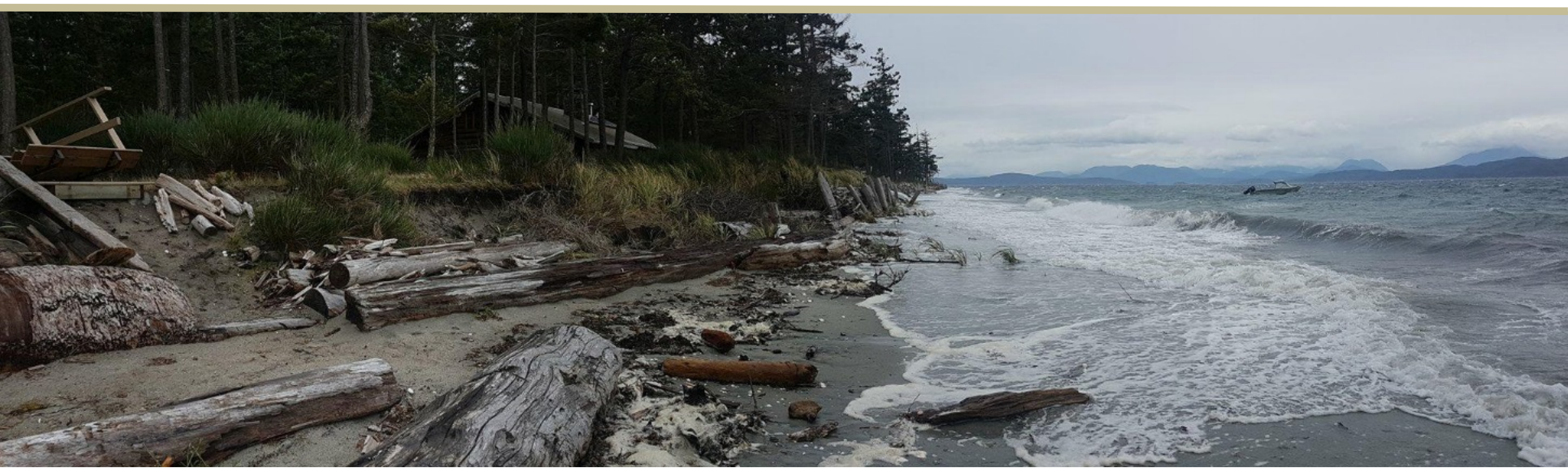
Appendix A

Powell River Regional District
Overview Coastal Risk Assessment



PRESENTED TO

POWELL RIVER REGIONAL DISTRICT

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Photo on front page: Storm surge on Savary Island and beach erosion near 1069 Squirrel Lane that damaged the stairs (photo taken on November 14, 2017 by Bud Graham).

EXECUTIVE SUMMARY

Tetra Tech Canada Inc. (Tetra Tech) has been retained by the Powell River Regional District (the PRRD) to conduct an overview-level coastal risk assessment. The PRRD, Tla'amin Nation, City of Powell River, and Islands Trust have jurisdictions within the study area, and the PRRD is coordinating interests of these local governments. Funding for this study is provided to PRRD by the National Disaster Mitigation Program (NDMP) Stream 1.

Objectives

The objectives for this study are to:

- Provide an overview risk assessment for coastal hazards that could potentially impact public safety and/or critical infrastructure within the study area.
- Identify and characterize potential coastal hazards that are present in the study area and the risk they pose to people, the economy, infrastructure and the natural environment.
- Provide a technical basis for making proactive, risk-based decisions regarding the potential coastal hazard events that might impact the study area.
- Determine what priority measures could be taken to improve the safety and resilience of the community.
- Provide the technical basis to support a funding request to carry out a detailed risk assessment in the future under NDMP Stream 2 funding.

Scope

The study area includes the shorelines south of Desolation Sound and north of Lasqueti Island, within the areas under jurisdiction of the PRRD (Electoral Areas A, B, C, D and E), City of Powell River and Tla'amin Nation.

This study addresses coastal hazards such as Storm Surge, Coastal Erosion and Tsunami under consideration of Sea Level Rise (SLR).

Methods

Relevant guidelines by Engineers and Geoscientists BC (EGBC, formerly APEGBC) and the Provincial Government were applied. An extensive body of information and data was gathered and reviewed through stakeholder outreach to PRRD, City of Powell River, Tla'amin Nation, Islands Trust and BC Ferries. A small number of local residents were also interviewed.

A risk-based assessment was conducted to determine the assets exposed in each coastal hazard scenario and estimate their potential consequences. Fundamentally, risk is the combination of hazard and consequences.

Hazards were assessed using several methods. Storm surge hazards were assessed through statistical analysis of climate and hydrometric data as well as numerical modelling of storm events. Projected SLR of 0.5 m by 2050 was selected in accordance with provincial guidelines. Coastal erosion hazards were assessed based on review of available BC Shorezone mapping data. No analysis was carried out for tsunami hazards, however available information was considered in this assessment.

Vulnerabilities and consequences were assessed using available spatial data collected from federal, provincial and local governments. Census data was used to determine the number of people exposed. BC Assessment and parcel data were the primary sources utilized to develop a general building inventory which was used to roughly quantify

one type of economic loss. Tetra Tech worked with the PRRD to define critical assets in the region and developed a spatial asset inventory to determine specific assets that may be affected by coastal hazards.

Risk was assessed using a customized approach, developed to leverage flood damage estimating tools and methodologies including HAZUS Canada to monetize damages to buildings and assets. Potential impacts to transportation infrastructure, utilities, environmental and cultural resources and other valued assets were also assessed.

Key findings

1. **Historic events**: In total 16 historic coastal risk events were identified and documented. From this inventory it is obvious that coastal hazards pose a real and significant challenge to the community and local governments within the study area.
2. **Storm Impacts on Ferry Service**: Transportation in and out of the community depends heavily on BC Ferries Services. In the past 10 years cancellations of BC Ferry service between Comox and Powell River due to wind and storm events occurred about 40 times per year on average, ranging as high as 85 times per year.
3. **Coastal Erosion**: The study area includes about 565 km of shoreline length in total. Up to 2/3 thereof were ranked at high erosion potential. The highest percentage of shoreline ranked at high erosion potential are the lands of the Tla'amin Nation (100%) followed by the City of Powell River (96%). The entire coastline of Savary Island is at risk of ongoing erosion and is particularly vulnerable to sea level rise due to its low topography and sandy shorelines. With the exception of its northern, generally rocky, coast the entirety of Hernando Island is at risk of coastal erosion, particularly as sea level rises.
4. **Risk Assessment**: The worst scenario assessed in this study is 'High Tide, and 200-Year Surge and Waves (Southeast), and 0.5 m SLR (in 50 years), with a total of 408 people exposed. In terms of damage, the same scenario results in 504 buildings exposed with a total replacement cost exceeding $215 Million for structures and contents, as well as 37 critical, 22 commercial, 1 cultural and 32 other regional assets exposed with nearly $500 Million potential loss. As a result of the projected storm events, five main areas of Highway 101 may become inundated.
5. **Need for detailed coastal risk assessment and mapping**: Previous assessments related to coastal hazards in the study area are not detailed enough for planning or mitigation design purposes. They are also outdated.
6. **Need for coastal hazard specific planning policies:** This study demonstrates that coastal hazards are a real threat to the community. There is a strong need to develop planning policies specific to coastal hazards in the jurisdictions of the PRRD and the City of Powell River. Policies should follow the latest guidelines and best practices. The Tla'amin Land Use Plan specifically addresses coastal hazards, however it explicitly points out the need for a detailed study to delineate coastal hazard areas.

Key Recommendations

Recommendations are made at the end of the report. Selected key recommendations include:

1. Secure funding for a detailed coastal risk assessment. Inquire with NDMP about exact funding intake deadlines for NDMP Stream 2 applications (expected late summer early fall 2018).
2. Conduct a detailed coastal risk assessment. The detailed assessment should follow the latest guidelines listed under References at the end of this report. Specific recommendations for study scope and content are provided in the Recommendations section of the report.

3. Establish development policies specific to coastal hazard areas. Note that hazard areas will change over time (e.g. through SLR) and need to be updated periodically, based on latest guidelines, science and information available.
4. The 'Sea Level Rise Adaptation Primer – A Toolkit to Build Adaptive Capacity on Canada's South Coasts' (Arlington Group et al. 2013), should be considered for SLR adaptation strategies.
5. Partner with provincial and private entities (e.g. MOTI, BC Ferries, private marine operators) to conduct a vulnerability assessment focused on transportation and utility infrastructure, and recommend mitigation or adaptation measures where necessary.
6. The PRRD and MOTI are working on a Stormwater Management and Drainage Study. Findings thereof as well as from this Overview Coastal Risk Assessment should be evaluated jointly, to: 1) determine if there are overlapping high priority areas identified for mitigation, and 2) identify feasible mitigation project alternatives to address both stormwater and coastal flooding.
7. Update emergency response plans considering findings of this study. An update may be required once a detailed coastal risk assessment is completed. Impacts of coastal hazards on emergency response roads and ferry infrastructure need to be accounted for.

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Powell River Regional District and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the Powell River Regional District, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix A or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

1.1 General

Tetra Tech Canada Inc. (Tetra Tech) has been retained by the Powell River Regional District (PRRD) to carry out an overview coastal risk assessment within the PRRD.

This study was carried out according to the 'Work Plan: Powell River Regional District Coastal Risk Assessment' dated November 2, 2017 under the terms of a Tetra Tech Services Agreement signed November 17, 2017.

Funding for this project is provided to the PRRD by the National Disaster Mitigation Program (NDMP) under the Contribution Agreement (Contract #EMBCK06CS0025, dated for reference October 1, 2017).

1.2 Objective

The study should provide an overview risk assessment for coastal hazards within the PRRD, including the City of Powell River, Tla'amin Nation lands, and rural areas where the hazards could potentially impact public safety and/or critical infrastructure.

The objectives of the coastal risk assessment are to:

- Identify and characterize potential coastal hazards that are present in the study area and the risk they pose to people, the economy, infrastructure and the natural environment.
- Provide a technical basis for making proactive, risk-based decisions regarding the potential coastal hazard events that might impact the study area.
- Determine what priority measures could be taken to improve the safety and resilience of the community.

One key project output is the completion of the Risk Assessment Information Template (RAIT) as mandated by the NDMP. A completed RAIT is required in support of a funding request to carry out a detailed risk assessment in the future under NDMP Stream 2 funding.

1.3 Scope of Service

1.3.1 Extent of Study Area

The approximate extent of study shoreline is shown in Figure 1. The study area includes areas exposed to coastal hazards along the shoreline near Powell River from Saltery Bay to Lund, as well as the following islands:

- Lasqueti Island
- Texada Island
- Harwood Island
- Savary Island
- Hernando Island

1.3.2 Jurisdictions

These areas are within the jurisdictions of the PRRD, the City of Powell River, the Tla'amin Nation and Islands Trust. Land use in the area varies. The study is primarily focused on developed coastal areas.

1.3.3 Coastal Hazards Addressed in this Study

This study addresses coastal hazards such as Storm Surge, Coastal Erosion and Tsunami under consideration of Sea Level Rise (SLR). Appendix B includes a glossary including further terms used in this report.

2.0 HAZARD AND RISK ASSESSMENT APPROACH

This project is undertaken following the general risk management process after CAN/CSA-ISO 31000-10, where the risk management process consists of seven fundamental activities as illustrated in Figure 2-1. *Communication and Consultation*, and *Monitoring and Reviewing* are undertaken throughout the process while the remaining five activities usually occur in sequential order. As illustrated, the risk management process is iterative and should be subject to continuous improvement.

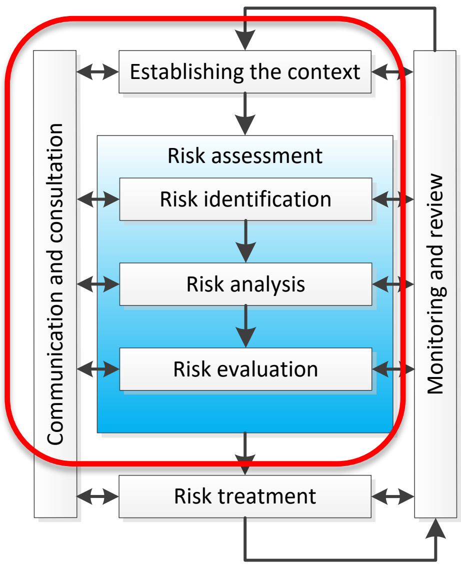

Figure 2-1. Seven fundamental activities of the Risk Management Process after CAN/CSA-ISO 31000-10. Activities within the red polygon are carried out within this study.

The current study involves the following steps:

- *Communication and Consultation*: Our team consulted closely with the PRRD who coordinated input and data provided by the local governments. As part of our information gathering we have reached out to various stakeholders. We effectively communicated through various means including; meetings, presentations, conference calls and a presentation to the Regional Emergency Executive Committee (scheduled for March 22, 2018). This report documents the study, findings and our recommendations. Official communication by the PRRD include a press release on February 27, 2018 informing the community of this ongoing study.

- *Establishing the Context*: The context has already been established by the PRRD together with officials of the other jurisdictions in the study area. The problem has been identified, and roles and responsibilities have been defined. The NDMP is providing funding for this project. Consequently, the focus of this study is on the three Risk Assessment activities *Risk Identification*, *Risk Analysis* and *Risk Evaluation*.

- *Risk Identification*: The coastal hazards and the extent of potential impacts are identified. The hazards are studied and characterized through a desktop study.

- *Risk Analysis*: This study quantifies the risk through numerical analysis of hazards and analysis of risk using a Geographical Information System (GIS).

- *Risk Evaluation*: Specific areas that require detailed risk assessments are identified. This report provides recommendations for more detailed risk assessments, thus implementing the iterative process identified in Figure 2-1.

3.0 INFORMATION REVIEWED

3.1 General

Information sources that were reviewed as part of this study are listed under References at the end of this report. A digital data package including the information gathered for this study will be provided to PRRD.

Stakeholder outreach was conducted to collect information about infrastructure, compile a history of coastal flood hazard events and losses, and known coastal flood hazard areas. Stakeholders that were contacted and their affiliation include:

- Ryan Thoms, Manager Emergency Services and Laura Roddan, Manager Planning, PRRD
- Gregg Clackson, Director Operations and Security Centre, British Columbia Ferry Services
- Bud Graham, Private resident
- Sandy Dunlop, Private resident

3.2 Relevant Guidelines

Relevant guidelines applied in this study listed under References at the end of this report.

3.3 Summary of Previous Hazard or Risk Studies

Tetra Tech is not aware of a formal coastal risk assessment (i.e. considering hazard and consequence) that has been completed for the local governments in the study area. However, recommendations of previous hazard studies are compiled in Appendix C, and summarized below:

Appendix C provides a summary of previous hazard and risk studies. The following list highlights findings by area:

- **Entire Study Area**: A coastal floodplain study was carried out for the entire coast of British Columbia by KWL (2011). A component of this study was a set of figures, available online, displaying potential shoreline areas that would be susceptible to flooding, estimated for the year 2100. Generally, mapping generated by this study shows that much of the PRRD shorezone would be susceptible to flooding due to SLR, but the spatial distribution of flooding prone areas is very spotty. The following disclaimer is attached to these maps: "The intent of these maps is to highlight areas that may benefit from development of coastal floodplain maps. Please note that floodplain areas have not been ground-proofed, verified or studied to confirm their exact location." A Tsunami hazard study was commissioned by the PRRD and carried out by Gardner (2007), the study is further discussed in Section 7.3.
- **Electoral Area A – Savary Island**: Thurber (2003) established hazard setback lines for the entire perimeter of Savary Island to ensure building locations are safe from erosion hazards for 50 and 200-year horizons. Thurber (2003) conclude that Savary Island will continue to be reduced in width from south to north by natural erosion force. If global warming causes a significant rise in sea level, erosion rates will almost certainly increase from those of the past. Non-regulatory (i.e. un-enforceable) geotechnical recommendations involving consideration of hazard and risk provide no assurance over public health and safety. This study is the most specific assessment of coastal hazards (in particular shoreline erosion) that we encountered in our review. However, the study for Savary Island was completed in 2003 and requires an update.
- **Electoral Area A**: For the Emmonds Beach area on Malaspina Peninsula, Planterra (2013) concludes and recommends: "There are presently signs of active shoreline erosion on many of the beaches within the study

area. A detailed assessment of the shoreline in these beach areas should be completed by a qualified Marine Engineer to determine present and future risk to low lying development".

- **Electoral Areas B and C**: Tetra Tech EBA (2015) studied landslide and fluvial hazards within the coastal portion of Electoral Areas B and C. While the study assessed landslide hazards along the shoreline, SLR, storm surges, wave hazards and coastal erosion are outside of the study scope and therefore not addressed. An assessment of these coastal hazards is required. Updates to the Official Community Plan following provincial guidelines are ongoing and promote a 30 m setback from the shoreline.
- **Electoral Area D (Texada Island)**: Golder (2004) identified flood or inundation hazard zones on Texada Island. A recommended flood construction elevation was developed based on the analysis of tides, storm surge and wave activity. Tetra Tech EBA (2016) assessed landslide and fluvial hazards in developed areas of the communities of Van Anda and Gillies Bay. While the study assessed landslide hazards along the shoreline, SLR, storm surges, wave hazards and coastal erosion were outside of the study scope and therefore not addressed. An assessment of these coastal hazards is required.

In summary, there is a need for detailed coastal hazard and risk mapping within the study area following the latest guidelines.

3.4 Need for Coastal Hazard Planning Policies

The current state of coastal hazard planning policies is summarized by jurisdiction in the following sections.

3.4.1 Powell River Regional District

In a Request for Decision Report dated December 6, 2017, it was concluded that "staff will be using the BC Flood Hazard Area Land Use Management Guidelines Amendment to guide future land use planning and policy recommendations". These guidelines are published by BCMFLNRORP (2018).

The PRRD Official Community Plans (OCP) vary by electoral area. The *PRRD does not currently have a coastal hazards plan (Electoral Areas A, B, C, and D).* In general, the PRRD OCP's recognize the following with respect to coastal hazards:

- Climate Change objectives that promote consideration of climate change impacts in all land use decisions.
- Foreshore Policies that encourage a 30 m setbacks from the boundary of the sea. This is consistent with guidelines contained in the publications Coastal Shore Stewardship: avoiding clearing, alteration or development of the waterfront within 30 m of the natural boundary of the sea.
- Natural Hazard Areas Policies that establish development permit areas for known hazard areas (geotechnical and fluvial).
- Hazard Areas Development Permit Area DPA II: 'Steep Slopes' is designated for some steep coastline portions for the protection of developments from hazardous conditions in relation to steep and unstable slopes which have a high potential for erosion. However, these are not based on a comprehensive coastal hazard assessment.
- Climate change policies include preparing for SLR by promoting provincial guidelines for building setbacks from the sea.

The *Savary Island OCP specifically addresses coastal hazards* and includes:

- Bluff development assessment areas and setbacks from natural boundary.

- Shoreline development assessment areas and shoreline development permit areas to ensure safety, to reduce the risk to private and public property and to maintain annual rates of coastal shoreline and cliff erosion at, or below, natural levels.

3.4.2 City of Powell River

The *City of Powell River does not currently have a coastal hazards plan*. However, the Sustainable Official Community Plan (SOCP) by the City of Powell River's (2017) recognizes the following with respect to coastal hazards:

- Land use area designated as 'Water'; i.e. freshwater areas and the portion of Malaspina Strait that extends from the natural boundary to a distance of 305 m (1,000 feet). This includes coastal marine areas in their natural state as well as docks, floats, and boat mooring facilities issued to riparian owners as well as shoreline protection measures or outfalls.
  - Objectives include: to retain coastal marine areas in their natural state as well as accommodate shoreline protection structures and minor structures that complement riparian uses.
  - Policies are defined as: a) Shoreline and intertidal protection structures to reduce coastal erosion and to dissipate incoming wave energy due to SLR and storm surges are permitted. b) Structures that complement and are accessory to adjacent riparian uses including docks, floats, boat mooring and boat launching are permitted. c) The existing Beach Gardens Marina is recognized.
- Tidal / Salt Water Riparian Areas are defined along most of the coastal shoreline.
  - Objectives include: a) Protect the shoreline along Malaspina Strait through the use of measures that take natural processes into consideration and do not detrimentally impact adjacent properties. b) Plan for long-term climate change including SLR and associated storm impacts.
  - Policies are defined as: a) All development along the shoreline of Malaspina Strait must plan for a SLR of 1.0 m and associated storm surge and coastal erosion. b) Except for shoreline protection measures and marine based structures such as ferry terminals, aquaculture facilities, breakwaters and moorage facilities, new buildings must be located a minimum of 15 m from the natural boundary. c) Minimize the degradation of natural systems through steps such as protecting the foreshore from erosion, by retaining embankment vegetation and through construction that does not require vertical sea walls. d) All shoreline protection measures should include environmentally sustainable practices such as the retention and restoration of natural shoreline vegetation, and landscaping strategies that require little or no revetment and minimize erosion but augment bank stabilization, in conformance with the guidelines contained in the 2003 Federal/Provincial publication entitled Coastal Shore Stewardship: A Guide for Planners, Builders and Developers. e) Parking lots at or near the water's edge should consider permeable surfaces (e.g. grass, gravel, or open interlocking paving systems) to ensure bio-filtration of hydrocarbons and heavy metals from the undercarriage of vehicles from surface water drainage. f) It is recognized that the coastal shoreline undergoes a natural progression of accretion and erosion gradually over the long term or suddenly in severe storm events. The City shall endeavour to map and track this process as it relates to the shoreline for the purposes of land use planning. g) The City supports ensuring that storm water runoff from buildings and land is managed through a stormwater management system or other natural bio-filtration system where possible.
- Considerable portions of the coastline have slopes greater than 30% (see Schedule N of SOCP) and are designated as 'Hazardous Land':
  - Objectives include: a) Avoid new development in areas subject to natural hazards. b) Protect people and the built environment from flooding, mass movement of steep slopes, erosion, sloughing and other natural hazards.

  - Policies are defined as: a) Any lands subject to flooding should, wherever possible, be left in a natural state or used for parks, agriculture or natural preserves. b) No new construction or developments should take place on land within 15 m of the natural boundary or top of bank of the ocean, lake or any stream shown on Schedule F, whichever is greater. c) Where a building or structure is permitted at the top or foot of a steep slope or bluff, the building should be set back a horizontal distance equal to three times the height of the bluff as measured from the toe of the bluff, or as determined by a qualified professional. d) The City may require the preparation of a geotechnical report by a qualified professional for development on, above or below steep slopes to ensure that a proposed development can proceed without hazard from erosion, slip or subsidence and that infrastructure will be adequately provided.

- Climate Change Policies include (among others): Integrating climate change mitigation and adaptation considerations into all City plans, policies and projects as well as updating minimum flood construction requirements to incorporate a projected SLR of 1 m based on Provincial guidance.

The City of Powell River further has a Marine Asset Management Plan (2013). The plan covers the infrastructure assets that serve the City of Powell River's marine infrastructure needs. These assets include boat launch/ramps, breakwater and seawalk structures, and float systems throughout the community. They provide marine service to the public, commercial fisherman, transient marine traffic and recreational users. The boat ramps allow vessels to be launched at the North Harbour and Gibsons Beach. The marinas provide moorage for pleasure craft in the North Harbour and commercial and transient vessels in the South Harbour. The breakwaters provide protection for moored vessels and habitat areas. The seawalk structures prevent soil erosion and provide recreational enjoyment for the public. As the Coastal Risk Assessment advances, information from this and future studies would presumably be incorporated into the City's Marine Asset Management Plan.

3.4.3 Tla'amin Nation

The *Tla'amin Land Use Plan (2010) specifically addresses coastal hazards* in Schedule D-2 Hazard Areas Guidelines: A hazard areas map indicates estimated hazard areas and is intended for reference only. Actual hazard area delineations are described and should be measured on site during site design and construction. The natural boundary of the sea is located at the limit of permanent terrestrial vegetation. Until such time that a specific study is available delineating the extents of coastal hazards including SLR and climate change impacts, the Shore Hazard Area is any land that lies between 0 and 3 vertical metres (10 feet) above the natural boundary of the sea. Schedule D-2 includes specific design guidelines for set-back, flood construction level, elevation by landfill, existing coastal lots and buildings and steep slopes.

3.5 Commentary

There is a strong need to develop coastal hazard planning policies based on the gaps identified in OCP's of the PRRD and the City of Powell River. While the Tla'amin Land Use Plan specifically addresses coastal hazards, it explicitly points out the need for a detailed study to delineate coastal hazard areas.

4.0 STUDY AREA

4.1 General

The Powell River region is located on the northern Sunshine Coast which is on the eastern shore of the Strait of Georgia in British Columbia.

4.2 Physiography

The project site is comprised of a complex network of inlets, straits, passes and narrows, which is contained within a larger physiographic region known as the Georgia Lowland, extending along much of the Strait of Georgia and the adjacent mainland coast (Holland 1976). The landscape has been considerably altered by the advance and retreat of glacial systems, which have left behind U-shaped valleys and inlets and deposits of unconsolidated sediments. The waters of the study area are characterized by deep, steep-sided channels, typically with a glacial-mud bottom with submarine sills formed from the terminus or interstadial deposits of glaciers. Most of Savary Island is formed by a Pleistocene (Ice Age) deposit known as Quadra Sand (Clague, 1977). It is a thick sequence of nearly horizontal layered, fine to coarse sand with lesser clay, silt and gravel. Quadra Sand is susceptible to coastal erosion.

The relatively rapid sea level changes and isostatic rebound following the last retreat of the continental glaciers has resulted in a highly irregular and unstable coastline. Oceanic processes are continually altering the shoreline, attempting to bring about a state of equilibrium following a period of rapid destabilization. In the process, some features are being lost or modified, while others are continuing to form. The stability of these land forms is essentially determined by: the degree of glacial scouring and deposition; the resistance of shore rock to erosion; the energy and direction of the prevailing wind, waves, and currents; tidal range; sediment availability; and the shape of the shoreline.

4.3 Climate and Vegetation

The study area includes the Coastal Western Hemlock and Coastal Douglas-Fir geobioclimatic zones of British Columbia (SFU 2017).

According to the 1981 to 2010 Canadian Climate Normals station data available from Environment Canada, daily average temperature ranges from 4.6 degrees Celsius in January to 18.6 degrees Celsius in August. January experiences the highest monthly precipitation of 138.1 mm, while July is the driest month with 36.5 mm.

4.3.1 Governance

There are three forms of government located in the region: 1) Powell River Regional District (PRRD); 2) City of Powell River and 3) the Tla'amin Nation, formerly the Sliammon First Nation.

The PRRD is one of 29 regional districts in British Columbia serving as a local government authority incorporating five (5) electoral areas. The City of Powell River is a municipality, geographically located within the PRRD. The PRRD covers an area of approximately 5,000 square kilometres located on the west coast of British Columbia about 175 kilometres north of Vancouver within the traditional territory of the Tla'amin Nation.

The Tla'amin First Nation is located just north of the City of Powell River, along Highway 101. The Nation is one of the indigenous Coast Salish peoples inhabiting the Pacific Northwest Coast. Archaeological and historical sites important to the Tla'amin First Nation and other community ethnic groups have been identified, are protected and are celebrated to maintain the community's connection to its cultural heritage.

4.3.2 Population

The combined population within the PRRD, City of Powell River and the Tla'amin Nation is 20,049 which increases during the summer months due to the significant number of summer homes and cabins in the region, primarily in rural areas. The population density is highest in the City (approximately 66 % of the region total), and then spreads out through the islands and along Highway 101 between Lund and Saltery Bay. Table 4-1 summarizes the 2016 population statistics for the region. According to the PRRD Regional Growth and Development Analysis, projected population growth in the region ranges from a decline to an estimated 10% increase over the next 20 years (Vannstruth, 2008).

Table 4-1: 2016 Census Population

Areas	Population	Percentage of Study Area
City	13,157	65.6%
Tla'amin Nation	707	3.5%
Electoral Area A – North of Tla'amin + Savary	1,105	5.5%
Electoral Area B – East of City	1,541	7.7%
Electoral Area C – South of City	2,064	10.3%
Electoral Area D – Texada	1,076	5.4%
Electoral Area E – Lasqueti	399	2.0%
Total	**20,049**	**100%**

Reference: Statistics Canada, 2016

Many settlements in the study area are along the coast and on the scenic islands. Powell River's lakes, coastlines and diverse mountain ranges offer year-round recreation opportunities. The region enjoys several provincial and marine parks that draw tourists and visitors. For example, Desolation Sound Marine Park is one of the most popular destinations for kayaking and sailing on the south coast of BC and the historic Lund Hotel, owned and operated by the Tla'amin Nation is a major tourist destination as well as an important community asset.

4.3.3 Emergency Management

The Powell River Regional Emergency Program coordinates emergency planning, preparedness, training, response, and recovery for all areas within the PRRD, including the City of Powell River and the Tla'amin Nation. The program works with emergency responders, government staff, volunteers, partner agencies, and the general public throughout the region. A formal agreement (dated December 9, 2014) between the PRRD and the Tla'amin Nation acknowledges the distinct governance authorities and responsibilities of each governing entity to their residents and members and also recognizes the need to work cooperatively together on key interests which include the following related to coastal hazard risk: culture and heritage protection, environmental protection, intergovernmental coordination, joint economic development and land-use planning and management.

4.3.4 Transportation

Although part of the mainland, the PRRD is inaccessible by road from the lower mainland and is dependent on boats, water taxis, ferries, barges and air travel for trips to the islands and out of the region. According to the Region's Transportation Plan by ISL (2014), the most frequent mode of transportation is vehicular; however, as noted, water transportation is part of the region's history and culture and is critical to living in the region. The major artery through PRRD is Highway 101, which runs parallel to the coastline. The Ministry of Transportation and Infrastructure (MOTI) has jurisdiction over the highway. In 2012, the average annual daily traffic count for Highway 101 was 874 vehicles per day (ISL, 2014). The Transportation Plan identified that Highway 101's is vulnerable to coastal flood and coastal erosion at 'Myrtle Rocks'.

4.3.5 Ecology

Access to both marine and freshwater ecosystems has created great opportunity for local food production. According to the Recreation and Greenspace Plan (PRRD 2010), local salmon populations are restored to historical levels and have regained their key role in Tla'amin diet, culture and heritage. There are many commercial fisheries in the PRRD including salmon and shellfish.

4.3.6 Economy

In terms of industry, the economic base industries in the region include the following listed from highest to lowest employment (2001 data): pulp and paper, mining and mineral processing, sawmills, construction, logging, non-resource manufacturing, public sector, high technology, fishing, other wood manufacturing, agriculture and food (which includes aquaculture) and tourism (Vannstruth, 2008). With a heavily resource-based economy, increasing demands on natural resources have prompted the PRRD Regional Board to develop the Regional District Parks and Greenspace Plan to promote regional sustainability from an environmental, social and economic perspective (Lanarc 2010). The plan acknowledges climate change and the Sustainability Charter for the Region that was developed to form a clear vision of a sustainable future.

4.3.7 Existing Mitigation Measures

The PRRD, through previous and ongoing mitigation activities, has demonstrated its awareness of their coastal flood vulnerability. A spatial inventory of mitigation structures in place, and their protection level, does not currently exist. The BC Water Resources Atlas lists a number of dams (e.g., Powell River Dam retaining Powell Lake), but no flood protection or dyke structures are shown within the study area. The list below summarizes mitigation measures in place, or in progress, based on best available information:

- There is a floating breakwater of concrete ships built during World War I and II on Malaspina Strait; originally constructed to protect the logging pond of the Powell River Company pulp and paper mill (currently owned by Catalyst Paper).
- There are breakwaters and walls located along the shoreline on both public and private property, including a rock retaining wall located parallel to HWY 101.
- The Tla'amin Nation constructed a seawall along the waterfront in the heart of the residential part of the community several years ago to mitigate impacts. The replacement cost of the sea wall is an estimated $500,000 (e-mail correspondence with PRRD from February 22 and 26, 2018).
- The PRRD has been partnering with the Stewardship Centre for British Columbia since 2014 to conduct annual training for the Green Shores for Homes Program throughout the region. Green Shores for Homes is a voluntary and incentive-based program designed to help communities restore natural shorelines and enjoy the many environmental, recreational, scenic, and shoreline-protection benefits they bring.
- The PRRD has received funding from Environment and Climate Change Canada to implement a restoration project at Palm Beach Regional Park where the shoreline hard wall will be removed and replaced with a natural green shore design. The project will also serve as a demonstration, training and community engagement opportunity for the district to promote waterfront sustainability.
- The PRRD and MOTI are working on a stormwater management and drainage study in Electoral Areas A, B and C and engage residents as part of the process.
- The PRRD Strategic Plan 2018 – 2022 states that proactive planning and action can reduce the impacts of climate change and enhances the environmental sustainability of our community. It further defines natural hazards identification as a strategic goal.

5.0 HAZARD PROCESS DEFINITIONS

The following sections provide definitions of flooding processes in general and the specific coastal hazard processes addressed in this study such as storm surge, coastal erosion and tsunami and SLR.

5.1 Types of Flooding

Flooding is a common, naturally occurring process in British Columbia. Floods occur any time of the year; however, the most severe floods typically occur in spring, as a result of high flow rates and consequent high water levels in local rivers, known as freshet, or during the fall and winter (British Columbia 2018a), due to high tides and energetic winds and waves. The PRRD is subject to flood hazards including fluvial (riverine) flooding, tidal flooding/king tides, storm surge, SLR, and tsunami.

High tides occur throughout the year but reach maximum levels in November, December, and January. Tidal flooding, also known as sunny day flooding or nuisance flooding, is the temporary inundation of low-lying areas, especially roadways, during exceptionally high tide events, such as at full and new moons. A king tide is a term often used to describe exceptionally high tides. Higher than normal tides typically occur during a new or full moon and when the Earth is at its perigee, or during specific seasons.

5.2 Storm Surge

Storm surge (Figure 5-1) occurs in coastal areas when strong onshore winds and low atmospheric pressure during passing storms raise water levels along the shore above predicted tidal levels. Storm surge occurs on all four Canadian coasts (Pacific, Arctic, Atlantic and Great Lakes). Storm surges, primarily in the winter months, can cause public safety concerns and property damage to low lying coastal areas.

Figure 5-1. Example of Storm Surge effects along shoreline in PRRD.

A change in water level is caused by the action of wind and atmospheric pressure variation on the sea surface. The typical effect is to raise the level of the sea above the predicted astronomical tide level, although in some situations, such as when winds blow offshore, the actual water level may be lower than that predicted. The magnitude of a storm surge on the BC coast will be dependent on the severity and duration of the storm event in the North Pacific, its track relative to the BC coast and the seabed bathymetry at the site (Ausenco Sandwell 2011a).

A storm surge is independent of tides, but its impact is most noticeable during a high tide. In addition, SLR accentuates the risks from storm surge activity as higher water levels advance further inland and affect areas of higher elevation. It is anticipated that climate change will cause more intense and frequent storms in the northern hemisphere and that SLR will increase the coastal areas at risk from these events (Arlington Group, EBA, and DE Jardine. 2013).

5.3 Tsunami

A tsunami is waves created when a large volume of water is rapidly displaced by processes such as earthquakes or landslides. Tsunamis have previously impacted parts of the BC coast and adjacent coastlines with wave heights and runups that far exceed other processes such as storm surges (APEGBC 2012).

The time between tsunami wave crests can range from minutes to hours, and in height from a few centimeters to several meters. In the deep ocean, the waves travel about 800 km/h, but start to slow in shallower, coastal waters where their heights increase dramatically (British Columbia 2018b).

5.4 Coastal Erosion

Coastal erosion can be defined as the removal of material from the coast by wave action, tidal currents, drainage, high winds and/or the activities of humans, typically causing a landward retreat of the coastline. The effects of coastal erosion can be observed on cliffs, tidal flats and saltmarshes, and beaches. Those most directly at risk from coastal erosion are those living in coastal lowland areas or along 'soft' sediment coastlines where coastal erosion can cause flooding, rock falls, loss of land and damage to infrastructure (British Geological Survey 2012). Figure 5-2 shows an example of coastal erosion.

Figure 5-2. Example of coastal erosion in PRRD.

5.5 Sea Level Rise

SLR is an increase in global mean sea level as a result of an increase in the volume of water in the world's oceans. SLR is caused primarily by two factors related to global warming: the added water from melting ice sheets and glaciers and the expansion of sea water as it warms.

From a planning perspective SLR is an allowance for increases in the anticipated mean elevation of the ocean associated with future climate change, including any regional effects such as crustal subsidence or uplift (Ausenco Sandwell 2011a).

6.0 HISTORIC EVENTS

6.1 Historic Coastal Hazard Events

As part of this study an inventory of historic coastal hazard events affecting the study area was developed. Information was gathered from various publicly available sources, interviews with PRRD staff and local residents, the Powell River Museum, and internet sources. In total 16 historic events were identified and documented from information available. A summary of these events is provided in Table 6-1. Details are documented in Appendix D. From the inventory it is obvious that coastal hazards pose a real and significant challenge to the community and local governments within the study area.

Table 6-1. Summary of Historic Coastal Hazard Events Inventory.

Event Date	Event Title	Event Location	Event Severity
February 1916	Victoria's Groundhog Day Snowstorm of 1916	Southern Coastal BC	Snow fell for 38 hours, bringing over 78 centimeters to Vancouver. In the PRRD, strong winds blew down homes and uprooted trees. Residents living along the shoreline had to evacuate their homes due to exceptional high tide.
June 23, 1946	Earthquake	PRRD	A 7.3 magnitude earthquake with its epicentre in western Canada and the northwestern United States, lasted about 30 seconds and caused numerous slides and subsidence. In the PRRD, the earthquake itself caused extensive damage, destroying underwater powerlines. The earthquake also produced a significant tsunami – a small wave affected shores along the Strait of Georgia, killing one person. A considerably larger ond wave occurred at Sisters Islets south of Texada Island and west of Lasqueti Island, with a reported height of 7 to 8 feet, i.e. 2.1 to 2.4 m (Hodgson 1946).
December 17-30, 1993	Storm Surge/Tidal Flooding	PRRD	Gulf Islands. Pender, Lasqueti (PRRD), and other islands suffered severe damage. Loss of communications was reported throughout the impacted areas
November/ December 1999	Coastal Flooding	Finn Bay Road, Baggi Road and Sarah Point Road	Flooding caused properties in the PRRD along Finn Bay Road, Baggi Road and Sarah Point Road to be blocked for several days.
2001	Storm	Savary Wharf, Lund Water Taxi dock	Savary wharf severely damaged. Ramp of water taxi dock in the Lund Harbour severely damaged
November 12, 2007	Winter Storm	PRRD	All ferry services were cancelled; thousands of residents were without power for several days.
January 2010	Winter Storm	Tla'amin Nation Waterfront	High tide and storm surge impacted the waterfront of Tla'amin Nation, resulting in debris accumulation.
December 24, 2010	King Tides	PRRD	unknown

Event Date	Event Title	Event Location	Event Severity
November 24, 2011	Fall Storms	BC South Coast	A one-day event brought storm surge on top of high tide that led to minor local flooding near the Tsawwassen Terminal (BC Ferries). BC Ferries cancelled several mid-day sailings between Vancouver and Vancouver Island. Winds of up to 100 km/h hit the North Coast and parts of Vancouver Island
2012	Storm	Saltery Bay Provincial Park	Storm damage to breakwater at Saltery Bay Provincial Park, just west of the Saltery Bay ferry terminal. Storm surge undermined the beach wall
October 22, 2014	Heavy Rain/Flood	Sliammon Creek Fish Hatchery	A one-day event brought heavy rainfall to the PRRD. Sliammon Creek near Powell River overflowed its banks and debris damaged the fish hatchery operated by the Tla'amin First Nation.
December 8-10, 2014	Heavy Rain/ Landslides	City of Powell River, Finn Bay Road, north of Lund, Atrevida Road near Lund, Stittle Road	A three-day storm brought 140 mm of rain to the PRRD. Landslides were reported all over the City of Powell River. Homes were shifted from the foundations, roads were closed, and sewer systems were at capacity. Basements were flooded as well. The PRRD activated their EOC. Powell River and PRRD (Area B) received assistance from British Columbia.
March 1, 2016	Landslide	Atrevida Road	A one-day rain event in the PRRD caused landslides, evacuations, and emergency services. Trees and debris blocked roadways.
November 14, 2017	Erosion	1069 Squirrel Lane, Savary Island	About 20 feet of shoreline erosion experienced between 1959 and 2017 at 1069 Squirrel Lane. The shoreline forms a natural berm in front of the house, and may be flooded should water overtop the crest. The shoreline has been left in its natural state at 1069 Squirrel Lane, where coastal erosion is significantly higher than on the neighboring property where semi-vertical logs were placed to protect against erosion.
January 19-23, 2018	Winter Storm	PRRD	A five-day event of heavy rain and gale force winds impacts the PRRD. The strong winds led to BC Ferries cancellations and downed trees, branches, and power lines. Streams and creeks overflowed their banks. Homes in low-lying areas flooded. Widespread power outages were also reported.
Date unknown	King Tides and Storm Surge	Marine Avenue in downtown Powell River	Flooded road hindering access to boat ramp and sewage treatment plant.

6.2 BC Ferries Comox to Powell River Cancellations due to Wind and Storm Events

Transportation in and out of the community depends heavily on BC Ferries Services.

The study team contacted Mr. Gregg Clackson, Director of Operations and Security Center at British Columbia Ferry Services, Inc. (BC Ferry). According to Mr. Clackson, delays or cancellations of service are mostly due to high winds; service resumes after several hours and the system passes. Most ferry bays are sheltered. BC Ferry assets in Powell River are above sea level with new a floating dock and trestle. At times, water may reach the terminal and puddles but it drains away and customers are diverted around the flood waters. Table 6-2 summarizes the aggregate number of BC Ferries Comox to Powell River cancellations due to wind and storm events, some cancellation events may have also been associated with flooding in the study area. Scheduling effects that may have affect the number of cancellations were not considered.

Table 6-2: Number of BC Ferries Comox to Powell River Cancellations due to Wind and Storm Events.

Year*	# of cancellations
2007	14
2008	12
2009	5
2010	12
2011	50
2012	85
2013	54
2014	45
2015	26
2016	72
2017	54

*Numbers by fiscal year ending March 31

7.0 HAZARD ANALYSIS

The following sections summarize the hazard analysis. This study concentrates on storms, coastal erosion and tsunami. SLR is considered as scenario in combination with storm surge.

7.1 Storm Hazard Analysis

The hazards associated with storm events include effects from tide, waves and SLR in addition to storm surge. These hazards include damage or loss associated with inundation and wave action. The following sections summarize the storm hazard analysis.

7.1.1 Concept of Designated Storm Event

The concept of Designated Storm Event was used to carry out the analysis of the storm hazard. The hazard is essentially associated with water at high elevations; thus, the analysis is fundamentally an examination of water levels. Water levels vary both in time and in space.

- Long-term variation (years to decades) is determined by mean sea level, as may be modified by SLR. While SLR will occur relatively gradually over time (i.e. temporal increase), it is not considered to vary spatially within the study area.
- Medium-term variation (minutes to hours) is determined by tides and storm surges, generally derived from tide station observations. Minor spatial variation is expected in the study area.
- Short-term variation (seconds) is determined by wave conditions, measured at specific stations and estimated elsewhere with numerical modelling or other methods. Significant spatial variation is expected in the study area.

These types of variation are generally cumulative: the water elevation at a particular place and time is the sum of mean sea level plus SLR, increased by tide stage and storm surge, modified by instantaneous wave forms. This is illustrated in Figure 7-1. Storm surges and wave conditions are linked to a Designated Storm Event (or Events) chosen to represent extreme conditions. Analysis details for each component are summarized below.

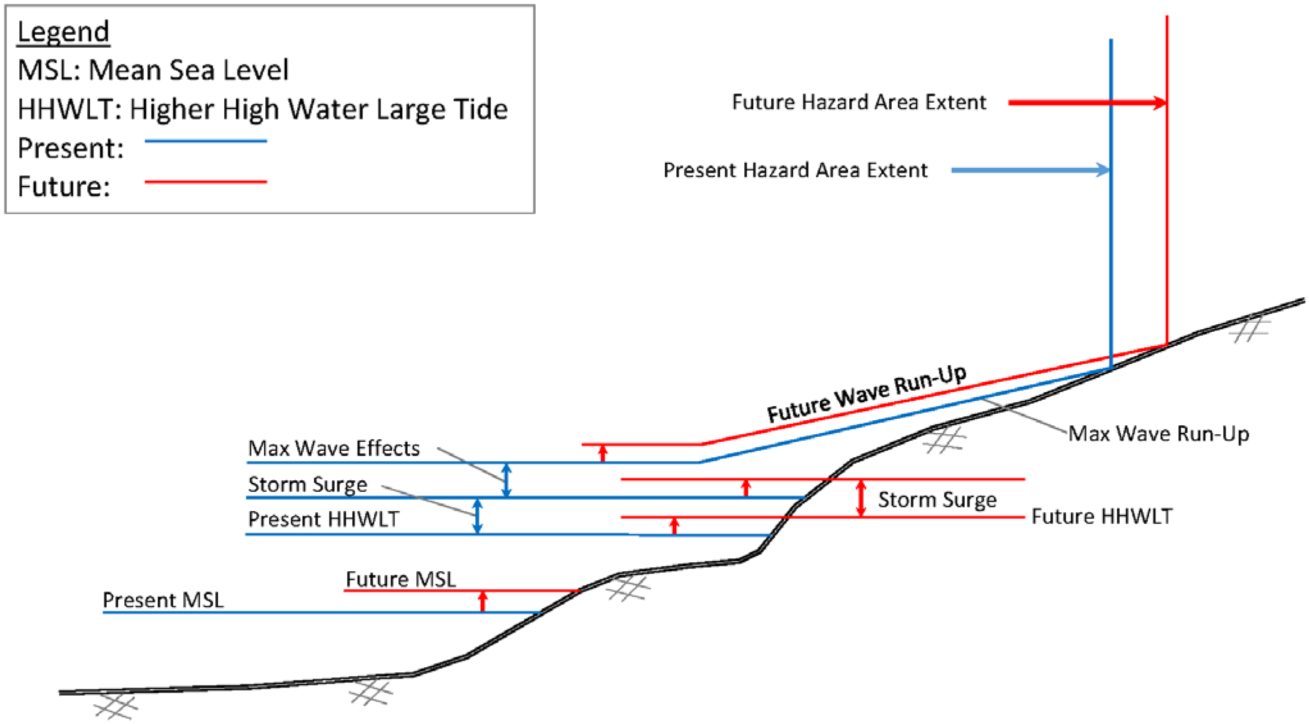

Figure 7-1. Schematic cross-section of components used in the storm hazard analysis

7.1.2 Derivation of the Designated Storm

Hazard processes associated with the designated storm event include storm surge and wind-generated waves. As storm surge and wind-waves share, for the greatest part, a common generating mechanism they are statistically dependent. This means that the joint probability (i.e. the probability that both will occur simultaneously) is close to 100% and it can be conservatively assumed that a 200-year storm surge will generally coincide with a 200-year wind-wave event. Tides are statistically independent of storm events, but have a duration such that it is likely that a high tide will occur at some point during the designated storm event. Therefore, a joint probability approach would be appropriate to assess the probability of a high tide coinciding with the peak of the designated storm event. In this study, however, it has been assumed that the designated storm event will coincide with the higher high water large tide (HHWLT), a conservative assumption adopted following the BC Ministry of Environment guidelines (Ausenco Sandwell 2011b).

To assess the hazard posed by extreme weather events, it is common practice to derive a representative storm that is sufficiently rare to represent a non-typical condition. The relative rarity of this designated event is typically expressed as an annual exceedance probability (AEP), with its likelihood of occurrence given in terms of its return period. Return periods are most commonly given as an ‘expected frequency’ such as a ‘1 in 200-year event’. This does not mean that a 200-year event will occur one time in 200 years, but that the probability of this event’s occurrence in any given year is 1/200 or 0.5%. It can be shown that it is possible for a 200-year event not to occur (36.7% probability), occur exactly once (36.9% probability) or occur twice or more (26.4% probability) over the span of 200 years.

In keeping with the recommendations of Kerr Wood Leidal (2011) for the Powell River region, Tetra Tech selected the 1/200 AEP event, or 200-year event, as the designated storm. The severity of a given return period event is generally determined from measured data at or near the location of interest. In this way, the severity of measured past events is used to extrapolate the potential severity of future events. Standard practice is to assign the largest recorded event in the period of record a return period equal to the period of record (e.g., the largest event in a 20 year record is assigned a 20-year return period). Smaller events in the period of record are assigned smaller return periods (e.g., if there are 20 events in the record, the second largest event in a 20-year record is assigned a 19-year return period) until each of the significant events in the record has an assigned return period. Several extreme event probability distributions are then fit to the recorded events. The distribution with the highest coefficient of determination (r^2) value is chosen as most representative of the extreme value distribution at the site and hence the best predictor of the event magnitude associated with a given return period.

Tetra Tech used the above method, as detailed by Goda (1988), to estimate 200-year winds and storm surges in the region.

7.1.3 Determination of Sea Level Rise

The anticipated global SLR is illustrated in Figure 7-2 from Ausenco Sandwell (2011b).

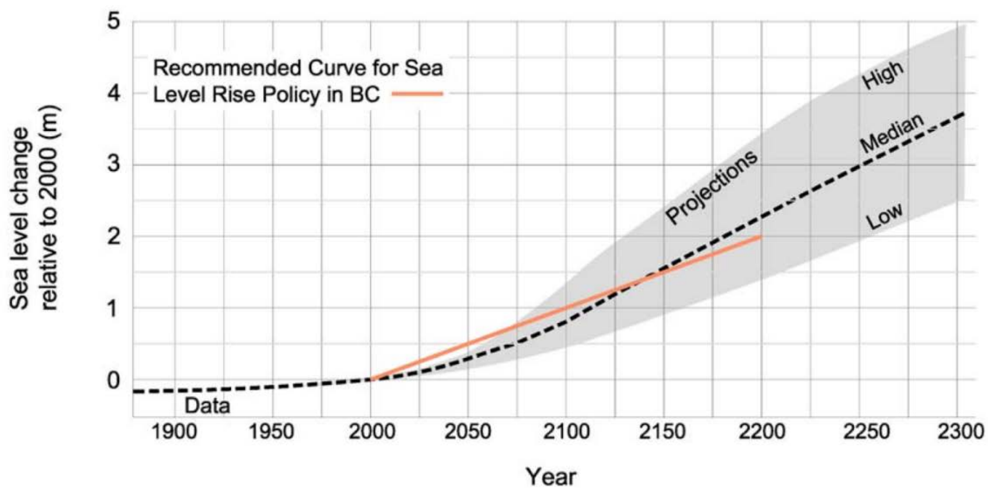

Figure 7-2. Projections of global sea level rise reproduced from © Ausenco Sandwell (2011b).

For the study area, the suggested time line for risk assessment is 50 years (Table 6-1 of Ausenco Sandwell 2011a). The recommended global SLR at 50 years is 0.5 m (Table 1 of Ausenco Sandwell 2011a); this is to be regionally adjusted based on crustal uplift rates.

Rates of crustal uplift and subsidence have been measured at a range of stations in BC (Ausenco Sandwell 2011a). The closest three stations to the study area are on Vancouver Island:

- Campbell River: +4.1 mm/yr (60 km NW of Powell River)
- Little River: +3.0 mm/yr (30 km W of Powell River)
- Nanoose Bay: +2.1 mm/yr (65 km S of Powell River)

The closest site on the mainland is located at Point Atkinson, registering +1.3 mm/yr (105 km SE of Powell River).

These observations suggest that the rate of uplift at Powell River may be on the order of 2 to 4 mm/yr or 0.1 to 0.2 m over 50 years. This uplift rate would counteract SLR to some degree, such that including it in the analysis would lead to a lesser distinction between scenarios with and without SLR. The likely amount of uplift is small relative to the uncertainty in SLR predictions. Since none of the observation stations are within the study area, and the validity of interpolating uplift rates from surrounding stations requires further assessment, Tetra Tech excluded it from the numerical parts of this analysis.

Therefore, the SLR scenario carried forward in the analysis reflects a 0.5 m rise in sea level with no crustal uplift, and corresponds to a 50-year time line. However, the rate of crustal uplift for the study area should be confirmed and considered in a more detailed assessment.

7.1.4 Determination of Water Level and Surge

From the 8-year period of record at the Powell River tide gauge, Tetra Tech estimated the HHWLT level to be 5.15 m above chart datum (CD, referring to nautical charts), or 2.14 m above mean sea level (MSL). Variation in tide levels over the study area was assumed to be negligible. For comparison, the HHWLT level at Point Atkinson is 5.00 m CD.

Previous studies have indicated a 200-year storm surge in the study area of 1.25 m (Kerr Wood Leidal 2011). To confirm this value, Tetra Tech estimated 200-year storm surges using tide gauges at Powell River and Point Atkinson, which have 8- and 77-year periods of record, respectively. The estimated 200-year storm surge from the Powell River gauge was 1.1 m to 1.2 m, while from the Point Atkinson gauge it was 1.1 m to 1.3 m. Since this analysis agreed with the recommended storm surge, Tetra Tech has applied the 1.25 m 200-year storm surge recommended previously for the study area (Kerr Wood Leidal, 2011).

Therefore, the extreme water level for tide plus 200-year storm surge was 5.15 + 1.25 m = 6.4 m CD; for the scenarios including SLR (see Section 7.1.3), the extreme water level was 5.15 + 1.25 + 0.5 = 6.9 m CD, where 0.5 m is the 50-year SLR.

7.1.5 Determination of Wave Conditions

Wave conditions in the study area are generated by winds in the Strait of Georgia. Figure 7-3 shows the wind observation stations from which 200-year winds were derived using the methods described above. Wind inputs to the wave model were created from the estimated 200-year southeasterly (i.e., from the southeast) and northwesterly winds at these measurement stations; the extreme winds were spatially interpolated over the domain to create a continuous field.

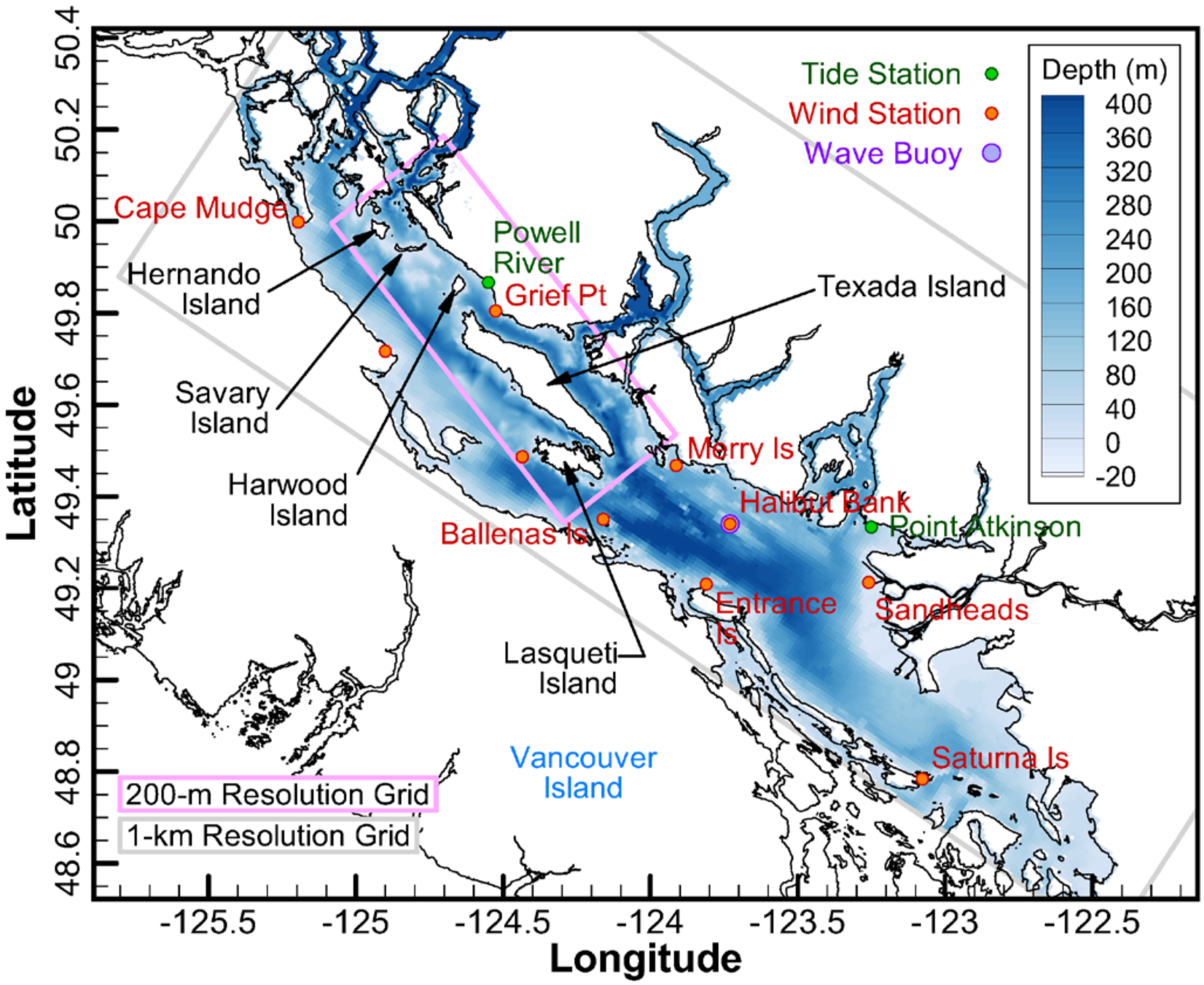

Figure 7-3. Wave model domains for the study area (200-m resolution) and Strait of Georgia (1-km resolution). Tide, wind and wave observation stations also shown.

Wind-generated waves were estimated using the 2D wave model, SWAN. The wave model was run in a nested configuration, with a 1-km resolution model of the Strait of Georgia providing boundary conditions to a 200-m resolution model of the study area (see Figure 7-3). Bathymetry in the 1-km resolution model was taken from Canadian Hydrographic Service (CHS) charts; for the 200-m resolution model, bathymetry was constructed from a

CHS digital bathymetry database combined with topography provided by PRRD, where available. The 1-km resolution wave model was validated against observations at the Halibut Bank wave buoy (see Figure 7-3) for two of the largest wave events on record.

Wave conditions throughout the study area model domain were predicted for the 200-year storm events from southeast and northwest, with and without SLR.

The southeast tip of the study area was outside the 200-m wave model domain, from approximately Saltery Bay eastward. To estimate 200-year wave conditions for this area, Tetra Tech applied the method of Kamphuis (2008) for southeast winds; northwest winds produce negligible wave conditions along this portion of the coast.

7.1.6 Combining Hazard Results

Delineation of areas affected by the storm hazard scenarios required the various components described above to be combined into unified sets of results.

Tetra Tech selected chart datum as the working vertical datum for reasons of efficiency: tides and the wave model bathymetry use this as their native datum. Topographic data for the study area were therefore converted to chart datum to facilitate comparisons. For each hazard scenario, Tetra Tech computed a map of maximum water surface elevations relative to chart datum by summing the following elements:

- Tide: HHWLT, or 5.15 m CD
- Storm surge: if applicable to the scenario, 1.25 m
- SLR: if applicable to the scenario, 0.5 m
- Waves: maximum expected wave crest or wave run-up height, as detailed below

The sum of the first three bullets above defined the medium-term still water shoreline. In Figure 7-1, this shoreline is the intersection of the storm surge elevation and land.

Wave conditions vary in both space and time. Temporal variation is handled statistically, with most models and methods giving predictions of the significant wave height, or the average of the highest one-third of the waves. The maximum expected wave crest height in shallow water, measured upward from the medium-term still water level, is 1.3 times the significant wave height; this height was applied in areas inundated at the medium-term still water level. In Figure 7-1, this height is labelled “Max Wave Effects.”

However, waves run up beyond the medium-term still water shoreline. The maximum height of wave run-up was estimated as 3.5 times the significant wave height, measured upward from the medium-term still water level. This run-up height defined a “run-up shoreline.” In Figure 7-1, the run-up shoreline is the intersection of wave run-up and land. Between the medium-term still water shoreline and the run-up shoreline, Tetra Tech interpolated heights to determine a maximum water surface elevation. This interpolation is shown in Figure 7-1 as the sloping wave run-up line.

A spatial analysis was carried out for each scenario, subtracting land elevation from the maximum water surface elevation to produce a depth representative of the maximum flooded depth at each location in the study area. In Figure 7-1, this depth is the vertical distance between land and the “Max Wave Effects” line.

For the purposes of estimating potential damages, water velocity was estimated as the wave crest velocity corresponding to the mean wave period. This estimate yields an upper bound to wave breaking velocities in shallow water.

For each scenario, the flooded depths and wave velocities, based on a grid with 10 m x 10 m cell size, were provided to our GIS analysts. The data was compiled in GIS as hazard layers (including water depth and water velocity) for each scenario. Selected scenarios are listed in Section 8.1.

7.2 Coastal Erosion Hazard Analysis

Table 7-1 below summarizes the extent of low-erosion shoreline (rocks, boulders) and high erosion (sand, gravel, cobbles, marsh) shorelines, based on BC Shorezone mapping data, published by Ministry of Forests, Lands, Natural Resource Operations and Rural Development. The information is shown graphically on Figures 3 to 13.

The results are likely conservative, i.e., the extent of high erosion shorelines is likely overestimated. Table 7-1 and the associated Figures 3 to 13 provide an indication of regions where the soils, rocks and sediments comprising specific shorelines are more or less susceptible to erosion. Areas where both wave energy is high and soils are predominantly high-erosion are likely susceptible to significant coastal erosion as sea levels rise, provided similar soil conditions exist inland of the current shoreline.

Table 7-1: Summary of Shoreline Erosion Potential

Area	Low Erosion (km)	High Erosion (km)	Total Shoreline (km)	Percent in High
City	0.7	17.0	17.7	96%
Tla'amin	0.0	6.0	6.0	100%
Electoral Area A - North of Tla'amin + Savary	53.8	148.5	202.3	73%
Electoral Area B – East of City	0.8	7.4	8.1	90%
Electoral Area C – South of City	4.7	33.2	37.9	88%
Electoral Area D – Texada	55.7	93.00	148.7	63%
Electoral Area E – Lasqueti	74.0	69.8	143.8	49%
Total	**189.7**	**374.9**	**564.5**	**66%**

Based on the outcomes of the analysis summarized in Table 7-1 above, it is estimated that up to 66% of PRRD's coastline is currently at risk due to coastal erosion. However, similar to the KWL (2011) study, it should be noted that the above values refer to shore composition, and do not include effects such as beach slope, wave exposure and wave climate and characteristics of the back beach, which all help determine the risk of shore erosion at each site. In general, coastal zones most at risk are composed of glacial deposits lacking a source of sediment and sedimentary rock cliffs and bluffs subject to wave action. In general, hard rock coastal zones are at the least risk from coastal erosion, however infrastructure along these shorelines may be damaged by ongoing wave action regardless, for example due to the failure of riprap slopes.

The shoreline has been broken down into several regions for analysis:

- **Mainland Coast:** The majority of the mainland coast consists of rocky outcrops, narrow gravel beach terraces and sand-grave pocket beaches. The narrow beach terraces will be very vulnerable to rising sea levels as the existing beaches are submerged and the back-beach area is exposed to wave action. The beaches will likely eventually reform at a higher elevation provided that recession of the back beach is permitted, but the shoreline retreat is inevitable. Rocky outcrops will be much more resilient to erosion; however, the interspersed pocket beaches may be submerged and lost. Urban areas along the mainland coast will be very vulnerable to SLR induced coastal erosion as properties have been constructed immediately adjacent to the shoreline.

- **Lasqueti Island:** The rocky and generally sparsely inhabited coast of Lasqueti Island will likely be resistant to coastal erosion in the near future. With elevated sea levels, minor cliff erosion may occur as wave cut terraces progress up the rocky shoreline, however large scale erosion is unlikely. The pocket beaches and fringing sediment deposits found along the island's shoreline are at risk for erosion and inundation as sea levels rise, however, it is likely they will gradually reform as higher water levels erode source material from adjacent cliffs and outcrops.
- **Texada Island:** The coastline of Texada Island is generally not expected to be subject to significant coastal erosion under present or future sea levels. Isolated sandstone outcrops along the western shore of the island may be subject to erosion as sea levels rise, but the process will likely be gradual and relatively minor. Given its proximity to the water, the community of Gilles Bay may be at risk due to coastal erosion as the margin for coastal retreat is extremely small. The community of Van Anda may be better positioned to withstand minor erosion arising from rising sea levels as it is built at a higher elevation and with a greater setback.
- **Harwood Island:** The southern point of Harwood Island consists of a rocky outcrop, which serves as an anchor point for narrow beaches running along the eastern and western edges of the island. To the north is a spit of sediment formed by material transported along the eastern and western shorelines by the prevailing southerly waves. As sea levels rise, it is expected that the narrow beaches fringing the island will be largely lost to erosion and the shoreline will recede. The coastal beaches may reform at a higher elevation as material is eroded from upland sources.
- **Savary Island:** The entire coastline of Savary Island is at risk of ongoing erosion and is particularly vulnerable to SLR due to its low topography and sandy shorelines. The southern coast of the island is more vulnerable to wave-induced erosion; however, the full perimeter of the island will experience coastal retreat as sea levels rise and the beaches adjust to higher water levels, except for localized areas such as the rocky outcrop on the eastern end of the island.
- **Hernando Island:** With the exception of its northern, generally rocky, coast the entirety of Hernando Island is at risk of coastal erosion, particularly as sea levels rise. Under current conditions, the island's shoreline is in approximate equilibrium with the local wave climate, with minor localized erosion taking place. The island's shoreline is low and relatively flat and will respond to elevated sea levels by retreating.

7.3 Tsunami

Tsunami hazards were assessed in the PRRD Tsunami Report by Gardner (2007) and concluded that the PRRD is not at significant risk from a devastating tsunami wave or series of waves. The PRRD, including its island communities, are largely protected from major Pacific tsunami threats due to attenuation that any large Pacific tsunami would undergo as it passes through Juan de Fuca Strait and Boundary Pass if coming from the south, or through Johnstone Strait and Discovery Pass if coming from the north.

Gardner (2007) indicated that the maximum expected tsunami wave heights in the study area would be 0.5 to 1.0 m. Table 6-1 indicated that the 1946 earthquake led to a 2.4 m tsunami wave at Sisters Islet. It is reasonable that the tsunami wave at Sisters Islet was considerably larger than the maximum expected wave in the PRRD because the Sisters site is much closer to the generating area, and the wave would attenuate with distance from the source.

8.0 RISK ASSESSMENT

This section summarizes the risk assessment, details are provided in Appendix E.

8.1 Scenarios Selected for Risk Analysis

The following scenarios were selected for risk analysis using the modelling results from the hazard analysis:

- High Tide and SLR
- High Tide and 200-Year Surge and Waves (Southeast)
- High Tide, and 200-Year Surge and Waves (Southeast), and SLR
- High Tide and 200-Year Surge and Waves (Northwest)
- High Tide, and 200-Year Surge and Waves (Northwest), and SLR

Information available for this study to assess coastal erosion was not sufficient to meaningfully estimate how far inland erosion would progress. This is primarily due to limitations in topography data, bathymetry data, and shore zone material composition data (e.g. sand, gravel etc.). Therefore, coastal erosion hazard areas could not be determined and consequently coastal erosion was not considered as a risk scenario. However, coastal erosion hazard was expressed as length of shoreline with low or high erosion potential (Section 5.4).

Maximum expected tsunami wave heights in the study area are 0.5 to 1.0 m (Section 5.3). Even if a tsunami happened to coincide with a high tide, the combined water elevation would be 5.15 + 1.0 = 6.15 m CD, which is less than the elevation associated with high tide plus storm surge. Therefore, no spatial analyses were carried out specifically for this water elevation as it is lower than the designated storm condition. The probability of a tsunami event coinciding with the designated storm event was considered too remote to consider for the risk analysis.

8.2 Risk Analysis

A risk-based assessment was conducted to determine the assets exposed to each coastal hazard scenario and estimate their potential impacts (vulnerability from exposure). Fundamentally, risk is the combination of hazard and consequences. The risk analysis applied a GIS approach where layers expressing the hazard analysis could be combined with infrastructure that is exposed, under consideration of the vulnerability of the infrastructure to the hazard.

The exposure and vulnerability assessments used best available GIS data collected from federal, provincial, PRRD and local sources. Census data was used to determine the number of people exposed, or located in the hazard area (or seaward of the hazard area), and potentially displaced for each scenario. BC Assessment and parcel data were the primary sources utilized to develop a general building stock inventory which was used to quantify one type of economic loss. Tetra Tech worked with the PRRD to define what a critical asset (see Glossary for definition) is to the region and develop a spatial asset inventory to determine what may be affected by the coastal hazards.

To estimate potential impacts, a custom approach was developed leveraging flood damage estimating tools and methodologies including HAZUS Canada to monetize damages to buildings and assets. Potential impacts to assets such as transportation infrastructure, utilities, environmental and cultural resources and other are assessed in terms of exposure to the flood scenarios, where location information was available, but were not monetized due to data limitations and the complex nature of valuing ecosystems.

For illustrative purposes, a 'composite hazard area' was developed to depict the largest coastal flood hazard area extent from all the scenarios listed in Section 8.1. This composite hazard area was developed merging all five scenario hazard areas and dissolving to create a single spatial extent. The composite hazard areas are shown in Figures 14 to 24. They were derived by overlaying all coastal flood hazard areas calculated for each of the scenarios evaluated. The vulnerability assessment outlines the potential impacts separately for each of the five coastal flood scenarios assessed.

8.3 Risk Analysis Results

The risk analysis addressed:

- Impacts to People and Society
- Environmental and Cultural Impacts
- Local Economic Impacts
- Local Infrastructure Impacts

Impacts are summarized below and further results are detailed in Appendix E.

The risk analysis results are organized by area for each asset type (refer to Table 8-1). The composite hazard areas are illustrated in Figures 14 to 24. The figures are organized by Index Map (Figure 2) location first, and subsequently by scenario.

8.3.1 Impacts to People and Assets

Table 8-1 summarizes the population and asset exposure, and estimated potential building damage for each coastal flood scenario. High tides combined with SLR, in absence of a coastal storm event, may cause impacts to population, buildings and assets throughout the PRRD. When examining the surge and waves during high tide from both southeasterly and northwesterly storm events, overall, southeasterly storms generate the greatest exposure and potential loss to the PRRD. However, both event-based scenarios cause significant potential impacts to the region. When factoring in SLR for these 200-year storms, there is a considerable increase in exposure and potential loss to the region resulting from both southeasterly and northwesterly events.

Table 8-1: Risk Analysis Summary

Area	Population Exposed	General Building Stock Potential Loss ($Million)	# of Regional Assets Exposed			
			Critical Assets	Commercial Assets	Cultural Assets	Other Assets
High Tide and SLR						
City	0	SLR hazard was not modelled for potential losses.	6	1	0	0
Tla'amin	34		0	0	0	0
Electoral Area A – North of Tla'amin + Savary	0		8	9	0	2
Electoral Area B – East of City	0		0	0	0	1
Electoral Area C – South of City	10		6	3	0	1
Electoral Area D – Texada	0		6	4	1	1
Electoral Area E – Lasqueti	0		2	3	0	0
Total	**44**		**28**	**20**	**1**	**5**
High Tide and 200-Year Surge and Waves (Southeast)						
City	78	39	7	2	0	0
Tla'amin	228	15	0	1	0	4
Electoral Area A – North of Tla'amin + Savary	10	14	8	9	0	9
Electoral Area B – East of City	0	12	0	0	0	4
Electoral Area C – South of City	59	23	8	3	0	9
Electoral Area D – Texada	33	7	12	4	1	4
Electoral Area E – Lasqueti	0	0	2	3	0	0
Total	**408**	**115**	**37**	**22**	**1**	**30**
High Tide, and 200-Year Surge and Waves (Southeast), and SLR						
City	78	54	7	2	0	0
Tla'amin	228	24	0	1	0	4
Electoral Area A – North of Tla'amin + Savary	10	19	8	9	0	11
Electoral Area B – East of City	0	14	0	0	0	4
Electoral Area C – South of City	59	23	8	3	0	9
Electoral Area D – Texada	33	7	12	4	1	4
Electoral Area E – Lasqueti	0	1	2	3	0	0
Total	**408**	**145**	**37**	**22**	**1**	**32**

Area	Population Exposed	General Building Stock Potential Loss ($Million)	# of Regional Assets Exposed			
			Critical Assets	Commercial Assets	Cultural Assets	Other Assets
High Tide and 200-Year Surge and Waves (Northwest)						
City	78	32	8	2	0	0
Tla'amin	52	9	0	1	0	4
Electoral Area A – North of Tla'amin + Savary	10	19	8	9	0	9
Electoral Area B – East of City	0	8	0	0	0	4
Electoral Area C – South of City	10	3	7	3	0	5
Electoral Area D – Texada	33	3	12	4	1	4
Electoral Area E – Lasqueti	0	0	2	3	0	0
Total	**183**	**77**	**37**	**22**	**1**	**26**
High Tide, and 200-Year Surge and Waves (Northwest), and SLR						
City	78	85	2	8	0	0
Tla'amin	181	22	1	0	0	4
Electoral Area A – North of Tla'amin + Savary	10	26	9	8	0	10
Electoral Area B – East of City	0	11	0	0	0	4
Electoral Area C – South of City	10	8	3	7	0	6
Electoral Area D – Texada	33	8	4	12	1	4
Electoral Area E – Lasqueti	0	1	3	2	0	0
Total	**312**	**165**	**37**	**22**	**1**	**28**

Other assets = The other asset category provides the PRRD an opportunity to include additional assets that do not fit within the pre-defined asset categories outlined in the RAIT.

8.3.2 Impacts to Roadways

For the mainland, the HWY 101 is the primary transit route to evacuate away from the coast. This highway is connected by paved and loose roadways throughout the region. The PRRD Transportation Plan noted the highway's vulnerability to coastal flood/erosion at 'Myrtle Rocks' (ISL 2014). When examining impacts to the highway resulting from high tide and sea-level rise alone, there is one section at the end of the highway in Lund that is anticipated to become inundated (0.02 km in length). As a result of the projected storm events, five main areas of the highway may become inundated by as depicted in Figure 80 and described below. Table 8-2 summarizes the length of roadway inundation anticipated as a result of each flood scenario evaluated.

1. Section of road and the Lang Creek Bridge near the intersection of the highway and Brew Bay Road in Brew Bay;
2. Section of road approximately 3 km south of the City;
3. Section of road approximately 1 km south of the Westview Ferry Terminal in the City;
4. Section of road at the end of the highway in Lund; and
5. Section of road at the end of the highway in Saltery Bay.

Table 8-2: Length of Inundated Roadway for Each Hazard Scenario

Sunshine Coast Highway HWY 101 (km)	Paved Roadway (km)	Loose Roadway (km)	Rough Roadway (km)
High Tide and 200-Year Surge and Waves (Southeast)			
0.7	9.6	12.5	2.3
High Tide, and 200-Year Surge and Waves, and Sea-Level Rise (Southeast)			
0.9	11.0	14.4	2.9
High Tide, and 200-Year Surge and Waves (Northwest)			
0.6	5.9	10.6	0.8
High Tide, and 200-Year Surge and Waves, and Sea-Level Rise (Northwest)			
0.74	7.0	11.2	1.3
High Tide and Sea-Level Rise			
0.02	0.4	0.4	0.1

8.3.3 Environmental and Cultural Impacts

To determine exposure of natural and beneficial land in the study area to coastal flooding hazard, acreages of wetlands and open land were calculated utilizing the combined flood hazard extent for all coastal flood scenarios evaluated. Details of the analysis are provided in Appendix D. Table 8-3 lists results of these calculations by area.

Table 8-3: Land Located in the Composite Coastal Flood Hazard Areas

Area	Wetlands (hectares)	Open Space (hectares)
City	0.0	46.4
Tla'amin	NA	NA
Electoral Area A – North of Tla'amin + Savary	3.0	182.5
Electoral Area B – East of City	0.0	1.3
Electoral Area C – South of City	0.0	23.3
Electoral Area D – Texada	0.0	202.4
Electoral Area E – Lasqueti	0.0	58.3
Total	**3.0**	**514.2**

Source: Powell River Regional District, BC Assessment, GeoBC
Note: EA A, B, C - Open Space includes forests, parks, resource, and reserves
City, EA D, and EA E – Parcels without a building value or without associated BC Assessment data assumed open space
NA = Parcel and land use data is not available for the Tla'amin Nation

Beaches and beach access points are another critical environmental asset for the Region as they provide public access to the water from the road. Of the 22 identified access points, 21 are located within the coastal flood hazard areas except for the Julian Road point on Savary Island.

The Tla'amin Nation is located just north of the City of Powell River, along Highway 101. The majority of the community lives in the main village of Sliammon located on the Strait of Georgia. There is a waterfront park located on First Nation land that is located in the coastal flood hazard area. In addition, there are archaeological and historical sites important to the Tla'amin Nation that may be located along the coast and potentially vulnerable to future coastal flood hazard events. Due the sensitive nature of this data, their specific locations were not included in the spatial risk assessment.

9.0 DISCUSSION

9.1 General

When modelling SLR alone, potential exposure and impacts may likely underestimate the area inundated or permanently submerged because the model does not account for waves, storm surge and coastal erosion that increase the extent of hazard areas and potential loss. For this reason, SLR was evaluated with high tides, and then also coupled with high tide and event-based coastal flooding scenarios to provide a more comprehensive picture of the extent of hazard exposure for the region.

It should be noted that the potential exposure and loss estimates reported do not encompass the full loss potential in the region. Collateral monetary losses that will occur from coastal flooding of transportation assets, utilities and other public infrastructure were not analyzed in this report and may amount to an order of magnitude greater than the potential economic losses from buildings. For example, 19 to 29 km of major roads are inundated across the PRRD including portions of both the main highway (HWY 101) and paved and loose roadways for the four 200-year events. Utilities such as water, wastewater and electrical systems often run parallel and underneath roadways making the identification of vulnerable roads a good indication of potentially vulnerable utility infrastructure as well.

The potential loss to invaluable environmental and cultural resources is even more challenging to quantify. Flooding can cause a wide range of environmental impacts including but not limited to erosion and loss of vegetation and habitats. Moreover, floods may generate large amounts of tree and construction debris, disperse household hazardous waste into the fluvial system, and contaminate water supplies and wildlife habitats with extremely toxic substances.

Many of the region's environmental assets are located along the coast and are exposed to coastal flood hazard events including beaches and regional parks. In addition, there are archaeological and historical sites important to the Tla'amin Nation that may be located along the coast and potentially vulnerable to future coastal flood hazard events. Due the sensitive nature of this data, their specific locations were not included in the spatial risk assessment.

9.2 Findings from Risk Analysis

The following provides the key findings for each coastal flood hazard scenario evaluated. Refer to Figures 14 to 24 which depict the location of identified assets relative to the composite hazard area. For each scenario, five valuations are presented: the number of buildings inundated, the replacement cost for structures and contents of the building stock in the affected areas; the amount of damage that the building stock would sustain; the damage to assets in the assets inventory, and the length of roadway projected to be inundated. Details of these valuations can be found in Appendix E, in particular Tables E-8, E-10, E-11, and E-12.

9.2.1 High-Tide and SLR

The high tide and sea level rise scenario depicts the anticipated high tide flood inundation that the PRRD may anticipate by the year 2050. The projected area of inundation is not associated with a storm event but the annually occurring highest tide, and may lead to permanent inundation. Figures 25 to 35 depict the projected inundation area and total exposure value of buildings located in the hazard area.

- High tide flooding will increase with SLR and is projected to impact the population, structures and assets near the coastline.
- Based on this analysis, there are five (5) structures in Electoral Areas A, C and D with a combined replacement cost of nearly $900,000 exposed to high tide and 0.5 meters of SLR by 2050.

- There are 54 assets, all of which are identified as critical, located in the high tide/SLR inundation area.
- An estimated 1 km of roadway (HWY 101, paved and loose roadway) may become permanently inundated jeopardizing critical access to communities and assets in the region.

9.2.2 High-Tide, 200-Year Surge and Waves (Southeast)

The southeast storm event scenario provides an understanding of projected inundation that may result from a southeast storm during high tide. Two southeast storm events were assessed; one of which included sea level rise as projected for the 50-year time horizon.

- Scenario without SLR: Figures 36 to 46 depict the projected inundation area and estimated potential loss to buildings.
  - There are an estimated 446 buildings located in the 200-year surge and waves at high tide projected hazard area. These buildings represent a replacement cost exceeding $200 Million for structures and contents.
  - Estimated loss to exposed buildings resulting from wave velocity and flood depth is $115 Million.
  - There are 90 assets located in the projected inundation area and exposed to this event. Of the 90 assets, 37 are identified as critical located in the City, and Electoral Areas A, C, D, and E. This equates to nearly $500 Million in potential loss with the greatest loss in Electoral Area D.
  - There is an estimated 25 km of roadway projected to be inundated with flood waters.
- Scenario with SLR: Figures 47 to 57 depict the projected inundation area and estimated potential loss to buildings.
  - There are an estimated 504 buildings located in the projected SLR hazard area. These buildings represent a replacement cost exceeding $215 Million for structures and contents; approximately $15 Million more than the same scenario that does not account for SLR.
  - Estimated damage to exposed buildings resulting from wave velocity and flood depth impacts is nearly $145 Million.
  - There are 92 assets located in the projected inundation area and exposed to this event. Of the 92 assets, 37 are identified as critical located in the City, and Electoral Areas A, C, D, and E. This equates to nearly $500 Million in potential loss with the greatest loss in Electoral Area D.
  - There is an estimated 29 km of roadway projected to be inundated with flood waters.

9.2.3 High-Tide, 200-Year Surge and Waves (Northwest)

The northwest storm event scenario provides an understanding of projected inundation that may result from a northwest storm during high tide. Two northwest storm events were assessed; one of which included sea level rise as projected for the 50-year time horizon.

- Scenario without SLR: Figures 58 to 68 depict the projected inundation area and estimated potential loss to buildings.
  - There are an estimated 335 buildings located in the projected 200-year surge and waves at high tide hazard area. These buildings represent a replacement cost exceeding $147 Million in structure and contents.
  - Estimated damage to exposed buildings resulting from wave velocity and flood depth impacts is $77 Million.

- There are 86 assets located in the projected inundation area and exposed to this event. Of the 86 assets, 37 are identified as critical located in the City, and Electoral Areas A, C, D, and E. This equates to nearly $187 Million in potential loss with the greatest loss in Electoral Area D. There is an estimated 18 km of roadway projected to be inundated with flood waters.

- Scenario with SLR: Figures 69 to 79 depict the projected inundation area and estimated potential loss to buildings.
  - There are an estimated 391 buildings located in the projected hazard area that includes SLR. These buildings represent a replacement cost exceeding $185 Million in structure and contents; approximately $38 Million more than the same scenario that does not account for SLR.
  - Estimated damage to exposed buildings resulting from wave velocity and flood depth impacts is nearly $165 Million.
  - There are 88 assets located in the projected inundation area and exposed to this event. Of the 88 assets, 37 are identified as critical located in the City, and Electoral Areas A, C, D, and E. This equates to nearly $515 Million in potential loss with the greatest loss in Electoral Area D.
  - There is an estimated 20 km of roadway projected to be inundated with flood waters.

9.3 Key Areas of Concern

After evaluating the risk analysis results, the PRRD identified criteria for prioritization of areas that will require a more detailed assessment and identification of mitigation measures to reduce future loss. An inventory of critical assets in the study area was developed as part of this study. To further rank the criticality or importance of each asset, a numeric value of 1 to 3 was assigned to each (refer to asset inventory tables at end of Appendix E). A numeric value of 1 was assigned to a critical asset if it was determined that this asset must continue to operate before, during and after an emergency or hazard event; a numeric value of 2 was assigned to a critical asset if the asset contains a building and/or infrastructure, is a location with vulnerable population or is critical to mobilization in the region; and a numeric value of 3 was assigned to a critical asset, if the asset provides a recreational function that contributes to the local economy (e.g., parks).

It was decided that the high tide and SLR scenario and critical assets within this projected inundation area are of highest priority for further evaluation. This is because the high tide and SLR scenario is the most probable scenario and may lead to permanent inundation over time. A grid with two kilometre spacing was overlaid in the study area and grid squares were color coded to identify priority areas (refer to Figure 81, Figure 82 shows the same information including asset locations). The following prioritization criteria were applied and their associated vulnerability rating noted in parentheses which is reported in the asset inventory tables at end of Appendix E:

- Highest (1) – If at least one asset with an ‘importance rating of 1’, or a portion of roadway is located in the high tide and SLR scenario inundation area, the 2-square kilometre grid square is identified as a highest priority area (depicted as a red square in Figure 81).
- High (2) – If at least one building, or an asset with an ‘importance rating of 1 and 2’ is located in a storm scenario inundation area, the 2-square kilometre grid square is identified as a high priority area (depicted as an orange square in Figure 81).
- Significant (3) – If at least one asset with an importance rating of 3 is located in the storm scenario inundation area, the 2-square kilometre grid square is identified as a significant priority area (depicted as a yellow square in Figure 81).

Note that areas deemed of highest priority may contain other assets or buildings that fall within the high and significant criteria listed above. Further, the significant priority grid squares do not contain buildings or assets with an importance rating of 1 or 2 located in the composite hazard area.

The following summarizes the assets and buildings located in the prioritized areas:

- There is a total of 28 assets and approximately 1 km of roadway located in the highest priority areas.
- There is a total of 34 assets (9 assets with an importance rating of 1 and 24 assets with an importance rating of 2) in the “high” priority areas. Additionally, there are 558 buildings with an estimated replacement cost value of approximately $230 million located in the high priority areas.
- There is a total of 12 assets located in the significant priority areas.

9.4 Key Transportation Concerns

While part of the mainland, the PRRD is inaccessible by road from the lower mainland and is dependent on boats, water taxis, ferries, barges and air travel for trips to the islands and out of the region. The major artery through PRRD is the Sunshine Coast Highway (HWY 101), which runs parallel to the coastline. In 2012, the average annual daily traffic count for Highway 101 was 874 vehicles per day (ISL 2014).

When examining impacts to the highway resulting from high tide and sea-level rise alone, there is one section at the end of the highway in Lund that is anticipated to become inundated (0.02 km in length). As a result of the projected storm events, five main areas of the highway may become inundated by as depicted in Figure 80 and described below.

- Section of road and the Lang Creek Bridge near the intersection of the highway and Brew Bay Road in Brew Bay;
- Section of road approximately 3 km south of the City;
- Section of road approximately 1 km south of the Westview Ferry Terminal in the City;
- Section of road at the end of the highway in Lund; and
- Section of road at the end of the highway in Saltery Bay.

Functioning transportation infrastructure is not only important for every day travel, but critical during the response and recovery phases of a flood event. Any disruptions to major transportation assets can result is serious complications for emergency responders and those evacuating an impacted area. Further, evacuation protocols, including specific routes and identified exits, are essential to help avoid confusion and prevent injuries during an event.

To evacuate flooded areas on the island communities, populations must either travel to higher ground or utilize marine transportation (boats, ferries) and assets along the shore (such as docks and boat ramps) to evacuate to the mainland. Strong waves and surge may generate unsafe conditions for ferries and boats traversing the waterway from the islands to the mainland. Waves crashing on the docks and ramps have historically damaged and destroyed these assets as a result of coastal flood and storm events. There are seven ramps along the mainland coast at risk to such impacts.

As reported by Mr. Gregg Clackson, Director of Operations and Security Center at BC Ferry, delays or cancellations of service are mostly due to high winds; service resumes after several hours and the storm system passes. BC

Ferry assets in Powell River are above sea level with a new floating dock and trestle. At times, water may reach the terminal and puddles but it drains away and customers are diverted around the flood waters.

Air rescue is an option for stranded populations on the islands if the use of a boat is not possible and there is access to a landing spot for a helicopter. For the region, six helipads are located in the coastal hazard area; three along the mainland coast and three on Texada Island.

9.5 Confidence Assessment

This assessment is a snapshot in time based on the best available data and level of funding available to conduct this screening assessment. Climate science including SLR and technology are continuously evolving and their advances should be integrated into future assessments. Utilizing the confidence levels outlined in the NDMP Risk Assessment Information Template (RAIT), the risk assessment conducted is given a moderate degree of confidence. The following outlines the major assumptions and limitations of the data and models used to conduct this assessment.

- Data Gaps:
  - Lack of high-resolution topography data in some parts of the study area (such as Saltery Bay and Lasqueti Island) limit the degree of spatial detail possible in the wave modelling, wave run-up and subsequent spatial analyses.
  - Lack of detailed bathymetry data for modelling of coastal hazard processes.
  - Lack of detailed shoreline data (bathymetry, topography, geological composition, groundwater conditions) to estimate shoreline retreat inland due to erosion and slope instability.
  - Uncertainties in the vertical datums associated with the topographic contours provided by PRRD translate to corresponding uncertainties in the extents of hazard areas in those areas. These uncertainties were on the order of a metre in some locations, due to the 2-m vertical resolution of the data.
  - Building footprints were not available with the parcel data so building locations were approximated.
  - BC Assessment data was not available for the Tla'amin Nation so building locations were approximated manually using publicly available satellite imagery.
  - Further, several structural attributes were not available to more thoroughly and accurately estimate potential losses to structures. This includes the following: construction type; foundation type; first-floor elevation.
  - Economic value data was not readily available for roads, transportation assets, utilities and other public infrastructure and requires a more in-depth level of analysis. Therefore, potential economic losses on critical infrastructure was not monetized.
  - A spatial inventory of mitigation structures in place, and their protection level, does not currently exist. The BC Water Resources Atlas lists a number of dams (e.g. Powell River Dam retaining Powell Lake), but no flood protection or dyke structures are shown within the study area. Best available information has been compiled for this study (see Section 4.3.7), however a formal inventory does not exist.
  - Environmental and cultural assets such as beaches and wetlands were not monetized due to the complexity in valuing ecosystem systems and their cascading contribution and potential impacts to the local economy.
  - The asset inventory developed for this study is incomplete, in particular archeological sites near the shoreline are missing. From conversation with the Tla'amin we understand that the provincial archeology inventory is incomplete as well. Further, the Sechelt First Nation may know of further archeological sites.

- Assumptions and Limitations:
  - Changes in shoreline location due to coastal erosion are not included in this modelling.
  - The modelling does not account for future (unknown) land use changes including mitigation or adaptation measures.
  - The coastal flooding model does not explicitly include flooding through stormwater infrastructure which could contribute to flooding along the coastline.
  - The potential impacts from SLR alone was not monetized, only an exposure assessment was conducted.
  - The coastal flooding model does not account for crustal uplift that would counteract SLR to some degree.
  - To estimate the population exposed to the coastal flood scenarios, the flood hazard boundaries were overlaid upon the 2016 Census population data in GIS. Census blocks are not consistent with boundaries of the floodplain, and gross overestimate or underestimate of exposed population can occur via use of the centroid or intersect of the Census block with these zones. Limitations of these analyses are recognized, and thus results are used only to provide a general estimate for planning purposes.
  - The evaluation of population exposed to the coastal flood scenarios does not account for the seasonal fluctuations in population totals, or the population that utilizes the roadways through the study area.
  - The total potential impacts to PRRD are underestimated as economic value data was not available or calculated as part of Stream 1. This includes potential impacts to transportation infrastructure, utilities and environmental assets. Further, macro-economic impacts to tourism and the real estate market resulting from flooding over time were not analyzed.

10.0 CONCLUSIONS

This study is a scoping level coastal risk assessment, intended to provide an initial screening for hazard areas, vulnerabilities and consequences that require more detailed assessment. The following conclusions are drawn:

1. **Historic events**: In total 16 historic coastal risk events were identified and documented. From this inventory it is obvious that coastal hazards pose a real and significant challenge to the community and local governments within the study area.

2. **Storm Impacts on Ferry Services**: Transportation in and out of the community depends heavily on BC Ferries Services. In the past 10 years cancellations of BC Ferry service between Comox and Powell River due to wind and storm events occurred about 40 times per year on average, ranging as high as 85 times per year.

3. **Coastal Erosion**: Coastal erosion hazard has been expressed as length of shoreline with low or high erosion potential. The study area includes about 565 km shoreline length in total and up to 2/3 thereof were ranked at high erosion potential. The highest percentage of shoreline ranked at high erosion potential are the lands of the Tla'amin Nation (100%) followed by the City of Powell River (96%). Shorelines most at risk are composed of glacial deposits lacking a source of sediment and sedimentary rock cliffs and bluffs subject to wave action. In general, hard rock coastal zones are at the least risk from coastal erosion. The entire coastline of Savary Island is at risk of ongoing erosion and is particularly vulnerable to SLR due to its low topography and sandy shorelines. With the exception of its northern, generally rocky, coast the entirety of Hernando Island is at risk of coastal erosion, particularly as sea levels rise.

4. **Risk Assessment**: The worst scenario assessed in this study is 'High Tide, and 200-Year Surge and Waves (Southeast), and 0.5 m SLR (in 50 years), with a total of 408 people exposed. In terms of damage, the same scenario results in 504 buildings exposed with a total replacement cost exceeding $215 Million for structures and contents, as well as 37 critical, 22 commercial, 1 cultural and 32 other regional assets exposed with nearly $500 Million potential loss. As a result of the projected storm events, five main areas of Highway 101 may become inundated.

5. **Need for detailed coastal risk assessment and mapping**: Previous assessments related to coastal hazards in the study area are not detailed enough for planning or mitigation design purposes. They are also outdated. This study identified shorelines with high erosion potential. It further identified assets exposed and potentially vulnerable to coastal flood events, whether from chronic flooding (high tide and SLR) or event-based flooding from storm events. More detailed hydrologic and engineering modelling and mapping is necessary to assess impacts at the scale of individual properties and infrastructure.

6. **Need for coastal hazard specific planning policies:** This study demonstrates that coastal hazards are a real threat to the community. There is a strong need to develop planning policies specific to coastal hazards in the jurisdictions of the PRRD and the City of Powell River. Policies should follow the latest guidelines and best practices. The Tla'amin Land Use Plan specifically addresses coastal hazards, however it explicitly points out the need for a detailed study to delineate coastal hazard areas.

11.0 RECOMMENDATIONS

Coastal Risk Assessment:

1. Secure funding for a detailed coastal risk assessment. Inquire with NDMP about exact funding intake deadlines for NDMP Stream 2 applications (expected late summer early fall 2018).

2. Conduct a detailed coastal risk assessment. The detailed assessment should follow the latest guidelines listed under References at the end of this report. It should focus on:

    a. Areas and assets exposed and potentially vulnerable to coastal flood events as well as shorelines identified with high erosion potential. Figure 81 at the end of this report highlights these areas to assist with prioritizing next steps.

    b. Gaps identified in Section 9.2 should be addressed by collecting more information and data:

        i. Detailed bathymetry and topography surveys as well as geological mapping should be carried out for shorelines with high erosion potential. For erodible beaches, geological investigation of the back beach areas, which would be subject to erosion under SLR conditions, should be carried out.

        ii. Crustal uplift rates should be determined for the study area and included in the detailed assessment.

        iii. Update and enhance the asset and building inventories to include missing building attributes (e.g., foundation type, first floor elevation and more accurate replacement cost values) to enable a more detailed economic loss impact assessment (for entire study area, but in particular for Tla'amin Nation where no information was available). The collection of additional data may include field surveys and outreach to property owners with assets in the identified hazard areas.

        iv. The Tla'amin and Sechelt First Nation should be consulted on how archeological sites could be considered in the detailed study.

        v. Map existing shoreline hardening and other mitigation measures, document their remaining life cycle and their current protection level to identify areas that are or will become more vulnerable to the coastal flood hazard.

    c. More detailed hydrologic and engineering modelling and mapping at a higher resolution to assess impacts at the scale of individual properties and infrastructure assets. A SLR planning horizon for the year 2100 (with anticipated 1 m of SLR) should be considered. Spatially uniform tides across the study area were applied in this analysis; for the detailed coastal risk assessment we recommend that side specific tides are considered.

    d. Gardner (2007) assessed the threat of a tsunami originating in the Pacific Ocean and to a lesser detail within the Strait of Georgia and recommended that the Regional District keeps abreast of new scientific developments. The detailed coastal risk assessment should review the latest research findings and in particular verify that inundation from a tsunami originating within the Strait of Georgia is less than the inundation resulting from storm scenarios considered.

e. Expand the risk assessment to include a more detailed economic impact loss analysis:

   i. Evaluate the value of land and structures that may become permanently lost for each projected SLR height over time providing an understanding of anticipated lost tax base.

   ii. Work with public and private entities to evaluate potential losses to critical infrastructure and assess cascading impacts to the PRRD.

   iii. Evaluate the macro-economic impacts (e.g., tourism or the real estate market) resulting from flooding and SLR.

f. Public outreach and engagement should be undertaken to raise awareness of the risks posed by the coastal hazards identified in this Overview Coastal Risk Assessment.

g. The Sechelt First Nation owns land within the study area, at the mouth of the Eagle River east of Brew Bay. This report should be shared with the Sechelt First Nation and they should be consulted to provide input for the detailed coastal risk assessment.

3. Establish development policies specific to coastal hazard areas. Note that hazard areas will change over time (e.g. through SLR) and need to be updated periodically, based on latest guidelines, science and information available.

4. The 'Sea Level Rise Adaptation Primer – A Toolkit to Build Adaptive Capacity on Canada's South Coasts' (Arlington Group et al. 2013), should be considered for SLR adaptation strategies.

5. Partner with provincial and private entities (e.g. MOTI, BC Ferries, private marine operators) to conduct a vulnerability assessment focused on transportation and utility infrastructure, and recommend mitigation or adaptation measures where necessary.

6. The PRRD and MOTI are working on a Stormwater Management and Drainage Study. Findings thereof as well as from this Overview Coastal Risk Assessment should be evaluated jointly, to; 1) determine if there are overlapping high priority areas identified for mitigation, and 2) identify feasible mitigation project alternatives to address both stormwater and coastal flooding.

Coastal Risk Management

7. Develop a systematic documentation procedure for coastal flood events impacts to improve coastal risk management with site-specific evidence.

8. Evaluate the feasibility of living shorelines for areas where current measures are failing and protection is needed to dissipate the energy of wave action and protect assets.

9. Develop an all-hazards risk management plan that defines how the PRRD integrates results of existing studies, identifies and documents mitigation and adaptation strategies for the region, prioritizes the measures and identifies potential funding sources to implement. A maintenance component should be included recognizing the evolving nature of climate science and technology and the implementation of mitigation and adaptation strategies changing the PRRD vulnerability over time.

Emergency Management

10. Update emergency response plans considering findings of this study. An update may be required once a detailed coastal risk assessment is completed. Impacts of coastal hazards on emergency response roads and ferry infrastructure need to be accounted for.

11. Consider developing a coastal flood warning and response plan.

12. Develop a debris management plan (e.g. removal of debris after storm events).

13. Validate the PRRD Emergency Plan by conducting training and exercises to enhance existing response capabilities.

12.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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Publicly available water level (tide) data from Fisheries and Oceans Canada recorded at the following stations (years of record): Lund (1), Powell River (8), Blubber Bay (1 month), Welcome Bay (1), Saltery Bay (1), False Bay (2), Irvines landing (1), Halfmoon Bay (2), Northwest Bay (1), Porpoise Bay (1), and Point Atkinson (77).

Publicly available wave data from Fisheries and Oceans Canada recorded at the following stations (years of record): Lund (1), Powell River (0.25), and Halibut Bank (26).

Shorezone data set: combination of BC and Washington coastlines, assembled by John Harper for Tetra Tech.

Data from the iMap BC portal – those sources were either GeoBC or Environment Canada.

Spatial data provided by PRRD, City of Powell River, Tla'amin Nation and Islands Trust.

FIGURES

Figure 1. Area of Study - Powell River Regional District

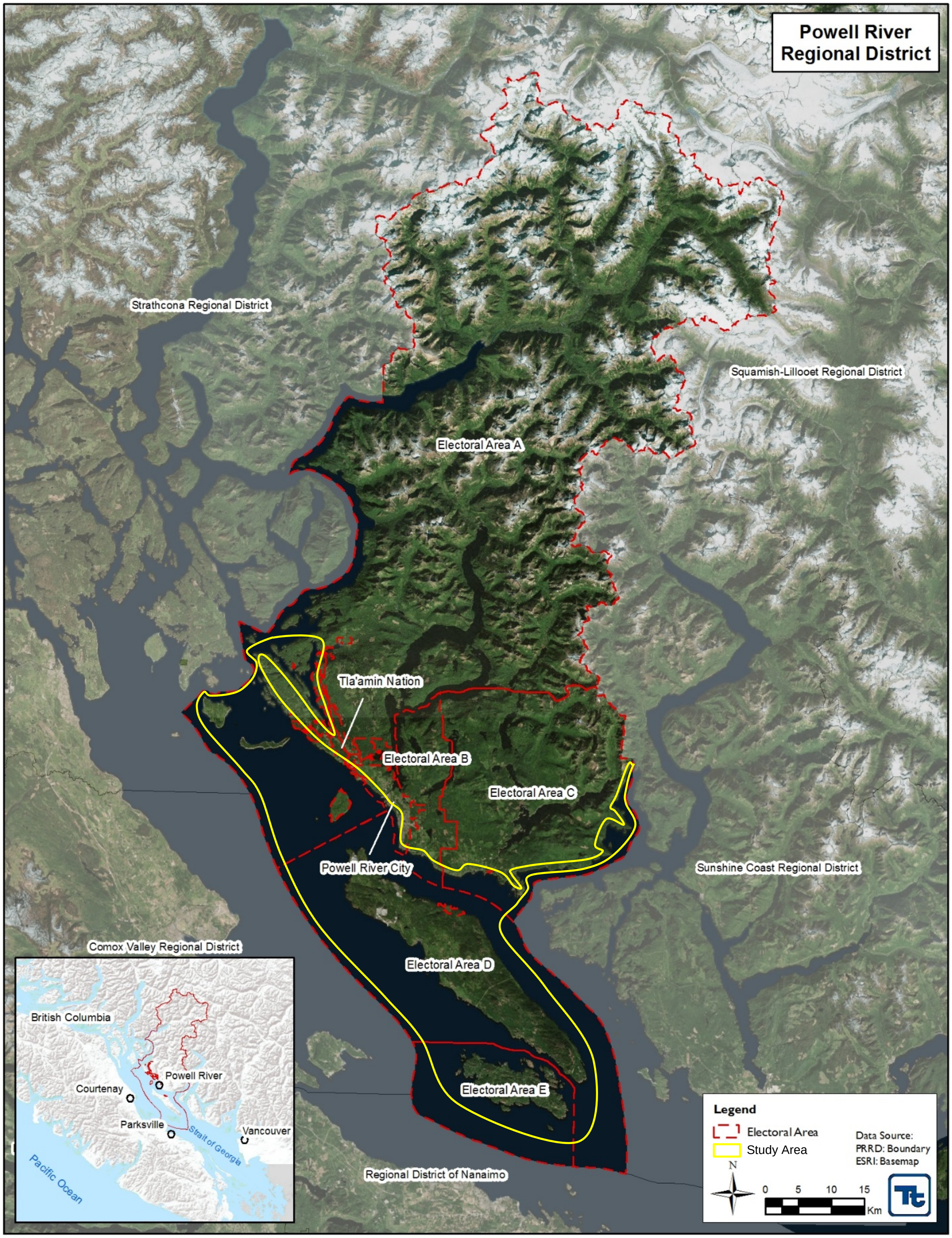


Figure 2. Index Map showing the location for Individual Grid Area Maps

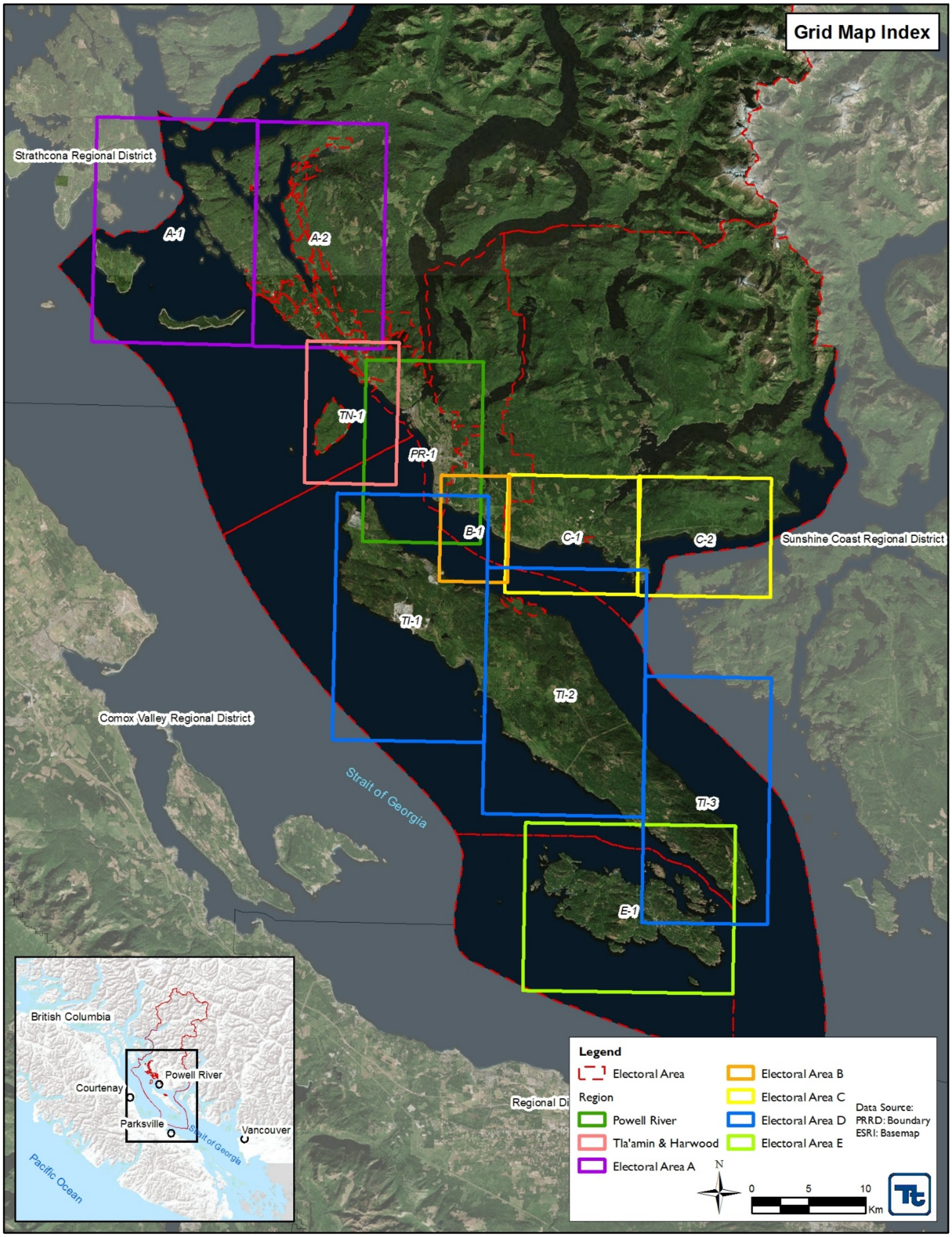


Figure 3. Grid Map A-1 with Potential Susceptibility to Coastal Erosion

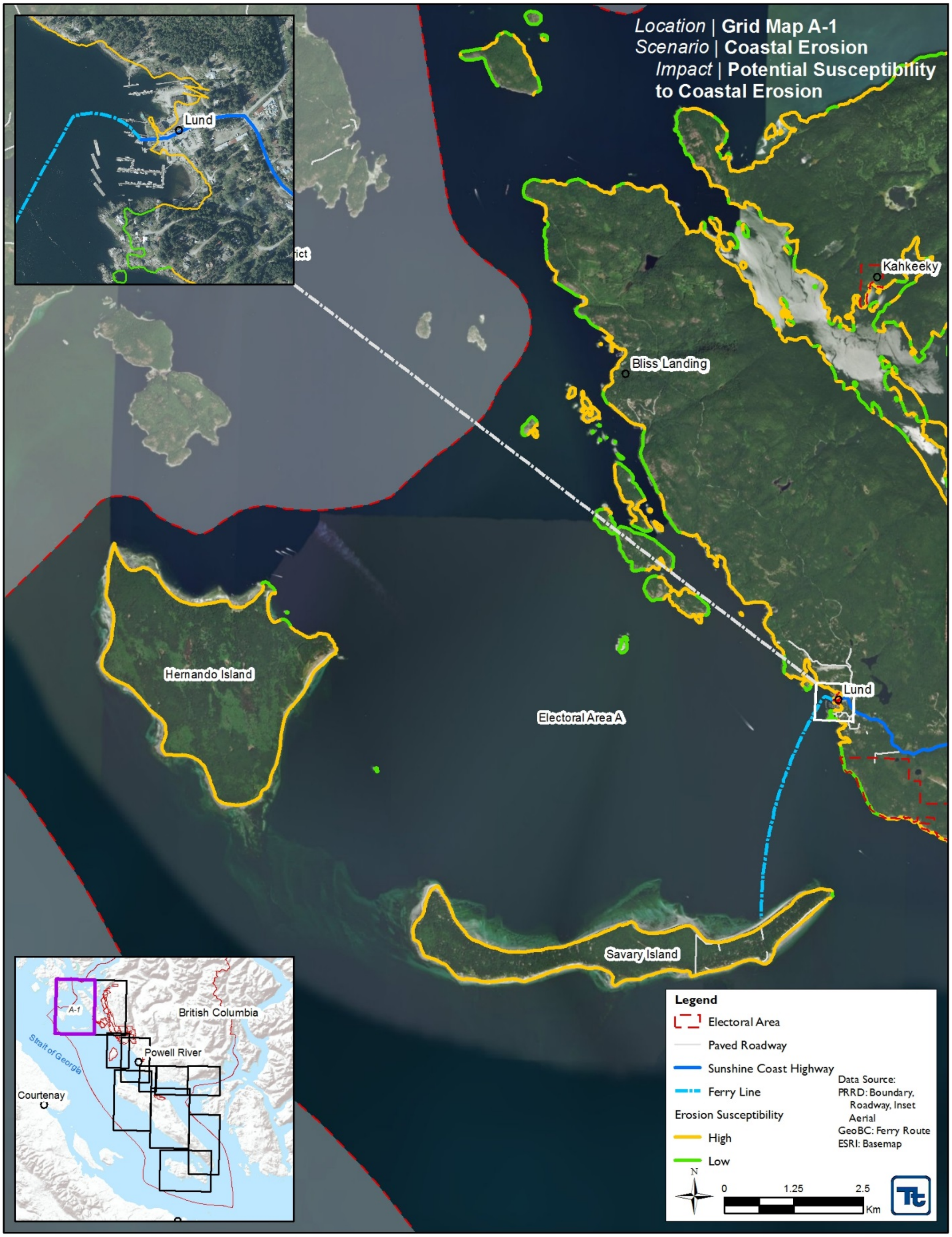


Figure 4. Grid Map A-2 with Potential Susceptibility to Coastal Erosion

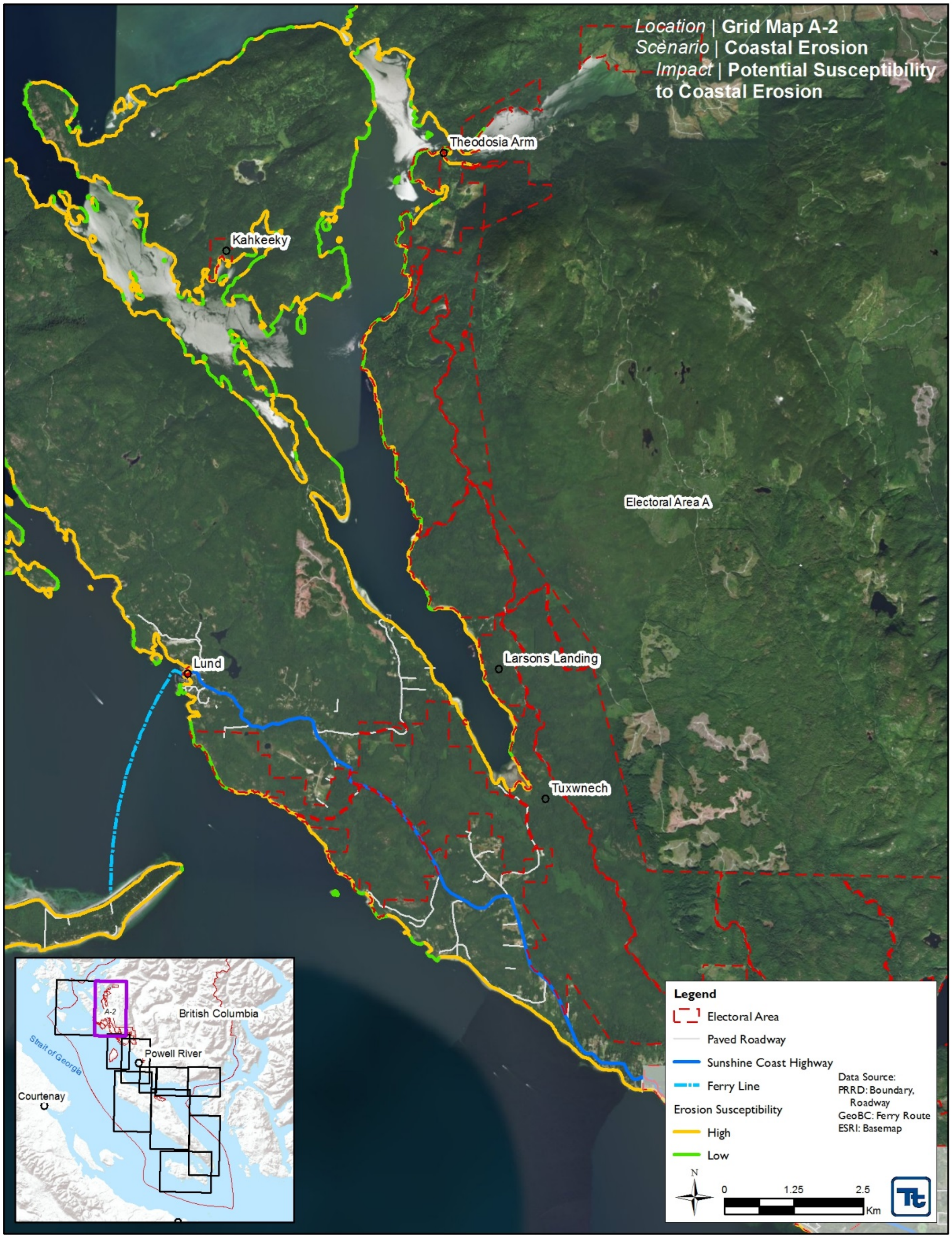


Figure 5. Grid Map B-1 with Potential Susceptibility to Coastal Erosion

Figure 6. Grid Map C-1 with Potential Susceptibility to Coastal Erosion

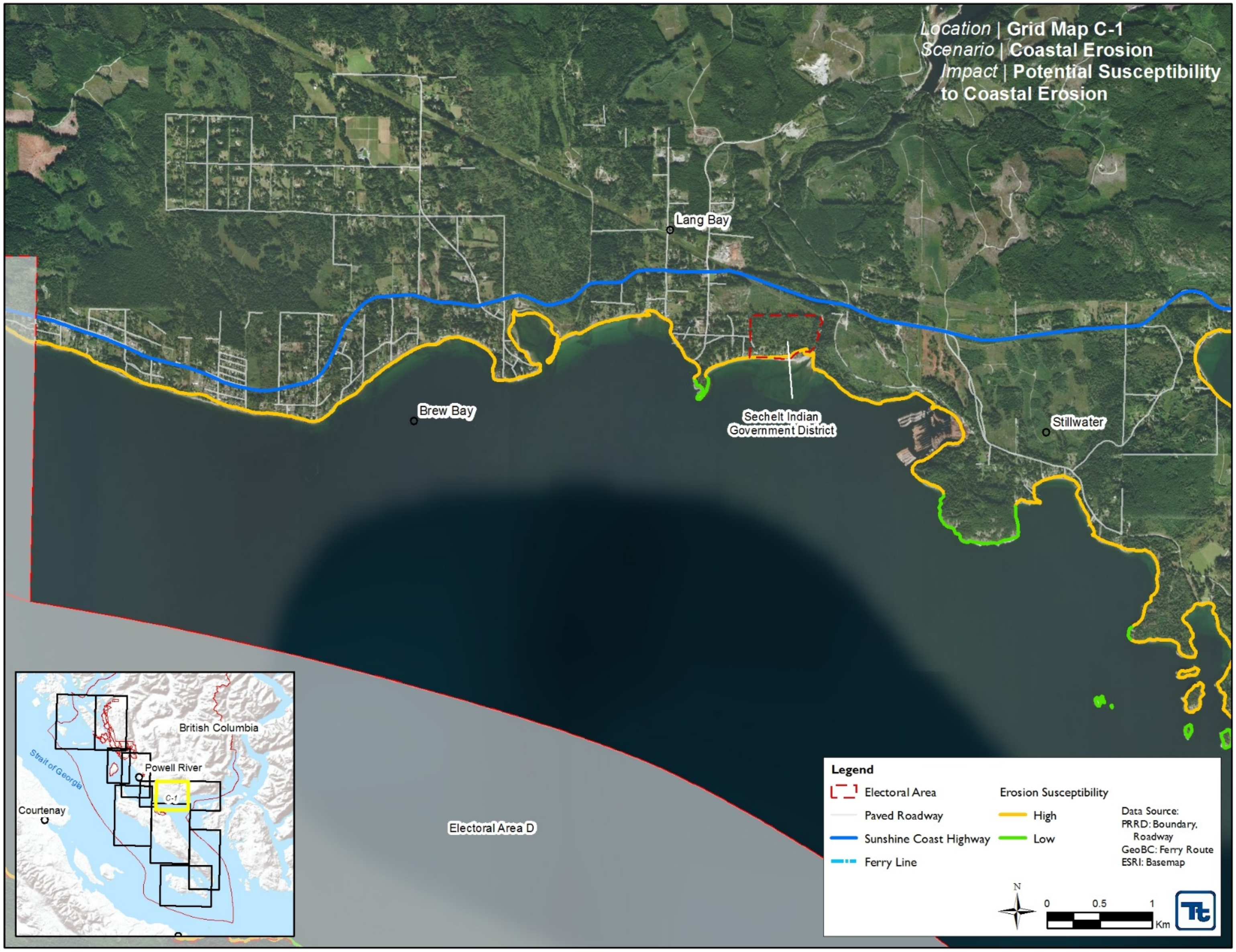


Figure 7. Grid Map C-2 with Potential Susceptibility to Coastal Erosion

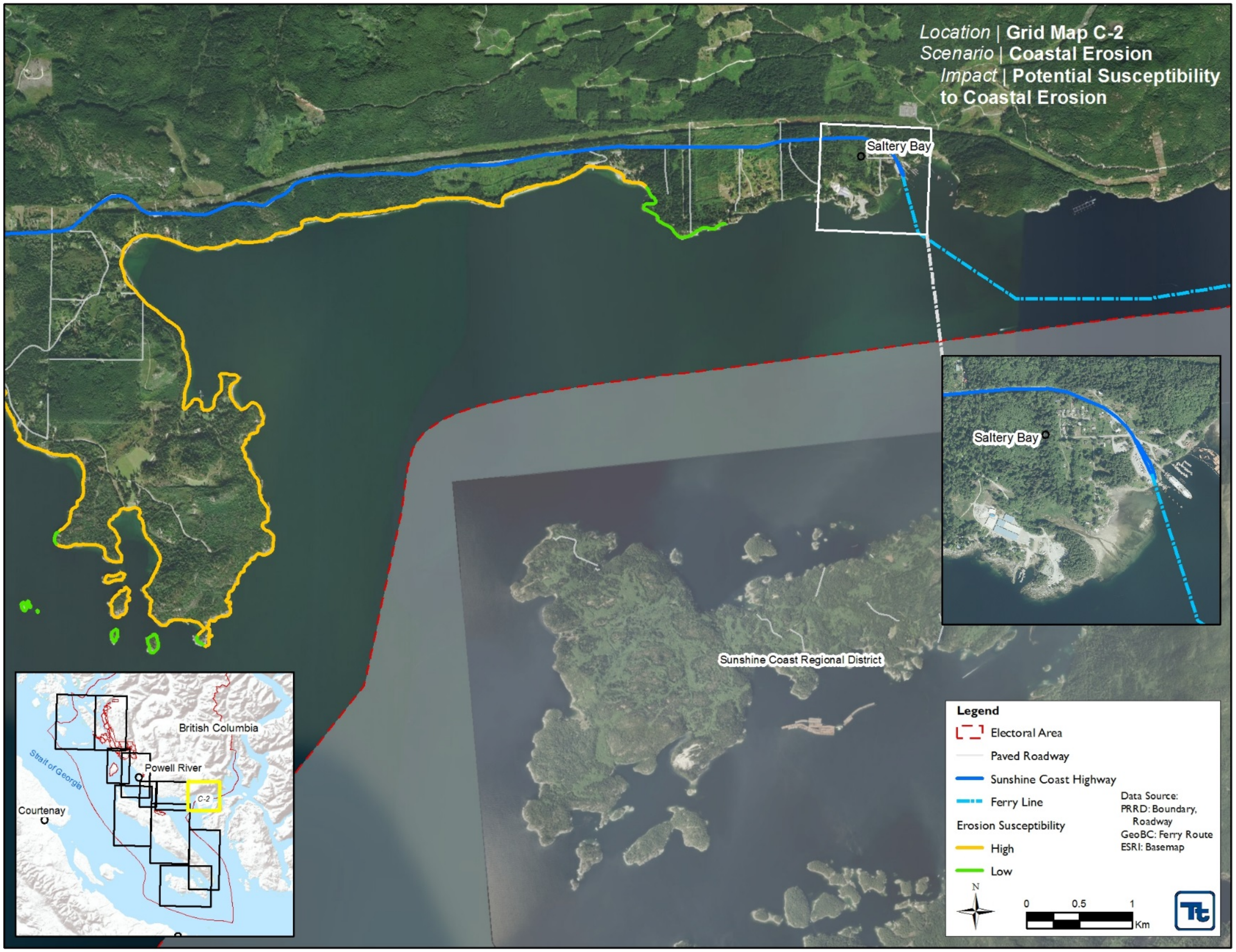


Figure 8. Grid Map E-1 with Potential Susceptibility to Coastal Erosion

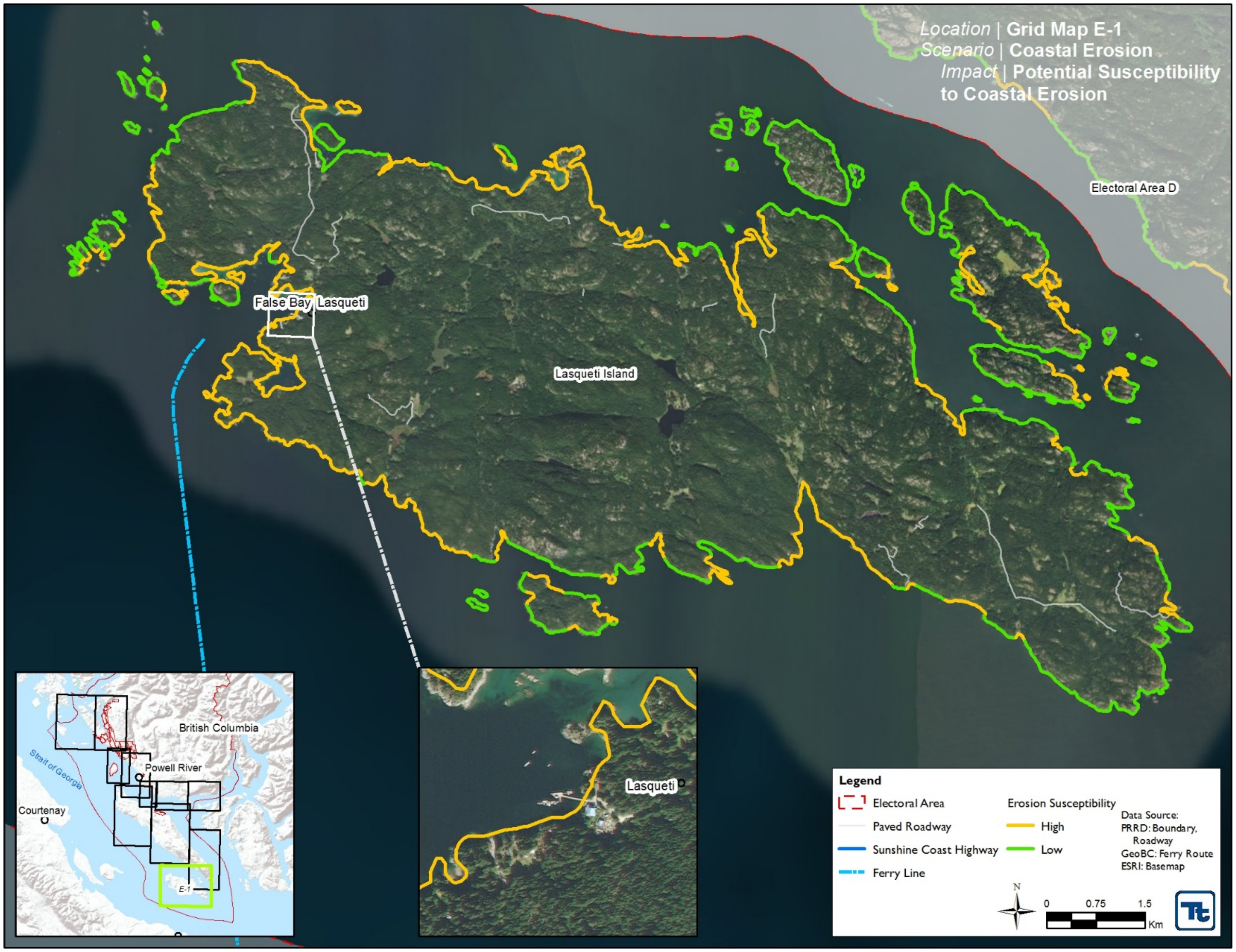


Figure 9. Grid Map PR-1 with Potential Susceptibility to Coastal Erosion

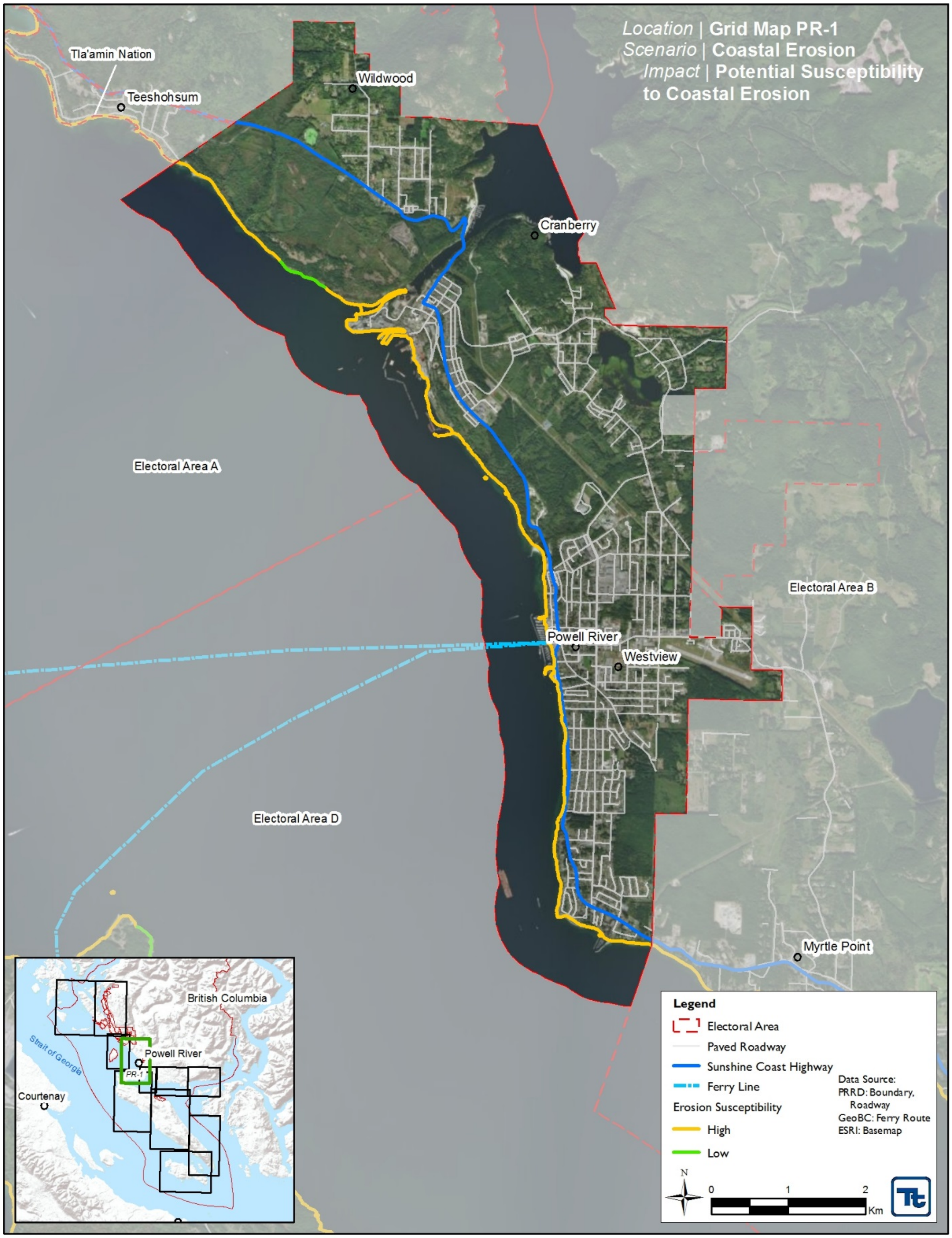


Figure 10. Grid Map TI-1 with Potential Susceptibility to Coastal Erosion

Figure 11. Grid Map TI-2 with Potential Susceptibility to Coastal Erosion

Figure 12. Grid Map TI-3 with Potential Susceptibility to Coastal Erosion

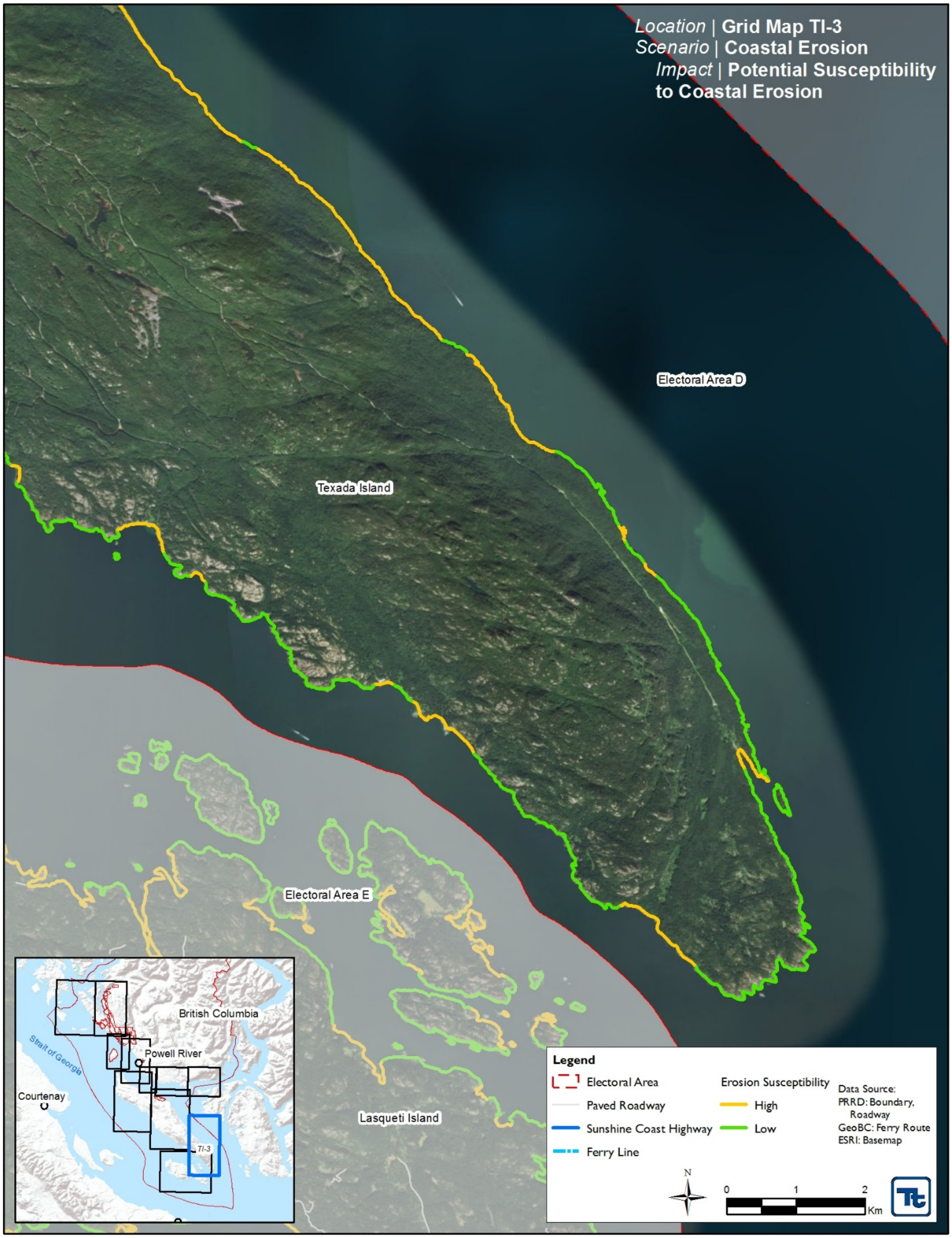


Figure 13. Grid Map TN-1 with Potential Susceptibility to Coastal Erosion

Figure 14. Grid Map A-1 with Composite Hazard Area and Regional Assets

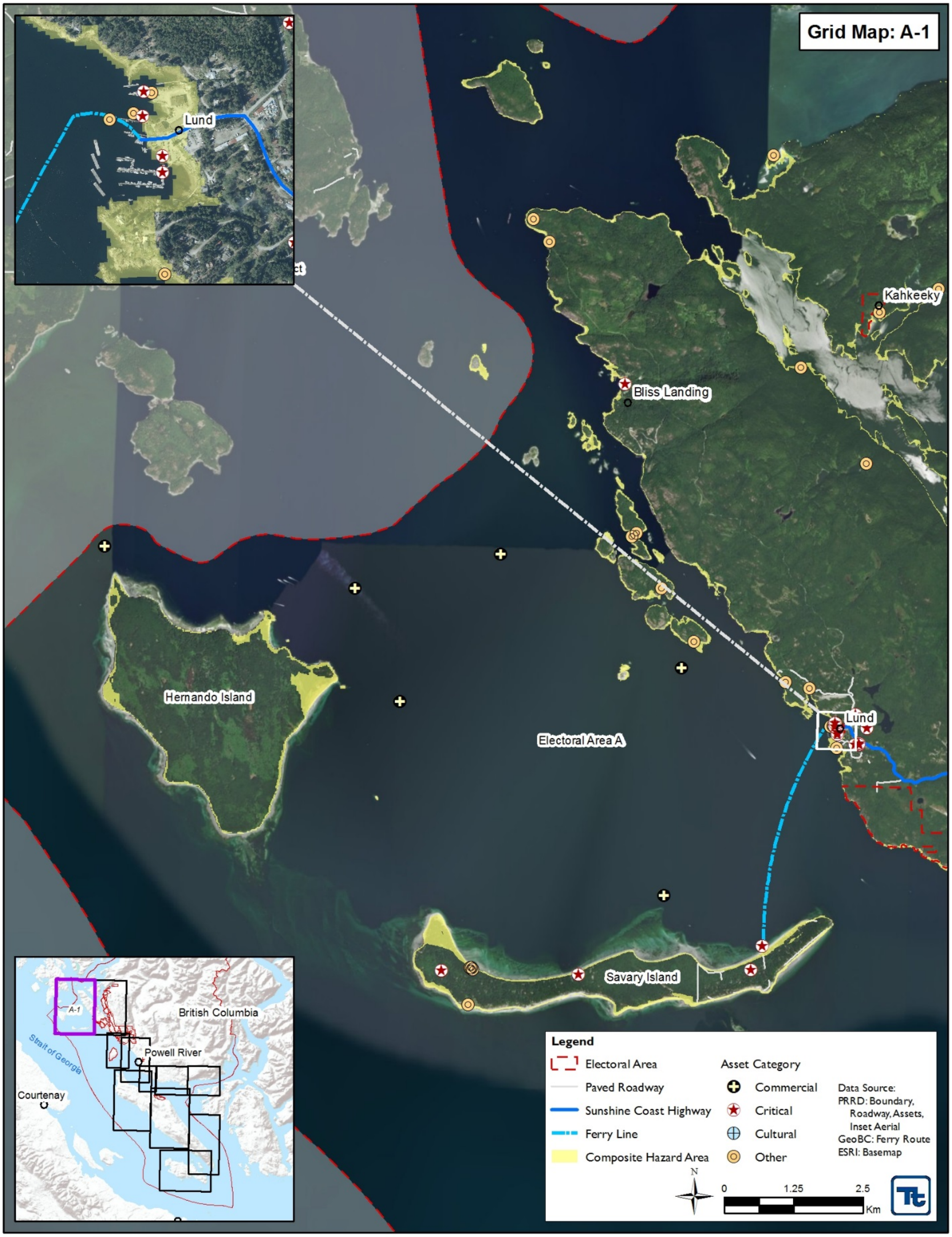


Figure 15. Grid Map A-2 with Composite Hazard Area and Regional Assets

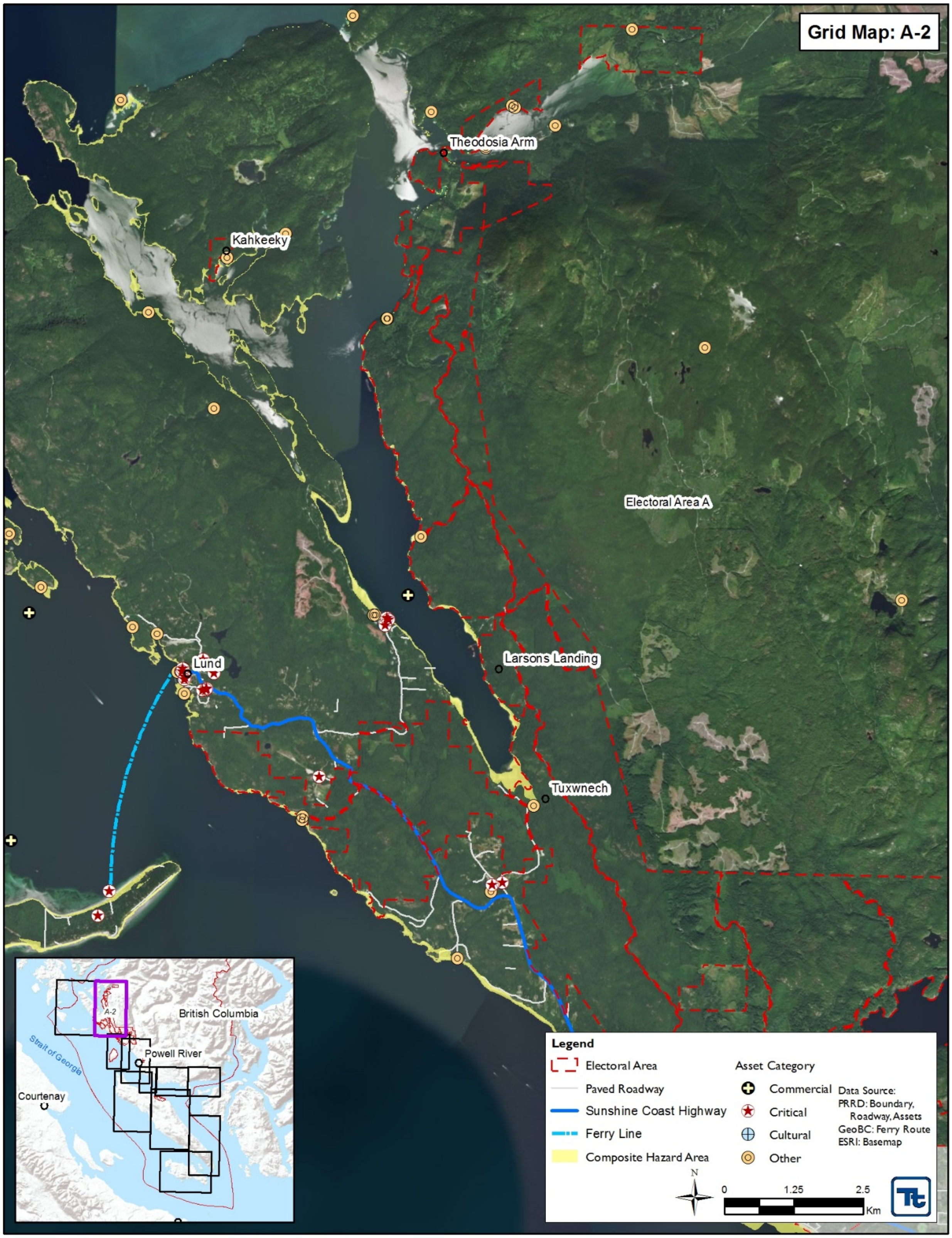


Figure 16. Grid Map B-1 with Composite Hazard Area and Regional Assets

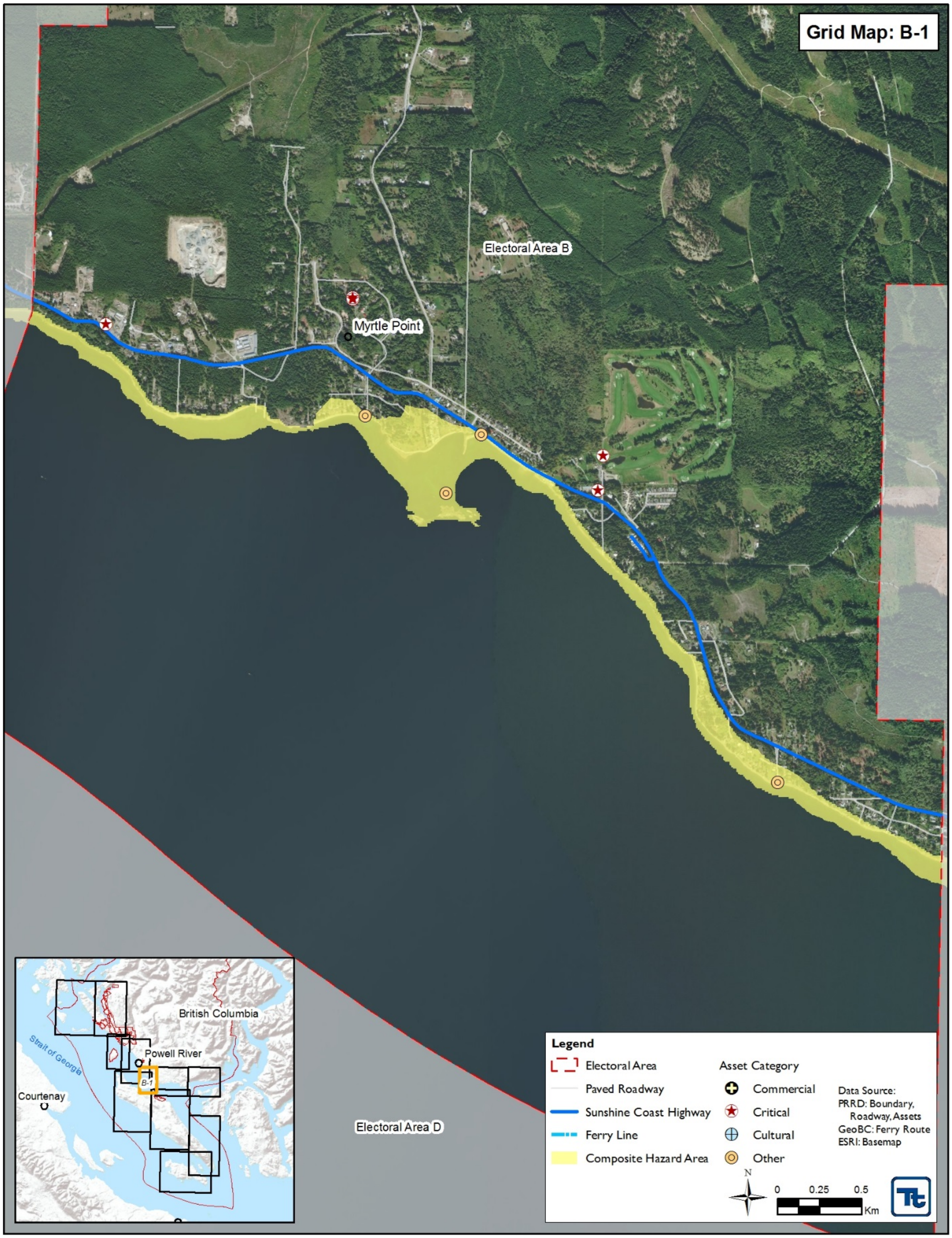


Figure 17. Grid Map C-1 with Composite Hazard Area and Regional Assets

Figure 18. Grid Map C-2 with Composite Hazard Area and Regional Assets

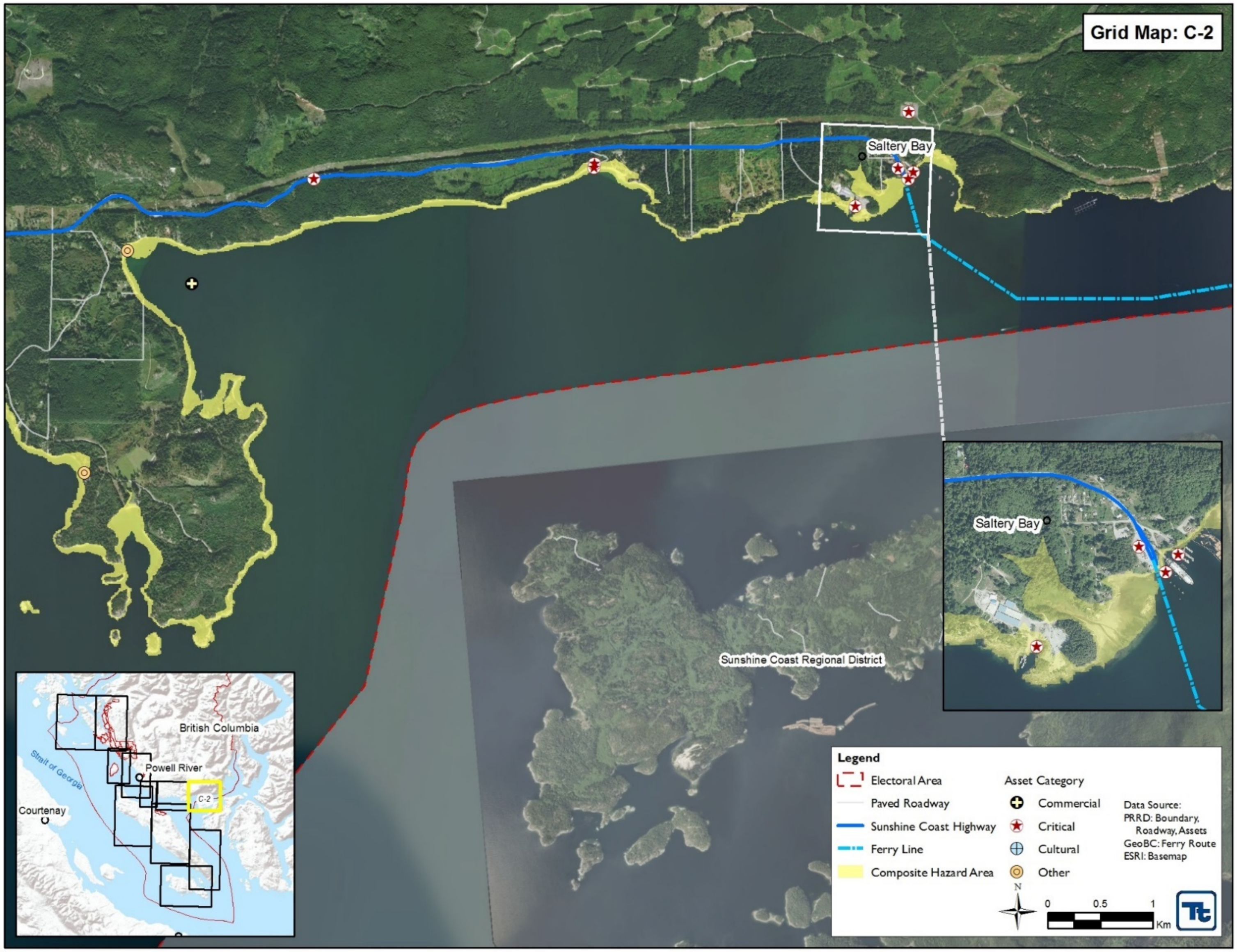


Figure 19. Grid Map E-1 with Composite Hazard Area and Regional Assets

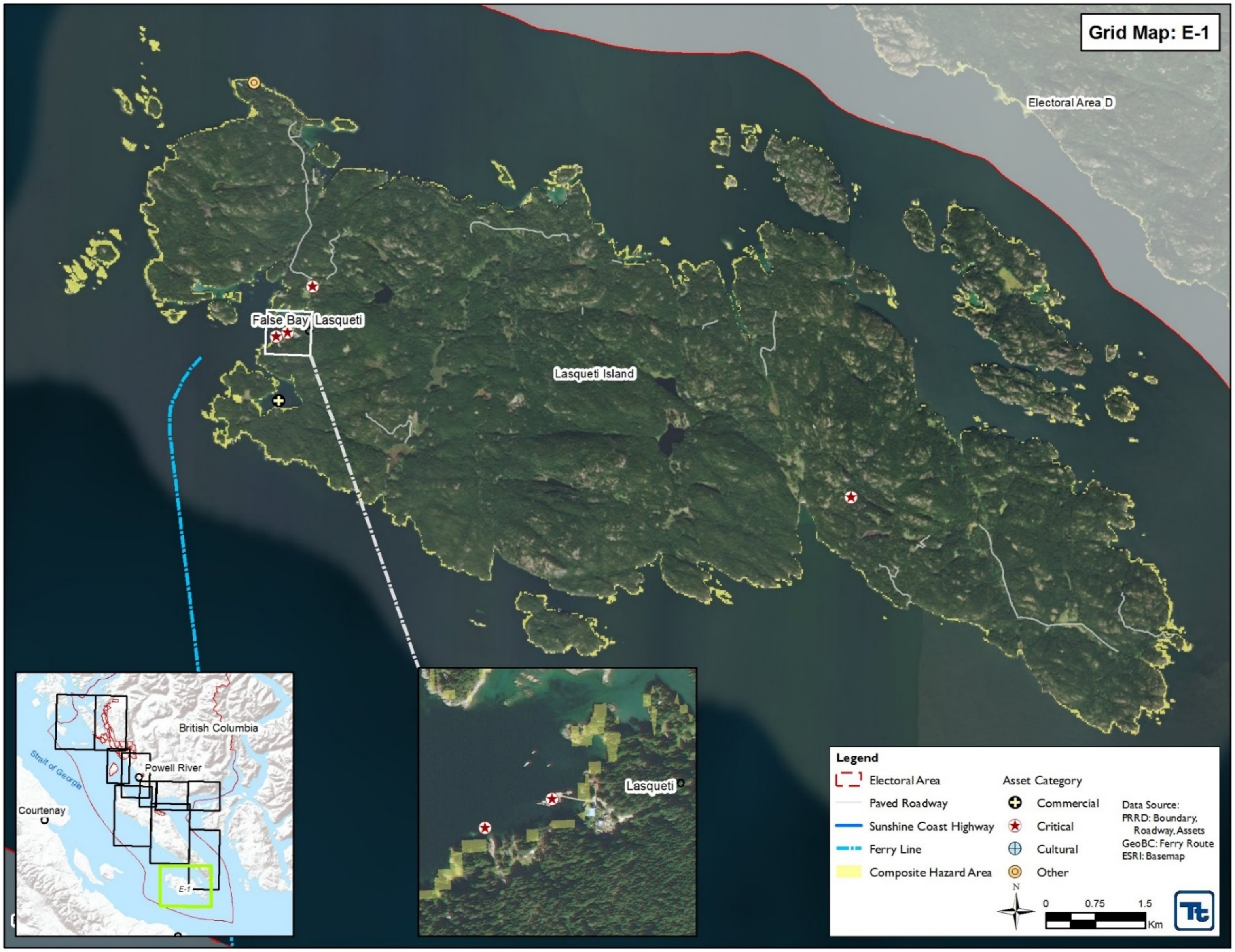


Figure 20. Grid Map PR-1 with Composite Hazard Area and Regional Assets

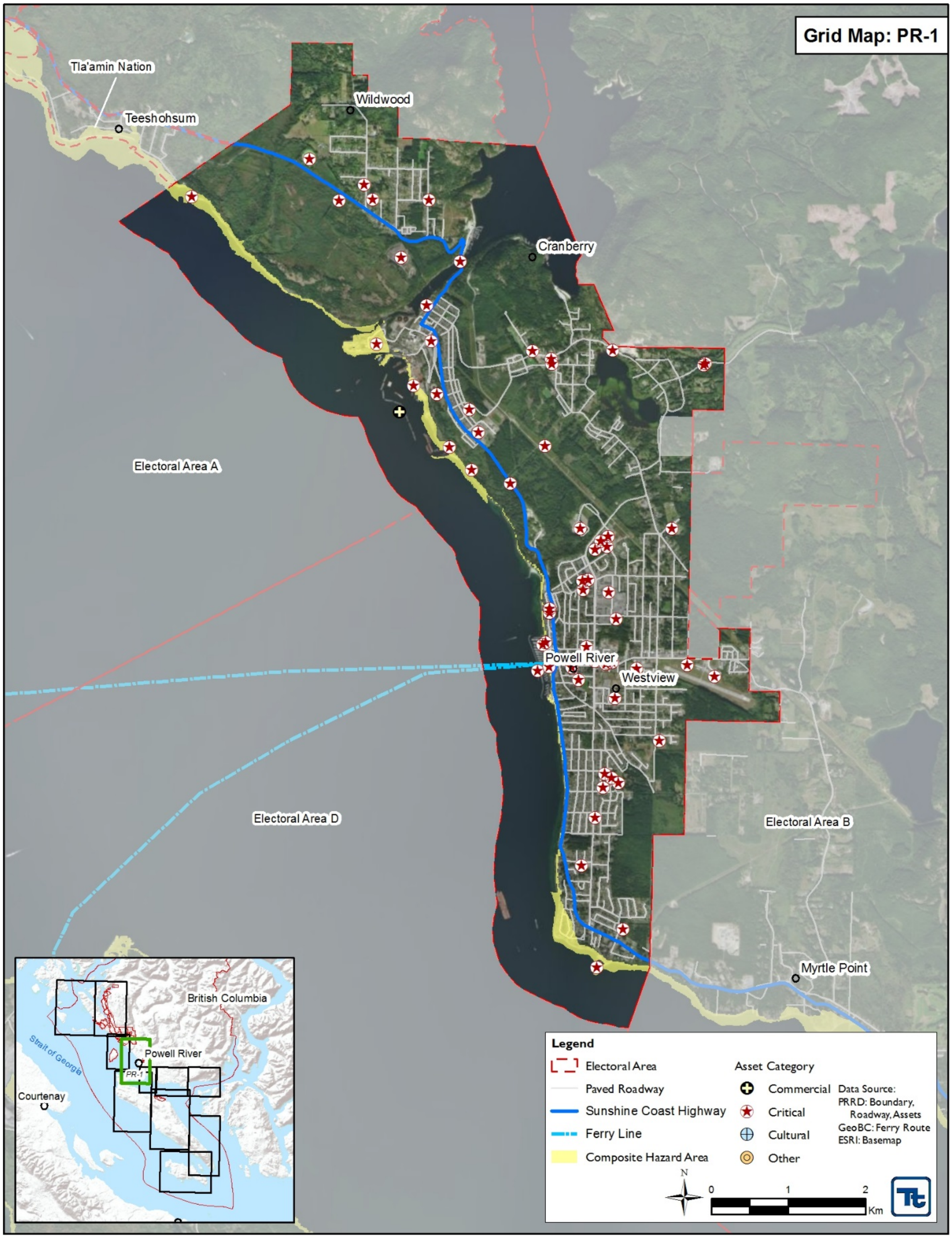


Figure 21. Grid Map TI-1 with Composite Hazard Area and Regional Assets

Figure 22. Grid Map TI-2 with Composite Hazard Area and Regional Assets

Figure 23. Grid Map TI-3 with Composite Hazard Area and Regional Assets

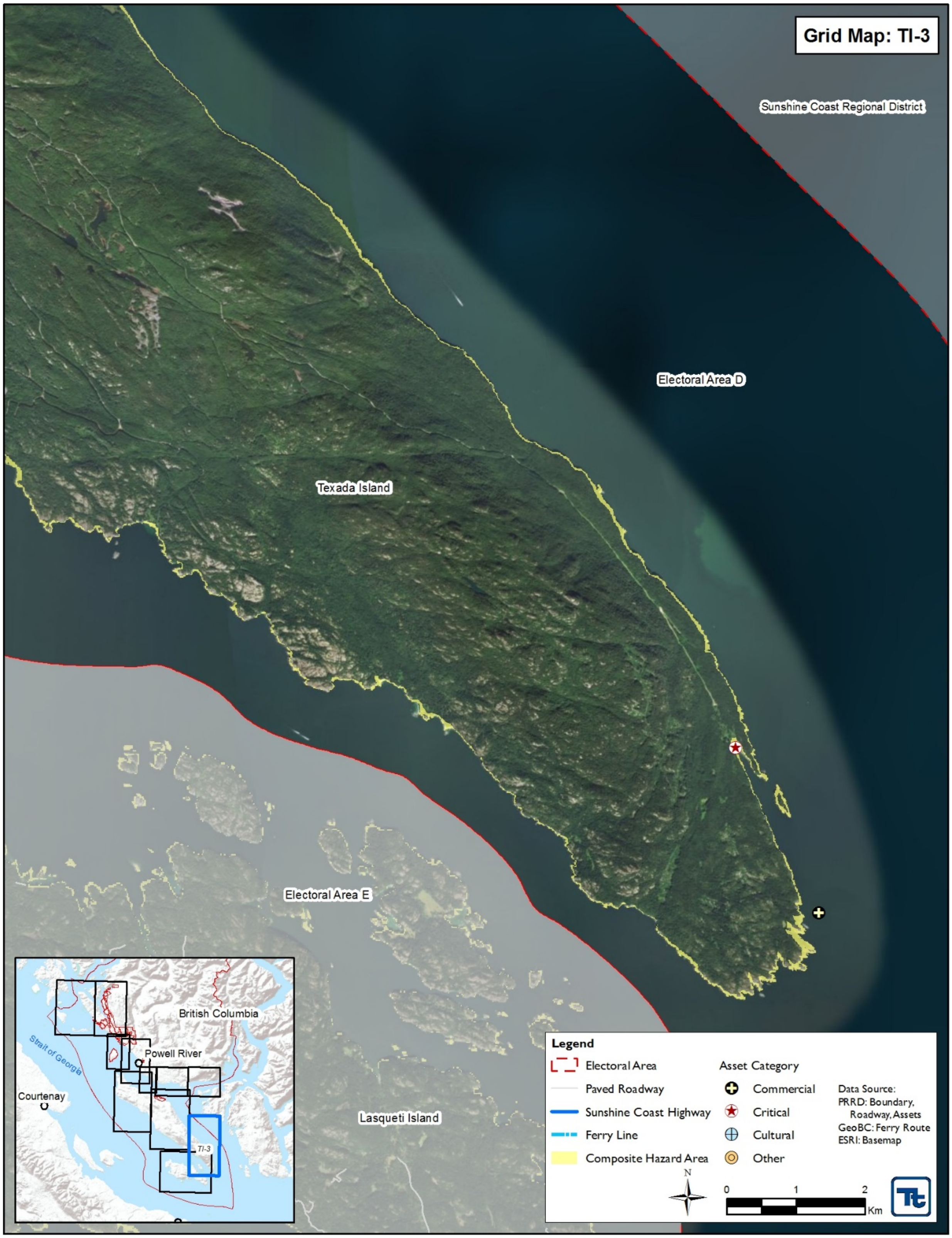


Figure 24. Grid Map TN-1 with Composite Hazard Area and Regional Assets

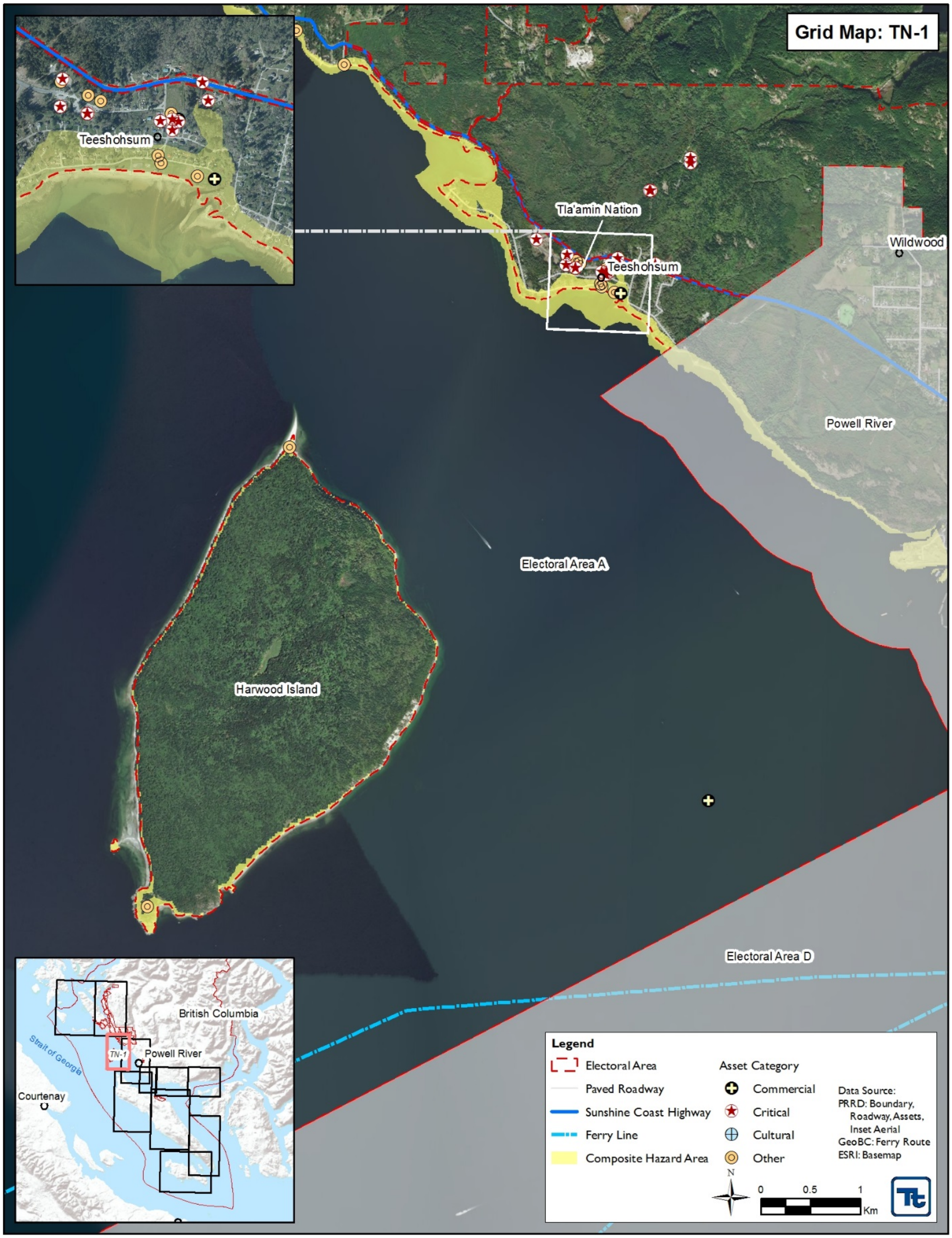


Figure 25. Grid Map A-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

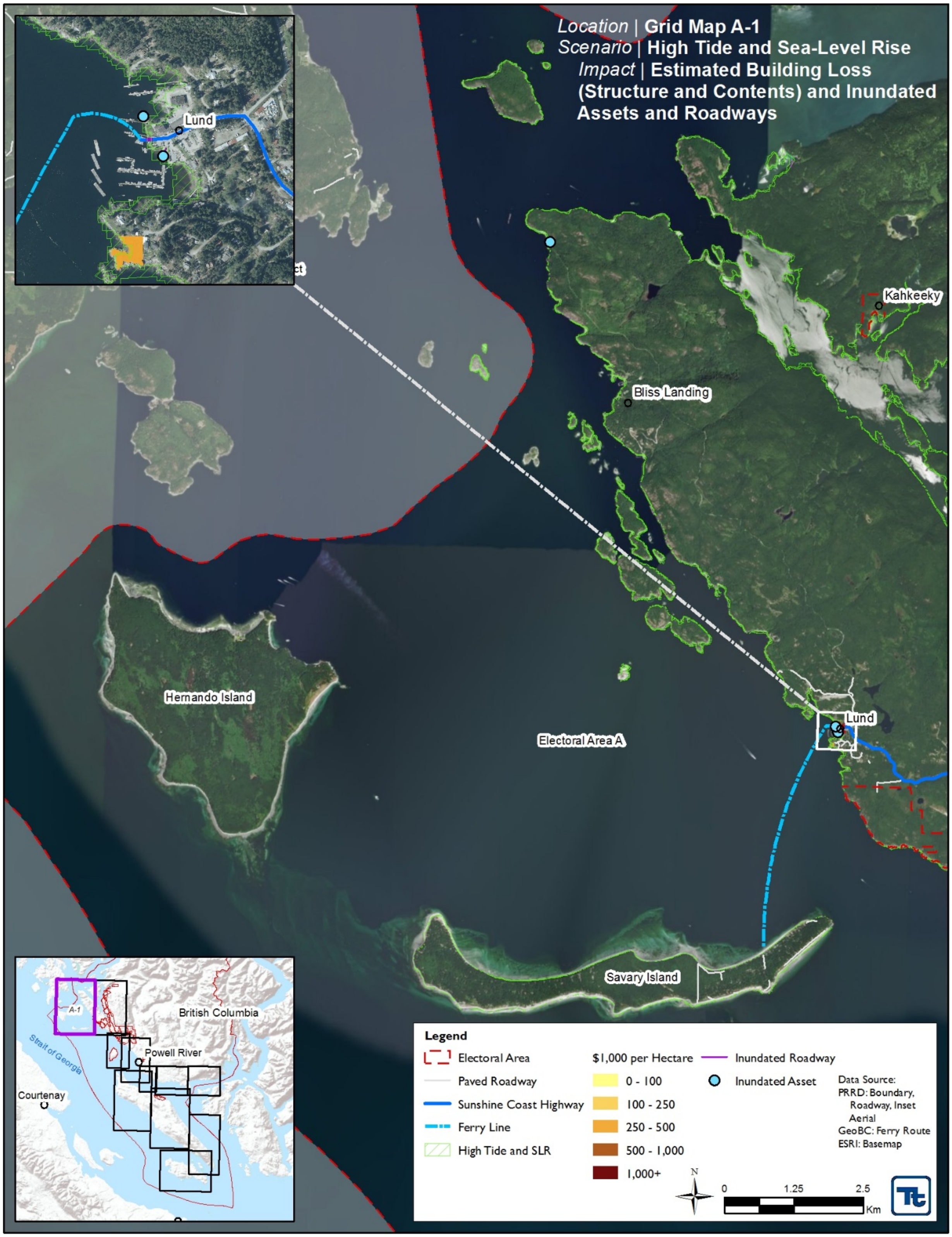


Figure 26. Grid Map A-2 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

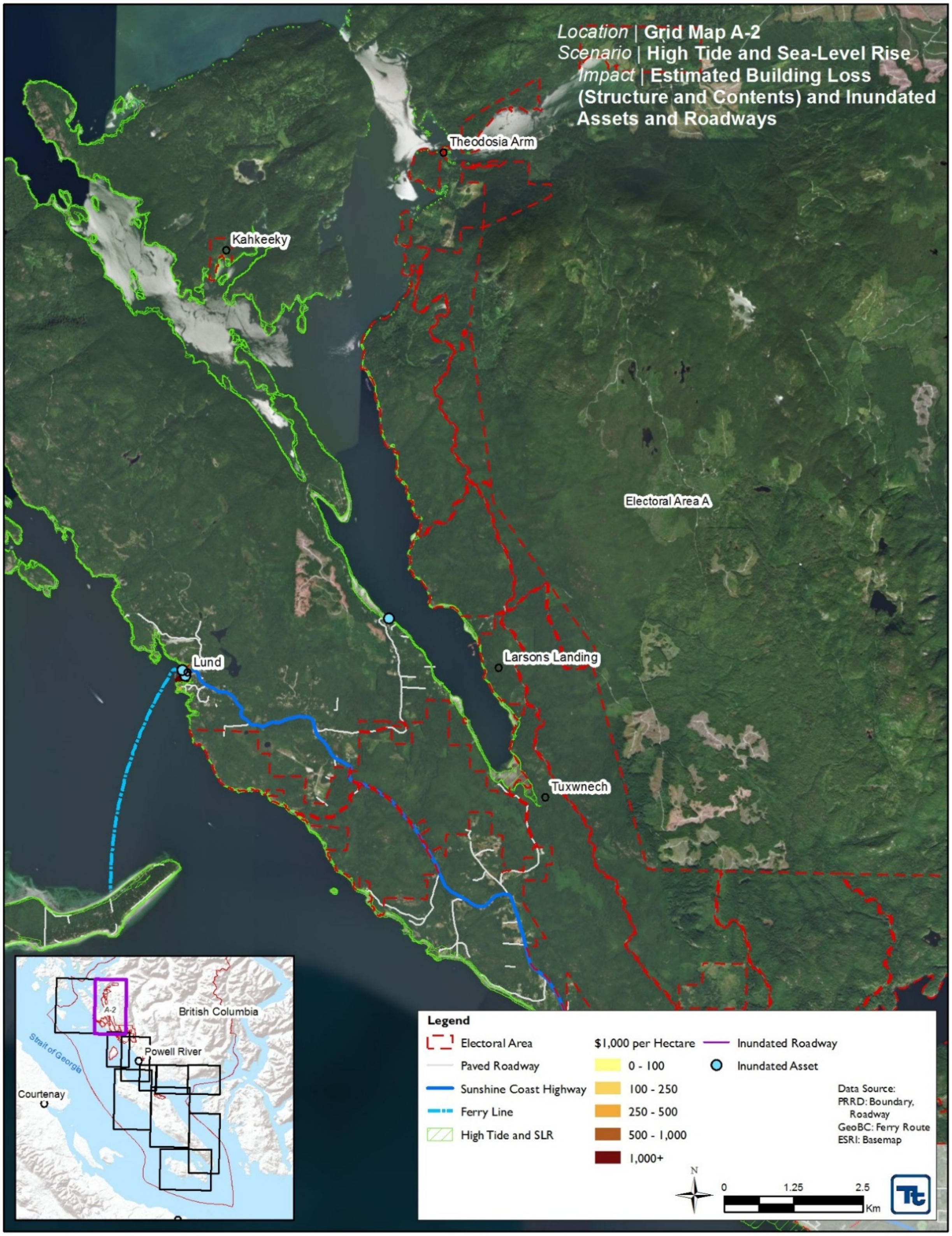


Figure 27. Grid Map B-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

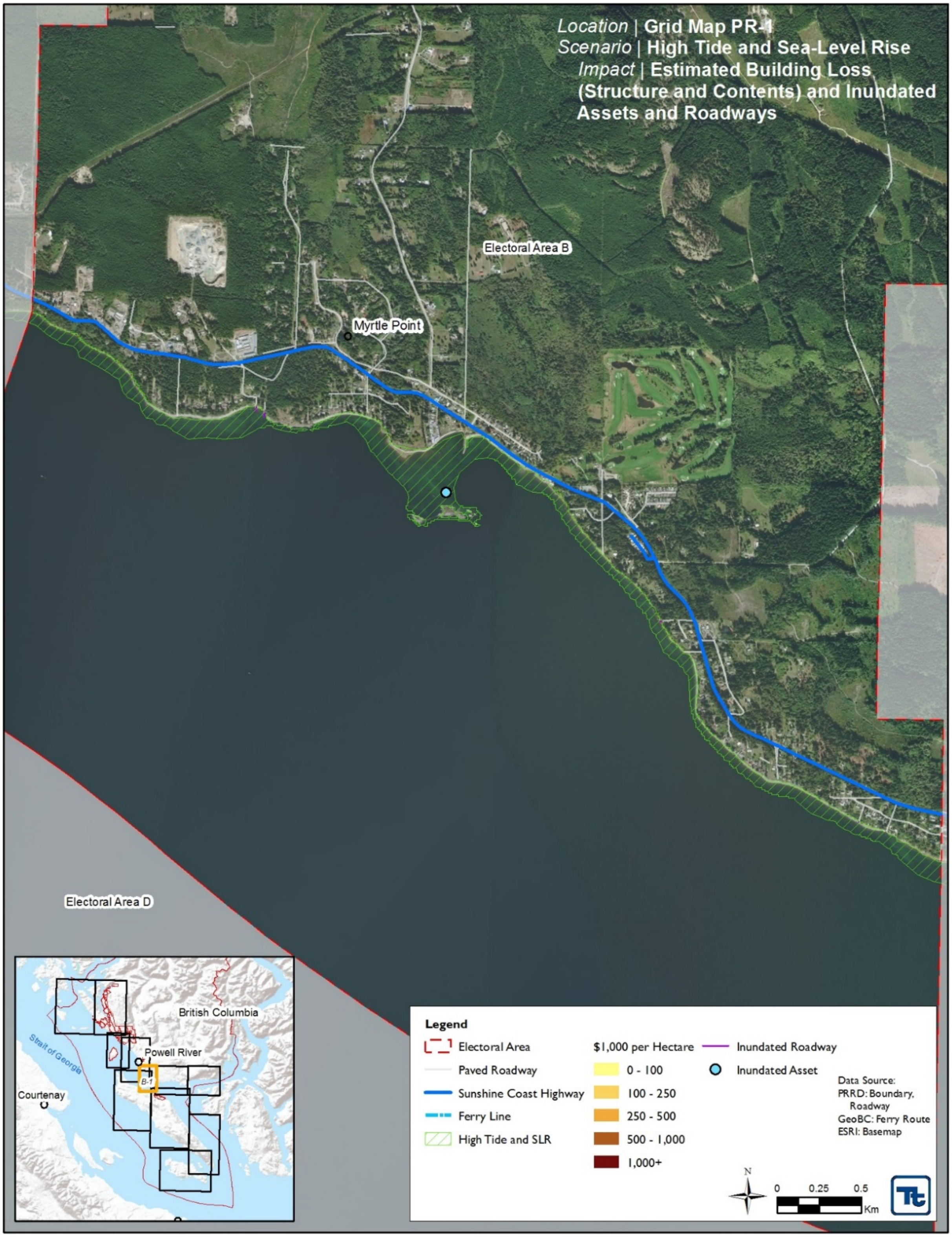


Figure 28. Grid Map C-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

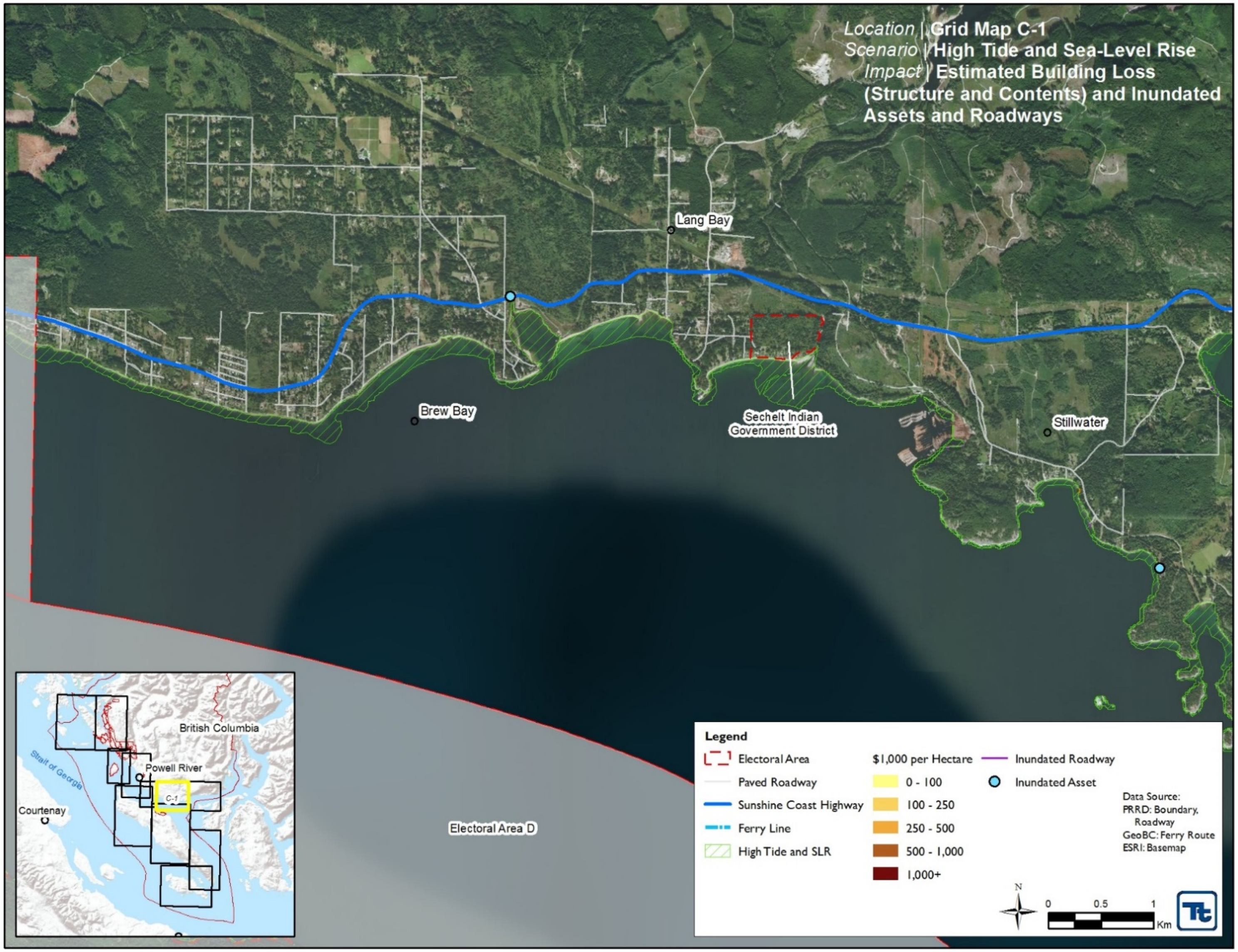


Figure 29. Grid Map C-2 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

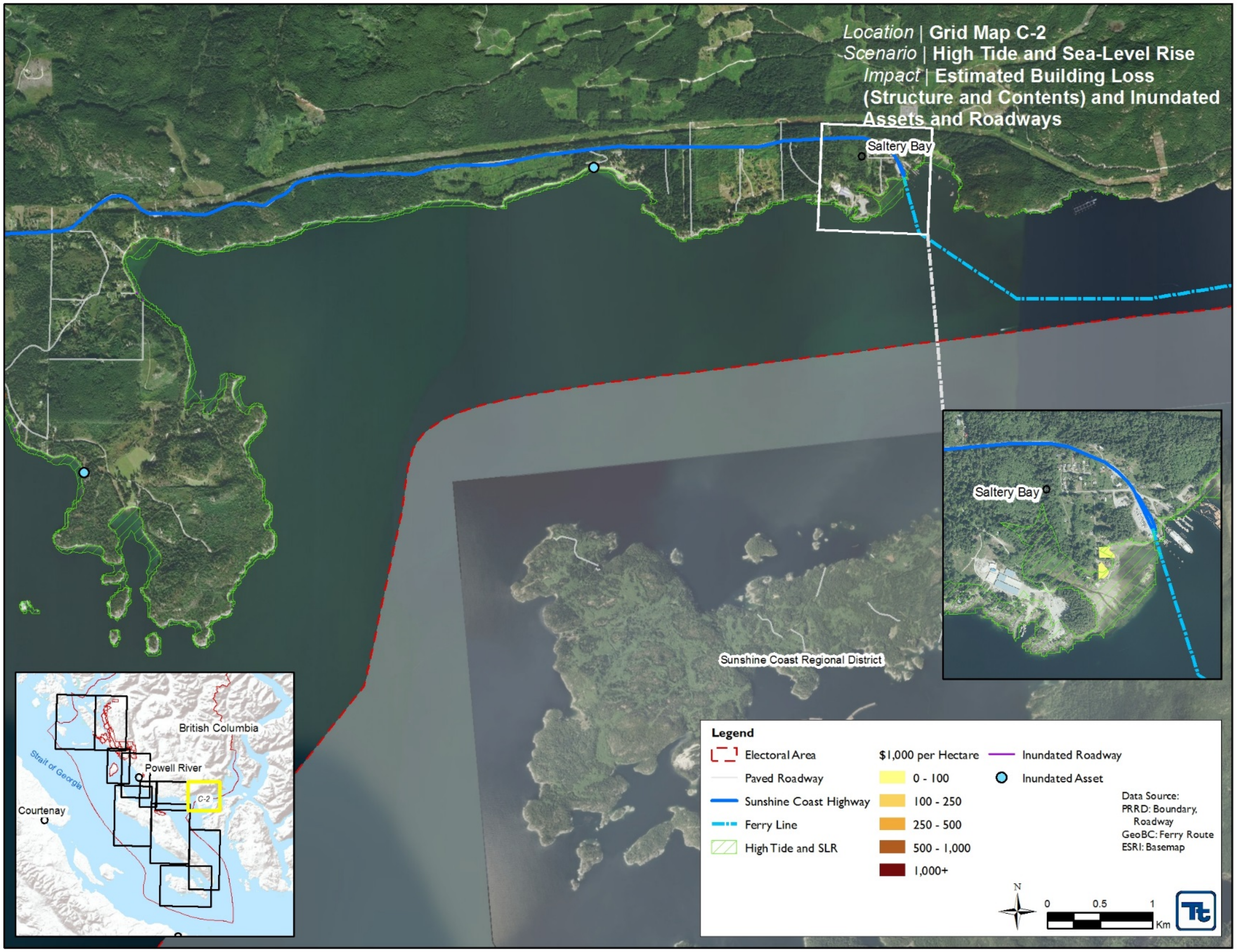


Figure 30. Grid Map E-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

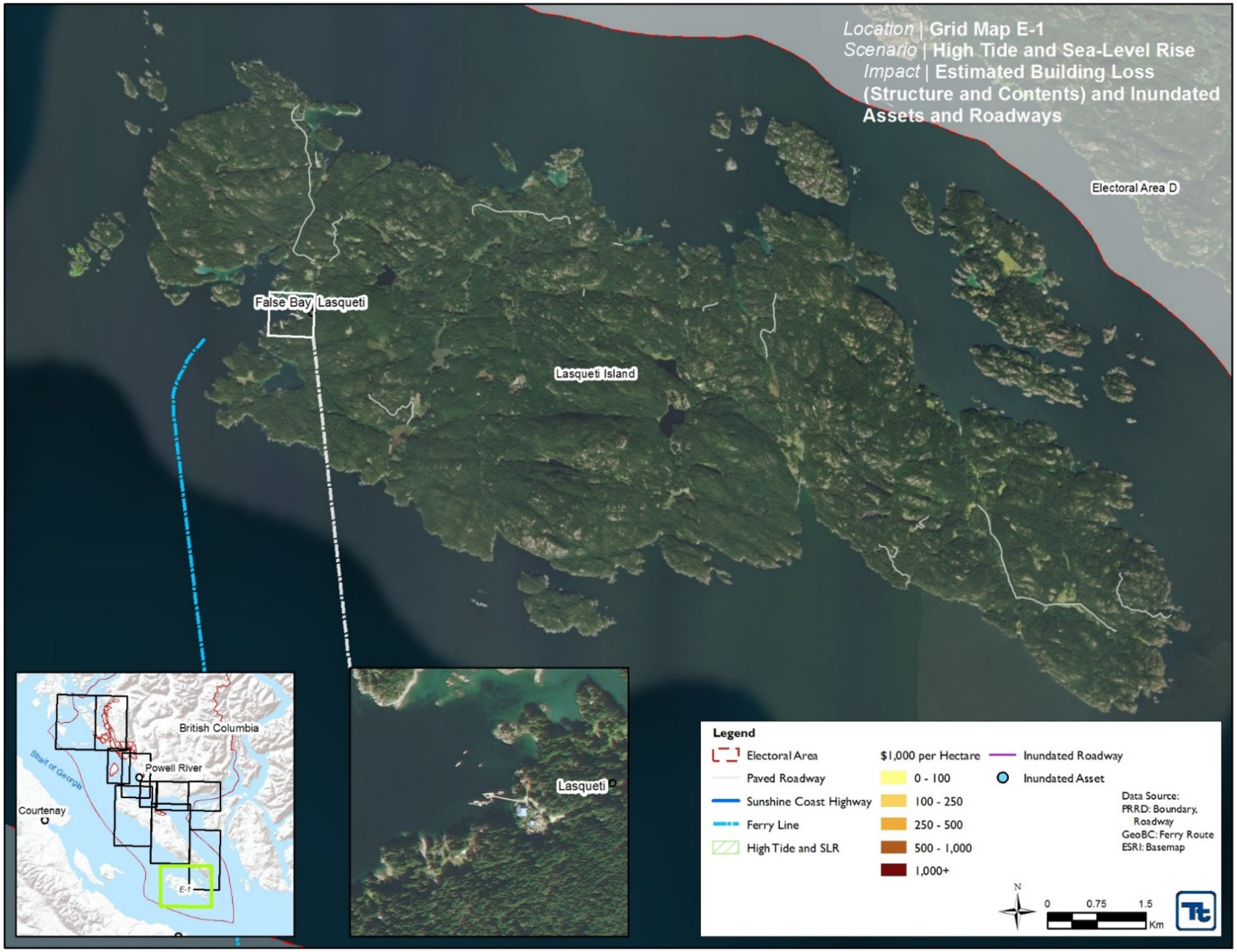


Figure 31. Grid Map PR-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

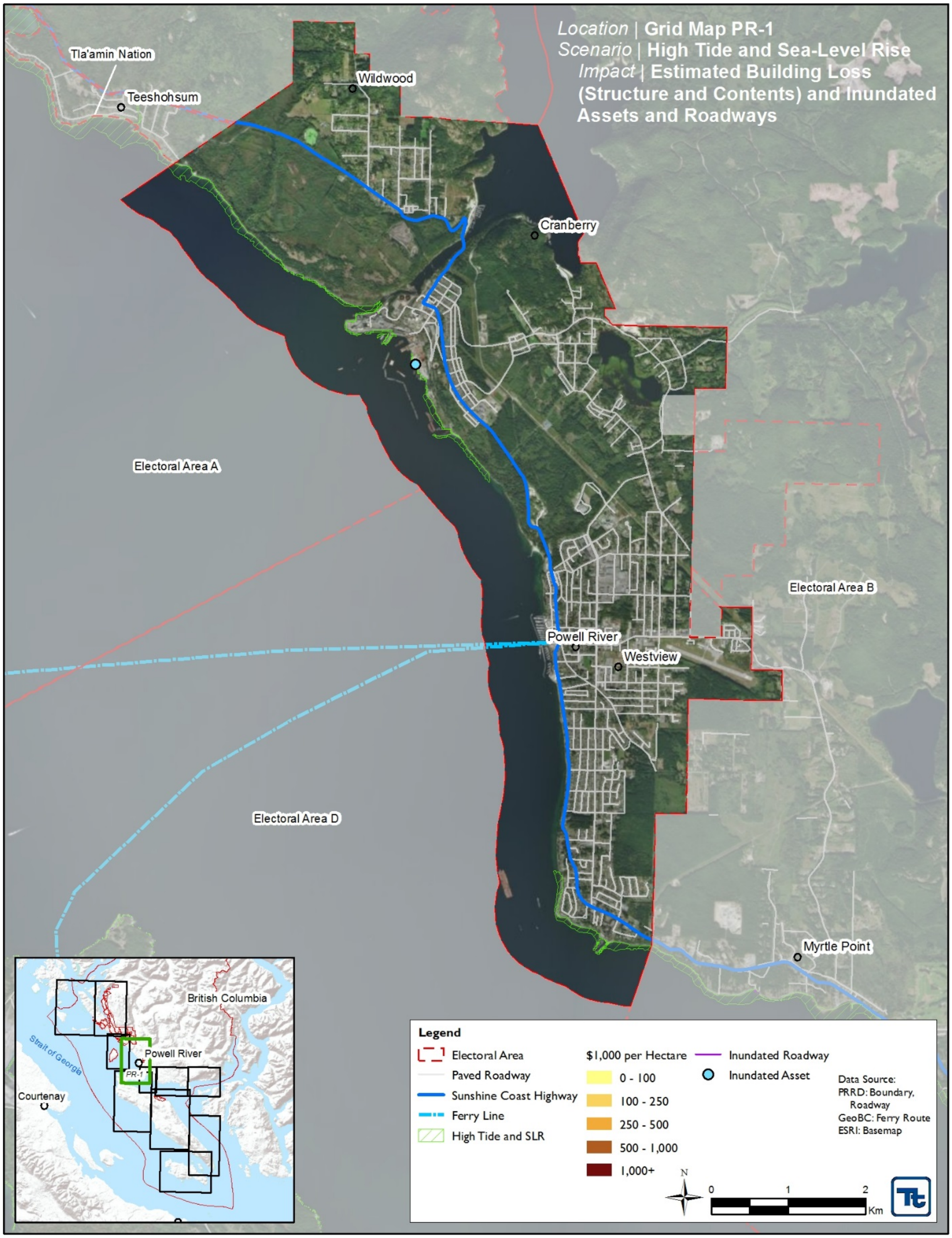


Figure 32. Map TI-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

Figure 33. Grid Map TI-2 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

Figure 34. Grid Map TI-3 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

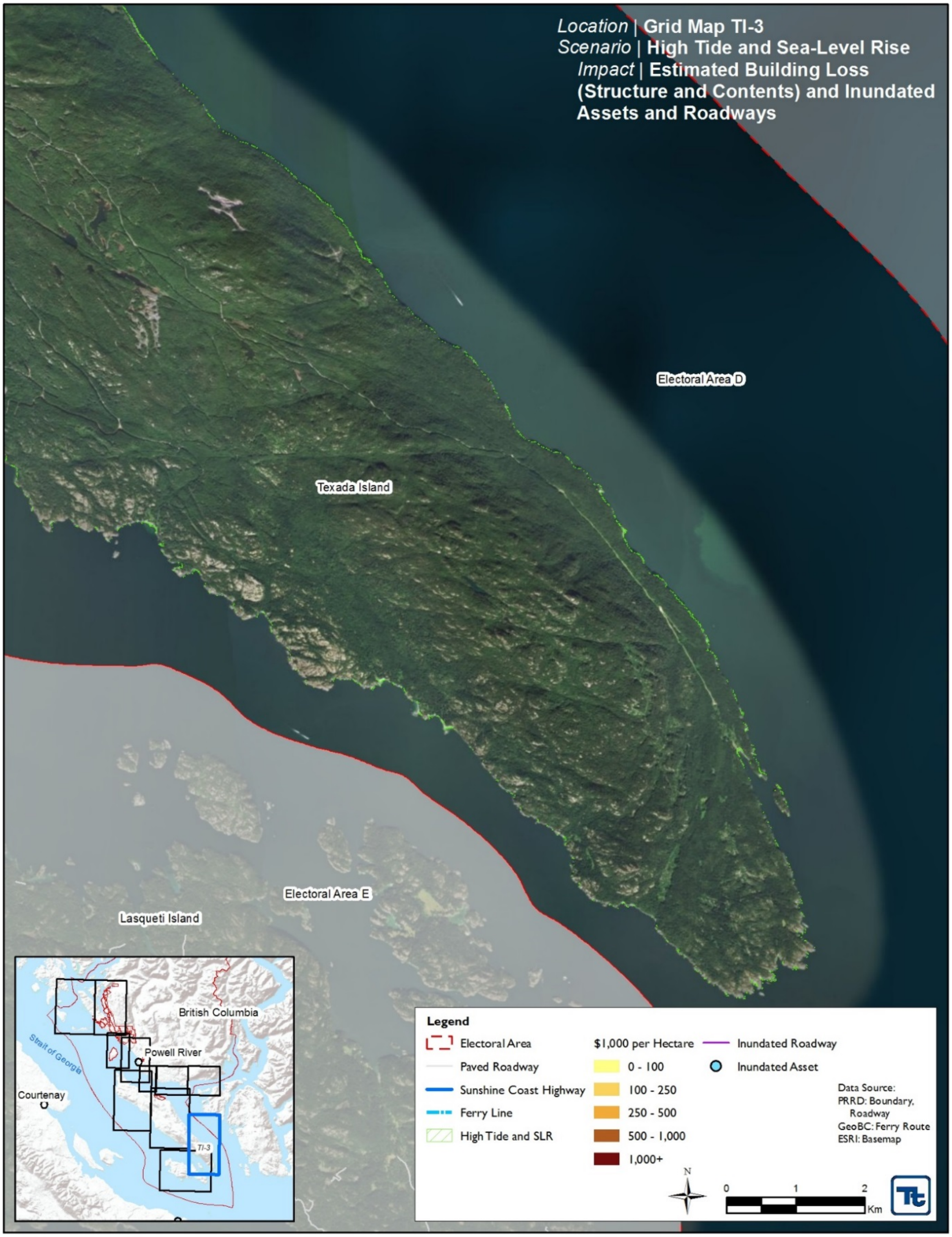


Figure 35. Grid Map TN-1 with Estimated Building Exposure (Structure and Contents) and Inundated Assets and Roadways for the High Tide and Sea-Level Rise Scenario

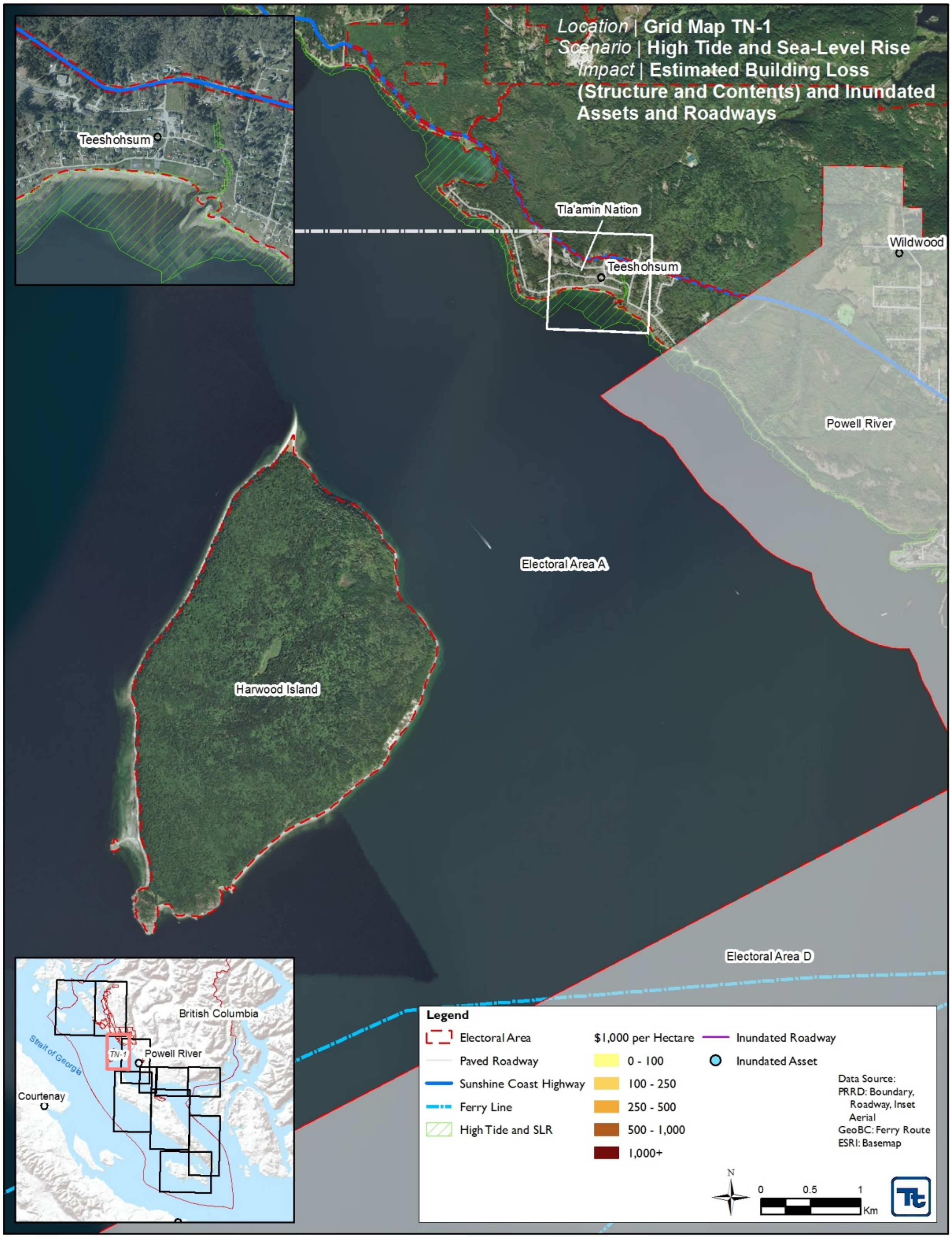


Figure 36. Grid Map A-1 with Estimated Building Loss (Structure and Contents) for the High Tide 200-year Wave and Surge (SE) Scenario at the Parcel Level

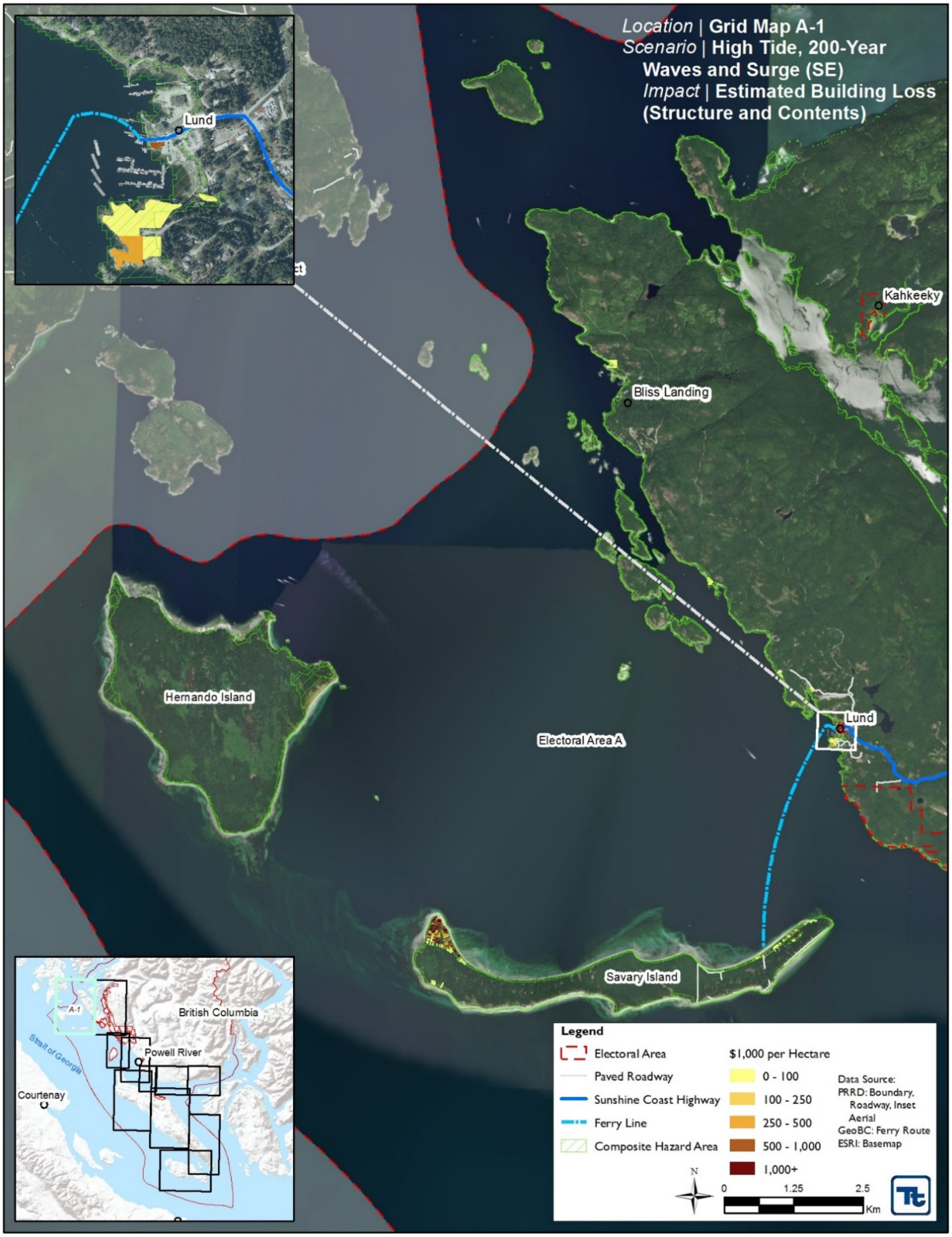


Figure 37. Grid Map A-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

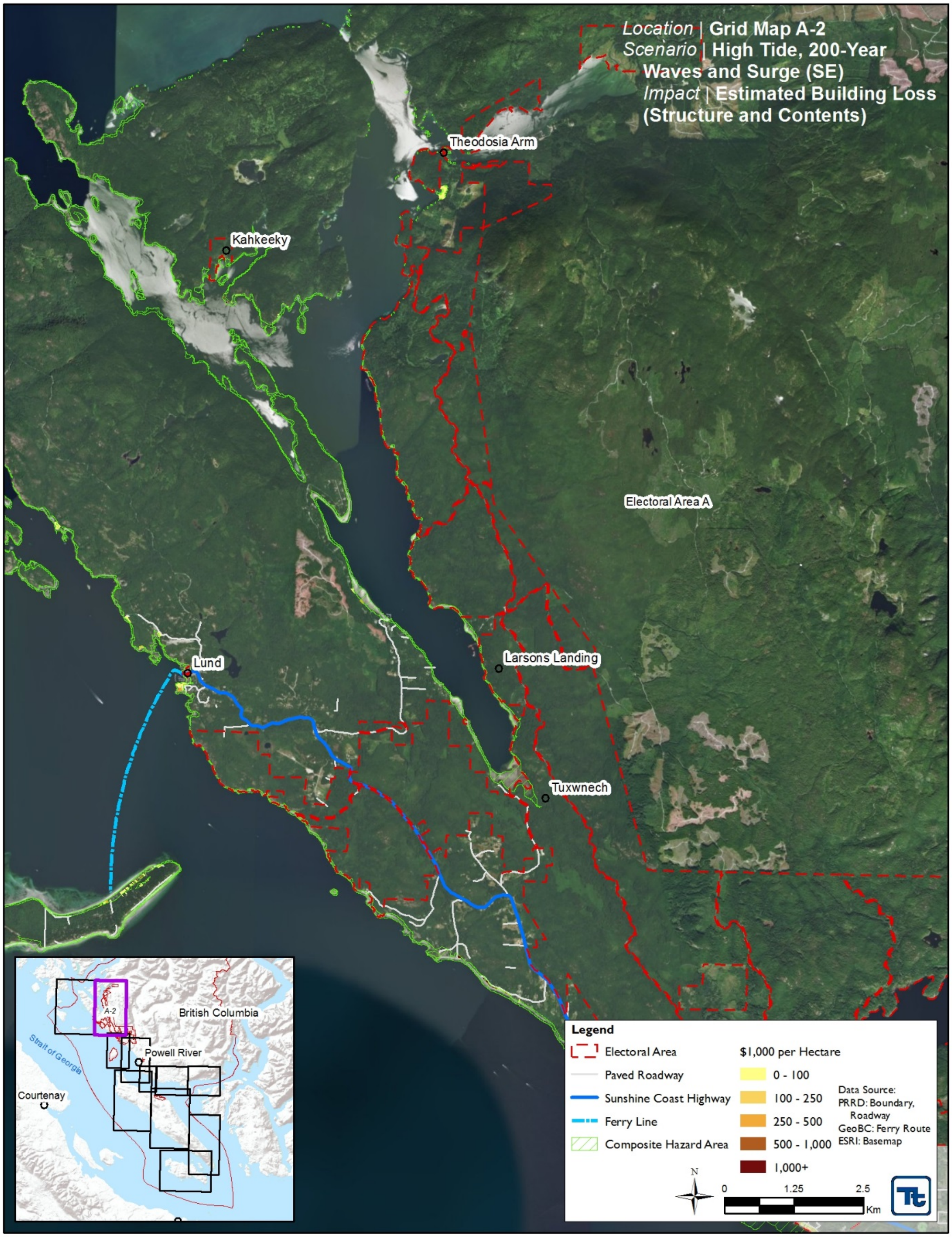


Figure 38. Grid Map B-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

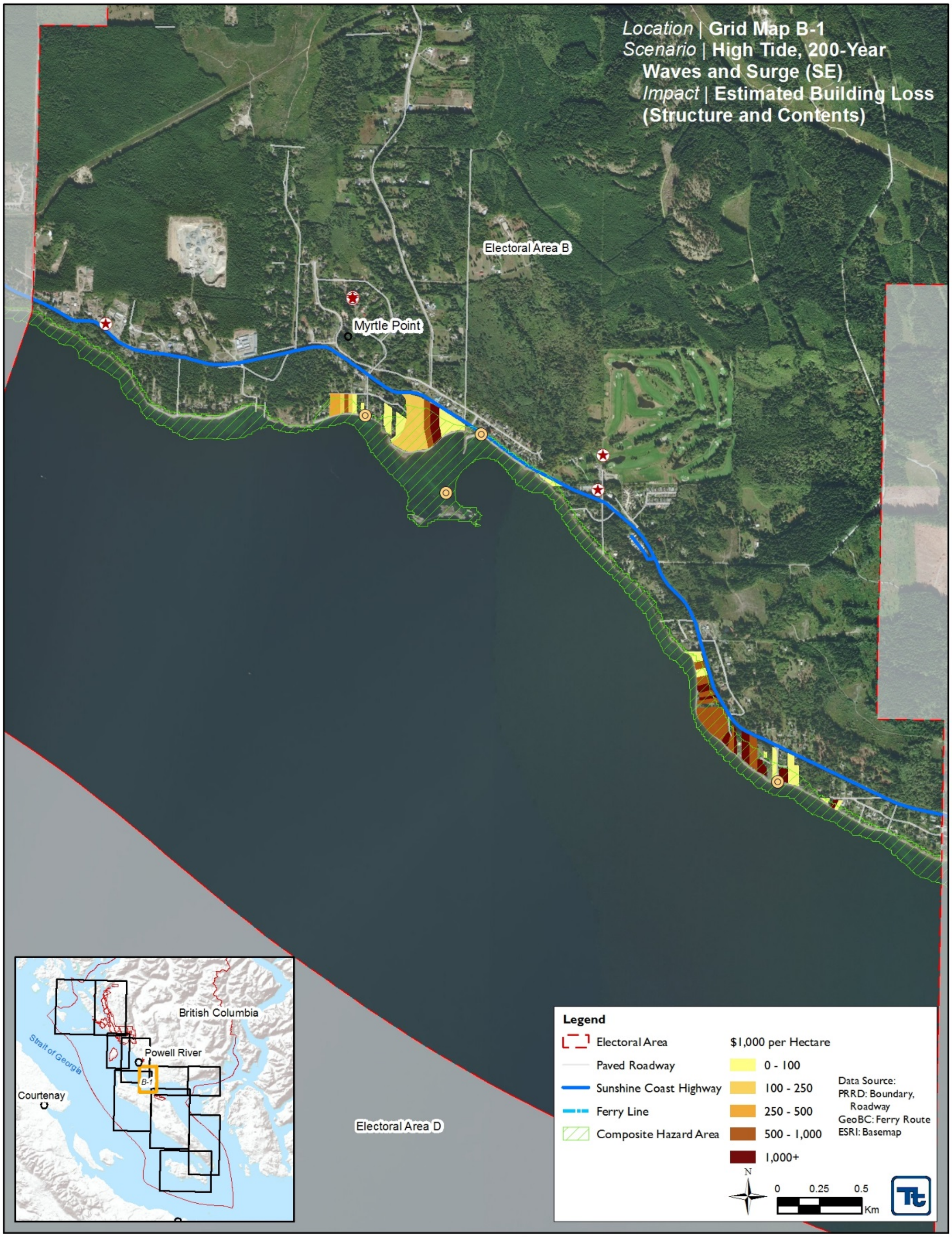


Figure 39. Grid Map C-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

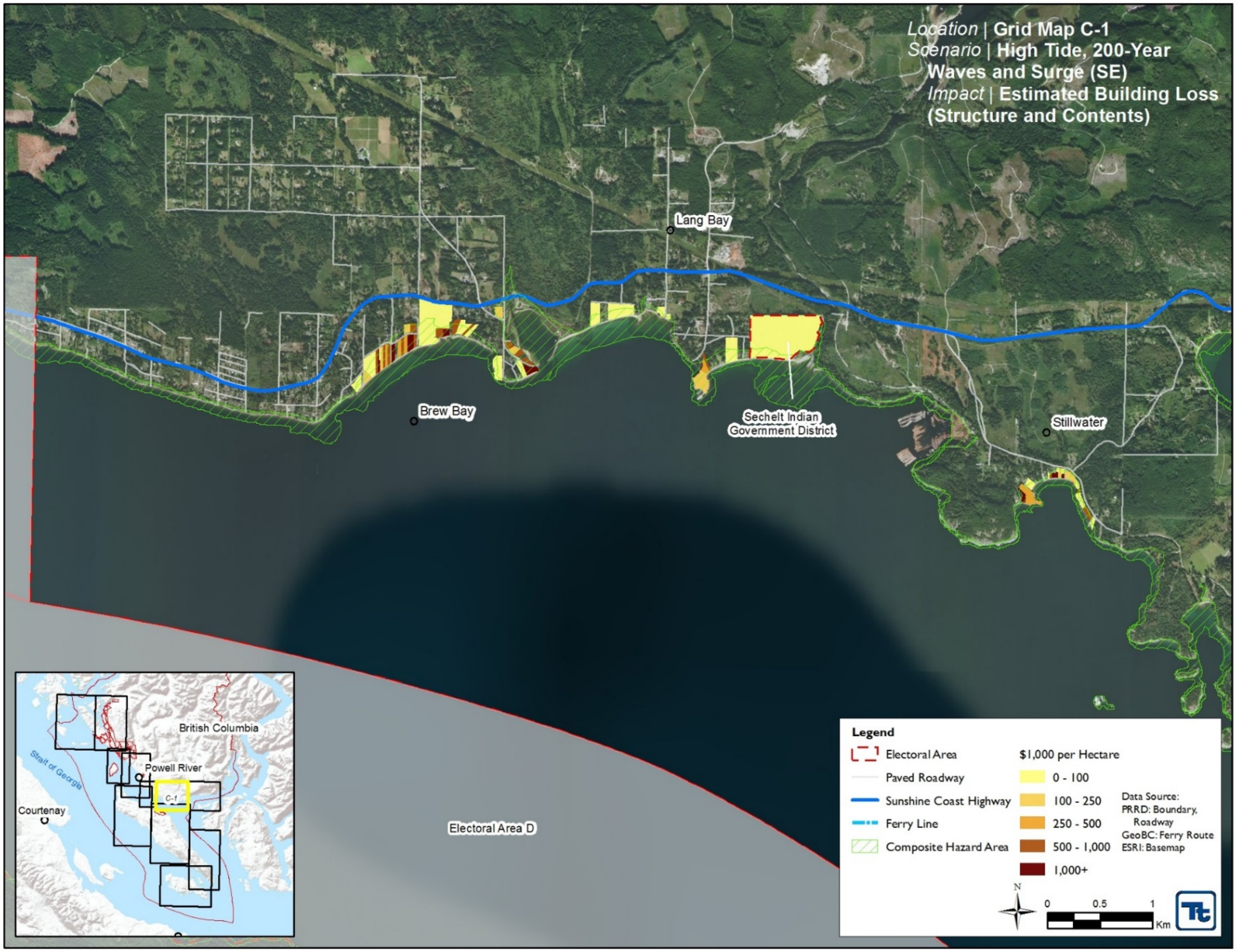


Figure 40. Grid Map C-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

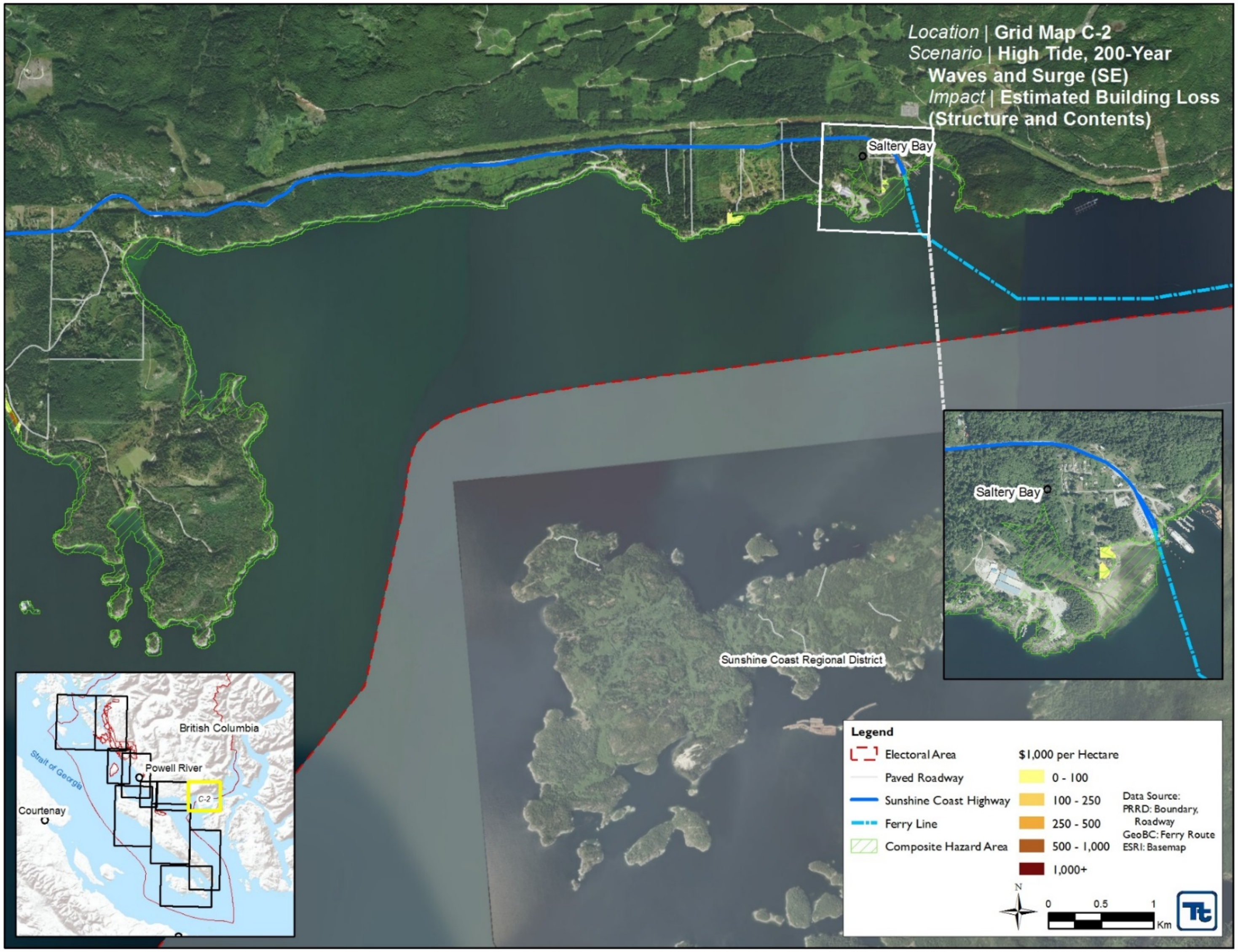


Figure 41. Grid Map E-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

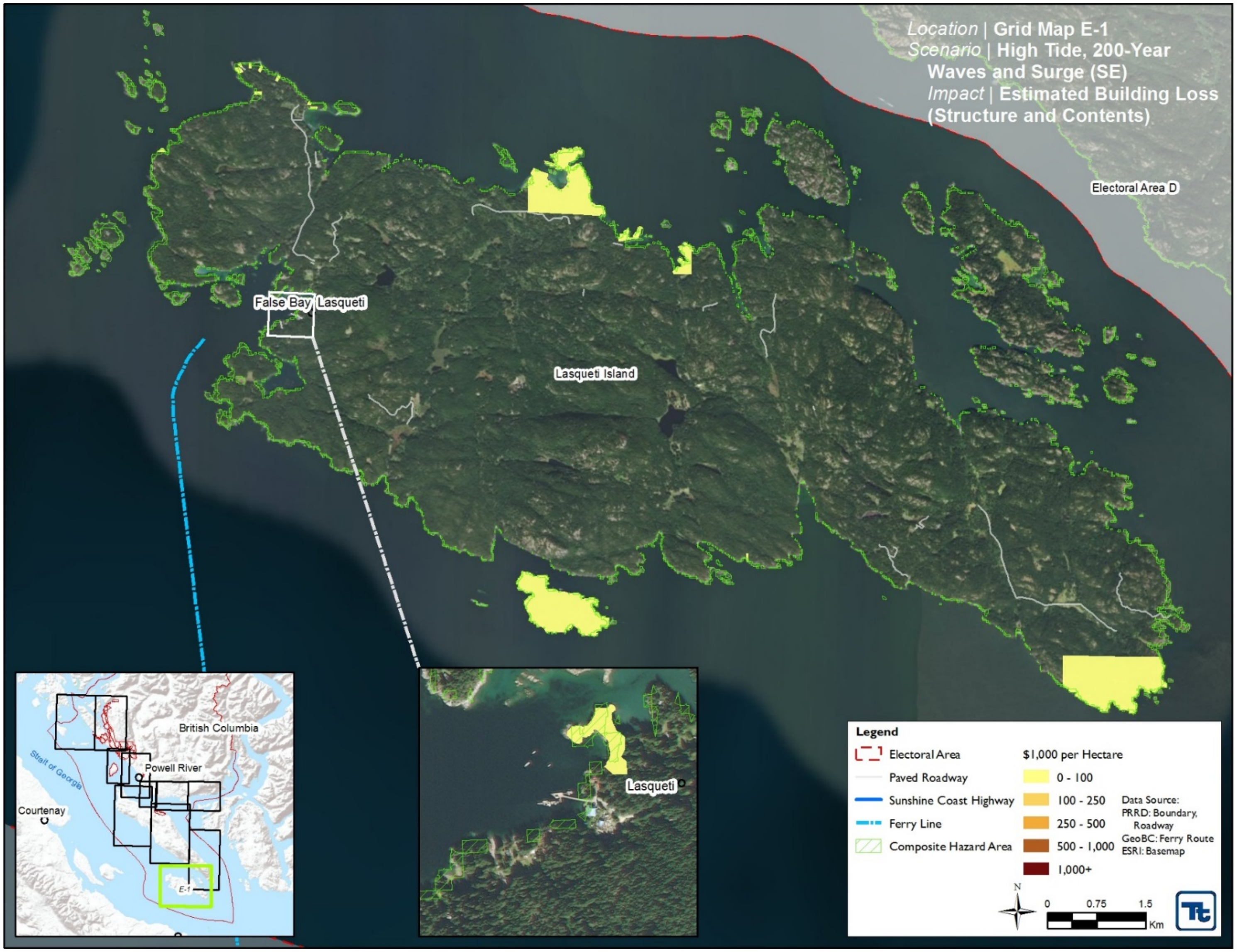


Figure 42. Grid Map PR-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

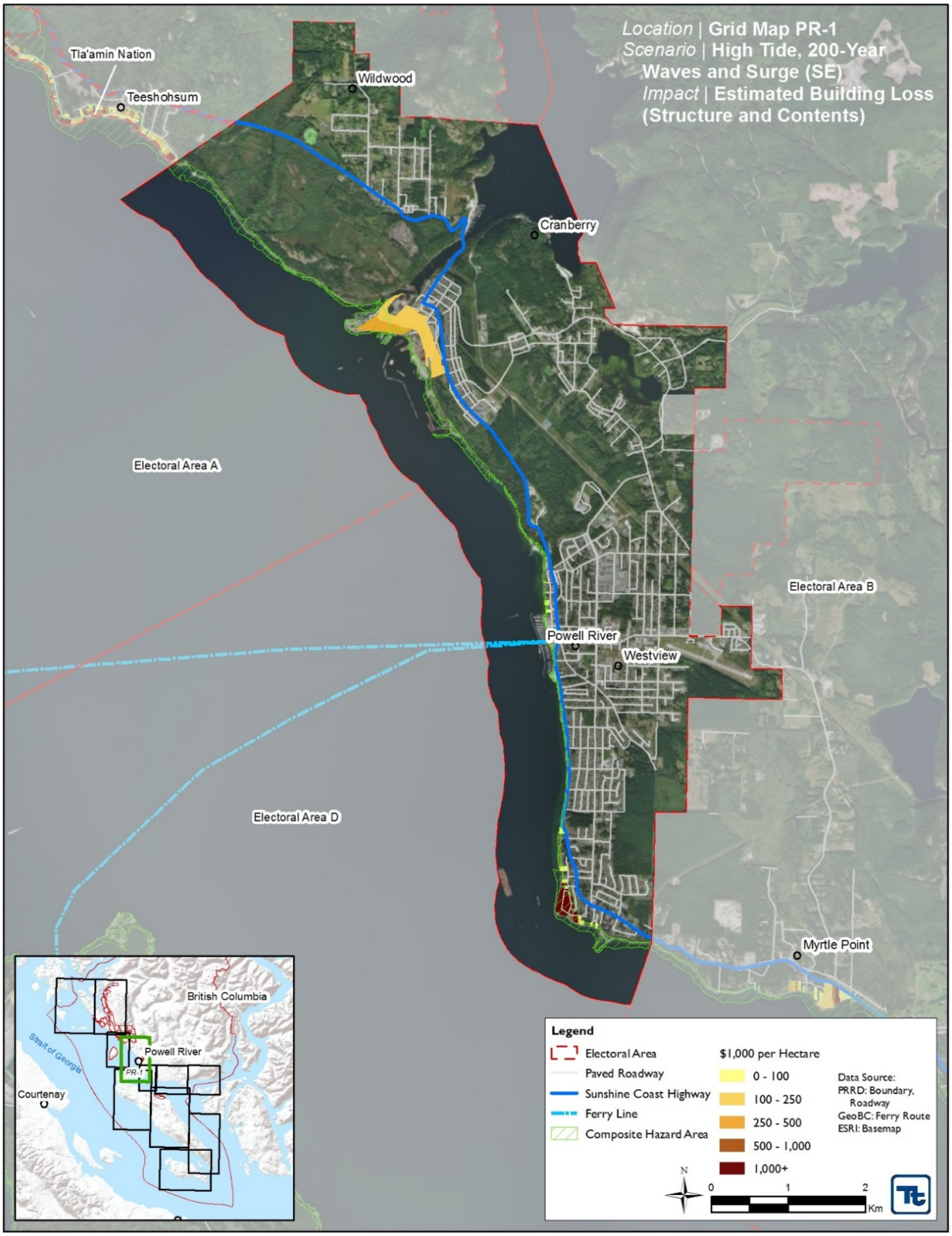


Figure 43. Grid Map TI-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

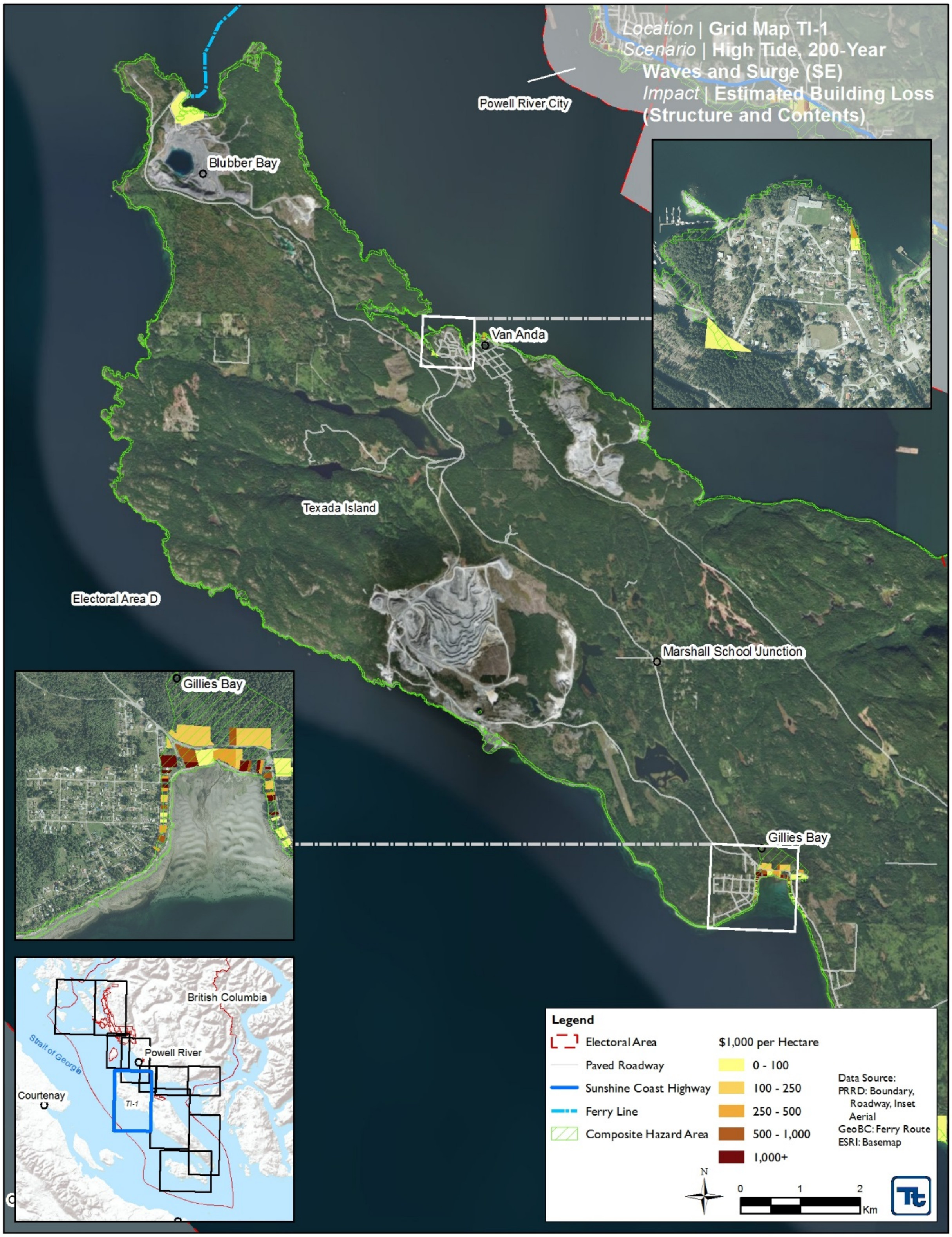


Figure 44. Grid Map TI-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

Figure 45. Grid Map TI-3 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

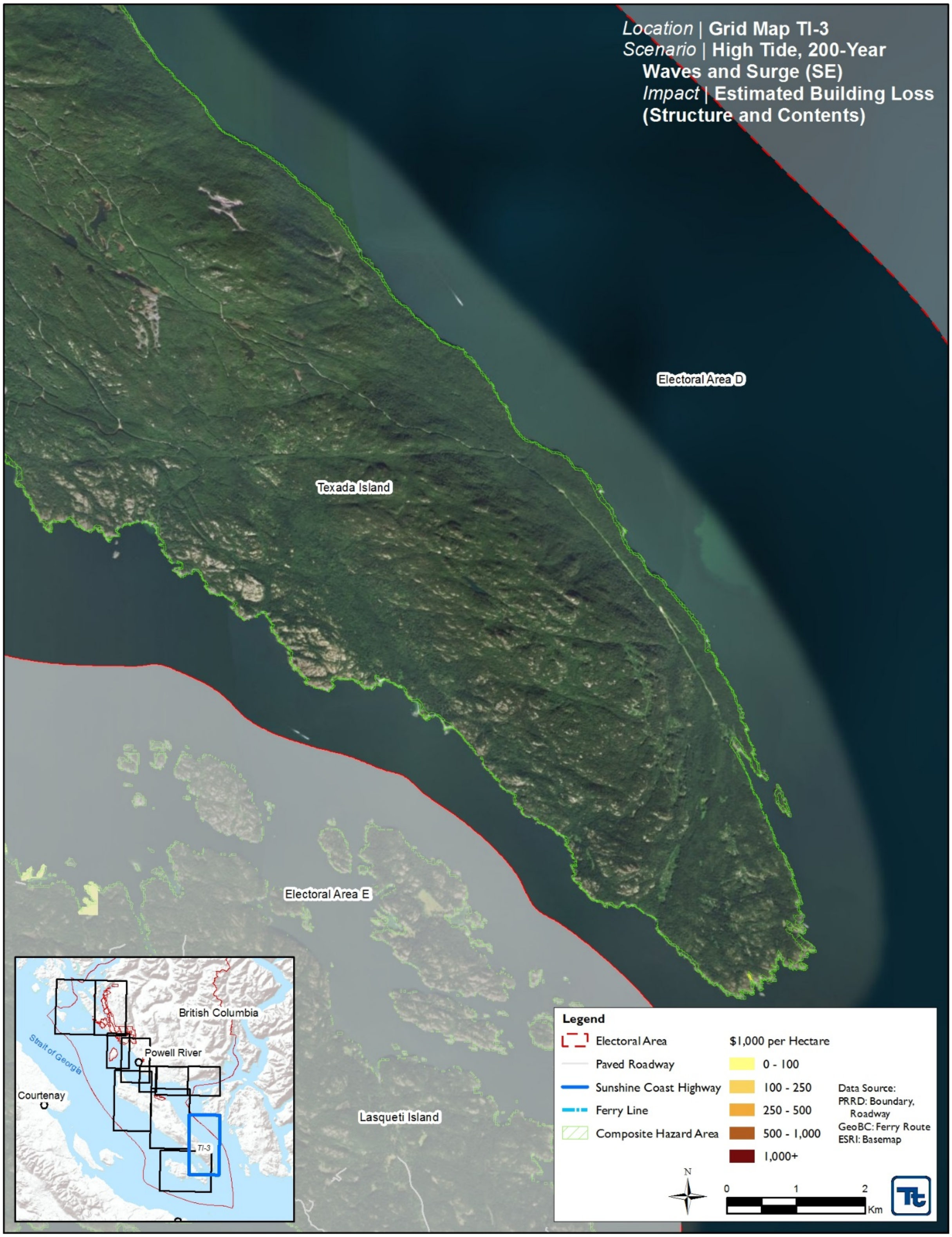


Figure 46. Grid Map TN-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (SE) Scenario at the Parcel Level

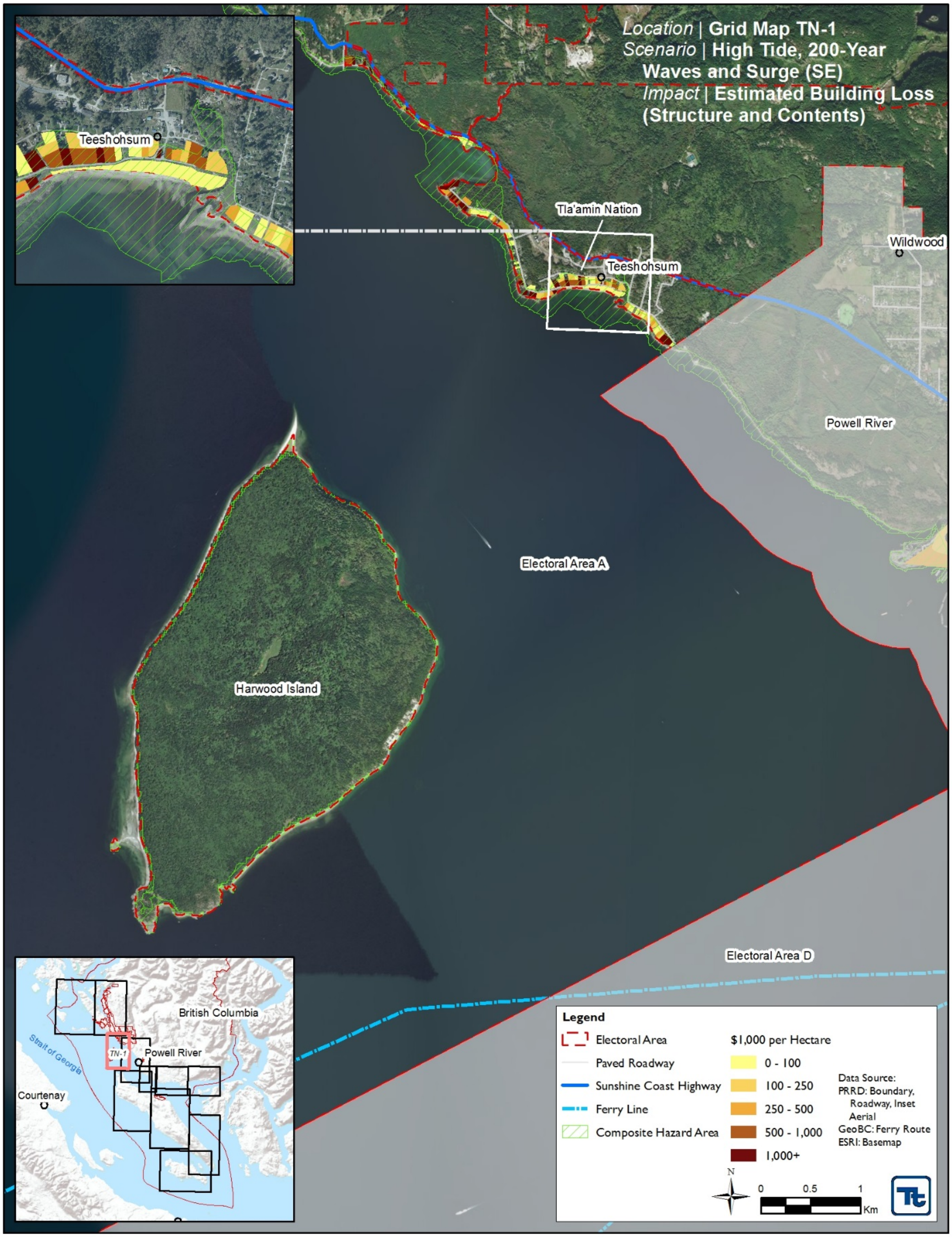


Figure 47. Grid Map A-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

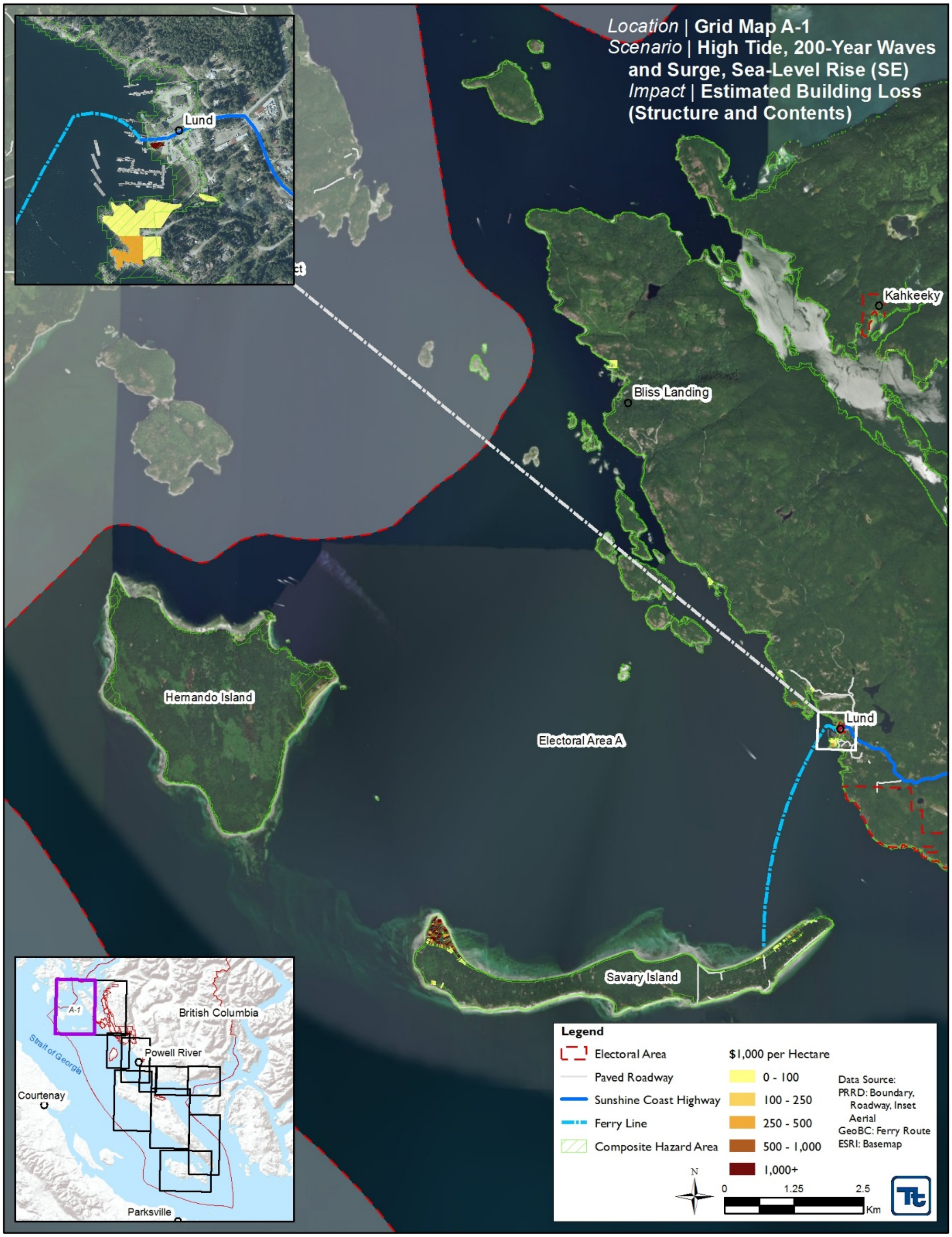


Figure 48. Grid Map A-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

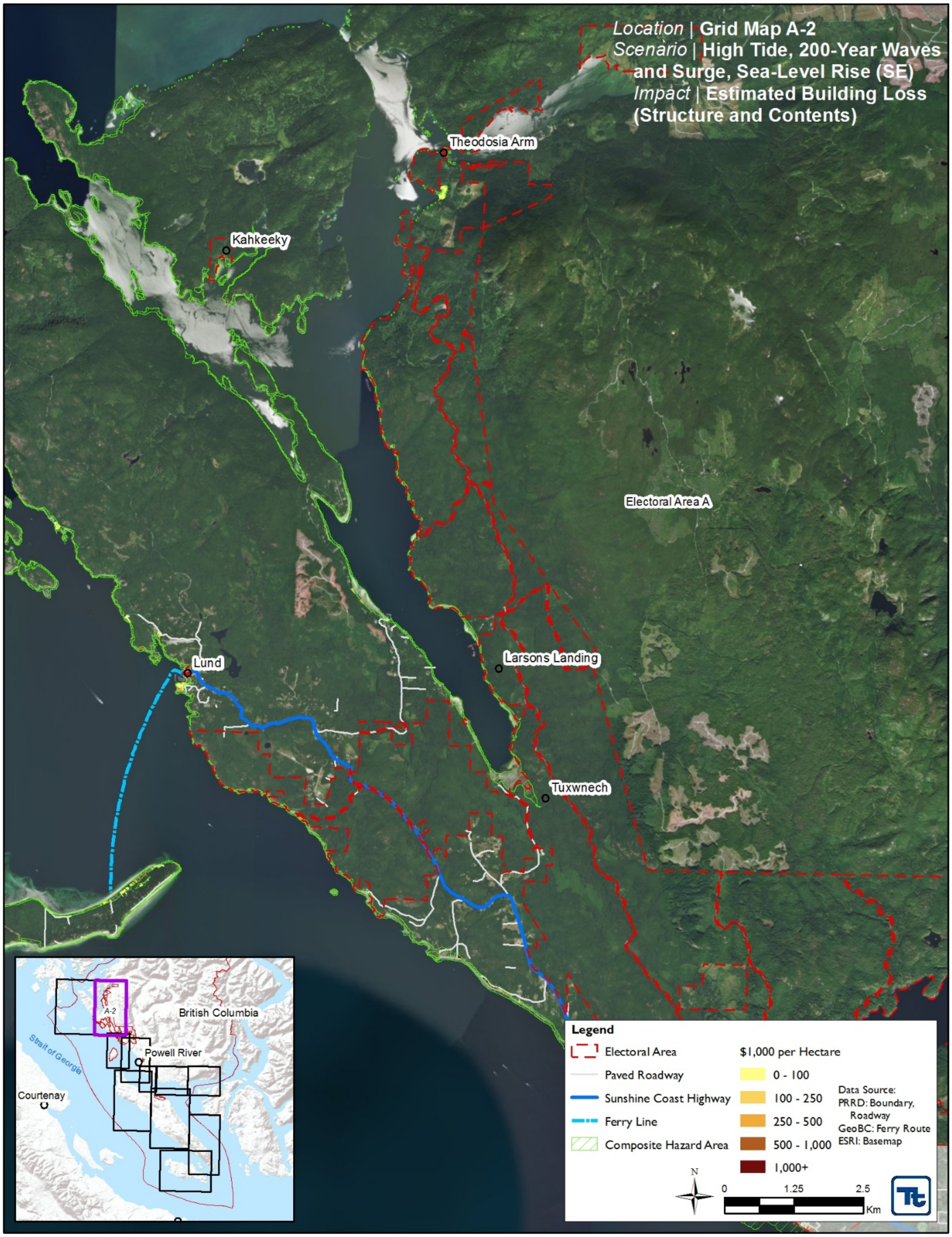


Figure 49. Grid Map B-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

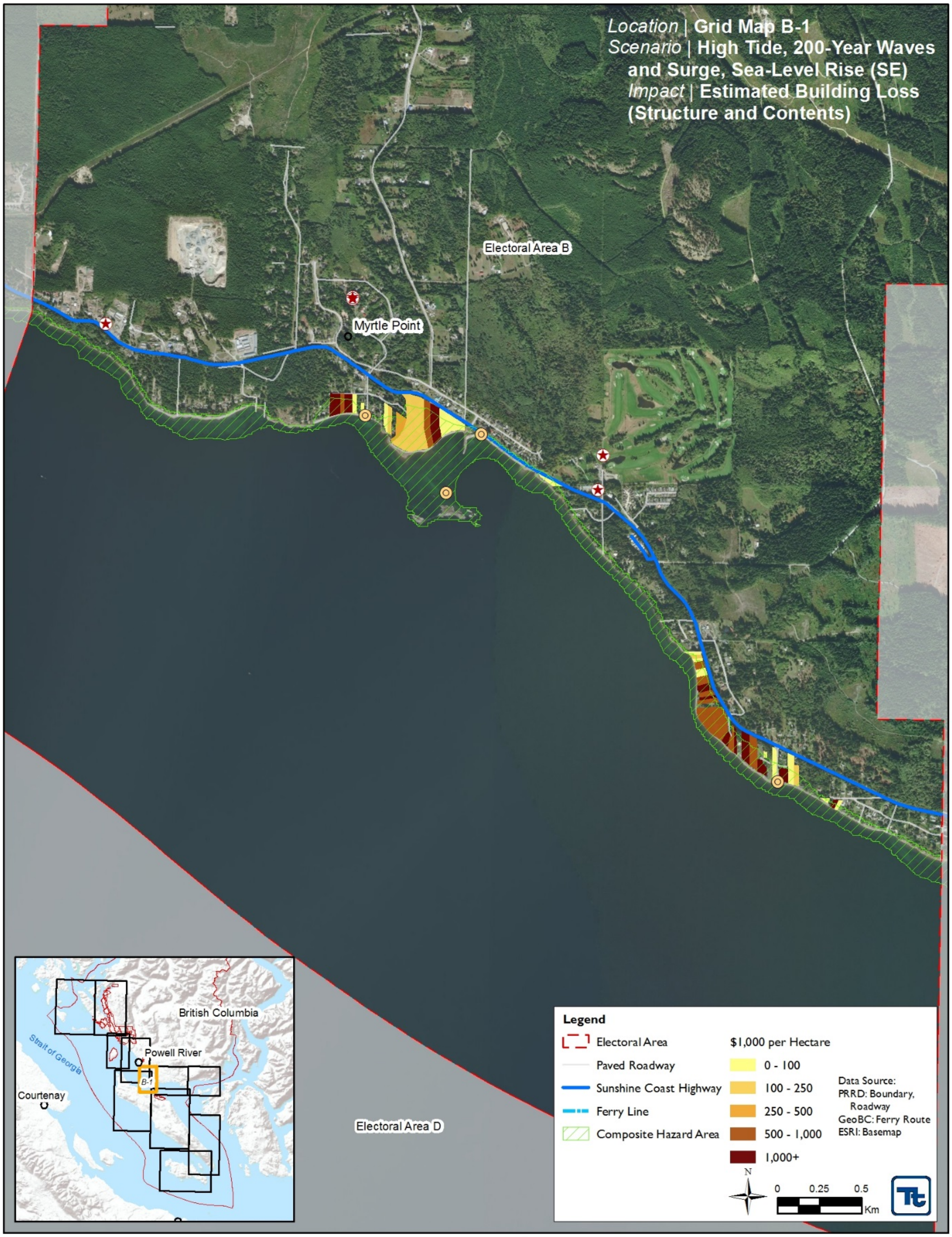


Figure 50. Grid Map C-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

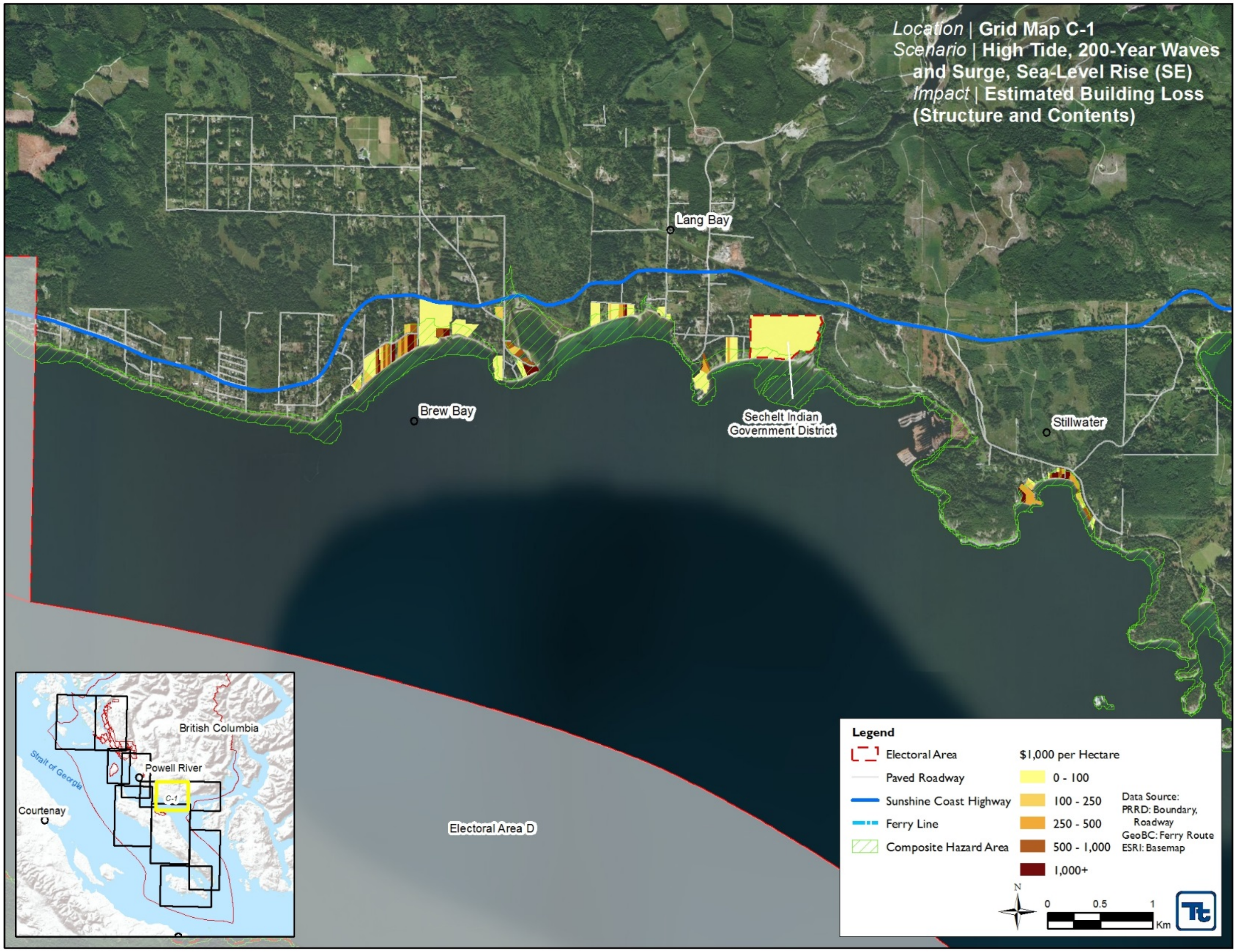


Figure 51. Grid Map C-2 with Estimated Building Loss (Structure and Contents) for the High Tide 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

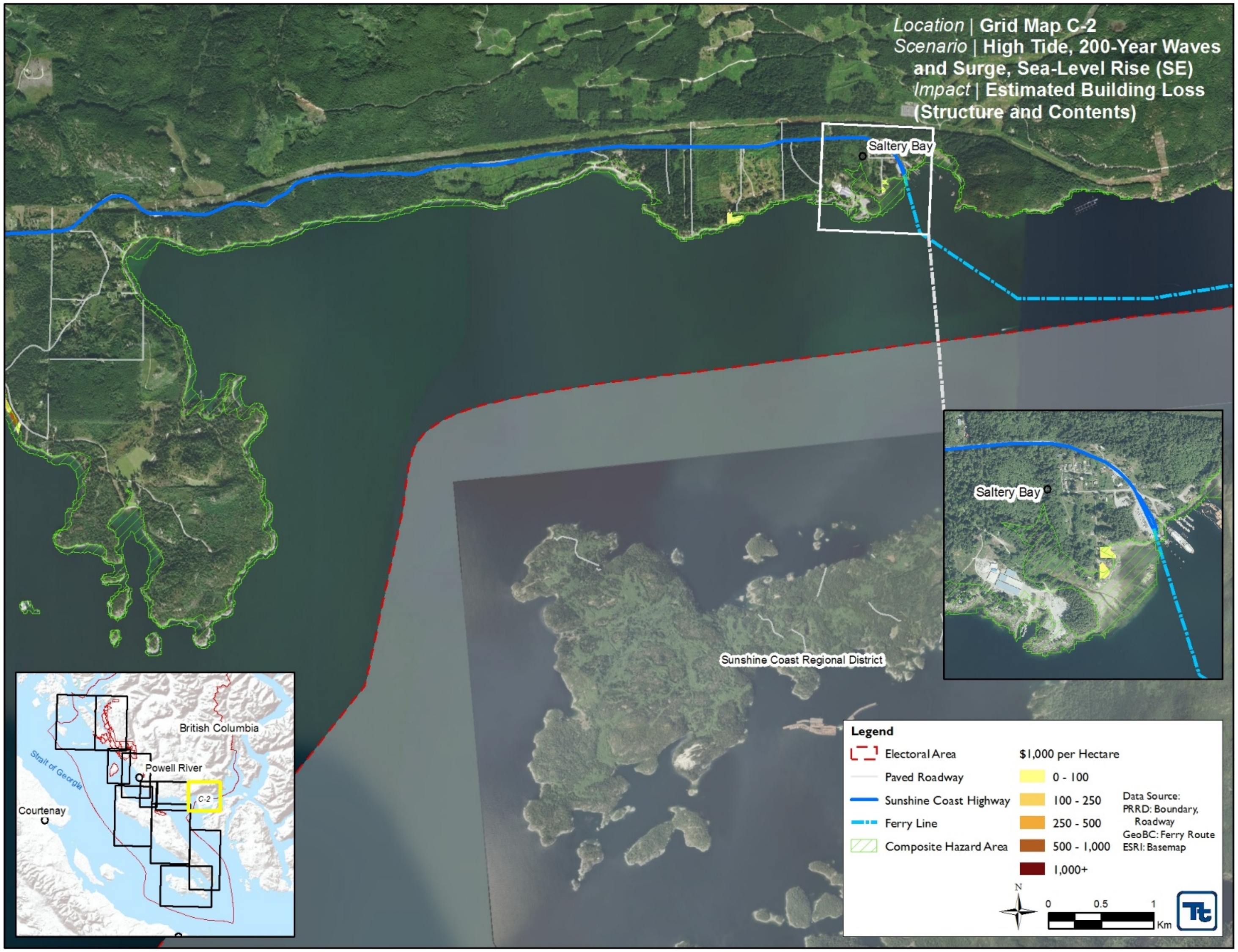


Figure 52. Grid Map E-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

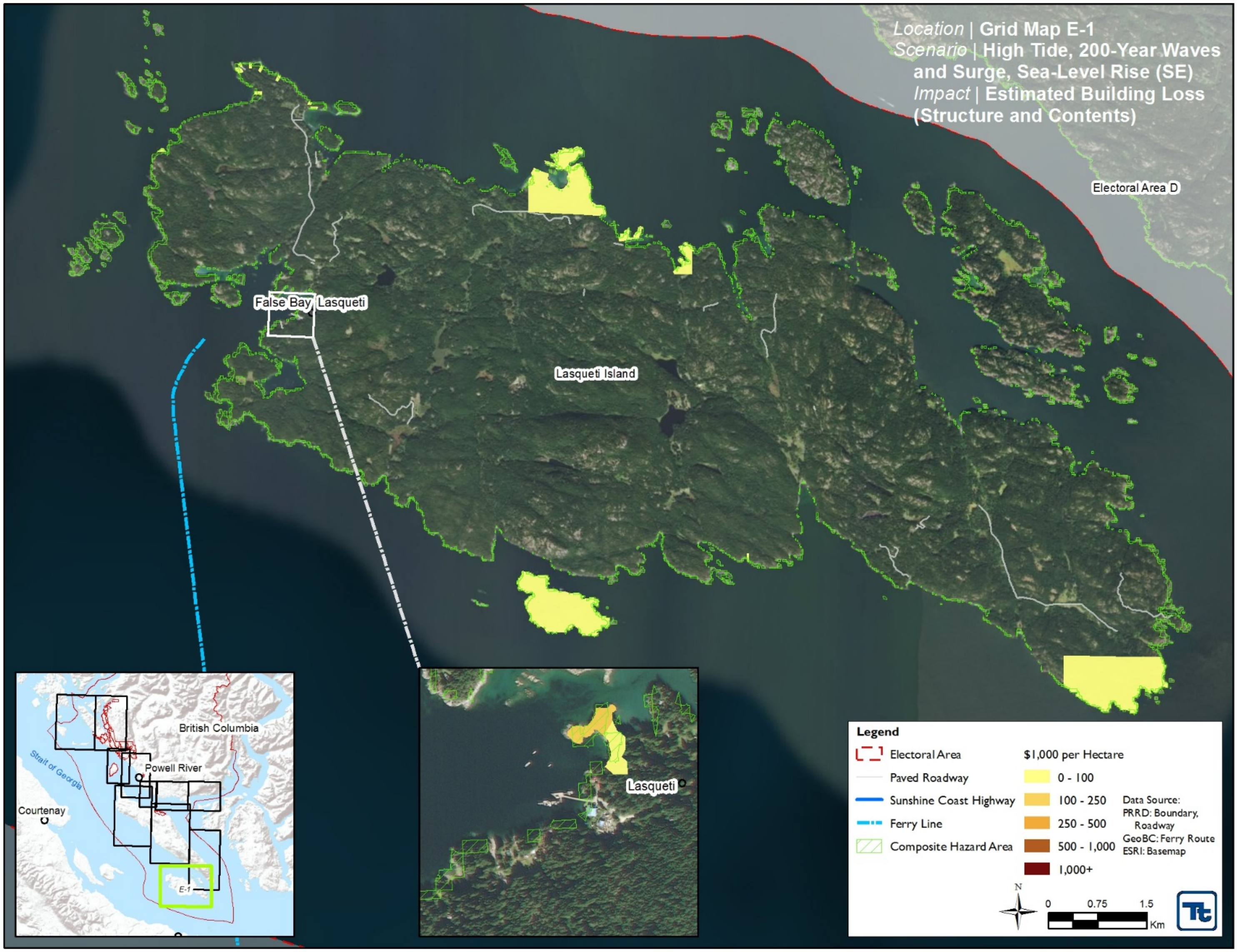


Figure 53. Grid Map PR-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

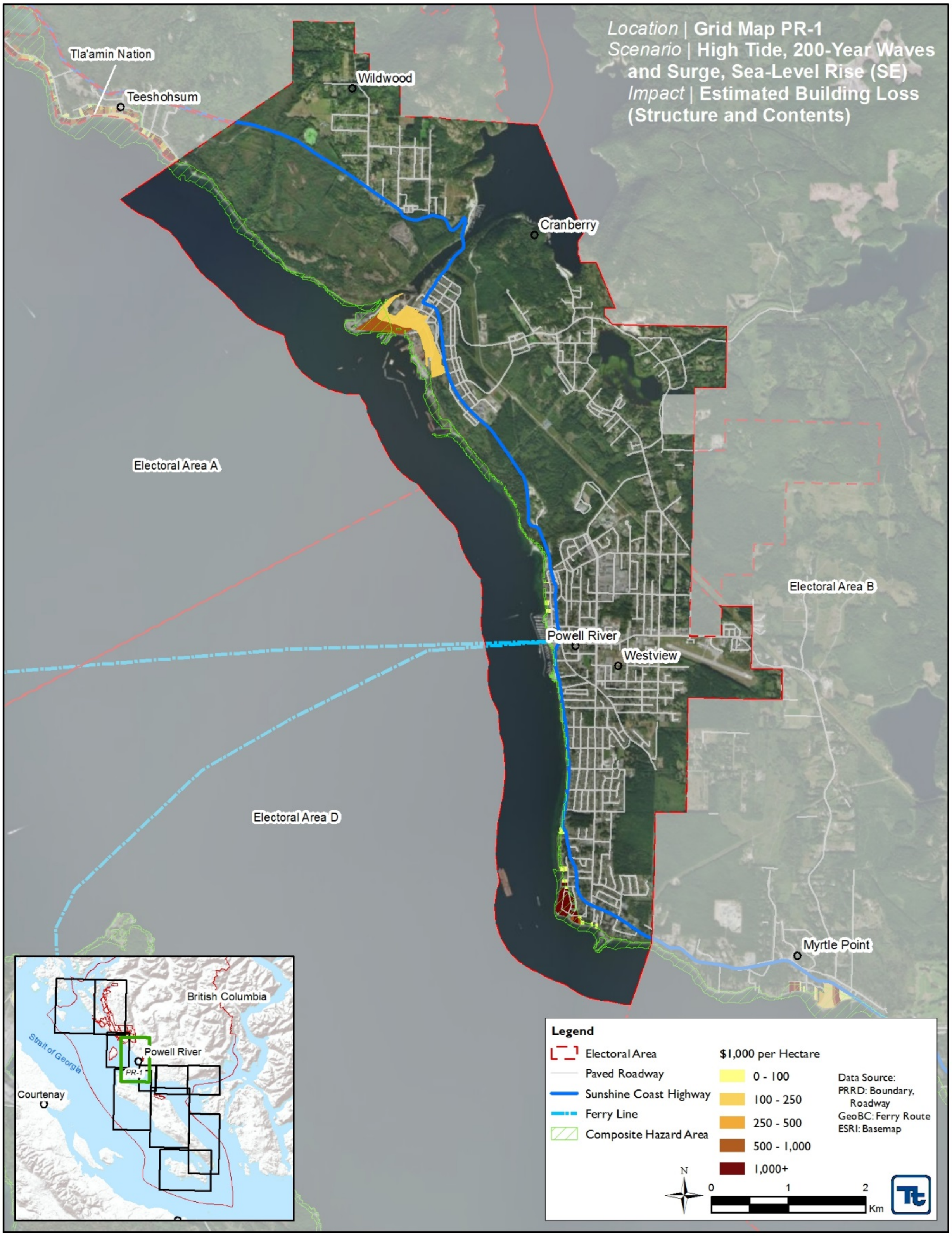


Figure 54. Grid Map TI-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

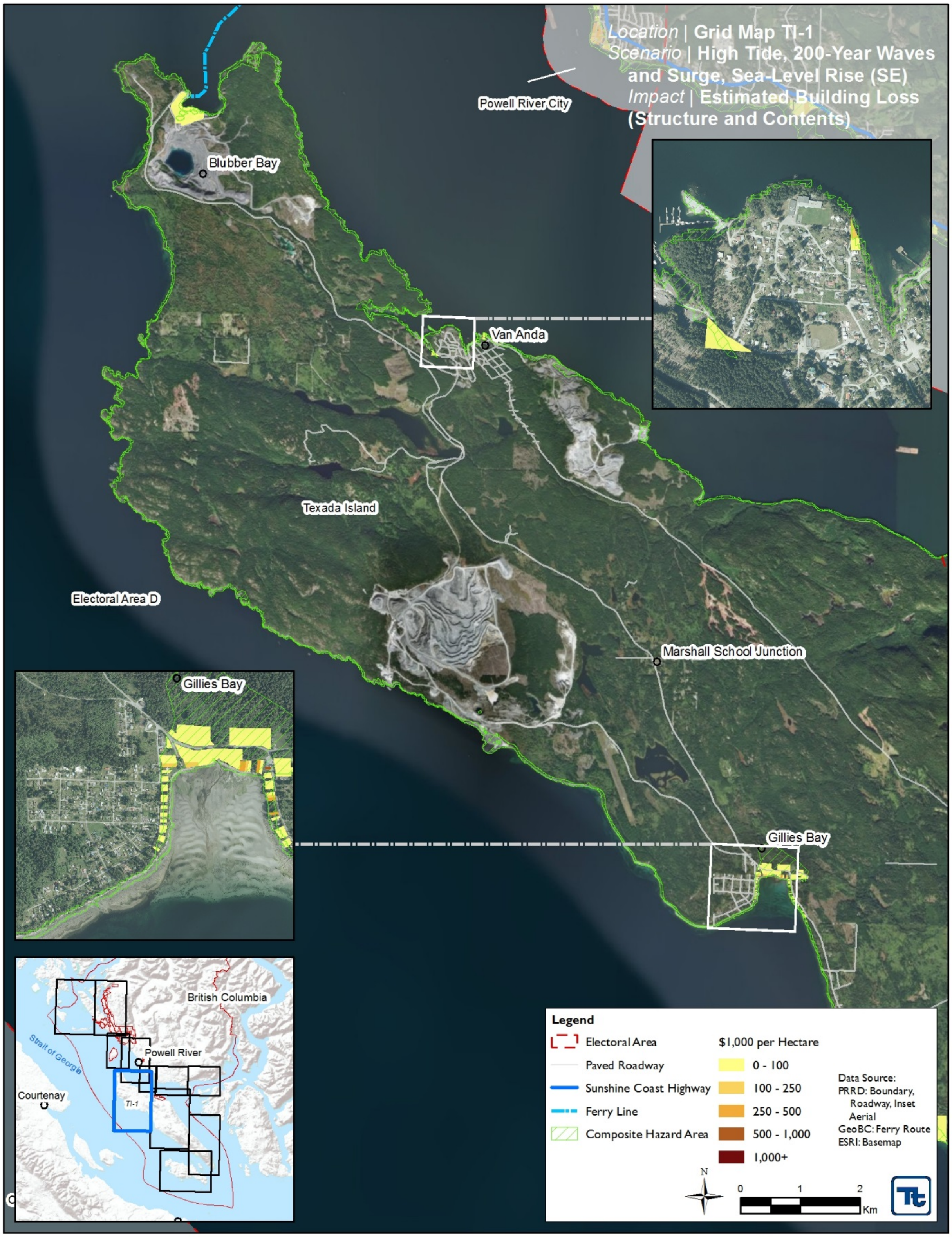


Figure 55. Grid Map TI-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

Figure 56. Grid Map TI-3 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

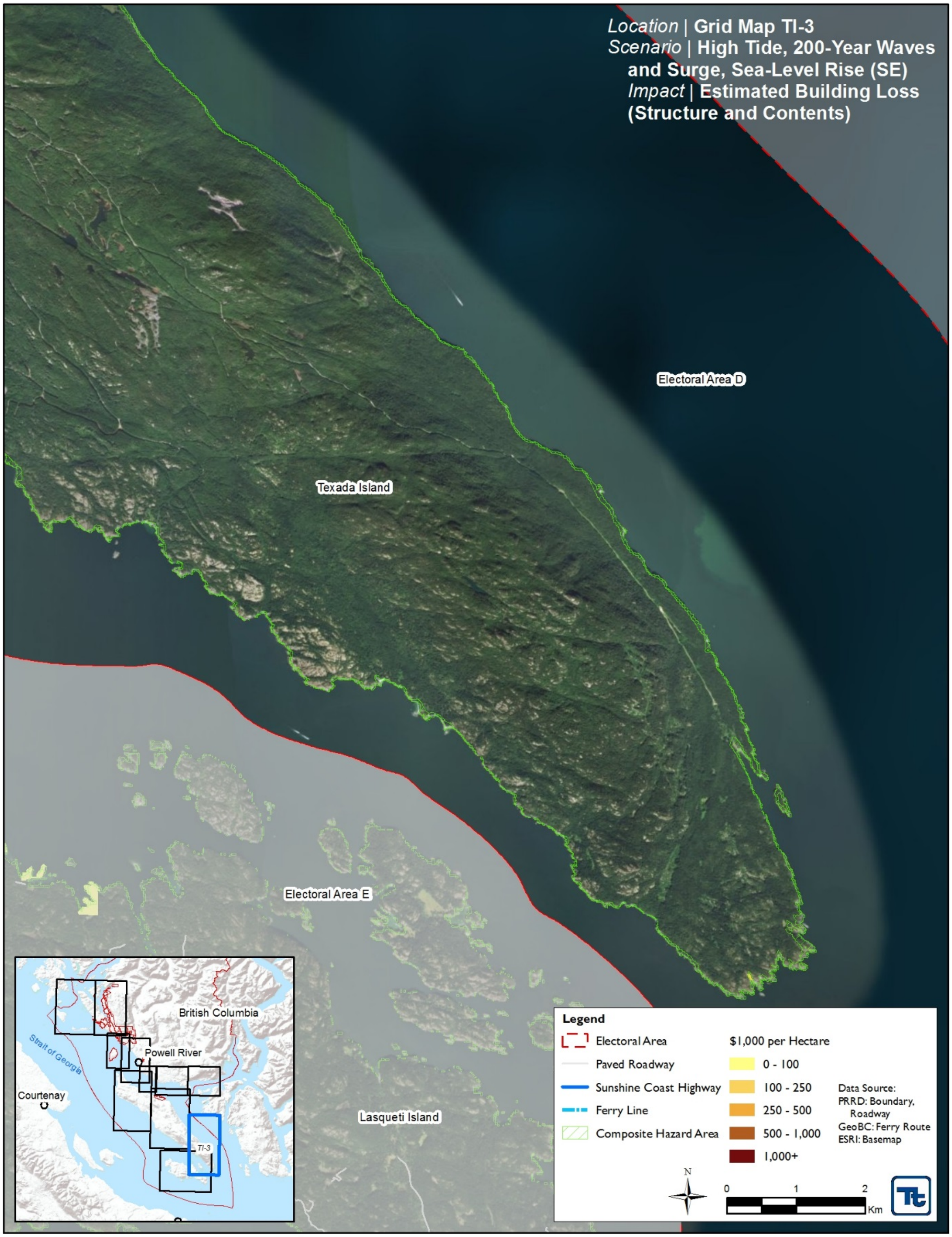


Figure 57. Grid Map TN-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (SE) Scenario at the Parcel Level

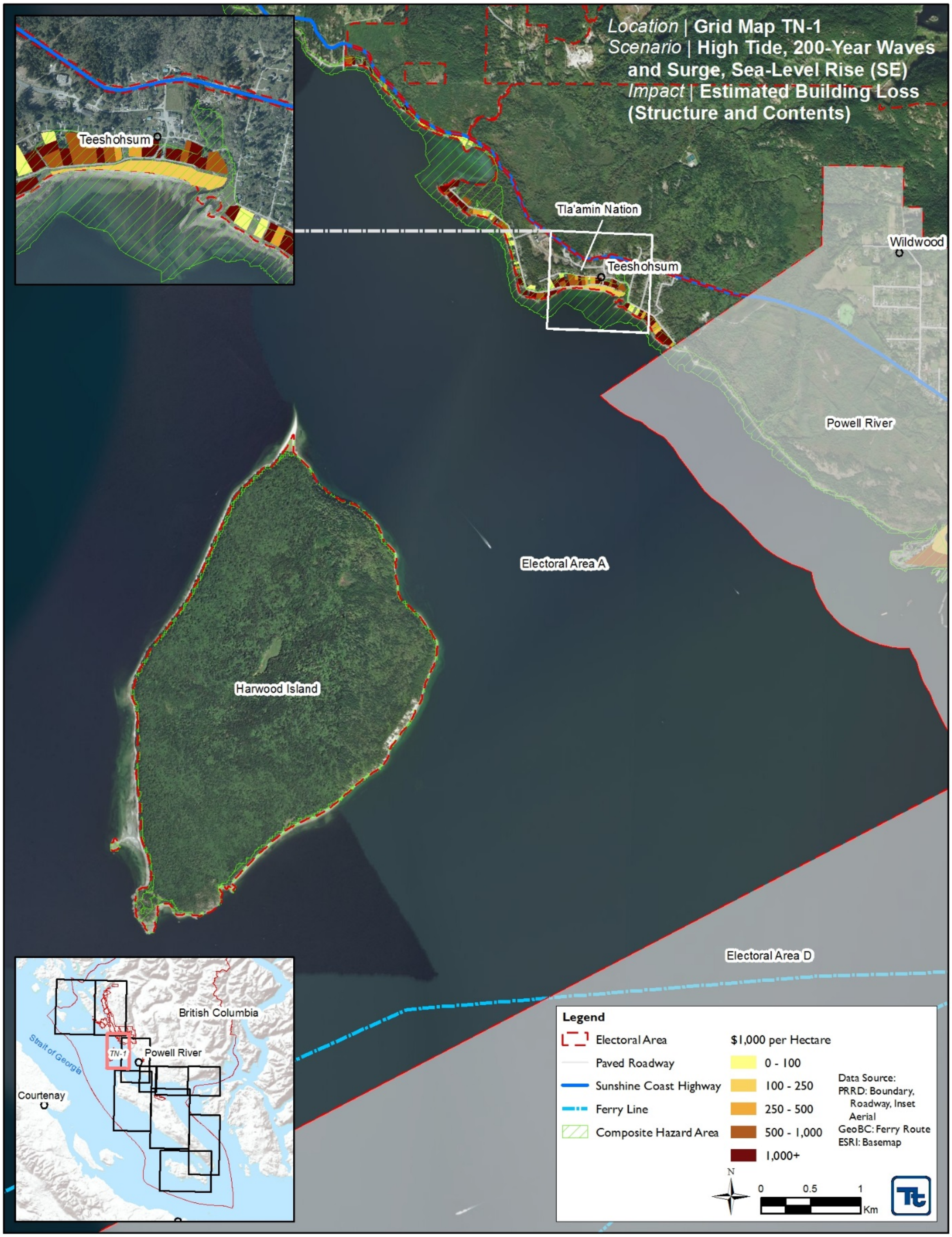


Figure 58. Grid Map A-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

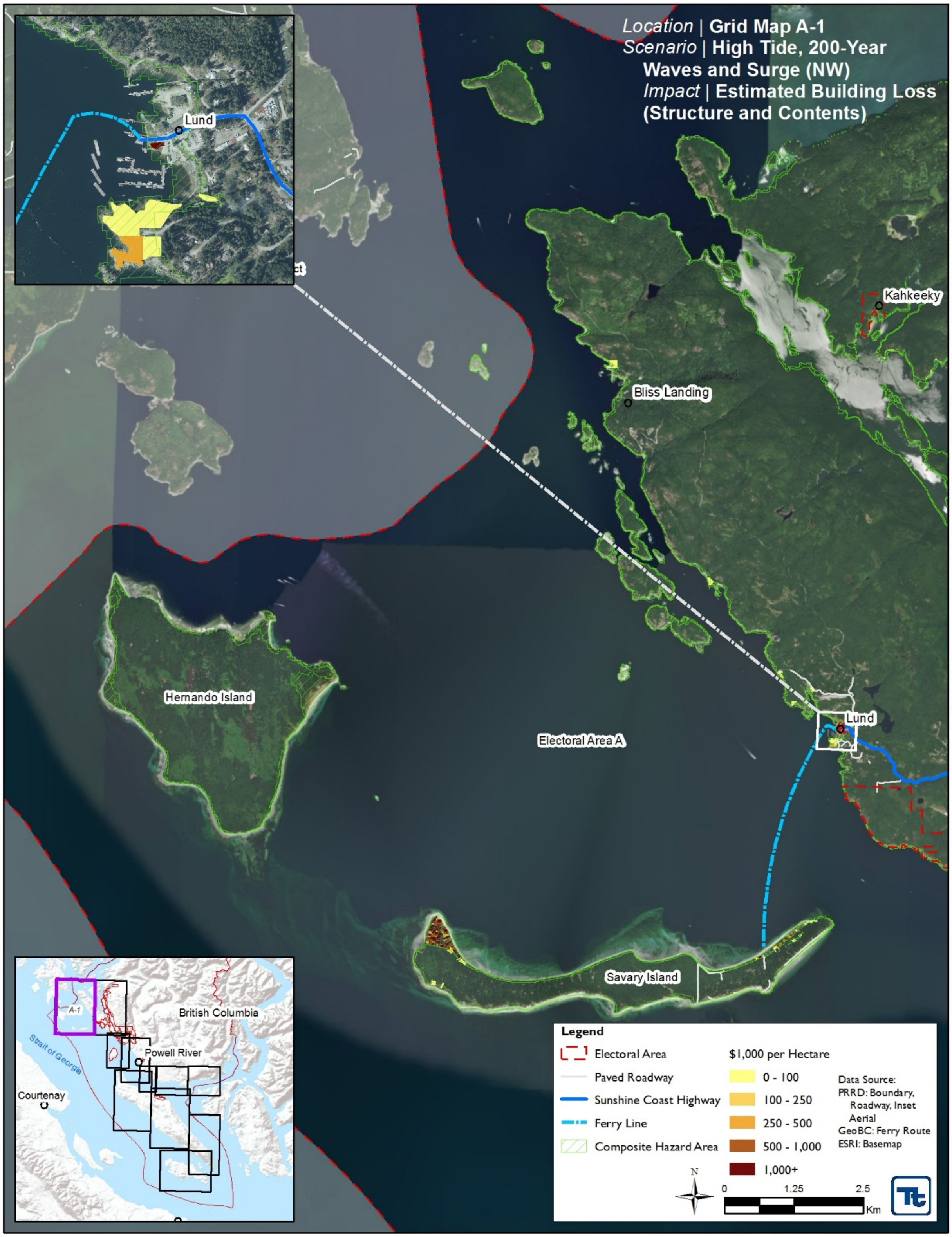


Figure 59. Grid Map A-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

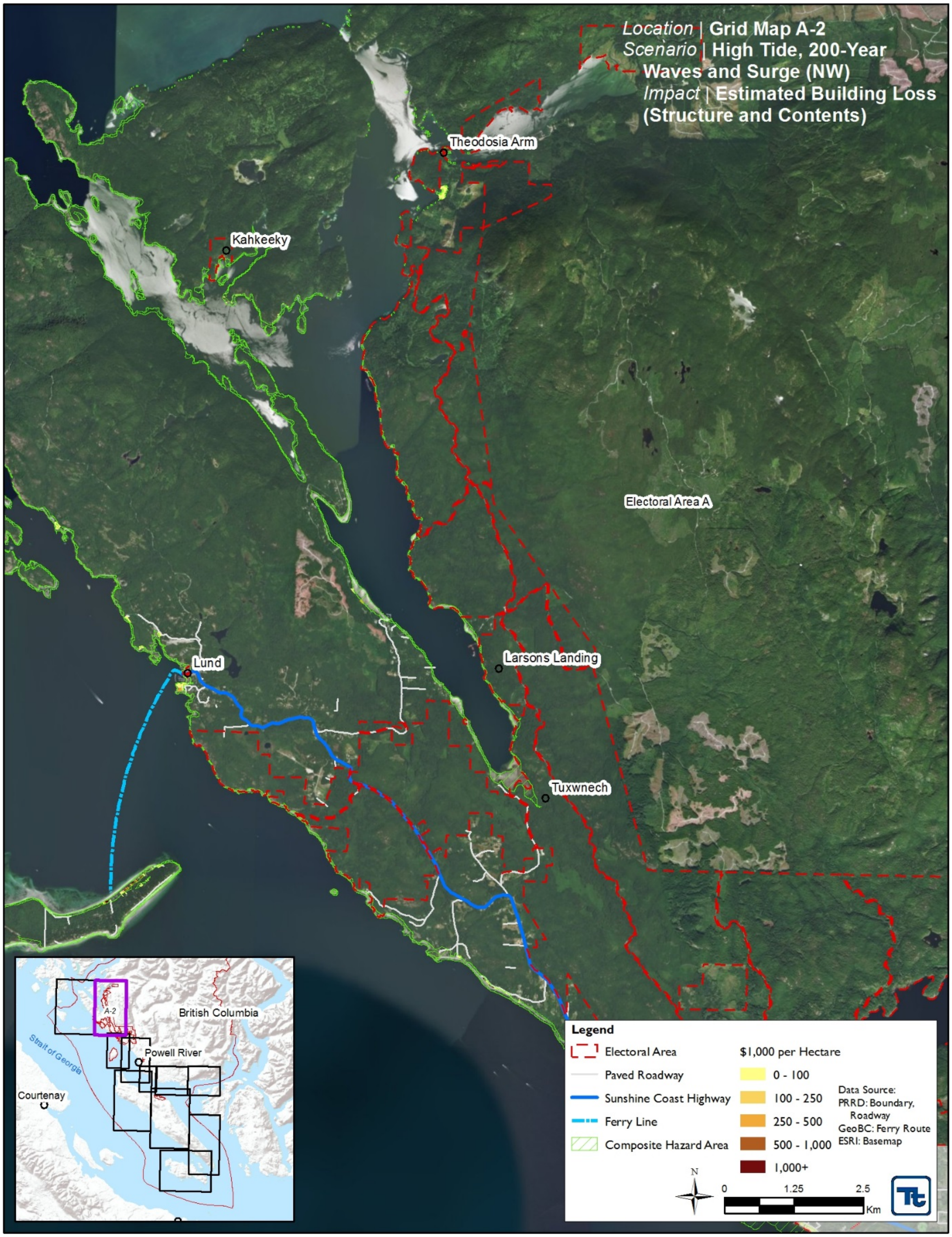


Figure 60. Grid Map B-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

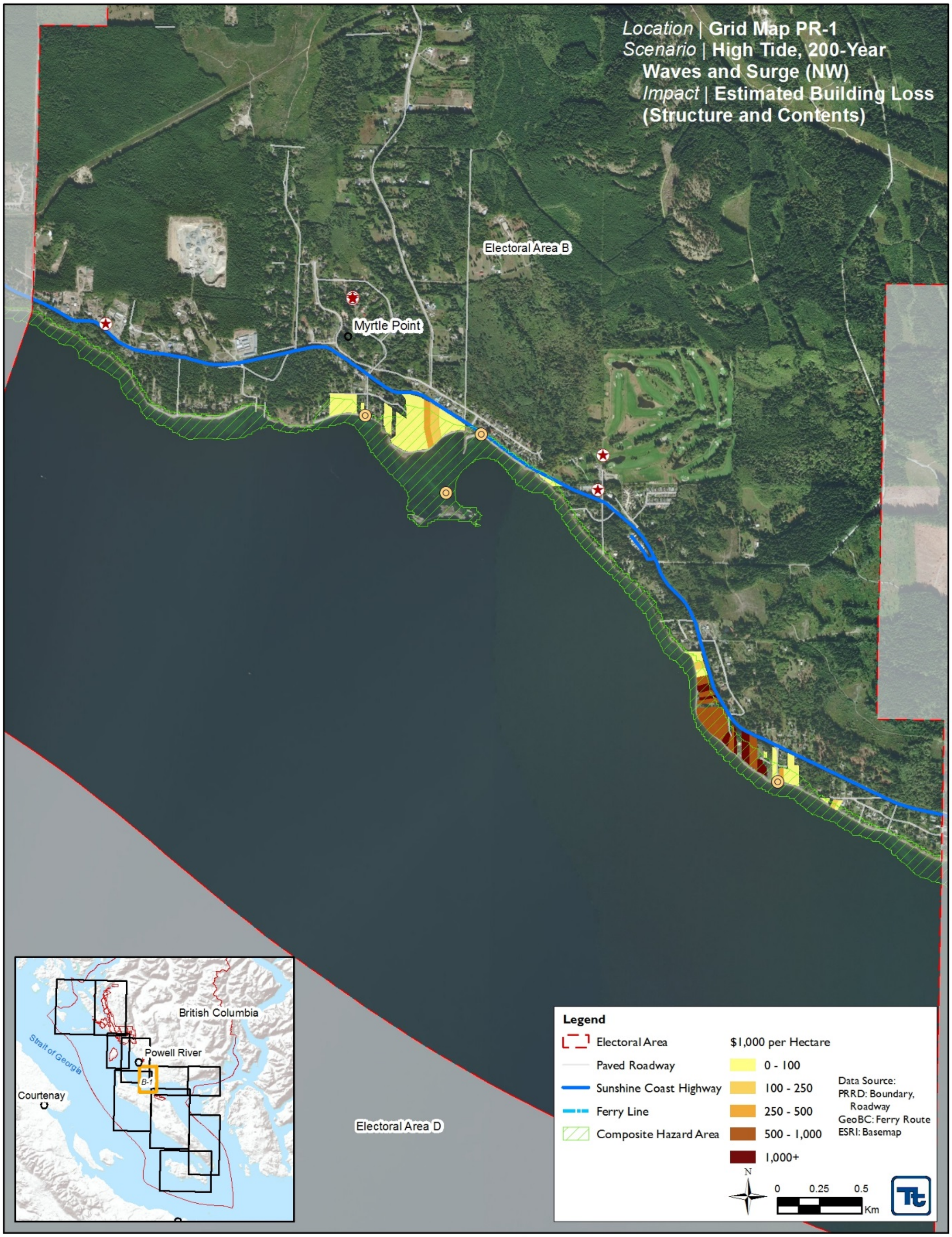


Figure 61. Grid Map C-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

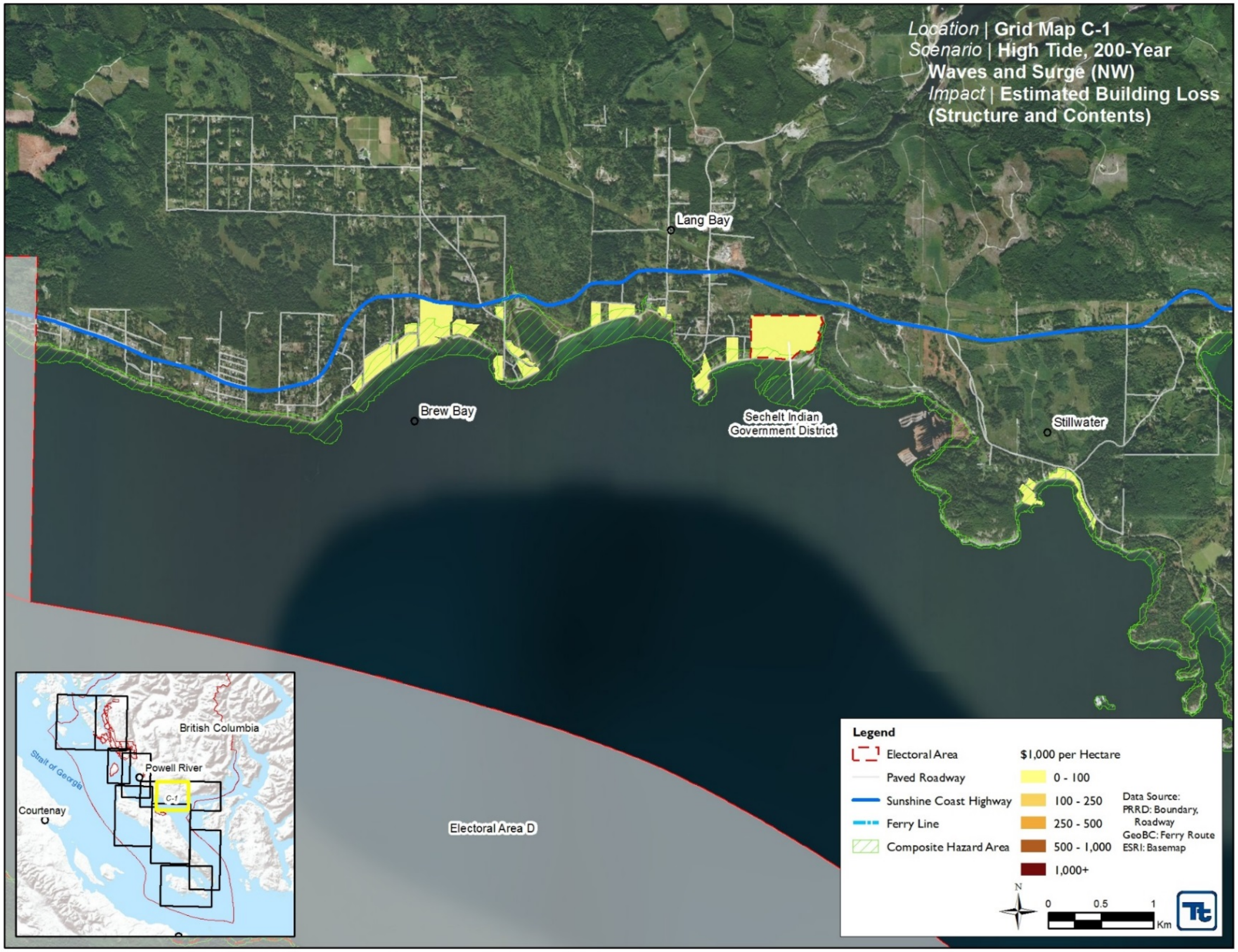


Figure 62. Grid Map C-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

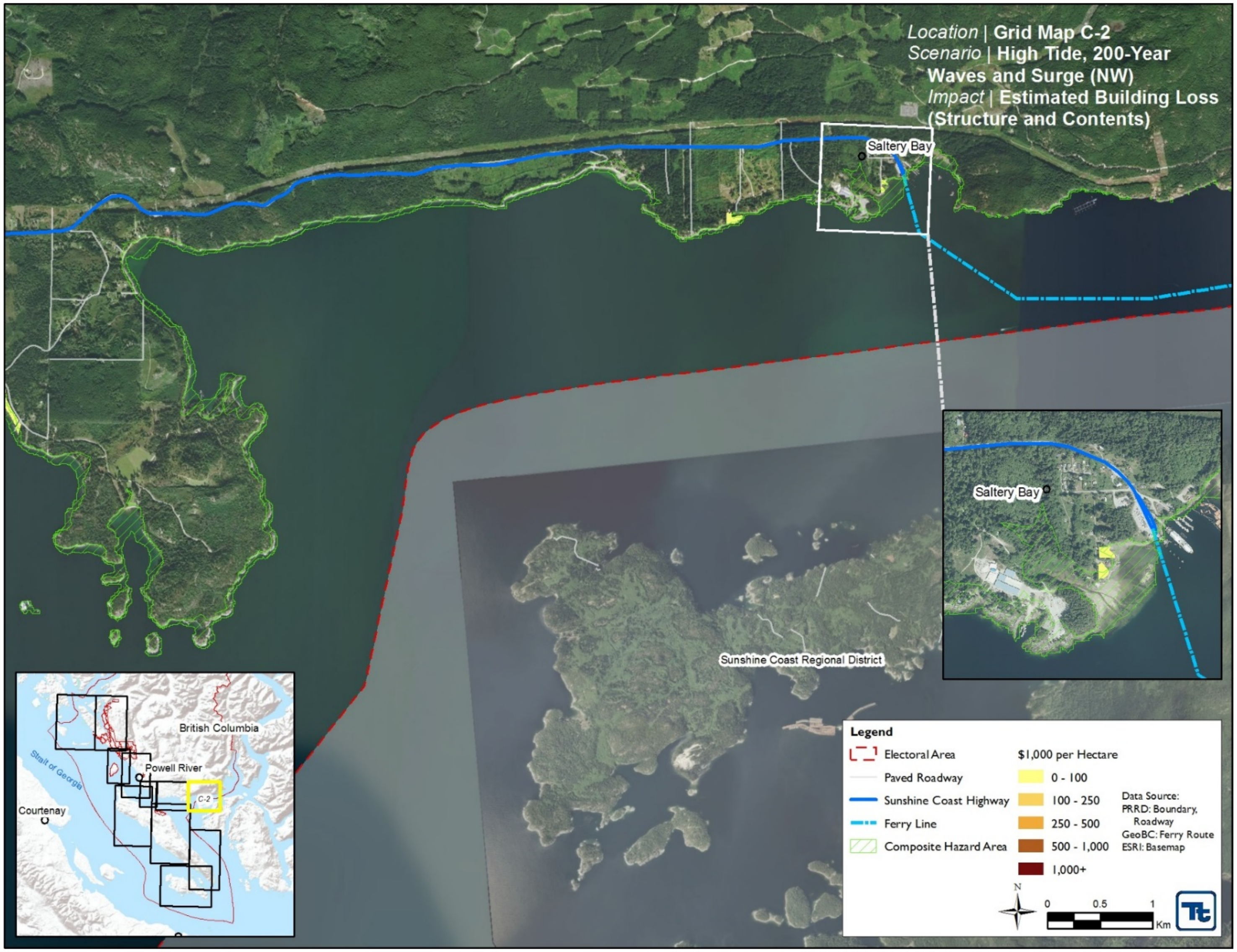


Figure 63. Grid Map E-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

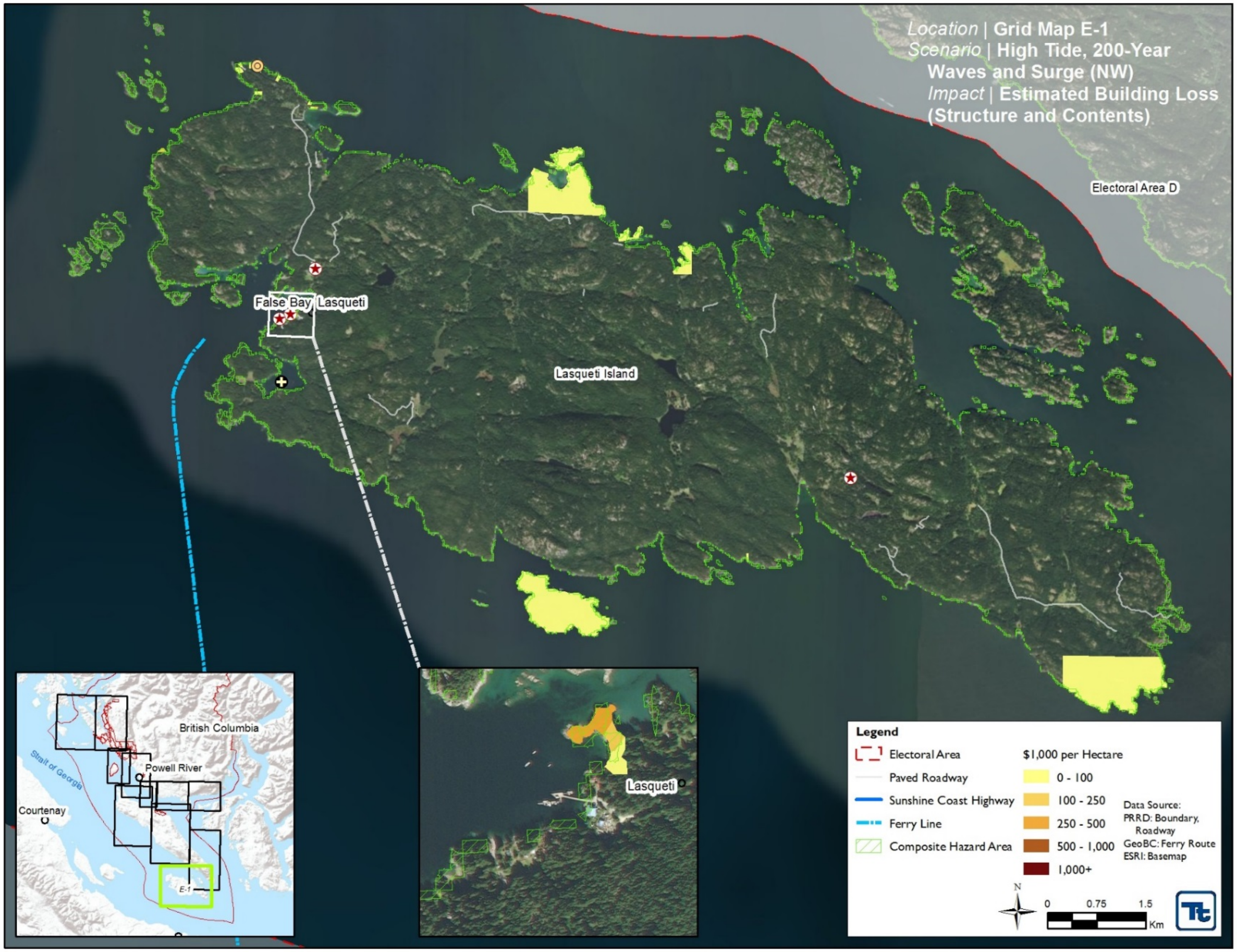


Figure 64. Grid Map PR-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

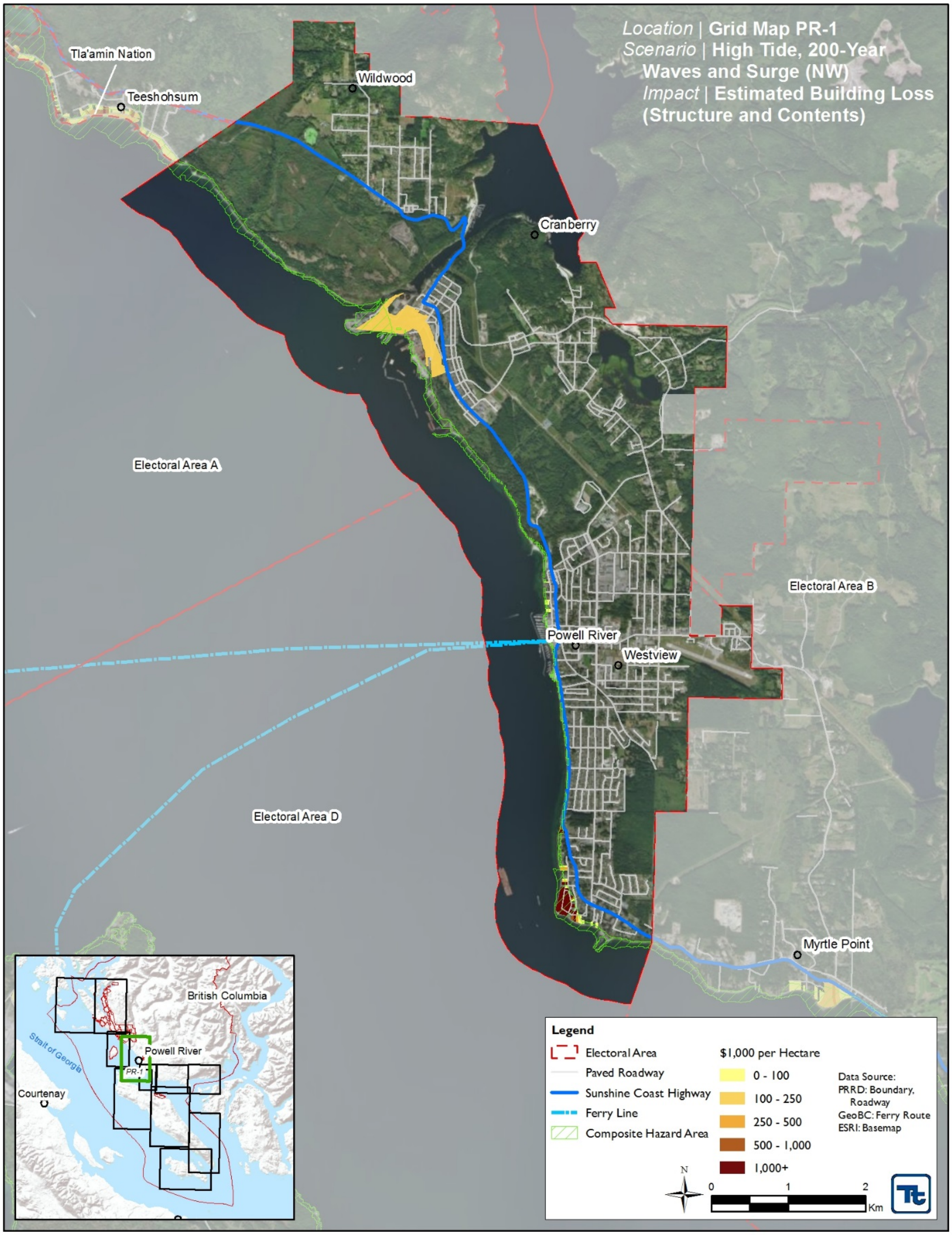


Figure 65. Grid Map TI-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

Figure 66. Grid Map TI-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

Figure 67. Grid Map TI-3 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

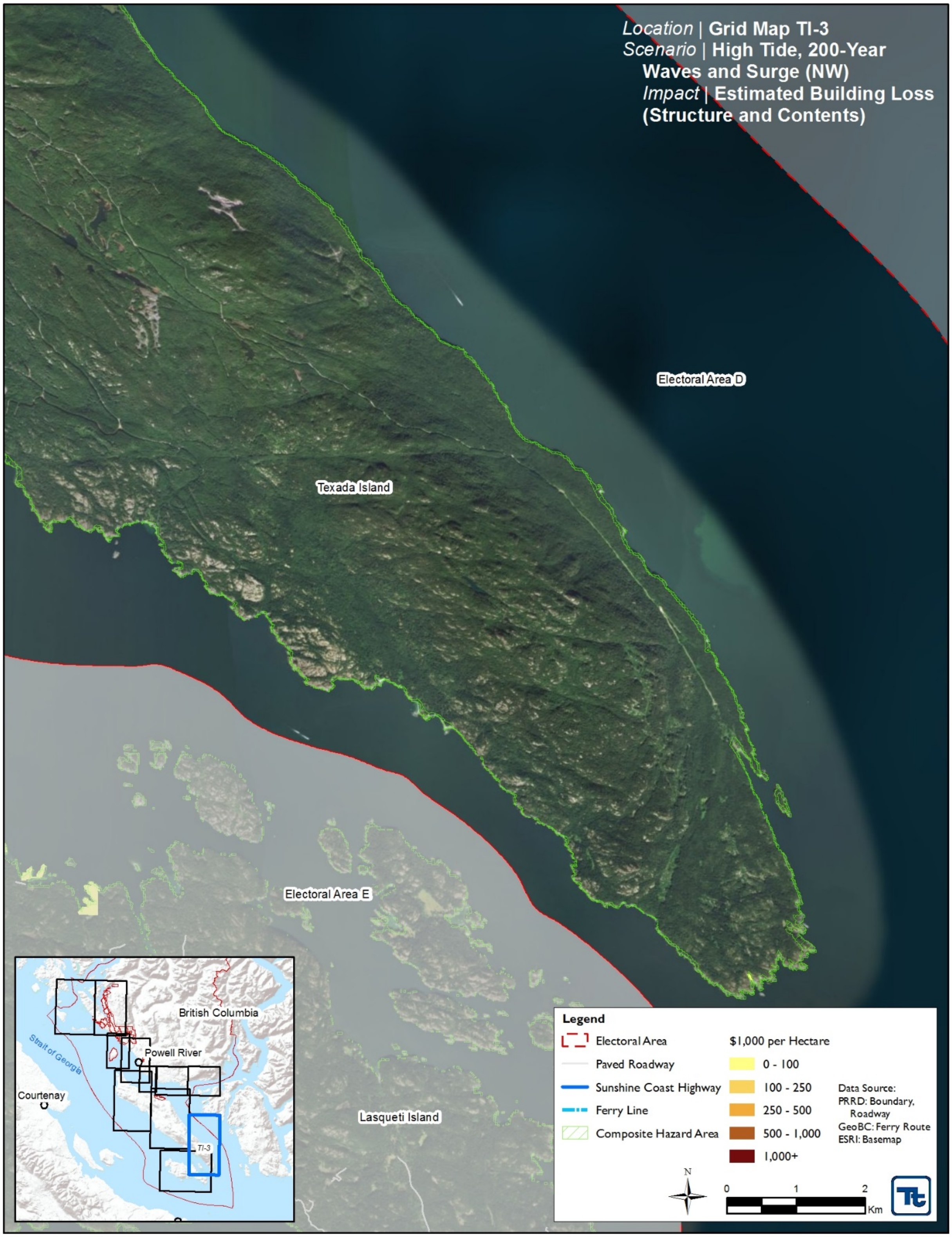


Figure 68. Grid Map TN-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge (NW) Scenario at the Parcel Level

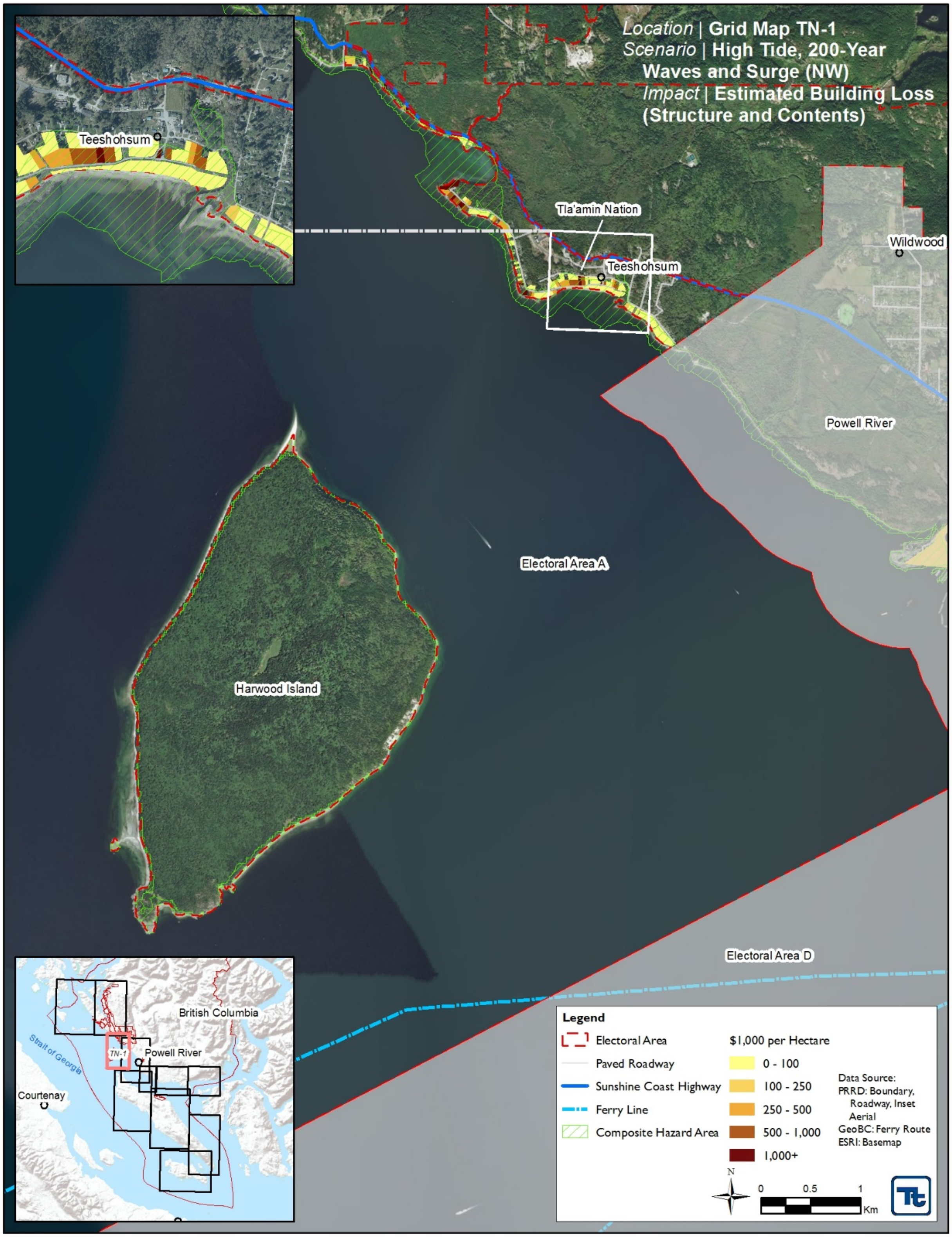


Figure 69. Grid Map A-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

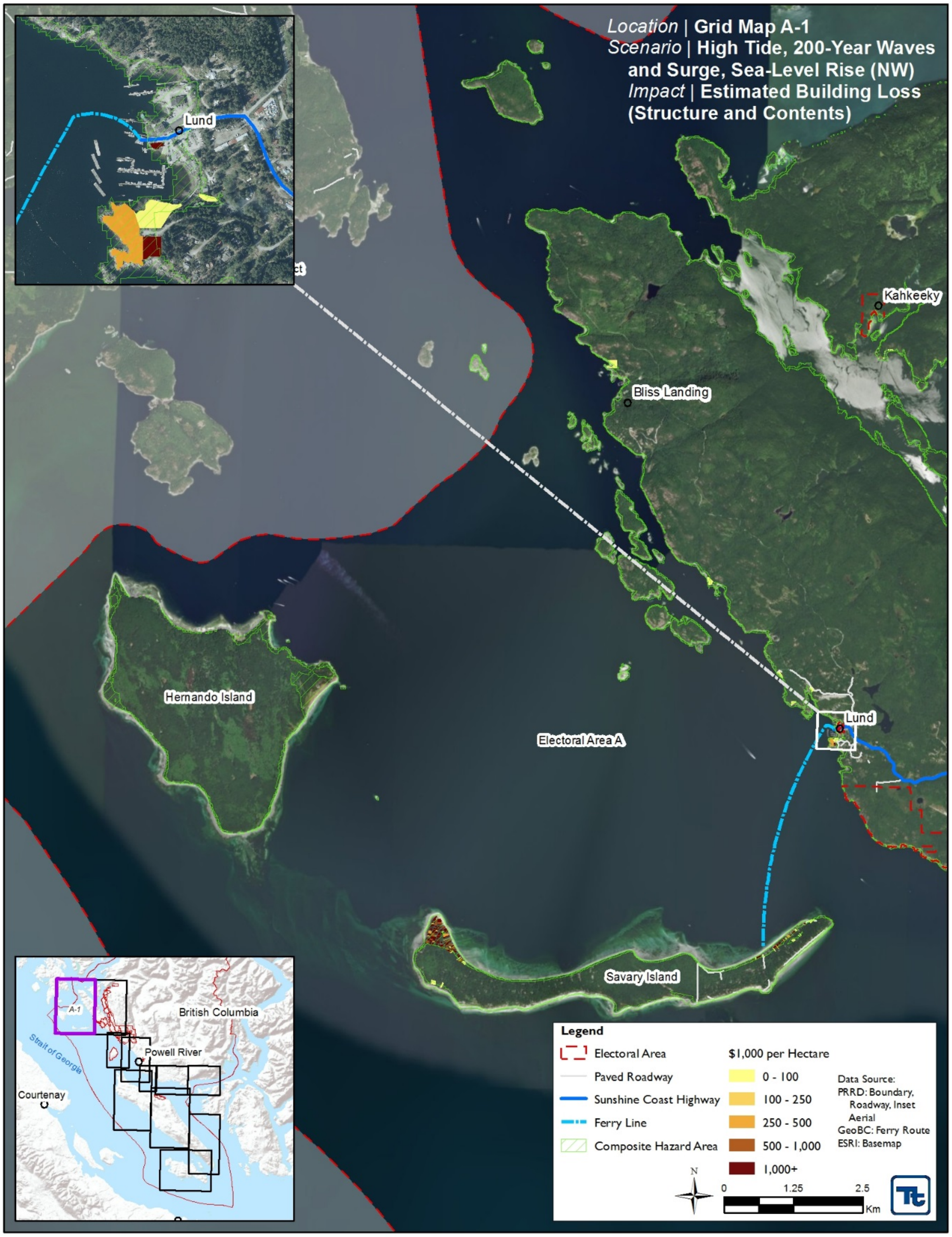


Figure 70. Grid Map A-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

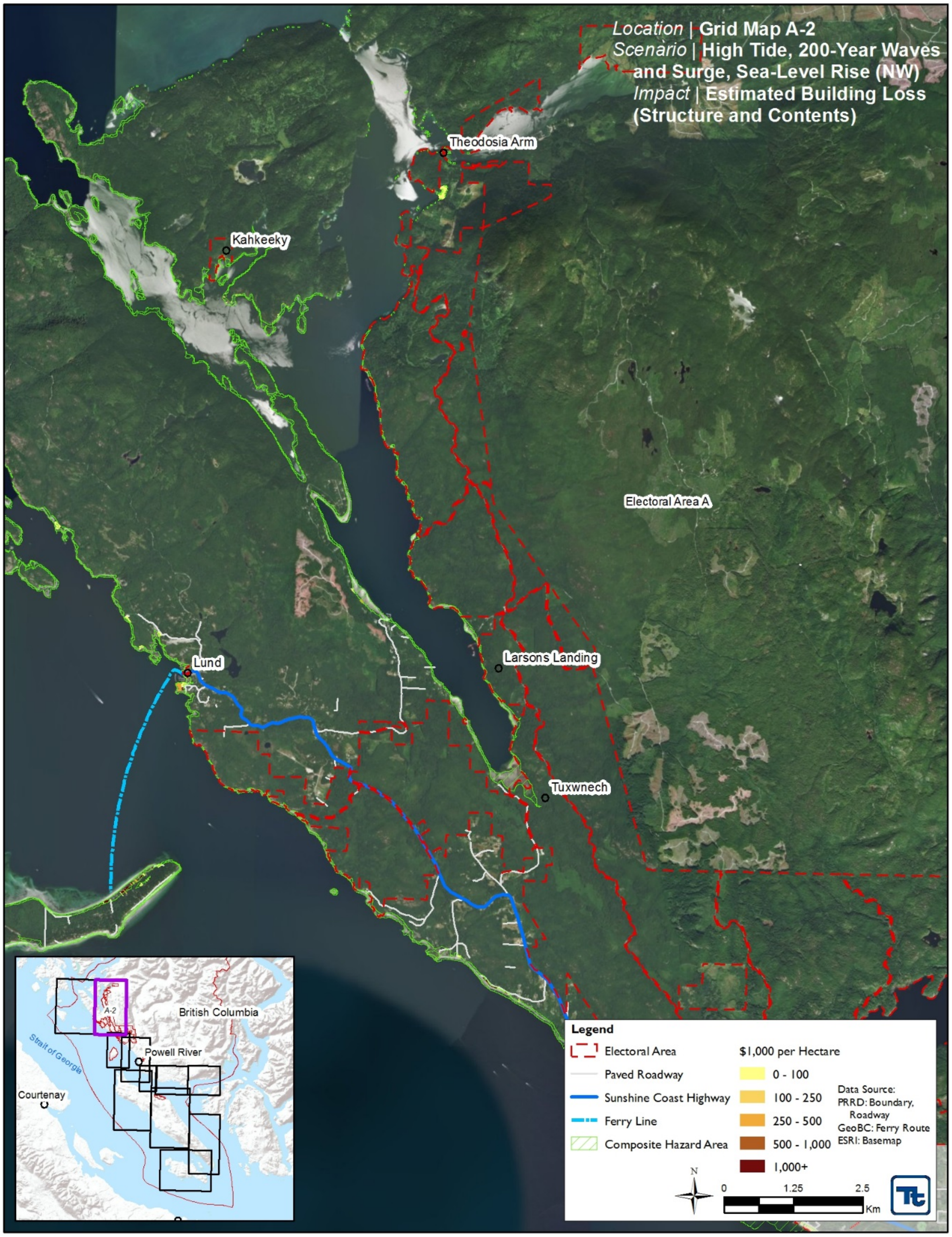


Figure 71. Grid Map B-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

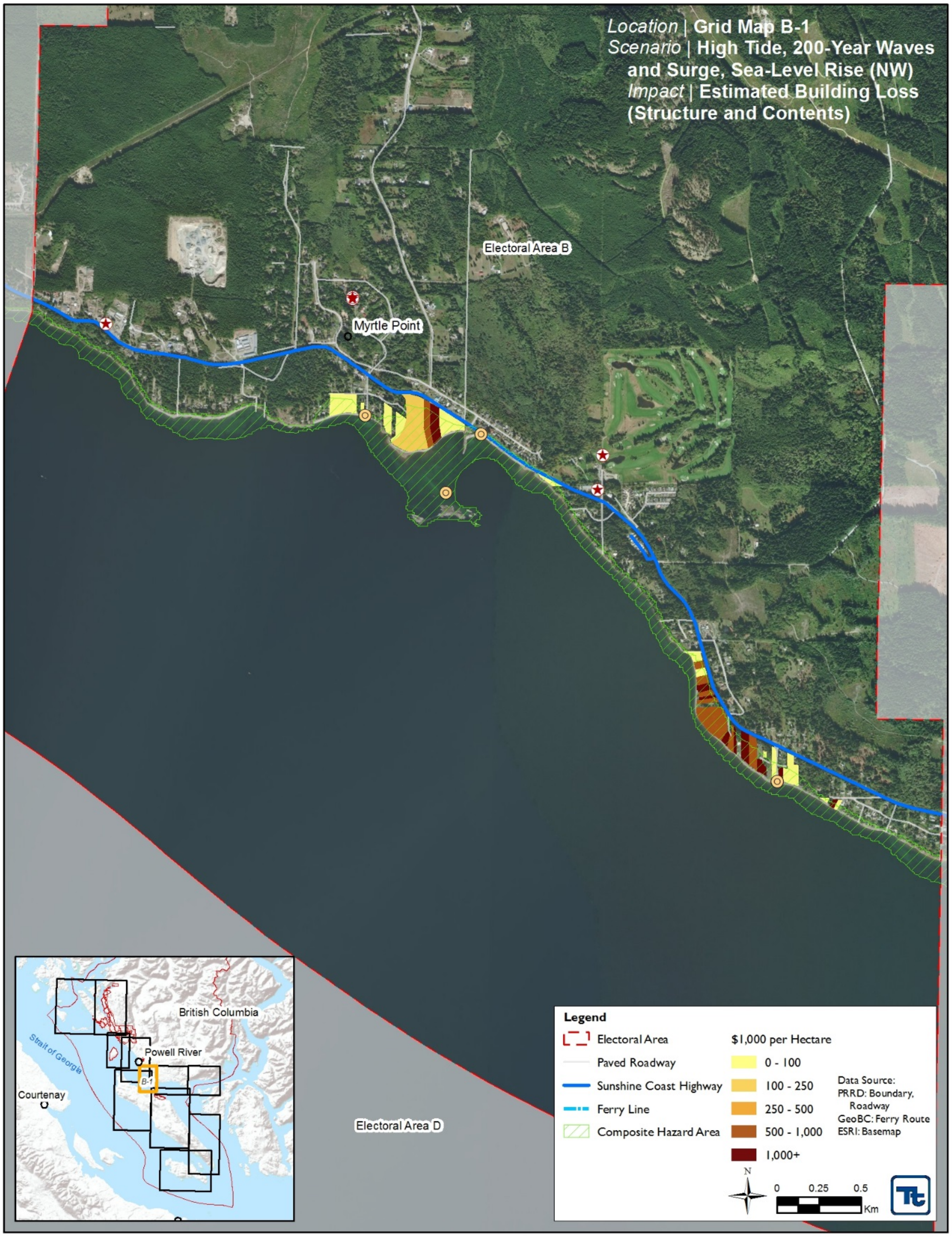


Figure 72. Grid Map C-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

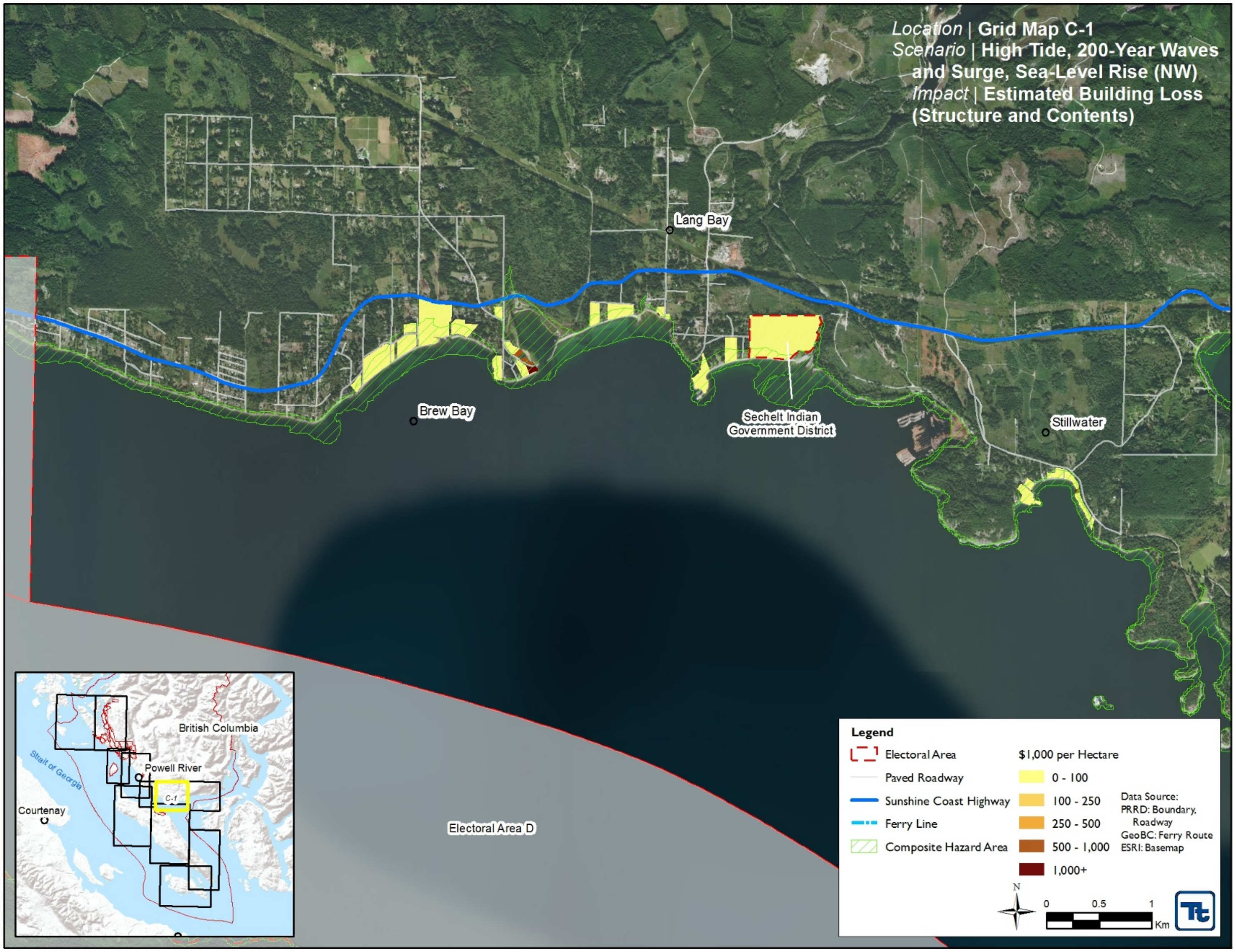


Figure 73. Grid Map C-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

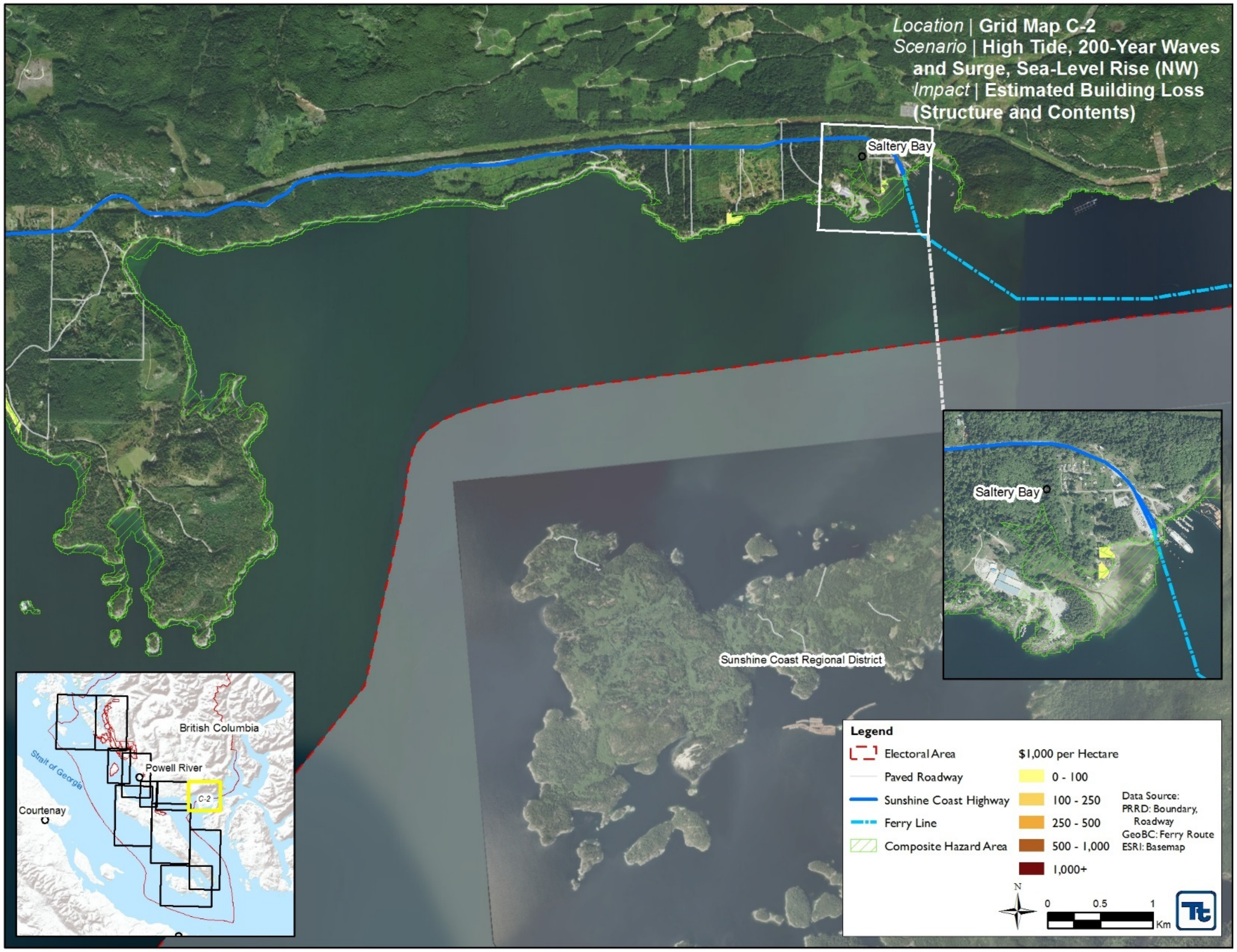


Figure 74. Grid Map E-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

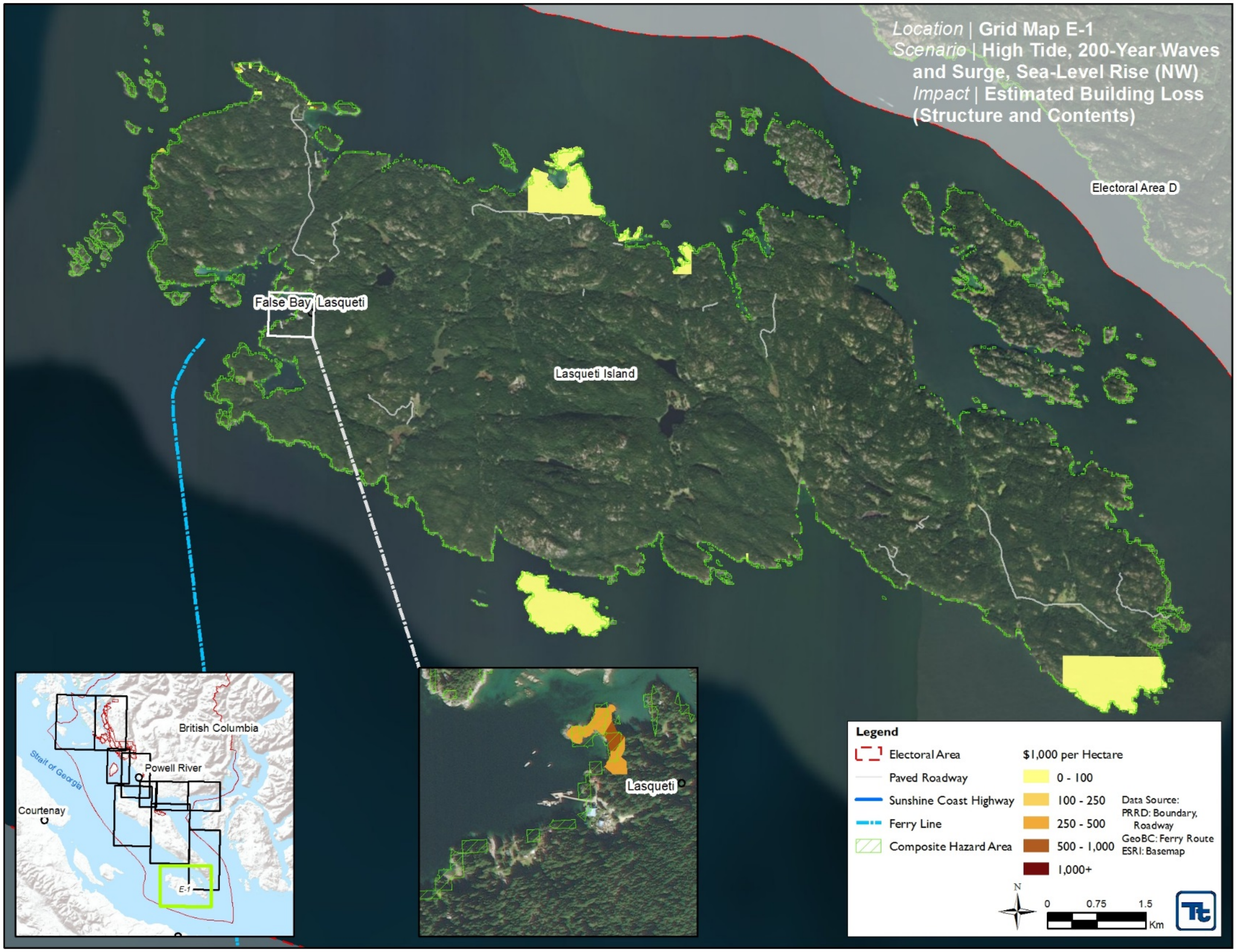


Figure 75. Grid Map PR-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

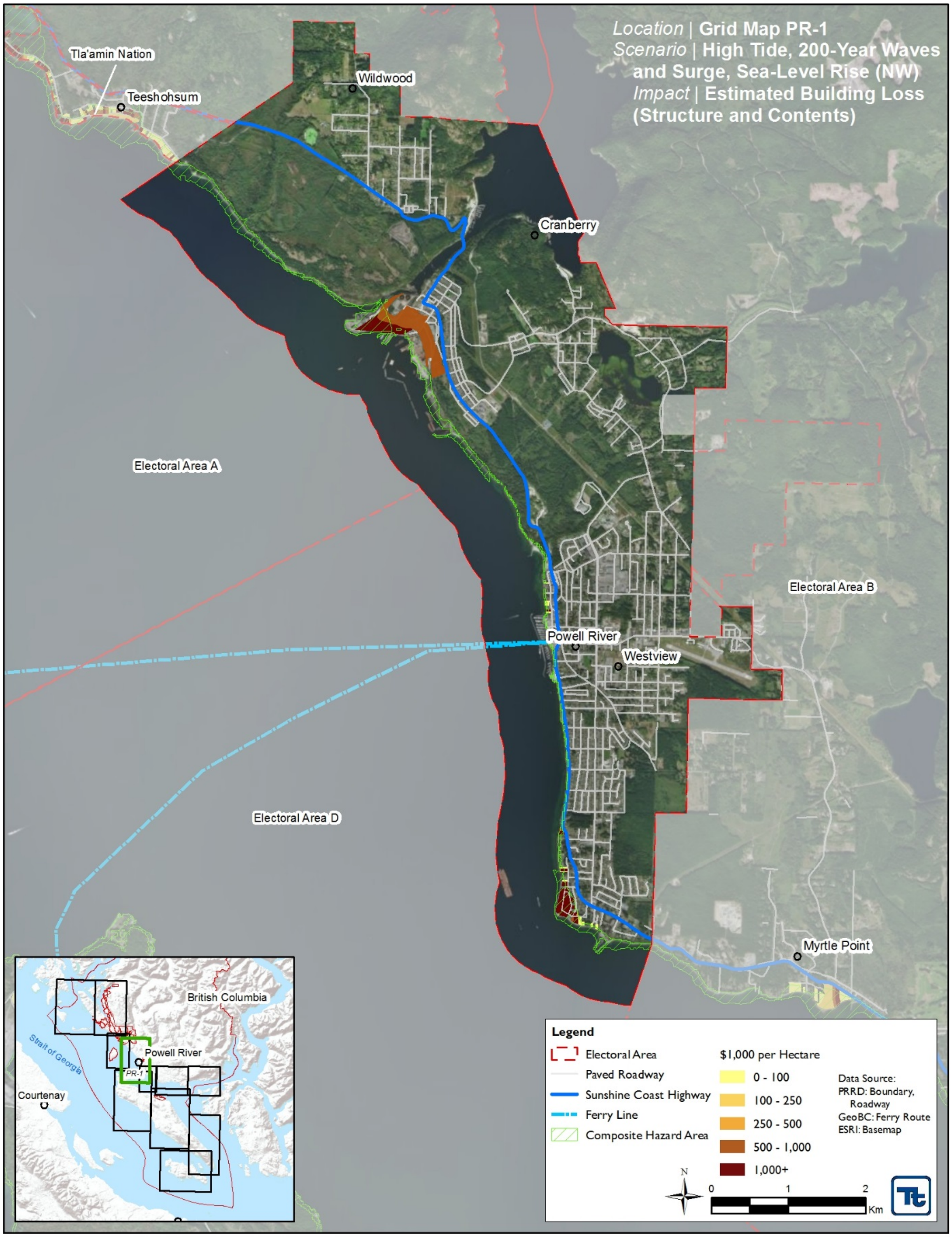


Figure 76. Grid Map TI-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

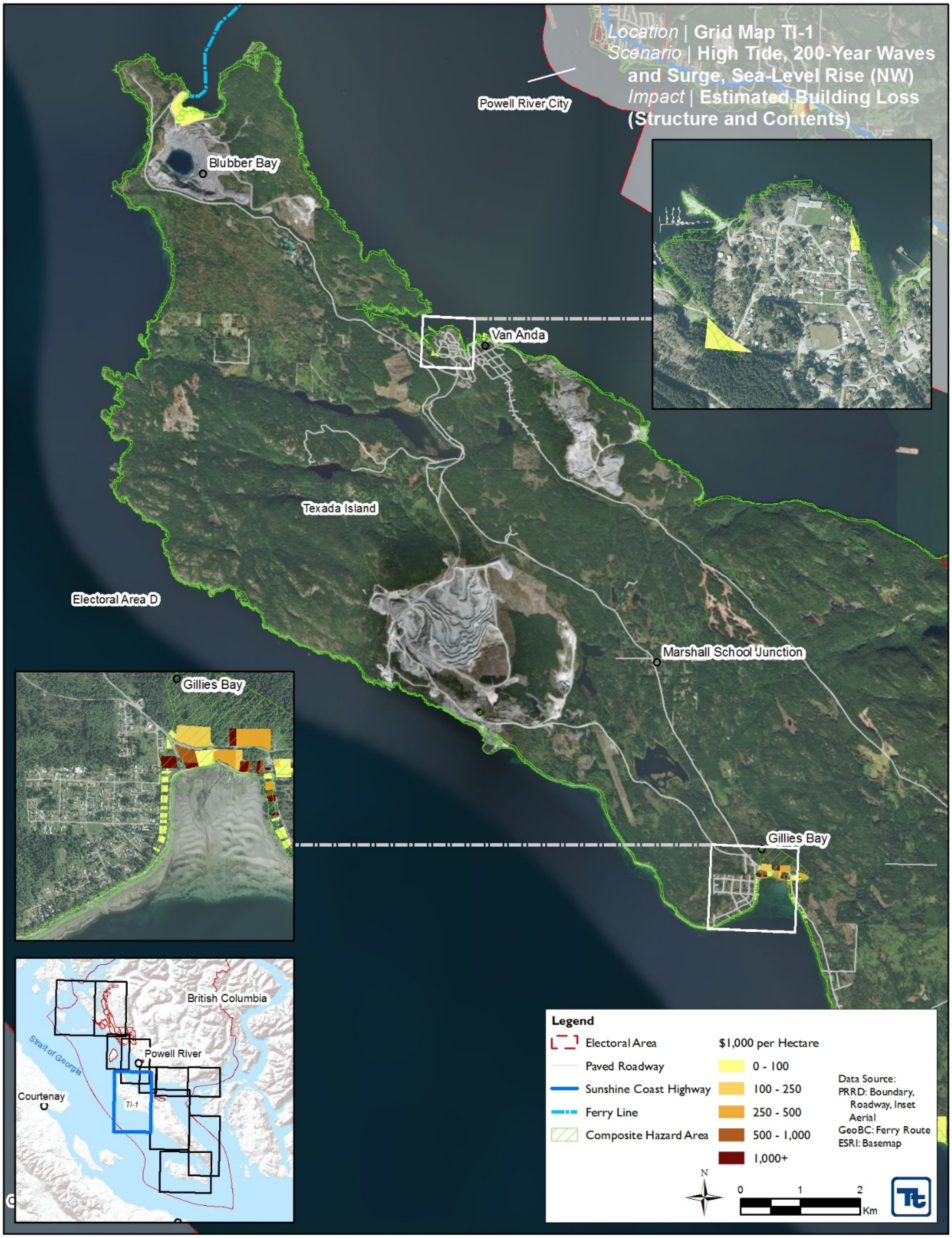


Figure 77. Grid Map TI-2 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

Figure 78. Grid Map TI-3 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

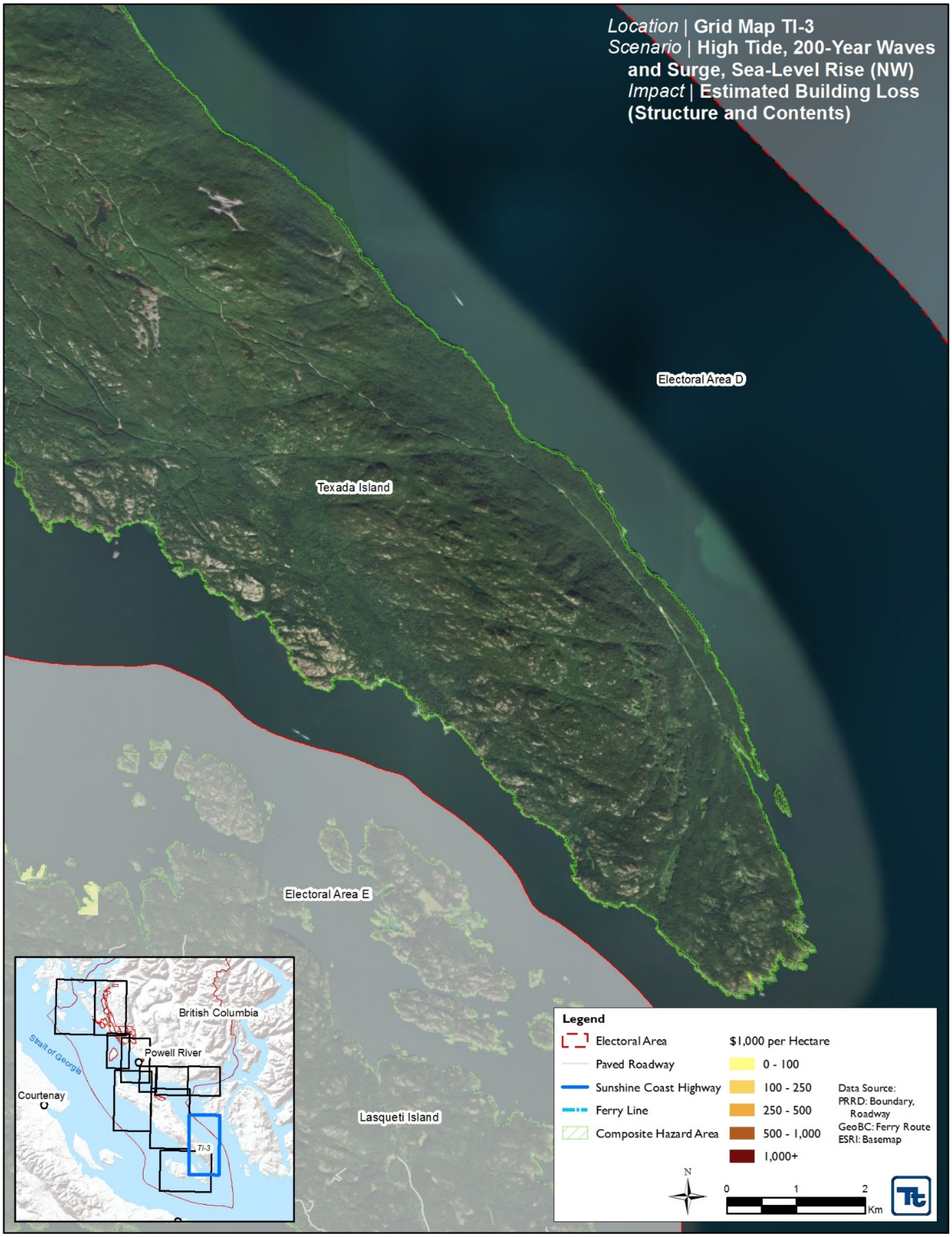


Figure 79. Grid Map TN-1 with Estimated Building Loss (Structure and Contents) for the High Tide, 200-year Wave and Surge, Sea-Level Rise (NW) Scenario at the Parcel Level

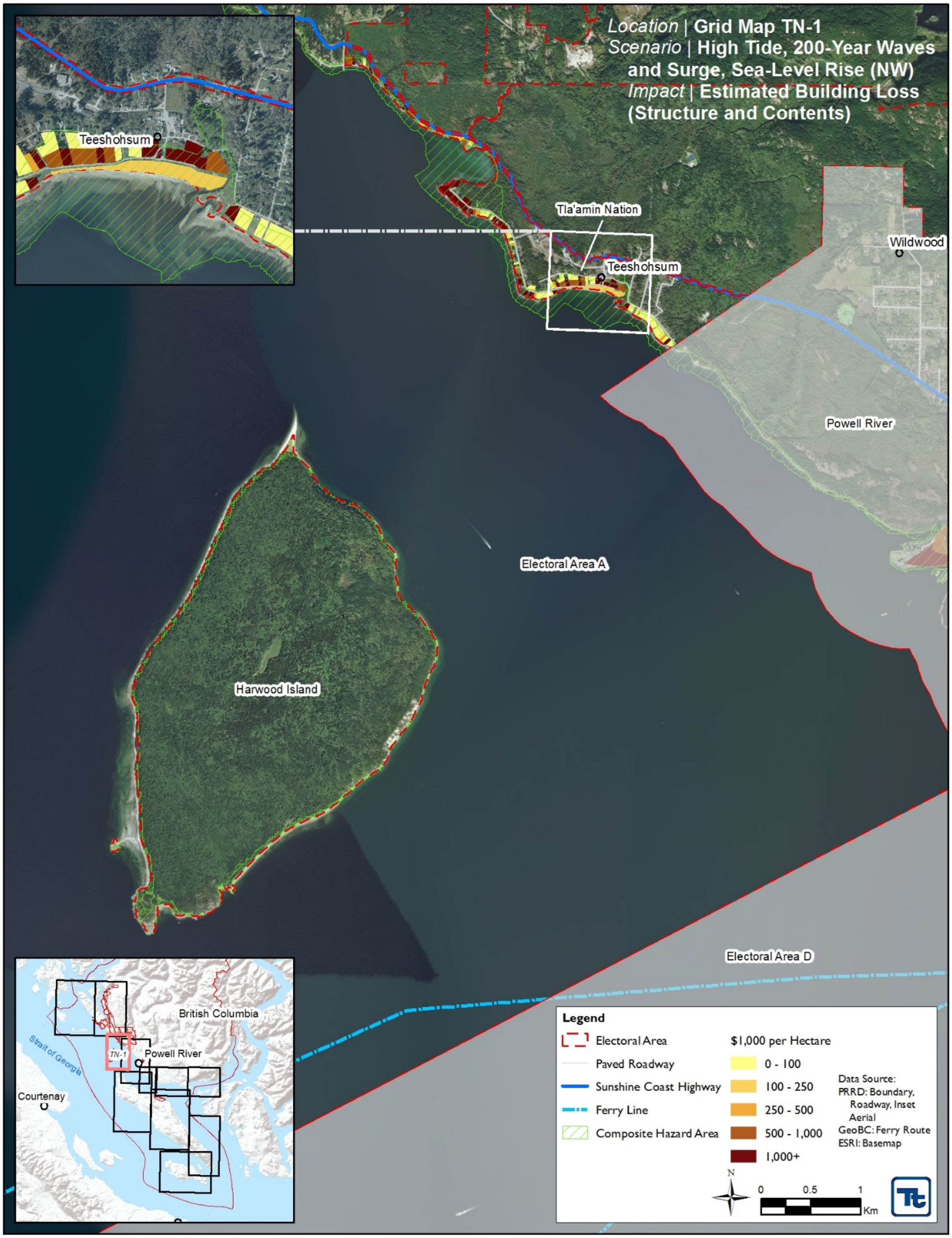


Figure 80. Lengths of Sunshine Coast Highway (HWY 101) Inundated by the Coastal Hazard Scenarios

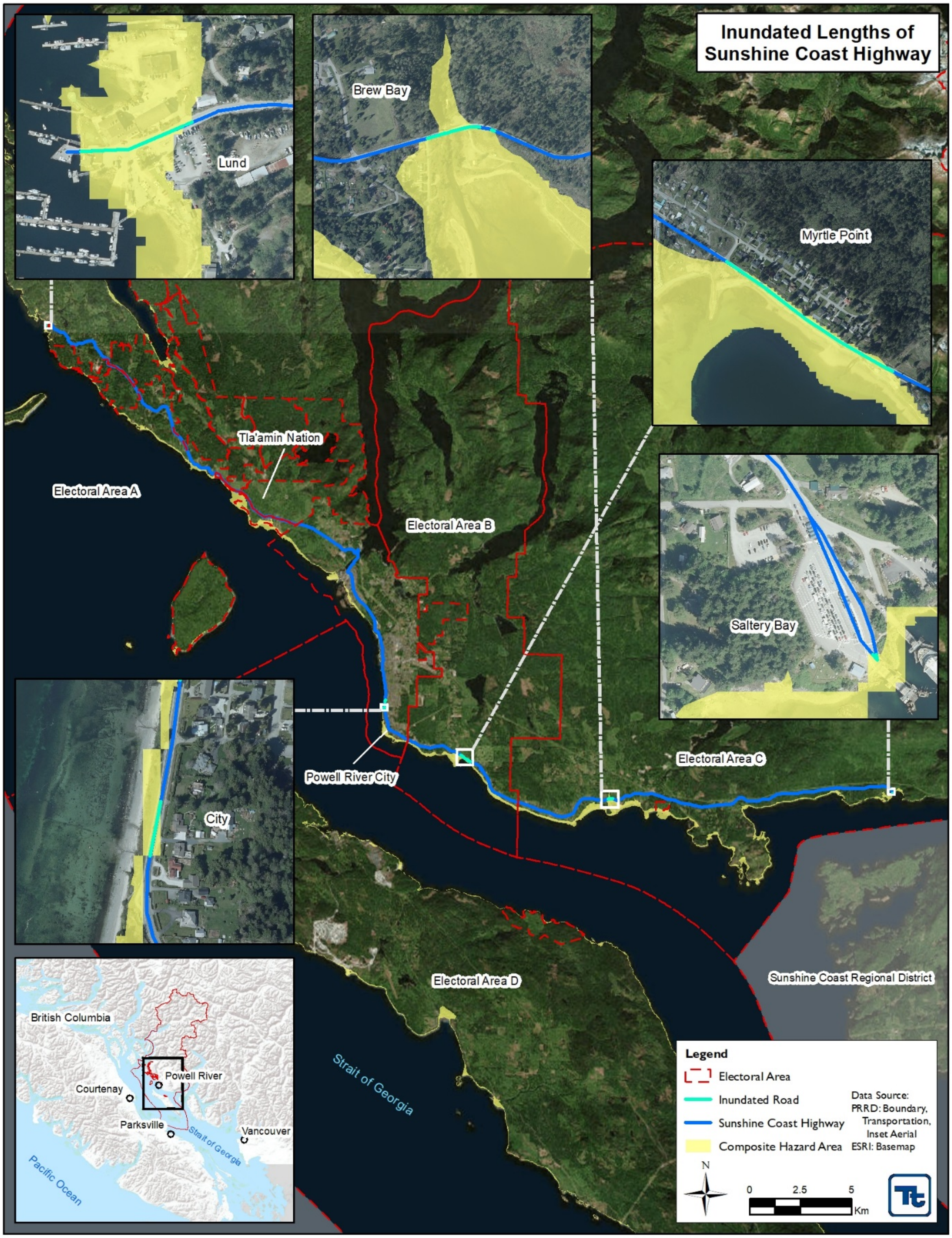


Figure 81. Grid Map of Prioritized Areas for Future Study

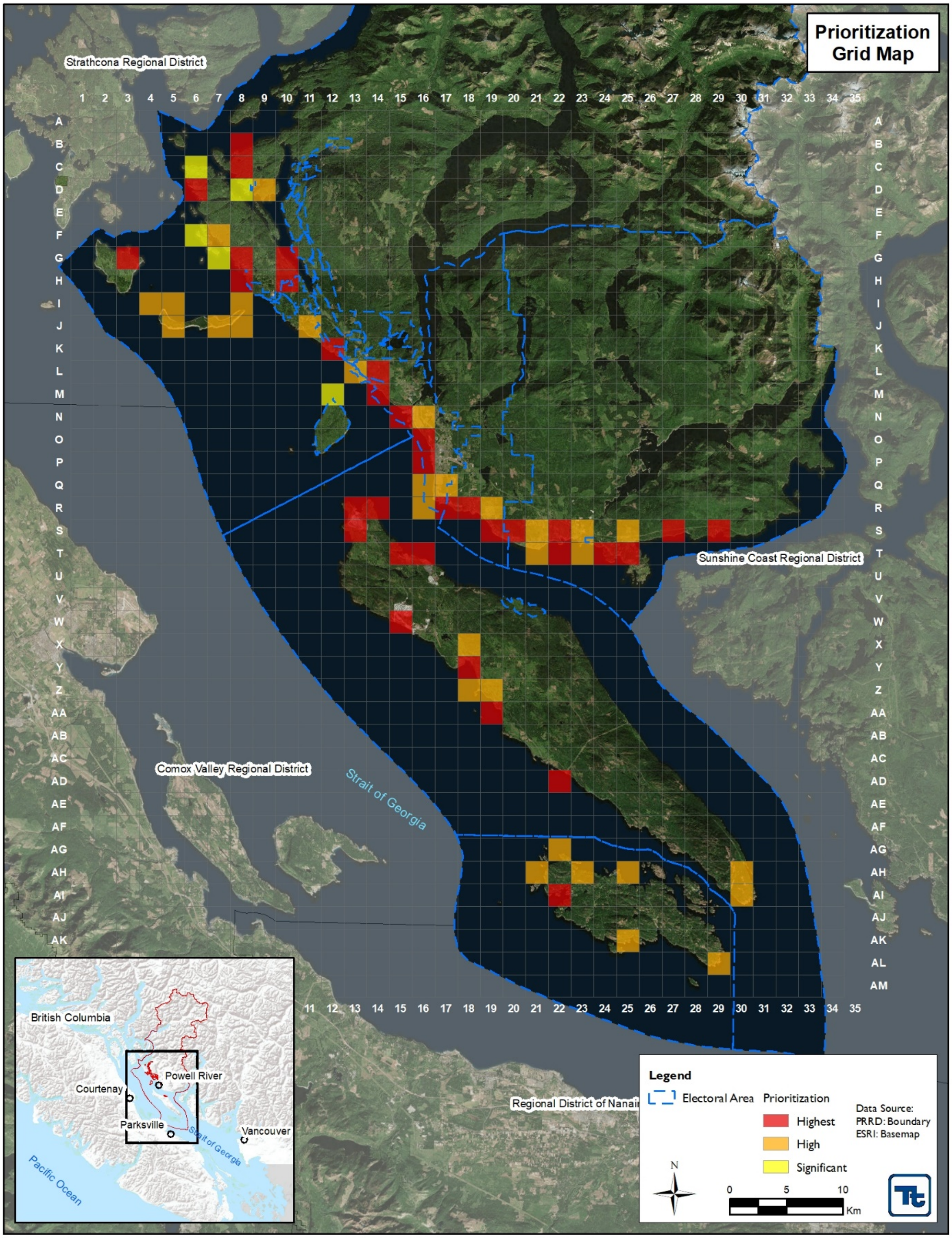
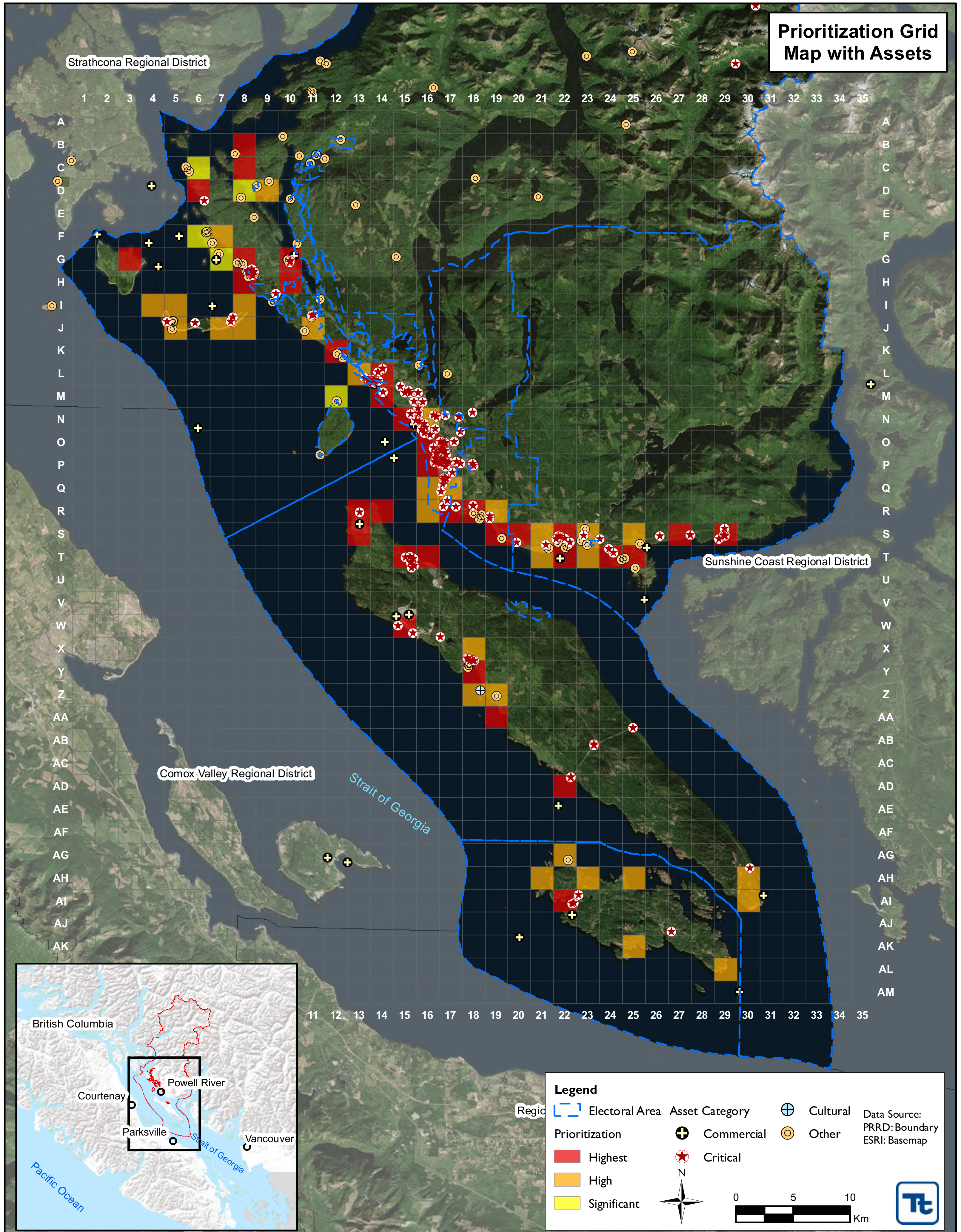


Figure 82. Grid Map of Prioritized Areas with Assets for Future Study

(See next page)



Grid ID	Name	Type	Importance	Asset Priority	Prioritization
B8	Deso 3	Hut	3		Highest
C6	Sarah Toilet	Restroom	3	Significant	Significant
D6	Bliss Landing Boat Launch	Ramp	1	Highest	Highest
D8	Pahk Ghee Chin (Cochrane Bay)	Shelter	3	Significant	Significant
D9	Lund Hotel	Hotel	3		High
D9	Grace Harbour Orchard	Lodge	3		High
F6	Koo Kwahk Thys (Copeland Is)	Hut	3		Significant
F6	Copeland Is	Campground	3	Significant	Significant
F7	Copeland Is	Hut	3		High
G10	Okeover Federal Dock	Docking	1	Highest	Highest
G10	Okeover Boat Launch	Ramp	1	Highest	Highest
G10	Laughing Oyster Parking Lot	Helipad	1		Highest
G10	Okeover Arm - Shellfish Industry	Fishing	2		Highest
G10	Okeover Toilet	Restroom	3		Highest
G10	Okeover Well	Well	3		Highest
G7	Salmon Trawl Fishery	Fishing	2		Significant
G7	Copeland Is	Hut	3	Significant	Significant
G8	Lund Sewer Plant	Waste Treatment Facility	1		Highest
G8	Diver's Rock Regional Park	Regional Park	3		Highest
G8	Finn Bay Road	Beach Access	2	High	Highest
H8	Northside 2	Firehall	1		Highest
H8	Water Treatment Plant	Water Treatment Plant	1		Highest
H8	Northside Community Recreation Centre	Community Hall	1		Highest
H8	Lund Harbour	Docking	1	Highest	Highest
H8	Lund Boat Launch	Ramp	1	Highest	Highest
H8	Lund North Harbour	Docking	1	Highest	Highest
H8	Northside Community Recreation Centre Field	Helipad	1		Highest
H8	Lund Hotel Helipad	Helipad	1	Highest	Highest
H8	Dinner Rock Camp	Open Shelter	3		Highest
H8	Portage	Open Shelter	3		Highest
H8	Lund Marine Centre	Dock	3	Significant	Highest
H8	Long Acre Road	Beach Access	2	High	Highest
J11	Craig Regional Park	Regional Park	3		High
J11	Emmonds Road	Beach Access	2	High	High
J5	Savary 3	Firehall	1		High
J5	Savary	Campground	3	Significant	High
J5	Savary Island Toilet	Restroom	3		High
J5	Indian Springs	Spring	3	Significant	High
J5	Julian Road	Beach Access	2		High
J7	Savary 1	Firehall	1		High
J7	Savary Island Dock	Docking	1		High
K12	Southview Road	Beach Access	2	High	Highest
K12	Sturt Beach	Beach Access	2	High	Highest
L13	Tla'amin Nation Government Building	Municipal Hall	1		High
L13	Tla'amin Salish Centre	Community Hall	1		High
L13	Sliammon CDRC Daycare & Out Of School Care	Daycare Centre	2		High
L13	Tla'amin Health Services	Medical	1		High
L13	Chi Chuy Child Centre	Daycare Centre	2		High
L13	Salish Centre	Unspecified Type	3		High
L13	Healing Lodge	Lodge	3		High
L13	Cultural Lodge	Lodge	3		High
L14	Tla'amin Nation Fire Dept	Firehall	1		Highest
L14	No Name	Water Treatment Plant	1		Highest
L14	No Name	Water Reservoir	1		Highest
L14	NS- Sliammon Ck Bridge	Bridge	1		Highest
L14	Water Storage Tanks	Water Storage	1		Highest
L14	Water Treatment Plant	Water Treatment Plant	1		Highest
L14	Community Policing Office	Government	1		Highest
L14	Fire Hall	Fire Hall	1		Highest
L14	Ahms Ta'ow Education Centre	Education	2		Highest
L14	Sewage Treatment Plant	Sewage Treatment Plant	1		Highest
L14	Tla'amin Soccer Field	Helipad	1		Highest
L14	Tla'amin Timber Products	Commercial	2		Highest
L14	Sliammon Fish Hatchery	Commercial	2	High	Highest
L14	Harwood North	Open Shelter	3	Significant	Highest
L14	Soccer Field	Recreation	3		Highest
L14	Band Administration	Unspecified Type	3		Highest
L14	Church	Religious	2	High	Highest
L14	Waterfront Park	Park	3	Significant	Highest
M12	Harwood Isle	Lodge	3	Significant	Significant
M14	Gibsons Beach Boat Launch	Ramp	1	Highest	Highest
N15	Catalyst Paper Mill	Heavy Industry	2	High	Highest
N15	Barge Terminal	Docking	1	Highest	Highest
N15	Thunder Bay Commercial Crab Fishery	Fishing	2		Highest
N16	PR SAR	SAR Base	1		High
N16	Brooks Secondary School	Secondary School	1		High
N16	Henderson Elementary School	Elementary School	2		High
N16	Dwight Hall	Community Hall	1		High
N16	Powell River Senior's Centre	Senior Centre	1		High
N16	Townsite Waste Treatment Site	Waste Treatment Facility	1		High
N16	Old Golf Course (Natural Gas Facility)	Natural Gas Facility	1		High
N16	Forest View Substation	Power Substation	1		High
N16	Powell River Curling Rink	Recreation Centre Hazmat	2		High
N16	No Name	Power Substation	1		High
N16	Tla'amin Timber Products	Commercial	2	High	High
O16	Power River Emergency Service	EOC	1		Highest

Grid ID	Name	Type	Importance	Asset Priority	Prioritization
O16	Powell River Regional District Office	Municipal Hall	1		Highest
O16	Natural Gas Facility	Natural Gas Facility	1		Highest
O16	Haul Road Overpass	Bridge	1		Highest
O16	Willingdon Dock Facility	Dock	1	Highest	Highest
P16	Royal Canadian Legion Branch 164 Powell River	Community Hall	1		Highest
P16	Westview Waste Treatment Plant	Waste Treatment Facility	1		Highest
P16	Esso Bulk Plant (To Be Relocated)	Fuel Storage Facility	1	High	Highest
P16	Powell River Westview	Ferry Terminal	1	Highest	Highest
P16	Westview Harbour	Docking	1	Highest	Highest
Q17	Westview Elementary School	Elementary School	2		High
Q17	Vancouver Island University	University-College	2		High
Q17	Powell River Christian School	Private School	2		High
Q17	Busy Bee Daycare	Daycare Centre	2		High
Q17	Oceanview Education Centre	Secondary School	2		High
Q17	Westview Elementary Playing Field (update)	Helipad	1		High
R13	Texada Island Blubber Bay	Ferry Terminal	1	Highest	Highest
R17	Grief Point Sub-Station	Power Substation	1		Highest
R17	Superior Propane Tank	Fuel Storage Facility	1		Highest
R17	Beach Garden Marina	Marina	1	Highest	Highest
R18	Myrtle Pond Water Tower	Water Reservoir	1		Highest
R18	Myrtle Pond Water Treatment Facility	Water Treatment Plant	1		Highest
R18	Myrtle Rocks Regional Park	Regional Park	3	Significant	Highest
R18	Pebble Beach Road	Beach Access	2	High	Highest
R18	Myrtle Rocks	Beach Access	2	High	Highest
R19	Powell River Regional District Maintenance Facility	Public Works Building	1		High
R19	Myrtle Pt Golf Club - First Tee	Helipad	1		High
S13	Quarry	Mining	2		Highest
S19	Armour Road	Beach Access	2	High	Highest
S20	Sunshine Coast Health Centre	Medical	1		Highest
S21	Malaspina 1	Firehall	1		High
S22	Kelly Creek Community School	Elementary School	2		Highest
S22	Kelly Creek Bridge	Bridge	1		Highest
S22	Lang Creek Bridge	Bridge	1	Highest	Highest
S22	Lang Creek Boat Launch (update)	Ramp	1	Highest	Highest
S22	Kelly Creek School Field	Helipad	1		Highest
S22	Patrick Road	Beach Access	2	High	Highest
S23	Lang Bay Community Hall	Community Hall	1		High
S23	Palm Beach Regional Park	Regional Park	3		High
S23	Rossander Regional Park	Regional Park	3		High
S23	Phillips Road	Beach Access	2	High	High
S25	Thunder Bay Road	Beach Access	2	High	High
S27	Saltery Bay Provincial Park Boat Launch	Ramp	1	Highest	Highest
S27	Saltery Bay Picnic Site	Helipad	1	High	Highest
S29	Saltery Bay Substation	Power Substation	1		Highest
S29	Powell River Saltery Bay	Ferry Terminal	1	Highest	Highest
S29	Hummingbird Cove Boat Launch (Update)	Ramp	1	Highest	Highest
S29	Saltery Bay Federal Dock	Docking	1	Highest	Highest
S29	BC Ferries Saltery Bay Terminal	Helipad	1		Highest
T15	BC Ambulance	Ambulance	1		Highest
T15	Van Anda 1	Firehall	1		Highest
T15	Texada Elementary	Elementary School	2		Highest
T15	Royal Canadian Legion Branch 32 Van Anda	Community Hall	1		Highest
T15	Van Anda Ball Field	Helipad	1		Highest
T15	Texada Boat Club Dock	Docking	1	Highest	Highest
T15	Van Anda Dock	Docking	1	Highest	Highest
T21	Broom Road	Beach Access	2	High	High
T22	Commercial Shrimp Fishery	Fishing	2		Highest
T22	Mahood Road	Beach Access	2	High	Highest
T22	Cove Road (look out)	Beach Access	2	High	Highest
T24	Stillwater Power House	Power Generation Facility	1		Highest
T24	Stillwater Log Sort	Helipad	1	High	Highest
T24	Hollingsworth Road	Beach Access	2	High	Highest
T25	Osprey Road	Beach Access	2	High	Highest
T25	Canoe Bay	Beach Access	2	High	Highest
W15	Marine Shipping Facility	Shipping	1	Highest	Highest
W15	Industrial	Industrial	2		Highest
W15	Salmon Trawl Fishery	Fishing	2		Highest
W15	Texada Island Quarry Port	Port	1	Highest	Highest
X18	Texada Health Centre	Medical	1		High
X18	Texada Community Hall	Community Hall	1		High
Y18	Gillies Bay 1	Firehall	1	High	Highest
Y18	RCMP (Texada)	RCMP	1	High	Highest
Y18	Gillies Bay Old School	Community Hall	1	High	Highest
Y18	Gillies Bay Old School	Helipad	1	High	Highest
Y18	Patton Road	Beach Access	2	High	Highest
Y18	Oak Street	Beach Access	2	High	Highest
Y18	Ash Street	Beach Access	2	High	Highest
Y18	Balsam Street	Beach Access	2	High	Highest
Z18	Archeological Study	Historic	3	Significant	High
Z19	Shelter Point Regional Park	Regional Park	3		High
AD22	TEXADA WEST TERMINAL	Power Substation	1	High	Highest
AD22	BC Hydro Line Helipad West	Helipad	1	Highest	Highest
AG22	Boot Point Regional Park	Regional Park	3		High
AH30	Anderson Bay	Helipad	1	High	High
AI22	Boat Ramp	Boat Ramp	1	Highest	Highest
AI22	Marina	Marina	1	Highest	Highest

APPENDIX A
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

HYDROTECHNICAL

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Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

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If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

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The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless expressly agreed to in the Services Agreement, TETRA TECH was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project.

1.8 LEVEL OF RISK

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the hydrotechnical information that was reasonably acquired to facilitate completion of the design.

APPENDIX B
GLOSSARY

The following glossary has been adapted and expanded from the sources referenced. The terms in this glossary have been defined and described in terms related to coastal flood hazards.

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no special management. Society does not generally consider expenditure to further reduce such risks to be justifiable.

Annual Exceedance Probability (AEP) – The probability, likelihood or chance of a particular event (e.g., a storm or a storm surge) being equaled or exceeded in any one year. It is defined either as a number between 0 and 1 or as a corresponding percentage. An AEP of 0.01 means there is a 1% chance of an event, of a given magnitude or larger, occurring in any single given year. An AEP of 0.01 or 1/100 yr also suggests that on average, under certain conditions, the Average Return Period, or interval between recurrences of this event, is approximately 100 years (Ausenco Sandwell 2011a).

Average Return Period – Over a long period of time, the average number of years between occurrences of a particular event. In general, the average return period is the reciprocal of the AEP – the relationship is illustrated in the following table:

AEP Probability	AEP (%)	Average Return Period (years)
0.5	50	2
0.1	10	10
0.01	1	100
0.005	0.5	200
0.001	0.1	1000
0.0005	0.05	2000
0.0002	0.02	5000
0.0001	0.01	10000

Using AEP to define the likelihood of hazard events is preferable to the average return period as return period can lead to a false sense of security created by the belief that the indicated number of years will pass before the next event of that magnitude occurs (Ausenco Sandwell 2011a).

Coastal Erosion – Coastal erosion is the wearing away of land and can be defined as the removal of beach or sand dune sediments from the coast by wave action, tidal currents, wave currents, drainage or, high winds and/or the activities of man, typically causing a landward retreat of the coastline. Waves, generated by storms, wind, or fast moving motor craft, can cause coastal erosion, which may take the form of long-term losses of sediment and rocks, or merely the temporary redistribution of coastal sediments; erosion in one location may result in accretion nearby. (Wikipedia). The effects of coastal erosion can be observed on cliffs, tidal flats and saltmarshes, and beaches. Those most directly at risk from coastal erosion are those living in coastal lowland areas or along 'soft' sediment coastlines where coastal erosion can cause flooding, rock falls, loss of land and damage to infrastructure (British Geological Survey 2012).

Coastal Hazard – For the purpose of this study coastal hazard includes storm surge, coastal erosion and tsunami under consideration of Sea Level Rise (SLR).

Composite Hazard Area – A composite hazard area is the envelope of the hazard areas of two or more hazard scenarios.

Consequence – The outcomes or potential outcomes arising from the occurrence of a flood expressed qualitatively or quantitatively in terms of loss, disadvantage or gain, damage, injury or loss of life (APEGBC 2012).

Critical Asset Definition – Asset that must continue to operate before, during and after an emergency or hazard event, are vital to public health and safety, and/or locations with vulnerable populations.

Designated Flood – A flood, which may occur in any given year, of such a magnitude as to equal a flood having a 200-year recurrence interval based on a frequency analysis of unregulated historic flood records or by regional analysis where there is inadequate streamflow data available. Where the flow of a large watercourse is controlled by a major dam, the designated flood shall be set on a site-specific basis. *In coastal areas, the existing definition of a Designated Flood is not appropriate as the probability of flooding from the sea is the result of the joint occurrence of tide and a storm crossing the coastal waters of British Columbia and at some time in the future, sea level rise due to climate change.* In estuaries, where a river discharges into the sea, the definition of the Designated Flood applies to the river. In these documents the definition "Designated Flood" is replaced with the term "Designated Storm" as defined below (Ausenco Sandwell 2011a).

Designated Flood Level (DFL) – The observed or calculated elevation for the Designated Flood and is used in the calculation of the Flood Construction Level. In coastal areas, the Designated Flood Level (DFL) includes the appropriate allowance for future sea level rise, tide and the total storm surge expected during the designated storm (Ausenco Sandwell 2011a).

Designated Storm (DS) – 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 will define components of the Designated Flood Level, including storm surge, wind set-up, wave run-up and overtopping 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- A time series of wave conditions, including wave heights, periods and directions during the passage of the storm in question (Ausenco Sandwell 2011a).

Elements at Risk – The population, buildings or engineering works, economic activities, public services, utilities, infrastructure and environmental features in the area potentially affected by floods or landslides (APEGBC 2012).

Flood Hazard – The potential for loss of life or injury and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods (APEGBC 2012).

Flood Hazard Assessment – A flood hazard assessment (FHA) characterizes the flood process, identifies the existing and future elements at risk and determines the flood intensity characteristics that may damage the proposed development (APECGBC, 2012).

Floodplain – Land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. In British Columbia, floodplains are typically referred to as areas inundated by a hypothetical design flood with a specific likelihood of occurrence (APEGBC 2012). For example, the 200-year (or 0.5% annual probability flood) has a 0.5% chance of being equaled or exceeded each year.

Hazard – Typically described as the probability of occurrence (or return period) for a hazard process with a specified magnitude.

Hazard Area – Spatial extent wherein a hazard may occur. For this study a hazard area is typically a relatively thin strip of land along the shoreline, in which flooding or extreme wave conditions may occur.

Hazard (or Event) Scenario – A specific scenario that could lead to an undesirable consequence (flooding, inundation, scour). As an example, a hazard scenario can be a storm event for a specified return period, dike breach for a specified return period or a glacial lake outburst flood.

Individual Risk – The risk of fatality or injury to any identifiable individual who lives within the zone impacted by the flood; or who follows a particular pattern of life that might subject him or her to the consequences of the flood (APEGBC 2012).

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability and consequence. A more general interpretation of risk involves a comparison of the probability and consequences in a non-product form. The combination of the probability of a hazardous event and the potential adverse consequences to human health, the environment and economic activity associated with the event (APEGBC 2012).

Risk Analysis – The use of available information to estimate the risk to individuals, or populations, property, or the environment, from hazards. Risk analyses contain scope definition, hazard identification, and risk estimation (APEGBC 2012).

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Evaluation – The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks (APEGBC 2012).

Risk-Based Approach – A systematic approach to quantify flood consequences that are compared with hazard scenarios to estimate flood risk. Human safety, economic and environmental losses are typically the most important consequence categories but loss of cultural values and mental stress associated with property loss can be induced (APECGBC, 2012).

Sea Level Rise (SLR) – An allowance for increases in the mean elevation of the ocean associated with future climate change, including any regional effects such as crustal subsidence or uplift (Ausenco Sandwell 2011a).

Sea Level Rise Planning Area (SLR Planning Area) An area of land that may be subject to future flooding due to Sea Level Rise. This area defines a future coastal flood plain. The SLR Planning Area extends from the existing Natural Boundary landward to the highest predicted point of potential flooding related to SLR plus flooding expected from the combination of high tide, total storm surge and expected wave runup during the Designated Storm. Predictions of SLR for the SLR Planning Area definition shall use best predictions for minimum periods of 90-100 years and 200 years forward. From time to time, both the Natural Boundary and the predictions for SLR are subject to change, and therefore the extent of a SLR Planning Area may be revised at regular intervals in the future (Ausenco Sandwell 2011a).

Storm Surge – A change in water level caused by the action of wind and atmospheric pressure variation on the sea surface. The typical effect is to raise the level of the sea above the predicted astronomical tide level, although in some situations, such as when winds blow offshore, the actual water level may be lower than that predicted. The magnitude of a storm surge on the BC coast will be dependent on the severity and duration of the storm event in the North Pacific, its track relative to the BC coast and the seabed bathymetry at the site (Ausenco Sandwell 2011a). A storm surge is independent of a high tide, but its impact may be magnified during a high tide. In addition, sea level rise accentuates the risks from storm surge activity as higher water levels advance further inland and affect areas of higher elevation. It is anticipated that climate change will cause more intense and frequent storms in the northern hemisphere and that sea level rise will increase the coastal areas at risk from these events (Arlington Group, EBA, and DE Jardine. 2013).

Tolerable Risk – A risk that society is willing to live with so as to secure certain benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible (APEGBC 2012).

Tsunami – Waves created when a large body of water is rapidly displaced by processes such as earthquakes or landslides. Tsunamis have previously impacted the BC coast and adjacent coastlines, particularly the outer coast at locations such as Port Alberni, with wave heights and runups that far exceed other processes such as storm surges (APEGBC 2012).

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the flood hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons it will be the probability that a particular life will be lost given that the person is subject to the flood, debris flood or debris flow (APEGBC 2012).

Wave Action – Wave action is a destructive force associated with storms. Shoreline type and exposure to open water will determine wave intensity and frequency and therefore the effects of increased wave action and height on erosion and flooding (Arlington Group, EBA, and DE Jardine. 2013).

APPENDIX C
RECOMMENDATIONS OF PREVIOUS STUDIES

This appendix provides a brief summary of relevant recommendations made in previous studies, including:

Kerr Wood Leidal Associates LTD. 2011. Coastal Floodplain Mapping Guidelines and Specifications. Final Report. June 27, 2011 to Ministry of Forests, Lands & Natural Resource Operations. url: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/coastal_floodplain_mapping-2011.pdf

Thurber Engineering Ltd. 2003. Savary Island Dune and Shoreline Study. Report to the Powell River Regional District., File 14-197-0, dated March 12, 2003, url: http://www.powellriverrd.bc.ca/savary-island-dune-shoreline-study/

Golder Associates Ltd. 2004. Texada Island, Shoreline Hazards Study, Van Anda and Gillies Bay. File 03-1414-059, report dated April 26, 2004, url: http://www.powellriverrd.bc.ca/wp-content/uploads/2011/09/Shoreline-Hazards-Study-Van-Anda-and-Gillies-Bay.pdf

Gardner, Ryan. 2007. Powell River Regional District Tsunami Report. Commissioned by Powell River Regional District. Dated September 2007. url: http://www.powellriverrd.bc.ca/community-services-2/emergency-preparedness/

Planterra Environmental Consulting. 2013. Identification of Natural Hazard Areas Malaspina Peninsula / Okeover Inlet. Report dated September 2013, url: http://www.powellriverrd.bc.ca/wp-content/uploads/Natural-Hazard-Report-Sept11_final_reduced1.pdf

Tetra Tech EBA. 2015. Powell River Regional District, Landslide and Fluvial Hazards Study, Electoral Areas B and C. File: V13103482-01, Document No: 002, issued for use September 4, 2015, url: http://www.powellriverrd.bc.ca/wp-content/uploads/PRRD-Landslide-Fluvial-Hazard-Report_IFU_20150904-reduced.pdf

Tetra Tech EBA. 2016. Landslides and Fluvial Hazards Study, Electoral Area D – Texada Island. File: V13103482-01.002, issued for use December 21, 2016, url: http://www.powellriverrd.bc.ca/wp-content/uploads/Final-Texada-Landslide-Fluvial-Hazard-Report_reduced.pdf

Coastal BC

The KWL (2011) report contains guidance on estimation of some Flood Construction Level (FCL) components, as well as scope of work undertaken for more detailed site-specific engineering studies undertaken to derive FCL in Coastal British Columbia. It recommends standards for topographic mapping to produce coastal floodplain maps. The report is intended to provide a technically-sound basis for local governments to develop coastal floodplain maps, including estimating FCL's based on best mapping and engineering practices. A part of the KWL (2011) study a web-based screening tool was developed that displays potential year 2100 floodplain areas based on approximate FCL's (incorporating sea level rise). Note that floodplain areas have not been ground proofed, verified or studied to confirm their exact location. The tool is available under the following url (Figures S13, S14 and T14 are within the PRRD study area): https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/integrated-flood-hazard-management/flood-hazard-land-use-management/floodplain-mapping/coastal

Savary Island

Thurber (2003) established hazard setback lines for the entire perimeter of the Savary Island to ensure building locations are safe from erosion hazards for 50 and 200 year horizons. Thurber (2003) conclude that: "Savary Island will continue to be reduced in width from south to north by natural erosion forces. Soil erosion, including landslide activity is a constraint to residential development along south island bluffs. Bluff wildfires are an ominous potential hazard which could greatly increase the rate of local slope erosion. If global warming causes a significant rise in sea level, erosion rates will almost certainly increase from those of the past. Non-regulatory (i.e. un-enforceable) geotechnical recommendations involving consideration of hazard and risk provide no assurance over public health and safety."

The Thurber (2003) study for Savary Island was completed 13 years ago and requires an update.

Texada Island

Golder (2004) identified five hazard zones within the Texada Island study area. Four zones are related to erosion and landslide hazard while the fifth zone is related to flood or inundation hazard. Recommended setback guidelines were developed based on observed conditions for the erosion/landslide hazard. These guidelines were developed for the 50-year and 200-year time horizons. A recommended flood construction elevation was developed based on the analysis of tides, storm surge and wave activity. This guideline was developed for the 200-year event since the 200-year event is the provincial guideline for flood hazard.

Golder (2004) recommended that the study should be periodically reviewed and updated to take new facts and experience into account.

Malaspina Peninsula

For the Emmonds Beach area on Malaspina Peninsula, Planterra (2013) concludes and recommends: "There are presently signs of active shoreline erosion on many of the beaches within the study area. A detailed assessment of the shoreline in these beach areas should be completed by a qualified Marine Engineer to determine present and future risk to low lying development. Property owners appear to be taking protective measure to protect their properties from erosion… It is predicted that coastline areas will be subjected to greater storm surges due to global climatic changes, therefore, any future development should be subjected to an established setback…"

Electoral Areas B and C

Tetra Tech EBA (2015) studied landslide and fluvial hazards within the coastal portion of Electoral Areas B and C. While the study assessed landslide hazards along the shoreline, sea level rise, storm surges, wave hazards and coastal erosion are outside of the study scope and therefore not addressed. An assessment of these coastal hazards is required.

Updates to the Official Community Plan following provincial guidelines are ongoing and promote a 30 m setback from the shoreline. The District is also collaborating with the Stewardship Centre for British Columbia as one of four local governments selected to join the Green Shores for Homes Pilot. Green Shores for Homes is a voluntary and incentive-based program designed to help communities restore natural shorelines and enjoy the many environmental, recreational, scenic, and shoreline-protection benefits they bring.

Taxeda Island (Electoral Area D)

Tetra Tech EBA (2016) assessed landslide and fluvial hazards in developed areas of the communities Van Anda and Gillies Bay. While the study is assessed landslide hazards along the shoreline, sea level rise, storm surges, wave hazards and coastal erosion were outside of the study scope and therefore not addressed. An assessment of these coastal hazards is required.

APPENDIX D
HISTORIC EVENT DETAILS – PREVIOUS OCCURENCES AND LOSSES

This Appendix provides information regarding the previous occurrences and losses that PRRD has experienced due to flooding. Please note that many sources were researched regarding previous occurrences and losses associated with flooding events in the PRRD. With numerous sources reviewed, loss and impact information for many events varies depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this project.

February 1916 – Victoria's Groundhog Day Snowstorm of 1916 – An intense, high pressure ridge forced cold arctic air through the interior mountain ranges and off the coast toward Vancouver Island. At the same time, a deep storm cell to the south hovered over the Pacific coast of the United States. This brought large snow amounts to British Columbia and the western United States. In Victoria and southern Vancouver Island, snow fell for 38 hours and strong winds impacted the area. By the end of the storm, 78.3 centimetres of snow covered the city (The Weather Doctor 2018). In the PRRD, from Thunder Bay to Saltery Bay, wind blew down houses and uprooted large trees. Along with an exceptional high tide, residents living along the shoreline had to evacuate their homes, which were in danger of either being washed out to sea or blown away. Wind gusts of up to 100 mph were reported in the entire area, destroying homes and uprooting trees. The storm cost residents and logging companies millions of dollars (Gray 2008).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: Feb 1916	End Date: Feb 1916
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	Snow fell for 38 hours, bringing over 78 centimetres to Vancouver. In the PRRD, strong winds blew down homes and uprooted trees. Residents living along the shoreline had to evacuate their homes due to exceptional high tide.	
Recovery Costs Related to the Risk Event	Provide details on the costs, in dollars, associated with implementing recovery strategies following the event.	Millions of dollars	

June 23, 1946 – A very strong, magnitude 7.3, earthquake in western Canada and the northwestern United States. In the epicenter zone, it lasted about 30 seconds and caused numerous slides and subsidence of the loose ground. The earthquake itself caused extensive damage on Vancouver Island and along the coast of British Columbia. In the PRRD, the earthquake caused extensive damage in the City of Powell River. Undersea power lines were destroyed in the long narrow Alberni Inlet and near the City of Powell River (Gunn 2007). The earthquake also produced several tsunamis that impacted the coast (NOAA NGDC 2018). A small tsunami affected shores along the Strait of Georgia that caused the death of person near Mapleguard Point on eastern Vancouver Island. At Sisters Rock near Texada Island, the main wave produced by the earthquake had an amplitude of approximately 2.4 meters. It is likely that the tsunami recorded at Texada Island was a result of the wave generated by a landslide rather than the tectonic displacement associated with the earthquake (Septer 2014).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 23 June 1946	End Date: 23 June 1946
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	A 7.3 magnitude earthquake epicentered in western Canada and the northwestern United States lasted about 30 seconds and caused numerous slides and subsidence. In the PRRD, the earthquake itself caused extensive damage, destroying underwater powerlines. The earthquake also produced two tsunamis – a small wave affected shores along the Strait of Georgia, killing one person. The second wave occurred at Sisters Islets south of Texada Island and west of Lasqueti Island, with a reported height of seven to eight feet, i.e. 2.1 to 2.4 meters (Hodgson 1946).	

December 17-30, 1993 – Storm Surge/Tidal Flooding – On December 17th, flooding started between 1,500 and 2,000 acres of lowlands in the area of the Serpentine and Nicomekl River, in Surrey BC. On December 19th, floods along the Fraser River inundated thousands of acres of farmland. Strong westerly winds pushed high tides inland. Hurricane-force winds downed telephone poles and electric service and there was extensive flooding from the Malahat to Chemainus. High tides driven ashore by the gales caused extensive damage. The high tides backed up waters and caused damaged.

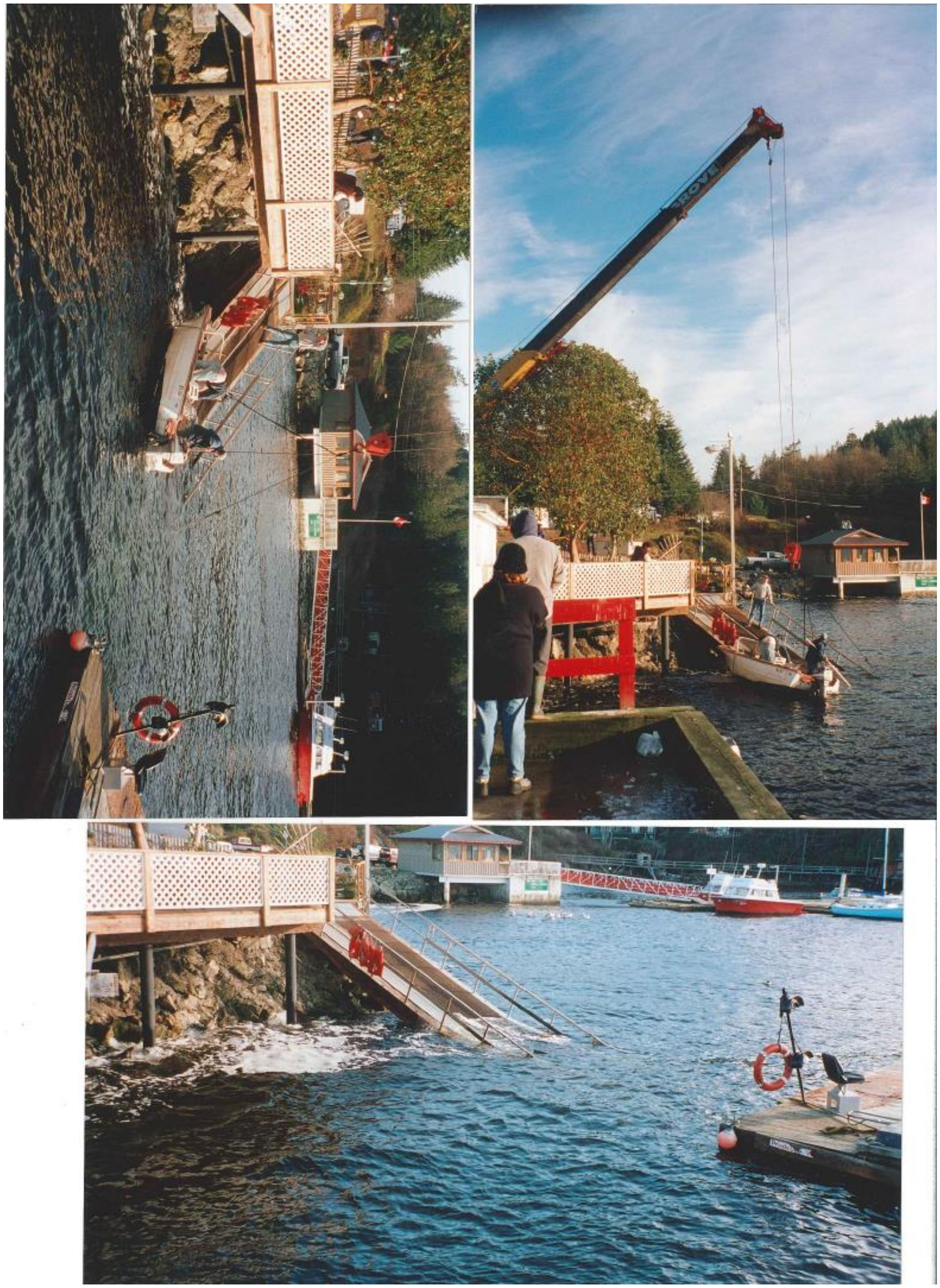
During the third week of December, hard winds hit the Gulf Islands. Pender, Lasqueti (PRRD), and other islands suffered severe damage. Loss of communications was reported throughout the impacted areas (Septer Date Unknown).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 17 Dec 1993	End Date: 30 Dec 1993
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	Gulf Islands. Pender, Lasqueti (PRRD), and other islands suffered severe damage. Loss of communications was reported throughout the impacted areas	

November/December 1999 – Coastal Flooding –Flooding caused properties in the PRRD along Finn Bay Road, Baggi Road and Sarah Point Road to be blocked for several days. Vehicular detours were made onto private property, up a steep hill that some vehicles could not manage. One resident noted costly repairs to their vehicle due to flooded waters over the floorboards (Dunlop, 2018).

2001 – Storm – Exact event date is unknown. A strong westerly / northwesterly storm damaged the water taxi dock in Lund, BC. Lund's aspect protects it from the typical southeaster storms (e-mail R. Thoms, February 15, 2018).

The two photos show the Savary wharf damage (photos by Lund Water Taxi Service).



The second three photos show the damage to the water taxi dock in the Lund Harbour (photos by Lund Water Taxi Service).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 2001	End Date: 2001
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	*Savary wharf severely damaged. Ramp of water taxi dock in the Lund Harbour severely damaged*	

November 12, 2007 – Winter Storm–The first major winter storm of the season impacted the PRRD. Wind gusts of up to 124 km/hr. were recorded in Powell River. Fifty-seven millimeters of rain fell in less than 12 hours. The storm led to the cancellation of all ferry services and thousands were without power for several days. At the Powell River weather station, 29.3 millimeters of rain was recorded.

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 12 Nov 2007	End Date: 12 Nov 2007
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	All ferry services were cancelled; thousands of residents were without power for several days.	
Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.	Several days – power needed to be restored and ferry service needed to resume	

January 2010 – Winter Storm - High tide and storm surge impacted the waterfront of Tla'amin Nation, resulting in debris accumulation. A rip-rap shoreline protection has been installed in recent years.

Photos: Permission from Hugh Prichard

Texada Island

Photographs: Shelter Point Beach (Texada Island) near Gillies Bay. Photos by Jack Paddock
Source: LiveSmart BC

December 24, 2010 – King Tides

Photograph: King tides at Powell River Grief Point. Photo by Mark Biagi Source: LiveSmart BC

November 24, 2011 – Fall Storms – A series of fall storms impacted the West Coast, forcing BC Ferries to cancel several mid-day sailings between Vancouver and Vancouver Island. Residents were warned to prepare for strong winds. Environment Canada reported winds of up to 100 km/h hit the North Coast and parts of Vancouver Island. A deep low pressure system with storm surge on top of high tide led to minor local flooding near the Tsawwassen Terminal (BC Ferries). The dock of the terminal was damaged and taken out for three months.

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 24 Nov 2011	End Date: 24 Nov 2011
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	A one-day event brought storm surge on top of high tide that led to minor local flooding near the Tsawwassen Terminal (BC Ferries). BC Ferries canceled several mid-day sailings between Vancouver and Vancouver Island. Winds of up to 100 km/h hit the North Coast and parts of Vancouver Island	
Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.	Three months – ferry terminal was damaged and needed repairs	

2012 – Storm – Storm damage to breakwater at Saltery Bay Provincial Park, just west of the Saltery Bay ferry terminal. Storm surge undermined the beach wall.


Photographs: View of storm damage to the breakwater at Saltery Bay Provincial Park, located west of the Saltery Bay ferry terminal

October 22, 2014 – Heavy Rain/Flood - Sliammon Creek near Powell River overflowed its banks due to heavy rainfall and debris in the river damaging the fish hatchery operated by the Sliammon First Nation. A helicopter was used to remove some logs from the river and the situation was monitored through the weekend (British Columbia 2014a).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 22 Oct 2014	End Date: 22 Oct 2014
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	A one-day event brought heavy rainfall to the PRRD. Sliammon Creek near Powell River overflowed its banks and debris damaged the fish hatchery operated by the Sliammon First Nation.	
Response During the Risk Event	Provide details on how the defined geographic area continued its essential operations while responding to the event.	Helicopter was used to clear some debris from the river	

December 8-10, 2014 – Heavy Rain/ Landslides – More than 140 millimeters of rain fell over the PRRD over the course of three days. Some hillsides were saturated enough to slide onto shoreline paths and into the sea or across roads. Landslides were reported all over the City of Powell River. On Atrevida Road near Lund, 100 cubic meters of rock and mud let go from the hillside above and blocked the road. The flow shifted one home off its foundation. South of town, residents on Stittle Road watched as approximately 1,100 cubic meters of hillside slid into the sea. The City's sanitary sewer system was at capacity due to a combination of inflow and infiltration in and around the Cranberry area. The City's public works office received over 80 calls from residents who were having drainage issues; with many reporting wet basements due to overland flow (Bolster 2014). The PRRD activated their Emergency Operations Centre following the Powell River Regional Emergency Plan to address issues relating to this event (British Columbia 2014b).

Finn Bay Road, north of Lund, was flooded causing residents to abandon their vehicle late at night, wade through 1 to 1.5 feet of water, and walk home. The next morning the water was still deep, and by afternoon the water was low enough to drive through (Dunlop, 2018). This may be due to the creek that crosses the road and backs up during high tides. Finn Bay Road has a southern aspect that may also experience swell from southeasters (Thoms, 2018).

As a result of this storm, assistance was made available to residents in 31 communities on Vancouver Island and across the Lower Mainland. The list of communities included Powell River and Powell River Regional District (Area B) (DeRosa 2014).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 8 Dec 2014	End Date: 10 Dec 2014
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	A three-day storm brought 140 mm of rain to the PRRD. Some hillsides were saturated enough to slide onto shoreline paths and into the sea or across roads. Landslides were reported all over the City of Powell River. On Atrevida Road near Lund, 100 cubic meters of rock and mud let go from the hillside above and blocked the road. The flow shifted one home off its foundation. South of town, residents on Stittle Road watched as approximately 1,100 cubic meters of hillside slid into the sea. The City's sanitary sewer system was at capacity due to a combination of inflow and infiltration in and around the Cranberry area. The City's public works office received over 80 calls from residents who were having drainage issues; with many reporting wet basements due to overland flow (Bolster 2014).	
Response During the Risk Event	Provide details on how the defined geographic area continued its essential operations while responding to the event.	The PRRD activated their Emergency Operations Centre following the Powell River Regional Emergency Plan to address issues relating to this event (British Columbia 2014b).	
Recovery Costs Related to the Risk Event	Provide details on the costs, in dollars, associated with implementing recovery strategies following the event.	Powell River and PRRD (Area B) received assistance from British Columbia.	

March 1, 2016 – Landslide – Approximately 24.8 millimeters of rain fell in the PRRD. The heavy rain led to a landslide occurring in the Atrevida Road area of Powell River. Trees and debris blocked the road. No homes were directly impacted by the slide, however seven evacuation notices were delivered by the RCMP to homes in the area. The Powell River District EPC advised that 3 residents were provided 72 hour assistance from Emergency Social Services (British Columbia 2016).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 1 Mar 2016	End Date: 1 Mar 2016
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	A one-day rain event (24.8 millimeters) in the PRRD caused landslides, evacuations, and emergency services. Trees and debris blocked roadways.	
Response During the Risk Event	Provide details on how the defined geographic area continued its essential operations while responding to the event.	Seven evacuation notices were delivered by the RCMP to homes in the area.	
Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.	The Powell River District EPC advised that 3 residents were provided 72 hour assistance from Emergency Social Services.	

November 14, 2017 – Erosion on Indian Point, Savary Island

Savary Island is experiencing erosion as a result of tides, surge and storm events. One property owner shares changes to their property on Indian Point, Savary Island. The photograph below was taken from middle of their property at 1069 Squirrel Lane, where they have 150 feet of waterfront. This photo was taken at a 15.9 foot tide.

When the property was purchased in 1959 there was a road allowance (i.e. Crown land) of about 20 – 25 feet across the front. There is only about 2 feet of this road allowance left. The shore line along 1069 Squirrel Lane has been left in its natural state and not been armored. Semi-vertical logs were put in front of the neighboring property, where a house is visible in the photo below. Note the coastal erosion in front of 1069 Squirrel Lane is significantly higher than on the neighboring property.

Photograph: Looking west along shoreline at 1069 Squirrel Lane. Photo by Bud Graham

The house on 1069 Squirrel Lane (see photo below) is at a lower elevation than the crest of the shoreline. The house it exposed to flooding should water overtop the crest.

Photograph: View of 1069 Squirrel Lane from the shoreline. Photo by Bud Graham

January 19-23, 2018 – Winter Storm – A series of strong storms brought heavy rain and gale force winds to the PRRD. Winds of up to 70 km/h caused multiple BC Ferries cancellations. The winds downed trees, branches, and power lines. The heavy rain forced creeks and streams to overflow the banks, flooding homes in low-lying areas (including Cranberry Lake). The storm resulted in widespread power outages to approximately 6,000 customers that lasted more than 12 hours (Brindle 2018). Power restoration on Texada Island was delayed due to cancelled ferry sailings. A number of sailings between Comox and Powell River were also cancelled (Powell River Peak 2018).

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 19 Jan 2018	End Date: 23 Jan 2018
Severity of the Risk Event	Provide details about the risk, including: ▪ Speed of onset and duration of event; ▪ Level and type of damaged caused; ▪ Insurable and non-insurable losses; and ▪ Other details, as appropriate.	A five-day event of heavy rain and gale force winds impacts the PRRD. The strong winds led to BC Ferries cancellations and downed trees, branches, and power lines. Streams and creeks overflowed their banks. Homes in low-lying areas flooded. Widespread power outages were also reported.	
Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.	12 hours for power restoration	

King Tides and Storm Surge (Date Unknown) – Storm surge and king tides impact PRRD. The following photographs depict the area near Marine Avenue in downtown Powell River. The building with the blue roof is the sewage treatment plan. The water in the foreground is hiding the City marina's boat ramp in the Westview Harbor immediately south of the ferry terminal. Typically, this area can be driven through to the sewage treatment plant; however king tides on this occasion flooded the road.

Photographs: Upper photos show Powell River Sewage treatment plant. The water in the foreground is hiding the city marina's boat ramp in the Westview Harbor immediately south of the ferry terminal – king tides can come up to cover the road. Lower photos show Storm surge in Powell River (all photos by Derek Poole)

APPENDIX E
RISK ANALYSIS

E1. GENERAL RISK ANALYSIS METHODS

In accordance with Appendix F of APEGBC, a flood risk assessment involves the estimation of the likelihood that a flood will occur and cause some magnitude and type of damage or loss. The following principal steps were followed to determine the risk to coastal flood hazards:

1. Identify the flood hazard scenarios.
2. Estimate the probability of each hazard scenario.
3. Estimate the consequences per APEGBC (2012, Appendix F).

E2. IDENTIFY THE FLOOD HAZARD SCENARIOS

E2.1 Selected Flood Type

The flood type for the selected scenarios is coastal inundation. Sea Level Rise (SLR) is considered as a component of certain of the selected scenarios.

E2.2 Selected Scenarios

The following scenarios are selected for this assessment:

- High Tide and SLR.
- High Tide and 200-Year Surge and Waves (Southeast).
- High Tide, and 200-Year Surge and Waves (Southeast), and SLR.
- High Tide and 200-Year Surge and Waves (Northwest).
- High Tide, and 200-Year Surge and Waves (Northwest), and SLR.

E3. ESTIMATE THE PROBABILITY OF EACH HAZARD SCENARIO

E3.1 Selected Return Periods

Hazard processes associated with the designated storm event include storm surge and wind-generated waves. As storm surge and wind-waves share, for the greatest part, a common generating mechanism they are statistically dependent. This means that the joint probability (i.e. the probability that both will occur simultaneously) is close to 100% and it can be conservatively assumed that a 200-year storm surge will generally coincide with a 200-year wind-wave event.

Tides are statistically independent of storm events, but have a duration such that it is likely that a high tide will occur at some point during the designated storm event. Therefore, a joint probability approach would be appropriate to assess the probability of a high tide coinciding with the peak of the designated storm event. In this study, however, it has been assumed that the designated storm event will coincide with the higher high water large tide (HHWLT), a conservative assumption adopted following the BC Ministry of Environment guidelines (Ausenco Sandwell 2011b).

To assess the hazard posed by extreme weather events, it is common practice to derive a representative storm that is sufficiently rare to represent a non-typical condition. The relative rarity of this designated event is typically expressed as an annual exceedance probability (AEP, with its likelihood of occurrence given in terms of its return period. Return periods are most commonly given as an 'expected frequency' such as a '1 in 200-year event'. This does not mean that a 200-year event will occur one time in 200 years, but that the probability of this event's occurrence in any given year is 1/200 or 0.5%. Therefore, it is possible for a 200-year event not to occur (36.7% probability), occur exactly once (36.9% probability) or occur twice or more (26.4% probability) over the span of 200 years.

In keeping with the recommendations of Kerr Wood Leidal (2011) for the Powell River region, Tetra Tech selected the 1/200 AEP event, or 200-year event, as the designated storm. The severity of a given return period event is generally determined from measured data at or near the location of interest. In this way, the severity of measured past events is used to extrapolate the potential severity of future events. Standard practice is to assign the largest recorded event in the period of record a return period equal to the period of record (e.g., the largest event in a 20-year record is assigned a 20-year return period). Smaller events in the period of record are assigned smaller return periods (e.g., if there are 20 events in the record, the second largest event in a 20-year record is assigned a 19-year return period) until each of the significant events in the record has an assigned return period. Several extreme event probability distributions are then fit to the recorded events. The distribution with the highest coefficient of determination (r^2) value is chosen as most representative of the extreme value distribution at the site and hence the best predictor of the event magnitude associated with a given return period.

Tetra Tech used the above method, as detailed by Goda (1988), to estimate 200-year winds and storm surges in the region.

E3.2 Event Likelihood Rating per RAIT

Table E-1 lists the likelihood rating for events defined in the Risk Assessment Information Template (RAIT) by the National Disaster Mitigation Program (NDMP).

Table E-1: RAIT Likelihood ratings for events.

Likelihood Rating	Definition
5	The event is expected and may be triggered by conditions expected over a 30-year period.
4	The event is expected and may be triggered by conditions expected over a 30 - 50-year period.
3	The event is expected and may be triggered by conditions expected over a 50 - 500-year period.
2	The event is expected and may be triggered by conditions expected over a 500 - 5000-year period.
1	The event is possible and may be triggered by conditions exceeding a period of 5000 years.

Table E-2 summarizes the likelihood ratings assigned to the selected scenarios.

Table E-2: Assigned Likelihood Ratings for Selected Scenarios

Scenario	Likelihood Rating per RAIT
High Tide and SLR	5
High Tide and 200-Year Surge and Waves (Southeast)	3
High Tide, and 200-Year Surge and Waves (Southeast), and SLR	3
High Tide and 200-Year Surge and Waves (Northwest)	3
High Tide, and 200-Year Surge and Waves (Northwest), and SLR	3

E3.3 Determine Composite Hazards

Three main types of hazard were examined in this study:

1. High astronomical tides.
2. Storms, which give rise to storm surge and large waves.
3. Sea level rise.

All three of these hazards cause sea level to rise, and the shoreline, where land meets the waters of the Strait of Georgia, to move inland, as shown, for example, in Figure 7.1 of the main report. For each location along the PRRD shoreline, the direct hazards are:

1. An increase in water level on either the short time scale of a storm, or the long time scale of sea level rise.
2. The presence of potentially strong currents, driven by the waves.
3. In addition, if sufficient energy is present, beach sediments may be dragged onto the land, as well as major debris, such as logs.

The hazards change from location to location: flooding is greater if the terrain is low-lying and relatively flat. Hazards and associated damage will usually be higher in those parts of the shore with exposure to the greatest waves.

The wave modelling data along with terrain elevation data were combined to produce raster files (10 m x 10 m pixel size) of the key parameters of depth of inundation and wave velocity, thereby identifying Hazard Areas.

E4. ESTIMATE THE CONSEQUENCES

The coastal hazard scenario modelling provides the projected future exposure in the study area. A risk-based assessment was then conducted to estimate the potential social, environmental and economic vulnerability to this exposure. The results of the assessment will serve as the foundation to identifying and designing appropriate mitigation measures to adapt to these projected future conditions.

E4.1 Methods

E4.1.1 Customized GIS Model based on HAZUS-MH

A Geographic Information System (GIS) is a common platform for the management and analysis of spatially-varying hazard data. Tetra Tech used HAZUS-MH Canada to estimate losses due to the coastal flood events. HAZUS-MH is a free ArcGIS extension developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS), and adapted for Canadian use by Natural Resources Canada (APEGBC 2012). The HAZUS-MH flood module produces loss estimates applicable to vulnerability assessments. Results are typically reported at the Canadian Census Block level of study detail; however, the custom building and asset inventory developed for PRRD were imported into HAZUS-MH as user-defined facilities to conduct a highly-detailed assessment of each structure.

HAZUS-MH Canada does not have the capability to run the coastal flood module for this study. A custom methodology was developed and implemented to estimate the potential building and critical asset impacts for each scenario.

E4.1.2 Demographics

Demographic information from Statistics Canada is only available at the Electoral Area level for 2016, while HAZUS-MH Canada has 2011 demographic information at the dissemination block level; a higher resolution data set more suitable for the risk-based approach. The change in population from 2011 to 2016 by Electoral Area was calculated and the small increase applied uniformly to the 2011 dissemination block population totals.

E4.1.3 Compilation of Asset Inventory

To estimate the consequences for each coastal hazard scenario, an asset inventory is needed. A comprehensive asset inventory did not exist for the study area, so Tetra Tech worked with the PRRD Emergency Manager to define the assets, gather existing spatial data from the City, PRRD, and provincial and federal sources, and identify asset locations that did not exist in a spatial format. The asset inventory (see tables at end of Appendix E) includes population, building stock, environment, critical assets, cultural and historical assets, commercial assets, and other assets deemed critical to the local governments in the study area. Thus, a comprehensive spatial asset inventory was developed to determine who and/or what may be affected by the coastal hazards.

Critical assets were defined as assets that must continue to operate before, during and after an emergency and/or hazard event and are vital to public health and safety, and locations with vulnerable populations. Examples of the identified critical assets include emergency services (e.g., ambulance, fire services, medical facilities), schools and key transportation infrastructure. Where possible, attributes for each asset were obtained from PRRD or assumptions made in order to proceed with the consequence analysis. Replacement cost and content values were obtained from the BC Assessment data where facilities were located on parcels with a building value. For assets that did not have an associated building value, HAZUS-Canada was consulted; however, this data was not available for British Columbia. Therefore, average values from asset and occupancy types in the HAZUS-MH v4.0 (U.S. version) for Washington State were converted to Canadian dollars to estimate the value for each asset. The PRRD reviewed the asset inventory and associated values and in many cases adjusted the replacement cost to reflect more accurate estimates; however, these values are still considered low and may be underestimating the potential loss to these assets. The asset inventory was organized in accordance with the attributes described in the National Disaster Mitigation Program Risk Assessment Information Template (RAIT) and will be included in the final report.

E4.1.4 Impact/Consequence Assessment

To assess the physical damage to buildings in the study area exposed to the coastal flood hazard scenarios, a custom building stock inventory was developed. Parcel boundaries and 2017 tax assessment data from BC Assessment were used to develop a detailed custom building stock inventory for the following areas: the City of Powell River, Electoral Area A, Electoral Area B, Electoral Area C, Electoral Area D, and Electoral Area E. Parcel and tax assessment data were not available for the Tla’amin Nation, therefore a building inventory was developed in GIS by assigning geographic coordinates to each structure viewed using aerial photography (dated 2017). Additionally, default building stock attribute information in HAZUS-MH Canada was used to complete the inventory for the Tla’amin Nation.

Table E-3 summarizes the source of data for each building attribute.

Table E-3. Building Attribute Sources and Assumptions

Attribute	Source	Attribute	Source
Building Type	Assumptions made based on Occupancy Class and HAZUS-MH building types: ▪ Residential/Agriculture: Wood ▪ Commercial/Industrial: Concrete ▪ Education/Government/Religious: Masonry ▪ Mobile Homes: Manufactured Housing	Year Built	BC Assessment – Year Constructed; Year constructed averaged by occupancy and used for buildings without associated construction year
Occupancy Class	BC Assessment – Manual/Primary Class Description	Replacement Cost	BC Assessment – Building Value used where available; Average value per structure was calculated using default HAZUS-MH Canada block data and applied for Tla'amin Nation
First-Floor Elevation	Assumed to be 0 m based on assumed slab foundation type	Content Cost	Estimated from BC Assessment – 50% replacement cost value for residential and 100% replacement cost value for non-residential occupancy classes; Average value per structure was calculated using default HAZUS-MH Canada block data and applied for Tla'amin Nation
Square Footage	BC Assessment; Area averaged by occupancy and used for building without associated square footage	Number of Stories	BC Assessment – Manual Class Description; Non-residential – assumed to be 1-story structures
Foundation Type	All structures assumed to have a slab as most typical foundation type in Region	Latitude/Longitude	Estimated by calculating the centroid of each developed parcel; Building points were manually developed for Tla'amin Nation based on 2017 aerial photography because parcel data not available

The risk assessment evaluates both tangible and intangible impacts and estimates potential loss/damages resulting from the range of coastal flood scenarios described above. The potential impacts were categorized following the RAIT. An exposure analysis was conducted to determine which asset type is located in the hazard area, by scenario. Where possible, potential losses were calculated using Hazus-Canada to monetize the impact. Table E-4 outlines the assets assessed, their definitions and the data utilized to estimate potential impacts/loss.

Table E-4. Impact/Consequence Assessment Criteria and Methodology

Asset	Impact/Consequence	Methodology
People and Society	Injuries/fatalities; societal disruptions such as evacuation and relocation	Exposure analysis ▪ 2016 Census data Impact analysis ▪ Displaced Households/Sheltering Needs (HAZUS-MH Canada) ▪ Estimated injuries/fatalities – Figure F-1 (APEGBC, 2012) ▪ Duration of event utilized to estimate displacement costs [Exhibit 6.4 of NDR 2017].
Environment	Degree of damage and predicted scope of clean-up and restoration needed for air quality, water quality and availability; other nature indicators	Exposure analysis ▪ Land Use – Electoral Area A, B, C Land Use (PRRD) – Parcels with BC Assessment Data (2017) – Wetlands (GeoBC, 2017) ▪ Critically endangered species (Environment Canada, 2017) ▪ Marine mammal distribution (GeoBC, 2017) ▪ Beach Access (PRRD) ▪ Parks (PRRD)
Local Economy	Local economically productive assets; disruptions to normal functioning of the region's local economic system. This includes productivity losses, capital losses, operating costs, financial institutions and other financial losses.	▪ Exposure analysis ▪ Building Stock ▪ Impact analysis ▪ Hazus-MH Canada and damage functions to estimate potential loss to buildings ▪ Debris estimates (HAZUS-MH Canada) ▪ Economic Impacts (HAZUS-MH Canada) ▪ Proposed Development (Ministry of Advanced Education, Skills & Training)
Local Infrastructure	Vital to a community/region's viability and sustainability: ▪ Energy and utilities ▪ Information and communication technology ▪ Transportation; ▪ Health, food and water ▪ Safety and Security	Exposure analysis: ▪ Asset inventory Impact analysis: ▪ Hazus-MH Canada and damage functions to estimate potential loss to asset Qualitative assessment: ▪ Outreach to BC Ferries
Public Sensitivity	Public trust that all levels of government will respond effectively to a disaster event.	Qualitative assessment based on historic events and local knowledge from PRRD Emergency Management

HAZUS-MH Canada does not have the capability to run the coastal flood module for the study area. A custom methodology was developed and implemented to estimate the potential building and critical asset impacts for each scenario:

Step 1 – Utilized velocity-depth damage relationships for various building types as outlined by the NRC Canadian Guidelines and Database of Flood Vulnerability Functions to estimate total building collapse.

- Data and sources:

- Water depth grids and wave velocity grids developed by Tetra Tech
- Asset Inventory
- General Building Stock

- Methodology:
  - Depth of water and wave velocity were extracted from the grids at building locations
  - Using the velocity-depth damage functions, the potential for total collapse was determined. Note, water depths needed to be converted to feet and velocities converted to feet per second to be used with the equations outlined in the NRC guidelines.
  - Collapse and subsequent total loss determined if:
    - Depths – feet; Velocity – feet per second
    - Wood Buildings
      - Depth greater than Depth Threshold for each number of stories.
      - Velocity greater than Velocity Threshold for each number of stories if:
      - Depth > 268.38 x Velocity$^{-1.9642}$
    - Masonry/Concrete Buildings
      - Depth greater than Depth Threshold for each number of stories
      - Velocity greater than Velocity Threshold for each number of stories if:
      - Depth > 525.09 x Velocity$^{-2.0406}$
    - Manufactured/Mobile Homes
      - Depth greater than Depth Threshold and Velocity greater than Velocity Threshold

Step 2 – Added coastal damage depth damage functions to HAZUS-MH Canada

- HAZUS-MH Canada damage functions were updated using the HAZUS-MH v4.0 (US Version) coastal velocity (V)-zone damage functions to estimate potential structural and content losses based on water depth. The V-zone damage functions were selected, over coastal A-zone damage functions to provide worst-case scenario losses.

Step 3 – Import water depth grids developed by Tetra Tech for each scenario into HAZUS-MH Canada to quantify estimated potential loss to each structure.

Step 4 – Calculate potential losses by area by summing the following:

- 100% Replacement and Content Cost for buildings estimated to collapse.
- Estimated damage calculated by HAZUS-MH Canada for remaining exposed buildings.

E4.2 Potential Impacts

The coastal flood hazard exposure and loss estimate analysis is presented below for each coastal flood scenario.

E4.2.1 Impacts to People and Society

Impacts of flooding on life, health, and safety depend on several factors including severity of the event and whether or not adequate warning time is provided to residents. Assumedly, the population living in or near flood hazard areas that could be impacted by a flood would be considered exposed to the hazard. However, exposure should not be limited only to those who reside within a defined hazard zone, but everyone that may be affected by a hazard event (e.g., people are at risk while traveling through flooded areas via roadways, or their access to emergency services is compromised during an event); the degree of that impact varies and is not strictly measurable.

To estimate the population exposed to the coastal flood scenarios, the flood hazard boundaries were overlaid upon the 2016 Census population data in GIS. Census blocks are not consistent with boundaries of the floodplain, and gross overestimate or underestimate of exposed population can occur via use of the centroid or intersect of the Census block with these zones. Limitations of these analyses are recognized, and thus results are used only to provide a general estimate for planning purposes. Table E-5 below displays the total population exposed to the coastal hazard areas by regional district area.

Of the population exposed, the most vulnerable population is the population over the age of 65 and typically the economically disadvantaged. The population over the age of 65 is considered more vulnerable because they are more likely to seek or need medical attention that may not be available because of isolation during a flood event, and they may have more difficulty evacuating. For this analysis, an evaluation of the economically disadvantaged located in the hazard area was not completed. Table E-5 summarizes the population over 65 years in age located in the hazard areas.

Table E-5: Estimated Population Exposed to the Coastal Flood Hazard

Area	Total Population (2016 Census)	Population Exposed	Percent of Total	Over 65 Population Exposed	Percent of Total
High Tide and 200-Year Surge and Waves (Southeast)					
City	13,157	78	<1%	22	<1%
Tla'amin	707	228	32.2%	45	6.4%
Electoral Area A – North of Tla'amin + Savary	1,105	10	<1%	4	<1%
Electoral Area B – East of City	1,541	0	0.0%	0	0.0%
Electoral Area C – South of City	2,064	59	2.9%	7	<1%
Electoral Area D – Texada	1,076	33	3.1%	12	1.1%
Electoral Area E – Lasqueti	399	0	0.0%	0	0.0%
Total	**20,049**	**408**	**2.0%**	**90**	**<1%**
High Tide, and 200-Year Surge and Waves, and SLR (Southeast)					
City	13,157	78	<1%	22	<1%
Tla'amin	707	228	32.2%	45	6.4%
Electoral Area A – North of Tla'amin + Savary	1,105	10	<1%	4	<1%
Electoral Area B – East of City	1,541	0	0.0%	0	0.0%
Electoral Area C – South of City	2,064	59	2.9%	7	<1%
Electoral Area D – Texada	1,076	33	3.1%	12	1.1%
Electoral Area E – Lasqueti	399	0	0.0%	0	0.0%
Total	**20,049**	**408**	**2.0%**	**90**	**<1%**
High Tide and 200-Year Surge and Waves (Northwest)					
City	13,157	78	<1%	22	<1%
Tla'amin	707	52	7.4%	9	1.3%
Electoral Area A – North of Tla'amin + Savary	1,105	10	<1%	4	<1%
Electoral Area B – East of City	1,541	0	0.0%	0	0.0%
Electoral Area C – South of City	2,064	10	<1%	0	0.0%
Electoral Area D – Texada	1,076	33	3.1%	12	1.1%
Electoral Area E – Lasqueti	399	0	0.0%	0	0.0%
Total	**20,049**	**183**	**<1%**	**47**	**<1%**

Table E-5: Estimated Population Exposed to the Coastal Flood Hazard

Area	Total Population (2016 Census)	Population Exposed	Percent of Total	Over 65 Population Exposed	Percent of Total
High Tide, and 200-Year Surge and Waves, and SLR (Northwest)					
City	13,157	78	<1%	22	<1%
Tla'amin	707	181	25.6%	35	5.0%
Electoral Area A – North of Tla'amin + Savary	1,105	10	<1%	4	<1%
Electoral Area B – East of City	1,541	0	0.0%	0	0.0%
Electoral Area C – South of City	2,064	10	<1%	0	0.0%
Electoral Area D – Texada	1,076	33	3.1%	12	1.1%
Electoral Area E – Lasqueti	399	0	0.00%	0	0.0%
Total	**20,049**	**312**	**1.6%**	**73**	**<1%**
High Tide and SLR					
City	13,157	0	0.0%	0	0
Tla'amin	707	34	4.8%	6	<1%
Electoral Area A – North of Tla'amin + Savary	1,105	0	0.0%	0	0
Electoral Area B – East of City	1,541	0	0.0%	0	0
Electoral Area C – South of City	2,064	10	<1%	0	0
Electoral Area D – Texada	1,076	0	0.0%	0	0
Electoral Area E – Lasqueti	399	0	0.0%	0	0
Total	**20,049**	**44**	**<1%**	**6**	**<1%**

Source: Statistics Canada, 2016
Notes:

Based on the exposure analysis, as a result of high tide and SLR alone, an estimated 44 people may need to abandon and relocate from their current residence. Unlike populations that may be impacted by a storm surge event, temporarily though severe, populations impacted by only SLR will be unable to remain in place as their residences will be permanently inundated.

Using 2011 Census data, HAZUS-MH estimates potential sheltering needs for each coastal flood scenario; both households displaced and people seeking short-term sheltering. The estimated displaced population and number of persons seeking short-term sheltering differ from the number of persons because the displaced population numbers take into consideration that not all residents will be significantly impacted enough to be displaced or to require short-term sheltering during a flood event. Table E-6 summarizes these statistics by area and coastal flood scenario.

Table E-6: Estimated Displaced Households and Persons Seeking Short-Term Sheltering

Area	Total Population (2016 Census)	Displaced Households	Persons Seeking Short-Term Sheltering
High Tide and 200-Year Surge and Waves (Southeast)			
City	13,157	141	108
Tla'amin	707	134	87
Electoral Area A – North of Tla'amin + Savary	1,105	29	2
Electoral Area B – East of City	1,541	92	89
Electoral Area C – South of City	2,064	129	87
Electoral Area D – Texada	1,076	68	45
Electoral Area E – Lasqueti	399	6	0
Total	**20,049**	**599**	**418**
High Tide, and 200-Year Surge and Waves, and SLR (Southeast)			
City	13,157	144	110
Tla'amin	707	182	145
Electoral Area A – North of Tla'amin + Savary	1,105	32	2
Electoral Area B – East of City	1,541	100	97
Electoral Area C – South of City	2,064	133	87
Electoral Area D – Texada	1,076	68	45
Electoral Area E – Lasqueti	399	9	0
Total	**20,049**	**668**	**486**
High Tide and 200-Year Surge and Waves (Northwest)			
City	13,157	139	103
Tla'amin	707	108	72
Electoral Area A – North of Tla'amin + Savary	1,105	27	1
Electoral Area B – East of City	1,541	68	62
Electoral Area C – South of City	2,064	25	2
Electoral Area D – Texada	1,076	50	28
Electoral Area E – Lasqueti	399	8	0
Total	**20,049**	**425**	**268**

Table E-6: Estimated Displaced Households and Persons Seeking Short-Term Sheltering

Area	Total Population (2016 Census)	Displaced Households	Persons Seeking Short-Term Sheltering
High Tide, and 200-Year Surge and Waves, and SLR (Northwest)			
City	13,157	145	108
Tla'amin	707	146	105
Electoral Area A – North of Tla'amin + Savary	1,105	28	3
Electoral Area B – East of City	1,541	75	68
Electoral Area C – South of City	2,064	32	5
Electoral Area D – Texada	1,076	54	32
Electoral Area E – Lasqueti	399	10	0
Total	**20,049**	**490**	**321**

Source: HAZUS-MH Canada

Cascading impacts may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly, and pregnant women. The degree of impact will vary and is not strictly measurable.

Molds can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (Centers for Disease Control and Prevention [CDC] 2015).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food.
- Contaminated drinking and washing water and poor sanitation.
- Mosquitos and animals.
- Carbon monoxide poisoning.
- Secondary hazards associated with re-entering/cleaning flooded structures.
- Mental stress and fatigue.

Current loss estimation models such as HAZUS-MH are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

Total number of injuries and casualties resulting from flooding is generally limited because of advance weather forecasting and warnings. Therefore, injuries and deaths are not generally anticipated if proper warning occurs and precautions are in place. Populations without adequate warning of the event, lack of proper communication channels or language barriers are highly vulnerable to this hazard. As referenced by the APECGB Figure F-1, a relationship between water depth and mortality for areas in New Orleans for the 2005 Hurricane Katrina flood was developed. As water depth increases, as does the mortality rate.

Education and awareness are also essential to help the most likely cause of injury—persons trying to cross flooded roadways or in marine transportation vehicles not equipped to handle the event.

Epidemiological research shows there is a connection between natural disaster events and mental stress on the impacted population, frequently children. Expected recovery rates for a population ranging from mild/moderate to severe mental health problems can still be prevalent more than two years after the event. The FEMA Benefit-Cost Analysis module has established an economic value for the cost of treatment for mental health issues ($2,443 USD) and lost productivity, or the measure of the impact of lost employment productivity due to severe mental illness ($8,736 US over 30 months after a disaster). These values may also be used to estimate potential impacts to population affected by a coastal flood event.

E4.2.2 Environmental and Cultural Impacts

Flooding from coastal storms is a key process in providing such tangible benefits as increased soil fertility, wetland creation, rejuvenation of spawning gravel, creation of barrier islands, promotion of aquatic habitat, transportation of large woody material that provides fish habitat and bank stability, promotion of plant establishment, and the evolution of channels and shoreline features (ASFPM, 2008). However, flooding can cause a wide range of environmental impacts including but not limited to erosion and loss of vegetation and habitats. Moreover, floods may generate large amounts of tree and construction debris, disperse household hazardous waste into the fluvial system, and contaminate water supplies and wildlife habitats with extremely toxic substances.

To determine exposure of natural and beneficial land in the study area to the flood hazard, acreages of wetlands and open land were calculated utilizing the combined flood hazard extent for all coastal flood scenarios evaluated. Spatial land use data was utilized for Electoral Areas A, B, and C; whereas the parcel land use category from BC Assessment was utilized for the City of Powell River, Electoral Area D, and Electoral Area E. Parcels and land use data were not available for the Tla'amin Nation to support this evaluation. Table E-7 lists results of these calculations by area.

Table E-7: Land Located in the Composite Coastal Flood Hazard Areas

Area	Wetlands (hectares)	Open Space (hectares)
City	0.0	46.4
Tla'amin	NA	NA
Electoral Area A – North of Tla'amin + Savary	3.0	182.5
Electoral Area B – East of City	0.0	1.3
Electoral Area C – South of City	0.0	23.3
Electoral Area D – Texada	0.0	202.4
Electoral Area E – Lasqueti	0.0	58.3
Total	**3.0**	**514.2**

Source: Powell River Regional District, BC Assessment, GeoBC

Note: EA A, B, C - Open Space includes forests, parks, resource, and reserves

City, EA D, and EA E – Parcels without a building value or without associated BC Assessment data assumed open space

NA = Parcel and land use data is not available for the Tla'amin Nation

The study area is an environmentally and culturally rich region of British Columbia. Powell River's lakes, shorelines and diverse mountain ranges offer year-round recreation opportunities. The region enjoys significant provincial and marine parks that draw tourists and visitors that contribute to the local economy. Many of the Region's environmental assets are located along the coast and are exposed to these coastal flood hazard events including beaches and regional parks. Of the multiple regional parks in the Powell River Regional District, Myrtle Rock Regional Park, just south of the City, is located within the delineated coastal flood hazard areas. This park is accessible to the public for recreational use during low-tide. Beaches and beach access points are another critical environmental asset for the Region as they provide public access to the water from the road. Of the 22 identified access points, 21 are located within the coastal flood hazard areas except for the Julian Road point on Savary Island.

The Tla'amin Nation is located just north of the City of Powell River, along Highway 101. The majority of the community lives in the main village of Sliammon located on the Strait of Georgia. There is a waterfront park located on First Nation land that is located in the coastal flood hazard area. In addition, there are archaeological and historical sites important to the Tla'amin Nation that may be located along the coast and potentially vulnerable to future coastal flood hazard events. Due the sensitive nature of this data, their specific locations were not included in the spatial risk assessment.

According to geospatial data from Environment Canada, the habitat for two species at risk listed on Schedule 1 of the federal Species Risk Act are present within the study area. One of these species is the marbled murrelet, a small North Pacific seabird which nests in old-growth trees along the coast (BCMELP 1998). Habitat for the marbled murrelet is located on the coasts and inland areas of Hernando Island, Harwood Island, Savary Island, Texada Island, Lasqueti Island, as well as coastal and inland areas of the mainland.

The second species listed at risk is the Contorted-pod Evening-primrose, a small plant located in open, sandy lowland areas (Klinkenberg, 2017). The Contorted-pod Evening-primrose is located along the southern coast of Savary Island. Both species' habitat are exposed and potentially to coastal flood hazards.

GeoBC (2018) published a series of layers displaying the most likely distribution for various marine mammals in the region. Of these species, the orca and harbour porpoise are likely to be found within the Strait of Georgia around the study area. During high tide or a severe storm surge, it is possible for marine mammals to travel father inshore than they could during normal conditions. As high tide and/or the surge waves recede and the waterway returns to their normal state, the marine mammals could become stuck on the shallow coast (IFAW, 2018). In addition, the turbulence within the water and complex coastal areas can disorient the mammals and cause them to beach.

E4.2.3 Local Economic Impacts

Economic losses can be separated into the loss of assets and losses to the local or regional economy. Losses may include but are not limited to physical building damages, agricultural losses, business interruption, and impacts on tourism and tax base.

E4.2.3.1 Potential Impacts to Economic Assets

Direct damages are defined as the costs from the physical impacts of a coastal flood event (e.g., damages to building structure and contents, infrastructure and utilities). The following discusses the estimated potential damage to the buildings located in study area as a result of each scenario evaluated. Impacts to critical infrastructure such as transportation assets and utilities is discussed further in 'Local Infrastructure Impacts'.

To estimate general building stock exposure to the coastal flood hazard scenarios, the general building stock was overlaid with the coastal flood hazard boundaries in GIS. The total number of buildings and associated replacement cost value (structure and contents) located within the hazard area were totaled to estimate exposure to each scenario. HAZUS-MH was then used to estimate the potential building losses as a result of each scenario. Table E-8 below summarizes these results.

Table E-8: General Building Stock Exposed to the Coastal Flood Hazard and Potential Losses

Area	Total Number of Buildings	Total Replacement Cost (Structure and Contents) ($Million)	Total Number of Buildings Exposed to the Hazard Area	Percent of Total	Total Replacement Cost Exposed to the Hazard Area ($Million)	Percent of Total	Potential Losses to General Building Stock ($Million)	Percent of Total
High Tide and 200-Year Surge and Waves (Southeast)								
City	5,312	1,853	62	1.2%	97	5.3%	39	2.1%
Tla'amin	300	83	91	30.3%	26	30.9%	15	18.6%
Electoral Area A – North of Tla'amin + Savary	1,293	289	119	9.2%	22	7.6%	14	5.0%
Electoral Area B – East of City	685	174	39	5.7%	14	8.1%	12	7.1%
Electoral Area C – South of City	909	221	67	7.4%	25	11.2%	23	10.2%
Electoral Area D – Texada	686	122	63	9.2%	12	9.8%	7	6.0%
Electoral Area E – Lasqueti	341	78	4	1.2%	1	<1%	0	<1%
Total	**9,526**	2,820	446	4.7%	200	7.1%	115	4.1%
High Tide, and 200-Year Surge and Waves, and SLR (Southeast)								
City	5,312	1,853	63	1.2%	98	5.3%	54	2.9%
Tla'amin	300	83	114	38.0%	32	38.9%	24	28.5%
Electoral Area A – North of Tla'amin + Savary	1,293	289	145	11.2%	28	9.6%	19	6.7%
Electoral Area B – East of City	685	174	45	6.6%	15	8.7%	14	8.3%
Electoral Area C – South of City	909	221	76	8.4%	27	12.3%	23	10.3%
Electoral Area D – Texada	686	122	54	7.9%	11	8.6%	7	5.7%
Electoral Area E – Lasqueti	341	78	6	1.8%	1	1.1%	1	<1%
Total	**9,526**	2,820	504	5.3%	215	7.6%	145	5.1%

Table E-8: General Building Stock Exposed to the Coastal Flood Hazard and Potential Losses

Area	Total Number of Buildings	Total Replacement Cost (Structure and Contents) ($Million)	Total Number of Buildings Exposed to the Hazard Area	Percent of Total	Total Replacement Cost Exposed to the Hazard Area ($Million)	Percent of Total	Potential Losses to General Building Stock ($Million)	Percent of Total
High Tide, and 200-Year Surge and Waves (Northwest)								
City	5,312	1,853	62	1.2%	73	3.9%	32	1.7%
Tla'amin	300	83	60	20.0%	17	20.6%	9	10.7%
Electoral Area A – North of Tla'amin + Savary	1,293	289	133	10.3%	26	8.9%	19	6.6%
Electoral Area B – East of City	685	174	30	4.4%	11	6.4%	8	4.5%
Electoral Area C – South of City	909	221	13	1.4%	8	3.4%	3	1.2%
Electoral Area D – Texada	686	122	30	4.4%	8	6.3%	3	2.6%
Electoral Area E – Lasqueti	341	78	6	1.8%	1	1.0%	0	<1%
Total	**9,526**	2,820	335	3.5%	147	5.2%	77	2.7%
High Tide, and 200-Year Surge and Waves, and SLR (Northwest)								
City	5,312	1,853	67	1.3%	100	5.4%	85	4.6%
Tla'amin	300	83	87	29.0%	25	29.9%	22	26.8%
Electoral Area A – North of Tla'amin + Savary	1,293	289	148	11.4%	28	9.5%	26	8.9%
Electoral Area B – East of City	685	174	31	4.5%	11	6.5%	11	6.5%
Electoral Area C – South of City	909	221	16	1.8%	9	4.1%	8	3.8%
Electoral Area D – Texada	686	122	344	50.1%	8	6.7%	8	6.2%
Electoral Area E – Lasqueti	341	78	7	2.1%	1	1.1%	1	1.2%
Total	**9,526**	2,820	391	4.1%	185	6.6%	165	5.8%

Table E-8: General Building Stock Exposed to the Coastal Flood Hazard and Potential Losses

Area	Total Number of Buildings	Total Replacement Cost (Structure and Contents) ($Million)	Total Number of Buildings Exposed to the Hazard Area	Percent of Total	Total Replacement Cost Exposed to the Hazard Area ($Million)	Percent of Total	Potential Losses to General Building Stock ($Million)	Percent of Total
High Tide and SLR								
City	1,853	0	0.0%	1,853	-	0.0%	SLR hazard was not modeled for potential losses.	
Tla'amin	83	0	0.0%	83	-	0.0%		
Electoral Area A – North of Tla'amin + Savary	289	2	<1%	289	0.2	<1%		
Electoral Area B – East of City	174	0	0.0%	174	-	0.0%		
Electoral Area C – South of City	221	1	<1%	221	0.1	<1%		
Electoral Area D – Texada	122	2	<1%	122	0.6	<1%		
Electoral Area E – Lasqueti	78	0	0.0%	78	-	0.0%		
Total	2,820	5	<1%	2,820	0.9	<1%		

Source: BC Assessment, HAZUS-MH Canada

4.2.3.2 Potential Impacts to the Local Economy

Emergency costs associated with flood events can be costly and potentially strain local and regional economic resources. These costs may include the following:

- Actions taken by emergency responders (e.g., police and fire organizations) to warn and evacuate, direct traffic and maintain law and order.
- Flood mitigation to reduce damage (e.g., sandbagging and building closures).
- Debris management and disposal.
- Establishing shelters and providing supplies to victims.
- Evacuation costs.
- Administrative costs for public agencies and private relief agencies in delivering emergency services (USACE, 2015).

Historic emergency management and response costs were not available at the time of this report. However, HAZUS-MH Canada estimates the amount of debris generated from each flood event. Table E-9 summarizes the finish, structural and foundation debris HAZUS-MH Canada estimates as a result of each flood event. Notably, this table lists estimated debris generated only by flooding, and does not include additional potential damage and debris possibly generated by force of wind.

Table E-9: Estimated Total Debris as a Result of Each Scenario

Area	Total (Tons)	Finish (Tons)	Structure (Tons)	Foundation (Tons)
High Tide and 200-Year Surge and Waves (Southeast)				
City	2,176	570	925	681
Tla'amin	417	228	113	75
Electoral Area A – North of Tla'amin + Savary	0	0	0	0
Electoral Area B – East of City	1,123	354	449	320
Electoral Area C – South of City	0	0	0	0
Electoral Area D – Texada	613	258	209	147
Electoral Area E – Lasqueti	56	23	19	14
Total	**4,386**	**1,433**	**1,716**	**1,237**
High Tide, 200-Year Surge and Waves, and SLR (Southeast)				
City	2,407	608	1,019	780
Tla'amin	653	329	190	134
Electoral Area A – North of Tla'amin + Savary	0	0	0	0
Electoral Area B – East of City	1,402	398	576	428
Electoral Area C – South of City	0	0	0	0
Electoral Area D – Texada	717	268	260	188
Electoral Area E – Lasqueti	73	29	26	19
Total	**5,252**	**1,633**	**2,070**	**1,549**

Table E-9: Estimated Total Debris as a Result of Each Scenario

Area	Total (Tons)	Finish (Tons)	Structure (Tons)	Foundation (Tons)
High Tide, 200-Year Surge and Waves (Northwest)				
City	1,747	569	703	476
Tla'amin	280	161	72	47
Electoral Area A – North of Tla'amin + Savary	0	0	0	0
Electoral Area B – East of City	448	229	124	96
Electoral Area C – South of City	0	0	0	0
Electoral Area D – Texada	341	148	114	79
Electoral Area E – Lasqueti	57	28	18	12
Total	**2,874**	**1,134**	**1,030**	**710**
High Tide, 200-Year Surge and Waves, and SLR (Northwest)				
City	4,747	877	2,026	1,844
Tla'amin	2,446	584	914	948
Electoral Area A – North of Tla'amin + Savary	0	0	0	0
Electoral Area B – East of City	2,150	429	803	918
Electoral Area C – South of City	0	0	0	0
Electoral Area D – Texada	1,615	329	646	640
Electoral Area E – Lasqueti	306	65	116	125
Total	**11,264**	**2,284**	**4,504**	**4,475**

Source: HAZUS-MH Canada

Finish = This includes interior finish materials such as drywall, flooring and insulation.

Tons = Tons per thousand square feet of structure

According to the Growth and Development Analysis by Vannstruth (2008.), the economic base industries in the region include the following listed from highest to lowest employment: pulp and paper, mining and mineral processing, sawmills, construction, logging, non-resource manufacturing, public sector, high technology, fishing, other wood manufacturing, agriculture and food (which includes aquaculture) and tourism. Many of these industries are either located along the coast or depend on access to this natural resource to remain in business.

The Ministry of Advanced Education, Skills and Training publishes a quarterly report that provides a summary of major economic development projects in the British Columbia Province. According to the Third Quarter 2017 report, there are two proposed, major projects being developed within the study area; both projects are located within the City of Powell River. The first is a 20-acre marine industrial and 98-acre mixed-use site located near the former Catalyst Paper Mill that is proposed to include space for light industrial, commercial, and residential development. The second is a proposed 151 MW hydroelectric project near the Toba and Jarvis Inlets that will consist of 12 run-of-river sites and 150 km transmission line. The associated spatial layer developed for these projects was analyzed using the coastal flood hazard boundaries, and neither are estimated to be located within these hazard areas; however potential future development may change which may alter the results reported.

Powell River's lakes, shorelines and diverse mountain ranges offer year-round recreation opportunities. The region enjoys significant provincial and marine parks that draw tourists and visitors. For example, Desolation Sound Marine Park is one of the most popular destinations for kayaking and sailing on the south coast of BC and the historic Lund Hotel, owned and operated by the Tla'amin Nation is a major tourist destination as well as an important community asset. There are numerous recreational and tourist destination locations located along the coast that are vulnerable to coastal flooding, including the Sunshine Coast Trail, kayak destinations, public beaches and diving sites (Lanarc 2010). Economic losses such as loss of business and unemployment can be significant but difficult to quantify.

Other economic components such as loss of facility use, functional downtime, and social economic factors are less susceptible to measurement with a high degree of certainty.

E4.2.4 Local Infrastructure Impacts

It is essential that all critical and emergency assets remain operational during and post-event to provide needed support to the region. Similar to the general building stock, an exposure analysis was conducted to determine what emergency facilities, critical transportation infrastructure, utilities and other identified assets are located in the projected hazard areas. Additionally, HAZUS-MH Canada and the depth/velocity damage functions were used to estimate potential losses to the regional assets. Table E-10 and Table E-11 below display the results of the exposure analysis and estimated potential losses. Based on the analysis, there are several critical assets exposed to high tide and SLR alone, with a greater number located in the hazard area resulting from a storm event.

Table E-10: Regional Assets Exposed to the Coastal Flood Hazard

Area	Total Number of Assets	Critical Assets Exposed	Percent of Total	Commercial Assets Exposed	Percent of Total	Cultural Assets Exposed	Percent of Total	Other Assets Exposed	Percent of Total
High Tide and 200-Year Surge and Waves (Southeast)									
City	67	7	10.4%	2	3.0%	0	0.0%	0	0.0%
Tla'amin	27	0	0.0%	1	3.7%	0	0.0%	4	14.8%
Electoral Area A – North of Tla'amin + Savary	94	8	8.5%	9	9.6%	0	0.0%	9	9.6%
Electoral Area B – East of City	15	0	0.0%	0	0.0%	0	0.0%	4	26.7%
Electoral Area C – South of City	33	8	24.2%	3	9.1%	0	0.0%	9	27.3%
Electoral Area D – Texada	36	12	33.3%	4	11.1%	1	2.8%	4	11.1%
Electoral Area E – Lasqueti	8	2	25.0%	3	37.5%	0	0.0%	0	0.0%
Total	**280**	**37**	**13.2%**	**22**	**7.9%**	**1**	**0.4%**	**30**	**10.7%**
High Tide, and 200-Year Surge and Waves, and SLR (Southeast)									
City	67	7	10.4%	2	3.0%	0	0.0%	0	0.0%
Tla'amin	27	0	0.0%	1	3.7%	0	0.0%	4	14.8%
Electoral Area A – North of Tla'amin + Savary	94	8	8.5%	9	9.6%	0	0.0%	11	11.7%
Electoral Area B – East of City	15	0	0.0%	0	0.0%	0	0.0%	4	26.7%
Electoral Area C – South of City	33	8	24.2%	3	9.1%	0	0.0%	9	27.3%
Electoral Area D – Texada	36	12	33.3%	4	11.1%	1	2.8%	4	11.1%
Electoral Area E – Lasqueti	8	2	25.0%	3	37.5%	0	0.0%	0	0.0%
Total	**280**	**37**	**13.2%**	**22**	**7.9%**	**1**	**0.4%**	**32**	**11.4%**
High Tide, and 200-Year Surge and Waves (Northwest)									
City	67	8	11.9%	2	3.0%	0	0.0%	0	0.0%
Tla'amin	27	0	0.0%	1	3.7%	0	0.0%	4	14.8%
Electoral Area A – North of Tla'amin + Savary	94	8	8.5%	9	9.6%	0	0.0%	9	9.6%
Electoral Area B – East of City	15	0	0.0%	0	0.0%	0	0.0%	4	26.7%
Electoral Area C – South of City	33	7	21.2%	3	9.1%	0	0.0%	5	15.2%
Electoral Area D – Texada	36	12	33.3%	4	11.1%	1	2.8%	4	11.1%
Electoral Area E – Lasqueti	8	2	25.0%	3	37.5%	0	0.0%	0	0.0%
Total	**280**	**37**	**13.2%**	**22**	**7.9%**	**1**	**0.4%**	**26**	**9.3%**

Table E-10: Regional Assets Exposed to the Coastal Flood Hazard

Area	Total Number of Assets	Critical Assets Exposed	Percent of Total	Commercial Assets Exposed	Percent of Total	Cultural Assets Exposed	Percent of Total	Other Assets Exposed	Percent of Total
High Tide, and 200-Year Surge and Waves, and SLR (Northwest)									
City	67	8	11.9%	2	3.0%	0	0.0%	0	0.0%
Tla'amin	27	0	0.0%	1	3.7%	0	0.0%	4	14.8%
Electoral Area A – North of Tla'amin + Savary	94	8	8.5%	9	9.6%	0	0.0%	10	10.6%
Electoral Area B – East of City	15	0	0.0%	0	0.0%	0	0.0%	4	26.7%
Electoral Area C – South of City	33	7	21.2%	3	9.1%	0	0.0%	6	18.2%
Electoral Area D – Texada	36	12	33.3%	4	11.1%	1	2.8%	4	11.1%
Electoral Area E – Lasqueti	8	2	25.0%	3	37.5%	0	0.0%	0	0.0%
Total	**280**	**37**	**13.2%**	**22**	**7.9%**	**1**	**0.4%**	**28**	**10.0%**
High Tide and SLR									
City	67	6	9.0%	1	1.5%	0	0.0%	0	0.0%
Tla'amin	27	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Electoral Area A – North of Tla'amin + Savary	94	8	8.5%	9	9.6%	0	0.0%	2	2.1%
Electoral Area B – East of City	15	0	0.0%	0	0.0%	0	0.0%	1	6.7%
Electoral Area C – South of City	33	6	18.2%	3	9.1%	0	0.0%	1	3.0%
Electoral Area D – Texada	36	6	16.7%	4	11.1%	1	<1%	1	2.8%
Electoral Area E – Lasqueti	8	2	25.0%	3	37.5%	0	0.0%	0	0.0%
Total	**280**	**28**	**10.0%**	**20**	**7.1%**	**1**	**0.0%**	**5**	**1.8%**

Source: Powell River Region District, HAZUS-MH Canada, HAZUS-MH v4.0

Table E-11: Regional Asset Replacement Cost Exposed to the Coastal Flood Hazard and Potential Losses

Area	Total Replacement Cost Value (Structure and Contents) ($Millions)	Total Replacement Cost Exposed to the Hazard Area ($Millions)	Percent of Total	Potential Losses to Regional Assets ($Millions)	Percent of Total
High Tide and 200-Year Surge and Waves (Southeast)					
City	1,864	14	<1%	8	0.4%
Tla'amin	803	1	<1%	0	0.0%
Electoral Area A – North of Tla'amin + Savary	794	38	4.7%	38	4.8%
Electoral Area B – East of City	74	-	0.0%	-	0.0%
Electoral Area C – South of City	857	102	11.9%	48	5.6%
Electoral Area D – Texada	1,113	390	35.0%	386	34.7%
Electoral Area E – Lasqueti	9	-	0.0%	-	0.0%
Total	**5,514**	**545**	**9.9%**	**486**	**8.8%**
High Tide, and 200-Year Surge and Waves, and SLR (Southeast)					
City	1,864	14	<1%	8	0.4%
Tla'amin	803	1	<1%	1	0.1%
Electoral Area A – North of Tla'amin + Savary	794	38	4.7%	38	4.8%
Electoral Area B – East of City	74	-	0.0%	-	0.0%
Electoral Area C – South of City	857	102	11.9%	44	5.1%
Electoral Area D – Texada	1,113	390	35.0%	386	34.7%
Electoral Area E – Lasqueti	9	-	0.0%	-	0.0%
Total	**5,514**	**545**	**9.9%**	**484**	**8.8%**
High Tide, and 200-Year Surge and Waves (Northwest)					
City	1,864	16	<1%	8	0.4%
Tla'amin	803	1	<1%	0	0.0%
Electoral Area A – North of Tla'amin + Savary	794	38	4.7%	38	4.8%
Electoral Area B – East of City	74	-	0.0%	-	0.0%

Table E-11: Regional Asset Replacement Cost Exposed to the Coastal Flood Hazard and Potential Losses

Area	Total Replacement Cost Value (Structure and Contents) ($Millions)	Total Replacement Cost Exposed to the Hazard Area ($Millions)	Percent of Total	Potential Losses to Regional Assets ($Millions)	Percent of Total
Electoral Area C – South of City	857	68	7.9%	41	4.8%
Electoral Area D – Texada	1,113	390	35.0%	97	8.7%
Electoral Area E – Lasqueti	9	-	0.0%	-	0.0%
Total	**5,514**	**513**	**9.3%**	**187**	**3.4%**
High Tide, and 200-Year Surge and Waves, and SLR (Northwest)					
City	1,864	16	<1%	15	0.8%
Tla'amin	803	1	<1%	1	0.1%
Electoral Area A – North of Tla'amin + Savary	794	38	4.7%	38	4.8%
Electoral Area B – East of City	74	-	0.0%	-	0.0%
Electoral Area C – South of City	857	71	8.3%	68	7.9%
Electoral Area D – Texada	1,113	390	35.0%	386	34.7%
Electoral Area E – Lasqueti	9	-	0.0%	-	0.0%
Total	**5,514**	**516**	**9.4%**	**515**	**9.3%**
High Tide and SLR					
City	1,864	19	1.0%	SLR hazard was not modeled for potential losses.	
Tla'amin	803	-	0.0%		
Electoral Area A – North of Tla'amin + Savary	794	51	6.4%		
Electoral Area B – East of City	74	-	0.0%		
Electoral Area C – South of City	857	54	6.4%		
Electoral Area D – Texada	1,113	42	3.8%		
Electoral Area E – Lasqueti	9	8	92.8%		
Total	**5,514**	**175**	**3.2%**		

Source: Powell River Regional District, HAZUS-MH Canada, HAZUS-MH v4.0

Note: Not all assets were assigned a replacement cost value; therefore, the results listed may be underestimating the potential exposure.

E4.2.4.1 Transportation

While part of the mainland, the PRRD is inaccessible by road from the lower mainland and is dependent on boats, water taxis, ferries, barges and air travel for trips to the islands and out of the region. The major artery through PRRD is the Sunshine Coast Highway (HWY 101), which runs parallel to the coastline. The Ministry of Transportation and Infrastructure has jurisdiction over the highway. In 2012, the average annual daily traffic count for Highway 101 was 874 vehicles per day (ISL 2014).

Functioning transportation infrastructure is not only important for every day travel, but critical during the response and recovery phases of a flood event. Any disruptions to major transportation assets can result is serious complications for emergency responders and those evacuating an impacted area. Further, evacuation protocols, including specific routes and identified exits, are essential to help avoid confusion and prevent injuries during an event.

For the mainland, the HWY 101 is the primary transit route to evacuate away from the coast. This highway is connected by paved and loose roadways throughout the region. The PRRD Transportation Plan noted the highway's vulnerability to coastal flood/erosion at 'Myrtle Rocks'. When examining impacts to the highway resulting from high tide and SLR alone, there is one section at the end of the highway in Lund that is anticipated to become inundated (0.02 km in length). As a result of the projected storm events, five main areas of the highway may become inundated by as depicted in Figure 80 and described below. Table E-12 summarizes the length of roadway inundation anticipated as a result of each flood scenario evaluated.

1. Section of road and the Lang Creek Bridge near the intersection of the highway and Brew Bay Road in Brew Bay.
2. Section of road approximately 3 km south of the City.
3. Section of road approximately 1 km south of the Westview Ferry Terminal in the City.
4. Section of road at the end of the highway in Lund.
5. Section of road at the end of the highway in Saltery Bay.

Table E-12: Length of Inundated Roadway for Each Hazard Scenario

Sunshine Coast Highway (km)	Paved Roadway (km)	Loose Roadway (km)	Rough Roadway (km)
High Tide and 200-Year Surge and Waves (Southeast)			
0.7	9.6	12.5	2.3
High Tide, and 200-Year Surge and Waves, and SLR (Southeast)			
0.9	11.0	14.4	2.9
High Tide, and 200-Year Surge and Waves (Northwest)			
0.6	5.9	10.6	0.8
High Tide, and 200-Year Surge and Waves, and SLR (Northwest)			
0.74	7.0	11.2	1.3
High Tide and SLR			
0.02	0.4	0.4	0.1

Source: PRRD

To evacuate flooded areas on the island communities, populations must either travel to higher ground or utilize marine transportation (boats, ferries) and assets along the shore (such as docks and boat ramps) to evacuate to the mainland. Strong waves and surge may generate unsafe conditions for ferries and boats traversing the waterway from the islands to the mainland. Waves crashing on the docks and ramps have historically damaged and destroyed these assets as a result of coastal flood and storm events. There are seven ramps along the mainland coast at risk to such impacts.

As reported by Mr. Gregg Clackson, Director of Operations and Security Center at BC Ferry, delays or cancellations of service are mostly due to high winds; service resumes after several hours and the storm system passes. BC Ferry assets in Powell River are above sea level with a new floating dock and trestle. At times, water may reach the terminal and puddles but it drains away and customers are diverted around the flood waters.

Air rescue is an option for stranded populations on the islands if the use of a boat is not possible and there is access to a landing spot for a helicopter. For the region, six helipads are located in the coastal hazard area; three along the mainland coast and three on Texada Island.

E4.2.4.2 Energy and Utilities

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Maintaining an operational energy grid is essential to the continuity of emergency response and recovery efforts and operation of critical assets needed during and post- a natural hazard event. Energy and utility failure impacts range from short-term disruptions to prolonged outages with cascading impacts throughout the region. Regional loss of power affects lighting; heating, ventilation, and air conditioning (HVAC) and other support equipment; communications; fire and security systems; and refrigerators, which can in turn cause loss of water and sewer service, and food spoilage. Special medical equipment will not function without power. Likewise, a loss of air conditioning during periods of extreme heat or the loss of heating during extreme cold can be especially detrimental to those with medical needs, children, and the elderly.

A robust inventory of energy and utility assets was not available for a detailed and comprehensive impact analysis. Based on the analysis utilizing available energy and utility assets, the Texada West Terminal is exposed to flooding as a result of the four 200-year flood scenarios.

There are no quantified losses to report for energy and utility services at this time. However, FEMA BCA module has quantified the loss per day for utility services (USD) to provide a general understanding for potential loss (refer to Table E-13).

Table E-13: Estimated Utility Loss Values

Utility	Value per Unit of Service ($/person/day) USD
Electrical	$148
Potable Water	$105
Wastewater	$49

E4.2.4.3 Info and Communications

No information and communication assets were identified by the PRRD. However, as discussed above, in the event the Texada West Terminal substation on Texada Island undergoes a system failure, the power loss may affect the transfer of critical information with potential cascading impacts to the general population affected.

E4.2.4.4 Health/Food/Water

Access to both marine and freshwater ecosystems has created great opportunity for local food production. According to the Recreation and Greenspace Plan (Lanarc 2010), local salmon populations are restored to historical levels and have regained their key role in Tla'amin diet, culture and heritage. As noted earlier, there are many commercial fisheries in the study area including salmon and shellfish fisheries. Coastal flooding may impact the access to coastal waters that serve as local food sources, and cause economic impacts to local businesses as discussed above.

The salmon and shellfish industries are important to the diets of the people in the region. Spatial layers from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development display the locations of various fisheries in British Columbia. According to these layers, there are over 10 salmon fishery and trawling locations through the Strait of Georgia and the mainland waterways, as well as over 70 clam beds throughout these same water bodies; two of the clam beds in the study area are located in Okeover Arm and Lasqueti Island. Additional commercial fisheries include, herring roe, ground fish, prawn, shrimp, and crab. Like with marine mammals, the rough hydrologic conditions in the Strait of Georgia and coastal rivers and streams can affect the behavior of the fish populations. Additionally, the strong waves could alter the location of shellfish communities along the bottom of the region's waterbodies. Populations of fish and shellfish may not be found along the shorelines and affected by breaking waves but can still be impacted by the waves throughout a waterbody.

There are no water or wastewater treatment facilities identified as located within the projected hazard areas. However, if a severe storm event brings heavy precipitation in addition to the high winds, the large volume of water entering the systems from run-off and storm surge may have the potential to overload the treatment facilities if they exceed capacity.

E4.2.4.5 Safety and Security

The Powell River Regional Emergency Program (PRREP) coordinates emergency planning, preparedness, training, response, and recovery for all areas within the Powell River Regional District, including the City of Powell River and the Sliammon First Nation (Tla'amin) (PRRD 2018). The program works with emergency responders, government staff, volunteers, partner agencies, and the general public throughout our region. The PRREP recognizes the region has limited emergency resources and that in a major disaster there could be a delay in receiving emergency help.

Historically, roads have washed out on Texada Island and the inundation of roadways, including HWY 101, have caused populations to become isolated until floodwaters receded. In Gillies Bay on Texada Island, three critical assets are located within all four 200-year storm inundation areas: 1) Gillies Bay Fire; 2) RCMP Texada; and 3) Gillies Bay Old School. The inundation areas block off access to the community east of Sanderson Road. In addition to the estimated 33 people within the hazard area, the population to the west of Sanderson Road that is not within the hazard area may lack access to the adequate emergency response services that may be required.

E4.2.5 Public Sensitivity

Table E-14 lists the ratings for public sensitivity impact ratings defined in the RAIT.

Table E-14: RAIT Public Sensitivity Impact Ratings

Rating	Definition
5	Sustained, long term loss in reputation/public perception of public institutions and/or sustained, long term loss of trust and confidence in public institutions; or having an international level impact
4	Significant loss in reputation/public perception of public institutions and/or significant loss of trust and confidence in public institutions; significant resistance; or having a national level impact
3	Some loss in reputation/public perception of public institutions and/or some loss of trust and confidence in public institutions; escalating resistance
2	Isolated/minor, recoverable set-back in reputation, public perception, trust, and/or confidence of public institutions
1	No impact on reputation, public perception, trust, and/or confidence of public institutions

The PRRD assigned public impact ratings for the selected scenarios. These are summarized in Table E-15.

Table E-15: Assigned Public Impact Ratings for Selected Scenarios

Scenario	Sensitivity Impact Rating per RAIT	Comments
High Tide and SLR	4	Given the predictability of the combined impacts of High Tide and SLR, the PRRD assigns a higher rating for public sensitivity to these impacts. The public is trusting that emergency planning, infrastructure planning, and mitigation efforts will prioritize these impacts to public and private infrastructure.
High Tide and 200-Year Surge and Waves (Southeast)	3	Significant impacts to local public and private infrastructure will result in loss of public confidence.
High Tide, and 200-Year Surge and Waves (Southeast), and SLR	3	Highest severity of impacts to local public and private infrastructure. Public sensitivity rating is moderated slightly by public perception of infrequency of storm impacts vs High Tide and SLR.
High Tide and 200-Year Surge and Waves (Northwest)	3	Significant impacts to local public and private infrastructure will result in loss of public confidence.
High Tide, and 200-Year Surge and Waves (Northwest), and SLR	3	Highest severity of impacts to local public and private infrastructure. Public sensitivity rating is moderated slightly by public perception of infrequency of storm impacts vs High Tide and SLR.

E5. ASSET INVENTORY TABLES

The asset inventory details are listed in the following tables.

Name	Address	Type	Occupancy	Latitude	Longitude	Size	Replacement Cost	Content Value	RCV Source	Displacement Cost	Average daily cost to operate	Importance rating and rationale	Vulnerability rating and reason	Exposed to 200-year storm with High Tide from SE	Exposed to 200-year storm with High Tide and SLR from SE	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to High Tide and SLR	Grid Index ID	Priorization Rating Highest, High, Signifcant
Critical Assets (police, fire etc)																				
BC Ambulance	7061 Duncan St	Ambulance	GOV2	49.836159	-124.518499	3,092	$540,000.00	$540,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
BC Ambulance	2057 Giles Bay Rd	Ambulance	GOV2	49.75232	-124.555715	1,402	$741,000.00	$741,000.00	BC Assessment	Not available at this time	Not available at this time	1							T15	
Power River Emergency Service	#103-4675 Marine Ave	EOC	GOV2	49.842444	-124.528816	0	$68,100.00	$68,100.00	BC Assessment	Not available at this time	Not available at this time	1							O16	
Malaspina 2	4322 McLeod Rd	Firehall	GOV2	49.833505	-124.482989	3,380	$106,200.00	$106,200.00	BC Assessment	Not available at this time	Not available at this time	1							P18	
Malaspina 1	9999 Hwy. 101	Firehall	GOV2	49.772243	-124.393674	7,980	$286,000.00	$286,000.00	BC Assessment	Not available at this time	Not available at this time	1							S21	
Northside 2	9642 Larson Rd	Firehall	GOV2	49.978846	-124.757434	1,133	$41,700.00	$41,700.00	BC Assessment	Not available at this time	Not available at this time	1							H8	
Northside 1	8540 Plummer Creek Rd	Firehall	GOV2	49.948812	-124.681042	5,943	$537,000.00	$537,000.00	BC Assessment	Not available at this time	Not available at this time	1							I11	
Tla'amin Nation Fire Dept	6680 Sliammon Rd	Firehall	GOV2	49.897712	-124.607231	0	$89,789.00	$89,789.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Savary 3	1134 Vancouver BLVD	Firehall	GOV2	49.940714	-124.859789	1,088	$70,700.00	$70,700.00	BC Assessment	Not available at this time	Not available at this time	1							J5	
Savary 2	1847 Savary Island Rd	Firehall	GOV2	49.940555	-124.825424	1,572	$211,000.00	$211,000.00	BC Assessment	Not available at this time	Not available at this time	1							J6	
Savary 1	2856 Vancouver BLVD	Firehall	GOV2	49.941947	-124.782298	1,088	$70,700.00	$70,700.00	BC Assessment	Not available at this time	Not available at this time	1							J7	
City 1	6965 Courtenay St	Firehall	GOV2	49.838074	-124.522088	6,197	$461,000.00	$461,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
City 2	6459 Sutherland Ave	Firehall	GOV2	49.891347	-124.563847	3,070	$176,000.00	$176,000.00	BC Assessment	Not available at this time	Not available at this time	1							M15	
Van Anda 1	2036 Marble Bay Rd	Firehall	GOV2	49.756333	-124.556997	3,306	$192,000.00	$192,000.00	BC Assessment	Not available at this time	Not available at this time	1							T15	
Gillies Bay 1	5073 Gillies Bay Rd	Firehall	GOV2	49.680272	-124.479393	3,328	$206,000.00	$206,000.00	BC Assessment	Not available at this time	Not available at this time	1	2	X	X	X	X		Y18	High
Lasqueti 1	Main Rd	Firehall	GOV2	49.497694	-124.346504	1,350	$196,000.00	$196,000.00	BC Assessment	Not available at this time	Not available at this time	1							AI23	
Lasqueti 2	Main Rd	Firehall	GOV2	49.470316	-124.23346	1,864	$131,000.00	$131,000.00	BC Assessment	Not available at this time	Not available at this time	1							AJ27	
Powell River General Hospital	5000 Joyce Ave	Medical	GOV2	49.850968	-124.518504	27,816	$40,612,000.00	$40,612,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Texada Health Centre	4977 Sanderson Rd	Medical	GOV2	49.681122	-124.485329	2,140	$143,000.00	$143,000.00	BC Assessment	Not available at this time	Not available at this time	1							X18	
RCMP (PR RCMP)	7070 Barnet St	RCMP	GOV2	49.841374	-124.516814	10,692	$2,266,000.00	$2,266,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
RCMP (Texada)	5010 Gillies Bay Rd	RCMP	GOV2	49.679848	-124.482848	1,233	$209,000.00	$209,000.00	BC Assessment	Not available at this time	Not available at this time	1	2	X	X	X	X		Y18	High
PR SAR	6791 Drake St	SAR Base	GOV2	49.870956	-124.52938	2,306	$119,000.00	$119,000.00	BC Assessment	Not available at this time	Not available at this time	1							N16	
BC Wildfire	7400 Empress Way	Wildfire Base	GOV2	49.836187	-124.503809	0	$137,160.00	$137,160.00	HAZUS Estimate	Not available at this time	Not available at this time	1							P17	
Edgehill Elementary School	7312 ABBOTSFORD ST	Elementary School	EDU1	49.852065	-124.5071	0	$1,189,990.00	$1,189,990.00	HAZUS Estimate	Not available at this time	Not available at this time	2							O17	
Brooks Secondary School	5400 MARINE AVE	Secondary School	EDU1	49.862775	-124.542289	0	$297,180.00	$297,180.00	HAZUS Estimate	Not available at this time	Not available at this time	1							N16	
Powell River Academy of Music	7280 KEMANO ST	Private School	EDU1	49.827361	-124.508568	0	$119,253.00	$119,253.00	HAZUS Estimate	Not available at this time	Not available at this time	2							P17	
Assumption School	7091 GLACIER ST	Private School	EDU1	49.832169	-124.516785	5,527	$4,035,000.00	$4,035,000.00	BC Assessment	Not available at this time	Not available at this time	2							P17	
Ecole Cote-du-Soleil	4368 MICHIGAN AVE	Private School	EDU1	49.834205	-124.523368	0	$1,877,060.00	$1,877,060.00	HAZUS Estimate	Not available at this time	Not available at this time	2							P17	
Westview Elementary School	3900 SELKIRK AVE	Elementary School	EDU1	49.8218	-124.518606	0	$529,590.00	$264,795.00	HAZUS Estimate	Not available at this time	Not available at this time	2							Q17	
Vancouver Island University	7085 NOOTKA ST	University-College	EDU2	49.822922	-124.517061	0	$15,948,660.00	$15,948,660.00	HAZUS Estimate	Not available at this time	Not available at this time	2							Q17	
Henderson Elementary School	5506 WILLOW AVE	Elementary School	EDU1	49.865401	-124.543974	0	$1,922,780.00	$1,922,780.00	HAZUS Estimate	Not available at this time	Not available at this time	2							N16	
James Thomson Elementary	6388 SUTHERLAND AVE	Elementary School	EDU1	49.889645	-124.562201	0	$1,576,070.00	$1,576,070.00	HAZUS Estimate	Not available at this time	Not available at this time	2							M15	
Kelly Creek Community School	2341 ZILINSKY RD	Elementary School	EDU1	49.778904	-124.376598	0	$86,487.00	$86,487.00	HAZUS Estimate	Not available at this time	Not available at this time	2							S22	
Texada Elementary	2007 WATERMAN AVE	Elementary School	EDU1	49.760759	-124.558112	0	$623,570.00	$623,570.00	HAZUS Estimate	Not available at this time	Not available at this time	2							T15	
Powell River Christian School	6960 QUESNEL ST	Private School	EDU1	49.81264	-124.522215	0	$158,750.00	$158,750.00	HAZUS Estimate	Not available at this time	Not available at this time	2							Q17	
Lang Bay Community Hall	11090 HWY 101	Community Hall	REL1	49.779982	-124.347751	1,793	$108,000.00	$108,000.00	BC Assessment	Not available at this time	Not available at this time	1							S23	
Sunshine Coast Health Centre	2174A,B FLEURY RD	Medical	COM7	49.773843	-124.429093	803	$937,000.00	$937,000.00	BC Assessment	Not available at this time	Not available at this time	1							S20	
Powell River Regional District Maintenance Facility	2815 MCCAUSLAND RD	Public Works Building	GOV2	49.792047	-124.46237	0	$234,000.00	$234,000.00	BC Assessment	Not available at this time	Not available at this time	1							R19	
Myrtle Pond Water Tower	3184 BRADFORD RD	Water Reservoir	IND5	49.802116	-124.482991	0	$372,110.00	$372,110.00	HAZUS Estimate	Not available at this time	Not available at this time	1							R18	
Myrtle Pond Water Treatment Facility	3164 BRADFORD RD	Water Treatment Plant	IND5	49.802014	-124.482994	0	$161,290.00	$161,290.00	HAZUS Estimate	Not available at this time	Not available at this time	1							R18	
No Name	No Address	Water Treatment Plant	IND5	49.871365	-124.501647	0	$51,577,240.00	$25,788,620.00	HAZUS Estimate	Not available at this time	Not available at this time	1							N17	
No Name	No Address	Water Reservoir	IND5	49.871176	-124.501992	0	$51,577,240.00	$25,788,620.00	HAZUS Estimate	Not available at this time	Not available at this time	1							N17	
No Name	No Address	Water Treatment Plant	IND5	49.875121	-124.485422	0	$6,797,040.00	$3,398,520.00	HAZUS Estimate	Not available at this time	Not available at this time	1							N18	
No Name	No Address	Water Reservoir	IND5	49.889705	-124.552064	407	$93,900.00	$93,900.00	BC Assessment	Not available at this time	Not available at this time	1							M16	
Water Treatment Plant	9730 EMIL RD	Water Treatment Plant	IND5	49.981596	-124.754601	0	$3,448,882.49	$3,448,882.49	HAZUS Estimate	Not available at this time	Not available at this time	1							H8	
Northside Community Recreation Centre	9656 LARSON RD	Community Hall	GOV1	49.979082	-124.756458	0	$192,138.30	$192,138.30	HAZUS Estimate	Not available at this time	Not available at this time	1							H8	
Tla'amin Nation Government Building	4779 KLAHANIE RD	Municipal Hall	GOV1	49.900512	-124.617409	0	$1,796,493.11	$1,796,493.11	HAZUS Estimate	Not available at this time	Not available at this time	1							L13	
Tla'amin Salish Centre	4885A,B HWY 101	Community Hall	REL1	49.8992	-124.613089	0	$1,304,619.06	$1,304,619.06	HAZUS Estimate	Not available at this time	Not available at this time	1							L13	
Italian Community Centre	5866 LUND ST	Community Hall	REL1	49.889399	-124.568316	6,775	$239,000.00	$239,000.00	BC Assessment	Not available at this time	Not available at this time	1							M15	
Dwight Hall	6274 WALNUT ST	Community Hall	REL1	49.87327	-124.551139	22,443	$1,478,000.00	$1,478,000.00	BC Assessment	Not available at this time	Not available at this time	1							N16	
Powell River Senior's Centre	6792 CRANBERRY ST	Senior Centre	RES6	49.87154	-124.529472	5,612	$417,000.00	$208,500.00	BC Assessment	Not available at this time	Not available at this time	1							N16	
Powell River Recreation Complex	5001 JOYCE AVE	Recreation Centre Hazmat	COM8	49.85183	-124.523632	223,743	$12,558,000.00	$12,558,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
City of Powell River Public Works Yard	7158 DUNCAN ST	Public Works Building	GOV2	49.835712	-124.512987	16,936	$1,514,000.00	$1,514,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
City Hall City of Powell River	6910 DUNCAN ST	Municipal Hall	GOV1	49.83564	-124.524596	19,912	$1,241,000.00	$1,241,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
Powell River Regional District Office	202-4675 MARINE AVE	Municipal Hall	GOV1	49.842444	-124.528816	0	$68,100.00	$68,100.00	BC Assessment	Not available at this time	Not available at this time	1							O16	
Royal Canadian Legion Branch 164 Powell River	6811 ALEXANDER ST	Community Hall	REL1	49.84197	-124.528801	7,658	$491,000.00	$491,000.00	BC Assessment	Not available at this time	Not available at this time	1							P16	
Texada Community Hall	4913 GILLIES BAY RD	Community Hall	REL1	49.682146	-124.48587	2,918	$125,000.00	$125,000.00	BC Assessment	Not available at this time	Not available at this time	1							X18	
Gillies Bay Old School	5079 GILLIES BAY RD	Community Hall	REL1	49.680305	-124.478684	3,853	$267,000.00	$267,000.00	BC Assessment	Not available at this time	Not available at this time	1	2	X	X	X	X		Y18	High
Royal Canadian Legion Branch 32 Van Anda	2099 LEGION RD	Community Hall	REL1	49.753642	-124.553161	4,212	$339,900.00	$339,900.00	BC Assessment	Not available at this time	Not available at this time	1							T15	
Busy Bee Daycare	3784 JOYCE AVE	Daycare Centre	EDU1	49.818215	-124.519927	1,293	$163,000.00	$163,000.00	BC Assessment	Not available at this time	Not available at this time	2							Q17	
Cranberry Family Daycare Centre	7050 CRANBERRY ST	Daycare Centre	EDU1	49.872674	-124.518428	1,884	$293,000.00	$293,000.00	BC Assessment	Not available at this time	Not available at this time	2							N17	
Second Nature Daycare Centre Inc	4454 JOYCE AVE	Daycare Centre	EDU1	49.836479	-124.520431	2,064	$127,000.00	$127,000.00	BC Assessment	Not available at this time	Not available at this time	2							P17	
Sliammon CDRC Daycare & Out Of School Care	4915 SALISH DR	Daycare Centre	EDU1	49.898048	-124.611856	0	$7,966,710.00	$7,966,710.00	HAZUS Estimate	Not available at this time	Not available at this time	2							L13	
Oceanview Education Centre	7105 NOOTKA ST	Secondary School	EDU1	49.822344	-124.515818	0	$7,966,710.00	$7,966,710.00	HAZUS Estimate	Not available at this time	Not available at this time	2							Q17	
Camber College	204-4750 JOYCE AVE	University-College	EDU2	49.844502	-124.518247	0	$7,966,710.00	$7,966,710.00	HAZUS Estimate	Not available at this time	Not available at this time	2							O17	
Evergreen Care Unit	4970 JOYCE AVE	Senior Care	RES6	49.850442	-124.519831	27,816	$40,612,000.00	$20,306,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Willingdon Creek Village	4980 KIWANIS AVE	Senior Care	RES6	49.849794	-124.518747	27,816	$40,612,000.00	$20,306,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Kiwanis Garden Manor	4923 KIWANIS AVE	Senior Care	RES6	49.849445	-124.520867	38,551	$5,352,000.00	$2,676,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Powell Rvier Community Health	No Address	Public Health Department	GOV1	49.850968	-124.518504	27,816	$40,612,000.00	$40,612,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Front Counter BC	6953 ALBERNI ST	Provincial Building	GOV1	49.84576	-124.523011	15,950	$1,795,000.00	$1,795,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Powell River Public Library	6975 ALBERNI ST	Library	GOV1	49.845941	-124.521951	1,800	$100,000.00	$100,000.00	BC Assessment	Not available at this time	Not available at this time	2							O17	
Youth Family Employment Services	6944 ALBERNI ST	Provincial Building	GOV1	49.844689	-124.5229	8,625	$935,000.00	$935,000.00	BC Assessment	Not available at this time	Not available at this time	1							O17	
Ministry of Forests Land and Natural Resource Operations	7077 DUNCAN ST	Provincial Building	GOV1	49.836361	-124.517352	12,120	$679,000.00	$679,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
Service Canada	7061 DUNCAN ST	Federal Building	GOV1	49.836264	-124.518224	0	$540,000.00	$540,000.00	BC Assessment	Not available at this time	Not available at this time	1							P17	
BA Blacktop Asphalt Plant	7475 COVEY ST	Heavy Industry	IND1	49.859566	-124.499618	0	$3,034,129.78	$3,034,129.78	HAZUS Estimate	Not available at this time	Not available at this time	2							O17	
Grief Point Sub-Station	3308 CARIBOO AVE	Power Substation	IND5	49.805296	-124.514429	0	$158,667,398.37	$158,667,398.37	HAZUS Estimate	Not available at this time	Not available at this time	1							R17	
Catalyst Paper Mill	5775 ASH AVE	Heavy Industry	IND1	49.872839	-124.560967	0	$3,034,129.78	$3,034,129.78	HAZUS Estimate	Not available at this time	Not available at this time	2	2	X	X	X	X		N15	High
Westview Waste Treatment Plant	4529 WILLINGDON AVE	Waste Treatment Facility	IND5	49.838522	-124.529421	0	$48,032,948.78	$48,032,948.78	HAZUS Estimate	Not available at this time	Not available at this time	1							P16	
Townsite Waste Treatment Site	5401 LARCH AVE	Waste Treatment Facility	IND5	49.861036	-124.547444	0	$48,032,948.78	$48,032,948.78	HAZUS Estimate	Not available at this time	Not available at this time	1							N16	
Natural Gas Facility	Haul Road	Natural Gas Facility	IND5	49.858392	-124.5434	0	$1,572,249.67	$1,572,249.67	HAZUS Estimate	Not available at this time	Not available at this time	1							O16	
Old Golf Course (Natural Gas Facility)	5561 MARINE AVE	Natural Gas Facility	IND5	49.867117	-124.549938	0	$1,572,249.67	$1,572,249.67	HAZUS Estimate	Not available at this time	Not available at this time	1							N16	
Forest View Substation	No Address	Power Substation	IND5	49.861349	-124.53026	0	$158,667,398.37	$158,667,398.37	HAZUS Estimate	Not available at this time	Not available at this time	1							N16	

Name	Address	Type	Occupancy	Latitude	Longitude	Size	Replacement Cost	Content Value	RCV Source	Displacement Cost	Average daily cost to operate	Importance rating and rationale	Vulnerability rating and reason	Exposed to 200-year storm with High Tide from SE	Exposed to 200-year storm with High Tide and SLR from SE	Exposed to 200-year storm with High Tide from NW	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to High Tide and SLR	Grid Index ID	Priorization Rating Highest, High, Significant
Esso Bulk Plant (To Be Relocated)	4419 MARINE AVE	Fuel Storage Facility	IND5	49.835673	-124.528748	0	$905,193.97	$905,193.97	HAZUS Estimate	Not available at this time	Not available at this time	1	2			X	X		P16	High
Superior Propane Tank	7408 HWY 101	Fuel Storage Facility	IND5	49.800419	-124.503366	560	$788,700.00	$788,700.00	BC Assessment	Not available at this time	Not available at this time	1							R17	
Powell River Curling Rink	5750 CROWN AVE	Recreation Centre Hazmat	COM8	49.872408	-124.53285	0	$329,091.93	$329,091.93	HAZUS Estimate	Not available at this time	Not available at this time	2							N16	
Catalyst Landfill Site	6120 LUND ST	Heavy Industry	IND1	49.882974	-124.556894	0	$2,938,566.64	$2,938,566.64	HAZUS Estimate	Not available at this time	Not available at this time	2							M15	
Wildwood Lagoon	5685 LUND ST	Waste Treatment Facility	IND5	49.894172	-124.57373	280	$5,900.00	$5,900.00	BC Assessment	Not available at this time	Not available at this time	1							M15	
No Name	7070 EAGLE DR	Water Treatment Plant	IND5	49.908177	-124.596102	0	$93,040,200.00	$93,040,200.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
No Name	No Address	Water Reservoir	IND5	49.905169	-124.601537	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
No Name	5927 ARBUTUS AVE	Power Substation	IND5	49.877419	-124.5521	0	$153,670,000.00	$153,670,000.00	HAZUS Estimate	Not available at this time	Not available at this time	1							N16	
Saltery Bay Substation	No Address	Power Substation	IND5	49.787196	-124.177223	0	$153,670,000.00	$153,670,000.00	HAZUS Estimate	Not available at this time	Not available at this time	1							S29	
TEXADA ISLAND REACTOR	No Address	Power Substation	IND5	49.615686	-124.330871	0	$153,670,000.00	$153,670,000.00	HAZUS Estimate	Not available at this time	Not available at this time	1							AB23	
TEXADA EAST TERMINAL	No Address	Power Substation	IND5	49.62998	-124.284223	0	$153,670,000.00	$153,670,000.00	HAZUS Estimate	Not available at this time	Not available at this time	1							AA25	
TEXADA WEST TERMINAL	No Address	Power Substation	IND5	49.590186	-124.35822	0	$153,670,000.00	$153,670,000.00	HAZUS Estimate	Not available at this time	Not available at this time	1	2	X	X	X	X		AD22	High
Stillwater Power House	2020 STILLWATER MAIN	Power Generation Facility	IND5	49.769884	-124.317	0	$153,670,000.00	$153,670,000.00	HAZUS Estimate	Not available at this time	Not available at this time	1							T24	
Lund Sewer Plant	9810 FINN BAY RD	Waste Treatment Facility	IND5	49.983755	-124.757489	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							G8	
Lois River Bridge	No Address	Bridge	-	49.777531	-124.328638	0	$18,785,840.00	$18,785,840.00	HAZUS Estimate	Not available at this time	Not available at this time	1							S24	
Kelly Creek Bridge	No Address	Bridge	-	49.77694	-124.380848	0	$18,785,840.00	$18,785,840.00	HAZUS Estimate	Not available at this time	Not available at this time	1							S22	
NS- Powell River Bridge	No Address	Bridge	-	49.882643	-124.546257	0	$18,785,840.00	$18,785,840.00	HAZUS Estimate	Not available at this time	Not available at this time	1							M16	
NS- Sliammon Ck Bridge	No Address	Bridge	-	49.898991	-124.605981	0	$18,785,840.00	$18,785,840.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Haul Road Overpass	No Address	Bridge	-	49.856904	-124.536355	0	$18,785,840.00	$18,785,840.00	HAZUS Estimate	Not available at this time	Not available at this time	1							O16	
Lang Creek Bridge	No Address	Bridge	-	49.777422	-124.370943	0	$18,785,840.00	$18,785,840.00	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	S22	Highest
Water Storage Tanks	No Address	Water Storage	IND5	49.905166	-124.601759	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Water Treatment Plant	No Address	Water Treatment Plant	IND5	49.907697	-124.596057	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Tla'amin Health Services	No Address	Medical	COM7	49.898284	-124.613229	0	$11,075,670.00	$11,075,670.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L13	
Chi Chuy Child Centre	No Address	Daycare Centre	EDU1	49.898033	-124.611881	0	$7,966,710.00	$7,966,710.00	HAZUS Estimate	Not available at this time	Not available at this time	2							L13	
Community Policing Office	No Address	Government	GOV1	49.897792	-124.607538	0	$1,836,847.99	$1,836,847.99	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Fire Hall	No Address	Fire Hall	GOV2	49.897452	-124.607556	0	$1,836,847.99	$1,836,847.99	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Ahms Ta'ow Education Centre	No Address	Education	EDU1	49.897745	-124.608151	0	$7,966,710.00	$7,966,710.00	HAZUS Estimate	Not available at this time	Not available at this time	2							L14	
Sewage Treatment Plant	No Address	Sewage Treatment Plant	IND5	49.898388	-124.605693	0	$93,040,200.00	$93,040,200.00	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Sliammon - Water Intake	Eldred River NE Trib 1	Water Intake	IND2	50.198334	-124.149167	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							Outside Study Area	
Sliammon - Water Intake	Eldred River SE Trib 1	Water Intake	IND2	50.152501	-124.1725	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							Outside Study Area	
Sliammon - Water Intake	Jim Brown Creek	Water Intake	IND2	50.225278	-124.304722	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							Outside Study Area	
Sliammon - Water Intake	Powell River Trib 1	Water Intake	IND2	50.340278	-124.23	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							Outside Study Area	
Sliammon - Water Intake	Powell River Upper	Water Intake	IND2	50.386112	-124.257222	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							Outside Study Area	
Sliammon - Water Intake	Powell River Trib 2	Water Intake	IND2	50.316945	-124.363056	0	$46,520,100.00	$46,520,100.00	HAZUS Estimate	Not available at this time	Not available at this time	1							Outside Study Area	
Powell River Saltery Bay	No Address Provided	Ferry Terminal		49.781483	-124.177167	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	S29	Highest
Saltery Bay Provincial Park Boat Launch	No Address Provided	Ramp		49.782041	-124.218569	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	S27	Highest
Hummingbird Cove Boat Launch (Update)	No Address Provided	Ramp		49.779072	-124.184005	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	S29	Highest
Saltery Bay Federal Dock	No Address Provided	Docking		49.782066	-124.176506	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	S29	Highest
Okeover Federal Dock	No Address Provided	Docking		49.99118	-124.711567	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	G10	Highest
Okeover Boat Launch	No Address Provided	Ramp		49.990905	-124.711132	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	G10	Highest
Lund Harbour	No Address Provided	Docking		49.980458	-124.761962	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	H8	Highest
Lund Boat Launch	No Address Provided	Ramp		49.980825	-124.761959	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	H8	Highest
Lund North Harbour	No Address Provided	Docking		49.98227	-124.762567	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	H8	Highest
Gibsons Beach Boat Launch	No Address Provided	Ramp		49.889531	-124.594861	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	M14	Highest
Lang Creek Boat Launch (update)	No Address Provided	Ramp		49.774343	-124.36425	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	S22	Highest
Bliss Landing Boat Launch	No Address Provided	Ramp		50.036334	-124.817419	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	D6	Highest
BC Ferries Saltery Bay Terminal	No Address Provided	Helipad		49.782361	-124.178538	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							S29	
Saltery Bay Picnic Site	No Address Provided	Helipad		49.782374	-124.2185	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1	2	X	X				S27	High
Saltery Bay Viewpoint	No Address Provided	Helipad		49.780655	-124.255414	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							S26	
Stillwater Log Sort	No Address Provided	Helipad		49.766823	-124.311669	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1	2	X	X	X	X		T24	High
Kelly Creek School Field	No Address Provided	Helipad		49.779167	-124.378133	0	$738,000	$738,000	BC Assessment	Not available at this time	Not available at this time	1							S22	
Myrtle Pt Golf Club - First Tee	No Address Provided	Helipad		49.793883	-124.462033	660	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							R19	
Westview Elementary Playing Field (update)	No Address Provided	Helipad		49.823354	-124.518304	0	$106,200	$106,200	BC Assessment	Not available at this time	Not available at this time	1							Q17	
Farmer's Market Grounds	No Address Provided	Helipad		49.834449	-124.48473	3,380	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							P18	
Powell River Municipal Airport	No Address Provided	Helipad		49.83493	-124.498901	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							P17	
Tla'amin Soccer Field	No Address Provided	Helipad		49.898531	-124.600676	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							L14	
Craig Park	No Address Provided	Helipad		49.948375	-124.683568	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							I11	
Krompocker Estates	No Address Provided	Helipad		49.965209	-124.727606	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							H9	
Northside Community Recreation Centre Field	No Address Provided	Helipad		49.978894	-124.756517	0	$281,000	$281,000	BC Assessment	Not available at this time	Not available at this time	1							H8	
Laughing Oyster Parking Lot	No Address Provided	Helipad		49.989946	-124.711926	1,022	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							G10	
Lund Hotel Helipad	No Address Provided	Helipad		49.981728	-124.762635	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	H8	Highest
Van Anda Ball Field	No Address Provided	Helipad		49.756924	-124.557429	0	$267,000	$267,000	BC Assessment	Not available at this time	Not available at this time	1							T15	
Gillies Bay Old School	No Address Provided	Helipad		49.680317	-124.477925	3,853	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1	2	X	X	X	X		Y18	High
BC Hydro Line Helipad West	No Address Provided	Helipad		49.590032	-124.358721	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	AD22	Highest
BC Hydro Line Helipad Middle	No Address Provided	Helipad		49.616477	-124.331144	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							AB23	
BC Hydro Line Helipad East	No Address Provided	Helipad		49.63007	-124.28384	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							AA25	
Anderson Bay	No Address Provided	Helipad		49.521042	-124.140302	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1	2	X	X	X	X		AH30	High
Powell River Westview	No Address Provided	Ferry Terminal		49.835197	-124.530731	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	P16	Highest
Westview Harbour	No Address Provided	Docking		49.838224	-124.529971	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	P16	Highest
Texada Island Blubber Bay	No Address Provided	Ferry Terminal		49.794828	-124.619995	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	R13	Highest
Texada Boat Club Dock	No Address Provided	Docking		49.760456	-124.563234	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	T15	Highest
Van Anda Dock	No Address Provided	Docking		49.759297	-124.553998	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	T15	Highest
Savary Island Dock	No Address	Docking		49.945936	-124.779551	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	J7	Highest
Airport	No Address	Airport		49.698032	-124.519108	0	$13,526,770	$13,526,770	HAZUS Estimate	Not available at this time	Not available at this time	1							X17	
Marine Shipping Facility	No Address	Shipping		49.70646	-124.57059	0	$2,536,190	$2,536,190	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	W15	Highest
Boat Ramp	No Address	Boat Ramp		49.490775	-124.353896	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	AI22	Highest
Marina	No Address	Marina		49.491379	-124.351598	0	$2,536,190	$2,536,190	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	AI22	Highest
Beach Garden Marina	No Address	Marina		49.800827	-124.519	0	$2,536,190	$2,536,190	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	R17	Highest
Barge Terminal	No Address	Docking		49.868069	-124.554176	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	N15	Highest
Texada Island Quarry Port	No Address	Port	-	49.700931	-124.552246	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	W15	Highest
Willingdon Dock Facility	No Address	Dock	-	49.84671	-124.532458	0	$1,690,370	$1,690,370	HAZUS Estimate	Not available at this time	Not available at this time	1	1	X	X	X	X	X	O16	Highest
Commercial Assets																				
Tla'amin Timber Products	No Address	Commercial		49.897803	-124.607231	0	$181,835	$181,835	HAZUS Estimate	Not available at this time	Not available at this time	2							L14	

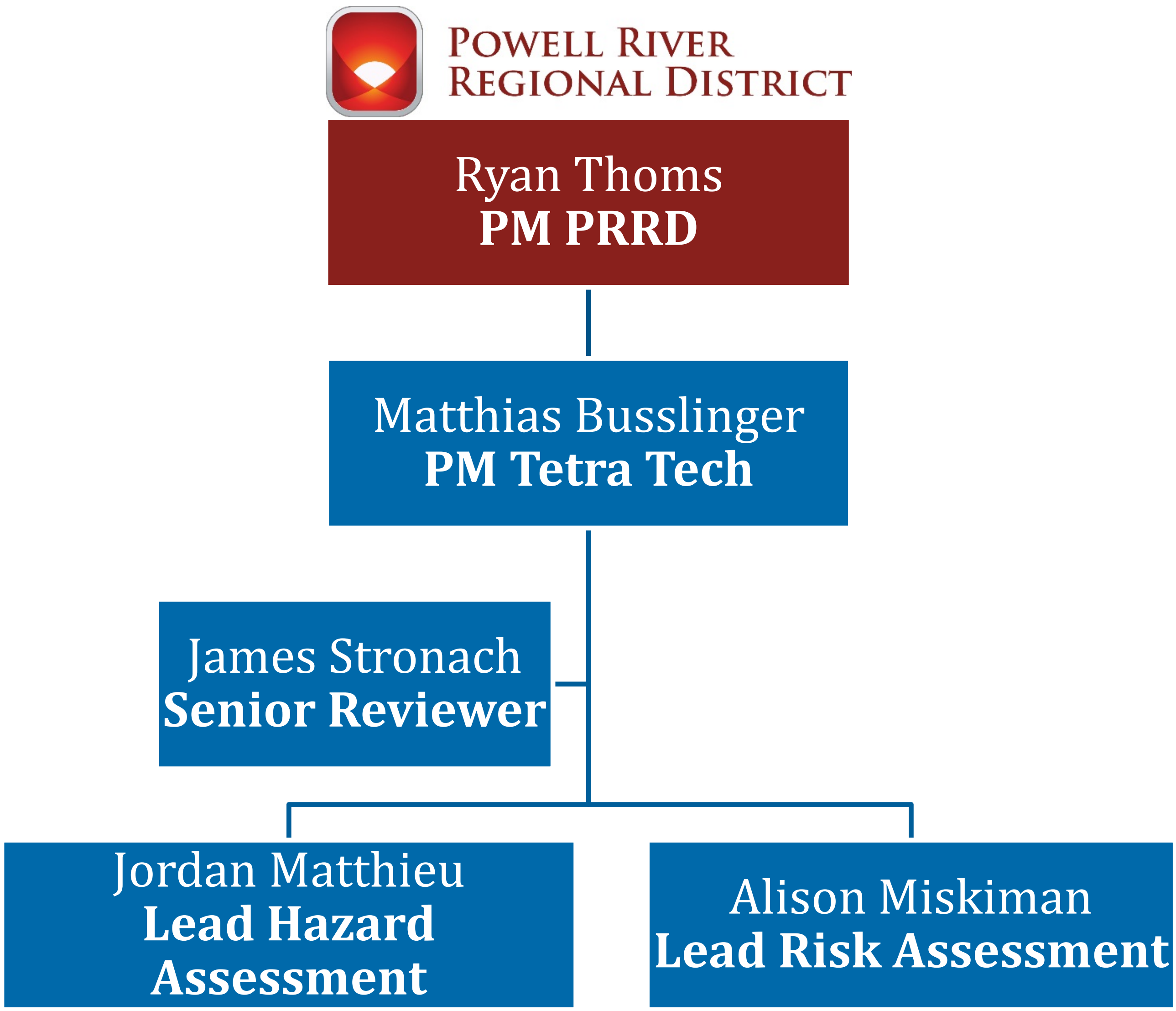
Name	Address	Type	Occupancy	Latitude	Longitude	Size	Replacement Cost	Content Value	RCV Source	Displacement Cost	Average daily cost to operate	Importance rating and rationale	Vulnerability rating and reason	Exposed to 200-year storm with High Tide from SE	Exposed to 200-year storm with High Tide and SLR from SE	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to High Tide and SLR	Grid Index ID	Priorization Rating Highest, High, Signifcant
Tla'amin Timber Products	No Address	Commercial		49.864047	-124.550852	0	$750,000	$750,000	PRRD	Not available at this time	Not available at this time	2	2	X	X	X	X		N16	High
Sliammon Fish Hatchery	No Address	Commercial	-	49.895809	-124.605448	0				Not available at this time	Not available at this time	2	2	X	X	X	X		L14	High
Okeover Arm - Shellfish Industry	No Address	Fishing	-	49.99492	-124.706451	0				Not available at this time	Not available at this time	2		X	X	X	X	X	G10	
Quarry	No Address	Mining	IND4	49.785439	-124.620044	1,132	$1,694,200	$1,694,200	BC Assessment	Not available at this time	Not available at this time	2							S13	
Industrial	No Address	Industrial	IND2	49.715259	-124.557941	0	$1,768,447	$1,768,447	HAZUS Estimate	Not available at this time	Not available at this time	2							W15	
Lasqueti Island - Shellfish Industry	No Address	Fishing	-	49.482134	-124.353237	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AJ22	
Commercial Shrimp Fishery	No Address	Fishing	-	49.857961	-124.818635	0				Not available at this time	Not available at this time	2		X	X	X	X	X	N6	
Commercial Shrimp Fishery	No Address	Fishing	-	49.837699	-124.580133	0				Not available at this time	Not available at this time	2		X	X	X	X	X	P15	
Commercial Shrimp Fishery	No Address	Fishing	-	49.761896	-124.375979	0				Not available at this time	Not available at this time	2		X	X	X	X	X	T22	
North Savary Island Commercial Crab Fishery	No Address	Fishing	-	49.953759	-124.80459	0				Not available at this time	Not available at this time	2		X	X	X	X	X	I7	
Thunder Bay Commercial Crab Fishery	No Address	Fishing	-	49.864975	-124.556642	0				Not available at this time	Not available at this time	2		X	X	X	X	X	N15	
Commercial Crab Fishery off Powell River	No Address	Fishing	-	49.771584	-124.271271	0				Not available at this time	Not available at this time	2		X	X	X	X	X	T26	
Commercial Groundfish Fishery	No Address	Fishing	-			0				Not available at this time	Not available at this time	2		X	X	X	X	X	Located in Strait of Georgia	
Commercial Prawn Fishery	No Address	Fishing	-			0				Not available at this time	Not available at this time	2		X	X	X	X	X	Located in Strait of Georgia	
Commercial Clam Fishery	No Address	Fishing	-			0				Not available at this time	Not available at this time	2		X	X	X	X	X	Located in Strait of Georgia	
Salmon Trawl Fishery	No Address	Fishing	-	49.71379	-124.573021	0				Not available at this time	Not available at this time	2		X	X	X	X	X	W15	
Salmon Trawl Fishery	No Address	Fishing	-	49.73055	-124.272745	0				Not available at this time	Not available at this time	2		X	X	X	X	X	V25	
Salmon Trawl Fishery	No Address	Fishing	-	50.047043	-124.882461	0				Not available at this time	Not available at this time	2		X	X	X	X	X	D4	
Salmon Trawl Fishery	No Address	Fishing	-	50.00834	-124.847585	0				Not available at this time	Not available at this time	2		X	X	X	X	X	F5	
Salmon Trawl Fishery	No Address	Fishing	-	50.008019	-124.947075	0				Not available at this time	Not available at this time	2		X	X	X	X	X	F2	
Salmon Trawl Fishery	No Address	Fishing	-	49.990634	-124.801415	0				Not available at this time	Not available at this time	2		X	X	X	X	X	G7	
Salmon Trawl Fishery	No Address	Fishing	-	50.002182	-124.883968	0				Not available at this time	Not available at this time	2		X	X	X	X	X	F4	
Salmon Trawl Fishery	No Address	Fishing	-	49.984042	-124.87197	0				Not available at this time	Not available at this time	2		X	X	X	X	X	G4	
Salmon Trawl Fishery	No Address	Fishing	-	49.499698	-124.123158	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AI31	
Salmon Trawl Fishery	No Address	Fishing	-	49.463674	-124.416889	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AK20	
Salmon Trawl Fishery	No Address	Fishing	-	49.423934	-124.150333	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AM30	
Salmon Fishery	No Address	Fishing	-	49.90245	-124.002417	0				Not available at this time	Not available at this time	2		X	X	X	X	X	L35	
Salmon Fishery	No Address	Fishing	-	49.519988	-124.625554	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AG13	
Salmon Fishery	No Address	Fishing	-	49.567549	-124.372163	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AE22	
Commercial Herring Roe Fishery	No Address	Fishing	-	49.850184	-124.591738	0				Not available at this time	Not available at this time	2		X	X	X	X	X	O14	
Commercial Herring Roe Fishery	No Address	Fishing	-	49.523134	-124.650177	0				Not available at this time	Not available at this time	2		X	X	X	X	X	AG12	
Cultural or Historic Assets																				
Archeological Study	Off Texada Island	Historic		49.657206	-124.469301	0				Not available at this time	Not available at this time	3	3	X	X	X	X	X	Z18	Significant
Other Assets																				
Palm Beach Regional Park	No Address	Regional Park		49.773111	-124.343179	0				Not available at this time	Not available at this time	3							S23	
Myrtle Rocks Regional Park	No Address	Regional Park		49.791718	-124.474943	0				Not available at this time	Not available at this time	3	3	X	X	X	X	X	R18	Significant
Craig Regional Park	No Address	Regional Park		49.947257	-124.683924	0				Not available at this time	Not available at this time	3							J11	
Shelter Point Regional Park	No Address	Regional Park		49.652719	-124.449928	0				Not available at this time	Not available at this time	3							Z19	
Paradise Exhibition Park	No Address	Regional Park		49.835212	-124.484083	3,380	$106,200	$106,200	BC Assessment	Not available at this time	Not available at this time	3							P18	
Boot Point Regional Park	No Address	Regional Park		49.525231	-124.359447	0				Not available at this time	Not available at this time	3							AG22	
Diver's Rock Regional Park	No Address	Regional Park		49.98875	-124.775306	0				Not available at this time	Not available at this time	3							G8	
Haywire Bay Regional Park	No Address	Regional Park		49.904722	-124.517148	0				Not available at this time	Not available at this time	3							L17	
Rossander Regional Park	No Address	Regional Park		49.785101	-124.346291	0				Not available at this time	Not available at this time	3							S23	
Okeover Park	No Address	Open Shelter		49.958223	-124.731708	0				Not available at this time	Not available at this time	3							I9	
Dinner Rock Camp	No Address	Open Shelter		49.981664	-124.76376	0				Not available at this time	Not available at this time	3							H8	
Lund Hotel	No Address	Hotel		50.052938	-124.739176	0	$195,641	$195,641	HAZUS Estimate	Not available at this time	Not available at this time	3							D9	
Grace Harbour South	No Address	Open Shelter		50.036057	-124.633257	0				Not available at this time	Not available at this time	3							E13	
Bunster	No Address	Hut		49.995897	-124.582329	0				Not available at this time	Not available at this time	3							G15	
Bunster2	No Address	Hut		50.103449	-124.305239	0				Not available at this time	Not available at this time	3							Outside Study Area	
Beartooth Alpine	No Address	Unspecified Type		50.160595	-124.298766	0				Not available at this time	Not available at this time	3							Outside Study Area	
Macmillan Alpine	No Address	Unspecified Type		50.088491	-124.723583	0				Not available at this time	Not available at this time	3							B10	
Portage	No Address	Open Shelter		49.982248	-124.762292	0				Not available at this time	Not available at this time	3							H8	
Lund	No Address	Campground		49.839529	-124.669737	0				Not available at this time	Not available at this time	3							P11	
Harwood Isle	No Address	Lodge		49.881261	-124.651276	0	$159,058	$159,058	HAZUS Estimate	Not available at this time	Not available at this time	3	3	X	X	X	X		M12	Significant
Harwood North	No Address	Open Shelter		49.895912	-124.606335	0				Not available at this time	Not available at this time	3	3	X	X	X	X		L14	Significant
Lund Marine Centre	No Address	Dock		49.981786	-124.762942	0				Not available at this time	Not available at this time	3	3	X	X	X	X	X	H8	Significant
Sarah Point	No Address	Open Shelter		50.06267	-124.841408	0				Not available at this time	Not available at this time	3							C5	
Pah Kee Ahjim (Cortes Maples)	No Address	Hut		50.049021	-124.997326	0				Not available at this time	Not available at this time	3							Outside Study Area	
Savary	No Address	Campground		49.941287	-124.852341	0				Not available at this time	Not available at this time	3	3	X	X	X	X		J5	Significant
Grace Harbour Orchard	No Address	Lodge		50.04889	-124.753827	0	$159,058	$159,058	HAZUS Estimate	Not available at this time	Not available at this time	3							D9	
Wednesday Lake	No Address	Open Shelter		50.024388	-124.756259	0				Not available at this time	Not available at this time	3							E8	
Pahk Ghee Chin (Cochrane Bay)	No Address	Shelter		50.039696	-124.773252	0				Not available at this time	Not available at this time	3	3	X	X	X	X		D8	Significant
Schmarge Bay	No Address	Unspecified Type		49.911025	-124.551535	0				Not available at this time	Not available at this time	3							L16	
Clover Creek	No Address	Unspecified Type		50.059004	-124.487676	0				Not available at this time	Not available at this time	3							C18	
Frogpond Lake	No Address	Unspecified Type		50.045275	-124.410648	0				Not available at this time	Not available at this time	3							D21	
Macmillan Creek	No Address	Unspecified Type		50.156364	-124.354938	0				Not available at this time	Not available at this time	3							Outside Study Area	
Bradburn Creek	No Address	Unspecified Type		50.212704	-124.39903	0				Not available at this time	Not available at this time	3							Outside Study Area	
Bradburn Alpine 2	No Address	Unspecified Type		50.224165	-124.455336	0				Not available at this time	Not available at this time	3							Outside Study Area	
Bradburn Alpine 1	No Address	Unspecified Type		50.230815	-124.463501	0				Not available at this time	Not available at this time	3							Outside Study Area	
Olson Diversion	No Address	Open Shelter		50.129164	-124.541134	0				Not available at this time	Not available at this time	3							Outside Study Area	
Theo Bench	No Address	Lodge		50.087252	-124.653211	0	$159,058	$159,058	HAZUS Estimate	Not available at this time	Not available at this time	3							B12	
Theo Landing	No Address	Dock		50.071492	-124.672031	0				Not available at this time	Not available at this time	3							C12	
Theo West	No Address	Campground		50.07427	-124.682322	0				Not available at this time	Not available at this time	3							B11	
Theo Entrance	No Address	Hut		50.067903	-124.68936	0				Not available at this time	Not available at this time	3							C11	
Deso 3	No Address	Hut		50.073946	-124.781423	0				Not available at this time	Not available at this time	3							B8	
Tenedos Bay	No Address	Hut		50.124448	-124.689463	0				Not available at this time	Not available at this time	3							Outside Study Area	
Prideaux Haven	No Address	Hut		50.146202	-124.672766	0				Not available at this time	Not available at this time	3							Outside Study Area	
Koo Kwahk Thys (Copeland Is)	No Address	Hut		50.011664	-124.814757	0				Not available at this time	Not available at this time	3							F6	
Squirrel Cove	No Address	Shelter		50.06545	-124.980849	0				Not available at this time	Not available at this time	3							Outside Study Area	
Mutl Natch	No Address	Open Shelter		49.951298	-125.000164	0				Not available at this time	Not available at this time	3							Outside Study Area	
Theodosia Alpine	No Address	Unspecified Type		50.233752	-124.505582	0				Not available at this time	Not available at this time	3							Outside Study Area	
Lancelot Inlet	No Address	Camp		50.039613	-124.713102	0				Not available at this time	Not available at this time	3							D10	
No Name Provided	No Address	Hut		50.004511	-124.703474	0				Not available at this time	Not available at this time	3							F10	

Name	Address	Type	Occupancy	Latitude	Longitude	Size	Replacement Cost	Content Value	RCV Source	Displacement Cost	Average daily cost to operate	Importance rating and rationale	Vulnerability rating and reason	Exposed to 200-year storm with High Tide from SE	Exposed to 200-year storm with High Tide and SLR from SE	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to 200-year storm with High Tide and SLR from NW	Exposed to High Tide and SLR	Grid Index ID	Priorization Rating Highest, High, Signifcant
Okeover Reserve	No Address	Campground		49.961383	-124.673636	0				Not available at this time	Not available at this time	3							I11	
Tenedos Bay	No Address	Hut		50.123385	-124.688597	0				Not available at this time	Not available at this time	3							Outside Study Area	
Copeland Is	No Address	Campground		50.012301	-124.813522	0				Not available at this time	Not available at this time	3	3		X				F6	Significant
Copeland Is	No Address	Hut		50.00342	-124.806906	0				Not available at this time	Not available at this time	3							F7	
Copeland Is	No Address	Hut		49.99486	-124.798508	0				Not available at this time	Not available at this time	3	3		X				G7	Significant
Prideaux Haven	No Address	Hut		50.148235	-124.680623	0				Not available at this time	Not available at this time	3							Outside Study Area	
Sarah Toilet	No Address	Restroom		50.05906	-124.837178	0				Not available at this time	Not available at this time	3	3	X	X	X	X	X	C6	Significant
Theo Entr Toilet	No Address	Restroom		50.067643	-124.68932	0				Not available at this time	Not available at this time	3							C11	
Theo West Toilet	No Address	Restroom		50.07454	-124.683026	0				Not available at this time	Not available at this time	3							B11	
Dr Toilet	No Address	Restroom		49.958702	-124.731476	0				Not available at this time	Not available at this time	3							I9	
Savary Island Toilet	No Address	Restroom		49.941226	-124.852634	0				Not available at this time	Not available at this time	3							J5	
Indian Springs	No Address	Spring		49.941028	-124.85205	0				Not available at this time	Not available at this time	3	3				X		J5	Significant
Lancelot Toilet	No Address	Restroom		50.039598	-124.713296	0				Not available at this time	Not available at this time	3							D10	
Okeover Toilet	No Address	Restroom		49.991645	-124.714842	0				Not available at this time	Not available at this time	3							G10	
Okeover Well	No Address	Well		49.991651	-124.714434	0				Not available at this time	Not available at this time	3							G10	
Desolation 4	No Address	Hut		50.073213	-124.70328	0				Not available at this time	Not available at this time	3							C10	
Soccer Field	No Address	Recreation		49.898563	-124.600757	0	$329,092	$329,092	HAZUS Estimate	Not available at this time	Not available at this time	3							L14	
Band Administration	No Address	Unspecified Type		49.897984	-124.607584	0				Not available at this time	Not available at this time	3							L14	
Salish Centre	No Address	Unspecified Type		49.899105	-124.613167	0				Not available at this time	Not available at this time	3							L13	
Healing Lodge	No Address	Lodge		49.898637	-124.611782	0	$159,058	$159,058	HAZUS Estimate	Not available at this time	Not available at this time	3							L13	
Cultural Lodge	No Address	Lodge		49.89844	-124.61117	0	$159,058	$159,058	HAZUS Estimate	Not available at this time	Not available at this time	3							L13	
Church	No Address	Religious	REL1	49.896616	-124.608292	0	$632,862	$632,862	HAZUS Estimate	Not available at this time	Not available at this time	2	2	X	X	X	X		L14	High
Waterfront Park	No Address	Park		49.896361	-124.608155	0				Not available at this time	Not available at this time	3	3	X	X	X	X		L14	Significant
Southview Road	No Address	Beach Access	-	49.915925	-124.644821	0				Not available at this time	Not available at this time	3	2	X	X	X	X		K12	High
Emmonds Road	No Address	Beach Access	-	49.936373	-124.691909	0				Not available at this time	Not available at this time	2	2	X	X	X	X		J11	High
Finn Bay Road	No Address	Beach Access	-	49.987786	-124.769211	0				Not available at this time	Not available at this time	2	2	X	X	X	X		G8	High
Long Acre Road	No Address	Beach Access	-	49.978186	-124.761949	0	$25,000	$25,000	PRRD	Not available at this time	Not available at this time	2	2	X	X	X	X		H8	High
Sturt Beach	No Address	Beach Access	-	49.918924	-124.651649	0				Not available at this time	Not available at this time	2	2	X	X	X	X		K12	High
Pebble Beach Road	No Address	Beach Access	-	49.795775	-124.481734	0				Not available at this time	Not available at this time	2	2	X	X	X	X		R18	High
Myrtle Rocks	No Address	Beach Access	-	49.79489	-124.472101	0				Not available at this time	Not available at this time	2	2	X	X	X	X		R18	High
Armour Road	No Address	Beach Access	-	49.776579	-124.447025	0				Not available at this time	Not available at this time	2	2	X	X	X	X		S19	High
Patrick Road	No Address	Beach Access	-	49.774076	-124.378673	0				Not available at this time	Not available at this time	2	2	X	X	X	X		S22	High
Mahood Road	No Address	Beach Access	-	49.771647	-124.367254	0				Not available at this time	Not available at this time	2	2	X	X	X	X		T22	High
Phillips Road	No Address	Beach Access	-	49.775926	-124.350412	0				Not available at this time	Not available at this time	2	2	X	X		X		S23	High
Osprey Road	No Address	Beach Access	-	49.762797	-124.297496	0	$25,000	$25,000	PRRD	Not available at this time	Not available at this time	2	2	X	X	X	X		T25	High
Hollingsworth Road	No Address	Beach Access	-	49.76164	-124.301789	0				Not available at this time	Not available at this time	2	2	X	X				T24	High
Thunder Bay Road	No Address	Beach Access	-	49.774275	-124.279756	0				Not available at this time	Not available at this time	2	2	X	X	X	X		S25	High
Cove Road (look out)	No Address	Beach Access	-	49.770395	-124.369822	0				Not available at this time	Not available at this time	2	2	X	X				T22	High
Broom Road	No Address	Beach Access	-	49.769621	-124.390128	0	$25,000	$25,000	PRRD	Not available at this time	Not available at this time	2	2	X	X				T21	High
Canoe Bay	No Address	Beach Access	-	49.755255	-124.284946	0				Not available at this time	Not available at this time	2	2	X	X	X	X	X	T25	High
Julian Road	No Address	Beach Access	-	49.935245	-124.853002	0				Not available at this time	Not available at this time	2							J5	
Patton Road	No Address	Beach Access	-	49.67909	-124.483305	0				Not available at this time	Not available at this time	2	2	X	X	X	X	X	Y18	High
Oak Street	No Address	Beach Access	-	49.678366	-124.483864	0				Not available at this time	Not available at this time	2	2	X	X	X	X		Y18	High
Ash Street	No Address	Beach Access	-	49.676422	-124.484012	0				Not available at this time	Not available at this time	2	2	X	X	X	X		Y18	High
Balsam Street	No Address	Beach Access	-	49.674655	-124.485361	0				Not available at this time	Not available at this time	2	2	X	X	X	X		Y18	High

TETRA TECH

APPENDIX F
PROJECT TEAM

Tetra Tech assembled a technical team of specialists with experience in coastal hazard assessment and risk assessment. Tetra Tech's project team reported to Mr. Ryan Thoms, Manager of Emergency Services, at the Powell River Regional District and was organized as shown in the organigram below.



Experience and project responsibilities of the team members are summarized below:

Ryan Thoms **Project Manager Powell River Regional District**

Mr. Thoms is the Manager of Emergency Services at PRRD. His responsibilities for this project included; managing the PRRD Coastal Risk Assessment project on behalf of the Regional District and reporting to the Board, fulfilling the Regional District's responsibilities under the NDMP Contribution Agreement, liaison with other stakeholders (Tla'amin Nation, City of Powell River, Islands Trust), and managing the consultant (Tetra Tech). In addition Mr. Thoms provided context for the study as well as information of past historic events.

Matthias Busslinger, M.A.Sc., P.Eng. **Project Manager**

Mr. Busslinger is a Senior Geotechnical Engineer at Tetra Tech in Vancouver, BC with 11 years of experience. He specializes in natural hazard mitigation and has a thorough understanding of hazard processes and risk. Quantifying spatial impacts of landslides and comparing debris flow behaviour in coastal and interior British Columbia was the focus of his Master thesis. His consulting experience includes various projects with numerical modelling of two- and three-dimensional landslide runout processes. His project management experience includes leading interdisciplinary teams of scientists and engineers with budgets up to $1M. Mr. Busslinger was the project manager for the previous two studies on landslide and fluvial hazards within the Electoral areas D and B & C within the PRRD.

For this project, Mr. Busslinger is the project manager for the Tetra Tech team. He liaises with the PRRD project manager on a regular basis. He leads the project team and is responsible for planning and coordinating the resource requirements, and delivering the project.

James A. Stronach, Ph.D., P.Eng. **Senior Reviewer**

Dr. Stronach is a Senior Physical Oceanographer with Tetra Tech in Vancouver, BC with over 40 years of experience. His principal technical expertise includes the measurement and modelling of currents and water property distributions in coastal waters. A large part of Dr. Stronach's professional career has been concerned with the development of numerical modelling techniques. Recent oceanographic projects include the development of a wave current prediction system for the mouth of the Fraser River and development of oil spill models for the north coast of British Columbia and the Fraser River. Dr. Stronach and co-workers have developed sophisticated numerical models of geomorphological transformation for sand bed rivers and wave-influenced beaches, built on H3D.

For this project, Dr. Stronach is the Tetra Tech internal Senior Reviewer and provides technical guidance. He is responsible for reviewing deliverables and recommendations before they are issued.

Jordan Matthieu, M.Sc., P.Eng. **Hazard Assessment Lead**

Mr. Jordan Matthieu is a Coastal Engineer with Tetra Tech in the Water and Marine Group. Mr. Matthieu has extensive research and practical experience with hydrodynamics, scour, morphology and sediment transport. He has 5+ years of experience applying numerical and physical modelling techniques to problems of sediment dispersion, scour and erosion, coastal and offshore morphology, wave impacts and forces, and subsea pipeline and cable stability. He has been active in the North Sea, Australia and North America and brings particular expertise in sediment transport modelling.

For this project, Mr. Jordan is the Hazard Assessment Lead. He is responsible for hazard characterization and modelling of hazard processes.

Alison Miskiman, GISP, CFM **Risk Assessment Lead**

Ms. Miskiman is a Hazard Mitigation Project Manager and senior Risk Assessor for Tetra Tech's Emergency Management/Community Resilience division with 15 years of experience. She is a Certified Floodplain Manager (CFM) and a Certified Geographic Information Systems (GIS) Professional (GISP). She manages state and local hazard mitigation plans and is a recognized expert at designing and customizing quantifiable natural hazard risk assessments. Ms. Miskiman utilizes GIS and risk models, including FEMA's Hazus, to estimate community-wide and asset-specific potential losses for flooding, coastal inundation, earthquakes, hurricane winds, tornadoes while integrating climate change.

For this project, Ms. Miskiman is the Risk Assessment Lead and provides technical guidance. She is responsible for GIS analysis, consequence and risk assessment.