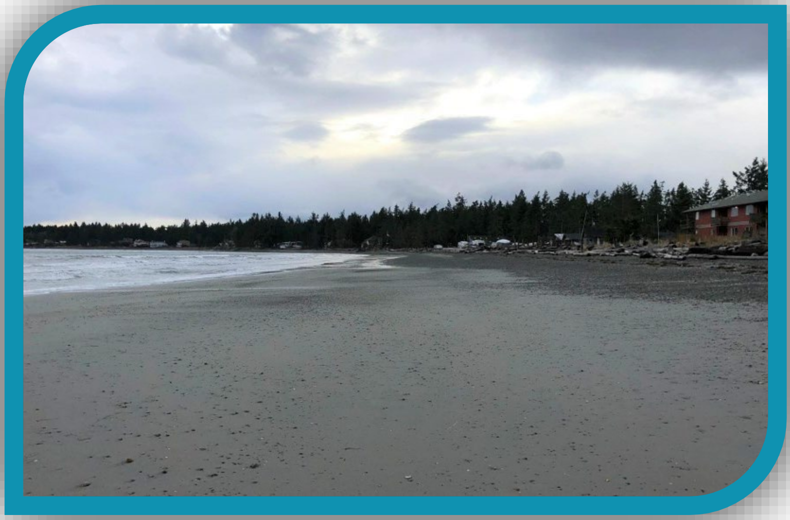
Coastal Flood Adaptation Strategy Phase 2: Flood Risk and Options Assessments

Final Report



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Cover Photo: Saratoga Beach, 2018.

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Revision History

Revision No.	Date	Author of Record	Description	Remarks
1	22 Nov 2021	Tamsin Lyle, P.Eng.	Initial draft report	Preliminary content with draft chapters 1 to 3.
2	20 Dec 2021	Tamsin Lyle, P.Eng.	Draft report	Full draft report with content for all chapters and appendices.
3	31 Jan 2022	Tamsin Lyle, P.Eng.	Final report	Incorporated comments from CVRD.

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Ebbwater would like to acknowledge that this report was written at the Ebbwater Consulting Inc. office (and home offices), which are located primarily on the unceded and traditional Territory of the Coast Salish Peoples.

The analyses were completed, and the report written by a multi-disciplinary team as follows:

- Erica Crawford, MA (SHIFT Collaborative), led the development, coordination, and delivery of the engagement sessions, as well as managing feedback and writing results.
- Tamsin Lyle, M.Eng., MRM, P.Eng. (Principal of Ebbwater) was the project technical lead, which included directing and presenting the risk and options assessments throughout the project's progress. Tamsin also provided general project direction and reports review.
- Robert Larson, M.S., P.Ag., managed the project including supporting the development of the risk assessment, pre-meeting materials, and report-writing.
- Yinlue Wang, M.Sc., conducted technical analyses and mapping to complete the risk assessment and support other materials.
- Nikoletta Stamatatou, M.S., M.Eng., EIT, provided specialist support to the risk assessment and mapping.

Executive Summary

The Comox Valley Regional District (CVRD) coastline is cherished by residents for its natural beauty. However, the shoreline environments that are responsible for thriving tourism and other economic, social, and cultural benefits are also affected by coastal storms. The flood damages that have been experienced in the past, will increase with time as storms become more intense and the sea levels rise. To respond to these events, the CVRD has recognized the need to adapt to the increasing potential for coastal flood hazard and has initiated a multi-phase Coastal Flood Adaptation Strategy (CFAS).

With support from the Community Emergency Preparedness Fund (CEPF), this Phase 2 project built upon Phase 1 work in which coastal and riverine flood hazards were modelled and mapped. The goal of the Phase 2 project was **to develop a decision process to support the selection, prioritization, and implementation of coastal flood adaptation options within the CVRD**. The project required targeted engagement activities and a risk assessment, for which the CVRD retained Ebbwater Consulting Inc. (Ebbwater). Ebbwater partnered with SHIFT Collaborative (Shift) to lead the design and delivery of engagement sessions. An important by-product of this project is the capacity-building at CVRD and with its partners, to better enable understanding of the complex nature of flood mitigation and climate adaptation.

Project Approach

The project consisted of three components. The engagement activities and risk assessment were iterative and supported the project's decision process and tools. The decision process was designed to address the project's three objectives (identify values, develop options, and assess options) (Figure 1). Each project component is summarized in the next sections.

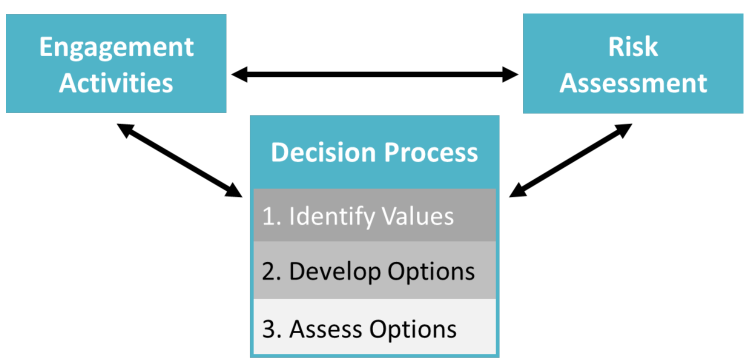

Figure 1: Interaction of the three project components.

Engagement Activities

A participatory approach is part of building a basis for future decisions that are more likely to be supported by stakeholders, partner organizations, and the public, which will be key to the effectiveness of the CFAS overall. We engaged with a wide variety of stakeholders, decision-makers, and partners to better understand local values related to coastal flood hazard. These values were then used to inform the types of options and the criteria considered to understand trade-offs between them. Engagement occurred in three rounds.

The engagement activities were intended to develop and test information and materials. The completion of the engagement component in Phase 2 will support a range of future activities to promote awareness and risk-based decision-making by individuals, agencies, and organizations in the region.

Risk Assessment

Risk in the context of this project

Risk describes the intersection between natural hazards (i.e., phenomena that can cause harm), exposure (i.e., elements such as people, infrastructure, and environment that are in the way), and vulnerability (i.e., the susceptibility of those elements impacted). A risk assessment is a process to analyze information that provides a rigorous, logical, and defensible basis on which to make informed investment and planning decisions.

This component of the project built on the flood hazard modelling outputs from the CFAS Phase 1. From those outputs, we defined three coastal flood hazard extents, which we associated with three planning range timelines. The "short-term" planning scenario is a coastal storm flood that is considered likely to occur in any given year, combined with 0 m of sea level rise (SLR). It is a relatively small flood. The "mid-term" scenario is a flood that is considered unlikely to occur in any given year, combined with 0.5 m of SLR. It is a relatively large flood. The "long- term" scenario is also an unlikely flood, but it is relatively larger as it considers 1.0 m of SLR.

To assess a broad range of elements exposed to the hazards, we considered a holistic set of indicators: affected people, mortality, economy, environment, culture, and critical infrastructure. While the risk assessment was primarily driven by quantitative data, it also considered qualitative information, gathered through the engagement activities, about what else could be impacted by coastal flood in affected areas.

Decision Process

A key outcome for this project was a process and tool to enable good decisions for coastal flood adaptation. This component required fleshing out possible adaptation options, informed by stakeholder and partner values and insight, and then examining the benefits, costs, and relative trade-offs each option brings to the community.

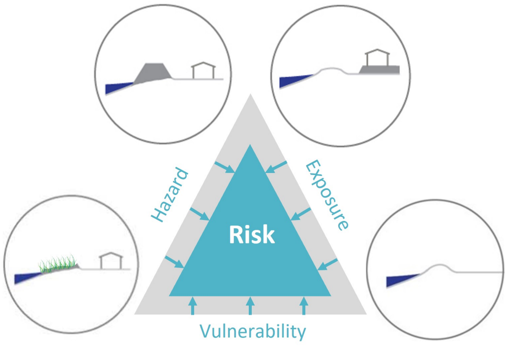

Figure 2: Variety of coastal flood adaptation strategies considered to reduce risk and increase resilience.

The process included an iteration to consider and evaluate, at a high-level, a series of coastal flood adaptation strategies. Simplified visuals of what some of the strategies look like are provided in Figure 2. Each strategy aims to reduce risk (by reducing hazard, exposure, and vulnerability, also shown in Figure 2). The five strategies considered were "Protect" (both structural and green versions), "Accommodate", "Retreat", "Avoid", and "Resilience-Building" (abbreviated as PARAR).

We developed an evaluation framework to help the project team consider a wide set of criteria and performance measures in relation to options. The framework was separated into the evaluation of options based on their effect at reducing risk during a flood, and the effect of the option itself (i.e., how the option performs the rest of the time). The *effects of the option during a flood* considered questions such as "how many fewer people and properties will stay dry?", and "how will emergency response be affected?". For the *effects of the option itself*, criteria included consideration of both positive and negative externalities, asking questions such as "what effects does the option have on ecological health?", "does the option damage or improve recreational opportunities?", and "what are the costs and regulatory requirements?".

Spatial Scales

The project area covered the CVRD electoral areas. The project looked at the project area as a whole, as well as four focus areas: Saratoga Beach, Comox Road, Goose Spit, and Union Bay. The latter were defined to provide a more practical, place-based, understanding of how adaptation options could be developed and implemented. The project area and focus areas are shown in Figure 3.

In the later engagement sessions, the Saratoga Beach area was used as an illustrative example to test the decision process. For this focus area, we developed four adaptation pathways (narratives based on a combination of adaptation strategies) for participants to consider and discuss. Note that the choice of Saratoga Beach as a focus area did not necessarily indicate its level of priority for planning purposes.

Limitations

As with any study of this type, many uncertainties result from an effort to represent complex realities. Simplifications of the hazard layers produced in Phase 1 were necessary to complete the risk assessment. There were also data gaps associated with the consequence indicator data. **The risk maps are not intended to inform property-level design decisions, but rather to be used as a high-level screening and prioritization tool**.

The decision process that was adopted was designed to be used for scanning purposes, and to be easily repeatable by the CVRD in future. The process allows for preferred options (or low-hanging fruit) to be more easily identified. It also allows for least preferred options to be eliminated. However, we caution that **the decision process that was developed does not provide 'an answer'.** As demonstrated through its development, the provision of a single solution does not in itself make a lot of sense. Rather, in the local context, the process can be used to inform subsequent deliberation over different options, to ultimately identify combinations that could best address the range of impacts, values, and preferences present in that location. This should be applied to defined areas and with broad public, stakeholder, and partner involvement, to develop strategies for the region.

Consequence and Risk Results

The following sections summarize the quantitative consequences for each indicator. Results are provided for the project area as a whole. The report contains additional results, including qualitative consequences, for the Saratoga Beach focus area. In reading the information it is important to understand that the broad results are based on an aggregation of data. Any one single coastal flood hazard event would not likely affect the entire project area. In this sense, the consequence results may be conservatively high.

Affected People

The estimated number of affected people within the project area ranges from 1,253 to 2,115 (up to approximately 10% of the project area population). Large proportions of the total number of people potentially affected are exposed to the short- and mid-term scenarios (59% and 85%, respectively).

Figure 3 shows consequences for the affected people indicator. The map shows results for the project area, and for the focus areas (including Saratoga Beach). The map shows "hot spots" for consequences, where areas of larger concentration appear as darker shades of red. For example, the Saratoga Beach and Little River areas stand out in this map because these areas have the largest number of people within a hazard area. Risk maps for the other consequence indicator data, which show different patterns, are provided within the report materials.

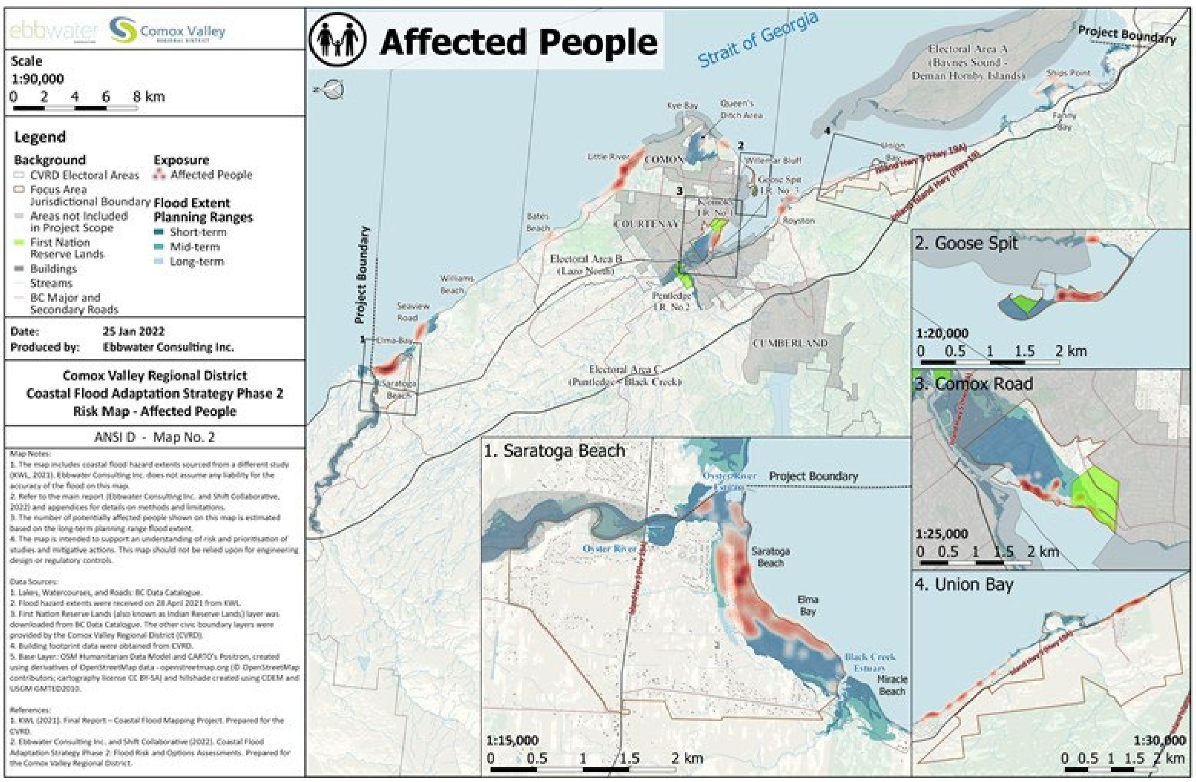

Figure 3: Map showing affected people indicator data in the CVRD project area for the three planning range scenarios. Large-size printable PDF maps are provided with the report.

Mortality Indicator

Based on the method used, the consequences for people related to missing or mortality cases is negligible (<0.3 for the long-term scenario).

Economy Indicator

The number of parcels exposed to coastal flood in the project area ranges from approximately 1400 to 1800. Based on assessed building values, the total amount exposed ranges from approximately $450M to $540M for the short- and long-term scenarios, respectively (all figures in Canadian dollars). Most of the affected building value (between 83% and 94%) is exposed to the short- and mid-term scenarios.

Environment Indicator

Based on the data analyzed, there are 23 potential contamination source locations that are exposed to the long-term scenario. However, this number is highly underestimated, as other important local sources such as septic systems were not included in the analysis. In terms of sensitive ecosystems, the total land exposed ranges from approximately 397 ha to 558 ha.

Culture Indicator

The total number of exposed cultural sites ranges from 54 to 64 for the project area. These are primarily Indigenous archaeological sites, but also include other archaeology and heritage sites, as well as community buildings. The length of recreational trails exposed is approximately 1 km.

Critical Infrastructure Indicator

One electrical power system and two transmission structures are exposed to the short-term scenario. Two water distribution systems are exposed to the mid- and long-term scenarios. Up to 19 telecommunication facilities are exposed to the long-term scenario. The length of the roads exposed to the flood scenarios ranges from approximately 15 km to 26 km (including Highway 19A).

Regional Risk Matrices

Risk scores for each consequence indicator were calculated by first assigning likelihood scores to the three flood scenarios, and consequence scores to the relevant quantitative data for each indicator. Risk scoring results for the project area are shown in the six matrices in Figure 4. The results are distinguished by way of flood hazard icons of different sizes; the larger icon represents the mid- and long-term scenarios (larger magnitude flood events) and the smaller icon represents the short-term scenario (small flood).

Note that, based on the scoring classifications used for all indicators, the resultant risk scores for the mid- and long-term scenarios were equivalent. This means that the differences between these scenarios is small or negligible. This result is significant, as it suggests that the changes in SLR between the mid- and long-term (i.e., 0.5 m to 1 m) are likely to have a relatively small effect on flood risk.

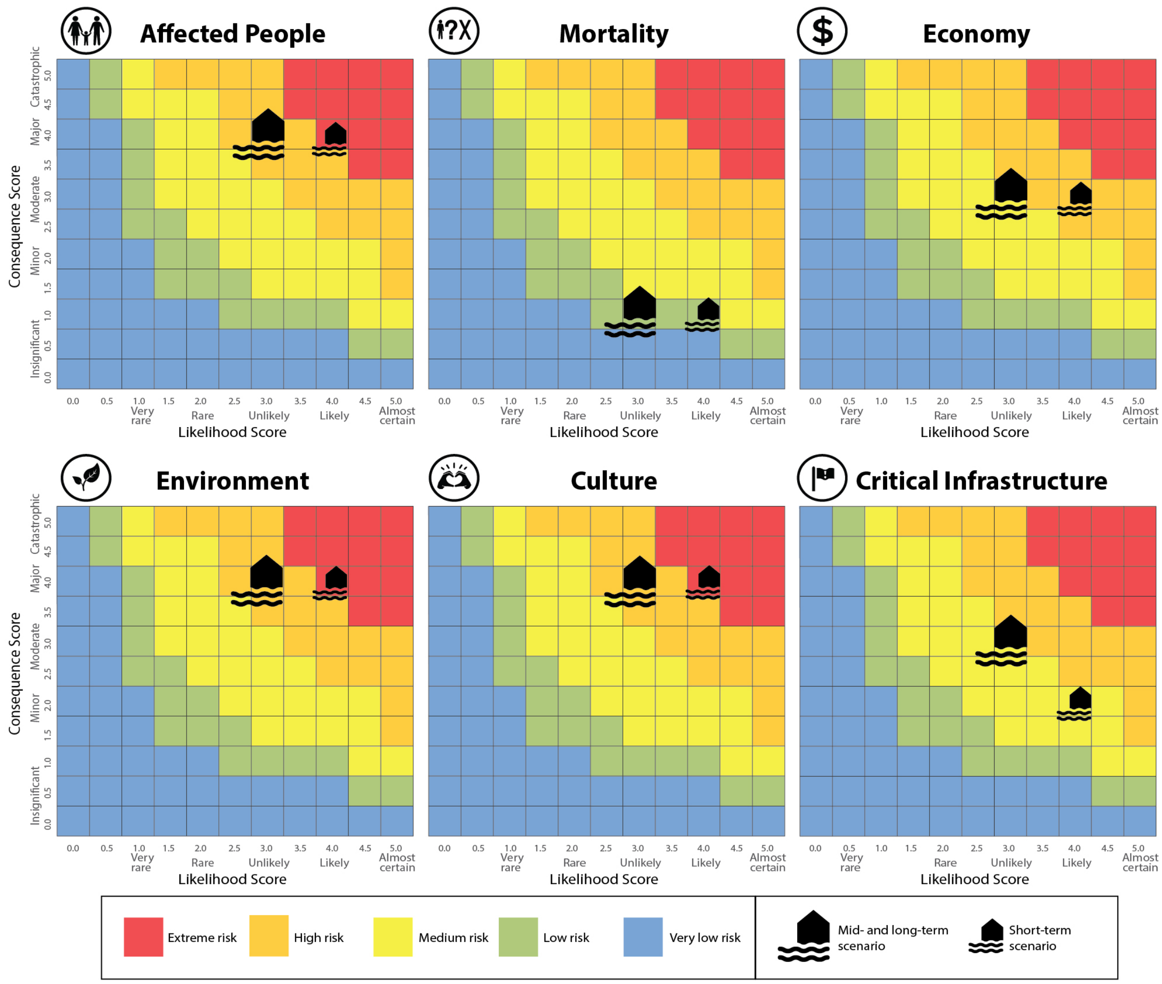

Figure 4: Risk matrices for the project area.

The following are two key findings derived from the matrices for the project area:

- The risk from the short-term scenario (i.e., likely flood event with no SLR – small flood) is generally higher than the risk for the mid- and long-term scenarios (i.e., unlikely flood event with SLR – larger floods). **This suggests that adapting to the short-term scenario should be prioritized.**
- Under all planning scenarios, the risk for the affected people, environment, and culture indicators is generally higher than the risk for the mortality, economy, and critical infrastructure indicators.

The results provide a basis for prioritizing local scale coastal flood adaptation activities. The type of risk results presented above could also be developed for other focus areas to inform future phases of this work.

Moving Through the Decision Process

Drawing from the risk assessment results and the engagement activities, the project team produced information and tools that can be used to inform decision-making on coastal flood adaptation in the CVRD. A values-based decision tool was developed that can be used to make decision-making more transparent. The following sections summarize what we heard, developed—and ultimately learned—from the process.

What We Heard

When we asked participants what they valued in the region, nature was commonly mentioned (along with recreation, aesthetics, fresh air, and peacefulness). Interestingly, and as alluded-to in the environment indicator consequences in the previous section, nature was also understood as a key part of what would make a resilient region. Answers to the latter question are shown in Figure 5. Through a number of related discussions, key themes emerged as follows to define characteristics of a resilient region:

Figure 5: Participant responses: What makes for a resilient region?

- **Collaboration and relationships** (trust, partnerships, working together, whole community, formal and informal networks, common goals).
- **Flexibility and creativity** (responsive, bouncing back, open to change, movement).
- **Diversity** (types of knowledge, cultural diversity, ecological / landform diversity, accessibility).
- **Community involvement** (local governments reaching out, many perspectives, positions, opinions).
- **Nature and stewardship** (conservation, natural assets, shoreline, vegetation).
- **Capacity and resources** (infrastructure, expertise, people, self-sufficiency).
- **Being informed and prepared** (education, communication, sharing information, build understanding, emergency management, proactive).

What We Developed

A key outcome for this project was a process and tools to enable good decisions for coastal flood adaptation. Building on what we heard, we assembled a range of criteria that were based primarily on values. The criteria were like the consequence indicators presented earlier; however, they considered more factors to encompass broader considerations.

Two versions of the criteria were developed. The simplified criteria (shown in Table 1) are primarily for use in engaging with stakeholders and the public. They could also be used as a screening tool to conduct similar analyses presented in the report for other priority areas. The simplified criteria were derived from a set of more detailed criteria, which would be used for detailed planning and 'final' decisions.

The simplified criteria were used to evaluate a baseline "do nothing" approach, and four adaptation pathways. Each pathway was comprised of a different combination of the adaptation strategies (i.e., PARAR) that were described earlier. The evaluation results, which describe how the pathway performs relative to the status quo, are shown in Table 1. The results were meant to be indicative only, to highlight relative differences and trade-offs between pathways.

Table 1: High-level evaluation of the adaptation pathways completed by the projected team, with the performance scales.

Pathway Number and Strategies Emphasized	Do Nothing	1: Protect (Nature-Based and Structural)	2: Avoid, Retreat, Resilience	3: Accom-modate, Resilience	4: Resilience, Retreat
Effect of the Pathway During a Flood					
Human Health and Safety	Worse	Slightly better	Better	Slightly better	Far better
Residential Properties	Worse	Slightly better	Far better	Slightly better	Far better
Culture	Worse	Slightly better	Slightly worse	Far better	Far better
Infrastructure	Slightly worse	Far better	Far better	Far better	Better
Economy	$$	Neutral	-$	Neutral	-$$
Effect of the Pathway Itself					
Community involvement	Much worse	Neutral	Far better	Far better	Far better
Environment	Worse	Slightly worse	Far better	Slightly better	Far better
Recreation	Worse	Slightly worse	Slightly better	Slightly better	Far better
Implementation cost	Neutral	$$$	$$	$$	Neutral
Maintenance cost	No Change	$$	-$$$	Neutral	-$$$
Implementation	No Change	Challenging	Slightly challenging	Slightly challenging	Very challenging

Performance Scale (relative to status quo)						
Much Worse, $$$, Very Challenging	Worse / $$ / Challenging	Slightly Worse / $ / Slightly Challenging	Neutral / No Change	Slightly Better / -$	Better / -$$	Far Better / -$$$

The evaluation comparison highlights relative benefits and drawbacks between the pathways. For example, Pathway 1 (which primarily relies on "protect" adaptation strategies) entails a very high implementation cost, but during a flood its effects are largely better than the status quo. Pathway 4 (which relies primarily on "resilience-building" strategies) largely performs better or far better on most criteria, compared to the status quo; however, its implementation is very challenging due to deep systemic and cultural changes required for its implementation.

The decision tool is valuable to help communities more clearly consider some of the key trade-offs associated with choosing one option over another. For example, participants asked "who benefits and who pays?" People who are not affected by flood generally do not want to pay additional taxes to solve the problem. At the same time, lower-income households cannot necessarily afford to take individual actions at the property level. The tool does not resolve these questions but helps to make them visible so that they can be considered as part of the decision being made.

What We Learned

With consideration of the various tensions, constraints, strengths, and challenges identified throughout engagement Round 1 and Round 2, participants developed ideas for how to approach flood risk and resilience in an area like Saratoga Beach. Again, the objective of this exercise was not to decide on options for this area, but rather to use a specific example to "ground-truth" the values-based criteria, the overall process, and the different adaptation strategies within a particular set of conditions, providing insight on how to approach issues. The suggestions that emerged among participant groups included:

- **Take a coordinated approach that combines elements of all strategies.** Groups agreed that the best way to address coastal flood risk is to combine strategy elements in nuanced and creative ways.
- **Build social resilience by investing in education, communication, and dialogue.** A key message across groups was the need to build understanding and capacity among those affected and those responsible for implementation (which includes a wide range of actors including property owners, residents, business owners, local government staff and elected officials, government agencies, service organizations, etc.).
- **Start with small steps now, build into bigger ones over time.** Change is hard, especially when the way forward includes a lot of uncertainty and complexity. To ease this process, participants suggested laying out options in an understandable sequence that builds from smaller more obvious steps into making the bigger decisions.
- **Community-building strengthens all approaches.** When considering the diversity of perspectives and complexity of the issues, it made sense that community-building would enable better decisions that could serve a greater diversity of needs.
- **Prioritize nature-based solutions.** These solutions create multiple benefits and may help to buffer and respond to a range of possible futures. Building on existing knowledge and innovation in the region already, Green Shores™ approaches, and stewardship of upper watersheds could contribute to enhanced resilience for both ecosystems and human settlements.
- **Prepare for tough decisions and trade-offs.** There is a large range of perspectives and preferences, as well as combinations of costs and benefits, in decision making. This requires leadership, including from the community itself. The limitation of resources and funding forces us to choose between possible options. With any pathway that is chosen, aiming for "resilient enough" (as opposed to perfectly resilient) can help to decide where to draw the line.
- **Include an equity lens.** Equity concerns were highlighted in our sessions and warrants consistent consideration throughout planning, decision-making, and implementation. For example, we should ensure that information and resources to support individual floodproofing actions are

accessible for those with lower incomes, or for service organizations that are in the flood hazard area, and not only to wealthier residents.

- **Keep the short- and the long-term in view.** Participants observed that there is a careful balance to ensure enough is done in the short-term, while not losing sight of a range of possible futures. An easy example is to use available planning and regulatory tools to take practical steps that are already possible – like embedding a climate lens into the Regional Growth Strategy.
- **Keep options open, stay flexible.** Since we don't know what the future holds, it is wise to proceed in ways that continue to keep a range of options available to us, rather than painting ourselves into a corner. For example, while engineered "hard" infrastructure can be appropriate in some instances, it can lock us into a path that can create greater risk over time (e.g., as more development occurs behind a dike) and where resources cannot be redirected if we need to change course.
- **Seek synergies by including actions at both the individual and collective level.** A key tension that emerged was the pull between individual and collective benefit and responsibility. It is important that this not be seen as solely the purvey of government, but that responsibility and agency is extended more broadly.

At the conclusion of the final engagement session, we circled back to acknowledge some of the current patterns at play in the region, both strengths and challenges. From here, participants articulated some of the desired patterns they would want to create as they build regional coastal flood resilience, and ideas for principles and practices that could help to get them there.

Participants were asked, "what is one thing that stands out to you from your experience [from the engagement session]?" The intention was to find out what felt important to participants after going through this process together. The answers revealed key themes that included:

- **Thinking Systemically** (watershed-scale, interconnections, time scales, redundancy, staying adaptive).
- **Values of Community, Nature, and Equity** (key drivers / values).
- **Complexity** (many details and variables make it challenging).
- **Importance of Collective Action** (foundational, and challenging; local leadership and participation needed).
- **Commonalities** (we have more in common than expected).

These ideas could inform development of a framework for collaborative action and governance of flood resilience in the region.

Recommendations

The Sendai Framework for Disaster Risk Reduction (Sendai Framework) is the United Nations "global blueprint" that provides governments with guidance on how to mitigate hazards such as from coastal floods. A major tenet of the framework is a *risk-based* approach, where hazard (including hazard likelihood), exposure, and vulnerability all play a role.

Expanding on the Sendai Framework, this study integrated an appreciative lens and focused more directly on resilience-building, in addition to risk reduction. For the purposes of grouping our recommendations, we have adapted the Sendai Framework Priorities slightly, to include these qualities. Key themes are bulleted under each Priority below (detailed recommendations are presented in tables in the report).

Priority 1: Understand Disaster Risk, Complexity, and Resilience

- **Support Interested Parties to Apply Flood Risk Information to Individual and Collective Decisions:** There is a good deal of technical information now available to support understanding of coastal flood risk in the region, and some of this has now been translated in ways that supported the engagement process in Phase 2. This work needs to continue, to develop materials that can support a broader range of education and engagement to a wider range of audiences. Building on this engagement, diverse groups should be involved in planning and decision-making at a local level. Participants in Phase 2 emphasized the importance of this type of process, to create space for the difficult conversations that are needed. Introducing the concept of risk tolerance will be critical.
- **Integrate the Public into the Process:** The CVRD has been leading on important formative steps to ensure that broader public engagement is well informed and designed. These include the development of flood hazard maps, a risk assessment, and decision-support materials and tools, all customized for the region. Next steps in the process should include a range of opportunities to share and engage with the public, building awareness and involvement in the development of appropriate adaptation strategies.
- **Promote the Collection of More Comprehensive and Relevant Data:** The CVRD could coordinate data collection with partners in the region to address data gaps related to exposure and vulnerability. Hydroclimate monitoring and post-flood event measurements should be expanded to obtain more accurate and representative data across the region. Exposure data sets should aim to improve understanding on contamination sources, transport, and impacts to receptors such as fish and human health; seasonal population distribution, including tourism; and indirect and intangible impacts such as lack of access to services and psychosocial stress.

Priority 2: Strengthen Disaster Risk Governance

- **Develop a Collaborative Framework to Implement Flood Resilience:** To take the next steps towards developing and implementing place-based and region-wide strategies to build coastal flood resilience will require having necessary partners and stakeholders involved and committed to the process. Every one of the focus areas identified in Phase 2 includes multiple jurisdictions, decision-makers, actors, and affected parties. Establishing a collaborative framework for this work will enable the right people to be informed and involved as work progresses. It would ensure that commitment is made at organizational levels so that the work will continue if and when individuals leave those positions. And as a result, it would assist in building the shared understanding, investment, trust, experience, and relationships necessary to make harder decisions over time.
- **Continue to Develop and Apply Decision-Support Tools and Processes:** As the CFAS project transitions into strategy and implementation phases, specific attention will be needed to continue developing and implementing materials, tools, and processes that support a broad cross-section

of individuals and organizations to participate meaningfully. The research and decision-tool developed under this project lay the foundation for future work.

Priority 3: Invest in Disaster Risk Reduction and Resilience-Building Measures

- **Avoid Making the Problem Worse:** A starting place is to simply take steps to minimize or eliminate new or growing contributors to risk that are within local control or authority. For example, utilizing policies and bylaws to prevent new or further development or high risk uses in flood hazard areas, and educating interested parties about risk and options to manage it**.**
- **Place Community and Nature at the Centre of Decision-Making:** Community-building and nature-based solutions align strongly with values of stakeholders in the region and provide benefits far beyond flood management. In addition, these solutions perform well across a range of possible futures, adding to both social and ecological resilience. Community-building was specifically recognized as a foundational strategy that strengthens the effectiveness of other options and enables more creative and difficult decisions and solutions to potentially be realized.
- **Sequence Adaptation Actions Over Time:** One aspect of managing the complexity of what will be needed to address coastal flood risk is to look at needs and options over time, identifying where to start and at what point future options will need to be considered and initiated. This approach should also be supported by an understanding of the risk tolerance within a community or focus area.
- **Advance Actions at Individual and Collective Levels:** An important tension that repeatedly arose as we explored options, was the dynamic relationship between individual and collective needs and actions. Different perspectives can inform and shape options in ways that best draw on both, while thoughtfully considering necessary trade-offs.

Priority 4: Enhance Preparedness, Response, and Recovery to Build Resilience

- **Enable Options Through Proactive Recovery Planning:** Project participants noted that strategies such as “accommodate” could be an effective option. However, careful consideration and thought are required to be able to implement such strategies effectively. Flood (and other hazard) events, provide a “window of opportunity” to implement the strategy. Some buildings can be retrofitted to be more flood resilient, and Flood Construction Levels can be implemented for new builds to raise the height of damageable components of structures. More space should also be given to nature. The established flood recovery plan should clearly define the actions that will reshape local areas following a hazard event. This type of proactive thinking can be applied to other adaptation strategies, so that resilience is built into the flood recovery process.

Next Steps for the CVRD to Progress the CFAS

Building on the recommendation themes discussed in the previous sections, the CVRD should prioritize the following actions in the near-term (1-2 years) to progress the CFAS (more details are in the report):

- Expand public communications and engagement.
- Establish a collaborative framework for flood resilience in the region.
- Initiate the decision process for the Comox Road focus area.

Contents

Figures

Tables

List of Abbreviations and Acronyms

AAFC	Agriculture and Agri-Foods Canada
AEP	Annual Exceedance Probability
AIDR	Australian Institute for Disaster Resilience
ALR	Agricultural Land Reserve
BC	British Columbia
BCA	British Columbia Assessment
CEPF	Community Emergency Preparedness Fund
CFAS	Coastal Flood Adaptation Strategy
CGVD2013	Canadian Vertical Datum 2013
COVID-19	Coronavirus 2019
CVEP	Comox Valley Emergency Program
CVRD	Comox Valley Regional District
DEM	Digital Elevation Model
DPA	Development Permit Area
EASC	Electoral Area Services Committee
EGBC	Engineers and Geoscientists British Columbia (formerly APEGBC)
EMBC	Emergency Management British Columbia
ENSO	El Niño Southern Oscillation
EPA	Emergency Program Act
GFDRR	Global Facility for Disaster Risk Reduction
GIS	Geospatial Information System
IAP2	International Association of Public Participation Practitioners
IBA	Important Bird Area
IPCC	Intergovernmental Panel on Climate Change
IR	Indigenous Reserve
KWL	Kerr Wood Leidal Associates Ltd.
LAP	Local Area Plan
LiDAR	Light Detection and Ranging
MECCS	Ministry of Environment and Climate Change Strategy
MFLNRORD	Ministry of Forests, Lands and Natural Resource Operations Region and District
MOTI	Ministry of Transportation and Infrastructure
MOU	Memorandum of Understanding
NDMP	National Disaster Mitigation Program
NGO	Non-Governmental Organization
NRCan	Natural Resources Canada
OCP	Official Community Plan
PARAR	Protect, Accommodate, Retreat, Avoid, and Resilience
PDO	Pacific Decadal Oscillation
PSC	Public Safety Canada
QGIS	Quantum Geographic Information System

RD	Regional District
RGS	Regional Growth Strategy
RIBA	Royal Institute of British Architects
RSLR	Relative Sea Level Rise (more commonly referred to as SLR)
SDM	Structured Decision Making
SOVI	Social Vulnerability Index
UBCM	Union of BC Municipalities
DRIPA	BC Declaration on the Rights of Indigenous Peoples Act
UNDRR	United Nations Office for Disaster Risk Reduction (Formerly UNISDR)

1 Introduction

The Comox Valley Regional District (CVRD) coastline is cherished by residents for its natural beauty. However, the shoreline environments that are responsible for thriving tourism and other economic, social, and cultural benefits are affected by coastal storms. The CVRD and K'ómoks First Nation Territories are perched on the edge of the Georgia Strait. All of this coastline is subject to flood waters and damaging wave action to varying degrees.

The CVRD is no stranger to flood damages having experienced them on their riverine and coastal hazard zones in recent years (e.g., 2014, 2016). These damages will increase with time as storms become more intense and the sea levels rise. To respond to these events, the CVRD has recognized the imperative need to adapt to the increasing potential for coastal flood hazard and has initiated a multi-phase Coastal Flood Adaptation Strategy (CFAS).

With support from the Community Emergency Preparedness Fund (CEPF), this Phase 2 project builds upon Phase 1 work in which coastal and riverine flood hazards were modelled and mapped. The goal of the Phase 2 project was **to develop a decision process to support the selection, prioritization, and implementation of adaptation options within the CVRD.** The project required targeted engagement activities and a risk assessment, for which the CVRD retained Ebbwater Consulting Inc. (Ebbwater). Ebbwater partnered with SHIFT Collaborative (Shift) to lead the design and delivery of the engagement sessions. An important by-product of this project is the capacity-building at CVRD and with its partners, to better enable understanding of the complex nature of flood mitigation and climate adaptation.

1.1 Coastal Flood Adaptation Strategy Project Background

The CFAS is a multi-year process with an overall goal to minimize risks and increase community resilience from coastal flood. The CFAS began in June 2019 with a coastal flood mapping project (Phase 1). Figure 1-1 shows an overview of the strategy's phases and timelines.

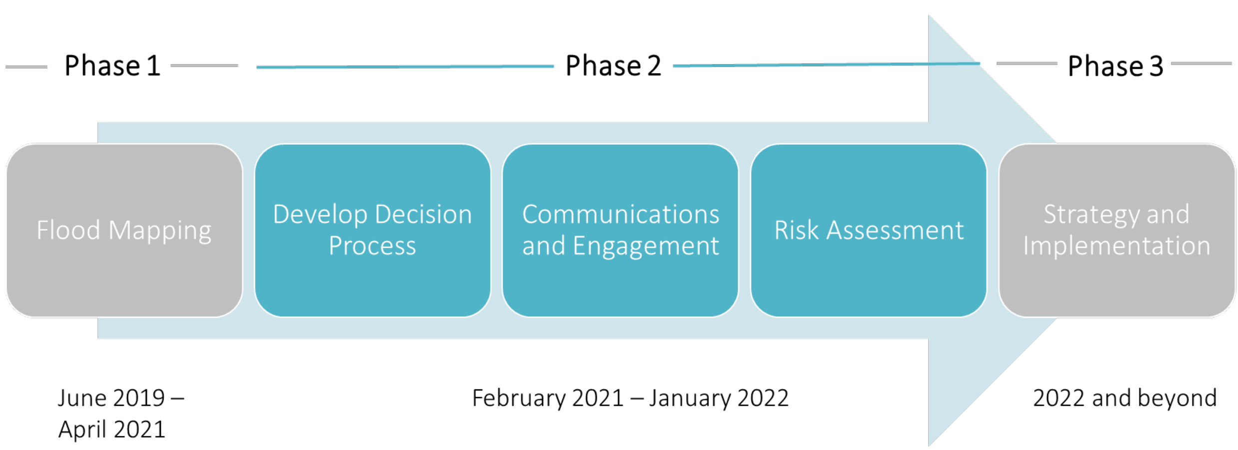

Figure 1-1: CFAS overview of phases and timelines.

1.1.1 Phase 1 Summary

A necessary first step in flood management is to acquire coastal flood hazard maps to better understand where and how deep the water might be in a flood event. Phase 1 of the CFAS involved detailed analysis and modelling of riverine and coastal flood hazards, including various combinations of coastal storm and sea level rise scenarios. With funding support from the National Disaster Mitigation Program, this work was conducted by Kerr Wood Leidal (KWL) Associates Ltd. A variety of mapping products were created. These included region-wide base mapping, regulatory floodplain maps, and digital mapping data (Kerr Wood Leidal Associates Ltd., 2021).

Section 4.2 expands on the flood hazard extent results based on the Phase 2 scope of work. However, two key high-level takeaways from the Phase 1 project are as follows:

- There are a number of communities and agricultural lands in low-lying areas that are exposed to coastal flooding from an extreme storm, even without sea level rise (i.e., current conditions). These areas include a significant portion of lands in Electoral Area B and K'ómoks First Nation reserve lands (IR#1, IR#2, IR#3).
- Sea level rise means that areas that would currently only see flooding very rarely today will be flooded more frequently in future. Some areas, which would currently be outside the flood hazard zone, will be inundated in future.

1.1.2 Key Questions

Building on the CFAS Phase 1 results, to progress toward the goal of the CFAS, the CVRD needs to develop tools to answer the following questions:

- **Where** are the priority areas?
- **What** adaptation options will be most effective?
- **When** will decisions for specific adaptation options be required?

1.2 Project Approach

The Phase 2 project approach was designed to provide understanding of the first and second questions described above (where and what). To answer these questions, the goal of Phase 2 of the CFAS centred around establishing a values-based decision process that was transparent and repeatable. This was the key development of the project; such a tool is needed to support the selection, prioritization, and implementation of adaptation options to respond to coastal flooding within the CVRD in future project steps.

1.2.1 Project Objectives

The project objectives were defined as follows:

- Identify values that matter to the community related to coastal flood.
- Develop options to help the community adapt to coastal flood.
- Assess options informed by risk-based information.

Underpinning the project objectives was a need to present the complex topic of adaptation options in a simplified manner; the project team needed to manage "information overload". With this in mind, the team needed to define a decision process with the following characteristics:

- Risk-based (i.e., considers both the local hazard and local impacts of flooding).
- Mindful of other strategic planning processes being undertaken at the CVRD.
- Responsive to new planning and/or development directions and new sea level rise science.
- That builds internal and stakeholder capacity to understand and act in the face of sea level rise.

1.2.2 Supporting Components

To support the key project development, we conducted two supporting project components:

- **Engagement activities.** We worked extensively with CVRD stakeholders, partners, and the public. Under this supporting component, we informed these groups about the Phase 1 project, and obtained critical input and feedback on Phase 2 development.
- **Risk assessment.** We conducted a risk assessment of coastal flood hazards to provide a basis to prioritize efforts and support decision-making. This second supporting component built on the technical work from Phase 1, evaluated it, and improved upon it, to provide robust results for consideration within the project's key development.

Outputs from the supporting project components were shared iteratively within the development of the decision process to reach the project objectives. The interaction between the key project development (i.e., the decision process) and supporting components, is shown in Figure 1-2, and further details are provided in Chapter 3.

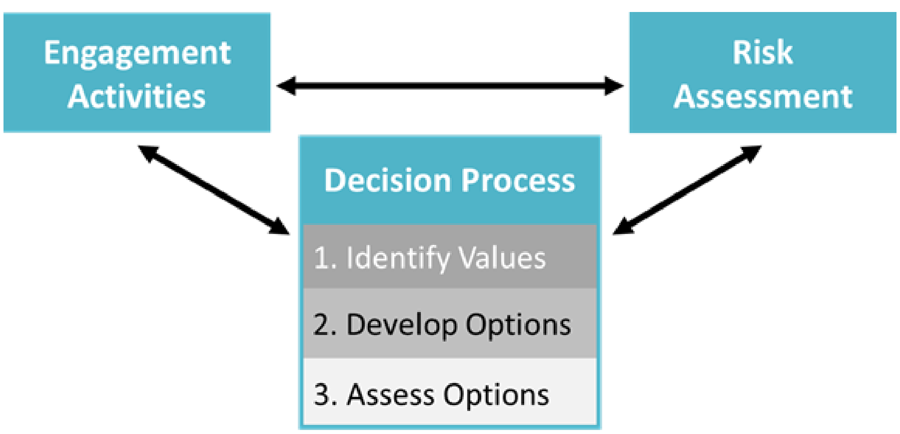

Figure 1-2: Interaction of the three project components.

Spatial Scope

The project area is shown in Figure 1-3. Consistent with Phase 1, the project area generally consisted of the CVRD electoral area coastlines. However, the area excluded coastlines within the jurisdictional areas of the City of Courtenay, Town of Comox, and Denman and Hornby Islands. The area also excluded the riverine flood hazard areas that were analyzed within Phase 1 (i.e., Oyster and Courtenay Rivers); excluded areas are shaded grey in Figure 1-3. It was the intent of the project to include K'ómoks First Nation IR#1, IR#2, and IR#3 to the extent possible.

Two spatial scales were used for the project, as described below:

- **Regional Scale:** All the engagement activities were conducted based on participant representation for the project area described above. The broad concepts were presented, and the decision process that was developed, is intended to be implemented across the project area. A full risk assessment was conducted at this scale.
- **Local Scales (Focus Areas):** To provide a more practical, place-based, understanding of how adaptation options could be developed and implemented, the engagement and decision processes was applied at a local scale. Four candidate focus areas were considered: Saratoga Beach, Comox Road, Goose Spit, and Union Bay (these are shown in Figure 1-3, and described further in Sub-section 1.3.4). Information, including outputs from the regional scale risk assessment supported discussions on trade-offs associated with adaptation options. In later engagement sessions, the Saratoga Beach area was used as an illustrative example for further consideration. Note that the choice of focus areas did not indicate prioritization of these areas for planning purposes.

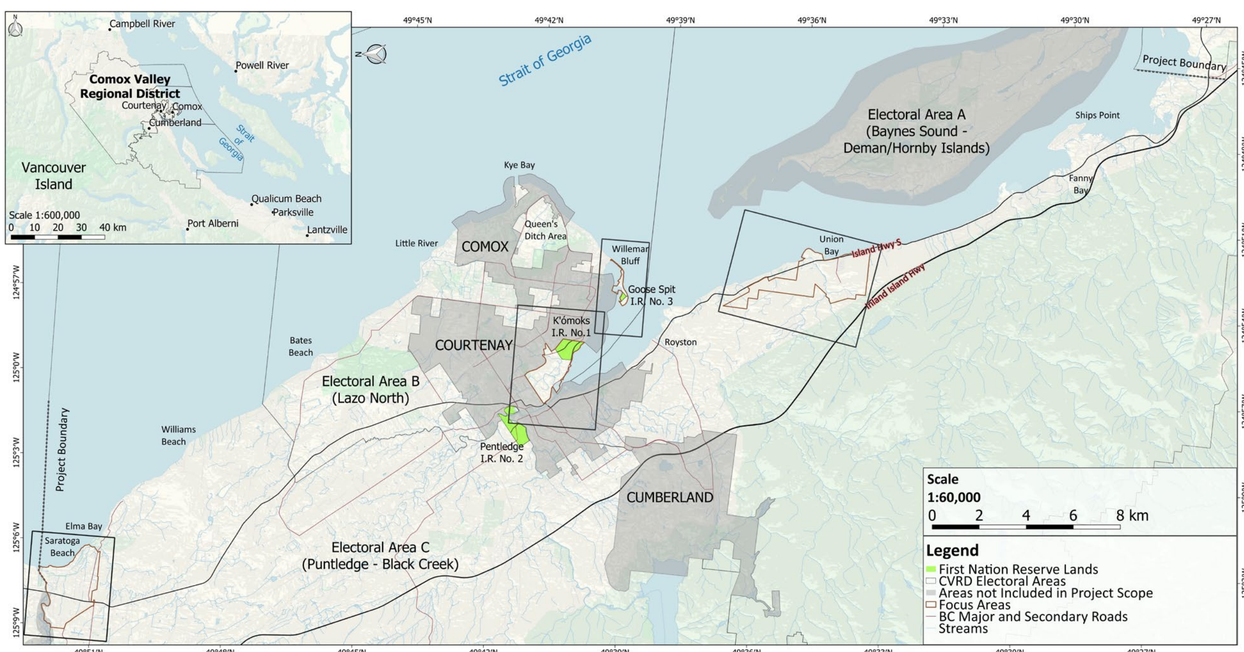

Figure 1-3: Project regional and local focus areas.

1.3 About the Project Area

1.3.1 Societal Setting

For thousands of years, Indigenous people occupied the shoreline of eastern Vancouver Island. This is the traditional territory of the people called K'ómoks today; they have called this the 'land of plenty' since time immemorial[1]. Following European settlement, conflict, and colonial policies and practices, the K'ómoks families endured hardship through loss of land, resources, and cultural connection. Today, the CVRD has a government-to-government relationship with the K'ómoks First Nation. They work together under a shared understanding for living on, and caring for, the lands in the Comox Valley.

The project area includes over 100 km of coastline and is home to approximately 15,000[2] people (the total population within the CVRD, is approximately 66,500). Benefitting from colonial practices, the CVRD has consistently grown over the last century. Approximately 65% of the population now lives in core settlement areas of the three municipalities. Population growth is expected to continue, in both urban and rural settings, with the population estimated to reach over 88,000 people by 2030 (Urban Strategies Inc., Ecoplan International Inc., and Ear to the Ground Planning, 2010).

Settlement areas within the project area (e.g., Saratoga Beach, Little River, Union Bay, Ships Point) are relatively small, but they can grow substantially during the summer tourism season. Single-family homes, parks, and recreation properties (e.g., vacation homes and campsites) line the coast, with views and access to the beaches in the region (Comox Valley Regional District, 2014).

The Rural Comox Valley Official Community Plan (OCP) indicates that residents care about retaining local agricultural lands, maintaining a more rural quality of life, and protecting the environment (Comox Valley Regional District, 2014). The shoreline offers a variety of recreation amenities, especially related to appreciating natural areas.

1.3.2 Environment

Shoreline types within the project area range from low-lying marsh areas in the K'ómoks Estuary to the natural quadra sand deposit of the Willemar Bluffs, which have been eroded by coastal processes. The coastline provides habitat for a range of bird and animal species, many of which are endangered and at-risk. The K'ómoks Important Bird Area (IBA) extends 14 km from Bates Beach to Mud Bay; it includes intertidal and salt marsh habitat for migratory and resident birds (Current Environmental, 2018). The coast is also a spawning ground for forage fish including Pacific sand lance and surf smelt; they rely on sediment from erosion processes to that form their spawning habitat. These habitats support fish populations and ecology, which in turn provide an essential food source for other fish, birds, and marine mammals (Current Environmental, 2018).

1.3.3 Past Coastal Flood Events

The Phase 1 report includes a timeline of historical flood events within the CVRD. Most of the flood events have occurred due to a combination of riverine and coastal floods. Two large, exclusively coastal events were recorded in December of 1967 and 1982. On both occasions, coastal water levels reached highest levels recorded (2.88 m above mean sea level, CGVD2013).

[1] K'ómoks First Nation. Weblink: https://komoks.ca/. Accessed 16 November 2021.

[2] All population estimates are based on the 2016 Census.

1.3.4 Focus Areas

To support engagement, learn about stakeholder values, and to test the decision process it was important to engage in place-based thinking. Four focus areas (Saratoga Beach, Goose Spit, Comox Road, and Union Bay) were initially considered. Each of these areas has existing flood risk but each are unique with different risk profiles, jurisdictional make-up, and future risk. The four focus areas are summarized in the following sections, and further descriptions are in Appendix D. The figures shown include the jurisdictional boundaries of the focus area.

Of the four focus areas, Saratoga Beach was selected for further consideration by the CVRD. This area is entirely within the jurisdiction of the CVRD, it is subject to short-term coastal flood hazards, and it contains rural residential areas that can be considered typical to other coastal areas within the CVRD.

1.3.4.1 <u>Saratoga Beach</u>

The Saratoga Beach area has 3.7 km of exposed coastline, and it is located in Electoral Area C (Figure 1-4). The area's key features relevant to the project are as follows:

- Large sandy beach attracts summer tourists and is an important recreational area for locals.
- Coastal flooding can be exacerbated by freshwater flooding from pluvial events and the rivers.
- Oyster River and Black Creek estuaries create river flood hazard (when they overtop their banks); however, they are also areas that can absorb coastal flood waters.
- Area has been designated as a CVRD "Settlement Node" (future growth area, see Sub-section 2.5.2).
- Anticipated growth focuses on coastal tourism and residential housing (143 new residential lots); an existing Master Development Agreement plans for these new lots.

Figure 1-4: The Saratoga Beach area. Map Data ©2020 Google.

The following sections summarize relevant characteristics of the other three focus areas.

1.3.4.2 Goose Spit

This focus area has 5.2 km of exposed coastline, and it is located in Electoral Area B (Figure 1-5). The area's key features relevant to the project are as follows:

- Unique coastal sand ecosystem that is fed by the Willemar Bluffs to the north.
- Habitat for protected migratory birds and plants.
- The sheltered lagoon is valued by water-based recreationalists.
- CVRD parks department uses log piles and other means for shoreline protection; however, it is not regarded as a long-term solution.
- BC Ministry of Transportation and Infrastructure (MOTI) owns road in this key corridor that is shared with the Canadian Forces base and a K'ómoks First Nation reserve.

Figure 1-5: The Goose Spit area. Map Data ©2020 Google.

1.3.4.3 Comox Road

This focus area has 2.1 km of exposed coastline. Also referred to as the "Dyke Road", it is located within CVRD Electoral Area B. Figure 1-5 shows satellite imagery of the area. The area's key features relevant to the project are as follows:

- The road is multi-jurisdictional and passes through the City of Courtenay, the Town of Comox, and K'ómoks First Nation lands as well as the CVRD.
- The CVRD maintains a park space along the road; green spaces are important natural assets that can reduce flood effects.
- The area contains agricultural lands and residential buildings.
- The Kus-kus-sum remediation and restoration project involves regional collaboration and construction will begin in June 2021.
- There are other major capital works for a sewer line to an outfall at Willemar Bluffs in the near future.
- Some buildings along the road have been adapted for flooding.

Figure 1-6: The Comox Road area. Map Data ©2020 Google.

1.3.4.4 Union Bay

This focus area has 3.6 km of exposed coastline and is located within CVRD Electoral Area A. Figure 1-7 shows satellite imagery of the area. The area's key features relevant to the project are as follows:

- The area has been designated by the CVRD as a "Settlement Node" (future growth area, see Sub-section 2.5.2).

- Water, street lighting, and fire services will be under CVRD's jurisdiction as of 1 July 2021.
- Includes the planned development of Union Bay Estates (3,000 mixed residential / commercial lots with park land along the shore).
- A new sewage line is planned.

Figure 1-7: The Union Bay area. Map Data ©2020 Google.

1.4 Project Challenges and Limitations

Given the information, timing, and resources available to complete this project, there were challenges and limitations to the work completed. These are summarized below.

1. **Project area and diversity.** As noted above there is more than 100 km of coastline in the Regional District. There is a great diversity of hazard and risk along this coast. The challenges faced by the CVRD are not uniform—some areas will flood earlier or more frequently than others, and the asset mix (i.e., the people, infrastructure, etc.) in the floodplains are varied and changing. There is also a diversity in values across the project area, which affects how communities should respond to flood. Mapping and decision tools were developed to help capture these differences. However, it is impossible to fully represent the complexity of the large area within a project of this scope.
2. **Lack of face-to-face engagement.** Traditionally, these types of projects benefit from in-person engagement, which allows for natural mixing of interested and affected parties that enables individuals to better understand other viewpoints. This project could not benefit from this type of engagement, due to COVID-19 restrictions. Instead, on-line tools were developed. While these presented some opportunities for the project (e.g., making sessions more accessible through the elimination of travel), the inability to interact in person, read body language, etc. was difficult. This was exacerbated by the messiness of the project (see Challenge 3).
3. **Messiness of adaptation planning.** Flood management, especially in the context of a changing climate, is an extremely complex, or indeed *wicked*[3] problem. The uncertain nature of climate change, the unknown timelines, and the intangibility of many flood impacts makes decision-making for flood management very challenging. This makes the development of a decision-making process even more challenging. It needs to be practical and understandable. Further, careful consideration was required related to understanding jurisdiction, authority, and responsibility; limited resources; range of values; and externalities. These factors were introduced into project activities by way of various frameworks to support participants in thinking about them.

1.5 Project Report Structure

The next chapter provides background and supporting information on coastal flood hazards, risk and resilience, and guidance related to risk reduction. It also provides the flood management context of the CVRD. Chapter 3 describes the project methods, which includes engagement activities, risk assessment, and development of the decision process. Chapter 4 presents the results, in terms of the values obtained through the engagement process, the regional risk assessment, the Saratoga Beach consequence assessment, the decision tool, and adaptation options. Chapter 5 Provides a series of recommendations. This is followed by the report conclusion in Chapter 6, as well as the glossary of terms and the list of references.

The appendices referenced in this report are as follows:

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[3] A wicked problem in policy, planning, or natural resource management is one that is difficult or impossible to solve. Where competing interests mean that there is no single solution, and because of complex interdependencies, solving one part of the problem will worsen or create other problems.

- Appendix A – Risk Assessment Details
- Appendix B – Flood Hazard Layer Sensitivity Analysis
- Appendix C – Risk Assessment Maps
- Appendix D – Focus Area Profiles
- Appendix E – Adaptation Strategies
- Appendix F – Adaptation Pathways

2 Background and Supporting Information

This section provides background materials to support the understanding and interpretation of the main body of the report. It provides a brief introduction to coastal flood hazards, and the risk assessment process, including best practice for risk reduction decision processes. It also provides flood management governance context in BC, as well specifics related to the CVRD.

2.1 Understanding Coastal Flood Hazards

The British Columbia (BC) coastline is exposed to a number of coastal flood hazards; a hazard is a process or phenomenon that may cause damage. Coastal flood hazards are generally grouped into two main categories: coastal storm floods and tsunamis. Erosion, induced by flood hazards, can also cause damage along the coast.

Not all coastal flood hazards are created equal—flood hazard characteristics can differ in terms of water depth and velocity, frequency, onset, and duration. These characteristics affect how the shore and the assets on it are impacted by flood. Therefore, it is important to understand as many aspects of the hazard as possible. In addition, these characteristics are changing due to climate change; the frequency of weather-driven events is likely to increase and sea levels are rising (IPCC, 2014).

2.1.1 Coastal Storm Flood Hazard

Weather-driven hazards arise when water levels are higher than normal in the Pacific Ocean because of storm activities. Water levels in the ocean off the coast are a function of many components. Some of these components are predictable (deterministic), such as tides. Other components are less predictable (probabilistic); these are factors that increase water elevations as a result of storm events and include storm surge, wind and wave set-up, and waves (see Figure 2-1). These processes have varying likelihoods of occurrence and require detailed analyses of specific events to quantify the resultant combined effect on total water levels.

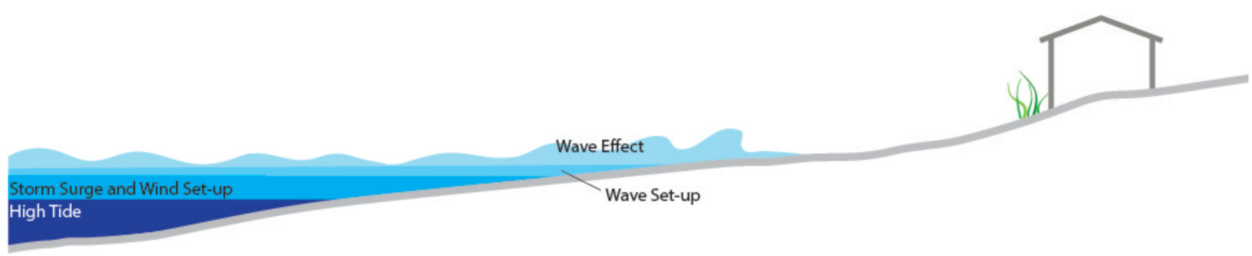


Figure 2-1: Components of total water level (total water level is composed of tide, storm surge, wind set-up, wave set-up and wave runup).

Tides (Deterministic)

Tides are the periodic rise and fall of the ocean surface. Tide levels vary throughout the day, but are also subject to longer-term cycles, caused primarily by the relative positions of the sun, moon, and Earth. The maximum tidal elevation occurs once every 18.6 years in BC, but the level comes close to this for a few tides each year. These yearly large tides are often referred to as king tides.

Storm Surge (Probabilistic)

A storm surge is a localized increase in water levels due to low-pressure systems in the atmosphere (storms). As these systems move from the Pacific into coastal water, the reduced localized atmospheric pressure on the ocean causes the water levels to rise.

Wind Set-Up (Probabilistic)

Wind set-up is associated with strong local onshore winds blowing over shallow water. This wind blows the water onto the shore resulting in a localized increase in the water level as the water is “piled up” against the shore.

Wave Effects (Probabilistic)

Wind-generated wave effects are a key component of coastal flooding. The wave effect is dependent on the shoreline characteristics and exposure at a given location. Shallow, gentle slopes are more effective at dissipating wave energy and lower the magnitude of wave effects (also called wave runup), which is manifested as overtopping or splashing (see diagram A in Figure 2-2). Steeper slopes or vertical features such as a rocky bluff or steep cliff cause relatively higher wave runup (see diagram C in Figure 2-2).

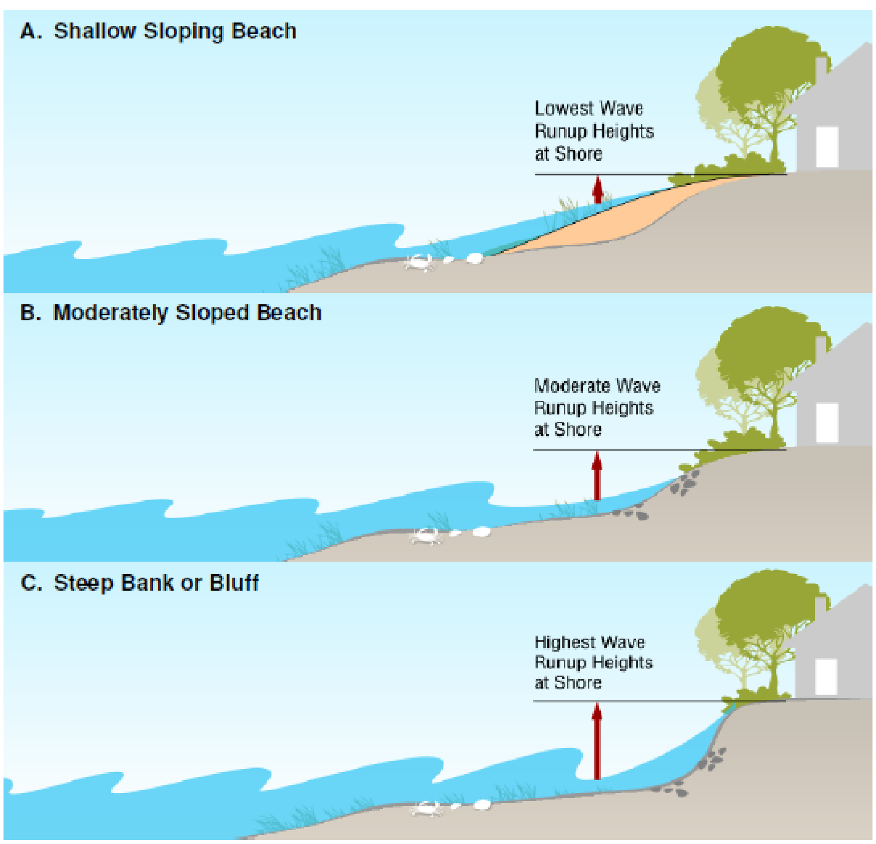


Figure 2-2: Effect of different shoreline slopes on wave runup. Source: KWL (2021) (used with permission).

In addition to affecting total still water levels, many components of coastal storms have significant associated forces that can damage the shoreline and assets on it. Coastal erosion can be induced by storms and creates a significant secondary hazard (see Sub-section 2.1.3).

Inter-Annual Climate Variation

Inter-annual climate variation refers to cyclical shifts in climate conditions due to global atmosphere-ocean circulations, for example the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO). Variations of sea level with these oscillations are mostly due to changes in water temperatures and the resulting expansion or contraction of sea water.

2.1.2 Climate Change and Sea Level Rise

Around the world, sea levels are rising due to the melting of ice caps and glaciers with climate change, and the expansion of ocean water caused by warming (Union of Concerned Scientists, 2015). Variations in local sea level rise occur due to differences in topography, gravitational forces, and ocean currents; the west coast of North America generally experiences lower than average global SLR rates.

Relative sea level rise (RSLR) is a function of the rise in sea level compared to vertical changes resulting from geological processes (land subsidence or uplift over time) (Figure 2-3).

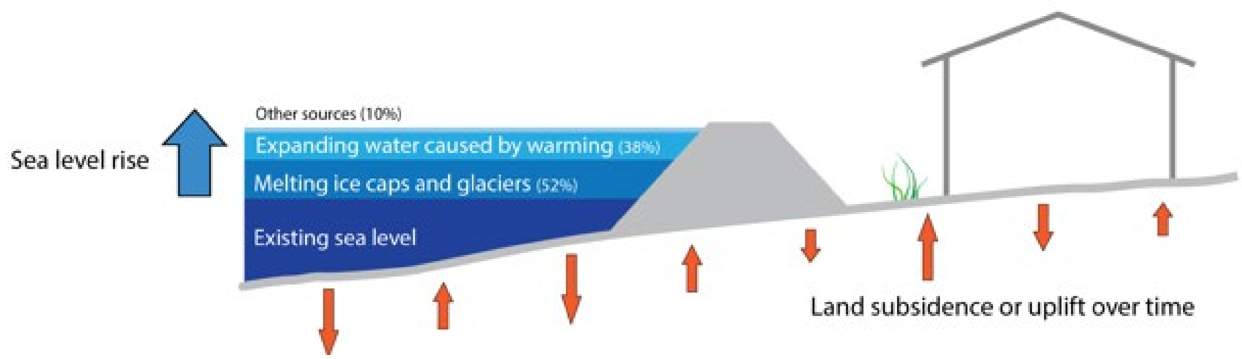


Figure 2-3: Drivers of RSLR including components of SLR and land subsidence or uplift—estimates of factors contributing to SLR are based on Union of Concerned Scientists (2015).

Sea level rise (SLR) [4] is a quasi-deterministic process (i.e., the upward trend is known, but the rate of change is unknown) and the uncertainty in projections is large. For example, a global study projected SLR of several metres on a time scale of 50 to 150 years (Hansen et al., 2016). The study considered the possibility that the Greenland and Antarctic ice sheets would melt; this has begun and is assumed to be a non-linear process.

The most recent sea level rise projections for Canada are based on the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report. For the project area, the median projection for the year

[4] In this report, references to sea level rise (SLR) usually refer to relative sea level rise (RSLR).

2050 is an increase of 1 cm in RSLR for the Representative Concentration Pathway (RCP) 8.5 (considered the “business-as-usual” greenhouse gas emissions scenario). However, projections for the year 2100 for the same RCP are for an increase of 22 cm. Projections for an “enhanced” RCP 8.5 scenario, which considers an enhanced meltwater source from West Antarctica, increases the projection to 95 cm for the year 2100. The increases are relative to the 1986 to 2005 period (James, Robin, Henton, and M. Craymer, 2021)[5]. The *Professional Practice Guidelines* and the *Provincial Guidelines* both propose 1 m of SLR by 2100 (see Figure 2-4).

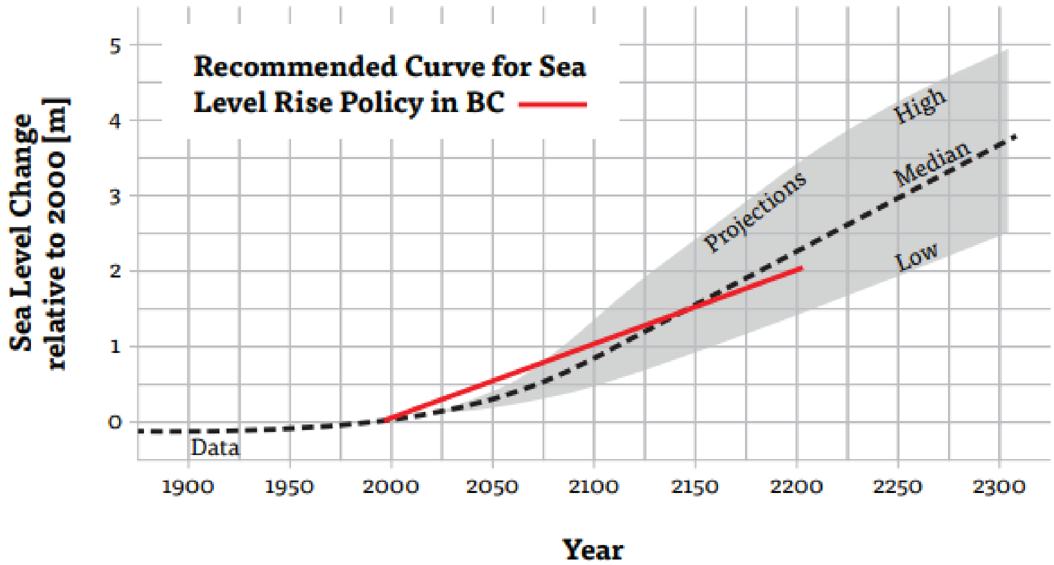


Figure 2-4: Projections of global SLR (Figure from (EGBC, 2017)**.**

Climate change and SLR must be considered to determine total water levels resulting from storm hazards. It should be noted that there is limited information to inform changes to the storm hazard intensity (sometimes called storminess) and frequency off the west coast of Canada as a result of climate change. At present, the guidance is to continue to use historic records to inform flood hazard assessments and mapping.

Key message: Sea level is rising, but an unknown rate. Embrace the uncertainty.	**Action:** Don’t rush in; preserve options. Avoid solutions that are single-minded or remove future pathways. Strive for adaptive solutions that will work under multiple futures.

[5] The refined data from James et al. (2021) was obtained from Climate Data for a Resilient Canada. Weblink: https://climatedata.ca/explore/variable/slr/?coords=49.79855248452189,-124.31373596191408,10&geo-select=&rcp=rcp85-p95&decade=2100&rightrcp=disabled. Accessed 14 December 2021.

2.1.3 Erosion Hazards

Coastal erosion describes the loss of land due to the net removal of sediment or bedrock (UNISDR, 2017). It can occur as a result of the forces associated with waves and currents, and therefore significant coastal erosion is generally associated with extreme weather events and other coastal hazards (e.g., tsunamis). During extreme weather, waves are generally more intense, but also reach further inland to landforms that are otherwise not exposed. Waves are often also accompanied by intense precipitation, which can saturate and weaken the coastal landforms.

Coastal erosion can also occur because of geomorphic mass wasting processes, and subsidence. However, these are not directly related to flood hazards. In developed areas, erosion protection measures such as rip rap slopes and seawalls can influence flooding and wave effects and can lead to increased beach erosion and bank destabilization over time (Kerr Wood Leidal Associates Ltd., 2021). Climate change is expected to accelerate erosion on Canada’s coasts (Vadeboncoeur, 2016).

2.2 Hazard Components

A natural hazard such as coastal flooding is generally defined by considering a hazard profile, which is made up of the flood hazard magnitude and associated characteristics (onset, depth, velocity, etc.) and the likelihood (probability) of the hazard occurring. Storm events have a range of likelihoods and associated magnitudes. Risk management professionals generally consider the risk associated with an event to be the product of the probability of it occurring and the consequences.

An understanding of the hazard profile is important when considering planning and response. A full flood hazard assessment requires an understanding of what will flood, and how likely this is. The work conducted as part of this project considered a variety of hazard scenarios to support the concept of a hazard profile, and future risk profiles.

2.2.1 Likelihood and Magnitude

Likelihood (the probability that a flood of a certain size will occur) and magnitude (the size of a flood) are two defining characteristics of flood. These are inversely proportional to each other; large events occur rarely, and small events more frequently (see Figure 2-5). Frequent but small floods present very different risks than rare and large floods.

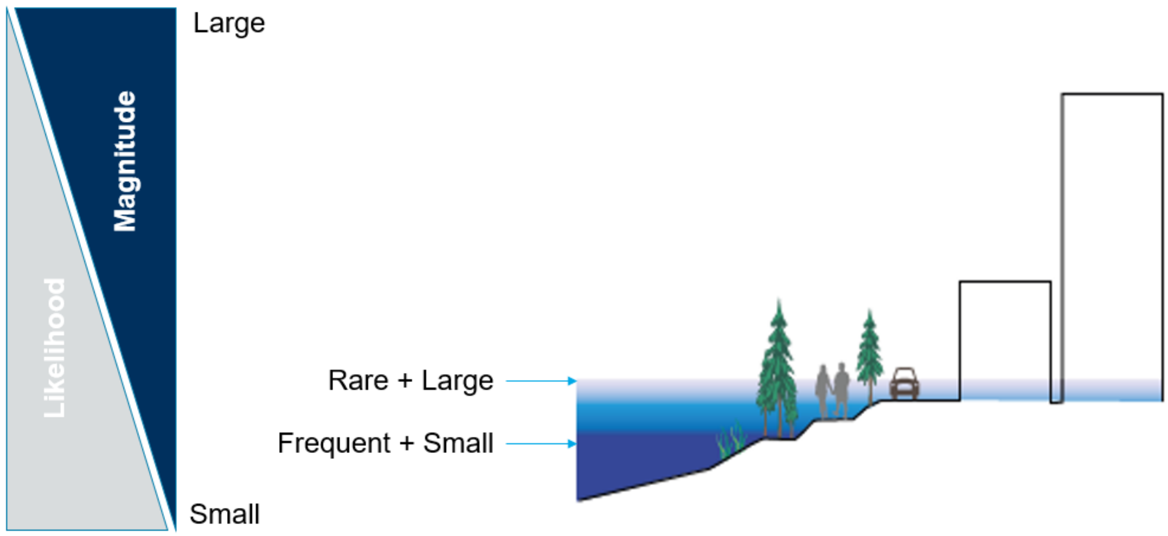


Figure 2-5: Simplified relationship between flood hazard likelihood and magnitude.

Flood magnitude describes the size of an event. It is measured in cubic metres per second for creek and river flooding and in elevation or volume for lake (coastal) flooding.

Likelihood is generally defined or presented as an Annual Exceedance Probability (AEP), which is the probability of an event of a given size occurring or being exceeded in any year, described as a percentage. For example, a 0.5% AEP event, has a 0.5% chance of occurring or being exceeded in any given year. This is sometimes referred to as a 1/200 or 200-year event. However, this is misleading, as it infers that once an event of this size has occurred, it will not occur again for 200-years, which is not the case.

Another way to think about flood likelihood is through the use of encounter probabilities, where it is possible to calculate the likelihood of encountering an event of a given size over a defined time period—for example, the length of an average mortgage (25 years). For instance, there is a 93% chance that a 10% AEP flood will occur over this time period, and there is a 12% that a 0.5% AEP flood will occur (Table 2-1). Understanding the likelihood of an event, as well as the encounter probability of an event, can support decisions related to flood management.

Table 2-1: Encounter probabilities for various flood likelihoods.

Annual Exceedance Probability (AEP)	Indicative Return Period	Encounter Probability of Occurrence in 25 years	Encounter Probability of Occurrence in 50 years	Encounter Probability of Occurrence in 75 years	Encounter Probability of Occurrence in 100 years
10%	Once every 10 years	93%	99%	100%	100%
2%	Once every 50 years	40%	64%	78%	87%
1%	Once every 100 years	22%	39%	53%	63%

Annual Exceedance Probability (AEP)	Indicative Return Period	Encounter Probability of Occurrence in 25 years	Encounter Probability of Occurrence in 50 years	Encounter Probability of Occurrence in 75 years	Encounter Probability of Occurrence in 100 years
0.5%	Once every 200 years	12%	22%	31%	39%
0.2%	Once every 500 years	5%	10%	14%	18%

2.2.2 Depth and Power

In addition to the total volume or flow associated with a flood event, how the water spreads and moves over the floodplain is an important consideration.

Flood depth is a big determinant of how much damage is caused. Nuisance flooding in a basement, for example, is very different from moderate (>30 cm) or severe (>2m) flooding, which can respectively cause significant to sometimes unrecoverable damage. Depth generally, but not always, decreases with distance from the water source.

Water velocity as it moves down a channel or across a floodplain also affects its damage potential. Faster moving water, especially if it has entrained materials (this could be rocks and logs from natural slopes, or garden furniture or cars that are picked off the urban floodplain) can be more damaging than slow, stagnant water. Higher velocity systems have more power, and can cause erosion or avulsion of natural systems, as well as knocking over people, cars, and even some structures.

Similarly, powerful waves on the shoreline of lakes have additional energy that can cause erosion and other damage to assets within the wave zone.

2.2.3 Spatial Scale

The spatial scale (how widespread or localized a flood is) will matter for response and recovery. Large regional events that affect many communities at once may stretch resources, whereas a small, localized event on one shoreline reach or area might be more manageable, if it is a location with good access and response systems.

2.2.4 Onset and Duration

Finally, the characteristic of temporal scale (how quickly it happens, when, and how long it lasts) is an important consideration. The onset time is directly related to the efficacy of many temporary flood mitigation actions, as these are only effective if they are put in place in time.

Further, it is important to consider how long an event will last, and therefore how long water will be in contact with elements on the flood plain. In general, the damage associated with flood is less for shorter events, whereas if a building is wet for days or weeks the structural damage will be severe and may require that the building be destroyed.

2.2.5 Hazard Scenarios

Often, coastal storms are presented as single scenarios (i.e., one hazard magnitude and likelihood), which then become the designated event (this is generally the 0.5% AEP scenario). However, impacts of flooding can also occur at lower magnitudes, and, although rare, larger-magnitude events do occur. Thus, best practice for flood management is to consider multiple events (from smaller, more frequent events through larger, rarer events).

Key message: Flood hazards are nuanced. Adaptation actions need to be too.

Action: Consider the nuance and range of events in decision processes.

2.3 Risk and Resilience

Coastal areas inundating shorelines are not in themselves a problem. It is when flood waters interact with things we care about on the floodplain and cause negative consequences that we have cause for concern. This project uses the concepts of risk and resilience to support a holistic understanding of flood and the adaptation options that can be taken to mitigate its damages.

The following sections discuss how the hazard information, explained in the previous section, is used within the context of a risk assessment.

2.3.1 Key Terms

Risk is the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society, or a community, determined probabilistically as a function of hazard, exposure and vulnerability (UNDRR, 2017).

As illustrated in Figure 2-6, risk is defined by the total area of a triangle, whose vertices are **hazard** (in this case flood), **exposure** (the things people, organizations, and stakeholders care about that are exposed to floodwaters) and the **vulnerability** of these things being damaged by floodwaters.

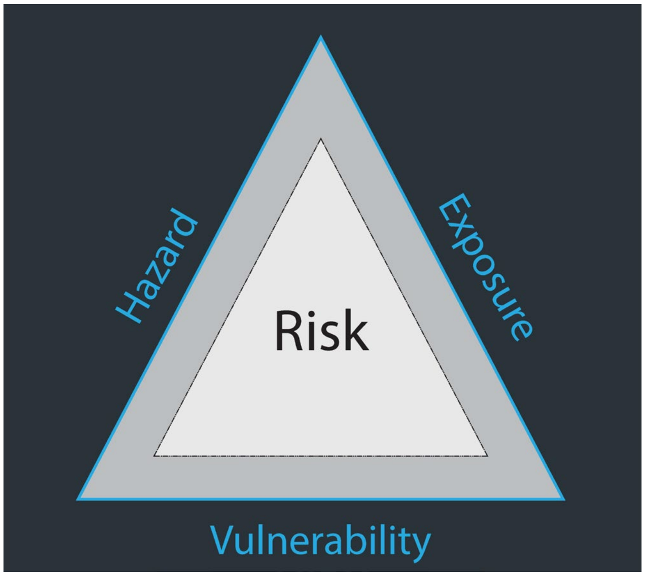


Figure 2-6: Risk as a function of hazard, exposure, and vulnerability. Based on (GFDRR, 2016).

There are three levers to increase OR reduce risk. Hazard, exposure and/or vulnerability reduction can all play a role in overall risk reduction. This more complex, but important take on flood mitigation, means that there are many more tools available to support risk reduction.

In the last hundred or so years, many western governments have focused on trying to stop water from interacting with assets through the construction of large engineering works. This effectively limits risk reduction options to one of three possible levers.

2.3.2 Dynamic Risk

Risk is not static. It can both increase and decrease with time. The challenge is that given present day pressures, two vertices are trending outwards, increasing the overall risk (Figure 2-7). Climate change is affecting the frequency and severity of flood events, increasing the overall hazard, and development pressures and trends mean that more people and things are being placed in flood hazard areas (i.e., increased exposure).

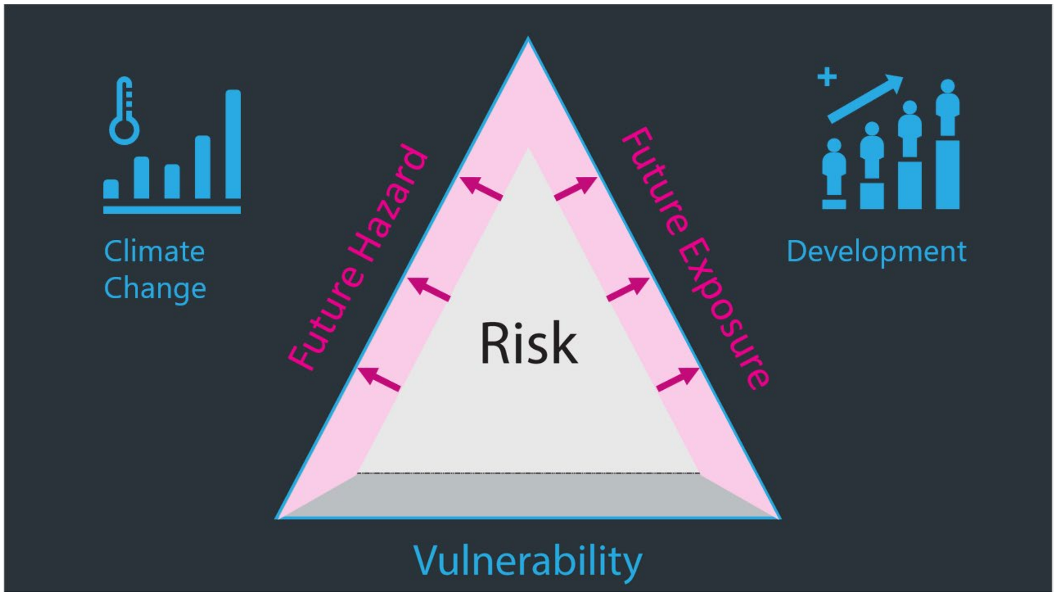


Figure 2-7: Increasing risk with climate change and increased development.

While risk is tending to increase, there is still opportunity to arrest the increase, especially as it relates to increased exposure. And, of course, there is still opportunity to reduce risk through careful considerations of actions that reduce future hazard, exposure and/or vulnerability.

2.3.3 Systemic and Wide-Ranging Risk

Floods and disasters are extremely complex. Society has become acutely aware of this through experiencing the COVID-19 pandemic. Impacts have been felt widely, to human health, but also to local and global economies. And, impacts have not been felt equally, some people have faced insurmountable challenges, whereas others have had limited impacts. These discrepancies are linked to differences in vulnerability (described in Sub-section 2.3.1) and resilience. **Resilience** is defined as the "ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management." (UN, 2016; UNDRR, 2017)

Even when risk reduction measures are taken, risk from natural hazards can never be completely eliminated. This is known as **residual risk**. Additional or complementary measures, such as flood insurance, are designed for this purpose.

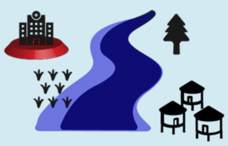
Key message: It's risk that matters. Risk is messy and complex.

Action: Use risk as the basis for analysis. Acknowledge the messiness and uncertainty. Apply a decision process that does too.

2.3.4 Evolution of Flood Management

Risk reduction in flood management is a relatively new concept that requires detailed site-specific information while keeping the big picture in sight. To better understand how risk reduction can inform adaptation options in the CVRD, it is useful to think about how flood management has evolved in recent history. Sayers et al. (2013) describes this evolution in terms of six generalized stages, which apply to the project area (Table 2-2). Table 2-2 also indicates generally if the actions in each stage contribute to increasing or decreasing flood risk levels.

Table 2-2: The evolution of flood management and the general change in flood risk (adapted from Sayers et al. [2013]).

Icon	Stage / Description of Actions
	A willingness to live with floods • Individual and small communities adapt to nature’s rhythm.
	A desire to use the floodplain • Fertile land in the floodplain is drained. • Permanent communities are established. • Local uncoordinated dikes are constructed
	A desire to control flood flows and defend against flooding • Large-scale structural approaches (dikes, dams, and other controls) are planned and implemented.
	A desire to reduce flood damages • A recognition that engineering alone has limitations. • Effort is devoted to increasing resilience of communities.
	A desire to manage risks effectively • A recognition that budgets are limited and not all problems are equal. • Risk management is seen as a means to target limited resources.
	A desire to promote opportunities and manage risks adaptively • Adaptive management used to work with uncertainties in future climate change, demographics, and funding.

In many regions where development pressures, similar to those experienced by the CVRD, are occurring around the world, governments’ abilities to find solutions to reduce risk are constrained by their path dependence. This has led decision makers to be “locked-in” to past policies and actions that favoured engineered structural approaches to flood management (Parsons, Nalau, Fisher, & Brown, 2019). The evolution of flood management described in Table 2-2 can help decision makers disrupt the path dependence and get on a risk reduction pathway. Risk assessment is a tool that can be used to help inform related decisions (see Appendix A for background on risk assessment).

2.4 Flood Risk Reduction Best Practice

Flood risk reduction is a challenging space. Fortunately, there are some guidance frameworks and principles that can be leveraged. These are described below.

2.4.1 Best Practice Frameworks

Many jurisdictions around the world are in the process of transitioning toward a risk-based approach to flood management[6]. A global driver is the Sendai Framework for Disaster Risk Reduction (Sendai Framework)[7]. The 10 golden rules of strategic flood management also provide practical insights on risk reduction.

2.4.1.1 <u>Sendai Framework</u>

Sendai is the global blueprint for reducing disaster risk and increasing community resilience. The goal of Sendai is to "prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures… to strengthen resilience". The framework is thus multi-disciplinary and follows four priorities (Figure 2-8). This project's activities fit within Priority 1.

Figure 2-8: Four priorities of the Sendai Framework for Disaster Risk Reduction.

The Sendai Framework recognizes that humans are at the centre of disasters. I.e., not only are humans responsible for increasing hazards, hazards themselves are not problematic unless they interact with humans. The framework thus places human decisions at the centre of disaster risk reduction, and advocates for a risk-based approach to managing multiple hazards (i.e., all-hazards approach).

The Federal Government is a signatory to the Sendai Framework, with Public Safety Canada as the lead agency[8]. The BC Government was the first jurisdiction in Canada to have formally adopted the Sendai

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[7] United Nations. Sendai Framework for Disaster Risk Reduction 2015-2030. Weblink: https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf. Accessed 24 May 2019.

[8] Public Safety Canada. Sendai Framework for Disaster Risk Reduction 2015-2030. Weblink: https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/pltfrm-dsstr-rsk-rdctn/snd-frmwrk-en.aspx. Accessed 4 July 2019.

Framework. It will form a cornerstone of BC's modernization of the *Emergency Program Act* [1996] (EPA)[9]. The Sendai Framework also contains language around Indigenous inclusion, which in BC aligns with the *Declaration on the Rights of Indigenous Peoples Act* [2019] (DRIPA).

2.4.1.2 The 10 Golden Rules of Strategic Flood Management

The consensus in global peer-reviewed literature is that implementing a holistic, risk-based approach to flood management reduces negative impacts while promoting other aspects of societal well-being over the long-term. In this section we draw on an internationally recognised paper by Sayers et al. (2014), which captures guiding approaches and rules for sound strategic flood management. This paper and framework have been cited upwards of 50 times in peer-reviewed journals in the five years since publication. Further, this paper and the 'golden rules' also map well with Sendai.

The Sayers et al. (2014) paper was co-authored by representatives of diverse perspectives (academic and government officials, engineers and planners) as well as recognized leaders in the field of flood risk management. The authors suggest that strategic flood risk management provides a means of working towards sustainable development, and associated social, environmental, and economic goals. However, they also acknowledge that resources to achieve this are limited, and that pragmatic trade-offs must be made between reducing flood risk and investing resources towards achieving other societal goals. In this respect, they emphasise the importance of investing resources effectively and efficiently.

Therefore, the primary goals of strategic flood management are to efficiently use limited resources to:

- Reduce risk to people and communities from flood sources;
- Promote ecosystem goods and services;
- Reduce risk to, and promote, economies; and
- Promote social well-being.

The authors note that these are lofty goals; however, programs aren't expected to reach these goals at the outset. Rather, the goals are intended to guide an iterative, adaptive strategic planning process. The authors go on to outline several common characteristics of successful, strategic plans including:

- They will be based on understanding of the whole-system behaviour and societal goals (i.e., consideration of cumulative pressures and associated values);
- Decision-making will be informed by knowledge of risk and uncertainty over time; and
- A portfolio of measures and instruments will be used to manage risk.

In addition to these characteristics, the authors present ten 'golden rules' for sound strategic flood management Table 2-3. The authors state that these 'golden rules' are necessary, but not necessarily sufficient, components of successful flood management.

[9] BC Emergency Program Act Modernization: https://engage.gov.bc.ca/govtogetherbc/consultation/emergency-program-act-modernization/. Accessed 14 May 2021.

Table 2-3: Ten Golden Rules of Strategic Flood Risk Management.

Rule	Description
1. Accept that absolute protection is not possible and plan for exceedance.	There will always be a bigger flood. Residual risk always exists and resilience to future, inevitable, flood events can be built through the planning process.
2. Promote some flooding as desirable.	The natural connection between land and water is critical. Floodplains provide fertile land and other ecosystem services in addition to accommodating flood waters.
3. Base decisions on understanding risk and uncertainty	Managers should not delay decision-making and action based on uncertainty. Rather, managers should draw on the available knowledge, explicitly account for uncertainty, and then monitor and adapt management plans with time.
4. Recognize that the future will be different from the past	Climate and flood risk are changing. Managers need to move beyond planning processes that focus on historic flood records and information, and account for future changes in flood risk.
5. Do not rely on a single measure; implement a portfolio of responses	Flood risk has multiple components. Management tools can be used to reduce hazard, exposure, and consequence while also working towards other environmental, economic, and social goals.
6. Utilize limited resources efficiently and fairly to reduce risk	A management plan should be tailored to the specific context, with consideration of not only the cost-efficiency of risk reduction outcomes, but also the fairness of these outcomes and the associated ecosystem enhancement opportunities.
7. Be clear on responsibilities for governance and action	Funding and decision-making should reflect shared responsibility. Collaboration on a watershed scale is critical to achieve shared outcomes and to avoid conflicts.
8. Communicate risk and uncertainty effectively and widely	The public does not often understand the degree of flood risk they face. Significant and targeted awareness programs are required to obtain greater public and political support for progressive management initiatives.
9. Promote stakeholder participation in the decision-making process	All interested and affected people play an important role in developing and delivering management activities. This should be done in a way that promotes "living with floods" rather than "fighting against them".
10. Reflect local context and integrate with other planning processes	There is a need for locally relevant and specific management planning, as opposed to focusing on compliance with a one-size-fits-all engineering standard.

The golden rules should be considered throughout the process of reducing risk from flood. Through the completion of this project, the CVRD has embarked on this path and has started addressing a few of the rules listed in Table 2-3. Sayers et al. (2014) mentions that plans themselves should be underpinned by a continuous process of monitoring and review to be flexible in shifting priorities and governance structures. Section 2.5 summarizes the flood management context for CVRD. These need to be taken into account when considering adaptation actions.

2.4.2 Adaptation Actions

Successful coastal flood adaptation actions require that successive or parallel processes be completed. For example, legislation and regulation which set the legal framework, guidance documents which provide interpretation of the regulations, funding programs and incentivize or disincentivize activities, and monitoring and enforcement of activities.

Given the systemic and broad issue of flood, there are innumerable activities and competencies that are required. In many cases there are dependencies between components and activities (e.g., property level building controls require local government building bylaws, potentially updates to provincial and federal building codes, guidelines, financing to incentivize the activity, as well as enforcement to ensure success).

Also, as noted in Sub-section 2.4.1.2, reliance on structural measures in the past, and the path dependence that is creates, is no longer considered as best practice. These solutions can no longer be considered as "fail-safe" alternatives. Rather, adaptation options should consider a full suite of options that encompass broad risk reduction strategies:

- Protect strategies (a mix of hard engineering and nature-based solutions).
- Exposure reduction strategies (land use activities to reduce the number of exposed assets, or to redistribute assets to make best use of the land).
- Vulnerability reduction strategies (building and planning, inclusive of social planning, strategies to reduce the susceptibility of people and the built environment to flood).

As well, strategies to increase resilience should complement the above. Often a suite of responses is appropriate as a means to achieve a desired level of risk. More information on the adaptation strategies considered for this project, is in Section 3.3.

2.4.3 Decision-Making Processes

As noted earlier, flood is a wicked problem with infinite potential impacts, and therefore decision-making to support flood risk reduction requires consideration of the many tradeoffs associated with flood. These include considerations to risk reduction (e.g., the potential number of structures that would or wouldn't be damaged, the potential for mortality, etc.) as well as commonly used criteria for government decisions (e.g., cost, public and/or political will, etc.).

In addition, most flood-management options involve the *definite* expenditure of resources and alteration of current land uses or environments to create new situations that, except during future *potential* flood events themselves, are otherwise less-desirable than they were before: a scenic beach becomes spoiled by a berm; a café near the shoreline has its view of the water obscured by a raised seawall. However, not all changes are negative. With an understanding of values, creativity, deliberation, and skill, mitigation features can become seamlessly integrated into the landscape. Nevertheless, where there is a need to take an existing location and intervene to incorporate features that are only necessary in rare flood events, controversy is to be expected. This will occur no matter which alternative option is selected.

To help the CVRD tackle controversial, or wicked problem, issues thoughtfully, a decision process was adopted. To develop a process that was robust, the principles of structured decision making (SDM) were considered (R. Gregory, L. Failing, M. Harstone, G. Long, T. McDaniels, 2012) and applied in a simplified manner (see Section 3.3). SDM is centred on a set of generic planning steps that guide working through decisions. The steps start with clarifying the decision context, and bringing stakeholders, partners, and decision-makers through to implementation. The steps are shown in Figure 2-9, and described below.

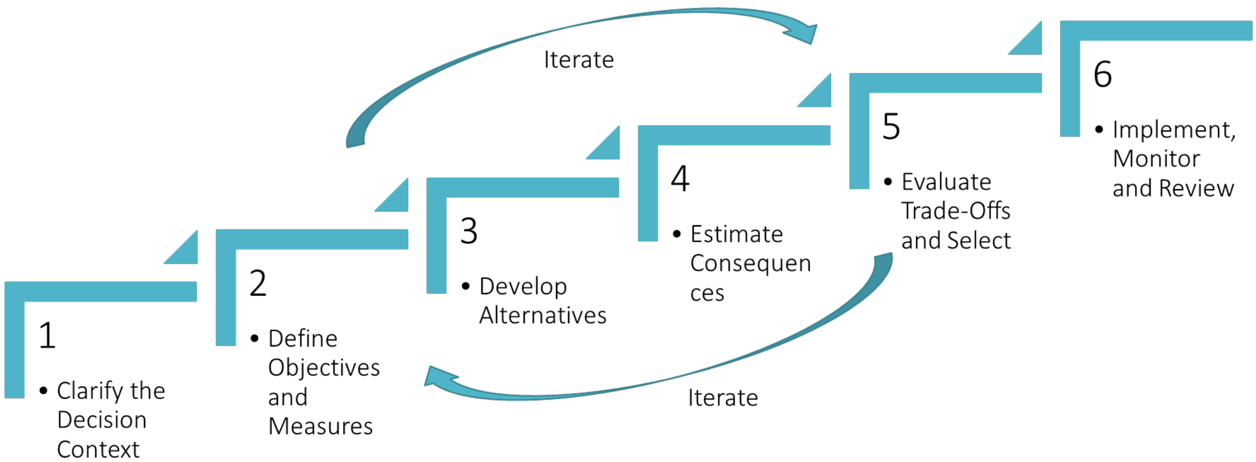

Figure 2-9: Example structured decision-making process (adapted from Gregory et al., 2012).

- **Step 1: Clarify the Decision Context.** This involves defining the geographic scope of the study, as well as the hazard assumptions. Other example assumptions could include growth projections and civil liability.
- **Step 2: Define Objectives and Measures.** Objectives are simple values-based statements of the things that matter to people when considering coastal flooding. They aim to capture many of the aspects that are important to local government staff, decision makers, and the public. Performance measures provide a means of assessing the suitability of different alternative options across objectives. Various methods may be used to estimate the value of the performance measures.
- **Step 3: Develop Alternatives.** These can range from conceptual-level strategies and pathways to more defined options, and specific actions that can be taken by a particular actor. Example coastal adaptation options include protect, avoid, retreat, accommodate, and resilience (PARAR; see Sub-section 3.3.2 for details).
- **Step 4: Estimate the Consequences.** This step involves estimating the performance of each alternative across objectives using the selected performance measures. Performance is measured using empirical data, models, or judgement. Consequence tables are used to facilitate comparison of the performance measures in rows, with each cell in the matrix indicating an alternative's performance on a particular measure. The performance of each alternative can then be compared against one another, facilitating the identification of key trade-offs for decision-making.

- **Step 5: Evaluate Trade-offs and Select Alternative.** This step involves comparing the performance of alternatives across objectives and performance measures to understand how they perform relative to each other, and to identify key trade-offs to be considered when selecting an alternative. It is also an opportunity to review and refine objectives and performance measures, and to iteratively improve alternatives and develop new hybrid alternatives designed to take the best aspects of existing alternatives to improve performance.
- **Step 6: Implement, Monitor, and Review.** Once an alternative has been selected, its implementation is monitored. The alternative's performance is reviewed at a pre-defined frequency (e.g., 5 years). This allows lessons to be learned for application elsewhere, and to make changes if necessary.

A decision-making process such as the one described above should feed the flood management governance process at federal and provincial levels and at local levels (discussed in Section 2.5).

2.5 CVRD Flood Management Context

This section describes key points related to flood management in the CVRD. It builds on information provided in the Phase 1 report. As a regional district, the CVRD plays a key role in flood management. It is responsible for providing services that reach across multiple jurisdictions, such as sewer and water services, watershed management, and emergency response. However regional districts such as the CVRD have little to no authority to implement flood management initiatives within municipal or First Nation boundaries. Collaboration among all governments is important to address the wicked nature of the problem (Ebbwater Consulting Inc., 2021a)[10]. To ensure consistency across the region, the CVRD must work with member municipalities and neighbouring First Nations.

2.5.1 Policies and Bylaws

The Phase 1 report included a scan of CVRD policy documents relevant to flood management. These documents outline strategies for emergency response during storm events, reducing flood impacts on existing properties in floodplain areas, and incorporating climate change considerations in infrastructure and development planning. The policy documents and their purpose are outlined below:

- **Floodplain Management Bylaw**, No. 600 (2020) – regulates flood construction levels, setbacks, and construction requirements for properties in unincorporated areas within the floodplain.
- **Rural Comox Valley Zoning Bylaw**, No. 520 (2019) – regulates development siting through setbacks and flood construction levels in the Floodplain Management Bylaw.
- **Regional District Building Bylaw**, No. 142 (2011) – requires building permits to adhere to setbacks, flood construction levels, and other siting requirements for flood management.
- **Rural Comox Valley Official Community Plan**, No. 337 (2014) – includes Development Permit Area (DPA) guidelines on shoreline and aquatic and riparian habitat protection measures for

[10] The report outlines the challenges of managing floods in BC due to their complex, systemic, and long-term impacts. It presents drivers for action on flood governance, as well as gaps and limitations of the existing governance model. A new model is also proposed. Weblink: https://www.fraserbasin.bc.ca/_Library/Water_Flood_BC/A-1_Flood_Risk_Governance.pdf. Accessed 16 December 2021.

waterfront properties.

- **Comox Valley Regional Growth Strategy**, No. 120 (2010) – includes policies for incorporating climate change into strategic decision-making.
- **Comox Valley Emergency Plan** (2018) – provides a high-level risk assessment for emergency events and preparedness, response, and recovery protocols to mitigate impacts.
- **Comox Valley Sustainability Strategy** (2010) – sets objectives for protecting and enhancing natural systems to support environmental services and health.
- **CVRD 2019 – 2022 Strategic and Financial Plan** (2019) – adopts climate change as a strategic driver for decision-making and requires climate change to be considered in every project.

2.5.2 Policies Relevant to Phase 2

The main policy drivers related to the Phase 2 of the CFAS is found in the Rural Official Community Plan (OCP). In an attempt to reduce the path-dependence described in Sub-section 2.3.4, Section 70.(9) (Coastal Areas) of the OCP states the following:

> *Generally prohibit hardening of the coastal shoreline through the use of rip rap, concrete embankments and revetment walls, and other similar structural interventions that alter the ecological function and service of the coastal shoreline, disturb natural vegetation, disrupt natural coastal processes, redirect wave energy to adjacent properties, and/or destroy coastal shore habitat, including forage and spawning areas. If a qualified professional has submitted development approval information that concludes that shoreline hardening is required to protect life or a principal building on the property and that the impacts of the proposed hardening can be mitigated, the board may consider issuance of a shoreline protection device development permit.*

2.5.2.1 Settlement Nodes

The Regional Growth Strategy (RGS) and the OCP designate Saratoga Beach and Union Bay as Settlement Nodes[11]. This designation is meant to direct growth and guide existing settlement/development to these areas. Each Settlement Node is unique and will be developed based on its particular characteristics. New Settlement Nodes can only be created through an amendment to the RGS. According to the RGS, Settlement Nodes are meant to accommodate growth through a balance of new development, intensification, and improvements to public infrastructure.

Policies outlined in the OCP include approving Local Area Plans (LAPs) within Settlement Nodes that establish the goals and objectives for residential, commercial, park, industrial and institutional land uses including a range of residential types and densities[12]; facilitating the provision of water and sewer services and to protect public health and the natural environment where on-site and privately owned systems are

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[11] Mt Washington is a third Settlement Node; however, it is located inland and was not considered in this project.

[12] The Saratoga LAP was drafted and brought forward for first reading. The LAP process has been placed on hold since the Oyster River Risk Assessment (Ebbwater Consulting Inc., 2018) was undertaken in 2018 as the project made it clear Saratoga was not an area the CVRD should be directing growth towards.

deemed to be insufficient; and promoting community facilities that enhance cultural activities, social interaction, and educational opportunities.

The OCP contains further details related to the vision for Settlement Node communities. It states that the nodes are "intended to be mixed density communities with a range of housing types, local service commercial uses and service industries to foster complete communities." The objectives for Settlement Nodes stated within the OCP consider equity issues. Objectives include ensuring that the design of the built environment strengthens and enhances the character of existing distinctive locations and neighbourhoods; integrating assisted and special needs housing; promoting complete communities and neighbourhoods where people can live, work, play and shop.

2.5.3 Green Shores

The CVRD is a part of the Green Shores Local Government Group where we participate in a peer network of learning and policy and project initiatives. Also, the CVRD encourages nature-based solutions to shoreline management through OCP policy and Development Permit Guidelines. Periodically, the CVRD hosts Level 1 Green Shores Workshops for members of the community to learn more about nature-based shoreline solutions[13].

2.5.4 Rainwater Management

The CVRD has considered rainwater management practices as a means of managing stormwater. Many of these practices have the objective of reducing pluvial flooding by increasing infiltration. Key practices include minimizing the area of impervious surfaces (such as roads and parking lots), and restoring and conserving natural areas. Continued development and implementation of these practices will complement efforts to adapt to coastal flooding[14].

2.5.5 Existing Infrastructure

Currently the CVRD does not have any major flood management structures, such as dikes, within its jurisdiction. However, within the project area, individual property owners have constructed flood and erosion protection works. A study conducted in 2018 found that over 60% of the shoreline between Saratoga Beach and Kin Beach has been visibly altered for this purpose, predominantly with hard structures such as rip rap or groyne installation (Current Environmental, 2018). The CVRD continues to collaborate with external and neighbouring groups to support a coordinated approach to flood and erosion management.

2.6 Summary

Understanding coastal flood hazards is a key component of the various components of risk (which also includes exposure and vulnerability) and undertaking a risk assessment. Risk assessment for natural hazards is a challenging and evolving field, and the level of effort required is very dependent on the use of the information, but also on the available data and resources. A true risk assessment, one that looks at

[13] Weblink: https://www.comoxvalleyrd.ca/greenshores. Accessed 20 December 2021.

[14] Weblink: https://waterbucket.ca/viw/files/2013/04/Fernhill_Rainwater-Management-Comox-Valley_Current-Practice-Future-Options_Feb-2013.pdf. Accessed 20 December 2021.

consequences for different likelihood scenarios over time, is an invaluable instrument to consider risk reduction best practices. Decision-makers, policy makers, and planners can use the outputs to consider adaptation actions following robust decision-making processes. To be successful in this process, an understanding of the regional flood management context is critical.

3 Methods

This section describes the approaches and methods used to meet the project goal and objectives. Methods are described for the two supporting components (engagement and risk assessment) and for the key development component (the creation and testing of a decision process). Although the supporting and key development components are presented as distinct here, the actual project effort involved considerable feedback and iterations between the components. Table 3-1 summarizes the rationale and activities for each project component (their interactions are illustrated in Figure 1-2).

Table 3-1: Summary of project supporting tasks and key outcome.

Project Component		Why Did We Do It?	What Did We Do?
Supporting	**Engagement Activities**	To strengthen relationships and shared understanding across the region, share information, and build capacity.	This component involved engaging with a wide variety of stakeholders, decision-makers, and partners to better understand local values related to coastal flood hazard. These values were then used to inform the types of options and the criteria used to understand tradeoffs between them. This element was a core component of the other two elements and occurred in three rounds.
Supporting	**Risk Assessment**	To better understand how hazard interacts with the valued assets exposed to them, both at regional and local scales.	This component built on the flood hazard modelling outputs from Phase 1, to provide an understanding of risk across the CVRD, including focus areas. While the element was primarily driven by quantitative data, it also considered qualitative information gathered through the engagement sessions.
Key Development	**Decision Process**	To develop a process and tool that the CVRD can use as a basis to make coastal flood adaptation decisions at local levels across the region.	This component consisted of developing and fleshing out possible adaptation options, informed by stakeholder and partner values and insight. Options were further developed based on a decision process applied in engagement sessions to compare adaptation strategies. The decision process was tested by applying it to one focus area, with an understanding that it could be refined and then applied to other focus areas in future steps of the project.

The methods used to carry out the three project components are described in the following sections.

3.1 Engagement Activities

Engagement aimed to increase the understanding and capacity of stakeholders to tackle difficult climate adaptation problems. The engagement activities also supported the consultant team to better understand the values of importance to people in the region.

A participatory approach is part of building a basis for future decisions that are more likely to be supported by stakeholders, partner organizations and the public, which will be key to the effectiveness of the CFAS overall.

The engagement component had the following objectives:

- To increase awareness and education among CVRD staff, stakeholders, partners, and the community to enhance coastal adaptation and flood risk understanding and capacity.
- To strengthen the relationship between the CVRD and external stakeholders.
- To support the consultant team to understand locally specific values.
- To share risk assessment information and inform the priority setting process.

The level of engagement in Phase 2 was mainly at the "Inform" and "Consult" levels of the IAP2 spectrum[15]. This was intentional at this time, as the project aimed to develop and test information and materials that would translate technical information about coastal flood hazard into decision-support tools and processes. This step will support a range of future possibilities to promote awareness and risk-based decision-making by individuals, agencies, and organizations in the region.

Due to the provincial guidelines around COVID-19, we held all sessions virtually using a range of online engagement platforms and techniques. We used a variety of tools and techniques to engage with four key groups: the CVRD Board, CVRD staff, stakeholders and partners, and the general public.

An overview of engagement activities in Phase 2 is provided in Figure 3-1. Pre-meeting packages for engagement Rounds 1, 2, and 3 are found in Appendices D, E, and F, respectively.

[15] Weblink: https://iap2canada.ca/. Accessed 15 October 2021.

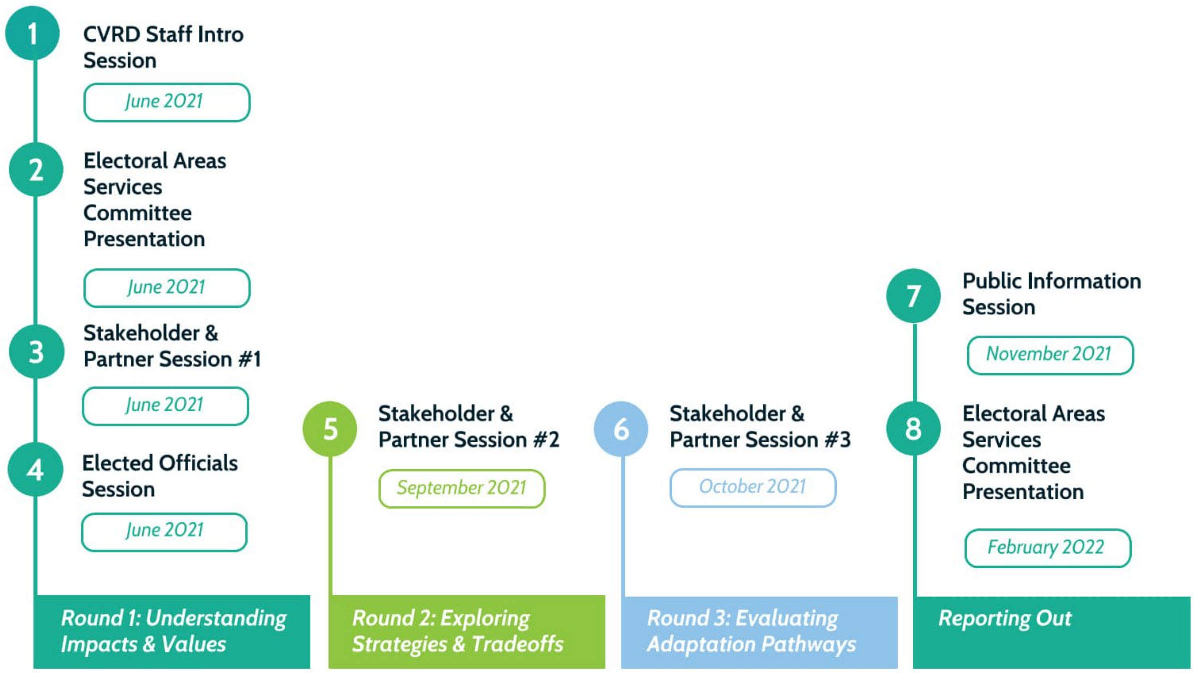

Figure 3-1. Overview of Engagement Activities in Phase 2.

3.1.1 Activity Summaries

3.1.1.1 CVRD staff Introductory Session

This meeting was held on 1 June 2021 and included staff from different CVRD departments (e.g., Engineering Services, Community Services, Corporate Services, Planning and Development Services, and Emergency Program). The objectives of the meeting included sharing best practice process in disaster risk reduction and developing a preliminary understanding and rationale for the screening-level selection of the project's focus areas. This informed decisions about what should be considered in the risk assessment and decision objectives. The meeting was intended to build in-house capacity by achieving a shared level of understanding of the CFAS among internal departments.

3.1.1.2 Electoral Area Services Committee Presentations

Two presentations were given to the CVRD's Electoral Area Services Committee (EASC). These presentations were relatively brief (15 minutes in duration) and served to keep board members up to speed on the CFAS project and provide a chance to ask questions. The first presentation was provided on 14 June 2021 and focused primarily on summarizing the Phase 1 project and introducing the Phase 2 project. The second presentation was provided at the end of the project (Feb 2022).

3.1.1.3 Stakeholder and Partner Engagement Sessions

A series of three sessions held with stakeholders and partners who were invited to participate in the whole series, formed the core of the engagement component. Each session was opened with a welcoming prayer by K'ómoks Elder Vivian Fortin.

The sessions are described below. The invitation to attend the sessions was sent to over 70 representatives of organizations, sectors, and groups with an interest or stake in coastal flooding and actions to adapt to this challenge. Staff were invited from across a wide range of departments within local government. Elected officials from all governments in the region (K'ómoks First Nation, Comox Valley Regional District, City of Courtenay, Village of Cumberland and Town of Comox) attended one or more sessions.

The organizations that participated include:

- Comox Valley Regional District
- K'ómoks First Nation
- City of Courtenay
- Town of Comox
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD - Marine Planning)
- Regional District of Nanaimo
- Strathcona Regional District BC Ferries
- BC Hydro
- Project Watershed
- Comox Valley Conservation Partnership
- Comox Valley Land Trust
- Comox Valley Community Health Network
- Island Health

The elements of each round of engagement are outlined below:

Round 1

- Shared best practice approaches to planning for coastal flood risk.
- Provided an overview of past and present project work, including results from the Phase 1 (Coastal Flood Mapping) project.
- Gathered input on key values and impacts.

Round 2

- Provided a recap of what was heard during Session 1.
- Discussed key messages and best practice responses.
- Presented preliminary regional and focus area risk results.
- Introduced adaptation strategies (i.e., PARAR).
- Discussed trade-offs associated with various options and the values on which they are based.
- Introduced the decision process.
- Conducted breakout sessions for relationship-building and to obtain feedback on decision criteria and strategies.

Round 3

- Presented the adaptation pathway concept.
- Reviewed and discuss the four adaptation pathways and preferred options.
- "Stress-tested" preferred options by considering four tipping points.

3.1.1.4 Public Information Session

At the end of the project, an information session was held to more widely introduce the project and its results so far. Over 200 people registered, with attendance of approximately 148 people. This created an opportunity to share some core concepts for understanding coastal flood risk and made space for participants to ask questions of the consultant and CVRD representatives about an array of topics relating to flood hazard in the region. A recording of the session along with an "FAQ" document based on the questions asked in this session, is available on the CVRD's website[16].

3.2 Risk Assessment

The risk assessment component of the project provided key technical information to support the decision process. The following sections summarize the approach, followed by the hazard and indicator data layers that were used. The method used for risk classification is then described, followed by the limitations. Details on the risk assessment methods are found in Appendix A.

3.2.1 Approach

The risk assessment applied an index-based approach that relied on spatial processing and classification to build on the results presented in previous chapters. As shown in Figure 3-1, likelihood was determined based on three coastal flood extent layers. The consequences were considered based on a set of six indicators (further described in Sub-section 3.2.3): affected people, mortality, economy, environment, culture, and critical infrastructure. All the spatial processing and mapping was completed using QGIS.

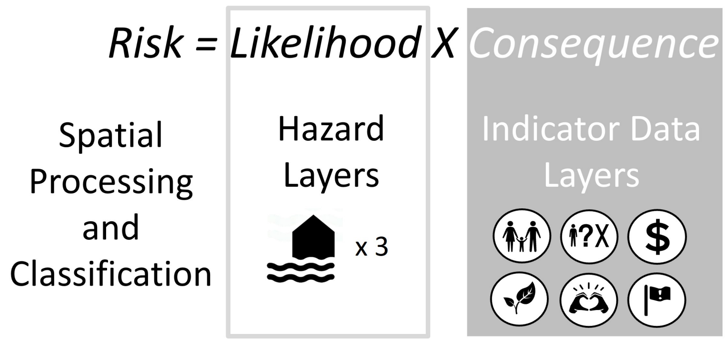

Figure 3-1: Summary of risk assessment approach.

The following sections describe the likelihood and consequence components of the risk assessment. The components are combined and the risk results for the indicators are then presented. Due to budget limitations, the risk assessment was primarily quantitative; a relatively small amount of qualitative information was obtained through the broader engagement process to assess adaptation options. Ideally, a qualitative information gathering process would be conducted for the purpose of a risk assessment.

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[16] Weblink: https://www.comoxvalleyrd.ca/projects-initiatives/past-current-projects/coastal-flood-adaptation-strategy. Accessed 16 December 2021.

3.2.2 Hazard Layers

A first step in understanding risk is to develop and map the hazards. We developed hazard scenarios based on the following information and principles:

- A review of the 20 scenarios mapped in Phase 1, which were a combination of 4 SLR and 5 coastal storm AEP floods.
- A desire to provide the CVRD with risk results that were based on a simplified yet robust range of scenarios.
- An understanding that differences between flood extents for different storm intensities are relatively minimal for different AEP floods. This is mostly due to the shape of the frequency-magnitude curve for storm events, which rises steeply before becoming quite shallow (i.e., the difference in flood elevation decreases substantially for the rarer events).
- A review of recent SLR projections for the project area (see Sub-section 2.1.2).
- A sensitivity analysis of the three hazard layers, based on data for two indicators (Section 3.2.3), conducted for two focus areas. Details are in Appendix B.

3.2.2.1 <u>Scenarios Selected</u>

Based on the above principles, we selected three coastal flood hazard scenarios from the Phase 1 data. Two AEP floods were considered within the selected scenarios. The 10% AEP flood is meant to represent a flood that would have occurred in the recent memory of the community members. In contrast, the 0.5% AEP flood is a very large but very rare event. SLR projections of 0.5 m and 1.0 m were also considered within the selected scenarios.

The coastal storm and SLR projections were combined into three scenarios, which are framed in terms of their planning range timelines (i.e., short-term, mid-term, and long-term). While timelines are not explicitly associated with the scenarios, generally the planning range can be loosely linked to the present-day, and the years 2060, and 2100, respectively.

The short-term planning range scenario is a flood with more frequent probability of occurrence, and no sea level rise. The long-term scenario is a flood with less probability of occurrence, and 1 m of sea level rise. The mid-term planning scenario has the same probability of occurrence as the long-term scenario; however, it includes half the amount of SLR (0.5 m) (Table 3-2).

Table 3-2: Selected hazard layer scenarios selected for the risk assessment.

Planning Range Scenario	Annual Exceedance Probability[1]	Encounter Probability over 25 years[2]	Relative Sea Level Rise	Surface Area (ha)	Proportion of Maximum Surface Area (%)
Short-term	10%	93%	0 m	1060	75%
Mid-term	0.5%	12%	0.5 m	1318	93%

Planning Range Scenario	Annual Exceedance Probability[1]	Encounter Probability over 25 years[2]	Relative Sea Level Rise	Surface Area (ha)	Proportion of Maximum Surface Area (%)
Long-term	0.5%	12%	1.0 m	1417	100%

Notes:
1 – The 10% AEP flood has indicative return period of 10 years; the 0.5% AEP flood has an indicative return period of 200 years.
2 – Obtained from Table 2-1.

Following best practice guidance (detailed in Appendix A), each of the three flood hazard layers was assigned a confidence rating of high.

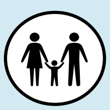
3.2.3 Indicator Data Layers

As discussed in Section 2.3 (and in more detail in Appendix A), consequences are a function of exposure and vulnerability characteristics within the hazard extents. For this high-level risk assessment, quantitative vulnerability characteristics were not included. Only limited vulnerability data was available, and methods that consider vulnerability in the Canadian context are in their infancy (Lyle and Hund, 2017). Therefore, the consequence assessment focused on exposure datasets. The following sections describe the wide range of data gathered.

3.2.3.1 Proxy Exposure/Consequence Information

Based on national and international best practice (UNDRR 2015, 2016, 2017; AIDR 2015; BC MECCS 2019), we selected a set of six indicators, aimed at providing a holistic view of potential consequences. Table 3-3 indicates which proxy data was used in consequence scoring, along with key limitations. The indicators are not listed in any order of importance. Details on the data sources and important data gaps are in Appendix A.

Table 3-3: Indicators for flood consequences assessed in this report. Based on Stantec Consulting Ltd. and Ebbwater Consulting Inc. (2017); AIDR (2015); UNDRR (2016).

Indicator	Description of Data Proxies	Confidence Rating
Affected People 	The location and number of affected people was determined based on census and building centroid data. The estimated population was used for consequence scoring.	Moderate
Mortality 	This indicator is a fraction that was applied based on results for the affected people indicator.	Very Low

Indicator	Description of Data Proxies	Confidence Rating
Economy	We considered building and property values. For flood hazard, only buildings values were used for consequence scoring.	High
Environment	This indicator usually includes the overflow or discharge of contamination sources into the receiving environment, in combination with damage to exposed environmentally sensitive areas that could be negatively affected. Limited data on sources of contamination were used for consequence scoring, meaning that the results should be considered with caution.	Low
Culture	We included community buildings, heritage sites, as well as Indigenous and non-Indigenous archaeological sites. Recreational trails were also considered but not included in consequence scoring.	Very Low
Critical Infrastructure	Consequence scoring was based on the number of critical infrastructure facilities. Power distribution poles were also considered but were not used in the consequence scoring.	Moderate

The indicator data described above was used both at the regional scale and for the Saratoga Beach focus area. For the Saratoga Beach area, the consequences were complemented with qualitative information gathered during one of the engagement sessions. Results from both analyses are presented in Chapter 4.

3.2.4 Risk Classification

As shown in Figure 4-11, the hazard and consequence results were combined applying spatial processing and classification. These steps are explained in the following sub-sections. Risk results were produced exclusively for the regional scale. The results provide a means to understand and prioritize risk reduction activities across the region. They also provide context to interpret the consequence results obtained for the Saratoga Beach focus area.

3.2.4.1 Spatial Analysis

Mapping processes were applied to determine where the indicator data spatially overlapped with the modelled hazard extents. The 18 data combinations in these overlapping areas (i.e., 3 flood scenarios and 6 indicators) was aggregated to quantify the consequences and produce associated maps. Separate hazard and consequence maps were also produced for Saratoga Beach. All the spatial processing and mapping was completed using QGIS software.

3.2.4.2 Scoring

The flood scenarios were assigned a frequency of occurrence, using a 5-point scale, to obtain a score associated with a likelihood ranging from *almost certain* to *very rare* (see Appendix A). For this project, the processed hazard data layers were only associated with the scores of *likely* and *unlikely* (i.e., 4 and 3); these are shown by the bold text in Table 3-4. Note that the likelihood scores were based on the associated AEP of the planning range scenario flood extent; SLR was not considered.

Regional-Scale Risk Scoring:
The classification of consequence data, and subsequent scoring, was only conducted for the regional-scale data, and using absolute consequence results. At the local scale, aggregated consequence data was used, but it was not deemed necessary to classify and score it.

Similarly, for each indicator, a 5-point scale was used to score consequences ranging from *negligible* to *catastrophic* (an example is shown for the affected people indicator in Table 3-5. The consequence scoring criteria were drawn from national and international best practice approaches (Public Safety Canada, Natural Resources Canada, National Research Council) (AIDR, 2015; Stantec Consulting Ltd. and Ebbwater Consulting Inc., 2017).

Table 3-4: flood hazard likelihood scoring, based on (Australian Institute for Disaster Resilience, 2020; Stantec Consulting Ltd. and Ebbwater Consulting, 2017; Verga, 2013).

Planning Range Scenario	Likelihood Qualifier	Score
-	Almost certain	5.0
Short-term (10% AEP + 0.0 SLR)	Likely	4.0
Mid-term (0.5% AEP + 0.5 SLR)	Unlikely	3.0
Long-term (0.5% AEP + 1.0 SLR)	Unlikely	3.0
-	Rare	2.0
-	Very rare	1.0

Table 3-5: Example scoring for the affected people indicator, drawn from (Australian Institute for Disaster Resilience, 2020; Stantec Consulting Ltd. and Ebbwater Consulting, 2017).

Consequence Criteria	Consequence Description	Score
Number of affected people > 10,000	Catastrophic	5.0
Number of affected people > 1,000 and ≤ 10,000	Major	4.0
Number of affected people > 100 and ≤ 1,000	Moderate	3.0
Number of affected people > 10 and ≤ 100	Minor	2.0
Number of affected people ≤ 10	Insignificant	1.0

3.2.5 Limitations

There are several limitations associated with the risk assessment. Related to the hazard layers, assumptions were required to transform the hazard layers produced in Phase 1 into a usable format for the risk assessment. The sensitivity analysis showed that different methods of achieving this presented advantages and disadvantages, and that a simplification of the layers was necessary. Three coastal flood hazard scenarios were selected and used within the risk assessment. While this approach follows best practice, the number of scenarios is not sufficient to complete a fully probabilistic risk analysis. Such an analysis was beyond the scope of this project.

There were also limitations related to the indicator layers. Limitations to the affected people indicator consequences included uncertainties related to the method of population distribution across the CVRD and outdated 2016 Census data. For the economy indicator consequences, we did not consider the range of potential direct and indirect economic losses besides building values. We conservatively used the 'whole' building values to calculate the consequences. In reality, building damages are likely to be a proportion of the total value. For the environment, culture, and critical infrastructure indicators, only limited datasets were available (not all local cultural sites, critical facilities or contamination sources were captured in the datasets).

The risk analysis contains the inherent limitations with the hazard assessment, as well as the exposure and consequence assessment methods. Appendix A describes the confidence rating system applied to the risk results.

Despite the limitations summarized above, a variety of quantitative data gathering activities were conducted to understand the consequence and risk associated with coastal flood in a fulsome manner. The method followed a logical flow starting with a hazard assessment, exposure, and consequence assessment, followed by risk scoring. The quantitative analyses were conducted in a consistent, robust, and scientifically reproducible manner, considering a set of holistic consequence indicators.

3.3 Development of the Decision Process

The decision process was the key development of the project. Its purpose was to build capacity within the CVRD to apply a tool to make coastal flood adaptation decisions at local levels across the region.

A scanning-level process was developed, inspired by Structured Decision Making (SDM) (see Sub-section 2.4.3). It contained several of the steps required in the SDM approach; however, the core steps were simplified with the aim of providing the CVRD with a tool that could be used to reproduce the process again. The decision process consisted of the following steps:

- Step 1: Identify Values and Determine Evaluation Criteria
- Step 2: Develop Options
- Step 3: Assess Options

Throughout the development of the process, the process "zoomed-in" and "zoomed-out" depending on whether it was important to consider the big picture, or to appreciate local-scale nuances that could highlight potential trade-offs. This process of shifting scales is described in the blue boxes within the following sub-sections.

Due to the iterations that occurred throughout the project progress, the following terminology variations were used/evolved related to adaptation approaches.

- **Adaptation option:** This term was used generally to describe the various adaptation concepts and ideas that can be used to mitigate flooding. The term was used more prominently within the initial stages of the project, and throughout when adaptation approaches were being discussed in a broad sense.
- **Adaptation strategy:** This term was used specifically to describe the five strategies that, collectively, are defined by PARAR (i.e., protect, accommodate, retreat, avoid, and resilience). The strategies were introduced in engagement Round 2.
- **Adaptation pathway:** This term was used to describe four pathways, which consisted of combinations of the strategies described above. The pathways were the focus of discussions in engagement Round 3.

3.3.1 Step 1: Identify Values and Determine Evaluation Criteria

Defining the values that people have in a community is critical to understanding what matters to them when they consider coastal flood. Round 1 and 2 of engagement provided insight into values and preferences held by a range of stakeholders. This process considered both regional and local scales (as explained in the box to the right). Based on these values, together with technical considerations, and best practice (e.g., Sendai) a set of evaluation criteria were developed.

Evaluation criteria can refer to the people, places, and things for which flood impacts should be minimized (e.g., the health and safety of people, environmental assets, and property). Criteria also include measures for assessing different adaptation options. Various methods may be used to define scales for measuring each criterion – some are quantitative (e.g., # of properties impacted) while others are qualitative measures (e.g., high, medium, low).

Zooming-out: What values are common to the region?

Values were identified that could apply across the project area.

Zooming-in: Are there location-specific values?

Four focus areas (Saratoga Beach, Comox Road, Goose Spit and Union Bay) were considered to gain an appreciation for the nuances of location-specific contexts that exist.

As a baseline, we first developed a detailed evaluation framework to help the project team consider a wide set of criteria and performance measures. The framework was separated into the evaluation of options based on their effect during a flood, and the effect of the option itself (i.e., how the option performs the rest of the time). The *effects during a flood* considered holistic objectives that related to risk reduction criteria (e.g., how many fewer people and properties will stay dry?), and resilience criteria (e.g., how will emergency response be affected?).

The effects of the *option itself* were also included within the evaluation. Key criteria within this part of the evaluation included consideration of both positive and negative externalities (e.g., what effects does the option have on ecological health? Does the option damage or improve recreational opportunities?), as well as implementation (e.g., what are the costs and regulatory requirements?).

The detailed evaluation framework was simplified using simplified criteria and categorized performance measures. The tool was also evolved iteratively with the development of the adaptation options (Step 2, Sub-section 3.3.2). In the simplified form of the evaluation criteria, the separation of the *effects during a* *flood*, and the *effects of the option itself*, were maintained (see Step 3, Sub-section 3.3.3). The simplified criteria provide an excellent base for communication with decision-makers and the public. They can also be used for initial screening of options and considering general trade-offs between adaptation options. However, when more detailed work is completed, the full list of criteria and performance measures is an important assessment tool.

3.3.2 Step 2: Develop Options

The selection of preferred options often comes down to values-based trade-offs. For example, is it better to accept the loss of tax revenues from increased development in the floodplain by holding the land and developing park spaces, or to accept the occasional costs associated with response and recovery to the increased development areas? Should government help a location become more resilient to occasional floods, or try to prevent it from ever getting wet? These questions have no technically optimal answers. An informed consultation of this kind requires communication about what the choices might entail and analysis of how these choices might affect the things people value the most.

To support discussion around choices and trade-offs, a high-level description of five common adaptation strategies was provided: Protect, Accommodate, Retreat, Avoid, and Resilience-Building (i.e., PARAR). Within each strategy there are a range of actions and options that could be implemented, and the strategies themselves are interconnected. An overall coastal flood adaptation strategy would likely include a combination of actions from many, or all, of these strategies.

In engagement Round 2, we discussed PARAR strategies at both local and regional scales as described in the box to the right. The sections below briefly summarize each adaptation strategy, including a list of typical actions within each. More details are found in Appendix E, including a comparison of advantages and disadvantages and further web resources.

Zooming-in: What values and trade-offs are associated with different strategies for the Saratoga Beach focus area?

We discussed various perspectives on strategies using the Saratoga Beach area as a focus. This helped to consider real-world issues and trade-offs that would be in play when deciding between options.

Zooming-out: How do these strategies fare for the project area?

The strategies were considered, at a high-level, for higher-risk areas within

3.3.2.1 Protect (Structural)

This strategy reduces the hazard by building infrastructure to keep floodwater out and shield areas and community assets. The strategy's concept is visually summarized in Figure 3-2.

Typical actions for this strategy range through educational, planning, and building options and include:

- Building large structural works such as shoreline and inland dikes, and seawalls.
- Construction of offshore features to help reduce wind and wave action (e.g., hardened sea barrier), or construction of hardened shorelines to reduce the power of wave action on the foreshore.

Figure 3-2: Conceptualization of the protect (structural) strategy.

3.3.2.2 Protect (Green)

This strategy reduces the hazard by restoring previous, enhancing existing, or constructing new nature-based features to reduce the power of the hazard and guard areas and community assets (see Eyquem (2021), and Sub-section 2.5.3 on GreenShores). Solutions are predominantly sediment- or vegetation-based. The strategy's concept is visually summarized in Figure 3-3.

Typical actions for this strategy range through educational, planning, and building options and include:

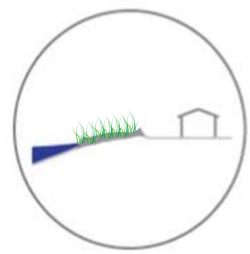


Figure 3-3: Conceptualization of the protect (green) strategy.

- Enhancement of natural offshore features (e.g., island restoration).
- Planting shoreline or submerged vegetation such as salt marshes and sea grasses to absorb wind and wave energy.
- Stabilizing shorelines using cobble berms, beach nourishment, and bioengineered fibre blankets.

3.3.2.3 Accommodate

This strategy reduces vulnerability by using a range of actions to allow flooding to occur with minimal damage / consequence. It is sometimes described as a "living with water" strategy, in the sense that humans adjust to accommodate the presence and movement of water. The strategy's concept is visually summarized in Figure 3-4.

Typical actions for this strategy range through educational, planning, and building options, and they include:

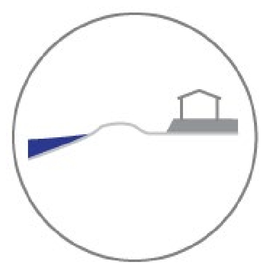


Figure 3-4: Conceptualization of the accommodate strategy.

- Giving nature the space to adapt gradually over time in natural and undeveloped areas using nature-based approaches such as constructed wetlands and beaches to manage erosion and wave effects.
- Using Flood Construction Levels to raise the height of the damageable components of structures.

- Retrofitting infrastructure, buildings, and communities over the natural building cycle to be flood-resilient.
- Raising the physical height of municipal services (roads, water, etc.) over time and taking advantage of regular planned infrastructure turnover cycles (e.g., asset management).
- Incorporating flood-resilient design adjustments to building codes and using options and incentives to help residents and businesses improve property-level protection.

3.3.2.4 Retreat

This strategy reduces exposure by moving existing structures out of flood risk areas. The strategy's concept is shown visually in Figure 3-5.

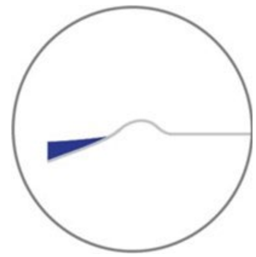


Figure 3-5: Conceptualization of the retreat strategy.

Typical actions for this strategy range through educational, planning, and building options and include:

- Moving high-risk structures out of flood-prone areas.
- Opportunistic buyouts as homes and businesses come up for sale over time, with more aggressive buyouts as hazard becomes greater with climate change.
- Opportunistic removal of roads, other infrastructure, and contaminants as land is vacated.
- Implementing renaturalization and restoration.

3.3.2.5 Avoid

This strategy reduces exposure by preventing or limiting development within the floodplain through planning tools. These actions reduce risk by avoiding increases in the three components of risk (hazard, exposure and vulnerability).

Typical actions for this strategy range through educational, planning, and building options and include:

- Developing tools such as flood bylaws to put in place the regional vision.
- Establishing policy and planning tools such development permit areas, sea level rise planning areas, and setbacks that guide future development to avoid building critical infrastructure in flood-prone areas.
- Integrating future flood hazard area considerations within guidance documents such as regional growth strategies and official community plans.
- Protection and restoration of natural assets.
- Creating watershed-based land use authorities and legislation.

3.3.2.6 Resilience-Building

In contrast to the previous four adaptation strategies, resilience-building is less about reducing risk and more about helping communities bounce back from flood events. It covers all aspects of work with the community to enhance its ability to cope with and recover from flood events, and the cumulative effects of change.

Typical actions for this strategy span educational, planning, and building options and include:

- Engaging broadly in planning for coastal flood risk, to build understanding and capacity of the community to address risk and build resilience (individual and collective).
- Educating and engaging the public about the short and long-term risks, and how they can take steps to improve their physical, social, and psychological resilience.
- Having tough conversations about values, trade-offs, risk tolerance and change, to develop shared understanding and direction over time.
- Grow social connectedness/capital (emphasis on care for vulnerable populations, shift to a low-carbon economy).
- Developing neighbourhood-level preparedness and resilience-building programs, being mindful of issues of equity
- Developing supports for dealing with psychosocial impacts of anticipated and experienced impacts.
- Creating flood recovery plans in advance of events, to enable communities to "build back better".
- Developing robust emergency preparedness and response plans (e.g., flood monitoring and warning systems) to limit damages during a flood event.

3.3.3 Step 3: Assess Options

Initial feedback was obtained from stakeholders and partners based on the range of adaptation strategies introduced in engagement Round 2. From this input, four adaptation pathways were developed by the project team. Pathways are descriptions of an imagined, but plausible, set of actions to address flood risk and resilience that would take the community in different directions. For the most part, the discussions in Round 3 focused on the local context. However, as described in the box to the right, some consideration of the regional context was also required.

Zooming-In: What Pathways Are Possible for Saratoga Beach?

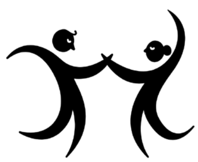
The Saratoga area was used as an example to help stakeholders and partners think about more tangible, place-based contexts, that would affect adaptation decisions.

Zooming-out: How Could They Be Affected by Tipping Points?

To stress-test the pathways at the local scale, regional-scale tipping point scenarios were considered.

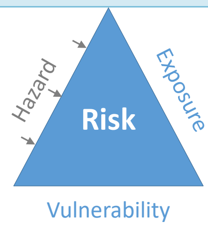
The pathways were developed specifically with reference to the Saratoga Beach area, to make the exercise more realistic and relatable to participants. The pathways reflect some of the preferences, values, and challenges identified by participants in engagement Round 2. Their short descriptions are provided in Table 3-6. Note that a fifth pathway (i.e., do nothing) is not described in Table 3-6, but such a pathway was considered in the assessment for comparative purposes.

Table 3-6: Adaptation pathway names and short descriptions.

Adaptation Pathway	Short Description
1. Staying Put and Taking the Edge Off 	• Maintain current settlement and use patterns. • Focus on physical protection, primarily focused on green infrastructure with some use of hard infrastructure. • Investment in emergency plans, early warning and monitoring. • Individuals are more aware of risks (hazard area disclosure statements), may choose. floodproofing measures for their homes, and can opt for insurance (if they can afford it). • Critical infrastructure gradually flood-proofed.
2. Dancing Out of The Way 	• Focus on education, communication and capacity building for joint decisions. • Phased approach focuses on land use patterns and managed retreat over time. • Post-disaster recovery plans include options for buy-outs and relocation. • Zoning / bylaws directs density and high value assets away from hazard areas, accompanied by incentives.
3. Putting on Raincoats 	• Focus on education, communication to support individual choices. • Flood Construction Levels implemented. • Extensive guidance, incentives and opportunities to encourage floodproofing of properties by individuals. • Funding and resources provided to ensure more equitable implementation. • Builds region-wide emergency preparedness, volunteership, neighbourhood preparedness programs.
4. Strengthening the Village 	• Ongoing education, communication and shared learning to build awareness and capacity for collective action. • Planning and zoning tools change land use patterns over time. • Avoids further development in hazard areas. • Prioritizes ecological restoration. • Partnership-based approach (with KFN, community partners, CVRD, etc.) builds relationships, shared investment and culture. • Risk and benefits distributed across the community over time.

Considering the pathways as a planning approach was based on best practice guidance for adaptation actions (see Sub-section 2.4.2); each pathway consisted of a combination of adaptation strategies that had been presented previously. The multiple adaptation strategies emphasized within each pathway is shown in Table 3-7. Whether the pathway works by way of reducing the hazard, exposure, or vulnerability, is also indicated using the “riskier triangle” concept, which was introduced in Section 2.3.

Table 3-7: Summary of adaptation pathways presented.

	Staying Put and Taking the Edge Off	Dancing Out of the Way	Putting on Raincoats	Strengthening the Village
Strategies Emphasized	Protect (green) Protect (structural) Resilience (residual risk)	Avoid Retreat Resilience	Accommodate Resilience	Resilience Retreat
Primary Influence on Risk Reduction				

3.3.3.1 Assessment Characteristics

A variety of characteristics were assessed by the project team to compare pathways. These characteristics included the pathway's flexibility and divergence from the status quo. A pathway's flexibility describes the ease of changing direction or reversing a decision over time, should climate or other risk be different than what is expected today. In general, a pathway is considered more robust to a range of possible future conditions, when it is flexible. How much the pathway diverges from the current situation (status quo) is a key issue affecting feasibility of implementation (as identified in Round 2).

Some adaptation options will take many years or decades to implement, while others can be implemented immediately. In contrast, some options can become more effective as the flood hazard increases (e.g., retreat), while others may cease to be effective at all, beyond a certain point (e.g., protect). These characteristics were assessed by the project team in terms of the pathways' effectiveness and residual risk.

3.3.3.2 Assessment Criteria

Based on the detailed adaptation options evaluation criteria presented in engagement Round 2 (Step 1, Sub-section 3.3.2), the criteria were simplified to compare pathways. However, consistent with the initial criteria, the pathways criteria considered the effects of the pathway *during a flood*, as well as the effects of the pathway *itself* (i.e., the rest of the time).

For the evaluation purposes, the simplified criteria presented in Round 3 (Step 3) were categorized according to values-based, cost-based, and feasibility-based performance measures. The values-based criteria were those that were informed by the project team's judgement and feedback obtained during

Round 2. These criteria included human health and safety, residential properties, culture, etc. The cost-based criteria were included by the project team to compare costs related to economic impacts, as well as costs related to implementation and maintenance. The feasibility-based criterion was included to consider feasibility factors such as regulatory requirements and political will. Table 3-8 summarizes the simplified evaluation criteria and the categories used to develop the performance scales.

Table 3-8: Simplified criteria and categories used to develop the performance scales.

	Criteria	Category
Effect of Pathway During a Flood	Human Health and Safety	Values-based
	Residential Properties	Values-based
	Culture	Values-based
	Infrastructure	Values-based
	Economy	Cost-based
Effect of Pathway Itself	Community Involvement	Values-based
	Environment	Values-based
	Recreation	Values-based
	Implementation Cost	Cost-based
	Maintenance Cost	Cost-based
	Feasibility (regulatory, political, etc.)	Feasibility-based

The performance scales developed for the criteria categories are shown in Table 3-9. The performance scale was applied considering what conditions would be like in the future if a “Do Nothing” (status quo) pathway was followed.

Table 3-9: Performance scales for criteria categories.

Criteria Category	Performance Scale (relative to status quo)						
Values-based	Much Worse	Worse	Slightly Worse	Neutral	Slightly Better	Better	Far Better
Cost-based[1]	$$$	$$	$	Neutral	-$	-$$	-$$$
Feasibility-based	Very Challenging	Challenging	Slightly Challenging	No Change	Not applicable[2]		

Note 1: Costs are presented as order of magnitude. Where $ represents a cost less than approximately $100,000, $$ represents a cost less than $1M and $$$ is a multi-million-dollar cost.
Note 2: It is assumed that no pathway’s feasibility is higher than the status quo.

The pathways were evaluated by the project team at a high-level (see Sub-section 4.5.2). Note that the evaluation process was meant to highlight *potential differences between the hypothetical pathways*. This led to conversations around what other criteria should be considered to better define pathways and distinguish them from each other. The process was not designed to select one pathway over another for implementation.

3.3.3.3 Stress-Test: Considering Tipping Points

The pathways were further discussed and assessed during Round 3, in terms of four hypothetical events or "tipping point" scenarios that could destabilize the area's socio-political and economic foundation. The effects of these events were discussed to identify in what ways any of the pathways fared better than others.

The tipping points considered were as follows:

- System shock caused by a large earthquake.
- No financial assistance following a flood caused by a macro-economic downturn.
- Accelerated damages from flooding due to runaway climate change.
- Loss of public trust due to political instability.

While in the past this exercise may have seemed hypothetical, it has become a lot more realistic and relevant, even during the span of this project. Over the year that this project has been conducted, the project area has experienced numerous overlapping stressors including the COVID-19 pandemic, drought, extreme heat and extreme rainfall, with associated social, political and economic implications. The catastrophic flood event that struck southern BC in November 2021 is a further illustration of this type of phenomenon being a real and current possibility.

3.3.4 Limitations

The decision process that was adopted was based on a simplified version of SDM. It was designed to be a scan, and to be easily repeatable by the CVRD in future. The process allows for preferred options (or low-hanging fruit) to be identified more easily. It also allows for least preferred options to be discounted. This approach also provides additional information on the weak points of an option that might be improved by augmenting the concept, or alternately might be complemented with a second or third option to better score across all criteria. Thoughts from stakeholders and partners related to these issues are presented in Chapter 4.

We caution that the decision process that was developed does not provide 'an answer'. As demonstrated through its development, the provision of a single solution does not in itself make a lot of sense. Rather, in the local context, the process can be used to inform subsequent deliberation over different options, to ultimately identify combinations of options that could best address the range of impacts, values, and preferences present in that location.

3.4 Summary

The methods used to reach the project goals were iterative and informed through engagement and risk assessment. These project components in turn supported the development of decision-support tools and a process. The decision process involved developing a range of adaptation options, which evolved from strategies to pathways based on feedback obtained during the engagement sessions. Together, the outputs from the project components provide a source of rich information and tools to inform further phases of engagement, planning, and decision-making.

4 Results

As outlined in the previous chapter, a number of iterative steps were taken for this project. The following sections present the results of the values explored and defined in the initial engagement sessions. This is followed by the results for the regional-scale (zoomed-out) risk assessment, followed by the Saratoga Beach (zoomed-in) consequence assessment. Key insights and themes from stakeholder and partner engagement sessions are summarized at the end of this chapter. This provides guidance for development of adaptation options.

4.1 Values within the Comox Valley

One of the main objectives of this phase of work was to develop a values-based tool to support decision-making related to coastal flood risk and risk reduction activities. Therefore, it was first necessary to understand what values, relevant to coastal flood, are held by stakeholders within the Comox Valley.

Through three rounds of stakeholder and partner engagement (see Section 3.1), feedback was obtained related to the participant's values in relation to coastal flood risk and resilience. Insights on values was obtained by implicit observations through conversations; they were also obtained explicitly by asking two key questions, as discussed in the following sub-sections.

4.1.1 Living in a Coastal Region

Participants were asked, in a number of ways, to share what they value most about living in a coastal region. The responses are summarized in Figure 4-1.

Figure 4-1: Round 1 participant responses: what do you value about living in a coastal region?

Responses fell into the following five top categories, with the number of individual responses indicated in parentheses:

- Environment, nature, biodiversity (39)
- Recreation and access to nature (21)
- Beauty and aesthetics (10)
- Fresh air (4)
- Peacefulness (3)

4.1.2 Characteristics of a Resilient Region

This project focuses on building resilience to coastal flood hazard; therefore, we also asked participants to share their ideas of what makes for a resilient region. These ideas provide an indication of desirable qualities and elements to include in potential strategies and approaches. The responses are summarized in Figure 4-2.

Figure 4-2: Round 1 participant responses: what makes for a resilient region?

Through a number of discussions, the following key themes emerged. Examples of the types of responses under each theme are provided below.

- **Collaboration and relationships** (trust, partnerships, working together, whole community, formal and informal networks, common goals).
- **Flexibility and creativity** (responsive, bouncing back, open to change, movement).
- **Diversity** (types of knowledge, cultural diversity, ecological / landform diversity, accessibility).
- **Community involvement** (local governments reaching out, many perspectives, positions, opinions).

- **Nature and stewardship** (conservation, natural assets, shoreline, vegetation).
- **Capacity and resources** (infrastructure, expertise, people, self-sufficiency).
- **Being informed and prepared** (education, communication, sharing information, build understanding, emergency management, proactive).

Building on the question of resilience, we asked participants in Round 1 of the engagement to share ideas about, specifically, what is most important when it comes to building resilience _to coastal flood risk in the region_. We repeated this question at the end of Round 3. Key themes we heard are in Table 4-1:

Table 4-1: Participant responses: what is most important when it comes to building resilience to coastal flood risk in the region?

Round 1	Round 3
• Understand and Communicate Risk • Plan and Prepare • Informed, Inclusive Decision-Making Process • Update Legislation • Address Land Use and Development • Adapt New and Existing Infrastructure • Prepare Existing Residential Areas	• Build Community, Capacity and Collaboration • Be Proactive • Flexibility / Adaptability • Nature-Based Solutions • Good Design • Equity

The responses in Round 1 provide a strong set of considerations for what actions or elements we need to include when planning for coastal flood risk. Round 3 responses, provided after deep consideration of different potential options, speak more to *how* participants would approach these elements, when building resilience to coastal flood risk.

4.1.3 Support to Evolving Adaptation Options

The values identified in engagement Round 1 informed the development of the criteria used in the decision process. This was achieved through a process of simplifying the decision criteria (see Section 4.4). The simplified criteria were also used in the process to evolve the adaptation strategies into adaptation pathways (see Section 4.5).

Even after the adaptation pathways were developed, the values discussion continued in later stages of the project (as shown in the Round 3 column in Table 4-1). An important value that was highlighted in engagement Round 3 was “equity”. While this influenced design of the adaptation pathways, it was not adequately reflected in the criteria, and deserves more systematic consideration in future decision processes.

4.2 Regional Risk Assessment

A quantitative risk assessment was completed at the regional scale based on the workflow described in Sub-section 3.2.1. Results were determined for the project area to support identification of areas with high risk. The procedure provides a consistent, robust, and scientifically reproducible means of comparing a range of hazard likelihoods and consequences. The results provided a basis to support discussions throughout the development of the decision process.

The following sections discuss the map outputs, coastal flood hazard extents, consequences for 6 indicators, and risk matrices.

4.2.1 Maps Design

Results of the regional coastal flood risk assessment are provided spatially in large-size (ANSI D format) suitable for printing using a plotter. Table 4-2 summarizes the maps. Map 1 shows the coastal flood hazard extents (see Sub-section 3.2.2 for details on the layer selection and Appendix B for a sensitivity analysis) for the project area (see Figure 4-3). Maps 2 to 6 show these hazards, in addition to the consequence results, for the 6 indicators. These risk maps also contain insets for the four focus areas (Saratoga Beach, Goose Spit, Comox Road, and Union Bay).

Table 4-2: Regional scale risk map book summary.

Map Type	Scales Shown	Map	Information Shown
Hazard	Regional scale	1	Short-, mid-, and long-term planning range scenario coastal flood hazard extents
Risk[1]	Regional scale plus focus area insets	2	Affected people indicator
		3	Economy indicator
		4	Environment indicator
		5	Culture indicator
		6	Critical Infrastructure indicator

Note 1: All ris maps show the hazard layers shown in Map 1.

The maps were designed to clearly organize and display the multiple spatial results. The three planning range flood scenarios are layered, with the short-term planning range scenario on top. Transparency is used to provide an understanding of key features on the land that is flooded. The maps use the indicator icons to clearly distinguish between the consequence maps.

4.2.2 Hazard Extents

Flood hazard extent maps show the overall area where flooding may occur. The map we produced, based on a review of the Phase 1 work including a sensitivity analysis and hazard layer selection (see Sub-section 3.2.2 and Appendix B), is shown in Figure 4-3. The darker blue areas show coastal flood hazard extents associated with the short-term scenario (likely flood event with no SLR; this is a small flood). The lighter shades of blue represent coastal flood hazard extents associated with the mid- and long-term scenarios (both unlikely flood events, with 0.5 m and 1.0 m SLR, respectively. These are larger floods).

Flood hazard extents are well distributed throughout the project area. Unsurprisingly, the hazard areas are low elevation waterfront areas that are typically desirable places to live (i.e., coastal areas in CVRD). Notable areas that are flooded even during the short-term planning range scenario include the Saratoga Beach area (see Figure 4-10 for detail) and Seaview Road, Little River, Queen's Ditch, Goose Spit, Courtenay River Estuary, Royston, Union Bay, Tsable River Estuary, Ships Point, and Fanny Bay. Figure 4-3 clearly shows that, even under the short-term scenario, the Ships Point peninsula is cut off from the mainland due to the flooding

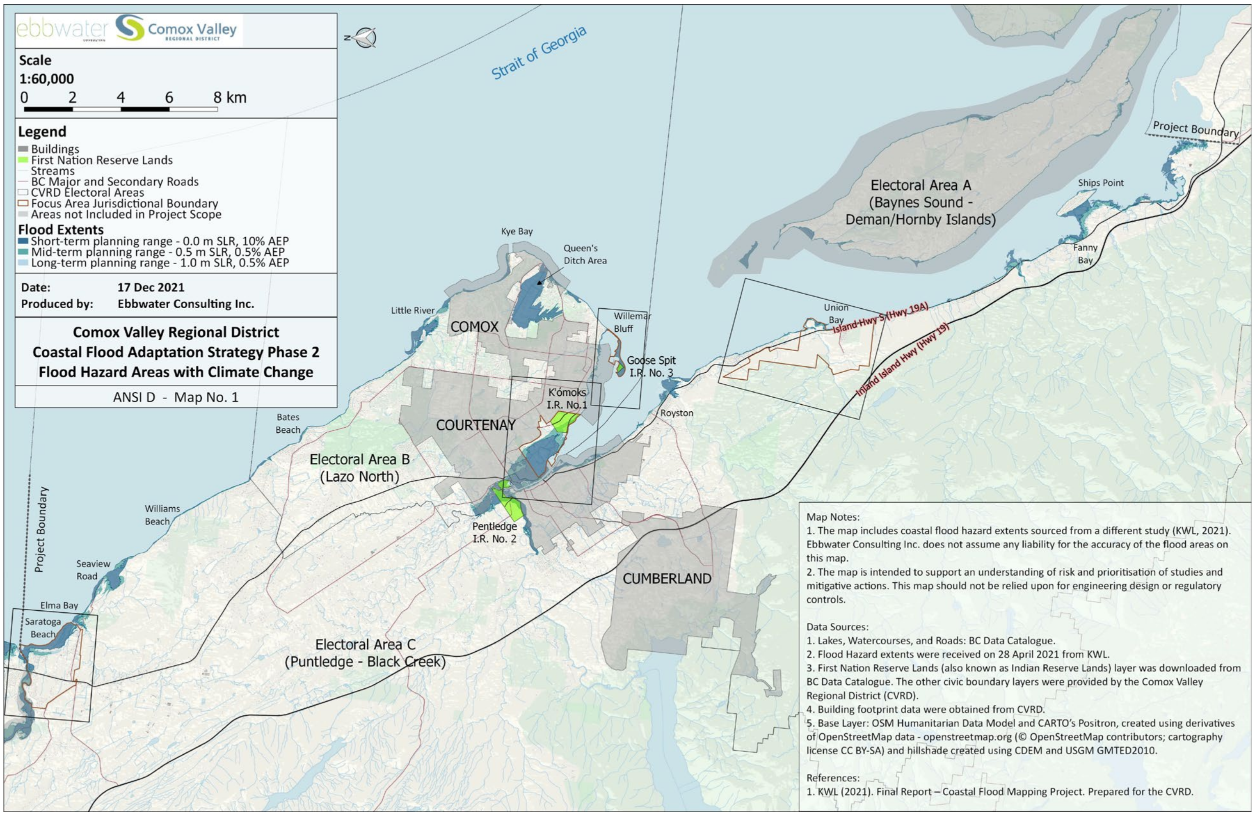


Figure 4-3: Coastal flood hazard extent in the CVRD project area (large-size map is included in Appendix C).

Over the whole project area, the area susceptible to flood ranges from 1060 ha to 1417 ha depending on the planning range scenario (Table 4-3); the majority of hazard areas are flooded in the short-term. As shown in the last column of Table 4-3, there is marginal increase of 34% in land that is flooded in the long-term scenario as compared to the short-term scenario. Relatively large encroachments of flood waters are seen in flatter areas such as beaches and low-lying agricultural land. However, coastal areas within the project area are generally steep enough to limit the inland extent of higher flood waters associated with the mid- and long-term planning range scenarios. Finally, when viewing the flood maps, it is important to note that not all areas are likely to flood *at the same time*, as the direction of a storm and the aspect of a particular piece of land play a large role in how high local water levels get.

Table 4-3: Surface areas affected by the flood scenarios.

Planning Range Scenario	Surface Area Affected (ha)	Marginal Increase in Surface Area Compared to the Short-term Scenario (%)
Short-term	1060	Not applicable
Mid-term	1318	24
Long-term	1417	34

4.2.3 Consequences

The consequences were determined by aggregating the proxy data for each indicator, for each of the three planning range scenarios. The results are provided both visually through mapping, and through descriptions, in the following sections.

4.2.3.1 Spatial Distribution

The spatial distribution of consequences differs depending on the indicator (i.e., affected people, economy, environment, culture, disruption). Figure 4-4 shows the consequences for the affected people indicator, as an example. The map shows "hot spots", where areas of larger concentration appear as darker shades of red. For example, the Saratoga Beach and Little River areas stand out in this scenario because these areas have the largest number of people within a hazard area.

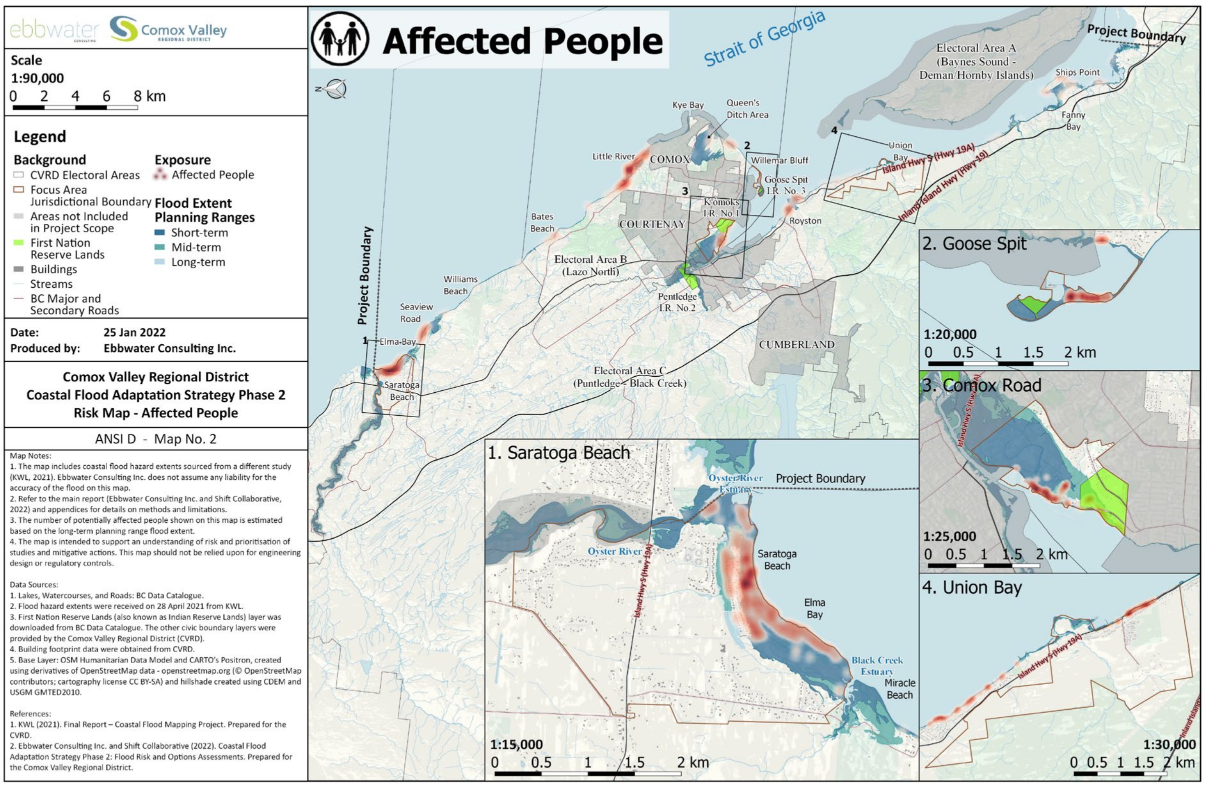


Figure 4-4: Map showing affected people indicator data in the CVRD project area for the three planning range scenarios. Large-size printable maps are provided in Appendix C.

For the affected people indicator, building centroids and population data were used. Approximately 60% of the estimated 2,115 people affected by the long-term scenario are affected by the short-term scenario. This confirms that a large proportion of people live within near-term flood hazard extents. Approximately 86% of people affected by the long-term scenario are also affected by the mid-term scenario.

The maps of other consequence indicators (economy, environment, culture, critical infrastructure) for the project area are in Figure 4-5 to Figure 4-8. Section 4.3 discusses the consequences to these indicators for the Saratoga Beach area.

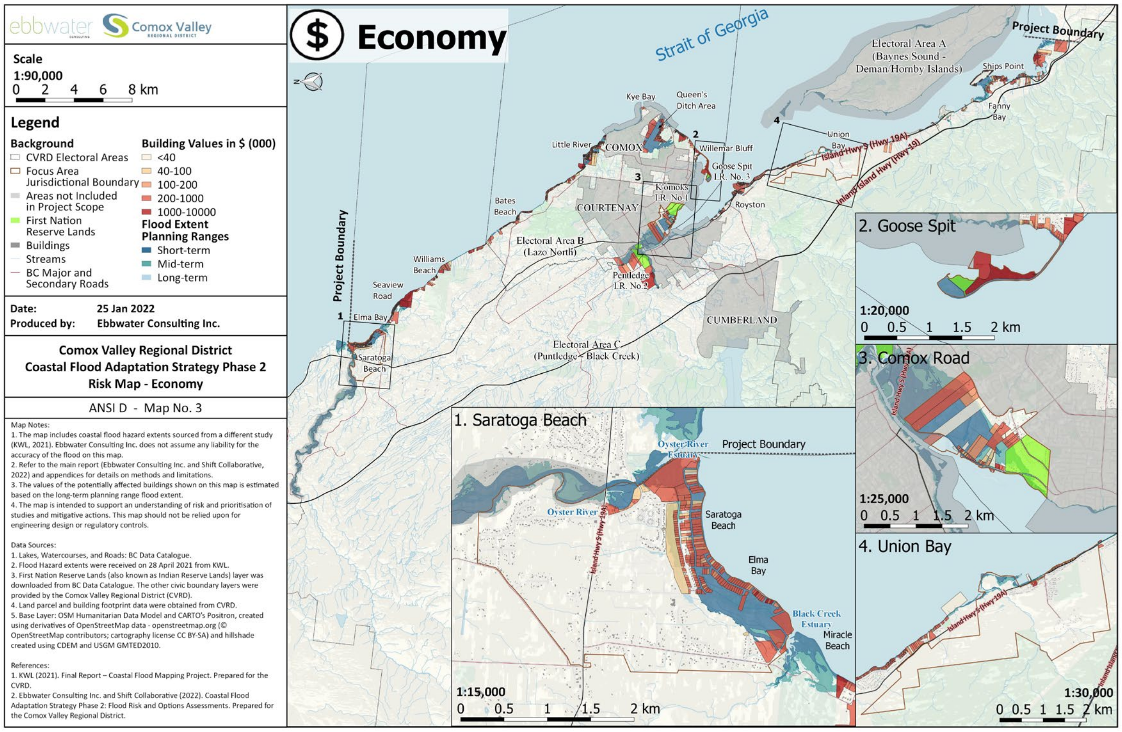


Figure 4-5: Map showing economy indicator data in the CVRD project area for the three planning range scenarios. Large-size printable maps are provided in Appendix C.

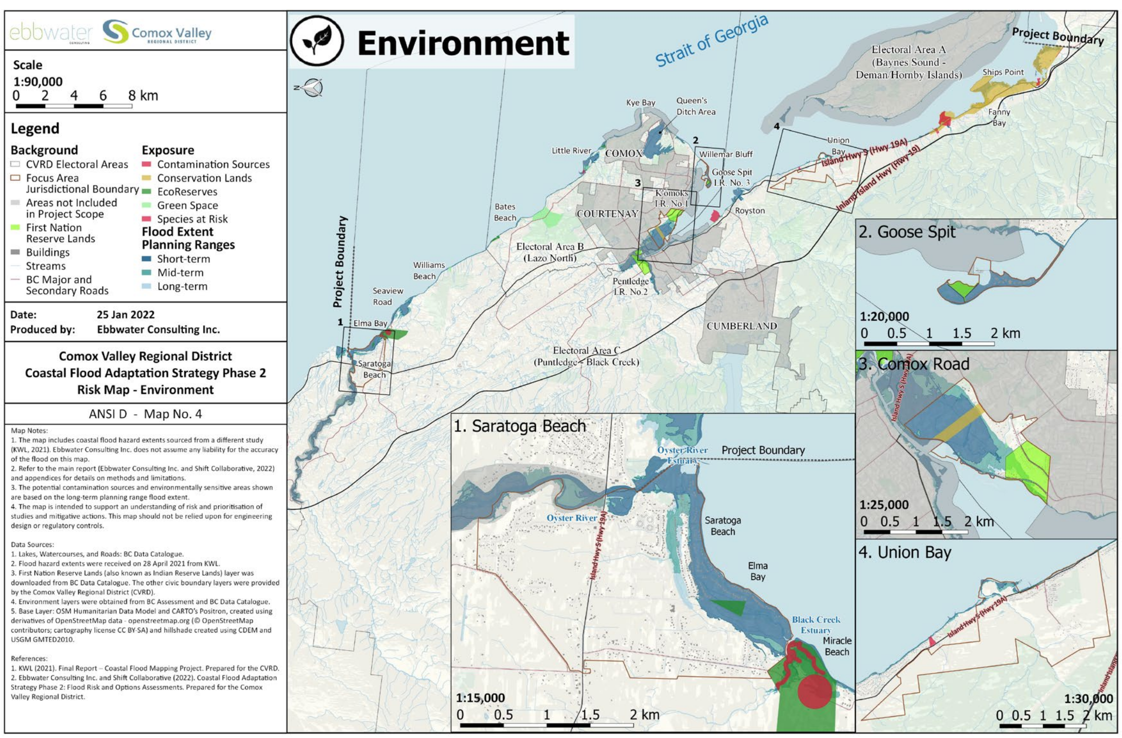


Figure 4-6: Map showing environment indicator data in the CVRD project area for the three planning range scenarios. Large-size printable maps are provided in Appendix C.

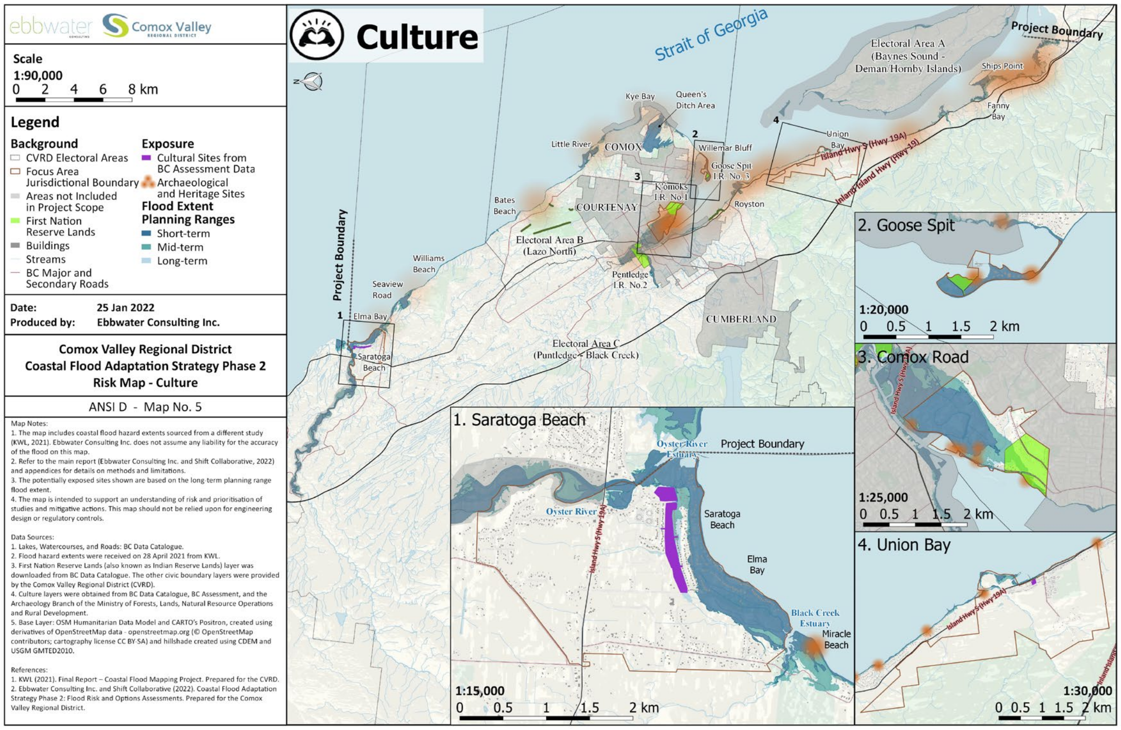


Figure 4-7: Map showing culture indicator data in the CVRD project area for the three planning range scenarios. Large-size printable maps are provided in Appendix C.

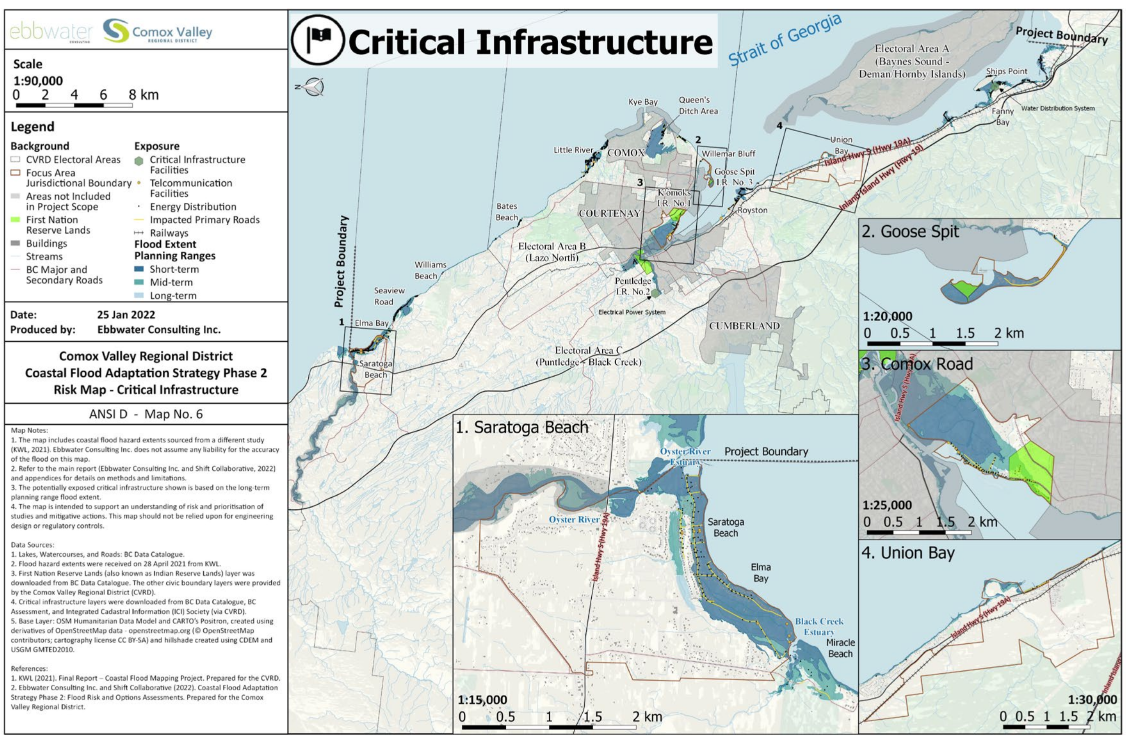


Figure 4-8: Map showing critical infrastructure indicator data in the CVRD project area for the three planning range scenarios. Large-size printable maps are provided in Appendix C.

4.2.3.2 Indicator Results – Quantitative

Table 4-4 summarizes the results for the 6 indicators for the project area. Note that for all indicators, the minimum quantitative consequence values are caused by the mid-term scenario and the maximum consequences values are caused by the long-term scenario. Please see Sub-section 3.2.5 and Appendix A for discussions on limitations of the datasets used for this analysis.

Table 4-4: Summary of regional-scale quantitative consequence results.

Indicator	Key Findings
Affected People	• The estimated number of potentially affected people ranges from 1,253 to 2,115 (up to approximately 10% of the project area population). • 59% and 85% of the total number of people potentially affected by flood are exposed to the short- and mid-term scenarios, respectively.
Mortality	• Based on the method used, the consequences for people related to missing or mortality cases is negligible (<0.3 for the long-term scenario).
Economy	• The number of parcels exposed to the flood ranges from approximately 1400 to 1800 in the project area. • The total exposed assessed building (improved) values (2020) ranges from approximately $450M to $540M for short- and long-term scenarios, respectively (all figures in Canadian dollars). • 83% and 94% of the total building value potentially affected is exposed to the short- and mid-term scenarios, respectively. This confirms that disproportionately higher amounts of buildings, and building values, are exposed to flooding that is likely in the nearer term.
Environment	• The number of exposed contamination sources is 20 for the short- and mid-term scenarios and is 23 for the long-term scenario. • The total number of contamination sources is likely underestimated, as other important local sources such as septic systems were not included in the analysis, due to data availability limitations. • In terms of sensitive ecosystems, approximately 26-33 ha of species at risk, 26-30 ha of greenspace parks, 19-36 ha of eco-reserves, and 326-459 ha of conservation land areas may be affected by flooding. • The total land of exposed to sensitive ecosystems ranges from approximately 397 ha to 558 ha.
Culture	• The total number of exposed sites ranges from 54 to 64. • The number of Indigenous sites affected ranges from 50 to 56. • The length of recreational trails exposed ranges from 0.7 km to 1.2 km.

Indicator	Key Findings
Critical Infrastructure	• 1 critical infrastructure facility (electrical power system) is exposed to the short-term scenario and 2 facilities (water distribution system) are exposed to the mid- and long-term scenarios. • 2 electrical transmission structures, regardless of the flood scenarios, and 461-863 electrical distribution poles are exposed to flooding. • 13 telecommunication facilities are exposed to the short and mid-term scenarios, and 19 facilities are exposed to the long-term scenario. • The length of the roads exposed to the flood scenarios ranges from 15.3 km to 25.8 km (including Highway 19A); approximately 0.1 km of railroad is potentially affected regardless of the planning range scenario.

The results from the regional risk assessment, which covered approximately 90% of the CVRD by area and 30% of the CVRD by population, show that consequences will affect a range of assets that are valued in the region. Approximately 10% of people in the project area (3% of people within the CVRD) are exposed to coastal flood hazard. There is a potential for approximately $0.5B in building damages. The natural systems within the project area can help buffer flood hazards; however, contamination resulting from spills occurring in floodwater is likely to affect receiving environments and cultural artefacts. Floods are likely to create cascading disruptions due to impacts to critical infrastructure that include electrical power and water distribution systems, telecommunications, and roads. The infrastructure underpins many services that are relied upon in the region for basic health and livelihood.

4.2.3.3 Likelihood and Consequence Scoring

The quantitative risk results were obtained by classifying the likelihood and consequence data, assigning scores, and subsequently multiplying those scores. Table 4-5 shows an example of the scores determined for the affected people indicator. The classification tables for each indicator are found in Appendix A.

Table 4-5: Example consequence and likelihood scores for the affected people indicator.

Planning Range Scenario	Hazard / Likelihood		Consequence		Risk Score
	Extent (ha)	Score	People Affected (#)	Score	
Short-term	1060	4	1253	4	16
Mid-term	1318	3	1814	4	12
Long-term	1417	3	2115	4	12

4.2.4 Risk Matrices

Risk scoring results for the project area are shown in the six matrices in Figure 4-9. The results are distinguished by way of flood hazard icons of different sizes; the larger icon represents the mid- and long-term flood hazard scenarios and the smaller icon represents the short-term scenario.

Note that, based on the scoring classifications used for all indicators, the likelihood and consequence scores for the mid- and long-term scenarios were equivalent (as shown in Table 4-5). This means that the differences between these scenarios is small or negligible. This result is significant, as it means that the changes in SLR between the mid- and long-term (i.e., 0.5 m to 1 m) are likely to have a relatively small effect on flood risk.

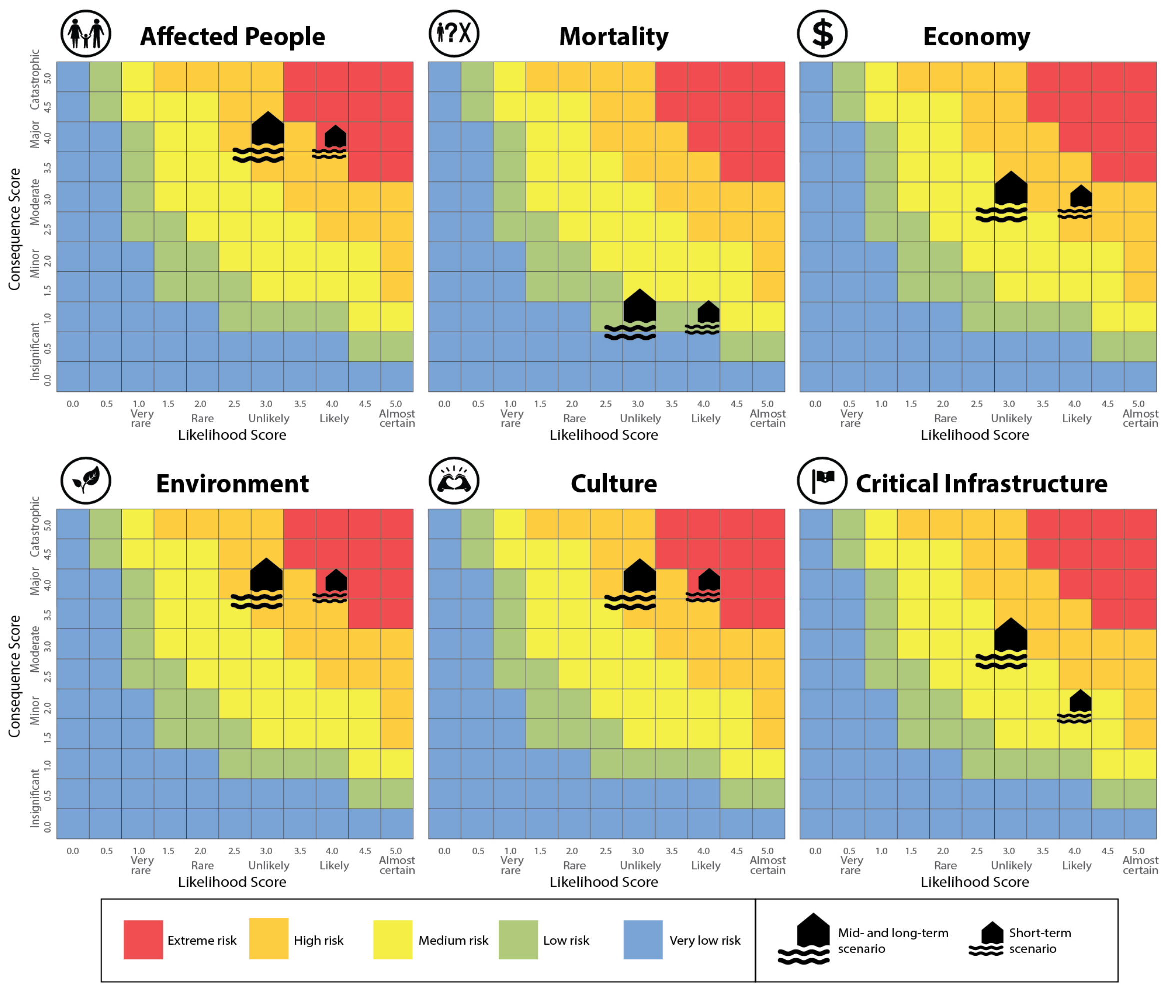


Figure 4-9: Risk matrices for the project area.

The following patterns are observed based on the matrices for the project area:

- The risk from the short-term scenario (i.e., frequent flood event with no SLR) is generally higher than the risk for the mid- and long-term scenarios (i.e., rare flood event with SLR). **This suggests that prioritization should be placed on adapting to the short-term scenario.**
- For the short-term scenario, the risk for the affected people, environment, and culture indicators is *extreme*, followed by the economy (*high*), then critical infrastructure (*medium*). The risk to mortality indicator risk is *low*.

- Under all planning range scenarios, the risk for the affected people, environment, and culture indicators is generally higher than the risk for the other indicators.
- Most risk results are at least medium (i.e., 15 out of 18 results).

The results provide a basis to prioritize local scale coastal flood mitigation activities. The type of risk results presented above could also be determined in future work for specific areas, while integrating more quantitative and qualitative data sources.

4.2.4.1 Risk Confidence

The risk confidence scores were determined by combining the hazard and consequence confidence ratings. The confidence rating for the hazard layers was high (see Sub-section 3.2.2). The consequence indicators confidence ratings are presented in Table 3-3 , and they ranged from very low to high. Based on the confidence ratings for hazard and consequence, a risk confidence rating of "moderate" was assigned to most of the indicators used in this assessment; the exception is with the economy indicator, which has a risk confidence rating of "high" was assigned to the economy indicator. Detailed information on risk confidence can be found in Appendix A.

The full quantitative results are provided to the CVRD in spreadsheet format. The results also include the consequence assessment results for the Saratoga Beach area, presented in the next section.

4.2.5 Support to Evolving Adaptation Options

The regional-scale risk assessment results provided a few insights to steer the decision process. First, the spatial distribution of risk confirmed that the focus areas that had been identified early in the process were indeed areas of high risk, based on data for a variety of indicators. Second, the consequence assessment showed that these differ depending on what is being measured, and that different adaptation options are required to minimize those consequences. Third, the risk results identified that efforts to adapt are needed now to mitigate risk related to the short-term planning range scenario. These insights were integrated into the evolved adaptation options (see Section 4.5).

4.3 Saratoga Beach Consequence Assessment

A consequence assessment was conducted for the Saratoga Beach area to support discussions around adaptation options (see Section 4.5). The following sub-sections present results for hazard extents, and consequences for this focus area. Note that risk matrices were not developed for this area as it was felt that these would provide marginal benefit to support discussions.

4.3.1 Hazard Extents

The areas susceptible to flooding in the Saratoga Beach area ranges from 87 ha to 111 ha. This is shown in Figure 4-10 and is listed in Table 4-6. Flooded areas occur on shorelines due to direct coastal flooding, and in-land areas where water intrudes through low-lying topography (see annotations in Figure 4-10). Like the regional scale results, there is marginal increase in areas exposed to the mid- and long-term scenarios, as compared to the short-term scenario. In this sense, the Saratoga Beach area is representative of the regional scale area.

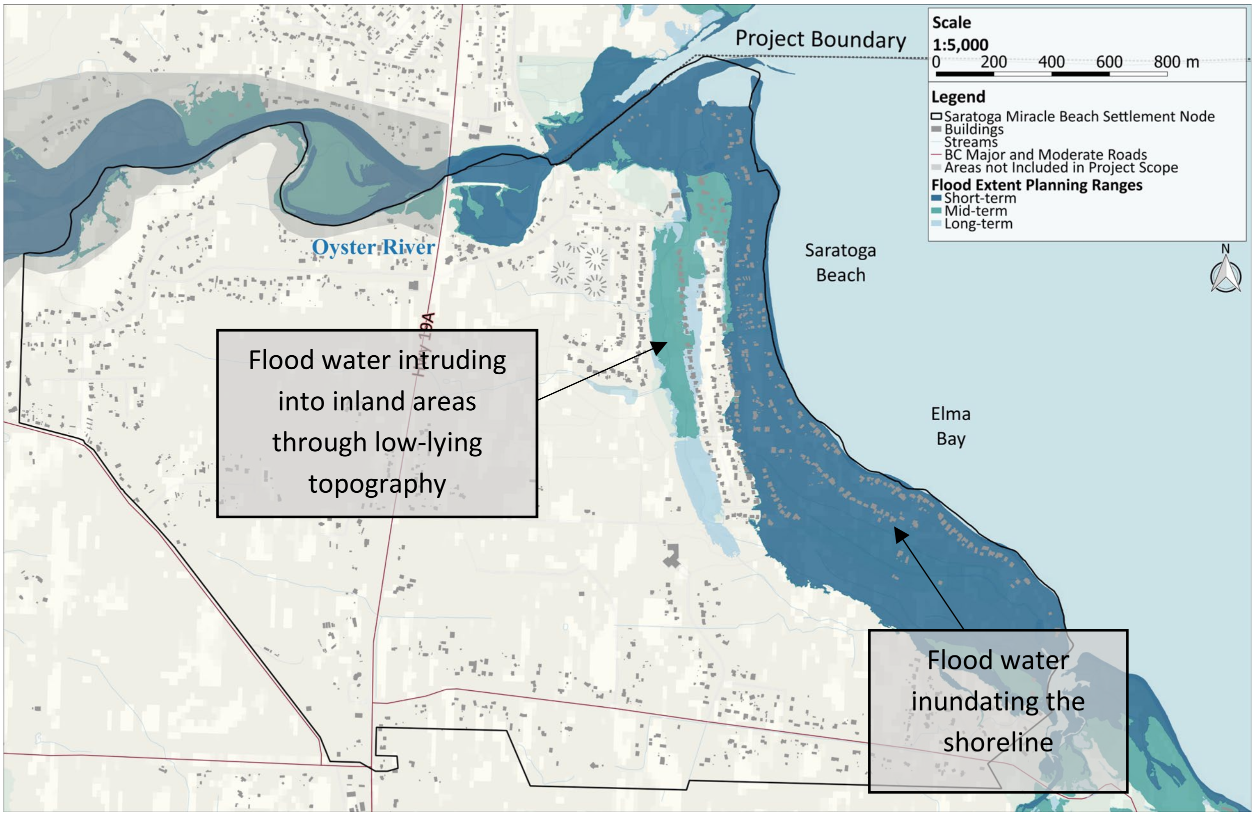


Figure 4-10: Flood extents for the three planning range scenarios in the Saratoga Beach area.

Table 4-6: Areas potentially affected by the three planning range scenarios for the Saratoga Beach area.

Planning Range Scenario	Surface Area Affected (ha)	Marginal Increase in Surface Area Compared to the Short-term Scenario (%)
Short-term	87	Not applicable
Mid-term	103	18
Long-term	111	28

4.3.2 Consequences

Like the consequence analysis for the regional scale, this analysis is shown by way of maps and descriptions for the various indicators, but for the Saratoga Beach area.

4.3.2.1 Spatial Distribution

Figure 4-11 shows the consequences for the affected people indicator. The map shows “hot spots”, where areas of larger concentration appear as darker shades of red. The consequences are relatively evenly distributed across the coastline. A large proportion of people are exposed to the short-term scenario, due to coastal floodwaters inundating the shoreline. However, people are also affected by the mid-term and long-term scenarios due to flood waters entering in-land areas through low-lying topography.

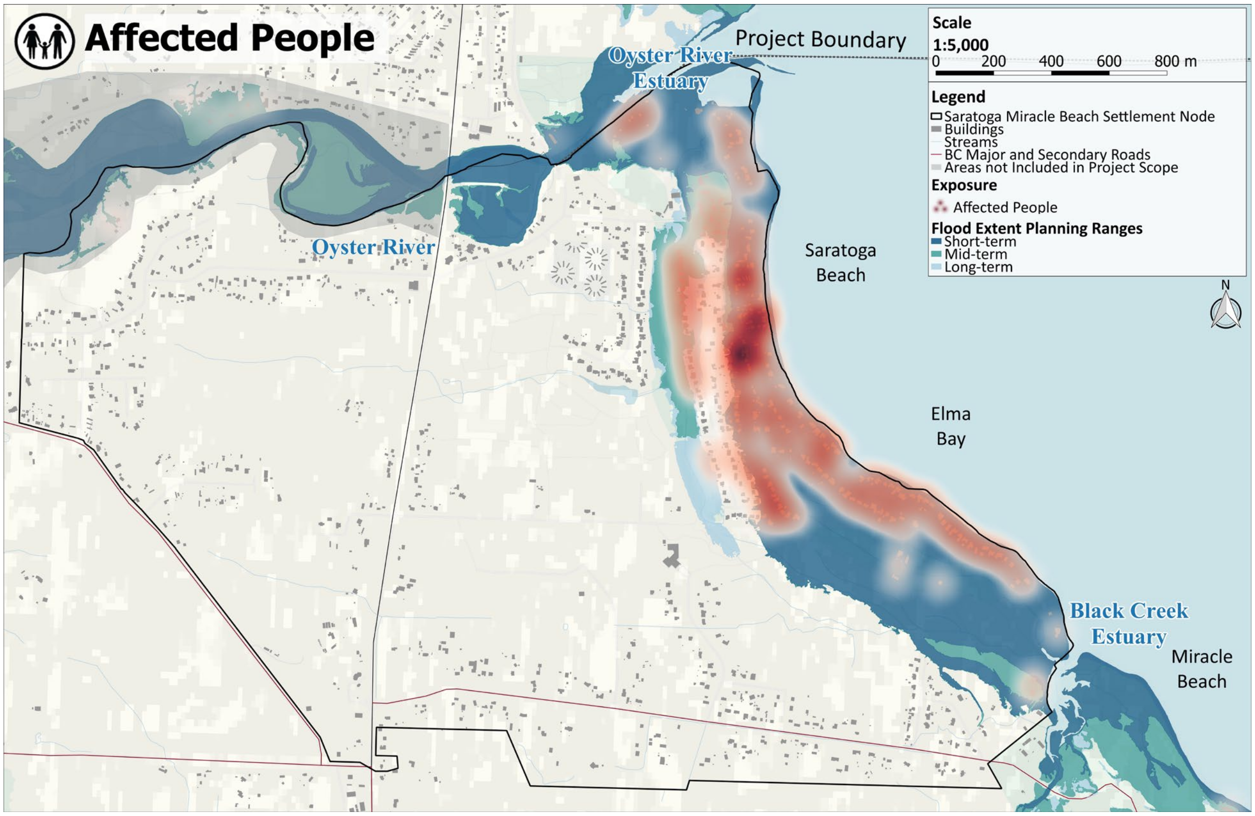


Figure 4-11: Map showing affected people indicator data in Saratoga Beach during three different flood scenarios.

Based on the proxy data used, the consequences related to the economy and critical infrastructure indicators were also well-spread across the coastline. Figure 4-12 shows maps for these indicators, as well as the environment and culture indicators. The spatial distribution of the mortality indicator is not shown as the pattern follows the spatial pattern of the affected people indicator.

Figure 4-12 highlights that there is a diversity of consequences within the area. For example, based on the economy indicator data, there is a range of property values within the flood hazard extents, and the highest-dollar-value properties are within the short-term flood hazard extents. This is not surprising, as presently, waterfront properties are considered high-value.

For the environment indicator, it important to not only consider the ecosystems that are exposed to flood, but also to recognize the positive benefits that these areas represent. As the map in the top-right of Figure 4-12 indicates, the Oyster River and Black Creek estuaries are important features that can absorb the power of coastal flood waters. The golf course and wetlands are other “nature-based” features that could be explicitly considered as flood mitigation solutions. For the culture indicator (bottom-left corner of Figure 4-12), archaeological sites along the southern areas of Saratoga beach are potentially exposed (the purple areas represent a golf course). For the critical infrastructure indicator (bottom-right of Figure 4-12), powerlines that provide electricity to homes are exposed to the flood hazard extents. There are eight telecommunications structures that are exposed to the long-term flood scenario.

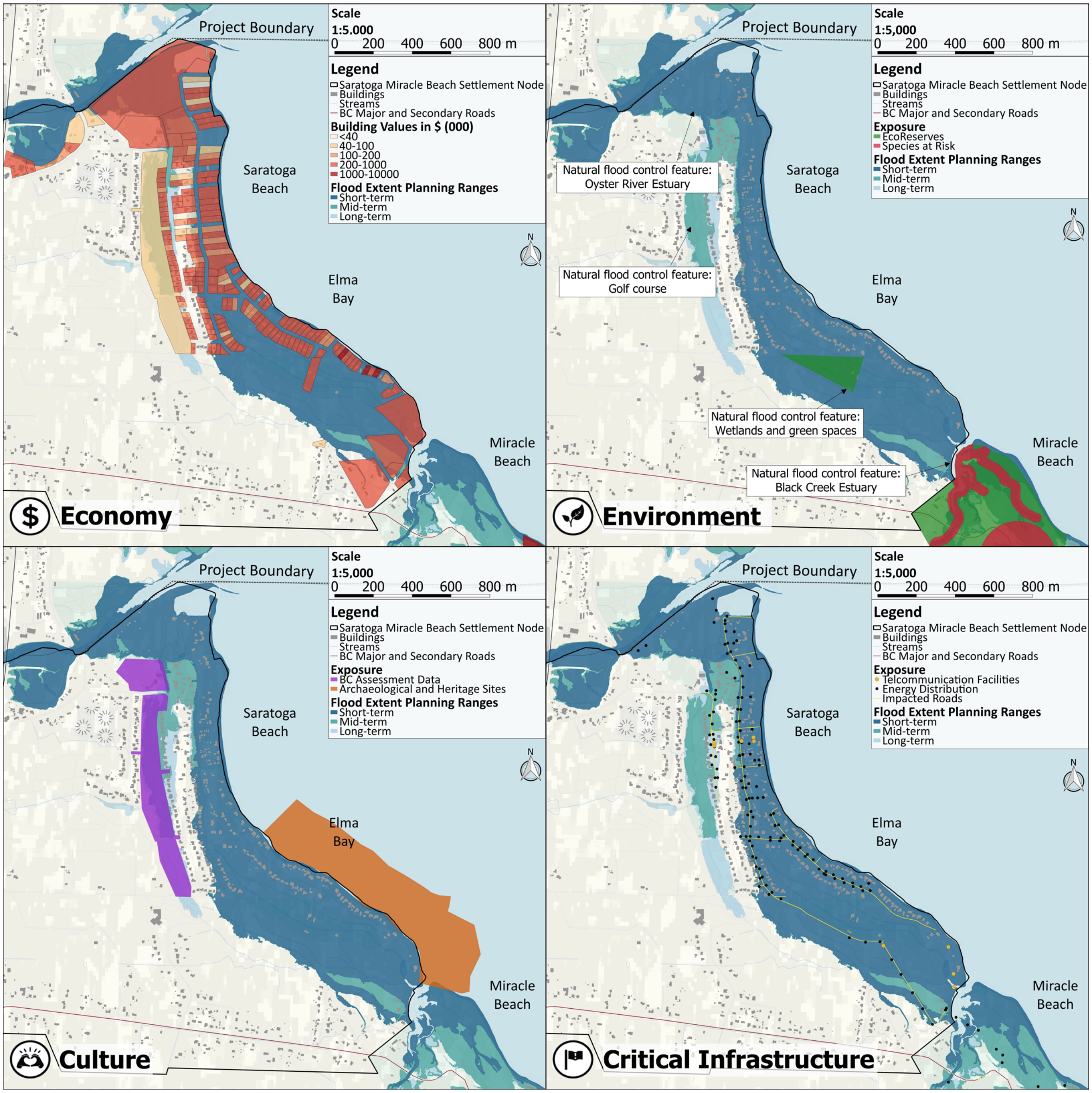


Figure 4-12 Maps showing indicator data for the economy, environment, culture, and critical infrastructure indicators for the Saratoga Beach area. The figure also shows the three planning range flood hazard scenarios.

4.3.2.2 Indicator Results

Table 4-7 summarizes the key quantitative consequence results for Saratoga Beach in bold text. Note that for all indicators, the minimum quantitative consequence values are caused by the short-term scenario and the maximum consequences values are caused by the long-term scenario. The table also integrates feedback from the engagement sessions on issues and areas of concern, and assets that would potentially be impacted.

Table 4-7: Key consequence results by indicator for the Saratoga Beach area.

Indicator	Key Findings
Affected People	• **The number of affected people in this focus area ranges from 309 to 392.** • Was designating a Settlement Node here the right thing? • Residential areas, cottages and RV areas. • Vocal constituency; some don't want change to happen. • Social impacts. • Since people are doing high-value improvements to their homes, tolerance for flooding is decreasing.
Mortality	• **Based on the quantitative method used, the consequences for people related to missing or mortal cases is negligible.**
Economy	• **The total building value potentially damaged ranges from $54M to $68M.** • Campground and marina. • Tourism and recreation (including Airbnb): o Indirect impacts to resorts not flooded • Farms, local food. • Implications to Settlement Node designation (high interest from developers). • Commercial properties.

Environment	• **No contamination sources, species at risk, conservation lands are exposed.**
	• **10.1 ha of greenspace parks and 3.9 ha of eco-reserves area are exposed regardless of flood magnitudes.**
	• Sensitive ecosystems:
	  o Miracle Beach Provincial Park
	  o Forage fish habitat?
	• Wildlife.
	• Mosquito problem; better or worse with projected changes?
	• Erosion.
	• Estuary system:
	  o Flood control asset (absorption, flexibility), restoration and hatchery activity.
	  o Black Creek is a rich estuary habitat, and opportunity to mitigate flood hazard.
	• Golf course and wetlands area:
	  o Water pools and does not escape. There was a rainwater management study completed. It may be possible to drain some of the wetland without losing natural values.
	• Contamination:
	  o Septic fields (contaminant source) for all rural homes.
	  o Drinking water wells.
	  o Vulnerable wetlands behind residential area, which could be source of contaminants during a flood.

Indicator	Key Findings

Culture	• **1 community building is exposed to the low flood scenario and 2 are exposed to the moderate and high flood scenarios.**
	• **1 Indigenous site is affected regardless of the flood magnitude.**
	• **No recreational trails are exposed to the flood scenarios.**
	• Pacific playground (important beaches in the region).
	    o Unique and "actual beach" area – long, sandy, open. You can let your dog run free without worry.
	    o Indirect impact: Lost recreation would put additional pressure on other parks and trails.
	• Recreational areas such as campgrounds.
	• Golf course.
	• Intergenerational value.

Critical Infrastructure	• **No critical infrastructure facilities are exposed to flood.**
	• **The number of power distribution poles potentially affected ranges from 109 to 135.**
	• **7 to11 telecommunication facilities are exposed to the floods.**
	• **The length of roads potentially affected ranges from 4.6 km to 5.4 km.**
	• Road network, transportation corridor:
	    o Highway and other bridge crossings. Access/egress potentially vulnerable.
	    o Flooding on key residential roads. Property owners have altered ditch system. This affects overland flood routing.
	• Wastewater and water systems:
	    o Failing septic systems (all rural, on septic).
	    o Working with private development, CVRD is contemplating a community sewer collection, treatment, and discharge system.
	    o Source water from Oyster River Nature Park. There are about 1000 connections.
	    o Drinking water wells.
	    o Private water system on south side of estuary at mouth of river. 130 properties and a couple large commercial operations. Old pipe.
	• Building flood prevention structures in wetlands area would be difficult as there is little elevation drop.

4.3.3 Considering Potential Adaptation Strategies

The consequences from the various flood hazard extents are widespread within the Saratoga Beach area, but they vary depending on what indicator is being considered. This understanding is important in the context of considering adaptation options.

Example high-level maps were created to visualize how different adaptation strategies could be used to mitigate flooding (see box to the right). The top map in Figure 4-13 shows the areas and buildings that would be subject to flooding or not by the construction of a dike under the "protect" strategy. We also considered buildings

Thought Experiments Only

The purpose of these analyses was to explore examples of the hypothetical adaptation strategies using mapping tools. These were "thought experiments" only, and they enabled the strategies to be compared. They were not used, nor do they form the basis, for specific decisions on mitigative actions.

characteristics that could inform decisions made under the "retreat" and "accommodate" strategies. One characteristic to consider regarding these decisions is building age (see bottom-right of Figure 4-13); older buildings are more likely to be replaced or undergo significant renovations that could include flood-resilient design principles. Building ages vary within the exposed areas.

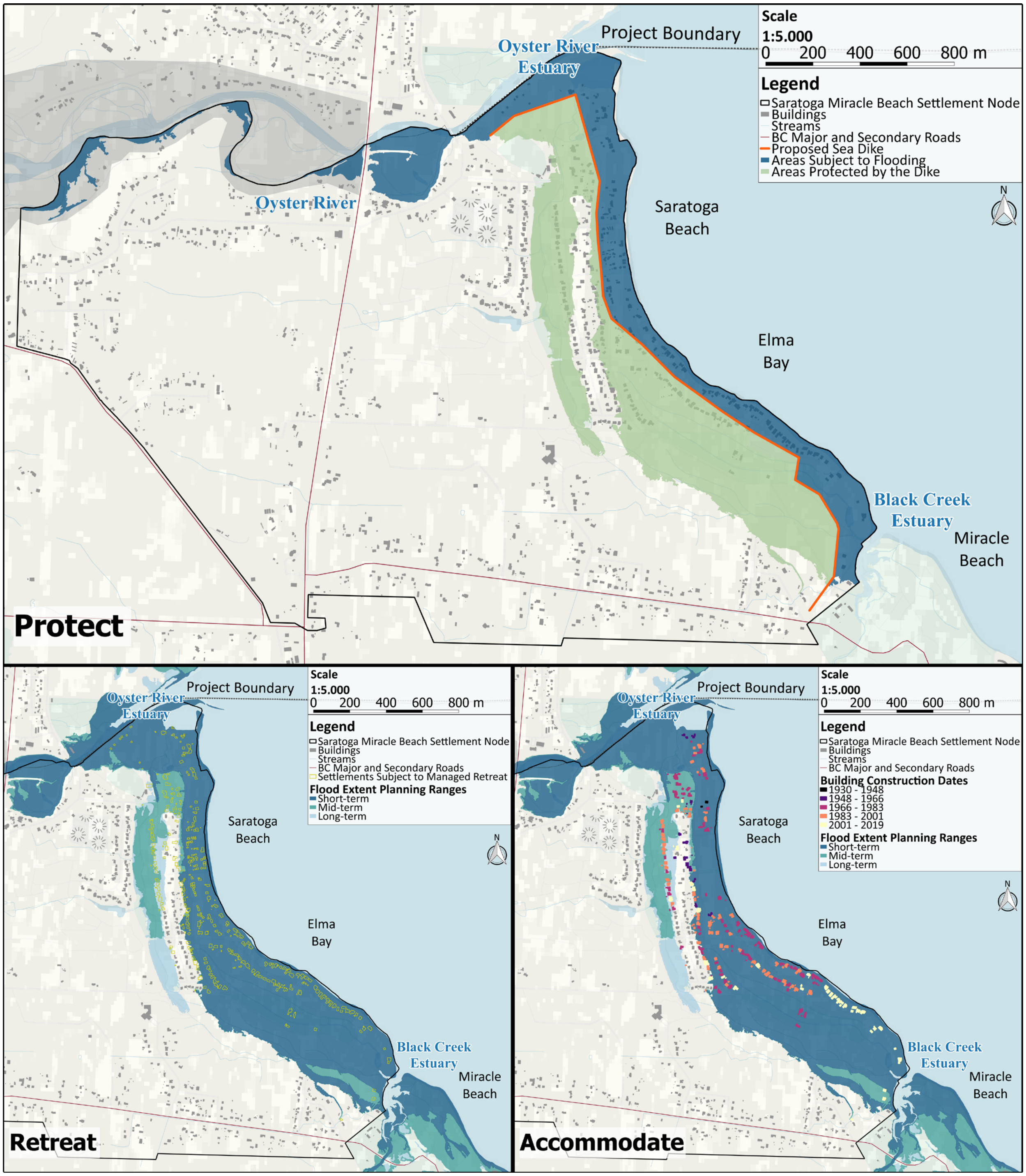


Figure 4-13: Example maps to visualize potential adaptation strategies for the Saratoga Beach area.

4.3.4 Support to Evolving Adaptation Options

The consequence analyses conducted for the Saratoga Beach area provided a “zoomed-in” view of exposure to floods based on six indicators. This more place-based information was fed into the engagement sessions to inform discussion related to values, development of the decision criteria, and to ultimately develop adaptation options (see Section 4.5).

4.4 Values-Based Decision Tool

The key outcome of this project was a preliminary process and tool to enable good decisions for coastal flood adaptation. As described in the methods chapter, this was approached by considering and developing a set of values-, cost-, and feasibility-based criteria. The criteria were similar to the consequence indicators presented in Sections 4.2 and 4.3; however, they considered more factors to encompass the full wicked and systemic nature of coastal flood.

The following section outlines the criteria that were developed and applied. Two iterations of the criteria were developed. The simplified criteria are presented first, as these were explicitly used in this project. Their purpose is primarily for use in communications and engagement with decision-makers and the public. They could also be used as a screening tool to conduct similar analyses presented in this report for other priority areas. The simplified criteria are then followed by the detailed criteria, which are more appropriate for detailed planning and ‘final’ decisions. These criteria, because they are more detailed, also require more resources to measure them.

4.4.1 Simplified Criteria

Simplified criteria, suitable for developing a snapshot of the trade-offs associated with an adaptation option were developed as described in Section 3.3.1. The criteria used subjective measures.

Table 4-8: Simplified criteria and descriptions.

	Criteria	Description (Measure)
Effect of Pathway During a Flood	Human Health and Safety	A measure to represent the health and safety of residents, business owners, and first responders.
	Residential Properties	A measure to represent how residences would be affected by floodwaters (structural damages)
	Culture	A measure to represent how Indigenous and settler cultural assets would be affected by floodwaters.
	Infrastructure	A measure to represent how public infrastructure would be affected (damaged) by floodwaters. This implicitly includes the disruption that is incurred when critical infrastructure is damage.
	Economy	A measure to represent the financial costs associated with a flood event AND the wider economic impacts (i.e., business disruption).
Effect of Pathway Itself	Community Involvement	A measure to represent how an option would increase community engagement and capacity (or conversely isolate community members)
	Environment	A measure to represent the potential damage or improvement to the natural environment that would be created through the implementation of an option
	Recreation	A measure to represent the loss or improvement of recreational opportunities stemming from the implementation of a measure

	Criteria	Description (Measure)
	Implementation Cost	A high-level estimate of the 'capital' cost to implement the option.
	Maintenance Cost	A high-level estimate of the annual costs to maintain an option.
	Feasibility (regulatory, political, etc.)	An overall measure to describe the potential challenges associated with an option.

This simplified level of criteria described in Table 4-8 is appropriate for the CVRD to use for communications and engagement purposes (including with decision-makers and the public). It should however be reviewed and refined prior to next use. For example, we heard in later engagement that equity should have been a stronger element in the decision process.

The simplified criteria above could also be applied to other areas within the CVRD as a screening tool for adaptation options. We note however that there is a challenge associated with applying simplified criteria to a complex problem. Much of the nuance is necessarily removed, which may come at a cost. For example, human health and safety is lumped into a single category and is only considered in the context of the flood itself. Whereas, we know that society is diverse, and that some people are more or less vulnerable to hazards (i.e., young and mobile versus older and house-bound, or low versus high income families). Further, some adaptation options can actually improve equity – through community engagement and community building, but this is not explicitly included in the criteria, and is unlikely to be implicitly considered by many reviewing the tool.

4.4.2 Detailed Criteria

Detailed criteria were developed by mapping value statements obtained through the engagement rounds (see Section 4.1) to specific criteria, and then developing a suitable metric to measure these criteria. The detailed criteria (see Figure 4-14) is much more comprehensive than the simplified criteria, and aims to manage the holistic, systemic, and wicked nature of flood.

The detailed criteria include a much longer list of measures, and also include more quantitative (rather than subjective) measures. This necessarily means that completing the criteria for a given set of projects will require significant resources (data and human resources).

The detailed criteria should be applied by staff or specialists at later stages in the planning process. For example, they could be applied to assess options for specific site to compare and understand the implications (including trade-offs) of proposed decisions. These implications could be considered to more fully assess whether the decision objectives will be met. Simplified results can then be shared with the public and decision-makers for confirmation and approvals.

		Criteria		Performance Measure	
		Category	Description	Description	Scale
Effect of option during flood event	Risk Reduction	People	Health & safety	Potential mortality related to flood event	1. Negligable 2. Moderate (1-5 deaths) 3. Severe (> 5 deaths)
			Disruption (General) - Direct	Disruption of residents as a direct result of flood (within the flood zone)	1 (no disruption) - 5 (1000s disrupted, multiple days)
			Disruption (Equity-lens) - Direct	Disruption of socially-vulnerable residents as a direct result of flood (within the flood z	1 (no disruption) - 5 (100s disrupted, multiple days)
		Environment	Damage to natural areas	Potential damage of natural areas	1 (no potential) - 5 (multiple/large areas damaged)
			Damage to sensitive habitats	Potential damage of sensitive habitats (e.g. COSEWIC species habitat)	1 (no potential) - 5 (multiple sensitive habitat areas at risk x particularly damaging events (waves, high-energy flood waters))
		Culture	Damage of culturally-sensitive assets/areas	Potential damage of culturally sensitive assets/areas	1 (no potential) - 5 (multiple sensitivecultural assets at risk x particularly damaging events (waves, high-energy flood waters))
		Structures	Damage to residential structures	Total cost of losses associated with residential structures (consider # structures, valu	1 (no losses) - 5 ($100s Millions of losses)
			Damage to commercial structures	Total cost of losses associated with residential structures (consider # structures, valu	1 (no losses) - 5 ($100s Millions of losses)
			Damage of public infrastructure (not CI)	Total cost of losses associated with residential structures (consider # structures, valu	1 (no losses) - 5 ($100s Millions of losses)
			Damage of critical infrastructure	Total cost of losses associated with residential structures (consider # structures, valu	1 (no losses) - 5 ($100s Millions of losses)
		Disruption	Disruption of service (electricity, gas, communic	Potential loss of key service for a period of time (e.g., loss of power for multiple days)	1 (no disruption) - 5 (>10% of population affected for multiple days)
			Disruption of transportation and mobility	Potential loss of access for a period of time (e.g., blocked road for multiple days)	1 (no disruption) - 5 (1000s disrupted or 100s disrupted for 2+ weeks)
		Economy	Damage to local economy	Potential for short-term and long-term economic losses to broader local economy	1 (no losses) - 5 ($100s Millions of losses, long-term impacts)
			Damage to agricultural sector	Potential for short-term and long-term economic losses to agricultural sector	1 (no losses) - 5 ($100s Millions of losses, long-term impacts)
			Damage to tourism sector (including marinas)	Potential for short-term and long-term economic losses to tourism sector	1 (no losses) - 5 ($100s Millions of losses, long-term impacts)
	Resilience	Emergency Response	Cost of response	Provides an estimate of the cost in dollars to respond to a given flood event. Takes in	1 (no cost) - 5 ($100s Millions)
			Capacity/Effectiveness of response personal	Provides a measure of effectiveness of response using personnel turnover as a prox	1 (no staff turnover year to year) - 5 (more than 50% of response personnel
		Adaptability	Adaptability of option to multiple futures (climate, development, political)	Provides a measure of how the option will function over time given uncertain future cl	1. No flexibility (standards based,entrenched), 2. Adjustable to a different (more severe) future, 2. Possible to reverse decision and choose different pathway, 3. Adjustable and reversible
		Residual Risk	Access to financing	Provides a measure of how possible it is to finance residual risk through private and p	1. No financing available. 2. Some financing (e.g. insurance/DFAA) available, but with considerable obstacles (too costly, especially for vulnerable populations), 3. Widely available, appropriately financially healthy financing.
Effect of option itself	Externalities	Community	Community involvement/environmental stewards	Potential for option to engage community in meaningful action to steward coastal are	-2. High potential for negative feelings/disengagement, 0. Neutral, +2. High potential for postive feelings/ long-term, meaningful, engagement
			Displacement (permanent)	Disruption of residents from implementation of option THROUGH improvement of qua	-2. >50 residents permenantly displaced, 0. Neutral, +2. >50 residents permanently in improved housing/living conditions
		Environment	Shoreline ecological health and diversity	Potential to conserve/improve or damage natural shoreline	-2 to +2
			Aesthetics (Natural bias)	Potential for option to damage or improve aesthetics	-2 to +2
		Recreation	Recreation/Outdoor Lifestyle	Potential for option to damage or improve recreational opportunities	-2 to +2
	Implementation	Cost	Implementation cost	Measure of cost to implement option (e.g., capital dollar costs)	1. (no cost) to 5. ($100s Millons)
			Maintenance cost	Measure of cost to maintain option over time (use 25-year timeline for simplicity)	1. (no cost) to 5. (Average > $1M annually)
		Opportunities and Obstacles	Collaboration	Measure of potential to build on existing collaborative networks to enable option	1. No possibility to 5. Easily builds on existing collaborative relationships
			Regulatory	Measure of the obstacles related to legislation/regulation	1. Not possible, 2. Possible with regulatory/legislative changes., 3. Easily implementable under existing regulations/legislation
			Political	Measure of obstacles/opportunities related to political will	-2 to +2
			Development Community	Measure of obstacles/opportunities related to political will	-2 to +2
			Public	Measure of obstacles/opportunities related to public perception	-2 to +2

Figure 4-14: The detailed evaluation criteria with objectives and performance measures used for the project team.

4.5 Evolving Adaptation Options

The values, regional risk assessment, and Saratoga Beach consequence assessment supported the development of the adaptation options. These evolved throughout the engagement rounds. The following sections explain the initial feedback on adaptation strategies, and how the consulting team built on this information to characterize and assess four adaptation pathways. The pathways assessment highlighted benefits and drawbacks associated with each. The evolution of the adaptation options was a result of the decision process at work.

4.5.1 Exploring Trade-Offs, Tensions, Strengths and Challenges

At the stage of developing options, the intent is to look at the issue as holistically as possible so we can design pathways that maximize desirable qualities and minimize harm. While we aim to find common ground where possible, we must also consider tensions that may be irresolvable, where we have to make choices that trade off one value versus another. This means valuing some things more than others. At the same time, participants repeatedly emphasized that benefits and costs do not accrue equally; equity and justice are important considerations when making trade-offs.

Table 4-9 summarizes some of the key tensions identified by participants in engagement Round 2, as they considered the various PARAR adaptation strategies for the first time, with Saratoga Beach as the example context. Alongside identified tensions are various ideas that participants shared for addressing these tensions, either in terms of process or outcomes. These ideas do not necessarily (or even often) resolve the tension. In many cases, they are mindsets or ways of being with the discomfort and challenge of irresolvable dilemmas so that we can make space for a "good enough" step through which we can learn, grow, and continue to adapt.

Table 4-9: Tensions highlighted and suggested ideas to address them.

Tensions	Suggested Ideas to Address
Who benefits and who pays? • Not everyone is affected by flood • Don't want taxes to increase • Not everyone can afford individual actions	• Equity-addressing programs / resources / approaches to ensure accessibility • Those who benefit, pay for it • When we think just about costs, we can miss opportunities ○ Create community assets that benefit everyone (e.g., public access to waterfront, parks, ecosystem health, etc.)
Limited funding and resources available	• Need to make difficult decisions, trade-offs • Balance different needs • Ensure equity is considered in design
Equity	• Resilience-oriented options • Include in decision-making criteria

<table>
<tr><th>Tensions</th><th>Suggested Ideas to Address</th></tr>
<tr><td>Current vs Future…

Risks:
Hard for people to understand, value or care about future risk, especially if they haven't experienced it
Risk changes over time
What if we implement the "wrong" options?
Costs / Benefits:
Upfront vs maintenance costs
A solution in the present could cost us more down the line (financially and in terms of risk)</td><td>Start with small adaptations, grow into larger ones
Evolving, adaptive solutions
Make clear commitments so people can be brave
Communication and education
Be honest, go out with a clear message even if its unpleasant.
Messaging from people in their own networks, people they trust
Use real examples to illustrate, make it tangible
Combine personal experience with information
Visual information, easy to understand and digest
Have plans in place to implement over time and when there are opportunities (e.g., during recovery from disasters, or when properties up for sale)
Sequencing, think this through in advance</td></tr>
<tr><td>This is complex, with no clear solution
people ignore difficult topics
gravity of the status quo
limited shared understanding
lack of courage
leads to being reactive</td><td>Make clear commitments so people can be brave
Have a shared body of knowledge with staff and elected officials
Communications to the public/education
The work we're doing with this project to be well educated and nuanced
Learning to live with uncertainty and try new things – understand that failure will be part of growth
At first there is a lot of emotion, but once the message comes through, we can discuss
Combine personal experience with information
Visual information, easy to understand and digest
Taking the time it takes, to learn about the issues and understand the nuance well enough to have informed discussions</td></tr>
<tr><td>Individual and collective
Individual actions have impacts to neighbours
Who bears the costs/benefits?
Decisions affect more than just CVRD and property owners</td><td>Coordinated approaches can help
Draw on the strengths of both individual and collective options
Develop tools/skills for collective decision-making (e.g., consensus decision-making process, structured decision-making)</td></tr>
</table>

Tensions	Suggested Ideas to Address
Broad range of values and priorities • Competing opinions • Potential for conflict, divisiveness • Complex trade-off of values	• Dialogue and conversation – takes thoughtful effort to find common ground • Education and awareness • Develop tools/skills for collective decision-making (e.g., consensus decision-making process, structured decision-making) • Solutions that are nuanced (use all strategies) and creative
Connection to place • Emotional connection • Historical / family connection (legacy) • Sense of loss • Having to leave community	• Include intangible values in decision criteria Make space for this to inform the process, choices
Inertia, gravity of the status quo • In politics • In individuals	• Engage community • Combine personal experience with information • Visual information, easy to understand and digest • Taking the time it takes, to learn about the issues and understand the nuance well enough to have informed discussions
Policy / regulatory context • Lacking regulations or standards • Current policies prevent desired action	• Change policies, establish regulations • Seek examples from elsewhere

Engagement Round 2 provided participants with a deeper understanding of the issues and trade-offs associated with planning and decisions for coastal flood risk. It also provided the consulting team with a better understanding of stakeholder and partner concerns, preferences, and ideas specific to the example of Saratoga Beach. This information was used to inform the creation of hypothetical pathways that aimed to provide contrasting sets of options, organized into plausible combinations.

As described in the methods (see Sub-section 3.3.3), four distinct adaptation pathways were designed as tools for further discussion in Round 3. Table 4-10 provides a summary of key strengths and challenges identified for each of these, when considered by participants in relation to a context like Saratoga Beach.

Table 4-10: Strengths and challenges associated with the adaptation pathways.

Pathway	Strengths	Challenges

Staying Put and Taking the Edge Off (Pathway 1)	• Easy to understand and implement – less disruptive of status quo
	• Could be implemented quickly, buying time while keeping other options open
	• Benefit to property owners
	• Aligns with values and local knowledge and awareness (green options)
	• Enable individual actions and responsibility
	• Other
	  o cultural shift
	  o increase food security
		• Could lose co-benefits and ability to choose other options
		• Questionable effectiveness, pushes risk into future
		• Doesn't position us better for future risk
		• High initial and ongoing costs
		• Lack of community building
		• Depends on individual uptake, can contribute to inequities, competing visions, inconsistent implementation
		• Limited by existing policy and regulation

Dancing Out of The Way (Pathway 2)	• Easy to understand • Sequencing: clear steps taken over time, building awareness, support and resilience. • Flexible in face of uncertainty • Lower costs spread over time • Co-benefits (community and natural assets) • Reconciliation • Clearly reduces exposure and risk • Collaborative, building partnerships • Older housing: chance to make change	• Loss of cultural sites • Does change happen fast enough? • Cost and logistics • Attachment to place, sense of loss • Inequity • Harder to build support • Who leads? • Requires high level of engagement, buy-in • Uncertainty: timing • Collective vs individual tension (and in present / future)
Putting on Raincoats (Pathway 3)	• Creativity, innovation, and collective benefits of individual actions • Could advance through both voluntary and regulatory mechanisms • Costs less to mitigate risk than pay for damages • Co-benefits • Inequity can be managed • Can combine with community-building	• Effective up to a threshold, but may not be effective on its own • Regulations, standards don't exist currently • High costs, favours those with financial resources; inequity • Lack of co-benefits • Equity vs effectiveness vs consistency • Relies on individual actions / personal responsibility • Overcoming inertia • Requires a diversified approach to outreach / engagement • Doesn't build community

Pathway	Strengths	Challenges
Strengthening the Village (Pathway 4)	• Represents a culture shift • Nature-based solutions • Flexibility • Complementary / strengthens all pathways • Collective leadership • Aspirational (values aligned) • Re-imagine local governance to serve collective future • Empowering the collective and individual • Co-benefits (shared assets) • This is the foundation for all actions, not a separate pathway	• Difficult, long-term project • Questionable effectiveness re: flood risk • Depends on people, relationships • Profound change (Realistic? Possible?) • This is a best-case scenario -- challenges will arise • High investment in engagement; vulnerable to public sentiment, buy-in • Differences in risk tolerance would make it hard to commit • Resilient but hard to achieve

Finally, participants considered a range of “tipping point” scenarios and how these would impact their chosen combination of pathways. These discussions identified a number of strategies that were beneficial across a range of stressors, along with mindsets or principles that would support more robust outcomes. These are integrated into the summary below.

4.5.2 Assessing Pathways

The project team assessed the four pathways based on a variety of characteristics, as well as simplified criteria. The assessments were based on the consulting team’s understanding of the pathways; therefore, the assessments were subjective.

4.5.2.1 Characteristics

Table 3-7 summarizes each characteristic in terms of their flexibility to keep a range of options open over time, and their divergence from the status quo.

Table 4-11: Summary of pathway deviation characteristics.

	Pathway 1: Staying Put and Taking the Edge Off	Pathway 2: Dancing Out of the Way	Pathway 3: Putting on Raincoats	Pathway 4: Strengthening the Village
Flexibility	Low	High	Moderate	High
Divergence from Status Quo	Moderate	High	Moderate	High

Generally, pathways that involve larger-scale structural (including green) mitigation options have lower flexibility (Pathway 1). While options that require minimal structural mitigation (Pathway 2 and 4) have higher flexibility. Generally, pathways that involve structural mitigation tend to diverge less from the status quo, given the current path-dependence toward engineering-based solutions that exists throughout the Province[17].

The pathways' time-based characteristics were also assessed. Figure 4-15 summarizes the effectiveness and residual risk for each pathway over time. These assessments are conceptual level. While the timelines shown in the x-axis do not have specific dates associated with them, they can be thought of as loosely matching the timelines associated with the flood hazard planning range scenarios (see Sub-section 3.2.2).

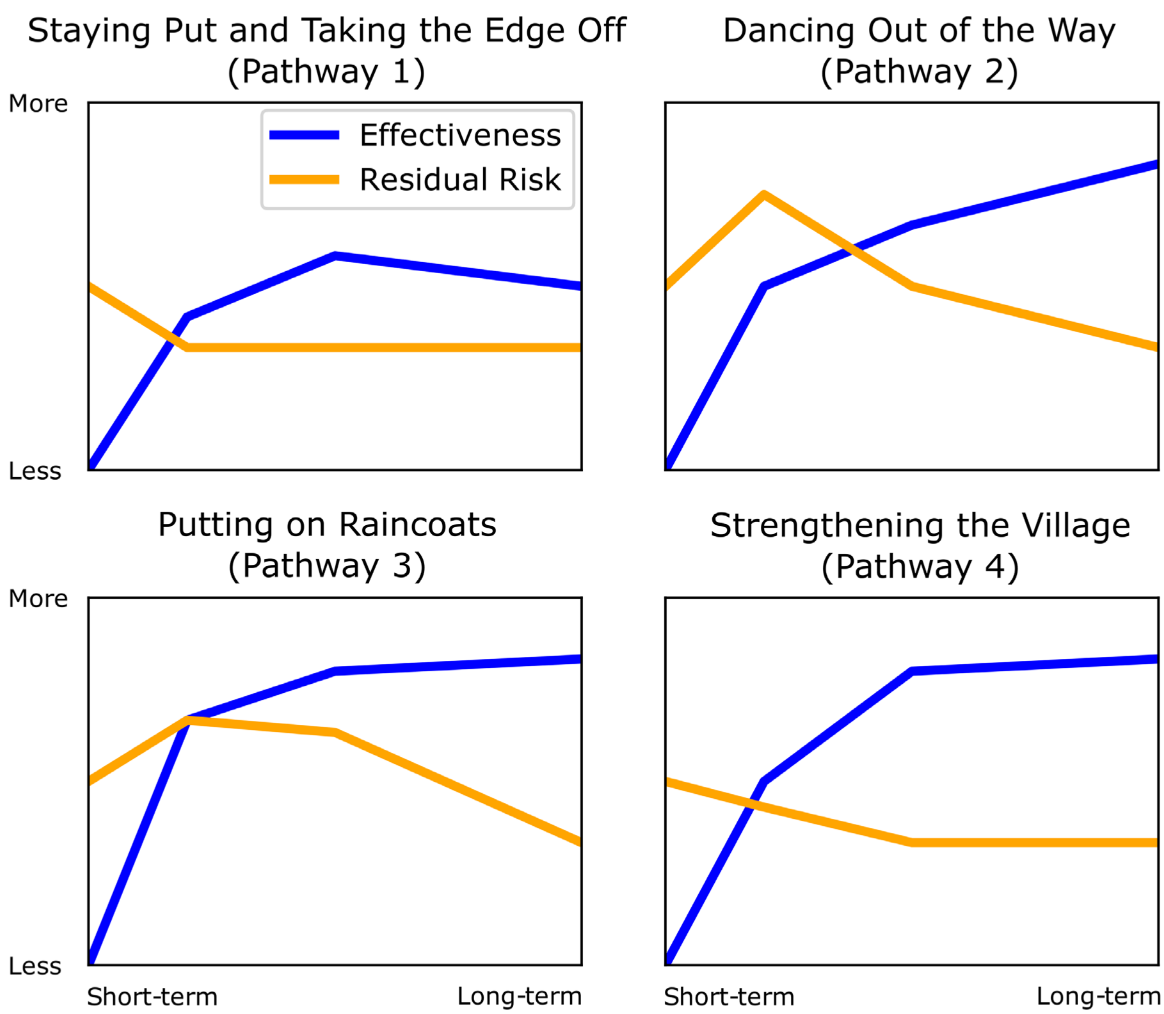


Figure 4-15: Summary of adaptation pathway timeline characteristics.

[17] It is acknowledged that the CVRD's policies aim to disrupt the path-dependence of engineered solutions (see Sub-section 2.5.1).

In general, effectiveness increases and residual risk decreases over time for all the identified pathways; although Pathway 1 may become slightly less effective in the long-term. However, the trajectories of these pathway characteristics are important to consider in decision-making. "Thresholds" may exist that drastically change effectiveness and residual risk.

4.5.2.2 Criteria

The pathways were evaluated based on the simplified criteria developed after Round 2. The results, which describe how the pathway affects a criterion relative to the status quo, are shown in Table 4-12. The results were meant to be indicative only, to highlight relative differences and trade-offs between pathways. The performance scales for the criteria categories are in included (See Table 3-9 for more detailed table).

Table 4-12: High-level evaluation of the adaptation pathways completed by the project team, with performance scales.

	Do Nothing	Staying Put and Taking the Edge Off (Pathway 1)	Dancing Out of the Way (Pathway 2)	Putting on Raincoats (Pathway 3)	Strengthen the Village (Pathway 4)
Effect of the Pathway During a Flood					
Human Health and Safety	Worse	Slightly better	Better	Slightly better	Far better
Residential Properties	Worse	Slightly better	Far better	Slightly better	Far better
Culture	Worse	Slightly better	Slightly worse	Far better	Far better
Infrastructure	Slightly worse	Far better	Far better	Far better	Better
Economy	$$	Neutral	-$	Neutral	-$$
Effect of the Pathway Itself					
Community involvement	Much worse	Neutral	Far better	Far better	Far better
Environment	Worse	Slightly worse	Far better	Slightly better	Far better
Recreation	Worse	Slightly worse	Slightly better	Slightly better	Far better
Implementation cost	Neutral	$$$	$$	$$	Neutral
Maintenance cost	No Change	$$	-$$$	Neutral	-$$$
Implementation	No Change	Challenging	Slightly challenging	Slightly challenging	Very challenging

Performance Scale (relative to status quo)						
Much Worse, $$$, Very Challenging	Worse / $$ / Challenging	Slightly Worse / $ / Slightly Challenging	Neutral / No Change	Slightly Better / -$	Better / -$$	Far Better / -$$$

The comparison highlights benefits and drawbacks between the pathways. For example, Pathway 1 (Taking the Edge Off) entails a very high implementation cost, but during a flood its effects are largely better than the status quo. Pathway 4 (Strengthening the Village) largely performs better or far better on most criteria, compared to the status quo; however, its implementation is very challenging due to deep systemic and cultural changes required to implement it.

4.5.3 Stress-Testing

The pathways were stress-tested for the Saratoga community by thinking about how they would fare based on tipping point scenarios. During engagement Round 3, the key problem presented by each tipping point was discussed, along with concepts to consider within potential solutions (Table 4-13).

Table 4-13: Tipping point problems and solution concepts.

Tipping Point Scenario	Key Problem	Solution Concepts Toolbox
Large Earthquake	Damage to critical infrastructure	Implement short-term recovery and develop re-building strategy; reduce dependence on engineered solutions.
Economic Downturn	No money to recover damages from disasters	Focus on developing and implementing low-cost actions; leverage community strengths.
Runaway Climate Change	Impacts getting far worse than expected	Acknowledge uncertainty; maintain flexibility to change course and develop new plans if required.
Political Instability	Reduced ability to work collectively	Strengthen trust at community scale; recognize the effectiveness and importance of collective versus individual action.

The potential solutions to the tipping point scenario key problems provide further insights for consideration when building desirable adaptation pathways, as discussed in the next section.

4.5.4 Building Desirable Adaptation Pathways

With consideration of the various tensions, constraints, strengths, and challenges identified throughout engagement Round 1 and Round 2, participants developed ideas for how to approach flood risk and resilience in an area like Saratoga Beach. Again, the objective of this exercise was not to decide on options for this area, but rather to use a specific example to “ground-truth” the values-based criteria, the overall process, and the different adaptation strategies within a particular set of conditions, providing insight on how to approach issues. The suggestions that emerged, included:

Take a coordinated approach that combines elements of all strategies

Groups agreed that the best way to address the issue is to combine elements of all strategies in nuanced and creative ways.

A first step along the path to providing coordinated direction on the issue would be to adjust the Regional Growth Strategy through a climate lens, particularly with the intention of using policy to avoid making the problem worse. The Accommodate and Avoid strategies could be the most feasible ways to achieve this, for example designating some areas where new or additional development is not permitted, and revisiting settlement node designations in the region. Options for retrofitting the existing built environment could be enabled by various means. Where possible, use Avoid or Retreat strategies to more safely locate, or relocate, critical infrastructure.

Build social resilience by investing in education, communication, and dialogue

A key message across groups was the importance of investing in education, communication, and dialogue to build understanding and capacity among those affected and those responsible for implementation (which includes a wide range of actors including property owners, residents, business owners, local government staff and elected officials, government agencies, service organizations, etc.). The work being done through this project – informed by research and analysis, combined with opportunities to integrate information, and engage in dialogue about tradeoffs – was recognized as an important way of supporting both individual and collective actions. Expanding this to more local and informal settings for conversation and dialogue was another. Investments in emergency preparedness, recovery and post-disaster planning is another dimension of this approach that strengthens all strategies.

Start with small steps now, build into bigger ones over time

Change is hard, especially when the way forward includes a lot of uncertainty and complexity. To ease this process, participants suggested laying out options in an understandable sequence that builds from smaller more obvious steps into making the bigger decisions. Small actions now, can raise awareness and serve as practice for larger decisions. At the same time, identifying and naming possible larger steps that will be needed later, helps to get people thinking about those options in advance of needing to make the decisions.

Protect strategies – with a focus on "green" options – were of interest to many and provide an example of beginning with small steps like exploring low-impact or temporary measures (e.g., like Courtenay's Aquadam ™) and also to build on existing knowledge and experience with Greenshores™ and natural asset-based approaches in the region. An example of a bigger decision to consider in the longer-term, is a framework for how to approach the possibility of Retreat in certain circumstances, and policies around rebuilding in the aftermath of larger events.

Community-building strengthens all approaches

Community-building was widely seen as a foundation for all approaches. When considering the diversity of perspectives and complexity of the issues, it made sense that community-building would enable better decisions that could better serve a diversity of needs. In addition, this builds capacity over time, which helps when faced with tough decisions and circumstances down the line. In theory, stronger community ties would enable certain creative solutions that would involve redistribution of risk and sharing of benefits. As well, the strength of partnerships, relationships and community ties will be of service across a range of possible future conditions.

Prioritize nature-based solutions

Nature-based solutions was another strong value and existing strength in the region, that creates multiple benefits and may help to buffer and respond to a range of possible futures. Building on existing knowledge and innovation in the region already, Greenshores™ approaches and stewardship of upper watersheds could contribute to enhanced resilience for both ecosystems and human settlements. In contrast, engineered or "hard" infrastructure solutions, while appropriate in some circumstances, will fail beyond a certain threshold, representing "sunk costs" (i.e.., resources are unavailable for other uses) and can even become hazards themselves if this happens. While nature-based solutions would also have a threshold for effectiveness, they offer a much broader range of benefits and contributions to resilience.

Prepare for tough decisions and trade-offs

The potential changes needed to address coastal flood risk over time will require some tough decisions and trade-offs to be made. Given the range of perspectives and preferences involved, as well as combinations of costs and benefits, this is an immense challenge requiring leadership, including from the community itself. One group suggested to "make clear commitments so people can be brave." This is especially important given the sense of urgency and need to speed up these efforts. Another element of this is the limitation of resources and funding, which forces us to choose between possible options. With any pathway that is chosen, aiming for "resilient enough" (as opposed to perfectly resilient) can help to decide where to draw the line.

Include an equity lens

The importance of equity concerns was an oft-repeated theme throughout our sessions and warrants consistent consideration throughout planning, decision-making, and implementation. For example, ensuring that information and resources to support individual floodproofing actions are accessible for those with lower incomes, or for service organizations that are in the flood hazard area, and not only to wealthier residents. Involving a wide range of people, including residents and the public, in the process of developing and evaluating options was also emphasized.

Keep the short- and the long-term in view

With respect to both the impacts and possible solutions, participants observed that there is a careful balance needed to ensure enough is done to ensure resilience in the short-term, while not losing sight of a range of possible futures. On one hand, this means to use what you have now, while starting to build what you'll need later. An easy example is to use available planning and regulatory tools to take practical steps that are already possible – like embedding a climate lens in the RGS. Another important observation is to ensure that actions in the short-term ensure enough resilience in the case of near-term events. In particular, critical impacts, infrastructure and services should be considered early.

Keep options open, stay flexible

Since we don't know what the future holds, it is wise to proceed in ways that continue to keep a range of options available to us, rather than painting ourselves into a corner. For example, while engineered "hard" infrastructure can be appropriate in some instances, it can lock us into a path that can create greater risk over time (e.g., as more development occurs behind a dike) and where resources cannot be redirected if we need to change course. In contrast, investing in building understanding and capacity to make difficult collective decisions, is something that can be repurposed to any situation that arises.

Seek synergies by including actions at both the individual and collective level

A key tension that emerged repeatedly was the pull between individual and collective benefit and responsibility. Participants realized that actions at both levels will be needed, and that there is an opportunity to leverage the benefits and possibilities of each to achieve better outcomes… it's not either/or. To be most effective, we need as much of the community to "join the dance" as possible, so that we can take advantage of a wider range of options and better balance both individual and collective needs. Relatedly, it is important that this not be seen as solely the purvey of government, but that responsibility and agency is extended more broadly.

4.5.5 Learning from the Process

At the conclusion of engagement Round 3 we circled back to acknowledge some of the current patterns at play in the region, both strengths and challenges. From here, participants articulated some of the desired patterns they would want to create as they build regional coastal flood resilience, and ideas for principles and practices that could help to get them there. Some of these ideas are included in Section 5.5.2, and could inform development of a framework for collaborative action and governance of flood resilience in the region.

At the end of Round 3, participants were asked the simple question, "what is one thing that stands out to you from your experience today?" The intention was to find out what felt important to participants after going through this process together. Key themes included:

- **Thinking Systemically** (watershed-scale, interconnections, time scales, redundancy, staying adaptive).
- **Values of Community, Nature, and Equity** (key drivers / values).
- **Complexity** (many details and variables make it challenging).
- **Importance of Collective Action** (foundational, and challenging; local leadership and participation needed).
- **Commonalities** (we have more in common than expected).

4.6 Summary

The project results consisted of a range of qualitative and technically-based information sources. The engagement and risk assessment components were leveraged, through iteration, to help develop a decision process that could be repeated by the CVRD. The results form the basis for recommendations provided in Chapter 5.

5 Recommendations

The following section provides recommendations based on the findings and key themes from the project tasks. These are organized using the Sendai Framework (Sub-section 2.4.1).

A major tenet of this framework is a *risk-based* approach to disaster management, where hazard (including hazard likelihood), exposure and vulnerability all play a role. Expanding on the approach provided by the Sendai Framework, this study has integrated an appreciative lens and focuses more directly on resilience-building, in addition to risk reduction. For the purposes of grouping our recommendations, we have adapted the Sendai Framework Priorities slightly, to include these qualities. The four priorities we include below are:

1. Understanding disaster risk, complexity and resilience.
2. Strengthening disaster risk governance.
3. Investing in disaster risk reduction and resilience-building measures.
4. Enhancing preparedness, response and recovery to build resilience.

Under each Priority, key themes are discussed, and specific recommendations are organized within a table. Each recommendation has been assigned a relative priority and cost, but in no specific order or rank. This is followed by a summary of "Next Steps for the CVRD to Progress the CFAS".

5.1 Understanding Disaster Risk, Complexity and Resilience

Understanding disaster risk includes obtaining better knowledge on hazards, exposure, and vulnerability that is place-based. To make informed decisions we need to understand more about the nuances and complexities of flood risk, and how human behaviour affects risk and the choices we make to mitigate them. Priority 1 has been a focus in Phase 1 and 2 of this work, and will continue to be an ongoing part of planning and decision-making in future phases of the CFAS. Table 5-1 provides specific recommendations, and the sub-sections below summarize recommendation themes.

5.1.1 Support Interested Parties to Apply Flood Risk Information to Individual and Collective Decisions

There is a good deal of technical information now available to support understanding of coastal flood risk in the region, and some of this has now been translated in ways that supported the engagement process in Phase 2. This work needs to continue, to develop materials that can support a broader range of education and engagement to a wider range of audiences. Building on this engagement, diverse groups should be involved in planning and decision-making at a local level. Participants in Phase 2 emphasized the importance of this type of process, to create space for the difficult conversations that are needed. Introducing the concept of risk tolerance will be critical.

5.1.2 Integrate Public into the Process

The CVRD has been leading on important formative steps to ensure that broader public engagement is well informed and designed. These include the development of flood hazard maps, a risk assessment, and decision-support materials and tools, all customized for the region. Next steps in the process should include a range of opportunities to share and engage with the public, building awareness and involvement in the development of appropriate adaptation strategies.

5.1.3 Promote the Collection of More Comprehensive and Relevant Data

The CVRD could coordinate data collection with partners in the region to address data gaps related to exposure and vulnerability. Hydroclimate monitoring and post-flood event measurements should be expanded to obtain more accurate and representative data across the region. Exposure data sets should aim to improve understanding on contamination sources, transport, and impacts to receptors such as fish and human health; seasonal population distribution, including tourism; and indirect and intangible impacts such as lack of access to services and psychosocial stress. Natural Resources Canada's (NRCan) social vulnerability index (SOVI) is an example dataset that could be leveraged.

Table 5-1: Recommendations related to Sendai Framework Priority 1.

High-level estimates of priority and cost (primarily dollar cost, but also in some instances human resources and skills) are provided in this table as H - High (red), M - Medium (yellow) and L - Low (green).

Recom. No.	Description	Development Details
1-1 Priority: H Cost: L	Translate risk information into public communications materials.	Generate a set of backgrounders and communications products (e.g., infographics, digital narratives) to convey important context (e.g., Flood Risk 101) and hazard and risk information developed during Phase 1 and 2, to assist with ongoing education and engagement. These materials would make the existing work more accessible to a broad audience, and support future engagement and planning (including Recommendation 1-2). Key audiences include the public, stakeholders, and decision-makers.

Recom. No.	Description	Development Details
1-2 Priority: H Cost: M	Develop a communications and engagement plan to continue to build understanding of risks and adaptation options among the public and stakeholders. The plan will guide next steps in raising awareness and building capacity for the community to make decisions and take action on coastal flood resilience.	Develop a communications and engagement plan to guide next steps in raising awareness and building capacity. Engagement in Phase 2 generated a number of suggestions from stakeholders, including: • Holding a range of types of sessions, including more informal, neighbourhood or community-based conversations • Include both technical information and personal stories – connect with people through others in their networks that they trust • Engage people through creativity • Support people to have difficult conversations Materials should incorporate the concept of risk tolerance, in anticipation of the next steps of the CFAS (see Section 5.5).
1-3 Priority: H Cost: L	Work with the Province and regional partners to continue to collect information during natural hazard events, to support robust event mapping.	During a natural hazard event it is common to focus on emergency response. However, the collection of event data (e.g., high water marks and flow measurements) is invaluable and should be seen as a priority. The data can be used for model calibration and validation, facilitating the development of studies to project future events with more accuracy. Drone technology can be deployed effectively for this purpose. The United States Geological Survey (USGS) has developed resources[18] that could easily be adapted for the CVRD and other local governments.

[18] See the guide for Identifying and Preserving High-Water Mark Data: Weblink: https://pubs.usgs.gov/tm/03/a24/tm3a24.pdf. Accessed 22-Apr-2021.

Recom. No.	Description	Development Details
1-4 Priority: H Cost: M	Increase research and training to improve understanding among local governments to adequately understand the complex issues of natural hazard risk.	This recommendation has been indicated in the Provincial Flood Investigations Project [19]. Education similar to that provided as part of this project should be rolled out to local government elected officials and staff as part of an on-going program. Partnerships may be strengthened with local educational institutions such as Vancouver Island University (Nanaimo) and the University of Victoria, such as the Pacific Climate Impacts Consortium.
1-5 Priority: H Cost: M	Work with Island Health to obtain septic system data.	Septic systems can be an important source of contamination in rural areas. Some health authorities in BC have locations data. CVRD should work with Island Health to acquire this data for its jurisdiction.
1-6 Priority: H Cost: L	Inform the local population and visitors of the consequences resulting from flooding in the region.	An example is to conduct water quality testing of polluted waters following flooding. Post public advisories when water quality is found to be below guidelines in recreational areas. An example of a great initiative is the Hazard and Hope video called "What Makes up Flood Water"[20].

5.2 Strengthening Disaster Risk Governance

Sendai Priority 2 promotes disaster risk governance through collaboration and partnership. Governance describes the process by which society organizes itself to make decisions and includes consideration of who has power, who makes decisions, how decisions are made, and how the ideas of interested and affected parties and broader society are considered and included in decision processes. This element of building coastal flood resilience is essential to ensure that future phases of the CFAS will be successful. Key directions under this Priority include:

5.2.1 Develop a Collaborative Framework to Implement Flood Resilience

To take the next steps towards developing and implementing place-based and region-wide strategies to build coastal flood resilience will require having necessary partners and stakeholders involved and committed to the process. Every one of the focus areas identified in Phase 2 includes multiple

[19] Weblink: https://www.fraserbasin.bc.ca/BC_Flood_Investigations.html. Accessed 30 November 2021.
[20] Weblink: https://youtu.be/MoMI6c27uOE. Accessed 30 March 2021.

jurisdictions, decision-makers, actors, and affected parties. Establishing a collaborative framework for this work will enable the right people to be informed and involved as work progresses. It would ensure that commitment is made at organizational levels so that the work will continue if and when individuals leave those positions. And as a result, it would assist in building the shared understanding, investment, trust, experience, and relationships necessary to make harder decisions over time. See Sub-section 5.5.2 for further details.

5.2.2 Continue to Develop and Apply Decision-Support Tools and Processes

As the CFAS project transitions into strategy and implementation phases, specific attention will be needed to continue developing and implementing materials, tools, and processes that support a broad cross-section of individuals and organizations to participate meaningfully. The research and decision tool developed under this project lay the foundation for future work.

Table 5-2: Recommendations related to Sendai Framework Priority 2.

High-level estimates of priority and cost (primarily dollar cost, but also in some instances human resources and skills) are provided in this table as H - High (red), M - Medium (yellow) and L - Low (green).

Recom. No.	Description	Development Details
2-1 Priority: H Cost: M	Establish a Collaborative Framework for working together on coastal flood resilience in the region.	A first step in this direction would be to develop an MOU between CVRD and regional partners (local governments, KFN, key agencies), to formalize commitments and clarify processes for working together on this issue. Beyond an MOU, a Collaborative Framework could lay out a more detailed roadmap for how this group will draw together the skills, knowledge and good will of many stakeholders and partners in the region to build flood resilience together over the next 5 – 10 years. Including development of principles for working together, shared goals, shared decision-making processes, and strategic direction. Implement participatory processes to continuously work to build trust, relationships and shared understanding of coastal flood risk, complexity, and resilience among those across the region. In the longer term, this body could expand to have more of an "all-hazards" focus, as many of the capacities being built will be transferable from flood resilience to other needs.

Recom. No.	Description	Development Details
2-2 Priority: H Cost: M	Conduct a broad risk tolerance assessment for the region	Develop risk tolerances to support the CVRD and neighbouring jurisdictions to better understand the sequencing of risk mitigation actions (i.e., to understand where risk will become intolerable first, and therefore where resources should be expended first).
2-3 Priority: H Cost: M	Conduct a refined options assessment and risk tolerance assessment for each focus area.	Over time, it is recommended that the CVRD conduct planning for each focus area, to address identified risks. To start, the Comox Road area was identified as a high-risk focus area, which also faces many of the challenges associated with regional planning for sea level rise – specifically, the multiple jurisdictions within the area. This would include a refined options assessment using updated tools and information developed in Phase 2 (e.g., values-based criteria), and incorporating a specific risk tolerance assessment to inform sequencing.
2-4 Priority: M Cost: L	Strengthen partnerships with First Nations, NGOs, and industry to facilitate collaborative research and the integration of traditional and emerging scientific knowledge into policy and practice.	These relationships will be pivotal to integrating multiple perspectives into solutions. Field tours led by local experts, including Indigenous knowledge keepers, should be included within studies (provided they have adequate resources and capacity).

5.3 Investing in Disaster Risk Reduction and Resilience-Building Measures

Sendai Priority 3 focuses on public and private investments in disaster risk reduction through non-structural and structural measures. As identified by stakeholders, a combination of strategies and options will be required to effectively address coastal flood risk in the region.

In the CVRD itself, engineered solutions are contrary to CVRD's existing bylaws/policies and the region currently has no dikes. Structural measures are in place in different jurisdictions in the area, such as the City of Courtenay's existing dikes, but in that case a recent report suggested that upgrading structural protections to a 0.5 % AEP (1:200-year) standard required by the Province faces significant limitations and challenges[21]. Non-structural measures[22], on the other hand, provide a large “toolbox” of options suitable to a range of purposes and conditions. These include measures relating to land stewardship, land use management, building management, education and awareness, emergency response and preparedness and financial tools.

Through the engagement process a number of key themes emerged in relation to how to approach selection and design of a suite of options for dealing with coastal flood risk in the region. While many decisions will require further planning and engagement and place-based consideration, participants provided a number of suggestions for how to proceed at a more general level.

5.3.1 Avoid Making the Problem Worse

A starting place is to simply take steps to minimize or eliminate new or growing contributors to risk that are within local control or authority. For example, utilizing policies and bylaws to prevent new or further development or high risk uses in flood hazard areas, and educating interested parties about risk and options to manage it.

5.3.2 Place Community and Nature at the Centre of Decision-Making

Community-building and nature-based solutions align strongly with values of stakeholders in the region, and provide benefits far beyond flood management. In addition, these solutions perform well across a range of possible futures, adding to both social and ecological resilience. Community-building was specifically recognized as a foundational strategy that strengthens the effectiveness of other options and enables more creative and difficult decisions and solutions to potentially be realized.

5.3.3 Sequence Adaptation Actions Over Time

One aspect of managing the complexity of what will be needed to address coastal flood risk is to look at needs and options over time, identifying where to start and at what point future options will need to be considered and initiated. This approach first requires an understanding of the risk tolerance within a community or focus area (see Section 5.2). In Phase 2, participants generally saw value in starting with smaller steps and building towards the bigger or tougher decisions that will be needed.

5.3.4 Enable and Advance Actions at Individual and Collective Levels

An important tension that repeatedly arose as we explored options, was the dynamic relationship between individual and collective needs and actions. Different perspectives can inform and shape options in ways that best draw on both, while thoughtfully considering necessary trade-offs.

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[21]City of Courtenay “Dike Replacement and Flood Management Strategy,” May 2021. Weblink: https://www.courtenay.ca/assets/City~Hall/Council/Agendas/2021/2021-05-17%20Council%20Agenda%20Complete%20AMENDED.pdf#page=35. Accessed 19 November 2021.

[22] For a thorough overview of non-structural measures and considerations for implementation in a BC jurisdiction, see Ebbwater Consulting Inc. (2021) “Non-Structural Flood Mitigation: Resource Guide” prepared for the Regional District of the Central Okanagan. Weblink: https://www.rdco.com/Flood-Mitigation-Planning-Resource-Guide.pdf. Accessed 20 December 2021.

Table 5-3: Recommendations related to Sendai Framework Priority 3.

High-level estimates of priority and cost (primarily dollar cost, but also in some instances human resources and skills) are provided in this table as H - High (red), M - Medium (yellow) and L - Low (green).

Recom. No.	Description	Development Details
3-1 Priority: H Cost: L	Include a climate risk lens in the Regional Growth Strategy.	Future iterations of the Regional Growth Strategy should consider the coastal flood hazard maps, and the risk-based information. For example, the settlement node designations for Saratoga and Union Bay should be revisited to ensure that the settlement node objectives are congruent. Land use planning approaches (e.g., see Ebbwater Consulting Inc., 2021a) should be considered to proactively adapt to climate change.
3-2 Priority: M Cost: M	Consider policy, planning, and regulatory tools.	Review the RDCO Non-Structural Flood Mitigation Resource Guide (Ebbwater Consulting Inc., 2021b) to identify appropriate land use policies for the CVRD, member First Nation, and local governments. This guide provides practical advice for non-structural flood mitigation activities. Example tools and policies related to avoidance and long-term retreat strategies are particularly relevant for coastal areas.
3-3 Priority: M Cost: L	Develop programming that supports education and action on flood resilience in the community.	This complements recommendations 1-2 and 4-1 to further emphasize the importance of investing in education and community-building that leads to individual and collective actions to build flood resilience.

Recom. No.	Description	Development Details
3-4 Priority: M Cost: M	Build on existing work in the region to identify and advance opportunities to implement nature-based solutions with co-benefits for flood resilience.	Nature-based solutions have strong support from a range of stakeholders and could contribute to raising awareness and greater support for additional flood resilience measures. There are a number of excellent resources on the topic[23,24,25], and organizations in the region who are leading the way on nature-based solutions to a range of issues[26]. The CVRD could identify opportunities to partner with others on nature-based solutions that are being pursued for other reasons, and also have co-benefits for flood resilience. This would create opportunities for education and awareness-building about coastal flood hazard, risk and resilience, and a range of options available.

[23] Rising Seas and Shifting Sands – Combining Natural and Grey Infrastructure to Protect Canada's Eastern and Western Coastal Communities. Weblink: UoW_ICCA_2021_12_Coastal_Protection_Grey_NbS.pdf (intactcentreclimateadaptation.ca). Accessed 13 December 2021.

[24] International Guidelines on Natural and Nature-Based Features for Flood Risk Management: https://ewn.erdc.dren.mil/?page_id=4351

[25] Natural and Nature-Based Flood Management: A Green Guide (Book): https://www.worldwildlife.org/publications/natural-and-nature-based-flood-management-a-green-guide

[26] Green Shores Program: https://stewardshipcentrebc.ca/green-shores-home/gs-about/. Accessed 29 September 2021.

Recom. No.	Description	Development Details
3-5 Priority: M Cost: L	Develop guidance materials to educate and enable property owners to consider flood mitigation and flood-proofing measures.	This falls under the "accommodate" strategy and is one of the areas that is largely in the domain of individuals to enact. However, the CVRD and partners can play an important role in educating the public about the flood hazard and options available at a property- or neighbourhood-level to reduce the vulnerability of homes and properties to flood events. A range of existing ideas can be leveraged and considered for application locally[27]. This could be selectively targeted to higher risk areas that are more likely to experience flood events in the near- to mid-term. As people begin to adopt these measures, others will be more likely to find out and consider it themselves. Refer to the RDCO Non-Structural Flood Mitigation Resource Guide and the FAQs developed to respond to questions at the Public Meeting for this project.
3-6 Priority: M Cost: M	Develop a system of targeted outreach, grants and/or incentives to support lower income residents and property managers / landlords to implement flood-proofing measures.	Equity was a key concern raised throughout the engagement process, and especially in relation to accessibility of flood-proofing information and measures. The CVRD should explore ways of improving access to these options for lower income residents (or rental properties), with a priority on higher risk locations.

[27] Retrofitting for Flood Resilience A Guide to Building and Community Design (Book): https://www.routledge.com/Retrofitting-for-Flood-Resilience-A-Guide-to-Building--Community-Design/Barsley/p/book/9781859467343. Accessed 29 September 2021.

Recom. No.	Description	Development Details
3-7 Priority: H Cost: M	Conduct more detailed analysis of large public infrastructure that is in the way of the hazard.	The regional scale risk assessment identified, at a high level, infrastructure that is exposed to flood hazards. Highway 19 is exposed in several areas, as well as the Comox Road artery and other secondary roads. Adapting or relocating this and other critical infrastructure needs consideration. The cost of assessment, and implementation in the near term, is likely small compared to the likely avoided damages.
3-8 Priority: H Cost: M	Consider acquiring temporary but reusable flood barriers (e.g., Aquadams ™) and support residents to learn about property level temporary barriers.	The feasibility and costs to acquire, store, and deploy these reusable solutions need to be explored to replace traditional sandbags, which are problematic. Sandbags have low capital cost; however, to be effective they must be strong enough to hold the sand and withstand contact with water indefinitely. They are usually saturated with contaminants and need to be disposed following a flood.
3-9 Priority: M Cost: L	Investigate options to support homeowners to transition into the flood insurance market.	In coordination with the Province and municipalities, Realtors ™, and insurers the CVRD could initiate a targeted public awareness and engagement program to alert homeowners to their need for flood insurance and how to access this. Producing standardized flood risk maps for insurance providers is one piece of this puzzle.
3-10 Priority: H Cost: L	Relocate sources of contamination to areas outside of hazard areas, especially when a flood is imminent, to reduce the chance of spills.	Contamination sources, such as fertilizer or fuel containers (and buried septic systems), should be permanently moved to areas on a property that are less likely to be flooded [28]. If this is not possible, alternative temporary storage areas, or floodproofing should be considered. Boat fuel barrels should be removed from docks.

5.4 Enhancing Preparedness, Response and Recovery to Build Resilience

[28] More farm-related measures are available in the Farm Flood Readiness Toolkit. Weblink: https://www.climateagriculturebc.ca/app/uploads/FV08-farm-flood-readiness-2020-toolkit.pdf. Accessed 13 December 2021.

The Sendai Framework Priority 4 recognizes the need for preparedness, response, and recovery at all levels. This process requires recognition that disaster management is a cycle that requires constant and proactive consideration in all its phases to achieve success during response. While we did not focus extensively on Priority 4 in this phase of the CFAS, stakeholders did note the synergy between recovery planning and opportunities to build back better, and differently, following a flood event. Table 5-4 provides specific recommendations with high-level costs and priorities, and the sub-sections below summarize recommendation themes.

5.4.1 Enable Options Through Proactive Recovery Planning

Project participants noted that strategies such as "retreat" could be an effective option over the longer term. However, careful consideration and thought are required to be able to implement such strategies effectively. Using retreat as an example, the implementation of this strategy is likely to occur over decades, based on building stock renewal timelines. While the planning process should not be primarily reactive to individual flood (and other hazard) events, such events do provide a "window of opportunity" to implement the strategy. The established plan should clearly spell out how a business or people dependent on an affected building/structure will be relocated, if/when a flood or wildfire destroys a building that is near the end of its lifecycle. This type of proactive thinking can be applied to other adaptation strategies as well.

Table 5-4: Recommendations related to Sendai Framework Priority 4.

High-level estimates of priority and cost (primarily dollar cost, but also in some instances human resources and skills) are provided in this table as H - High (red), M - Medium (yellow) and L - Low (green).

Recom. No.	Description	Development Details
4-1 Priority: M Cost: M	Work closely with existing Comox Valley Emergency Program (CVEP) [29] staff and resources to enhance individual, neighbourhood- and community-level awareness and resilience.	Find synergies with the existing CVEP (e.g., Neighbourhood Emergency Preparedness) to build awareness and capacity-building in the community and at a neighbourhood level that serves emergency preparedness as well as broader decision-making capacity for coastal flood resilience.

[29] Weblink: https://www.comoxvalleyrd.ca/services/emergency-management/about-comox-valley-emergency-program. Accessed 30 November 2021.

Recom. No.	Description	Development Details
4-2 Priority: M Cost: M	Develop an all-hazards regional recovery plan. The plan should consider a range of natural hazards and acknowledge the interdependencies between cumulative pressures such as climate change, wildfires, floods, debris flows, etc.	The recovery plan should include a framework applicable to all recovery efforts, and across a range of hazards and event magnitudes (e.g., not just extreme or catastrophic), alongside hazard-specific considerations and guidance. For example, wildfires can increase risk of flood in following seasons / years, necessitating additional interventions to mitigate flood risk in the aftermath. This should provide guidance about expected steps to take to learn from these events and make changes as we go.
4-3 Priority: H Cost: M	Develop a framework to guide decisions about rebuilding and retreating.	This could include the particular case where some areas are expected to become permanently flooded over time (due to sea level rise). This could also identify thresholds that would signal an action that is needed (e.g., the point at which to begin planning, construction, developing options, implementing buy-out programs, etc). This should identify areas for alignment with the recovery plan (Recommendation 4-2).
4-4 Priority: H Cost: L	Integrate flood mapping into the CVEP.	The hazard maps produced in Phase 1 of the CFAS, as well as the risk assessment information produced in Phase 2, should be integrated into the various components of the CVEP.

5.5 Next Steps for the CVRD to Progress the CFAS

Phase 2 of CFAS developed a suite of information and tools that can now be used to inform decision-making, planning, and implementation of adaptation options. These are early steps in what will be an ongoing process.

This section outlines three priority actions that CVRD can initiate in the short term to build on and advance the CFAS. In particular, the CVRD is now well-placed to expand the conversation to engage more broadly with the public. Another foundational component needed to support ongoing planning and decision-making would be to establish a collaborative arrangement for ongoing leadership and governance of flood resilience. Finally, these two elements will support the CVRD and partners to move forward with focus area planning processes. Based on the risk assessment and engagement in Phase 2, we would recommend that the CVRD begin with the Comox Road focus area. This area, because of its jurisdictional complexity and regional importance creates both an opportunity and a necessity to work collaboratively.

5.5.1 Expand Public Communications and Engagement

Phase 2 was designed to develop materials and tools that can support the CVRD and others in the region to have more informed conversations, develop shared language and understanding of risks, and therefore proceed more effectively in planning and decision-making processes. Engaging the public will be an essential part of developing supportable and effective strategies as a community. As evidenced by participation in the public information session, there is high interest in this topic and willingness to engage. First steps could include:

- Creating introductory materials to translate key concepts and findings from Phase 1 and 2 into publicly accessible and relevant communications materials (e.g., infographics, handouts).
- Hosting a series of public information sessions to engage interested participants in the type of process developed in Phase 2 (with participation from members of the public with an interest in the identified focus areas).
- Developing materials to support local community groups, organizations, and citizens to convene their own discussion groups and provide ongoing input to the CVRD and/or multi-stakeholder governance group.

5.5.2 Establish a Collaborative Framework for Flood Resilience in the Region

As we have described extensively in this report, the "wicked" problem of flood risk and resilience requires participatory and collaborative approaches to manage effectively. As a first step, an agreement such as a memorandum of understanding would enable more consistent involvement and alignment across CVRD and its partners, including the K'ómoks First Nation, Town of Comox, City of Courtenay, the BC Ministry of Transportation, as well as local non-governmental and community organizations in the area. This is a necessary step prior to initiating the Comox Road planning process. Once established, this group could work together to develop a Collaborative Framework / Terms of Reference to describe more specifically how the group will work together, its purpose, objectives, values, and principles. Ideas generated by participants in engagement Round 3 (see Box 1 to the right) could inform this step.

Box 1. Ideas for principles and practices that support a collaborative approach to flood resilience *(suggested by participants in engagement Round 3)*

- Imagine approaches that support local thriving
- Make clear commitments so people can be brave
- Willingness to have tough conversations
- Ensure equity in process and outcomes
- Meaningful truth and reconciliation
- Take a holistic view in design and decision-making
- Make trade-offs transparent
- Keep options open
- Accountability
- Place relationships at the centre
- See failure as part of growth
- Adaptive, evolving, flexible
- Lifelong learning
- Diverse ways of engaging
- Respectful conversations
- Build a shared vision

5.5.3 Initiate the Comox Road Focus Area Decision Process

The work in Phase 2 indicated that the Comox Road focus area is a high priority, based on the significant impacts and consequences along with the complexity of the multi-jurisdictional context relating to this area and assets.

Planning for sea level rise in this area will require participation from the City of Courtenay, Town of Comox, Ministry of Transportation and Infrastructure, CVRD, as well as K'ómoks First Nation, along with a range of stakeholders. As such, the MOU suggested in Sub-section 5.5.2 is a necessary precursor to beginning this process.

The decision tools and processes developed in Phase 2 would form the basis for this decision process. One of the key challenges associated with a multi-jurisdictional area such as the Comox Road, is that there will be competing interests and values, which will need to be meaningfully included in a decision process. For example, the regional importance of the infrastructure that runs through this area (road and water main) may be considered so important by some that it should be protected at all costs. Whereas, an alternate point of view might suggest that the cost of relocating this infrastructure is worth it given the ecological and recreational benefits that this would bring. In order to explicitly consider these types of challenges we propose that the CVRD undertake a structured-decision-making process for this area, leveraging the many materials completed for the region for this project. This would include a process along the lines of:

1. Identifying a full list of stakeholders, and developing agreements on how to work together (see also Sub-section 5.5.2).
2. Identifying place-based values for the Comox Road area. The larger regional values, developed for this project, could be leveraged, and simply 'gut-tested' for the Comox Area.
3. Identifying goals, objectives, and measures of success based on the values. Again, the materials developed for the region could be leveraged to support this effort.
4. Identifying mitigation actions for the Comox Road area. These could initially be based on the options identified for the Saratoga Beach focus area, but should be re-purposed to be more specific to the Comox Road Area. These would also have to be more specific and detailed than the archetypal options developed for Saratoga Beach. For example, full and detailed costing should be conducted, rather than using simple qualitative scales.
5. Identifying preferred mitigation actions, by comparing the options to each other using the goals, objectives, and measures of success.
6. Improving mitigation actions based on the outcomes of the scoring process.
7. Identifying a timeline for action, nominally based on a risk-tolerance (i.e., at what point, given our understanding of sea level rise trends, will the potential risk to the existing infrastructure become intolerable).

6 Conclusion

With climate change effects including sea level rise, the CVRD will continue to experience costal flood hazards with consequences to assets, people, and the environment. The CVRD is responding to this challenge by taking a risk-based approach, within the context of the Coastal Flood Adaptation Strategy, to reduce risks. The goal of this project was to build on the development of coastal flood hazard mapping in Phase 1, to develop a decision process to support the implementation of adaptation options. The development of the decision process was achieved by addressing the project's three main objectives, as follows:

1. **Identify values that matter to the community related to coastal flood**. Supported by extensive engagement activities and iteration, the project team obtained a solid understanding of what matters to the community. This was done by considering a broad set of criteria and consequence indicators (affected people, mortality, economy, environment, culture, and critical infrastructure) within the broader CVRD, and for specific focus areas.
2. **Develop options to help the community adapt to coastal flood.** A range of adaptation strategies (i.e., protect, accommodate, retreat, avoid, and resilience) were considered, both in terms of their conceptual characteristics, and how they might be combined and implemented (i.e., described through an adaptation pathway) at a local level.
3. **Assess options informed by risk-based information.** A regional-scale risk assessment was completed, based on hazard scenarios developed in Phase 1, and the consequence indicators. The results also provided comparative quantitative data for the focus areas that were considered. The risk-based results informed the development of adaptation pathways, which were assessed to highlight trade-offs between each of them.

The decision process, and the supporting risk information, developed through this Phase 2 have highlighted the need for new approaches in flood management. This project, report, and accompanying resources, such as the risk maps, form a strategic next step to help local governments implement flood risk reduction and resilience.

The development of the decision process was grounded in the CVRD context through engagement and risk assessment. Despite the many implementation challenges associated with adaptation options, the region now has more capacity and understanding of actionable concepts to move forward with both as individual local and First Nation governments, and collectively as a region.

Glossary

Term	Definition	Source
Adaptation	Adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.	United Nations Office for Disaster Risk Reduction (UNDRR)
Coastal Flood Adaptation Option	A solution to mitigate coastal flood impacts. This could include a number of strategies such as protect, accommodate, retreat, avoid, and resilience-building.	
All-Hazards	Referring to the entire spectrum of hazards, whether they are natural or human-induced. Note: For example, hazards can stem from geological events, industrial accidents, national security events, or cyber events.	Public Safety Canada (PSC)
All-Hazards Approach	An emergency management approach that recognizes that the actions required to mitigate the effects of emergencies are essentially the same, irrespective of the nature of the incident, thereby permitting an optimization of planning, response, and support resources.	PSC
Assets, Asset-At-Risk, (exposed and vulnerable element)	Refers to those things that may be harmed by hazard (e.g., people, houses, buildings, or the environment).	RIBA
Flood	An extreme hydrologic event where sediment comprises less than 20% of the discharge by weight (Wilford, Sakals, Innes, Sidle, and Bergerud, 2004). These events are commonly caused by moderate to heavy or prolonged rainfall, melting snow, or a combination of the two. This term is favoured over “flood” for clarity.	Wilford et al. 2004
Climate Change	A change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.	IPCC
Consequence Indicator	Describes groupings of generalized assets (e.g., environment, culture, affected people, economy, and disruption). Provides a means of assessing impacts (qualitative) and consequences (quantitative) by specifying the information used.	
Exposure	The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas.	UNDRR

Term	Definition	Source
Flood	Overflowing of water onto land that is normally dry. It may be caused by overtopping or breach of banks or defenses, inadequate or slow drainage of rainfall, underlying groundwater levels, or blocked drains and sewers. It presents a risk only when people and human assets are present in the area where it floods.	Royal Institute of British Architects (RIBA)
Frequency	The number of occurrences of an event in a defined period of time.	PSC
Geohazard	A hazard of natural geological or meteorological origin (i.e., this does not include biological hazards). It includes floods, fluvial (erosion), debris flood, debris flow, landslide and rockslide related processes and hazards.	
Hazard	A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life, injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may represent future threats, and can have different origins: natural (geological, hydrometeorological, and biological) or be induced by human processes. Hazards can be single, sequential, or combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency, and probability.	UNDRR
Hazard Assessment	Acquiring knowledge of the nature, extent, intensity, frequency, and probability of a hazard occurring.	Modified (NDMP)
(Natural) Hazard	Natural process or phenomenon that may cause loss of life, injury, other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.	UNDRR
Likelihood	A general concept relating to the chance of an event occurring. Likelihood is generally expressed as a probability or a frequency of a hazard of a given magnitude or severity occurring or being exceeded in any given year. It is based on the average frequency estimated, measured, or extrapolated from records over a large number of years, and is usually expressed as the chance of a particular hazard magnitude being exceeded in any one year.	RIBA
Magnitude	Refers to the size or extent of a geohazard event. In this project, it relates to the likelihood of a flood. A flood event with small likelihood will have a large magnitude, and vice versa.	
Mitigation	Relates to options, strategies, or measures that are used to directly reduce risk from natural hazards.	
Quantitative Risk Assessment	A risk assessment that is completed using quantified or calculated measures of risk.	UNDRR
Resilience	The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.	UNDRR

Term	Definition	Source
Risk	The combination of the probability of an event and its negative consequences.	UNDRR
Risk Assessment	A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods, and the environment on which they depend. Risk assessments (and associated risk mapping) include: a review of the technical characteristics of hazards, such as their location, intensity, frequency, and probability; the analysis of exposure and vulnerability, including the physical, social, health, economic, and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities, with respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process.	
Risk Management	The systematic approach and practice of managing uncertainty to minimize potential harm and loss.	UNDRR
Risk Tolerance	The boundary of risk-taking outside of which a community or organization is not prepared to venture.	UN (Adapted from Kamioka & Cronin (2020)
Scenario	The specifications of a modelled event (e.g., hazard type, temporal and spatial extent, magnitude, likelihood). In this project, relates to flood hazards, which are loosely attributed to likelihoods and associated scores to calculate risk.	
Vulnerability	The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard.	UNDRR

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Appendix A Risk Assessment Details

The document provides background on risk assessment, and the methods applied for this project. Document is provided separately.

Appendix B Flood Hazard Layer Sensitivity Analysis

The document describes how the Phase 1 hazard layers were post-processed for use within the risk assessment. Document is provided separately.

Appendix C Risk Assessment Maps

Hazard and consequence maps are provided for the 6 indicators for the regional scale risk assessment. Document is provided separately.

Appendix D Focus Area Profiles

The document is based on the pre-meeting materials package provided to participants prior to engagement Round 1. Document is provided separately.

Appendix E Adaptation Strategies

The document is based on the pre-meeting materials package provided to participants prior to engagement Round 2. Document is provided separately.

Appendix F Adaptation Pathways

The document is based on the pre-meeting materials package provided to participants prior to engagement Round 3. Document is provided separately.