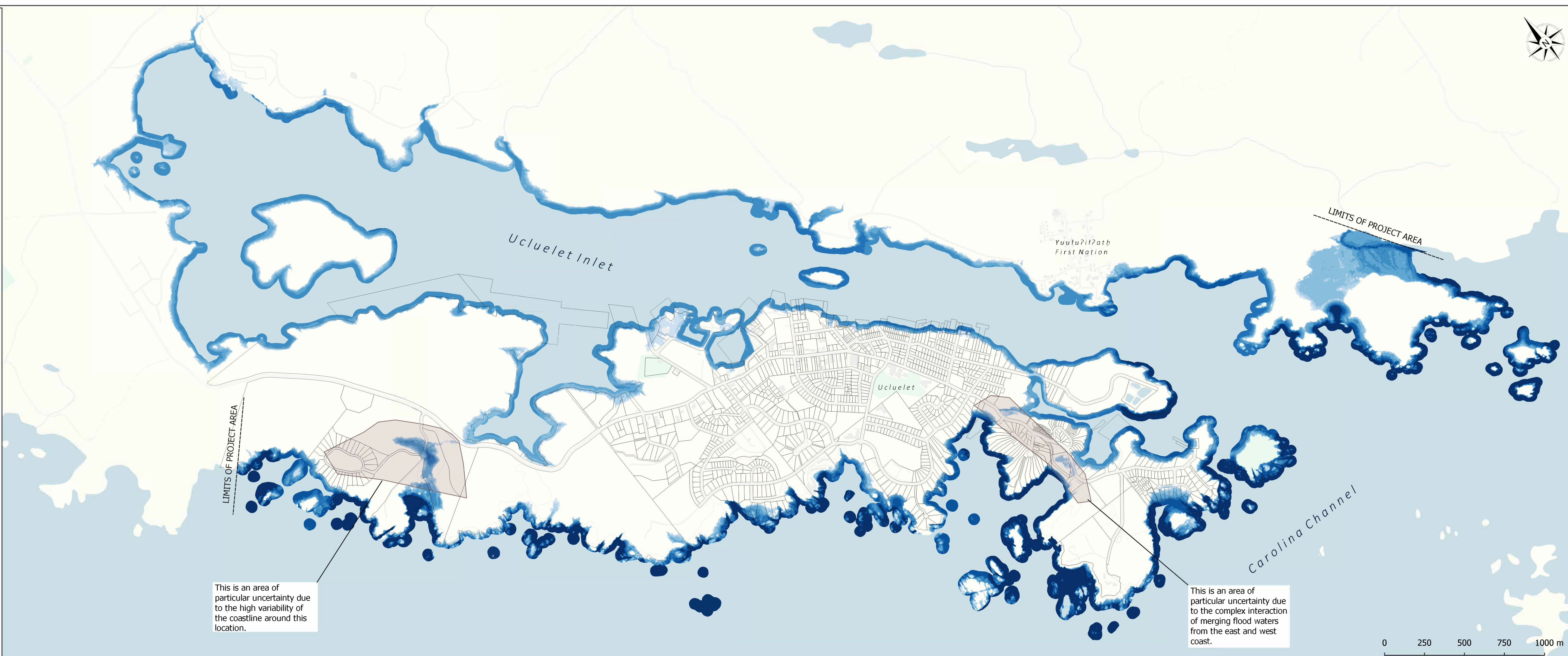
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This is an area of particular uncertainty due to the high variability of the coastline around this location.

This is an area of particular uncertainty due to the complex interaction of merging flood waters from the east and west coast.



**DISTRICT OF UCLUELET**

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**Coastal Flood Mapping**

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**Coastal Storm Flood Hazard Map 2/8**

**Flood Depth – Frequent Event (Future)**

**6.67% AEP, 1 m RSLR, no freeboard**

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Land Parcels

Area of High Uncertainty


**Water Depth (m) :**

- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

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0 250 500 750 1000 m



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2. Flood water levels were developed using a 6.67% Annual Exceedance Probability (AEP) flood and 2 m Relative Sea Level Rise (RSLR) to represent future flood levels.
3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 2 m of sea level rise approximately corresponds to the year 2200. However, this time period is subject to changes in climate projections and the response of the earth system and is likely to require reassessment in the future.
4. Water depths DO NOT include a freeboard allowance.
5. Flood depths and extents are presented for all areas landward of the cadastral shoreline layer (as provided by the District of Ucluelet (DOU)), including a small buffer to ensure all exposed areas are captured.

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This is an area of particular uncertainty due to the high variability of the coastline around this location.

This is an area of particular uncertainty due to the complex interaction of merging flood waters from the east and west coast.

Land Parcels  
 Area of High Uncertainty

**Water Depth (m) :**

- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
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2. Flood water levels were developed using a 0.5 % Annual Exceedance Probability (AEP) flood and 0 m Relative Sea Level Rise (RSLR) to represent present-day flood levels.
3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 0 m of sea level rise approximately corresponds to the year 2000.
4. Water depths DO NOT include a freeboard allowance.
5. Flood depths and extents are presented for all areas landward of the cadastral shoreline layer (as provided by the District of Ucluelet (DOU)), including a small buffer to ensure all exposed areas are captured.

**Limitations**

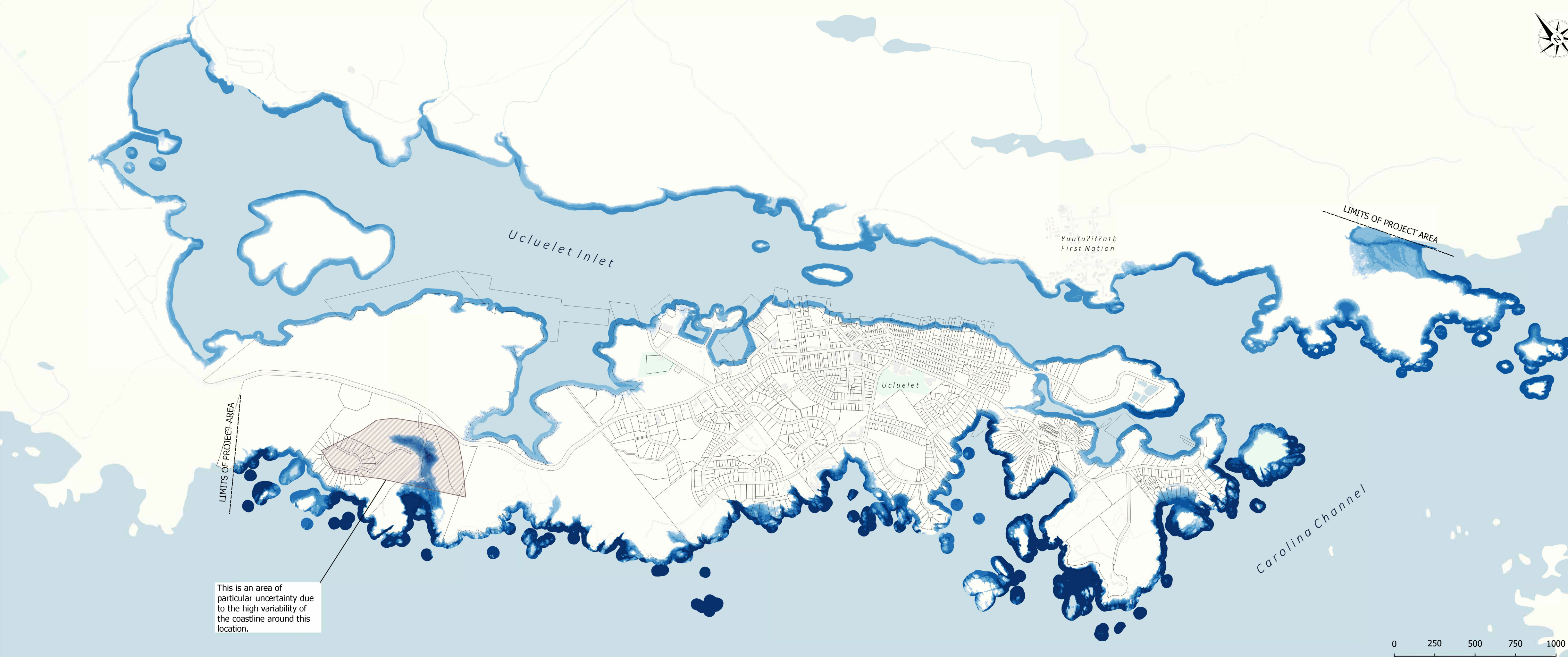
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This is an area of particular uncertainty due to the high variability of the coastline around this location.



**Coastal Storm Flood Hazard Map 4/8**  
**Flood Depth – Rare Event (Present-Day)**  
**0.5% AEP, 0 m RSLR, no freeboard**

- Land Parcels
  - Area of High Uncertainty
- Water Depth (m) :**
- 0.0 - 0.1
  - 0.1 - 0.5
  - 0.5 - 1.0
  - 1.0 - 2.0
  - 2.0 - 3.0
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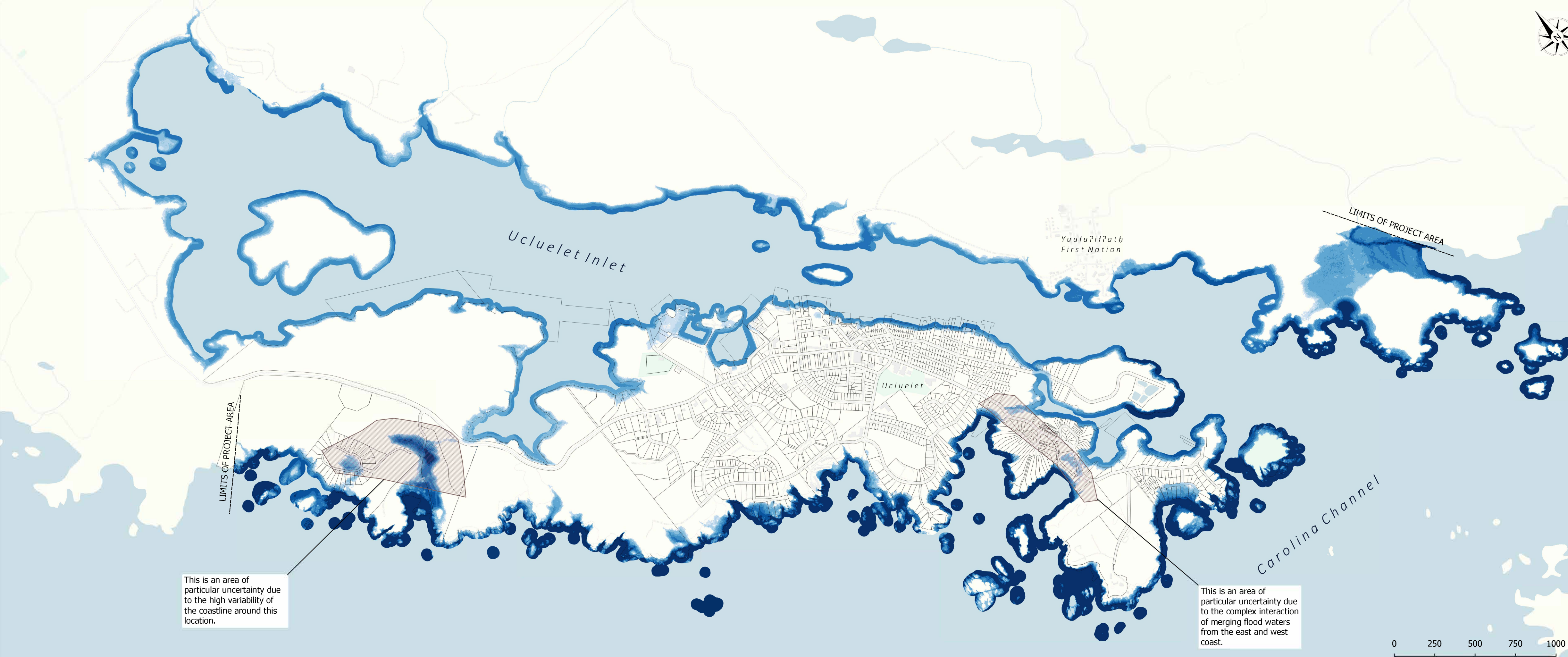
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**DISTRICT OF UCLUELET**

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**Coastal Flood Mapping**

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**Coastal Storm Flood Hazard Map 5/8**

**Flood Depth – Rare Event (Future)**

**0.5% AEP, 1 m RSLR, no freeboard**

---

Land Parcels

Area of High Uncertainty

**Water Depth (m) :**

- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- > 6.0

Date Created: June 26, 2020


Map Scale: 1:15,000

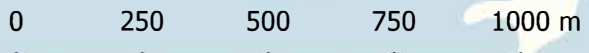
Coordinate System: NAD83, UTM 10N

Vertical Datum: CGVD 2013

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Stamp provided in original version







**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 % Annual Exceedance Probability (AEP) flood and 2 m Relative Sea Level Rise (RSLR) to represent future flood levels.
3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 2 m of sea level rise approximately corresponds to the year 2200. However, this time period is subject to changes in climate projections and the response of the earth system and is likely to require reassessment in the future.
4. Water depths DO NOT include a freeboard allowance.
5. Flood depths and extents are presented for all areas landward of the cadastral shoreline layer (as provided by the District of Ucluelet (DOU)), including a small buffer to ensure all exposed areas are captured.

**Limitations**

1. The accuracy of the presented flood depths is limited by available data and modelling approaches. Water elevations were interpolated from 1D cross-shore transects to calculate the flood depth layer. 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 DEM. 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.
5. Base map and parcel layers were provided by different data owners and are subject to differences.

**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, Shoreline layer 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**

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.



This is an area of particular uncertainty due to the high variability of the coastline around this location.

This is an area of particular uncertainty due to the complex interaction of merging flood waters from the east and west coast.



**Coastal Storm Flood Hazard Map 6/8**  
Flood Depth – Rare Event (Far Future)  
0.5% AEP, 2 m RSLR, no freeboard

- Land Parcels
  - Area of High Uncertainty
- Water Depth (m) :**
- 0.0 - 0.1
  - 0.1 - 0.5
  - 0.5 - 1.0
  - 1.0 - 2.0
  - 2.0 - 3.0
  - 3.0 - 4.0
  - 4.0 - 5.0
  - 5.0 - 6.0
  - > 6.0

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2. Flood water extents were developed using a 6.67% Annual Exceedance Probability (AEP) flood and 0 m, 1 m, and 2 m Relative Sea Level Rise (RSLR) to represent present-day and future flood extents.
3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 0 m, 1 m, and 2 m of sea level rise approximately correspond to the years 2000, 2100, and 2200, respectively. However, this time period is subject to changes in climate projections and the response of the earth system and is likely to require reassessment in the future.
4. Water depths DO NOT include a freeboard allowance.
5. Flood depths and extents are presented for all areas landward of the cadastral shoreline layer (as provided by the District of Ucluelet (DOU)), including a small buffer to ensure all exposed areas are captured.

**Limitations**

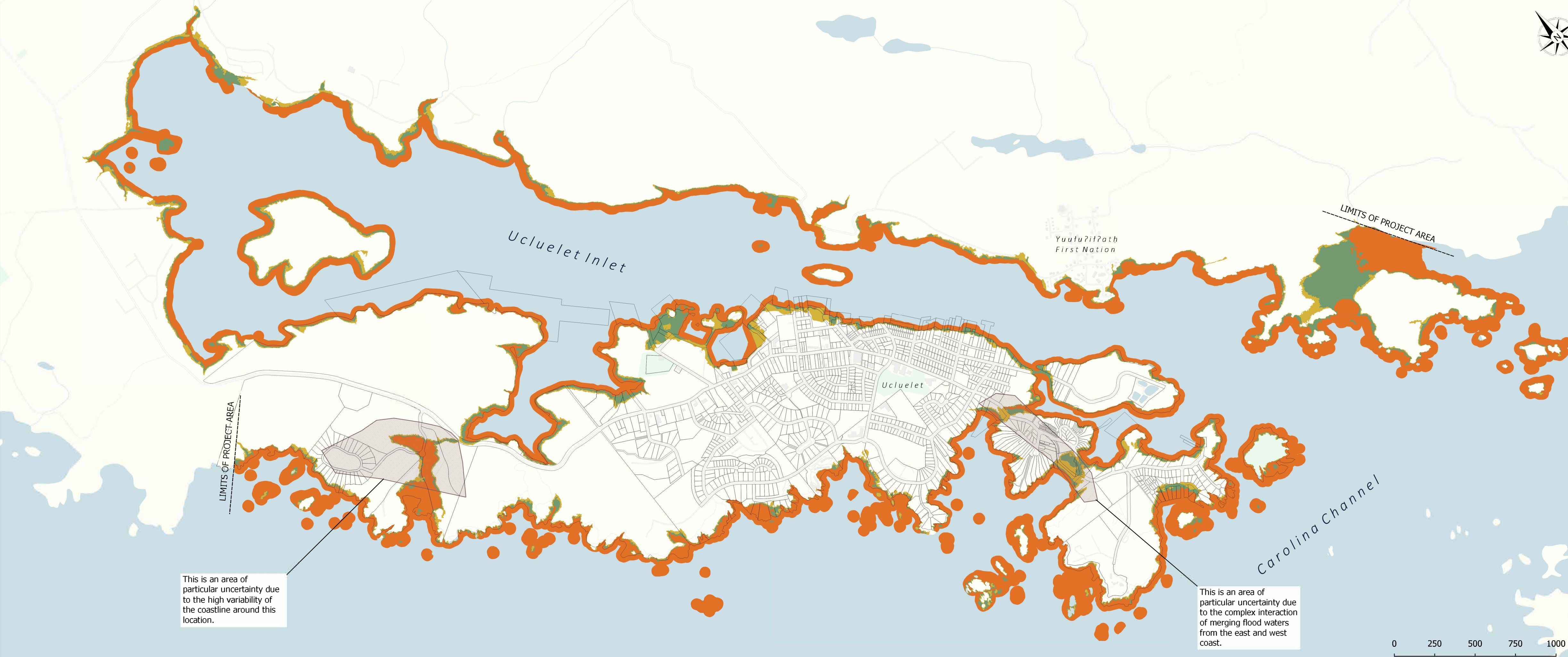
1. The accuracy of the presented flood extents is limited by available data and modelling approaches. Water elevations were interpolated from 1D cross-shore transects to calculate the flood extent layer. Please refer to the report for a detailed discussion of limitations.
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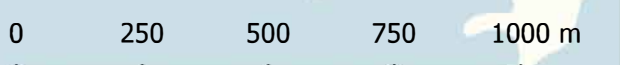
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**Coastal Storm Flood Hazard Map 7/8**  
**Flood Extent – Frequent Event (Present-Day, Future, Far Future)**  
 6.67% AEP, for 0 m, 1 m, and 2 m RSLR, no freeboard

- Land Parcels
- Area of High Uncertainty
- Flood Extents for 6.67% AEP:**
  - 0 m RSLR
  - 1 m RSLR
  - 2 m RSLR

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2. Flood water extents were developed using a 0.5% Annual Exceedance Probability (AEP) flood and 0 m, 1 m, and 2 m Relative Sea Level Rise (RSLR) to represent present-day and future flood extents.
3. Based on guidelines for the management of coastal flood hazard land use (Ausenco Sandwell 2011), 0 m, 1 m, and 2 m of sea level rise approximately correspond to the years 2000, 2100, and 2200, respectively. However, this time period is subject to changes in climate projections and the response of the earth system and is likely to require reassessment in the future.
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**Limitations**

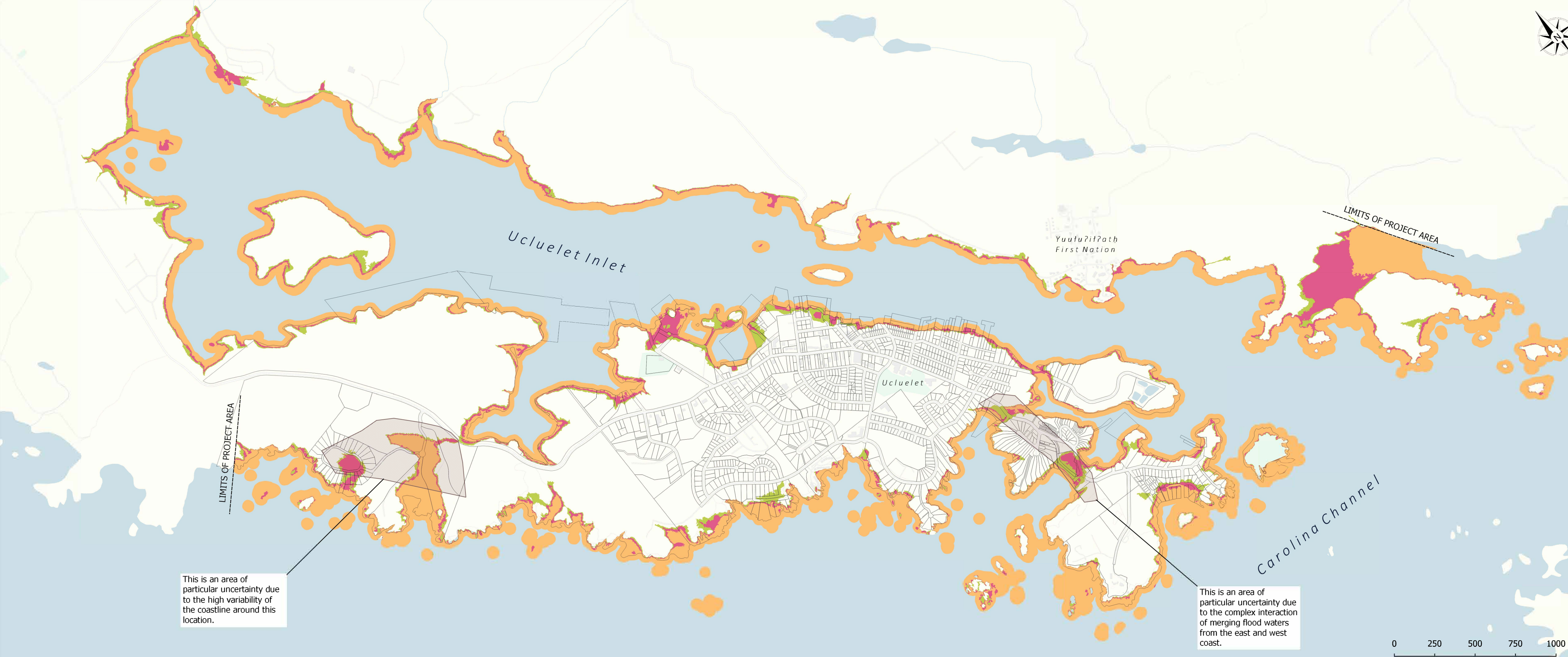
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**Coastal Storm Flood Hazard Map 8/8**  
**Flood Extent – Rare Event (Present-Day, Future, Far Future)**  
 0.5% AEP, for 0 m, 1 m, and 2 m RSLR, no freeboard

- Land Parcels
- Area of High Uncertainty
- Flood Extents for 0.5% AEP:**
  - 0 m RSLR
  - 1 m RSLR
  - 2 m RSLR

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