

INTEGRATED FLOOD HAZARD MANAGEMENT PLAN

Final Report

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Prepared by:

In association with:





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Executive Summary

The District of Squamish (District) is set in a beautiful but hazardous location at the head of Howe Sound where five rivers flow toward the sea. Much of the community is located within flood hazard areas, including historic Downtown Squamish. Many people outside of the community depend on regional transportation links that cross through the floodplain.

The District lies within traditional territory claimed by the Skwxwú7mesh Úxwumixw (Squamish Nation). Ten reserves located in the floodplain create a shared interest in flood protection. The District also lies within traditional territory claimed by the Tsleil-Waututh Nation.

Flood history in Squamish stretches back to the oral history of the Skwxwú7mesh Úxwumixw. Flood-related hazards include floods, erosion, and dike breaches along the Squamish, Mamquam, Cheakamus and Stawamus Rivers. The Cheekeye River and several smaller creeks present flood, debris flood, debris flow and avulsion hazards. Coastal flood and tsunami hazards from Howe Sound will worsen as sea levels rise due to continued global climate change.

The District relies on a combination of policy measures and structural flood protection works to manage flood risk. To date, policy measures have focussed on the Zoning Bylaw and provisions in the Official Community Plan. Structural protection works consist of over 20 km of dikes located throughout the District, most significantly along the Squamish River and Mamquam River. Coastal flood protection is currently provided by a variety of low, non-standard works around the downtown.

In 2014, the District began a comprehensive update to its 1994 Flood Hazard Management Plan. The new Integrated Flood Hazard Management Plan (IFHMP) responds to changes in the community. It also incorporates new tools in the field of flood hazard management. The term “integrated” reflects the District’s desire for an inclusive, systems-based approach. The IFHMP identifies community-supported options for flood risk management while promoting sustainable development opportunities.

District staff and consultants developed the IFHMP with input from the Squamish Nation, a Technical Working Group, and community stakeholders. The project had four main phases: a background analysis, technical studies of coastal floods and river floods, and preparation of the final plan described in this report. In a separate study, the District is reviewing options for managing debris flow risks on the Cheekeye Fan. The IFHMP does not yet address urban stormwater flooding and groundwater flooding.

The IFHMP carried out hazard and consequence assessments for the community’s most important flood risk areas. Some assessments had to make assumptions about how the community might look many decades from now. The IFHMP assumes that climate change will raise sea levels 1 metre higher than they are today, and increase peak flows during river floods by 10%. It also assumes that development will gradually fill in to the maximum density currently allowed, that buildings will be raised or “floodproofed”, and that open spaces called “floodways” will help convey flow through the community. These assumptions will help the IFHMP keep new buildings “safe” as the community continues to grow.

Coastal floods are caused by extreme combinations of tide, storm surge, wind and waves. The IFHMP recommends planning for a minimum coastal flood elevation of 4.59 metres geodetic. With 1 metre of sea level rise, there is a 1 in 200 (or 0.5%) chance of this flood level occurring each year. Many parts of Downtown Squamish have ground elevations between 2 m and 3 m geodetic. These areas are already at risk from coastal floods.

The IFHMP also modelled floods on the local rivers. Results show that many areas and properties may be at risk from river flooding. Some of the District’s existing dikes will not provide the intended level of protection during a 200-year return period flood. If the main Squamish River dike breaches during a



200-year return period flood, it will be very dangerous for anyone caught in the floodplain – even trained emergency responders. Economic damages could exceed \$450 million, and nearly 60% of the community's residents could be displaced. The loss of municipal facilities like fire halls, pump stations, and the wastewater treatment plant would create widespread hardship throughout Squamish.

A variety of tools and techniques helped to inform the community about flood risk, and helped the District learn about the community's goals and priorities. The community's response was clear: the District should use all practical approaches and tools to mitigate flood risk. This feedback helped to shape the IFHMP's overall strategy for flood risk management. Most IFHMP recommendations focus on managing risks from 200-year return period floods. The Squamish River floodplain is the heart of the community, and the community showed less tolerance for risk in these areas. A higher standard of flood protection is appropriate for these areas. Debris flow risks on the Cheekeye Fan are severe and also justify a higher standard for risk mitigation.

Options for reducing (or "mitigating") flood risk are based on balancing four key strategies:

- **Protecting** the community to keep floods away from developed areas;
- **Accommodating** hazards by adapting land use and development to reduce flood damages;
- **Avoiding** new development and densification in high-risk areas; and
- **Retreating** vulnerable development from areas where current risks are not acceptable.

The IFHMP recommends over 100 specific tools for mitigating flood risk. Recommendations address land use, new buildings, dikes, river management, emergency response, public education, and flood insurance. Some tools apply to the entire community, such as updates to OCP and a new Floodplain Bylaw. Other tools apply to specific Flood Hazard Areas. Some of the most important tools include construction of a new sea dike, long-term upgrades to the Squamish River dike, and new Flood Construction Levels for all flood hazard areas. IFHMP recommendations can be grouped into:

- policy measures that must be enacted by Council;
- operational measures implemented by District staff as part of their ongoing work;
- capital investments in flood protection and (where necessary) land acquisition; and
- further studies to support future updates to the IFHMP.

Some IFHMP recommendations should be implemented immediately. Others will take decades to plan and build. Some of the most important measures will require long-term financial commitments.

Funding sources should reflect the widespread and varying benefits of flood protection. Opportunities for local funding include general revenues, senior government grants, local stakeholders and future development. Further work is needed to determine an appropriate balance between these funding options.

Collaboration was very important in building the IFHMP, and will be even more important for its successful implementation. Partnerships can help the District through cost-sharing, regulation, data collection, monitoring, and ongoing stakeholder engagement.

The IFHMP represents an important step forward for the District's flood risk management program. The process has confirmed that there are no easy or inexpensive ways to reduce and manage flood risk in a growing community where so many hazards overlap. Successful implementation of the IFHMP will demand significant and ongoing financial, policy and administrative commitment from District Council, staff and partners. However, the community-supported solutions of the IFHMP can help the District achieve its goal of remaining a liveable, sustainable community. In achieving these goals, the District will demonstrate how proactive communities can adapt and respond to the challenges of natural hazards and climate change.



1. Introduction

Squamish is a community of 19,500 people located in a spectacular natural setting. Its natural advantages include rugged mountain vistas, pristine rivers and one of B.C.'s most beautiful *fjords*. However, these same features also expose Squamish to a range of natural *hazards*, including *floods* and related processes. Different kinds of flood-related hazards are present in many areas of the community, and include:

- river floods on the Squamish, Mamquam, Cheakamus, and Stawamus Rivers;
- *debris flows* and *debris floods* on the Cheekeye River and other local watersheds; and
- *coastal floods* and *tsunamis* from Howe Sound.

The District of Squamish (the District) is responsible for managing development in *flood hazard areas*, as well as providing the community with appropriate flood protection. The Skwxwú7mesh Úxwumixw (Squamish Nation) has similar responsibilities for reserve lands within the shared floodplain.

In 1994, the District completed a *Flood Hazard Management Plan* (FHMP). From 1994 to 2014, the FHMP provided guidance for development in flood hazard areas. However, flood protection measures recommended in the FHMP reflect engineering and policy standards that were in place in 1994.

Since 1994, there have been significant changes in the field of flood hazard management such as:

- an evolving understanding of *climate change*,
- improved tools to help understand flood hazards, and
- changing roles and responsibilities for individuals and governments who manage flood *risk*.

In addition, the Squamish community has experienced two decades of growth and development. The focus of the community has broadened from its industrial roots to embrace tourism, recreation, business, and sustainability. A generation after it was prepared, the 1994 FHMP no longer meets the community's flood protection needs.

In 2014, the District began an extensive multi-year update to the FHMP. The update process produced a new *Integrated Flood Hazard Management Plan* (IFHMP), developed with input from the Squamish Nation, community stakeholders, and other flood risk management partners. The IFHMP incorporates the latest guidelines, tools and best practices to support the District's liveability and sustainability objectives. IFHMP deliverables are summarized in the table below.

Table 1-1: IFHMP Deliverable Reports

Deliverable Report
Framework for Community Engagement
Electronic Forum (updated throughout project)
Background Report
Coastal Flood Risk Mitigation Options
River Flood Risk Mitigation Options
Integrated Flood Hazard Management Plan (this document)



This document is the final report for the IFHMP. It summarizes all major findings, recommendations and decisions to date. The report covers the following key topics:

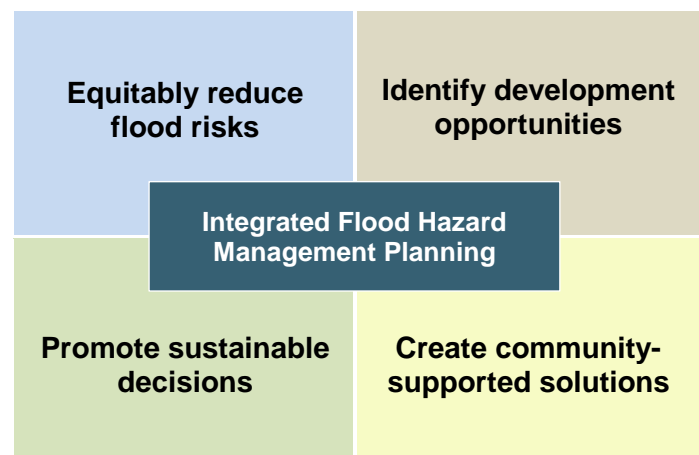
- Background information on flood hazards and historical flood mitigation practices in Squamish (Section 2);
- *Flood hazard assessments* for the coastal margin and river floodplains (Section 3);
- Engagement with regulators, partners, and the community to help shape the IFHMP (Section 4);
- Different approaches to flood risk mitigation (Section 5);
- Recommended flood risk mitigation measures that apply to the whole community (Section 6);
- Additional flood risk mitigation measures recommended for specific areas (Section 7); and
- Considerations for implementing IFHMP recommendations of the measures (Section 8).

A summary of the report contents is provided in Section 9. A Glossary of Technical Terms is provided in Appendix A. The glossary provides definitions for words in this report that appear in *italics*. Other appendices include documentation for the final phase of community engagement, draft District policies, and a detailed list of priorities for upgrading local flood defences.

1.1 Integrated Flood Hazard Management Plan

The Squamish IFHMP has four primary objectives:

- Reduce flood risks and share them fairly between everyone who uses the floodplain.
- Identify opportunities for continued economic, environmental and social development.
- Make decisions that promote social and environmental sustainability.
- Work with the community to achieve and implement realistic solutions.



The IFHMP is called "integrated" because it takes a systems-based approach to achieving its objectives. An integrated approach means:

- **assessing flood and flood-related hazards** from all possible sources - the ocean, rivers, creeks, lakes, urban stormwater, groundwater, and related hazards like *erosion*, *landslides* or ground instability;
- **identifying opportunities** to manage risk based on a wide range of possible actions; and
- **making decisions** that consider the different ways each decision might affect people, the community, and the environment.



The District's IFHMP will guide development and land use in Squamish for years to come. Completing an IFHMP is an important but resource-intensive process, and can challenge the resources of a small community. To meet its budget obligations, the District's IFHMP focusses on coastal floods and river floods. Studies are already in progress to address other hazards like urban stormwater and debris flows on the Cheekeye *fan*. Once complete, these studies can be harmonized with the IFHMP.

The District's IFHMP consists of four main phases:

- **Phase 1: Background Analysis** reviewed existing information about flood hazards in Squamish and the District's existing *flood risk management* tools. Phase 1 is summarized in the IFHMP Background Report.
- **Phase 2: Coastal Flood Risk Mitigation** developed a strategy for managing coastal flood risk. Phase 2 is summarized in the IFHMP Coastal Flood Risk Mitigation Options report.
- **Phase 3: River Flood Risk Mitigation** completed technical flood assessments and risk mitigation strategies for the Squamish River, Mamquam River, Cheakamus River and Stawamus River. Phase 3 is summarized in the IFHMP River Flood Risk Mitigation Options report.
- **Phase 4: Integrated Flood Hazard Management Plan** compiled all the previous work into a final report. It recommends specific technical and policy solutions for flood risk management. This document is the summary report for Phase 4 of the IFHMP.

1.2 Project Team, Partners and Key Stakeholders

The IFHMP was developed by a core team of District staff and consultants with input from the Skwxwú7mesh Úxwumixw (Squamish Nation), a Technical Working Group, and other community stakeholders.

Project Team

The District's IFHMP initiative was led by Municipal Engineer David Roulston, P.Eng. and Planner Matt Gunn, RPP, MCIP with direction and participation from senior District staff as well as Mayor and Council.

The multi-disciplinary consulting team includes:

- **Kerr Wood Leidal Associates Ltd.:** project management, hydrotechnical and civil engineering;
- **Arlington Group Planning + Architecture Inc.:** planning, policy and public consultation services;
- **SNC-Lavalin Inc.:** coastal engineering;
- **Thurber Engineering Ltd.:** geotechnical engineering and geoscience; and
- **Cascade Environmental Resource Group:** environmental science.

First Nations

The community of Squamish lies within traditional territories claimed by the Skwxwú7mesh Úxwumixw (Squamish Nation). The Squamish Nation has a well-established cultural interest in the local watersheds that is strongly rooted in their history and traditions. Cultural uses of the watersheds include activities like fishing, hunting, and plant and herb cultivation and harvesting. Cultural and archaeological sites of significance are located throughout the watersheds. The Squamish Nation has an abiding interest in protecting all of the land and resources within its traditional territories.



There are ten Squamish Nation reserves located throughout the community's *floodplain* areas. These lands are located side-by-side with lands administered by the District. Historical changes to the river system had significant impacts on Skwxwú7mesh Úxwumixw (Squamish Nation) reserve lands. Some Squamish Nation reserves lost about half their original area to river erosion in the early 1900s. More reserve land was used to build *dikes* along the new river alignment. The dikes protect both District and Nation lands. As a result, the District and Nation share a common interest in flood protection.

The District recognizes the contributions that the Squamish Nation has made in the development of this IFHMP. The District and the Squamish Nation will need to continue to work together to implement the IFHMP in a way that minimizes negative impacts on reserve lands while making Squamish a safer community for everyone.

IFHMP technical input and feedback was provided by Skwxwú7mesh Úxwumixw Chiefs and Council as well as Nation staff, and was co-ordinated by Squamish Valley Administrator Paul Wick.

The District also lies within traditional territories claimed by the Tsleil-Waututh Nation. Traditional territories claimed by the Tsleil-Waututh Nation and Squamish Nation overlap in the Squamish Valley area. While the two First Nations have separate governments and decision-making processes, the Tsleil-Waututh and Squamish Nations share an interest in protecting aboriginal rights and title, preserving opportunities for cultural use, and environmental stewardship.

Technical Working Group

The IFHMP Technical Working Group (TWG) consists of representatives from all orders of government as well as non-government stakeholders who have an interest in flood risk management for the Squamish community. Representatives from the following organizations were invited to participate at key stages of the IFHMP development:

- BC Hydro
- BC Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO)
 - Water Management Branch
 - Ecosystems Branch
- BC Ministry of Community, Sport and Cultural Development
- BC Ministry of Transportation and Infrastructure
- Emergency Management BC
- Fisheries and Oceans Canada
- CN Rail
- Fortis BC
- Vancouver Coastal Health

The TWG also includes representation from the District, Skwxwú7mesh Úxwumixw (Squamish Nation), and local stakeholder groups representing property owners, residents, business, and environmental organizations.



Community Stakeholders

The District hosted workshops and meetings with key community stakeholders at various stages of the project. Community stakeholders included 'Highly Affected Landowners' holding land in the Squamish River floodplain. A second group of 'Highly Affected Landowners' was established for those holding land in the Cheakamus River floodplain.

Environmental and community groups represented at community engagement workshops included:

- Canadian Home Builders Association – Sea to Sky Chapter
- Local Developers,
- School District No. 48
- Sea to Sky Forestry Centre Society
- Squamish & District Forestry Association
- Squamish Chamber of Commerce
- Squamish Community Services Society
- Squamish Downtown Business Improvement Association
- Squamish Environmental Society
- Squamish Estuary Management Plan Committee
- Squamish Historical Society
- Squamish River Watershed Society
- Squamish Streamkeepers
- Squamish Terminals
- Squamish Trail Society
- Tourism Squamish
- Urban Development Institute

In addition to stakeholder groups, the community engagement process also welcomed input from highly engaged citizens, *Qualified Professionals*, and the general public.

2. Background

For over twenty years, the 1994 Flood Hazard Management Plan (FHMP) helped the community of Squamish balance flood risk and development. However, key parts of the 1994 FHMP are now outdated due to community growth, changing priorities, new information about flood hazards, and new tools for managing flood risk. This section provides background information for the District's new Integrated Flood Hazard Management Plan (IFHMP), which replaces the 1994 FHMP.

2.1 Study Area

The District of Squamish is located at the head of Howe Sound where five rivers converge. These mountain rivers are fed by glaciers, snowmelt, rainfall and groundwater. They descend from their steep headwaters carrying water, sediment, and sometimes larger rocks and wood debris. When fast-flowing mountain rivers reach gently-sloping valley lands, they reduce their speed, deposit their sediment and spread out. Terms like *alluvial fan* and floodplain are commonly used to describe low-lying lands along these lower, flatter, and slower-moving parts of the river.

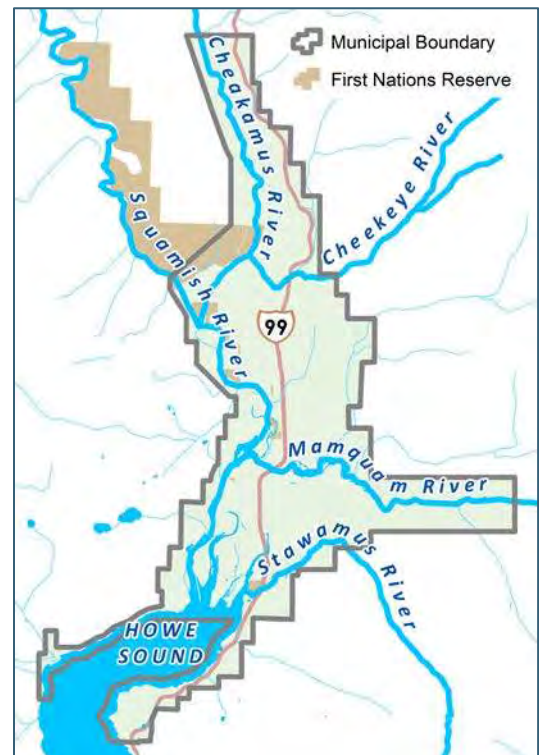
Gently-sloping lands near water have historically been viewed as the most suitable for human settlement, agriculture and transportation. Flooding has been a continuous risk in the Squamish area over the last 10,000 years, and is well-documented in the oral history of the Skwxwú7mesh Úxwumixw (Squamish Nation) as well as written accounts of more recent floods.

Today, Squamish is an active, modern and multi-cultural community with a population that lives, works and plays within the local watersheds. The natural environment is very important for both residents and visitors in an area marketed as the Outdoor Recreation Capital of Canada.

The community of Squamish is made up of established neighbourhoods and outlying rural areas. The majority of community gathering places are located within the local floodplains, including the historic town centre of Downtown Squamish. Most people depend on regional transportation links that cross flood hazard areas for employment, recreation or supplies. Many large employers, businesses and institutions are vulnerable to flooding. In addition, many of the community's unique recreation opportunities have evolved directly or indirectly from the local river and marine systems.

The IFHMP focuses on the coastal margin and river floodplains of four mountain rivers within Squamish: Squamish River, Cheakamus River, Mamquam River and Stawamus River. The District is also completing parallel work on the District's fifth river, the Cheekeye River.

A more detailed description of watershed characteristics, including topography, climate, hydrology, and natural environment, can be found in Section 2 of the IFHMP Background Report.



The District of Squamish faces flood hazards from five mountain rivers and the ocean.



2.2 Flood-Related Hazards in Squamish

Natural hazards in Squamish include flood hazards from the Squamish, Mamquam, Cheakamus, and Stawamus Rivers; flood and debris flow hazards from the Cheekeye River and several smaller creeks; and coastal flood and tsunami hazards from Howe Sound. Flood-related hazards can also erode land and deposit sediment.

Many of these different hazard areas overlap. In overlap areas, reducing risk from one source of flooding can sometimes increase risk from another. The District's overlapping flood hazard areas are shown in Figure 2-1, while each type of hazard is discussed separately below. A more detailed discussion of these hazards can be found in the IFHMP Background Report.

Coastal Flood Hazards

Squamish is located at the head of Howe Sound. The part of Howe Sound closest to Squamish is called a fjord – a long, narrow and deep inlet carved by glaciers. The District has a long coastline that stretches along Howe Sound from Watts Point in the east to Woodfibre in the west.

Along most of its length, the *foreshore* of Howe Sound is relatively steep and undeveloped. However, one large area at the mouth of the Squamish River and several other smaller areas are relatively flat and low elevation. These areas may be vulnerable to coastal floods.

Coastal floods in the District are created by extreme combinations of *tide*, *storm surge*, local wind and wave *setup*, and wave *runup* on the shoreline. Coastal flood hazards can vary based on a given location's exposure to wind and waves. Coastal communities are also at risk from tsunamis.

Vancouver Island protects Howe Sound from tsunamis generated a long distance away, so the most important tsunami risk for Squamish involves landslides into or beneath the waters of Howe Sound. Work done by the IFHMP and others shows that the risk from tsunamis is relatively low compared to other communities on the B.C. coast. The IFHMP concludes that the District should focus on reducing (or "mitigating") coastal flood risks and develop emergency plans for tsunami situations. The IFHMP also recommends more work to better understand coastal flood hazards and tsunami risk in Squamish.

River and Creek Hazards

Most floods on the District's larger rivers are caused by intense multi-day rainstorms that can occur throughout the fall and early winter. Under these conditions, rain falling throughout the watershed can melt a thin, wet layer of snow to create additional *runoff*. Sediment can build up in a river channel, increasing the flood risk. Many rivers have a broad, flat floodplain that is covered by water during a flood. A natural river channel will migrate back and forth across its floodplain over time by eroding land on one side of the river and depositing sediment on the other.

Floods on smaller creeks and rivers are most often caused by shorter, more intense rainstorms. On these streams, water levels usually rise and fall faster than on a large river. As a result, there may be less warning of a coming flood.

Due to their steeper slope, small creeks can transport proportionally more sediment and woody debris than rivers. Where a creek slope changes from steep to shallow, the water slows down and doesn't have as much energy to carry material downstream. Sediment and debris will often deposit in the form of a creek fan. On some fans, the creek channel regularly moves back and forth or spreads out across the fan surface. Other fans were formed a long time ago under very different geologic or climate



conditions, and may no longer be at risk. Experts typically study the upstream watershed, sediment, and vegetation of a creek fan to determine how much risk there is on different parts of the fan.

On some rivers and creeks, unstable terrain creates large volumes of sediment, rock and woody debris. If the creek is steep enough, these materials can be mobilized as a wet, channelized landslide called a *debris flow*. Debris flows usually move much faster than floods, and have much more energy. As a result, they can cause much more damage when they reach developed areas. The Cheekeye Fan north of Brackendale is a well-studied example of a debris flow hazard area. Smaller creeks throughout the District also have the potential to produce debris flows.

Parts of the Squamish River, Cheakamus River, and Stawamus River can be affected by landslides. If a landslide blocks the river, water will back up until it overtops and washes out the landslide dam. This can result in a process called a *debris flood*. Debris floods share some characteristics with both floods and debris flows. Debris floods can also occur where a debris flow reaches flatter ground and begins to deposit some of its larger sediment.

Other possible river flood hazards could include failure of BC Hydro's Daisy Lake Dam or collapse of The Barrier, an unstable lava formation that retains Garibaldi Lake above Rubble Creek and the Cheakamus River.

The possibility of dam failure at Daisy Lake is extremely remote, but the consequences for Squamish would be very severe. BC Hydro routinely works with the District and other local stakeholders to maintain emergency plans.

Large-scale collapse of The Barrier is also extremely unlikely, but could potentially block the Cheakamus River. A blockage of this nature increases the possibility of a debris flood that could affect all of the Paradise Valley, with the most intense impacts occurring near the District's northern boundary. Despite public misconceptions, there is no scientific evidence that collapse of the Barrier could drain Garibaldi Lake or cause extreme flooding in downstream neighbourhoods along the Squamish River.

Dike Breaches

Some parts of the District are within the river or coastal floodplain but are protected by *dikes*. These dikes (sometimes spelled "dykes" or called "levees") keep water out of built-up areas during a flood. The dikes also cut off some areas that used to be part of the river, and make it more difficult for the river to change its course within the floodplain.

Some dikes in the District are in better condition than others. Most of the District's dikes are regulated by the Government of B.C. through the provincial Inspector of Dikes. Some landowners, as well as the Skwxwú7mesh Úxwumixw (Squamish Nation), have dikes and flood protection works that are not provincially regulated. These structures may be regulated by other entities (such as the federal government for on-reserve dikes) or may be unregulated.

If a dike is overtopped or damaged during a flood, it can result in a dike breach. A dike breach allows floodwater into areas that are usually protected, and can develop very quickly. Flow through the breach can be very deep and very fast. A dike breach may take people by surprise, especially if the dike has been there for a long time and people lose awareness that they live or work in a flood hazard area.

When deep, fast-moving water flows into areas that are usually protected by dikes, it can cause extensive damage and sometimes loss of life. Dike breaches in New Orleans, Louisiana during Hurricane Katrina (2005) resulted in hundreds of fatalities. Large floods have higher water levels and put greater force on the dike, which increases the chance of a dike breach. Smaller floods – for example the annual spring *freshet* in Squamish – have a relatively low chance of causing a dike failure.



Erosion Hazards

Moving water – waves and currents – can wash away land. Rivers and creeks naturally move back and forth across their floodplain, eroding material at one location and depositing it somewhere else. These changes may occur gradually over many years, or very rapidly in a single event. Conflicts and damage can result where development has occurred too close to the river.

Videos from floods around the world often show houses and buildings being undermined and/or falling into rivers and creeks. Local Skwxwú7mesh Úxwumixw (Squamish Nation) reserves lost significant amounts of land to river erosion in the early to mid 1900s. In some cases, the loss was more than half the reserve area.

In many areas, coastlines and riverbanks are protected against erosion using large rocks called riprap or other structures such as steel sheet pile walls. Man-made structures built to protect against erosion can fail. The consequences of a failure are usually worse when there is little or no warning. Areas that used to be protected may remain vulnerable to continued erosion. Flood risk may also increase if erosion creates a new river or creek channel, or allows water to reach new areas.

Climate Change Considerations

Scientists agree that the *climate* is changing, and that human activities have been at least partly responsible for these changes. Locally, temperatures are expected to get warmer year-round. Summers will get drier, and winters will become wetter. The warmer air will hold more water and have more energy, which may lead to more extreme *weather* events. Warmer temperatures around the world are also melting glaciers and ice caps, which causes sea levels to rise slowly over time.

Sea level rise poses a significant threat to coastal ecosystems and development. Intertidal habitats may change from mostly dry to mostly wet. Higher sea levels will allow larger waves to reach the shoreline and increase the potential for erosion. Salt water may intrude further into groundwater and freshwater sources. Most importantly for the IFHMP, potential flood depths will increase in coastal flood hazard areas and new areas may be exposed to flood hazards. The IFHMP has reviewed and incorporated the latest available guidance on climate change issues.

To help coastal communities plan for the future, the Government of B.C. studied how climate change will affect water levels along the B.C. coast. The Government has concluded that communities should plan for 1 metre of sea level rise by Year 2100 and 2 metres of sea level rise by Year 2200.

Sea level rise may happen more quickly or more slowly than the government guidelines suggest, but it will happen eventually. Land that may be developed safely at present-day sea levels will be exposed to coastal flood hazards when sea levels rise by 1 m or 2 m. New buildings built today may still be in use at and beyond Year 2100. The IFHMP incorporates 1 m sea level rise into its analyses. It also considers 2 m sea level rise in its recommendations for very long-term planning.

River flood hazards may also increase if climate change leads to more extreme rainfall events. In places like Squamish where detailed climate change studies are not available, the Association of Professional Engineers and Geoscientists of B.C. (APEGBC) recommends increasing river flood *peak flows* by a precautionary allowance to account for future climate change. The IFHMP adopts APEGBC's recommended climate change allowance.

Climate change science is constantly evolving. The IFHMP will be updated from time to time to incorporate the latest information. More details on how the IFHMP addresses climate change can be found in the IFHMP Background Report.



Other Hazards

The IFHMP addresses several types of flood-related hazards for Squamish. Two types of flood hazards that are not addressed in the IFHMP include urban stormwater flooding and groundwater flooding.

Urban stormwater management plays an important role in flood protection and environmental stewardship. Many communities use Integrated Stormwater Management Plans (ISMPs) to balance growth, flood protection, and environmental goals. Over the next few years, the District plans to complete ISMPs for each of its key urban watersheds. These ISMPs will work together with the IFHMP to understand and mitigate flood risks when high river levels trap urban runoff in the floodplain.

Groundwater flooding occurs when an area is flooded by water coming through the soil (below ground) instead of across the ground surface. The most important type of groundwater flooding for Squamish is seepage through and beneath the local dike system. Dike seepage during the 2003 flood showed that the potential impacts of groundwater flooding are much less than other types of flooding considered in the IFHMP. Dike seepage will be assessed and mitigated as part of future upgrades to the District's dike system. Seepage can also be assessed and managed as part of an ISMP.

2.3 Historic Overview of Flooding and Flood Mitigation in Squamish

The oldest known record of flooding in Squamish is the Skwxwú7mesh Úxwumixw (Squamish Nation) oral history of the Flood. Over the past century, the recorded history of the Squamish community shows a constant struggle to protect the growing settlement from flooding. The IFHMP Background Report documents 17 major floods that affected the Squamish, Cheakamus, Mamquam, Cheekeye, and Stawamus Rivers as well as Howe Sound. Figure 2-2 summarizes these past floods.

Skwxwú7mesh Úxwumixw Oral History The Flood

The oral history of the Skwxwú7mesh Úxwumixw (Squamish Nation) has a legend called the Flood. According to the legend, when the people began to forget their old ways and failed to listen to their elders, the game began to disappear and then the fish and the berries. People became hungry and began to quarrel. Still they wouldn't listen to their elders and change their ways. Then the rains came. The waters rose and the people had to anchor their canoes to Nch'kay' (Mt. Garibaldi). When the waters receded, the people who survived came to their senses and listened to their elders. Then the game and the fish and the berries returned in abundance.

Several conclusions can be drawn from the flood history of Squamish:

1. All the rivers in Squamish pose a risk of flooding. All have caused multiple and damaging floods in the past. Damaging floods have also occurred as a result of coastal inundation from Howe Sound.
2. The flood risk in Squamish has strong seasonal variations. Most flooding has taken place between October and December. Major floods have also taken place in August.
3. Unlike many other B.C. communities, the spring freshet (typically in late May, June, and early July) has not been a major cause of flooding on local rivers.
4. The frequency of floods causing significant damage has decreased over the past 30 years compared to earlier time periods. This is attributed to significant improvements made to the dike system.
5. Extreme precipitation (rain and snow) has occurred on at least 5 occasions since 1980. These continue to test the limits of flood protection structures. The October 2003 flood was the most recent and most severe condition recorded in recent decades.



Response to past floods has typically involved fixing damage, rebuilding structures in the same location, and strengthening the dike system. This approach reflects the limited amount of developable land in Squamish as well as a historical bias that humans can “control” natural flood processes.

Structural Flood Protection

The District has historically used both policy and structural tools to manage flood risk. The IFHMP Background Report reviewed these tools and identified gaps where they no longer meet the needs of the community. The most important part of the District’s flood risk management program is its system of dikes and related structures. Figure 2-3 shows the location of flood protection structures throughout the District.

Dikes along the Squamish River and Mamquam River connect to each other where the two rivers meet. The Squamish River dike also connects to a training berm that extends out into Howe Sound at Squamish Spit. Together, these structures have a total length of about 20 km and are the most important part of the District’s dike system. A substantial part of the community is located within the two dike-protected Squamish River floodplains. The IFHMP refers to these floodplains as the “upper” floodplain (north of the Mamquam River) and the “lower” floodplain (south of the Mamquam River).

There are also District dikes in the Paradise Valley (Cheakamus River), along the Cheekeye River upstream of Highway 99, and adjacent to the Valleycliffe neighbourhood (Stawamus River). Several “private” river dikes throughout the District are maintained by the Skwxwú7mesh Úxwumixw (Squamish Nation) or individual landowners. Some “orphan” dikes are not currently maintained by anyone.

Coastal flood protection is currently provided by a variety of low, non-standard works around Downtown Squamish. The District’s only true sea dike extends from the foot of Cleveland Avenue around to the west end of Winnipeg Street. Conflicts with development have created challenges for future dike raising.

The history of the District’s structural flood protection works begins with the early European settlers, who built structures to protect the floodplain’s fertile agricultural lands. The early dikes were upgraded from time to time, often following major floods. The current dike system was largely built by the Province in the 1980s using gravel dug out of the local rivers. The community has experienced several large floods since 1980 but damages have been relatively modest. Dike improvements since the record-setting 2003 flood have been paid for the local, provincial, and federal governments.

From time to time the District has worked with the Skwxwú7mesh Úxwumixw (Squamish Nation), the Province, and other partners to remove sediment from the river channel to restore its capacity and preserve the margin of safety of the dike system.

The IFHMP’s review of the structural flood protection system identified key gaps in areas like design standards, jurisdiction and access, inspection, reporting and compliance, and environment and community. The most notable gaps included coastal defences, the lack of a continuous right-of-way, and outstanding maintenance issues.

Policy-Based Flood Risk Mitigation

Until 2003, the Ministry of Environment was responsible for approving subdivisions in flood hazard areas. Some subdivisions in ‘historic exempt areas’ such as Brackendale or Downtown Squamish were approved with no requirement for *floodproofing*. In 2004, the Province of B.C. delegated responsibility for approving subdivisions in flood hazard areas to local governments (including the District). Since that



time, the District has guided development based on the 1994 FHMP. A 1993 study of Cheekeye River debris flows provided additional support for managing development on the Cheekeye Fan.

The 1994 FHMP recommended that the District adopt a floodplain bylaw to establish *Flood Construction Levels* (FCLs) and minimum *setbacks* in floodplain areas. However, this recommendation was never implemented. Current flood hazard management relies primarily on the District's Official Community Plan (OCP) for guidance and the Zoning Bylaw for regulation. The *Local Government Act* and *Community Charter* grant legislative authority to regulate new development and to require flood hazard assessments.

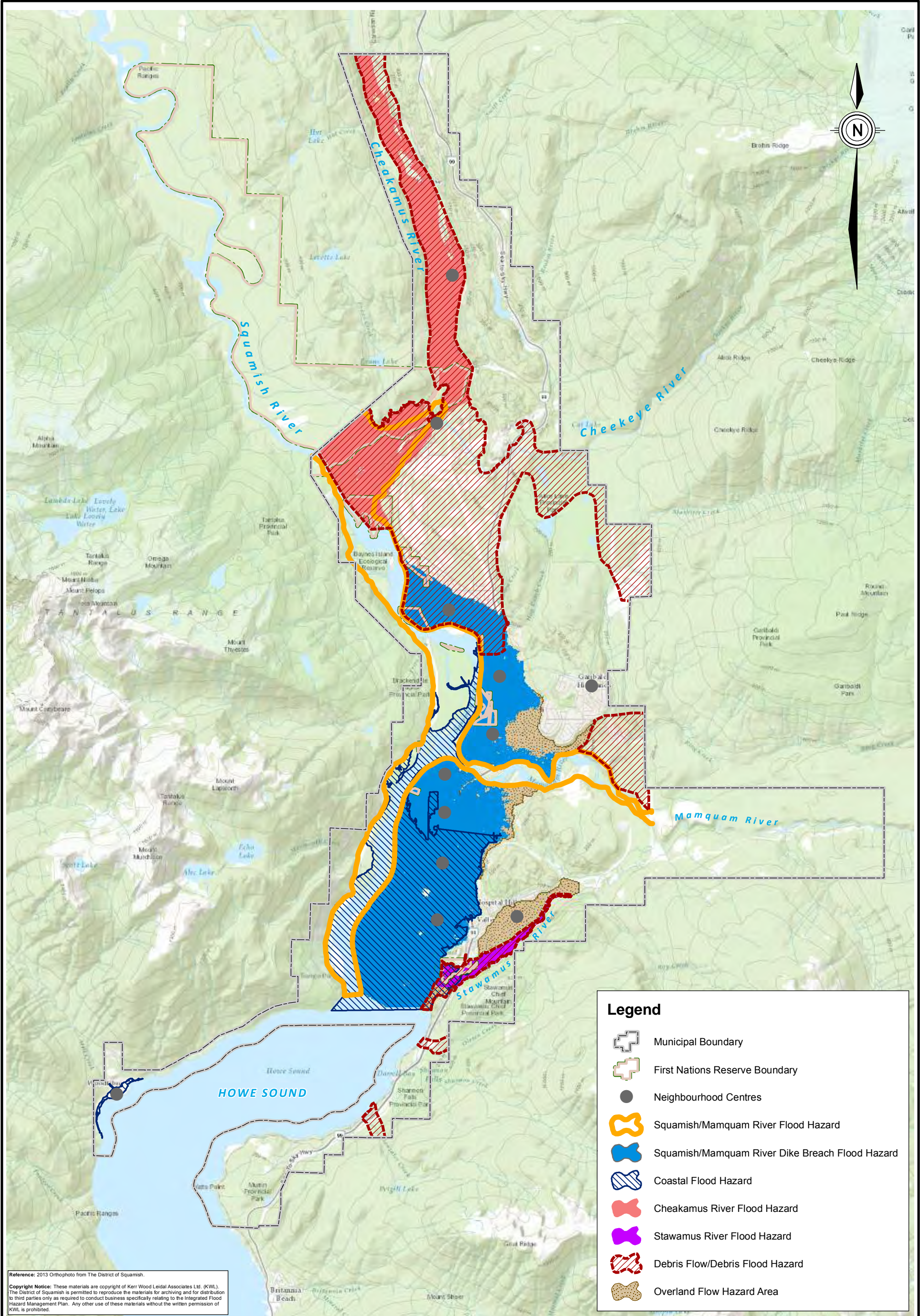
The District's 2009 OCP included strategic objectives for flood hazard management, but did not provide specific measures to manage development in natural hazard areas. The current Zoning Bylaw regulates land use, siting, elevation (Flood Construction Levels), requirements for structural protection and the use of covenants to reduce risk.


Under the provincial *Land Title Act* and *Community Charter*, developers can be required to prepare site specific hazard assessments for subdivision and building permit applications. While these assessments are useful and appropriate, the District's complex hazards are frequently beyond the scope of a site-specific review.

Under Section 219 of the *Land Title Act*, a covenant may be added to the legal title of a property. The District uses covenants to specify flood mitigation measures that must be followed, such as elevating buildings to the FCL. A covenant also typically indemnifies the District from any liability for future flood damages. Once registered on the legal title, a covenant applies to all future owners of the property.

In rare cases, the District has used expropriation to acquire privately-owned high-risk land that is required to support flood protection for the entire community.

The IFHMP review of the District's policy-based flood risk mitigation tools identified key gaps including risk management and analysis, regulation, and public education. The most notable gaps include planning for climate change, particularly sea level rise, and the need for a floodplain bylaw and flood hazard development permit area.





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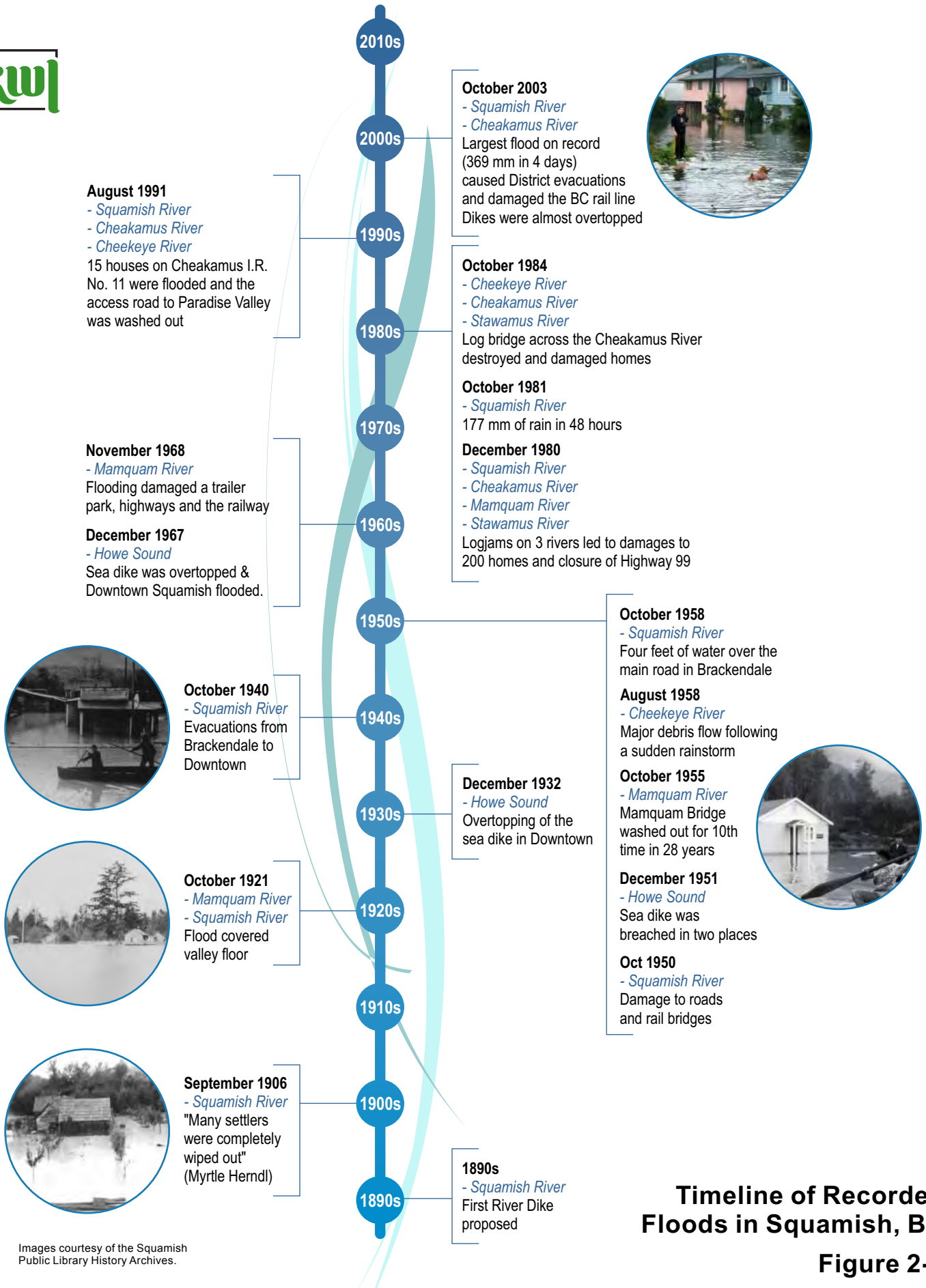
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District of Squamish - Integrated Flood Hazard Management Plan

District of Squamish Flood Hazard Areas

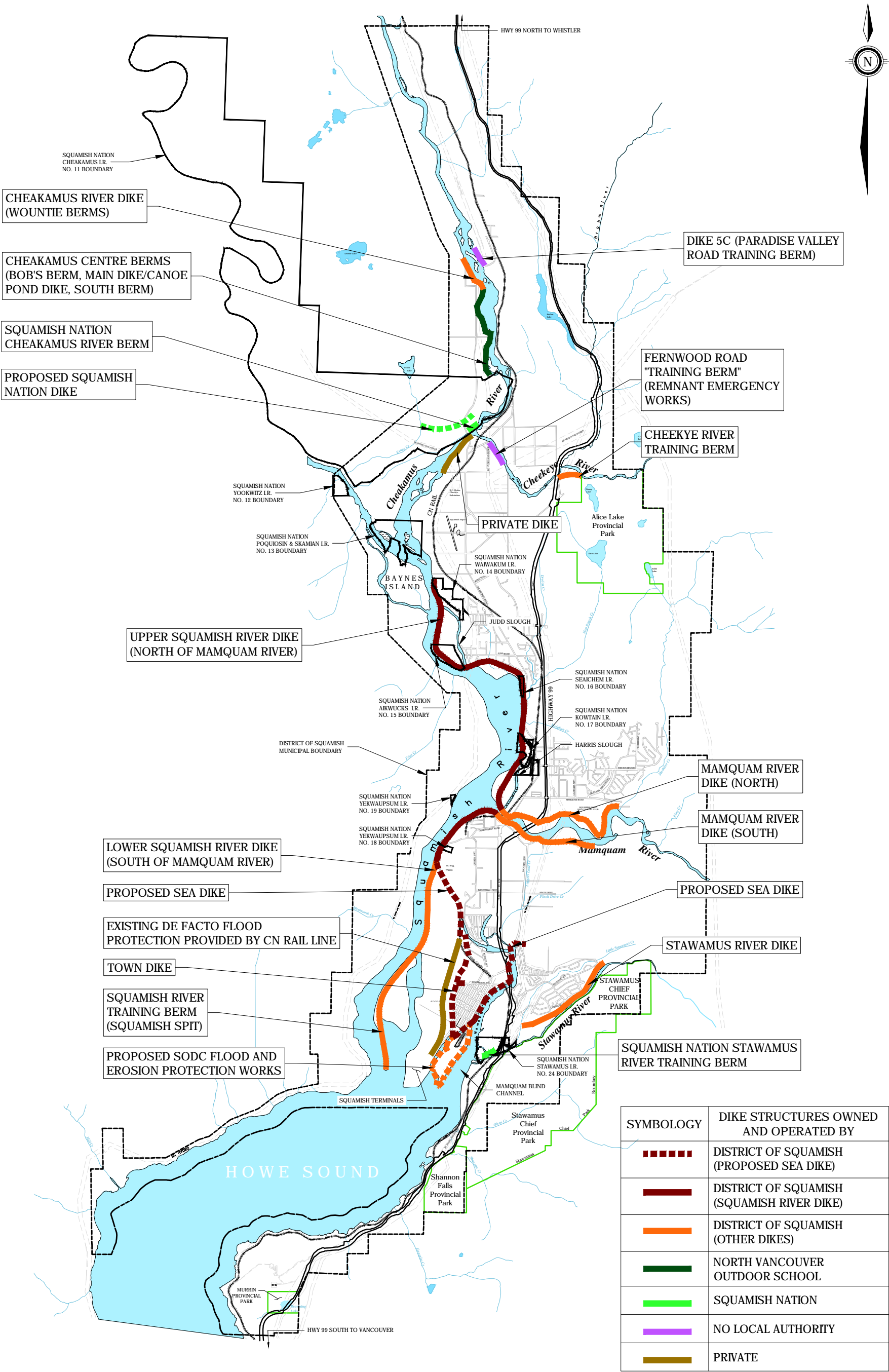
Figure 2-1



Timeline of Recorded Floods in Squamish, BC

Figure 2-2

Images courtesy of the Squamish Public Library History Archives.





3. Flood Hazard Assessments

This section summarizes the technical analyses completed for the IFHMP. Sub-sections focus on key concepts, timelines and assumptions, the coastal flood assessment, and the river flood assessments.

3.1 Hazard, Consequence and Risk

The IFHMP carried out hazard and consequence assessments to help the community develop a vision for flood risk management. Flood risk can be reduced (or “mitigated”) in two ways:

- by reducing the magnitude and/or probability with which flooding will affect the community, or
- by reducing the consequences that result if the community is flooded.

People use terms like hazard, consequence, and risk to talk about these issues. For discussions to be productive, everyone must have the same understanding of what these words mean.

A **Hazard** is a condition that can cause harm to society, infrastructure or the environment. For natural hazards like floods, small floods happen fairly frequently. Large, catastrophic floods occur only rarely. Each flood has a magnitude and a probability. Magnitude describes the size of the flood, and may refer to a maximum water level, peak flow, or volume of water (or debris). Probability describes how likely the event is to happen (or happen again). A flood hazard assessment is a study that determines how often and how much flooding should be expected to affect a community or development.

Consequences describe how the community would be impacted by flooding. Examples of consequences for a flood might include people killed or injured, properties and businesses damaged, environmental degradation, social services interrupted, or damage to cultural heritage sites. Assessing the consequences of flooding is often more difficult than assessing the corresponding flood hazard.

Risk is a product of hazard probability and corresponding consequences. The table at the right shows how risk depends on both factors. Risk assessments estimate consequences for different hazards and combine the results.

How Likely is the hazard?	How Severe are the Consequences?		
	Not Severe	Moderate	Very Severe
Not Likely	Low Risk	Low Risk	Moderate Risk
Moderate	Low Risk	Moderate Risk	High Risk
Very Likely	Moderate Risk	High Risk	High Risk

Some people are comfortable with more risk, while some people prefer less risk. Studies have shown that there are levels of risk that most people will accept. People may be willing to tolerate more risk if taking the risk brings other benefits for the community. People are usually less willing to accept risks that are imposed on them.

Larger communities often study potential consequences for each type of hazard at different probabilities. Even with a limited scope, the Squamish IFHMP is a very large project for a small community to undertake. The IFHMP had to focus on the hazards and probabilities that were most important for the community.



3.2 Planning Horizons and Development Assumptions

Decisions based on this IFHMP will affect the community for many decades. It is important that the IFHMP look beyond present-day conditions to consider conditions that might exist when today's buildings and developments reach the end of their service life. This is called a "planning horizon".

The District IFHMP adopted a modelling horizon of Year 2100. The project team's engineers and planners worked together to make assumptions about how hazards and development will change between now and Year 2100. These assumptions were incorporated into the IFHMP's flood hazard and consequence assessments.

Making assumptions about the future helps the IFHMP make good long-term decisions. Using these assumptions also means that IFHMP hazard assessments may not provide an accurate picture of present-day conditions.

The most important Year 2100 assumptions made for the IFHMP are listed below.

- Sea levels will be 1 metre higher than they are today.
- Peak flows for river floods will be 10% larger than they are today.
- Development will gradually fill in to the maximum density allowed under the current Zoning Bylaw.
- By Year 2100, all lots and buildings will be floodproofed. The amount of floodproofing fill assumed for each lot depends on the current zoning.
- Key *floodway* corridors will be maintained at present-day elevations.

The IFHMP will be updated from time to time to incorporate new information and refine assumptions like those listed above.

3.3 Coastal Flood Hazard Assessment

A coastal flood occurs due to an extreme combination of tide, storm surge, and local effects like wind and wave setup. The IFHMP Background Report compares different ways to combine these factors at the north end of Howe Sound. The Year 2100 allowance for sea level rise is also included.

After reviewing the Background Report, District Council decided to focus on a coastal flood that has a 1 in 200 (or 0.5%) chance of occurring in any given year. A flood with an annual probability of 1 in 200 is also called the 200-year *return period* event, and is the provincial standard for flood protection in most parts of B.C. The United States and most other Canadian jurisdictions use the 1 in 100-year flood. Some Canadian jurisdictions (including Lower Mainland communities along the Fraser River) as well as international jurisdictions like the Netherlands use more extreme events. IFHMP community engagement (described in Section 4) found that most people agree with Council's decision: the 200-year return period coastal flood is an appropriate focus for Squamish.

Adding all the different factors together gives a "still-water" coastal flood level of 3.99 metres *geodetic elevation*. An extra 0.6 metres is added to this level for uncertainty. Engineers call this extra allowance *freeboard*. With freeboard included, the minimum 200-year return period still-water coastal flood level becomes 4.59 m geodetic elevation. This is referred to as the "*Designated Flood Level*" for Squamish.

Much of Downtown Squamish is presently at risk of inundation from a coastal flood event with a return period of less than 200 years. Figure 3-1 shows the main area that could be affected by the 1 in 200-year return period coastal flood with 1 metre of sea level rise. The flooded area extends inland as far as North Yards.

Smaller areas at isolated sites like Woodfibre may also be at risk. The IFHMP refers to isolated sites like Woodfibre as “unconnected” coastal flood hazard areas because they only affect a small number of properties and aren’t part of a large coastal floodplain.

Additional allowances for waves and wind must be added to the still-water coastal flood at each site along the coast. The IFHMP Background Report includes a wave assessment for northern Howe Sound. The largest waves are expected to measure about 2 metres from crest to trough offshore near Squamish Terminals. Engineers will use this information to safely design buildings and coastal flood protection structures.

The IFHMP wave analysis showed how Squamish Terminals, the Squamish Oceanfront Development Lands, and the Squamish Spit help to keep larger waves away from Mamquam Blind Channel, Cattermole Slough, and Crescent Slough. Developers for the Squamish Oceanfront lands have already completed additional site-specific wave modelling. The IFHMP wave analysis should be updated if Squamish Terminals or the Squamish Spit are redeveloped.

IFHMP wave modelling assumes that a 200-year return period wind storm will occur at the same time as the 200-year return period coastal flood. This combination may create conditions that are more extreme than the intended 200-year return period criteria. However, there isn’t enough information about local waves and winds to support using a less extreme combination. The IFHMP recommends that the District collect more wind and wave data to better understand coastal flood hazards.

3.4 Squamish River / Mamquam River



Dike Breach with Downstream Dike

Engineers use computer models to help understand how high water might rise during a flood. River models give us information about water levels in the main river channel and any unprotected floodplain areas. A river model can also show whether dikes are high enough to prevent flooding. The District completed river modelling for the Squamish River and Mamquam River in 2011. The IFHMP Background Report updated the 2011 modelling using the latest available data.

River modelling is very important, but doesn’t provide any information about what might happen if a dike breaches. Water might spread out across the dike-protected floodplain and keep flowing downstream. If this happens, water levels in the floodplain will be lower than in the river. However, downstream dikes or high ground can also trap water in the floodplain. If this happens, the dike-protected floodplain can fill up like a bathtub until water gets high enough to overflow the dikes. Water levels in the “bathtub” part of the floodplain may be higher than in the adjacent river. In the inset figure (left), a sea dike stops storm surge but creates a “bathtub” during a river dike breach.



Dike Breach Hazard Assessment

To understand what might happen during a dike breach, the IFHMP constructed a model that includes both the river channel and the dike-protected floodplain. The model estimates how much water will flow through a dike breach and where it will go as it spreads out across the floodplain. It also models how water eventually gets back into the river.

A dike breach north of the Mamquam River would not cause flooding south of the Mamquam River, and vice versa. This meant the IFHMP could model the “upper” (north) and “lower” (south) floodplain areas separately. It is important to remember that separate dike breaches could still occur on both floodplains at the same time.

The IFHMP modelled dike breaches at four locations north of the Mamquam River and four locations south of the Mamquam River. The location of each dike breach was carefully selected to provide important information about how flow would progress through the floodplain. The model assumed that the dikes would breach during a 200-year return period river flood. The dikes are designed for these conditions, so the 200-year return period flood has a relatively low chance of causing a dike breach (compared to more extreme floods).

The IFHMP produced “composite envelope” maps that combine results from the different dike breach locations. Instead of showing results what would happen during a single dike breach at a specific location, these maps show the worst-case result for each location on the floodplain. Planners use maps like this to understand which parts of the community are most at risk.

In preparing the IFHMP, the District’s engineers and planners had to make assumptions about what might happen in the future. Some of these assumptions are precautionary, and the results may create challenges for some parts of the community. For example, the model suggests water levels inside the floodplain could be *above* the dike crest (with water flowing back into the river) at Brackendale, Garibaldi Estates, and Downtown Squamish.

After reviewing the dike breach modelling assumptions, the District decided not to add an additional freeboard allowance to modelled water levels. Water levels from the dike breach model were adopted as minimum Flood Construction Levels for the Squamish River / Mamquam River floodplain. The IFHMP refers to these as “minimum” levels because other criteria (e.g., ponding of site runoff) could result in a higher FCL at any given site.

Minimum FCLs for the upper floodplain (north of the Mamquam River) are shown in Figure 3-2. Minimum FCLs for the lower floodplain (south of the Mamquam River) are shown in Figure 3-3. FCLs in Downtown Squamish account for the effects of the future sea dike described in Section 7.1.

Engineers also need to know how fast water will flow through the floodplain. With this information, they can make sure building foundations and floodproofing fill will not be damaged by erosion or scour. The IFHMP River Flood Risk Mitigation Options report produced maps showing simplified design flood velocities for the upper and lower floodplain. These simplified velocities can be used for smaller projects or properties that don’t require a more detailed site-specific assessment. To be conservative, velocity results for Downtown Squamish assume the District would intentionally breach the future sea dike to let water out of the lower floodplain.

In addition to water levels and velocities, the IFHMP River Flood Risk Mitigation Options report uses an approach from Europe to map the danger to individuals who might be exposed to the dike breach flood. This value, called “Hazard Rating”, is a combination of water depth and velocity. During a dike breach, large parts of the floodplain would be dangerous for everyone, including emergency responders.



Dike Breach Consequence Assessment

The IFHMP used the dike breach model results to estimate economic, social, and environmental consequences. Estimates for economic loss, population displacement and debris generated (from damaged buildings, personal possessions, etc.) are shown in Table 3-1.

Table 3-1: Economic Consequences for 1 in 200-Year Return Period Dike Breaches

Dike Breach Location	Economic Losses	Population Displaced	Debris Generated (tonnes)
Upper Squamish River / North Mamquam River	\$190 million	7,000	20,000
South Mamquam River / Lower Squamish River	\$257 million	3,400	17,000
Total	\$447 Million	10,400	37,000

Results from the social consequence analysis show the importance of shared municipal facilities like fire halls, sewer pump stations, and the District's wastewater treatment plant. Loss of these facilities would create widespread hardship, even in parts of the community that were not flooded.

Results from the environmental consequence analysis show that flooding could mobilize contaminants and damage environmentally sensitive areas throughout the upper and lower floodplains.

A detailed discussion of the Squamish River / Mamquam River hazard and consequence assessment can be found in Section 2 of the IFHMP River Flood Risk Mitigation Options report.

3.5 Cheakamus River

Cheakamus River hazards include floods, erosion, and sediment deposition. At some locations, hazards can also include flooding behind landslide dams, and outburst debris floods when the landslide dam is finally overtopped and washed out. The most likely locations for landslide dams are where the Cheekeye River meets the Cheakamus River and at Culliton Creek near the District's northern boundary. Landslides could also block all or part of the river farther upstream at Rubble Creek or within the Cheakamus Canyon.

The District is reviewing debris flow hazards on the Cheekeye Fan separately from the IFHMP. Once both the IFHMP and Cheekeye Fan assessment are finalized, the District will better understand the risk of a debris flow landslide dam at the mouth of the Cheekeye River.

A detailed assessment of potential landslide dams north of the District boundary (including Culliton Creek) is beyond the scope of the IFHMP. However, the IFHMP river model includes some conservative assumptions in its simulation of the 200-year return period Cheakamus River flood. For example, water levels are modelled within the main river corridor but then extended across the entire floodplain. This is conservative, since water levels would be lower if flow spreads out into floodplain areas. Results from the IFHMP model are similar to results from previous debris flood hazard studies in the upper Paradise Valley.

To generate Flood Construction Levels, the District's preferred 0.6 metre freeboard allowance was added to the IFHMP 200-year return period water levels. Minimum FCLs for the Cheakamus River are shown in Figure 3-4 (north) and Figure 3-5 (south). These FCLs are appropriate for flood risk



management until more detailed landslide dam failure studies are completed. Engineers using the results should assume that the FCLs are caused by a debris flood event.

The FCL maps show that most of Paradise Valley could be flooded during a major flood event. Most private dikes along the Cheakamus River would be overtopped, and many would likely fail. Some dikes could be overtopped during a smaller (but more frequent) 20-year return period flood.

The most important consequence of Cheakamus River flooding is the potential loss of key access routes like Fergie's Bridge, Paradise Valley Road, and the Bailey Bridge. Loss of these routes would make it more difficult to share warnings and updates, evacuate residents, and respond to emergencies. Other consequences include flooding of rural properties, loss of land to erosion, damage to spawning channels, and disruption to local businesses.

A detailed discussion of the Cheakamus River hazard and consequence assessment can be found in Section 3 of the IFHMP River Flood Risk Mitigation Options report.

3.6 Stawamus River

Stawamus River hazards include floods, debris floods, bridge blockage, and deposition of sediment in the lower, flatter parts of the river. Peak flow from a debris flood could be larger than a comparable 'clear water' flood. The *estuary* is also subject to coastal backwater flooding from Howe Sound.

The Stawamus River hydraulic model is described in the IFHMP Background Report. The IFHMP identified the potential for debris floods, but did not have the resources for a detailed analysis. Instead, the hazard and consequence assessment described in the IFHMP River Flood Risk Mitigation Options report relied on the conservative assumptions listed below:

- The debris flood would occur after normal sediment deposits raise the bed of the Stawamus River 1 metre higher than it is today.
- The peak flow of a debris flood would be 1.5 to 2.0 times larger than the 1 in 200-year flood.
- Debris from the debris flood would block the Highway 99 bridge.

The IFHMP made some precautionary technical assumptions in the model to avoid underestimating the hazard.

The final draft River Flood Risk Mitigation Options report was publicly released in August 2016. Around the same time, the Skwxwú7mesh Úxwumixw (Squamish Nation) secured support from Indigenous and Northern Affairs Canada (INAC) to study flood hazards on St'á7mes (Stawamus) I.R. No. 24 and the Stawamus River estuary.

Having participated in IFHMP technical discussions, the Squamish Nation's work could pick up where the IFHMP left off. The Squamish Nation project included:

- a more detailed review of potential debris flood hazards;
- review of the IFHMP debris flood assumptions; and
- more detailed modelling of the complex hydraulics on the lower Stawamus River.

The Squamish Nation's assessment provides a considerable improvement on the hazard assessment documented in the IFHMP River Flood Risk Mitigation Options report. The Squamish Nation and the District agreed that the Nation's results should be incorporated into this final IFHMP report.



Squamish Nation Stawamus River Debris Flood Hazard Assessment

Geoscientists from Thurber Engineering Ltd. (Thurber) reviewed high-resolution topographic data for the Stawamus River watershed. They identified a landslide hazard area in a narrow part of the valley about 2 km upstream of the Valleycliffe neighbourhood. A landslide in this area could dam the river and is likely to govern debris flood hazards for the Stawamus River.

Thurber modelled some possible landslides that could block the river. They found that the steep river channel and narrow valley wouldn't be able to store much water behind the landslide dam. Their work concludes that a debris flood is possible, and would be larger than the 200-year flood.

Thurber also concluded that each of the original IFHMP debris flood assumptions was reasonable, but they might overestimate the hazard when considered together. The Squamish Nation's hazard assessment used this information to make some slightly different assumptions:

- The debris flood would occur after normal sediment deposits raise the bed of the Stawamus River 1 metre higher than it is today.
- The peak flow of a debris flood would be 1.5 to 2.0 times larger than the 1 in 200-year flood along the Valleycliffe reach of the Stawamus River.
- The river loses energy as it moves downstream. A debris flood would deposit most of its debris upstream of Highway 99. After allowing for a smaller amount of remaining debris to deposit downstream of Highway 99, the peak flow downstream of Highway 99 can be reduced to the 200-year return period flood.
- All three of the main bridges (Mamquam Forest Service Road (FSR), Highway 99, and CN Rail) could be half blocked by debris.

Based on Thurber's analysis, the volume of sediment that could be mobilized in a debris flood is unlikely to fully block the bridge at Highway 99 (as assumed in the IFHMP Background Report). It is more reasonable to assume a 50% bridge blockage than a complete blockage. For consistency, the same assumption was made at the CN Rail bridge and the Mamquam FSR bridge. These bridges were not blocked in the original IFHMP model.

These new assumptions were combined with a new two-dimensional hydraulic model capable of simulating multiple flow directions downstream of Highway 99. The update produced new and better flood maps that show lower water levels in most areas, particularly just upstream of Highway 99.

The District's preferred 0.6 metre freeboard allowance was added to the modelled water levels to produce the minimum Flood Construction Levels shown in Figure 3-6.

Consequence Assessment

The Squamish Nation hazard assessment produced new water levels but did not affect the general findings of the consequence assessment described in the IFHMP River Flood Risk Mitigation Options report.

Flood and debris flood hazards would be generally contained by the District's Stawamus River dike through the Valleycliffe reach. Downstream of the District dike, the flood hazard area spreads out along the lower reach of Little Stawamus Creek. Valley Drive and the Mamquam Forest Service Road would both be flooded.

Water flows across Highway 99 both north and south of the bridge, affecting Chances casino and the Squamish Nation gas bar. The Squamish Nation's existing training berm would be overtopped, and the



existing subdivision on St'á7mes (Stawamus) I.R. No. 24 would be flooded. Private industrial lots south of the current river channel would also be flooded.

Key consequences include flooding on St'á7mes (Stawamus) I.R. No. 24 and adjacent industrial lands, compromised access routes, potential damage to important bridges, loss of land to erosion, and disruption to local business operations. Flooding of the gas station could also create an environmental hazard for downstream areas.

A detailed discussion of the IFHMP hazard and consequence assessment can be found in Section 4 of the IFHMP River Flood Risk Mitigation Options report. The updated Stawamus River hazard assessment is documented in a separate memorandum prepared for the Squamish Nation.

3.7 Cheekeye River and Cheekeye Fan

Floods on the Cheekeye River can damage development within or adjacent to the river corridor. The river transports enough sediment to change river bed elevation and channel geometry very quickly. However, the greatest hazard on the Cheekeye Fan is the potential for debris flows. Debris flows on the Cheekeye Fan can mobilize very large volumes of boulders, mud, trees and water. Debris flows move quickly and do much more damage than floods when they impact human development.

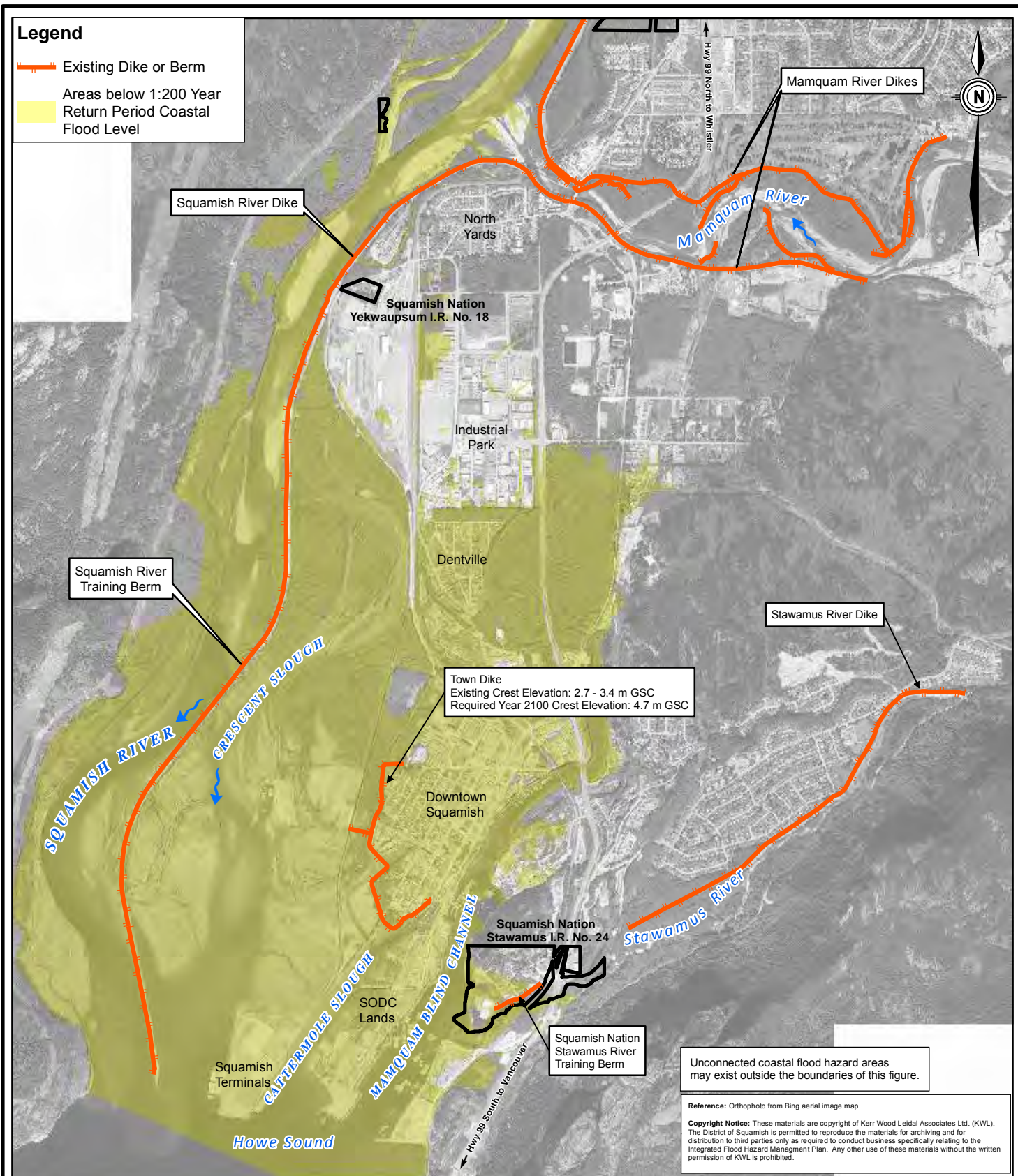
Small debris flows and debris floods frequently remain within the Cheekeye River channel. Larger debris flows can leave the channel (a process called avulsion) and could affect any part of the Cheekeye Fan. The largest debris flows are very destructive but have a very low probability of occurring in a given year: as low as 0.01%, equivalent to a return period of 1 in 10,000 years.

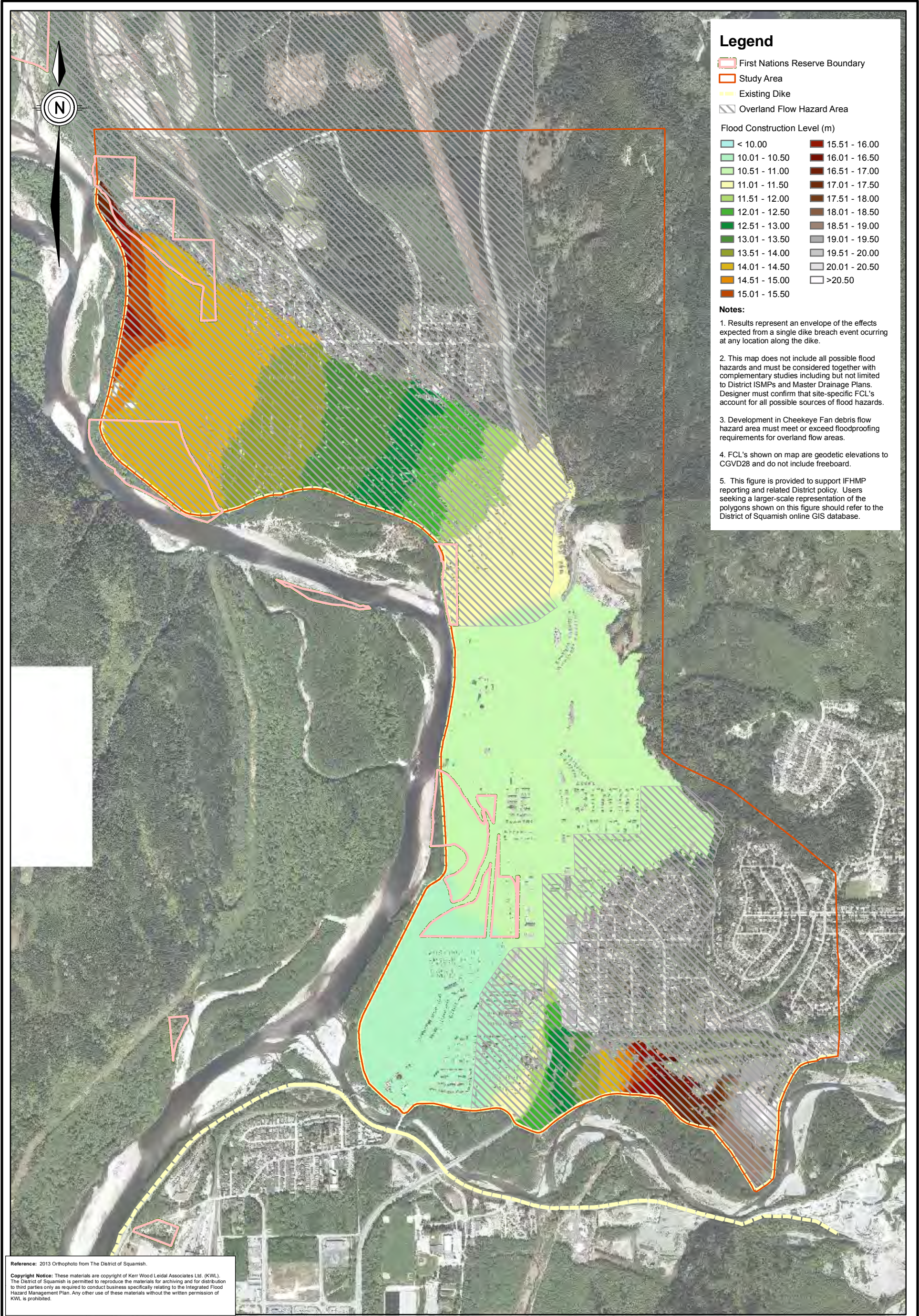
Managing and mitigating debris flow risk on the Cheekeye Fan will be an important part of the District's integrated flood hazard management program. However, rare and complex processes like debris flows on the Cheekeye Fan must be studied very carefully before making risk management decisions.

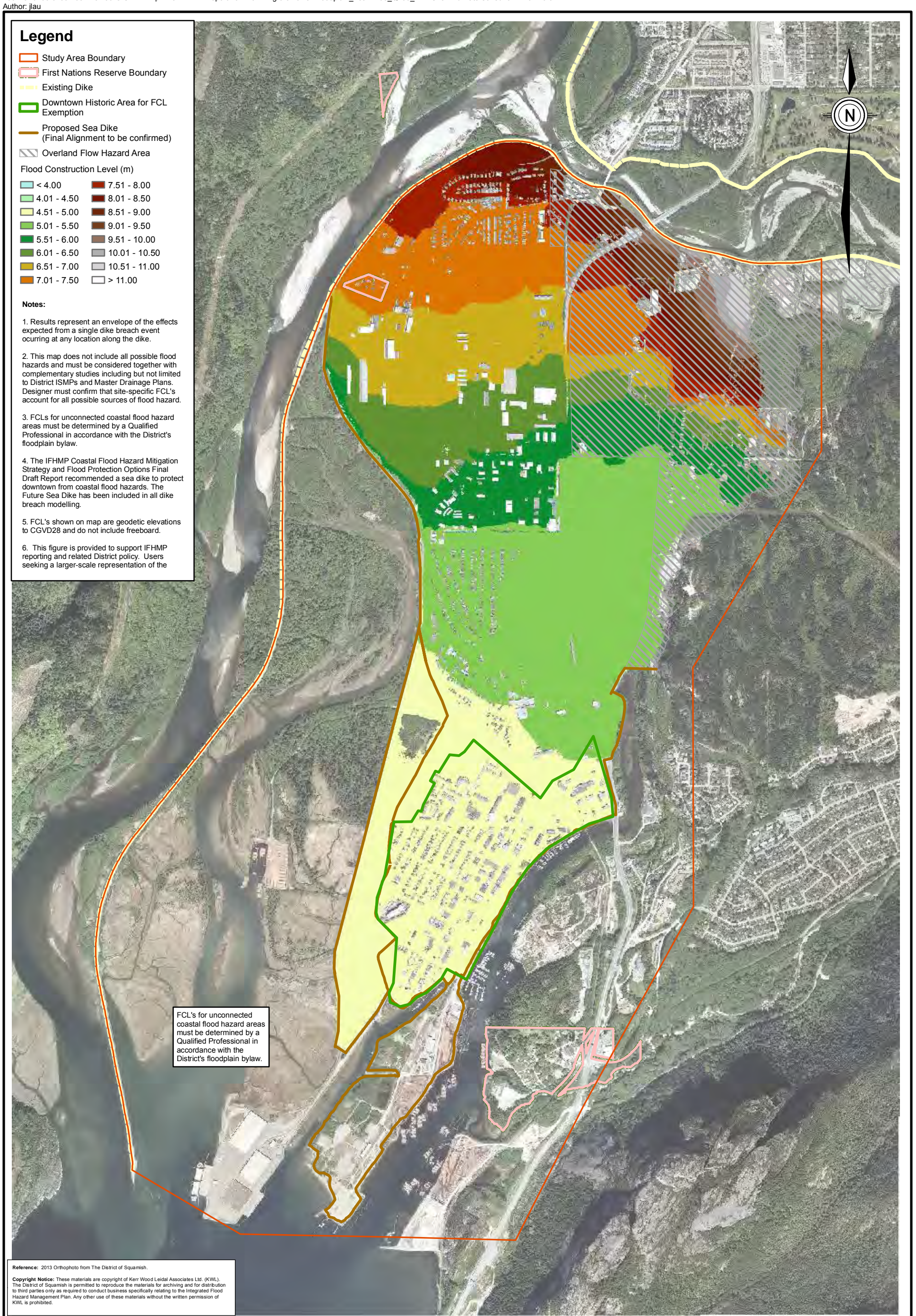
The District is working with internationally-recognized experts and potential community partners to better understand debris flow risks and risk management options for the Cheekeye Fan. These studies are proceeding separately from the IFHMP, but may become part of the IFHMP once they have been finalized.

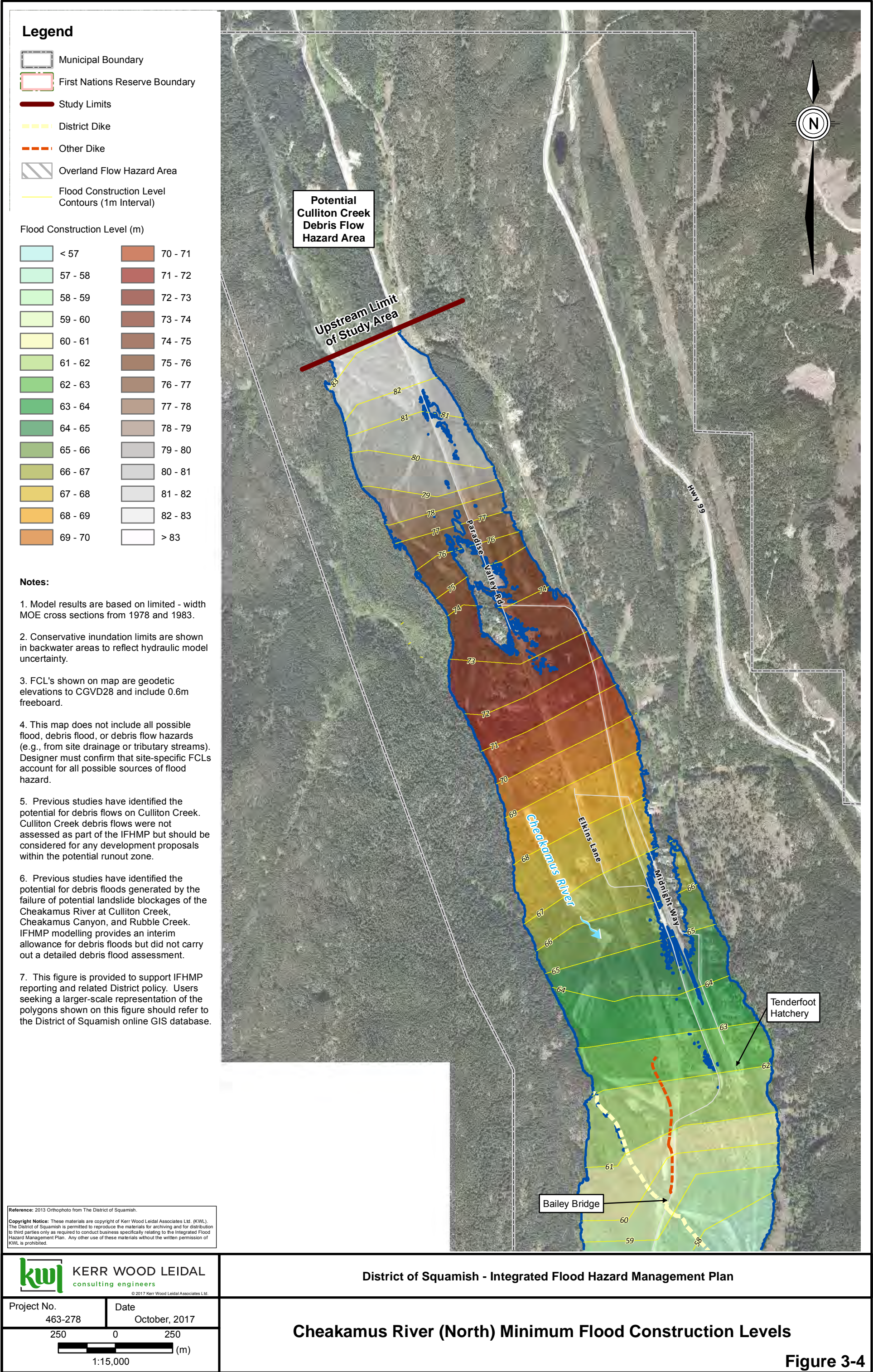
[ADDITIONAL DETAIL TO BE PROVIDED AS PARALLEL
CHEEKEYE FAN STUDIES ARE INTEGRATED WITH IFHMP]

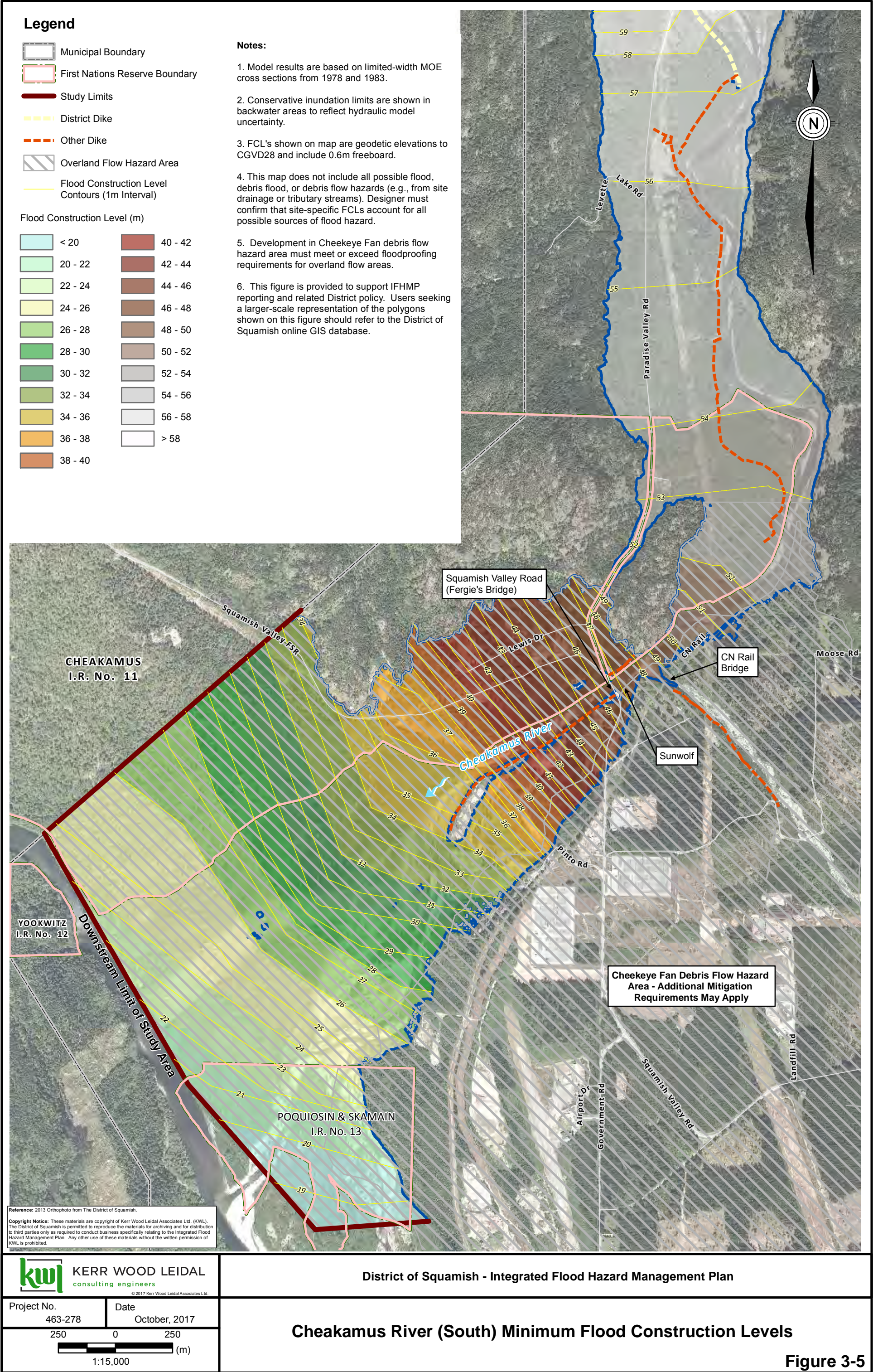
Path: O:\0400-0499\463-278\430-GIS\MXD-Rp\Final IFHMP Report\Figure 3-1 DowntownSquamishCoastalFloodImpacts_20171031.mxd Date Saved: 10/31/2017 4:09:48 PM
 Author: jlau

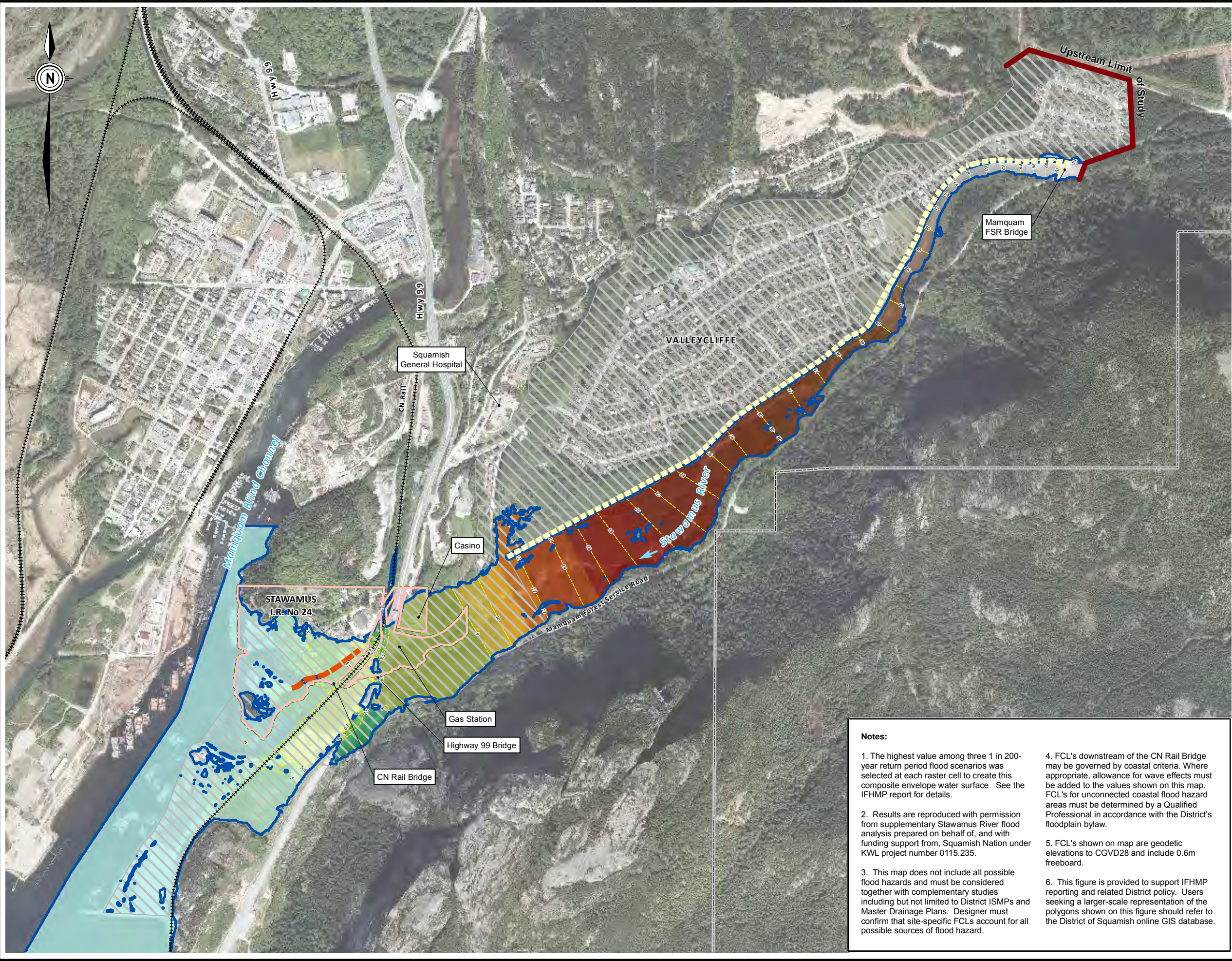












District of Squamish
Integrated Flood
Hazard Management Plan

Legend

Municipal Boundary

First Nations Reserve Boundary

Study Limits

District Dike

Other Dike

Overland Flow Hazard Area

Flood Construction Level Contours

0.5m Interval Downstream of Hwy 99

2m Interval Upstream of Hwy 99

Flood Construction Level (m)

	< 4.6		12 - 15
	4.6 - 5		15 - 20
	5 - 5.5		20 - 25
	5 - 6		25 - 30
	6 - 6.5		30 - 35
	6 - 7		35 - 40
	7 - 7.5		40 - 45
	7.5 - 8		45 - 50
	8 - 8.5		50 - 55
	8.5 - 9		55 - 60
	9 - 10		60 - 65
	10 - 11		65 - 70
	11 - 12		> 75

Reference: 2013 Orthophoto from the District of Squamish.

KERR WOOD LEIDAL

consulting engineers

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2500250

(m)

1:12,500

Project No.

463-278

Date

October 2017

Stawamus River
Minimum
Flood Construction Levels

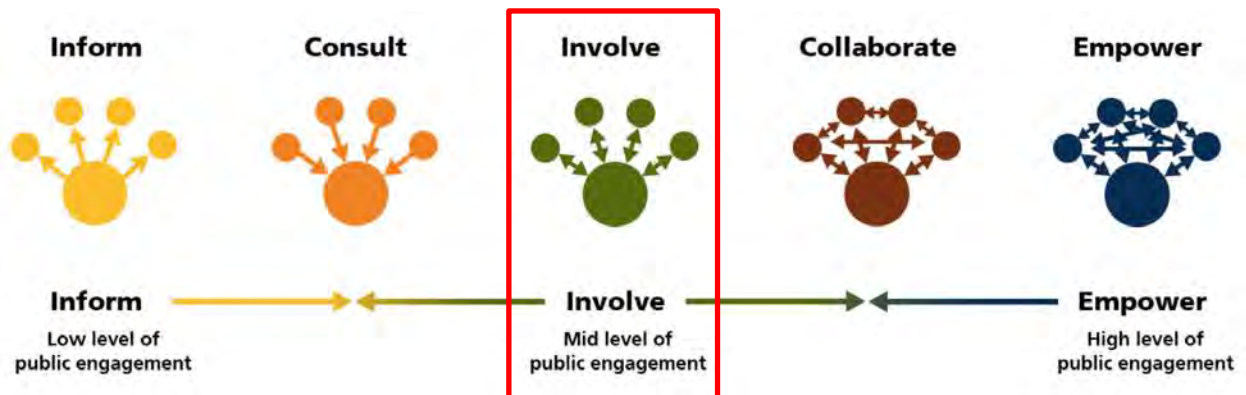
Figure 3-6

4. Engagement Process

Developing an IFHMP involves challenging trade-offs and difficult decisions. Stakeholders often have different values, and everyone may not be able to agree on the best solutions. Nonetheless, the engagement process is very important. Engagement is what gives the community a sense of ownership in the IFHMP. Ownership leads to more support from the community as the IFHMP is implemented.

At the beginning of the IFHMP, the District approved a community engagement plan for the IFHMP. The community engagement plan included consultation with the community (via digital media, social media and conventional open houses), dialogue with a Technical Working Group, and bi-lateral discussions with the Skwxwú7mesh Úxwumixw (Squamish Nation). The community engagement plan also specified key milestones where the IFHMP would require input from District Council.

Community engagement should be a major component of any IFHMP. However, like most other aspects of this IFHMP, the community engagement plan had to respect the District's limited resources. When some controversial issues arose in 2015, District Council approved an expanded community engagement plan. The expanded plan targeted the 'Involve' level on the International Association for Public Participation (IAP2) Spectrum of Public Engagement.



IAP2 Spectrum of Public Engagement

Adapted from City of Burlington, ON Community Engagement Charter, 2013

By targeting the 'Involve' level on the IAP2 spectrum, the District committed to:

- listen to the public's concerns and values;
- consider the public's input when developing and choosing alternatives; and
- provide feedback on how public input influenced the decision process.

The goal of the IFHMP community engagement process was to obtain balanced input from stakeholders that collectively represent the wider community.

This section summarizes key community engagement activities undertaken for the IFHMP. Additional details are provided in the IFHMP Coastal Flood Risk Mitigation Options report and the River Flood Risk Mitigation Options report.



4.1 Community Engagement

The District used a variety of tools and techniques to allow members of the community to become meaningfully engaged and provide input for the IFHMP. The primary tools were open houses, meetings, online surveys, and a project website. Each of these initiatives is discussed below. Information was also shared via social media, and email feedback was managed using an account set up specifically for the IFHMP.

Open Houses

The IFHMP included three Open House events. Each event took place at the Squamish Adventure Centre.

Open House #1 was held in Squamish on October 23, 2014. The Open House provided general information on flood risks in Squamish and collected feedback on long-term coastal flood protection options. Approximately 70 members of the community attended the Open House. Eighteen storyboards provided detailed documentation on the coastal flood risks and various mitigation options. The storyboards are appended to the Open House #1 documentation, which also summarizes feedback received. Documentation from Open House #1 can be found in Appendix A of the IFHMP Coastal Flood Risk Mitigation Options report.

Open House #2 was held on February 24, 2016. Approximately 35 people attended the event. The Open House provided information on river flood hazards and mitigation opportunities. It also asked attendees to provide feedback on what they considered to be an acceptable level of flood risk. Sixteen storyboards provided detailed information on river flood risks and risk mitigation. The storyboards also summarized outcomes from Open House #1. The storyboards for Open House #2 are appended to the Open House #2 documentation, which also summarizes feedback received from attendees. Documentation from Open House #2 can be found in Appendix G of the IFHMP River Flood Risk Mitigation Options report.

Open House #3 was held on June 26, 2017. Approximately 23 members of the community attended the Open House, which included a presentation on the Draft IFHMP, followed by a question and answer session. Attendees were also given the opportunity to review 14 storyboards that revisited information provided in Open Houses #1 and #2 and provided new information on proposed policy and recommended structural flood mitigation (including funding options and implementation approaches). The storyboards for Open House #3 are appended to the open house documentation, which also summarizes feedback received from attendees. More detailed information can be found in Appendix B of this report.

Stakeholder Meetings

Over the course of the IFHMP, District staff organized several meetings with key stakeholder groups. Meetings included the following groups and dates:

- Squamish Estuary Management Committee – February 19, 2015
- Highly-Affected Landowners – November 16, 2015
- Residents and Community Stakeholders – November 23, 2015
- Cheakamus River / Paradise Valley Stakeholders – February 1, 2016



Stakeholder meetings are discussed in Section 6.1 of the IFHMP River Flood Risk Mitigation Options report and documented in the report appendices.

Public Surveys

In addition to stakeholder workshops and public open houses, input for the IFHMP was sought through four online surveys. Survey #1, Survey #3, and Survey #4 were also circulated in hard copy at Open House #1, Open House #2, and Open House #3 respectively.

Survey #1: Coastal Flood Mitigation Online Survey

The first online survey launched at the October 2014 public open house. Participants were encouraged to provide their opinion on flood risks, mitigation strategies, and specific flood protection works. Following the open house, the survey was made available online through the project website.

The survey was open through November 2014. Approximately 30 responses were received. Results are summarized in the documentation report for Open House #1, which forms Appendix A of the IFHMP Coastal Flood Risk Mitigation Options report.

Survey #2: Values and Objectives Online Survey

An online survey was used to obtain public input about flood risk mitigation in the Squamish River floodplain. Questions asked about risk tolerance, evaluation criteria for mitigation options, and priorities. The survey was made available online through the District of Squamish website, and was promoted through District list-serves and social media outreach.

The survey was open for 7 weeks, between November 30, 2015 and January 15, 2016. A total of 117 responses were received. Results are summarized in the documentation report for Open House #2, which forms Appendix G of the IFHMP River Flood Risk Mitigation Options report.

Survey #3: Mitigation Strategy Online Survey

The February 2016 public open house marked the launch of a third online survey. This survey asked the community for input on strategies and tools proposed by the IFHMP to help manage river flood risks. Some questions related to general flood hazard management in Squamish. Other questions were specific to each neighbourhood.

The second survey was available on paper at Open House #2 on February 24, 2016. It was also available on the IFHMP website between February and April 2016. The survey was promoted through District of Squamish social media accounts.

Of the 38 responses received, 11 came from Open House #2. The response rate per question was quite varied. Only 14 people responded to some of the more technical questions. The questions were phrased as simply as possible, but the low response rate suggests some people were not comfortable commenting on these very complex issues.

Some stakeholder groups were strongly represented in the responses received. As a result, the responses may not be representative of the wider Squamish community. The results of this survey are useful, but are not considered statistically significant.

Results from this survey are summarized in the documentation report for Open House #2, which forms Appendix G of the IFHMP River Flood Risk Mitigation Options report.



Survey #4: Squamish Integrated Flood Hazard Management Plan Online Survey

The 4th online survey was launched with Open House #3, and was available from June 26 through July 16, 2017. This 15-question survey was designed to gauge the community's agreement with the IFHMP's key policy tools, on-site and off-site structural measures to mitigate flood risk to the community, controlled densification measures, approach to development in Downtown Squamish, and the suitability of different funding approaches that could be used to pay for flood hazard management measures.

A total of 57 responses were received for the survey, with 10 collected in hard-copy during Open House #3, 1 submitted in hard-copy to the District after the event and another 46 completed online. The majority of responses to all questions were in agreement with the measures or approaches proposed. Ninety percent of respondents also indicated that they believed the IFHMP has done an adequate job of identifying risks, options, and recommended approaches for managing flood risk in Squamish.

Attendance at the Open House and participation in the online survey represented a small proportion of the Squamish community or those neighbourhoods subject to flood hazards. Much of the information that the community was asked to comment on in the final survey had been previously made available on the District of Squamish website or through the Official Community Plan updating process. The responses received represent the views of interested members of the community who indicated their general support for the IFHMP.

IFHMP Website

The District hosted a dedicated project page on the District's squamish.ca website¹. The project website served as the main information portal for the IFHMP, allowing the public to download reports and materials as they became available. The website also provided ongoing opportunities for public feedback and engagement. All IFHMP reports and project materials were released through the project website.

Community Engagement Outcomes

The District committed to listen to the public's concerns and values and consider their input when developing and choosing alternatives throughout the development of the IFHMP. The Squamish community was informed of key findings and decisions and given multiple opportunities to provide feedback throughout the three distinct phases of the IFHMP development. The extensive community engagement program included three Open Houses, four online surveys, and numerous meetings with the Skwxwú7mesh Úxwumixw and highly affected landowners.

Documentation of the Open House events and online surveys shows that in-person involvement decreased throughout the process, from 70 attendees at Open House #1, to 35 attendees at Open House #2 and 23 attendees at Open House #3. Participation in the four online surveys fluctuated. The largest response rate received for an online survey was 117 responses for Online Survey #2. This Values and Objectives Survey asked questions about risk tolerance, evaluation criteria for mitigation options, and priorities. The number of responses to this survey was double or more compared to the other three online surveys. Community response was greatest when asked about their values, as opposed to feedback on technical questions and complex solutions.

Although the attendance and participation during the final phase of engagement (Open House #3 and Survey #4) was not large, the level of support for key aspects of the IFHMP for those attended the Open House and those that undertook the online survey was over 80%. There was no significant opposition

¹ <https://squamish.ca/yourgovernment/projects-and-initiatives/floodhazard/ifhmp-2016/>



or highly vocal opponents at the final public process. It can be concluded that the extensive community engagement answered the key questions and addressed the most pressing concerns that were raised by the public, resulting in broad support for both the process and proposed solutions of the IFHMP.

4.2 Technical Working Group

Community input is vital for identifying values and priorities. However, there is also an important role for discussions with regulators and other technical experts. To meet this need, the District convened a Technical Working Group (TWG).

The TWG consists of people and organizations who might have to make or review local flood risk management decisions. Involving the TWG in development of the IFHMP should help to avoid roadblocks as it is implemented. The TWG format has been used successfully on other recent river-related projects in Whistler and Chilliwack. TWG members for the Squamish IFHMP are listed in Section 1.2 of this report.

The IFHMP included both formal meetings and informal correspondence. IFHMP meetings took place on the following dates:

- June 16, 2014
- September 24, 2014
- April 20, 2015
- February 4, 2016

Informal correspondence continued throughout the project. By the fourth meeting, the volume of material to be reviewed at each meeting considerably exceeded expectations.

TWG members were provided with materials for review prior to the planned fifth meeting and sixth meeting, where the intended subject was this final report. The intent was to plan and schedule the meetings as needed based on key issues identified in TWG feedback. TWG member responses did not identify a need for further meetings, and the planned fifth and sixth TWG meetings did not occur.

4.3 Skwxwú7mesh Úxwumixw Engagement

The District and the Skwxwú7mesh Úxwumixw (Squamish Nation) share jurisdiction in most floodplain areas. All parties clearly understand that floods do not respect administrative boundaries. The IFHMP's bi-lateral engagement process with the Squamish Nation included the following activities:

- a meeting with Nation staff on February 19, 2014 to review the scope and intent of the IFHMP;
- an interim presentation to Skwxwú7mesh Úxwumixw Chiefs and Council on February 18, 2015;
- a workshop with an *ad hoc* committee of Skwxwú7mesh Úxwumixw Chiefs and Council on March 12, 2015;
- a staff workshop on November 23, 2015;
- an interim presentation to Skwxwú7mesh Úxwumixw Chiefs and Council on March 2, 2016; and
- a presentation of the draft IFHMP to a Squamish Nation working group on June 26, 2017.

In each case, the District presented the Squamish Nation representatives with the same material presented to their District counterparts. District and Squamish Nation staff exchanged informal feedback and technical information throughout the project. Co-operation and information sharing between the two authorities was key in obtaining improved flood hazard assessment results for the Stawamus River.



In addition to the bi-lateral engagement process, Squamish Nation staff were an important part of the IFHMP Technical Working Group. Chiefs, Councillors, staff and local members of the Squamish Nation were also invited to participate in all public engagement activities.

After reviewing the draft IFHMP, the Squamish Nation provided official comments that highlight Skwxwú7mesh Úxwumixw perspectives and interests. The official Squamish Nation response has been incorporated in the IFHMP as Appendix C to this report. The appendix consists of two parts:

- general comments provided in response to a June 2017 presentation of the near-final IFHMP; and
- a transcription of information shared verbally by Xwélxwelacha Siyam (Chief Richard Williams) describing the Skwxwú7mesh Úxwumixw (Squamish Nation) perspective on the effects that local dikes have had on the Squamish Nation and its peoples.

4.4 District Council Engagement

The IFHMP provides critical guidance that will help guide the course of the District for decades to come. District Council makes the final decision about what should be included in the IFHMP, and how its recommendations should be implemented. Council was engaged at a series of official functions as listed below:

- Committee of the Whole – August 19, 2014*
- Community Development Committee – February 3, 2015*
- Committee of the Whole – April 14, 2015
- Council Meeting – April 21, 2015
- Council Meeting – May 12, 2015*
- Committee of the Whole – June 9, 2015*
- Council Meeting – June 16, 2015;
- Committee of the Whole – September 29, 2015*
- Council Meeting – October 6, 2015
- Committee of the Whole – February 16, 2016*
- Committee of the Whole – March 22, 2016*
- Committee of the Whole – June 14, 2016*
- Committee of the Whole – July 12, 2016*
- Committee of the Whole – June 20, 2017*
- Community Development Standing Committee – October 3, 2017*
- Council meeting – October 17, 2017

Reports to District Council were prepared by District staff in advance of key District Council discussions. Staff reports for meetings marked with an asterisk (*) are provided in chronological order as:

- Appendix **F** (August 2014) of the IFHMP Background Report;
- Appendices **C** (February 2015), **D** (May 2015), **E** (June 2015), and **F** (September 2015) of the IFHMP Coastal Flood Risk Mitigation Options report;
- Appendices **H** (February 2016), **I** (March 2016), **J** (June 2016), and **K** (July 2016) of the River Flood Risk Mitigation Options report; and
- Appendices **D** (June 2017) and **E** (October 2017) of this report.

Additional meetings will be required to complete the legal process of adopting the recommended changes to the OCP (including the new Development Permit Area) and Floodplain Bylaw.



5. Flood Risk Mitigation Approaches

Previous sections of this report summarize background information, hazard assessments, and consequence assessments carried out for the IFHMP. These important technical studies provide a strong foundation for the IFHMP, but they are not its main goal. The goal of the IFHMP is to produce a new suite of tools to manage and mitigate flood risk. This section outlines the IFHMP's guiding principles and presents strategies and tools for flood risk management. It also summarizes key recommendations from the IFHMP technical reports.

5.1 IFHMP Guiding Principles

The four primary objectives of the IFHMP are outlined in Section 1.1 of this report. To meet those objectives, the IFHMP project team used guiding principles to help make difficult decisions. The IFHMP guiding principles reflect general integrated flood management concepts like equity and sustainability, community objectives from the 2009 OCP, and specific District priorities for this project. Key principles guiding the development of the IFHMP include:

- Build a safe, sustainable, resilient community
- Accept that there will always be residual risk
- Adopt a "multi-generational" long-term view
- Engage the public but respect project limitations
- Protect existing development
- Allow for community growth
- Equitably share risks, costs and benefits
- Work within natural constraints

A more detailed discussion of IFHMP guiding principles can be found in the IFHMP River Flood Risk Mitigation Options report.

5.2 Flood Risk Mitigation Strategies

The IFHMP considers four basic strategies to reduce or limit flood risk. These strategies, with some variations, are used throughout Canada, the US, and other developed countries. Different strategies can be used in different parts of the same community. Conditions and priorities change over time, and one strategy may support or replace another. The four strategies are summarized in the table below.

Table 5-1: Flood Risk Mitigation Strategies

Strategy	Description	Examples
Protect	Keep floods from reaching developed areas	<ul style="list-style-type: none">• Use dikes to keep floods within the river channel• Build dams to store water and reduce peak flows
Accommodate	Adapt land use and development to minimize damage	<ul style="list-style-type: none">• Raise buildings above flood levels• Build with less vulnerable flood-resistant materials
Retreat	Withdraw vulnerable development from hazard areas	<ul style="list-style-type: none">• Convert development to parks and natural spaces• Change from more intense to less intense land use
Avoid	Avoid increasing development within hazard areas	<ul style="list-style-type: none">• Leave space to let rivers be rivers• Limit growth in vulnerable and high-hazard areas



Many people favour a **Protect** strategy because it supports a “business as usual” approach for the community, or because costs are typically borne by government. However, this strategy usually has the greatest environmental impact and is vulnerable to failure during very large floods. When a “protect” strategy fails, damages are usually extensive and severe. A “protect” strategy may be cost-effective at first, but can become very expensive if hazards increase and floodplain development continues.

An **Accommodate** strategy is intended to minimize damage and allow a community to quickly resume its normal functions following a flood. This strategy typically incorporates on-site measures to reduce flood damage when a development is built. An “accommodate” strategy will reduce damages even if the flood is much larger than expected.

Avoid strategies are often favoured by planners whose job is to create a roadmap for how a community will grow over time. This is the most cost-effective strategy, since avoiding development is the only sure way to avoid flood damage. However, an “avoid” strategy may conflict with other community priorities like accessibility, affordable housing, liveability, and preserving historical character.

Retreat is the most controversial strategy, since it involves relocating part of an existing community. “Retreat” strategies can be difficult politically, logistically, economically and emotionally. However, a “retreat” strategy may sometimes be the best long-term approach. Ongoing sea level rise may eventually force some communities to retreat from coastal areas. Implementing a retreat strategy gradually over time – for example, relocating vulnerable buildings when they need to be replaced – can help reduce costs and impacts. The IFHMP calls this gradual approach “Managed Retreat”.

In addition to the four strategies discussed above, a community may choose to **Accept** some amount of flood risk. There are many local, provincial, national and international guidelines that help define how much risk is considered “safe” to accept. In B.C., the final decision on how much risk each community should accept is largely left to the local government.

5.3 IFHMP Flood Risk Mitigation Strategies for Squamish

Community engagement (Section 4.1) provided a clear message to the IFHMP: the District should use all practical approaches and tools to mitigate flood risk. This feedback helped to shape the District’s overall approach for flood risk management, which is shown in Figure 5-1.

Since some strategies are not always practical, the IFHMP uses different combinations of flood risk mitigation strategies in different flood hazard areas. Large floodplain areas include many different properties and land uses. These areas must adopt a shared strategy for flood risk management. In “unconnected” floodplain areas, strategies are more easily adapted for specific development proposals. Examples of “unconnected” floodplain areas include Woodfibre, Squamish Terminals, and the Squamish Oceanfront Development.

IFHMP flood risk mitigation strategies for different parts of the community are summarized in Table 5-2 below. The table shows that each strategy may play a primary, secondary, or supporting role for a given area.

District Council decided to focus on risks resulting from the 200-year return period flood for all areas except the Squamish River floodplain and the Cheekeye Fan. This is shown in the “Mitigation Target” column of Table 5-2. The Squamish River floodplain is the heart of the community and is exposed to some of the highest hazards, so Council decided these areas should eventually be provided with a higher level of protection. Similarly, debris flow risks on the Cheekeye Fan are currently unacceptable and justify a much higher standard for risk mitigation. Even with everyone working together, it is expected to take decades to reach these goals. Risks from events larger than those shown in Table 5-2 are considered “acceptable risks” for the purposes of this IFHMP.



Figure 5-1: Conceptual Flood Risk Mitigation Strategies for Squamish

Table 5-2: Flood Risk Mitigation Strategies for Squamish

Flood Hazard Area	Flood Risk Mitigation Strategies				
	Protect	Accommodate	Avoid	Managed Retreat	Mitigation Target
Squamish / Mamquam River	●	◐	◐	○	1 in 500 year
Cheakamus River	○	●	●	○	1 in 200 year
Cheekeye Fan (assuming no area-wide mitigation)	○	◐	●	○	Up to 1 in 10,000 year
Stawamus River (Valleycliffe)	●	◐	—	—	1 in 200 year
Stawamus River (Estuary)	—	◐	●	—	1 in 200 year
Other Creek / River	○	◐	●	●	1 in 200 year
“Connected” Coastal (Downtown)	●	◐	—	○	1 in 200 year
“Unconnected” Coastal	site-specific based on development proposals				1 in 200 year

● Very Important ◐ Important ○ Use Carefully — Not Recommended

A more detailed discussion of strategies for coastal flood hazard areas can be found in the IFHMP Coastal Flood Risk Mitigation Options report. A more detailed discussion of strategies for river flood hazard areas can be found in the River Flood Risk Mitigation Options report.

5.4 Flood Risk Mitigation Tools

A wide variety of tools can be used to support flood risk mitigation. The tools can be grouped in many different ways to help people understand the choices. Figure 5-2 shows one approach that groups tools into seven different functions. All the different tools work together to reduce risk to an acceptable level.

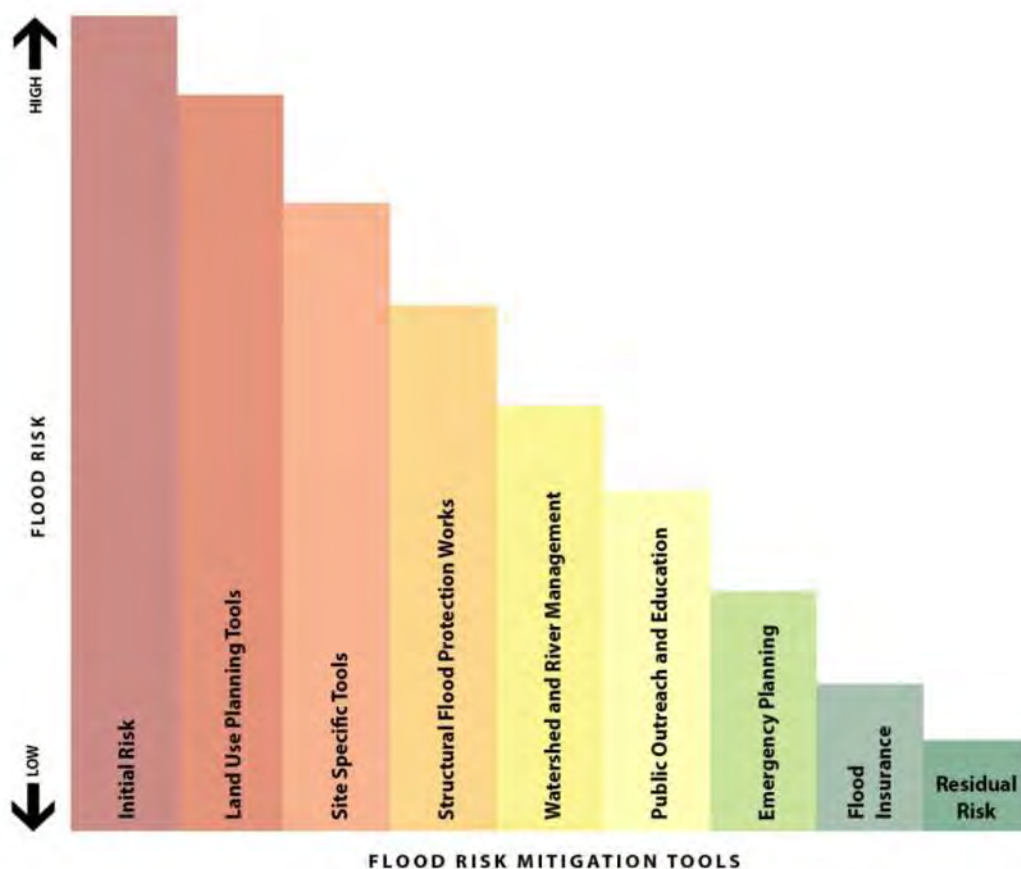


Figure 5-2: Flood Risk Management: Buying Down Flood Risk

Adapted from 2008 US Army Corps of Engineers Flood Policy White Paper prepared by D. Riley.

Land Use Planning Tools are the policies and regulations that guide and govern community growth.

Site-specific tools ensure that flood mitigation measures are incorporated at the subdivision and building scale. FCLs are an example of a site-specific tool.

Structural flood protection works are physical structures that keep floods away from the community. Flood control dams, dikes, and riverbank erosion protection are all structural flood protection works.



Watershed and river management refers to the holistic management of upstream watershed areas and rivers as a system. Examples include watershed revegetation, wetland restoration, appropriate river setbacks, and in-stream sediment management.

Emergency planning deals with “what if” scenarios that cannot be mitigated. The District is in the process of updating the Flood Annex to its Comprehensive Emergency Management Plan (CEMP).

Public outreach and education increases community awareness of the flood risk mitigation program. The District expects that this report becomes a key tool for public outreach and education.

Flood Insurance is available for businesses and strata corporations (multi-family developments). It is also starting to become available in B.C. for single-family residential areas.

The IFHMP Coastal Flood Risk Mitigation Options report and River Flood Risk Mitigation Options report make specific recommendations about tools that should be used to manage flood risk in Squamish. The next two sections discuss community-wide tools and area-specific tools.



6. Community-Wide Mitigation Measures

The IFHMP recommends over 100 specific tools grouped into the seven categories shown in Figure 5-2. Some recommendations apply to the entire community. Others apply to one or more designated Flood Hazard Areas. This section summarizes the most important recommendations that apply to the entire community.

6.1 Land Use Planning Tools

The most important land use planning tools focus on the need for updates to the District's flood risk mitigation policies. Section 8.1 of the IFHMP River Flood Risk Mitigation Options report identifies three key actions:

- Update the **Official Community Plan (OCP)**. The OCP sets out the District's vision for the future and guides the growth of the community. The 2009 OCP contains some provisions for flood risk management, but stronger and more specific policies are needed. In particular, growth should be encouraged in areas of lower flood risk. Growth in higher-hazard areas should be carefully managed to avoid unintentionally increasing the consequences of a flood.
- Develop a new **Floodplain Bylaw**. A floodplain bylaw can designate areas as floodplain and impose reasonable requirements like Flood Construction Levels and building setbacks for new developments. It can also clarify where and how the District might allow exemptions.
- Create a **Development Permit Area (DPA)** for Flood Hazard Areas and other natural hazard areas. A DPA would clarify requirements for developers and help guide District review of development applications. The DPA should capture any important IFHMP policy recommendations that can't be implemented through the OCP or floodplain bylaw. One important example is the regulation of development in *Primary Floodway* and *Secondary Floodway* Areas.

Protecting floodways is a very important part of the IFHMP. When the dikes were built in Squamish, they stopped the rivers from using large parts of their floodplains. This reduced the rivers' capacity to convey water. Now, because of climate change, more water must be able to get through the narrowed channel. The result of these changes was predictable: flood levels went up. Maintaining conveyance in floodways prevents further increases. Regulating development in floodway areas helps the District prevent or control the loss of conveyance.

Other recommended land use planning tools include managed retreat of critical facilities, allowance for dike right-of-ways, and further work on complementary hazard assessments.

6.2 Site-Specific Tools

Section 8.1 of the IFHMP River Flood Risk Mitigation Options report identifies 23 site-specific flood risk mitigation tools. Three of these tools are of critical importance: flood construction levels, setbacks, and restrictive covenants.

- **Flood Construction Levels** must be defined for potential building sites in Flood Hazard Areas. The District has confirmed the flood scenarios that will be used to define FCLs and specified freeboard allowances for different areas based on advice from the IFHMP project team.
- Each building must be **set back** an appropriate distance from potential flood hazards to allow for conveyance, waves, erosion, flood protection, emergency response, and important environmental



processes. Setbacks must also be provided to allow operation, maintenance, and upgrading of flood protection works.

- A **Restrictive Covenant** should be attached to the legal title of each property in a designated Flood Hazard Area or Overland Flow Hazard Area. A Restrictive Covenant can't be imposed on unwilling owners, but it can become a condition of District approval for development or redevelopment. A Restrictive Covenant can impose requirements (e.g., FCL) on current and future owners of the property. A Restrictive Covenant can also indemnify the District from liability for flood damages, and provide legal notice of the flood hazard for people who might want to buy the property.

Figures in Section 3 of this report show minimum Flood Construction Levels for different Flood Hazard Areas. In some areas, including the *Overland Flow Hazard Areas* shown in the figures, there are additional requirements. FCLs in Overland Flow Hazard Areas must be at least:

- 1.5 metres above the highest banks of any nearby creek or river;
- 0.6 metres above the crest (top) of any downstream road or berm; and
- 1 metre above the finished grade around the building.

Other area-specific FCL requirements are described in the next section.

Foundations and floodproofing fill used to raise a building to the FCL must be protected from erosion and scour. Also, any parts of a building that are below the FCL should be built with "*flood-resistant*" materials. A material is called "flood resistant" if it isn't easily damaged by floodwater.

One of the guiding principles of the IFHMP is to make sure risks are shared equitably. Based on this principle, the District will respect development opportunities allowed under current zoning. For some existing properties, it may not be possible to achieve the required FCL or setback. The IFHMP recommends allowing for exceptions in such cases. The process for requesting and granting an exemption should be structured so that it is clear and fair for everyone. The IFHMP provides the following guidance for granting an exemption:

- There must be a genuine hardship. Cost alone should not justify an exemption.
- All reasonable measures must be taken to reduce flood risk. For example, buildings that cannot meet the FCL should still be raised as high as possible.
- A Qualified Professional should certify that developments seeking an exemption will still be "safe". The QP's report should become part of a Restrictive Covenant attached to the legal title.
- Exemption requests should still meet a minimum level of flood protection. For example, any residential development should be able to achieve at least 2.5 m of floodproofing (1 metre of fill plus 1.5 metres of structural elevation).

One goal of the IFHMP policy tools is to standardize flood risk mitigation requirements for developers and reduce the reliance on site-specific flood hazard assessment reports. The exemption process outlined above is one example where a site-specific report will still be required.

Land Acquisition

Due to the high costs involved, the IFHMP recommends limited and opportunistic land acquisition that is focussed on the following situations:

- properties where flood risk is very high and mitigation is not practicable (e.g., developed properties located within a primary floodway);



- properties where development opportunities must be severely restricted to protect floodway conveyance; and
- properties where land is required to support the construction or upgrading of community flood defences.

The most important land acquisition issues for the IFHMP relate to the statutory right-of-way for the existing and planned dike system. The District is currently in discussions to acquire a statutory right-of-way along the Squamish River dike at Judd Slough. Other locations where the District may wish to consider land acquisition are identified in Section 8.2 the IFHMP River Flood Risk Mitigation Options report.

6.3 Structural Flood Protection Tools

Structural flood protection tools are presented in Section 4 of the IFHMP Coastal Flood Risk Mitigation Options report and Section 8.3 of the River Flood Risk Mitigation Options report. These tools focus on maintaining and improving the District's dike system. The IFHMP assumes that pump stations, floodboxes, and internal drainage infrastructure will be assessed as part of future Integrated Stormwater Management Plans.

The IFHMP recommends over 30 structural flood protection tools. Among the tools, there are four themes that stand out as particularly important:

- A **Sea Dike** is needed to protect the community from coastal flood hazards. Some improvements should begin immediately, and some work can be deferred. Specific recommendations about the sea dike are summarized in Section 7.1 of this report.
- **Upgrade existing river dikes** to meet or exceed provincial design standards. Understand where the dikes may be extremely hard to repair following an earthquake, and allow space for future upgrades. Implement upgrades based on a prioritized plan that can be integrated with other District funding priorities. Delay approval of new subdivisions in dike-protected areas until an upgrading plan and timeline are in place.
- In all other areas, the District should adopt a policy of **no new dikes**. Exceptions may apply where the District accepts responsibility for existing "orphan" dikes, or where new structures could protect existing neighbourhoods. Private dikes that protect a single property may still be allowed where they will be maintained by the landowner and do not transfer risk to other properties.
- **Secure continuous access** along all District dikes. Extend the system of public dike crest trails, and formalize arrangements for accessing dikes on Skwxwú7mesh Úxwumixw (Squamish Nation) lands.

While not as critical as the tools discussed above, the IFHMP also considers natural *overbank* areas located between the dike and the river. These areas are very important to the environment. They also keep fast-moving water and debris away from dike slopes.

Protecting overbank areas from river erosion would be very expensive, and construction would create a significant environmental disturbance. Protecting overbank areas also limits the river's ability to move back and forth within its floodway. Over time, the District will need to identify any overbank areas where the need for protection justifies the cost and environmental impacts. In other areas, dike improvements should allow for potential loss of the overbank area during future floods.

Protecting natural overbank areas is one area where the IFHMP considered both environmental and flood protection priorities. Other examples include using environmentally-friendly designs and materials,



reconnecting watercourses that were cut off by dikes, and sustainably managing vegetation along the dike system.

6.4 Watershed and River Management Tools

Watershed and river management tools focus on protecting primary floodway corridors and promoting sustainable land use throughout the watershed. Section 8.4 of the IFHMP River Flood Risk Mitigation Options report presents 12 tools related to watershed and river management. The most important tools are listed below:

- **Protect river corridors** to preserve flood conveyance and minimize environmental impacts. In diked areas, this means keeping development on the land side of the dike. In undiked areas, it means minimizing conflicts between natural river processes and development.
- **Manage sediment and debris** within the river corridor to support environmental needs and preserve flood conveyance. Focus on maintaining the intended channel capacity and guiding flow away from vulnerable locations. Begin with monitoring sediment and debris accumulation, then agree on triggers and environmental guidelines before taking action.
- **Plan to “Build Back Better”** following a disaster. Identify high-risk areas where it might be worth revisiting key decisions like dike alignment and grandfathered development approvals.

The IFHMP also recommends continued advocacy for re-forestation and other sustainable land use practices throughout the watershed.

6.5 Other Flood Risk Mitigation Tools

The IFHMP River Flood Risk Mitigation Options report recommends a total of 25 tools associated with Emergency Planning, Public Outreach and Education, and Flood Insurance. The most important of these tools are listed below.

- **Complete flood-related sections of the CEMP** and integrate the results with flood response protocols for the dike system. Updates should consider potential vulnerabilities like flooding of the District’s Emergency Operation Centre, shelter facilities, and key evacuation routes. Secondary health hazards could result from flooding of electrical, chemical storage, or wastewater treatment facilities.
- **Educate the public** by creating a streamlined portal for flood risk information. Work with partners to provide timely updates and address common flood-related concerns.
- **Support the adoption of flood insurance** throughout the community. In the future, people who do not have flood insurance may not be eligible for government disaster assistance programs.

More information on IFHMP tools related to Emergency Planning, Public Outreach and Education, and Flood Insurance can be found in Sections 8.5, 8.6 and 8.7 of the River Flood Risk Mitigation Options report.



7. Area-Specific Flood Risk Mitigation Measures

The previous section discussed IFHMP flood risk mitigation measures (or “tools”) that apply to the whole Squamish community. This section summarizes other tools that apply in specific Flood Hazard Areas. Flood Hazard Areas discussed include coastal, Squamish River / Mamquam River, Cheakamus River, and Stawamus River.

7.1 Coastal Flood Risk Mitigation Measures

The most important tool for coastal flood risk mitigation is a new District sea dike. Other tools include requiring new buildings to meet FCLs and maintaining wave protection for intertidal and harbour areas.

Sea Dike Alignment

The District's sea dike does not meet provincial standards, and Downtown Squamish is presently at risk from coastal floods. Sea level rise will make the situation worse. A new sea dike is needed, even if the District eventually decides to pursue other strategies for managing coastal flood risk.

By Year 2100, the sea dike will need to be much longer, higher, and more reliable than it is now. The sea dike will need to start at the Squamish River dike near North Yards, wrap around downtown, and tie into high ground north of Mamquam Blind Channel. The IFHMP divided this 7 km length into five parts called “reaches” as described below:

- Reach 1, along Government Road from the Squamish River dike to Bailey Street
- Reach 2, along the existing Town Dike to 3rd Ave
- Reach 3, along 3rd Ave and Cattermole Slough to the intersection of Vancouver Street and Loggers Lane, tying into future high ground at the north end of the Oceanfront Peninsula
- Reach 4, along the west side of Mamquam Blind Channel to Highway 99
- Reach 5, along Highway 99 to Loggers Lane, through Rose Park and across Upper Mamquam Blind Channel to meet high ground at Smoke Bluffs

Community engagement told the IFHMP which considerations should be most important for each reach. The environment was a priority for Reaches 1 and 2 (Crescent Slough) and Reach 5 (Upper Mamquam Blind Channel). The community would like to see bioengineering and GreenShores™ designs in these reaches.

Development opportunities were a priority for Reach 4 (Lower Mamquam Blind Channel). A seawall along this reach would maximize development potential and provide a new community amenity. A combination of seawall and conventional dike with riprap armour was preferred for Reach 3.

Preferred and alternate sea dike alignments and shoreline treatment options are shown in Figure 7-1. The figure also shows four special study areas:

- For **Study Area #1** (Crescent Slough / Lower Squamish River Estuary), the preferred sea dike alignment follows the existing Town Dike. Several issues must be explored before the alignment is confirmed, including impacts on private property, the environment, and stormwater management for Downtown Squamish. The alternative route would follow the west side of the CN spur track to Squamish Terminals, with more significant environmental impact and potentially higher costs.



- **Study Area #2** (north end of Oceanfront Peninsula) must resolve potential conflicts between road and dike grades as well as the boat ramp at the Squamish Yacht Club. Further work will confirm how the sea dike should tie into future high ground at the north end of the Oceanfront Peninsula.
- **Study Area #3** (Highway 99 at Mamquam Blind Channel) will address bicycle and pedestrian traffic circulation where the sea dike meets Highway 99 on the north side of Mamquam Blind Channel.
- **Study Area #4** (Upper Mamquam Blind Channel) will address road regrading, stormwater management issues, and development opportunities for the District-owned parking lot north of Rose Park.

Conceptual Design

The IFHMP produced a conceptual design for the sea dike. The Coastal Flood Mitigation Options report describes the design criteria, including a 200-year return period combination of tide and storm surge, 1 metre of sea level rise, wind setup, allowable wave overtopping of 10 L/s per metre, and a minimum freeboard of 0.6 m. Preliminary dike crest elevations were determined based on these assumptions. The preliminary crest elevation is 4.7 m geodetic for the majority of the sea dike, but increases to 4.8 m at the north end of Crescent Slough. Conceptual design for a sea dike with a riprap slope is shown in Figure 7-2. This concept was incorporated into the river dike breach model and used to establish FCLs in the downtown area. Conceptual design for a sea dike with a seawall is shown in Figure 7-3.

The conceptual design figures show geometry and minimum setbacks from the Year 2100 sea dike. These figures will help developers incorporate the Year 2100 sea dike into new projects along the foreshore. In other areas, the District will be responsible for building the sea dike.

Some work on the sea dike should start immediately to protect downtown against present-day coastal floods. However, the full height of the Year 2100 sea dike won't be needed right away. As long as the lower part of the sea dike is built wide enough and establishes a corresponding right-of-way, the upper part can be added later (once we know more about the rate of sea level rise). Phasing construction in this way makes the sea dike more affordable by spreading costs over a longer period of time. Regardless of whether the sea dike is built all at once or in phases, by the District or by developers, the District should start planning now to make sure that land and funding for the sea dike is available when it is needed.

Wave Overtopping

The IFHMP wave analysis was used to estimate how much splash and spray might come over the sea dike during a 1 in 200-year return period storm. To balance benefits and costs, the District accepted an overtopping rate of 10 L/s per metre of dike length. Higher rates of overtopping would be unsafe. Even at 10 L/s per metre, the dike would have to be closed to public access during a storm. However, there is a factor of safety built into other assumptions about the coastal flood and wave analysis. These conservative assumptions should keep the actual overtopping rate below 10 L/s per metre.

Overtopping of the sea dike might only happen for two or three hours at the peak of a storm. However, even a single hour of overtopping along a 7 km long sea dike would bring a very large amount of sea water into downtown. This water would have to drain through the District's stormwater system.

The downtown stormwater system currently drains to the ocean by gravity, with some storage capacity at Bridge Pond. In the future, ocean levels high enough for splash and spray to overtop the dike would also prevent gravity drainage. Storage may no longer be available at Bridge Pond, since Bridge Pond is



outside the District's preferred Reach 2 sea dike alignment. These challenges should be considered as part of an ISMP for Downtown Squamish.

Squamish River Training Berm

The Squamish River training berm extends south from the Squamish River dike into Howe Sound. The IFHMP Background Report concluded that it will be costly to preserve and protect the training berm from the effects of Sea Level Rise.

As the District begins planning for a new sea dike, there is also an opportunity to consider the future of the existing training berm. Several key issues should be considered:

- The training berm was originally built to support industrial development that never occurred. The estuary now provides valuable habitat as part of the Skwelwil'em Squamish Estuary Wildlife Management Area.
- Environmental assessments have recognized the value of reconnecting the river to Crescent Slough. Several large culverts through the training berm were installed to provide some connection.
- The future sea dike will mean that there is no longer any flood protection benefit for downtown.
- Removing the training berm may allow sediment to accumulate more quickly near Squamish Terminals.
- The training berm currently provides valuable recreational access to Squamish Spit.
- Removing the training berm would lead to long-term savings on operation, maintenance, repair, and upgrading.
- Cost savings may be available if material from the training berm can be used to construct the new sea dike.
- If the training berm is removed, larger waves will be able to travel further up Crescent Slough.

Questions about the future of the Squamish River training berm are beyond the scope of the IFHMP. The District should review its options as part of a future IFHMP update.

Flood Construction Levels for Downtown Squamish

If there is an upstream river dike breach, the new sea dike will trap water within the downtown. This raises water levels during a dike breach flood. As water levels go up, so do the consequences of a flood. The raised water levels become the recommended FCLs for Downtown Squamish. Minimum FCLs for downtown are shown in Figure 3-3.

Upgrades to the river dikes can reduce the probability of a dike breach. Reducing the probability of a breach can offset higher consequences (because risk = probability x consequence). To avoid increasing flood risk in the downtown, upstream dike improvements should be completed before the sea dike is completed (or "closed").



The IFHMP also considered the possibility of building a new “interceptor” dike north of downtown. An “interceptor” dike could direct flow from a river dike breach into Wilson Slough and out through Mamquam Blind Channel. An “interceptor” dike would keep Downtown FCLs low, but would be very expensive to build. It would also be disruptive and could increase risk for the Dentville neighbourhood. The District decided it was better to spend money on improving the river dikes, which protect everyone.

Downtown Squamish is a very important business hub for the community. The District has historically allowed commercial development to proceed at ground level within the downtown area. Council (and many local stakeholders) wanted the IFHMP to continue the historical exemption for non-residential development. The area covered by the exemption is shown in Figure 3-3. Residential development will still have to be above the FCL.

The IFHMP provided Council with some key points to consider about the downtown exemption:

- The sea dike will protect Downtown Squamish from a coastal flood. Upgraded river dikes will provide better protection from river floods. Even though the sea dike increases consequences for a river dike breach, flood risk will be lower than it has been in the past.
- FCLs assume that the sea dike will trap water in downtown. Appendix A of the River Flood Risk Mitigation Options report describes options for intentionally breaching the sea dike to let water out. If properly implemented, intentional sea dike breaches could reduce flood levels within downtown.
- Overland flood insurance is widely available for multi-residential and non-residential development, and is becoming more widely available for single-family residences.
- All new developments and redevelopments should be asked to acknowledge flood risks and indemnify the District for flood damages by signing a Restrictive Covenant.
- A dike breach may develop too quickly to evacuate downtown, but it would take some time for water levels to rise to the FCL. Where necessary, safe refuge areas could be built above the FCL to allow people to “shelter in place”.
- Property owners exempted from the FCL may not qualify for disaster assistance payments. Consultation with the provincial government would be appropriate.

Based on these considerations and other municipal priorities, the District decided to continue the FCL exemption for commercial development in the historic downtown area.

FCLs and Setbacks for Unconnected Coastal Flood Hazard Areas

Coastal flood mitigation tools for the large connected floodplain are well defined. This is because everyone must work toward a common goal. “Unconnected” coastal flood hazard areas are different. Unconnected coastal flood hazard lands will typically be held by one owner or a small group of owners. Risks can be managed differently in different unconnected areas.

The IFHMP defines an unconnected coastal Flood Hazard Area as any area that:

- is not, and will not be, protected by the District’s future sea dike; and
- is below 5.6 metres geodetic elevation.

Flood risk mitigation measures for unconnected areas will need to be defined and designed by a Qualified Professional (QP). Typically, the QP will work for someone who wants to build or develop within a Flood Hazard Area. The QP will need to consider many of the same issues as the IFHMP: flood hazards, water levels, freeboard, waves, tsunamis, erosion, and appropriate setbacks.



The IFHMP sets out some basic requirements for how the QP must calculate FCLs and setbacks. The minimum FCL for an unconnected coastal Flood Hazard Area should be calculated as the sum of:

- the IFHMP coastal flood level (3.99 m geodetic elevation);
- allowance for site-specific effects like wind setup and ground uplift or subsidence to the year 2100;
- estimated wave effects for a 200-year return period wind storm; and
- a minimum freeboard of 0.6 metres.

Where applicable, FCLs for unconnected coastal areas will also need to consider the tsunami runup elevation. To date, engineering studies have not identified a critical tsunami threat to Squamish. Based on information reviewed for the IFHMP, the coastal flood level provides a reasonable tsunami runup elevation.

The minimum required setback for buildings in an unconnected coastal Flood Hazard Area should be the greater of:

- 15 metres from the natural boundary of the sea at Year 2100 (i.e., after 1 metre of sea level rise);
- the distance from the natural boundary of the sea to the point where the existing ground (or future ground, if the land will be filled) meets the FCL;
- any additional distance required to accommodate future waves and erosion; and
- 15 metres from the waterside crest of any private dike or erosion protection works.

The District will evaluate development proposals for unconnected areas on a case-by-case basis.

7.2 Squamish River / Mamquam River

Section 8 of the IFHMP River Flood Risk Mitigation Options report presents preliminary planning maps for the upper and lower Squamish River floodplains. Planning maps like these have three important functions. They identify:

- areas of higher flood hazard where densification and growth should be controlled;
- corridors that convey water as primary and secondary floodways; and
- areas where development proposals should incorporate long-term upgrades to the dike system.

Flood hazard management planning maps for the upper and lower floodplain have been simplified and aligned with District cadastral information. The limits of Overland Flow Hazard Areas were also updated to clarify and simplify the transition between Overland Flow and Flood Hazard Areas. Final IFHMP planning maps for the upper and lower Squamish River / Mamquam River floodplain are shown in Figure 7-4 and Figure 7-5, respectively. Each of the three key functions is discussed below.

Controlled Densification Areas

The IFHMP recognizes that much of the historical development of Squamish has occurred in flood hazard areas. Stopping or reversing all development in historical areas can create liveability challenges. At the same time, flood risks may become unacceptable if ongoing development continually increases the consequences of a dike breach.

The IFHMP project team worked closely with District Council to balance growth and flood risk management objectives. When Council accepted the IFHMP River Flood Risk Mitigation Options report, it confirmed that the recommendations of that report reflect the values and priorities of the community. The IFHMP recommends that densification (i.e., rezoning) be controlled in three different areas:



- Properties located in **Restricted Densification Areas** should not be rezoned for additional density. Growth may still occur through infill development. Rezoning that concentrates the density allowed under existing zoning into a smaller part of the lot is also acceptable.
- Properties located in **Conditional Densification Areas** can be rezoned for additional density if the development proposal complies with a list of conditions established by the IFHMP. Recommended conditions are summarized below.
- Properties located in **Limited Densification Areas** may be rezoned up to a maximum density established by the District. The process recommended by District staff is described below. Development proposals located in Limited Densification Areas must also meet the requirements for Conditional Densification Areas.

The conditions for rezoning in Conditional Densification Areas and Limited Densification Areas were revised slightly from those documented in the IFHMP River Flood Risk Mitigation Options report. The final conditions for densification in high-hazard areas are listed below.

Conditions for Densification through Rezoning in High-Hazard Areas

1. All habitable buildings must be above the FCL specified in the Floodplain Bylaw, without exceptions.
2. Building foundations and structural fill must be protected from scour and erosion during a flood.
3. The proposed development must not adversely impact the conveyance of a secondary floodway.
4. Land left low for flood relief must be permanently protected from future development or obstruction.
5. Proposals must mitigate all environmental impacts and maintain a 30 m setback from watercourses.
6. Developments may not transfer flood or erosion risk to neighbouring properties.
7. Proposals adjacent to the Squamish / Mamquam River dike must upgrade the dike frontage and provide a statutory right-of-way that can accommodate the “super dike”.
8. Qualified professionals must certify that the above conditions can be met.
9. The District may require that the applicant pay for an independent review of these criteria.

Limited Densification Areas must meet the conditions listed above, but are also subject to a maximum allowable density. District staff defined the maximum allowable density as 29 dwelling units per net developable hectare. This value is equal to the maximum density that could be achieved under duplex (Residential 2 or RS-2) zoning. The maximum number of dwelling units for any given lot in a Limited Densification Area becomes $29 \times [\text{net development area in hectares}]$. The net developable area is the total area of a lot less any non-development areas (e.g., riparian areas or right-of-ways), assuming a 20% road allowance.

Controlled Densification Areas will limit, but not avoid, an increase in flood risk over time. Other key challenges will remain, including evacuation, shelter of displaced residents, and the cumulative effects



of floodproofing fill on upstream properties. Recognizing this, it is appropriate for the District to define stringent conditions for densification that may not be simple or easy to attain.

Floodways

Figure 7-4 and Figure 7-5 show Primary Floodway Areas and Secondary Floodway Areas for the Squamish River / Mamquam River floodplain. More detail is available in Section 8.1 of the IFHMP River Flood Risk Mitigation Options report.

General recommendations for Primary Floodway Areas are introduced in Section 6.1 of this report. The Squamish River / Mamquam River Primary Floodway Area includes all lands on the river side of the dikes. The District can avoid flood risk, protect conveyance capacity, safeguard sensitive habitat, and simplify emergency response by preventing new development in the Primary Floodway Area.

For Secondary Floodway Areas, the IFHMP objective is to allow development while avoiding or mitigating “adverse impacts” on floodway conveyance. The OCP should establish conditions for rezoning in Secondary Floodway Areas, since most secondary floodways are also part of a Controlled Densification Area. A new Development Permit Area should establish separate requirements for subdivisions, building permits, and the placement of fill in Secondary Floodway Areas.

In many cases, QPs will be able to use experience and judgement to say whether a development will have an adverse impact on secondary floodway conveyance. For example, alterations and repairs that do not increase a building’s footprint will not have an adverse impact on conveyance.

For subdivision and permit applications, developers must show that their design will maximize floodway conveyance and have minimal impact on upstream water levels. The developer’s QP should prepare a report that considers the location, orientation, dimensions, and form of all proposed buildings, fill and obstructions. Based on the QP’s report, the District may conclude that there is no adverse impact on floodway conveyance.

Rezoning applications in Limited or Conditional Densification Areas will need to measure their impact on conveyance using the IFHMP dike breach model. The dike breach model can also be used to evaluate subdivision and permit applications that would not otherwise meet the DPA requirements. The model will compare pre-development and post-development conditions to determine whether there is a change in results. The IFHMP was asked to determine how much change should be considered an “adverse impact”.

To define an “adverse impact”, the IFHMP looked at what is acceptable in other Canadian and U.S. jurisdictions. Most jurisdictions do not allow development to cause any measurable increase in upstream water levels. Adopting “no measurable increase” for Squamish would severely limit the potential for infill development in Secondary Floodway Areas.

The District chose to compromise between its development and flood protection objectives for Secondary Floodway Areas. Based on this compromise, the IFHMP defined “adverse impacts on conveyance” as:

- an increase of more than 0.1 metres due to the effects of a single development proposal; or
- an increase of more than 0.15 metres above the IFHMP FCL due to the cumulative impact of all developments to date.

These requirements will apply to all rezoning applications as well as to subdivision and permit applications that do not otherwise meet the DPA guidelines. To support the recommendations, the dike breach model must progressively incorporate the results of each new development. The District should



maintain a single evolving version of the dike breach model for this purpose. More discussion of this important recommendation is provided in Section 8.2.

Erosion Protection for Floodplain Development

Requirements for erosion protection are based on a further simplification of the velocity maps presented in the IFHMP River Flood Risk Mitigation Report. The updated maps group velocities into three classes, as shown in Figure 7-6 and Figure 7-7. Erosion protection requirements for each velocity class are shown in the table below.

Table 7-1: Erosion Protection Requirements for Squamish/Mamquam River Floodplain

Velocity (m/s)	Erosion Protection Requirements
< 0.8	Areas should not be left as bare earth
0.8 – 2.8	Protect foundations and fill using standard details in Figure 7-8 and Figure 7-9
> 2.8	Provide site-specific measures specified by a Professional Engineer

Dike Upgrades

In preparing the IFHMP, the District made several compromises that accept increased flood risk. Council considered these compromises necessary to support the continued growth of a vibrant community. Examples include allowing conditional densification in higher-hazard areas and preserving the historic downtown FCL exemption for commercial development.

Policy decisions that allow flood risk to increase were carefully considered and balanced with other policy decisions that reduce flood risk. One such balancing decision was to recognize the importance and extensive reliance on dike protection. Council agreed that upgrading deficient dikes to provincial standard status should be the highest priority. Council also agreed to work toward a higher standard of protection for the Squamish River dike and Mamquam River south dike, as described in Section 8 of the IFHMP River Flood Risk Mitigation Options report.

A conceptual vision for the enhanced Squamish River dike and Mamquam River south dike is shown in Figure 7-10. Key features of the enhanced dike include the following:

- The enhanced dike is **higher** than the provincial standard, providing 0.6 metres freeboard above the 1 in 500-year return period flood level. This reduces the likelihood of water getting over the top of the dike.
- The enhanced dike is **wider** than the provincial standard. An extra 2 m width will help to reduce seepage and will improve the District's ability to respond to emergencies on the dike crest. The extra width may also reduce the effects of spreading and slumping during a major earthquake.
- **Bioengineering** on the landside slope will slow down erosion of the dike fill if any flow does make it over the dike crest.
- A **rock trench** at the bottom of the landside slope will help to manage seepage under the dike and limit undercutting of the slope toe if the dike is overtopped.



- An upgraded **riprap revetment** includes more and larger rock at the toe of the river side slope. This extra material can “launch” into the river if erosion of the vegetated overbank starts to threaten the dike.

The costs for the remaining standard dike upgrades are considerable, and the cost for the “super dike” upgrade will be even greater. However, these upgrades considered necessary to protect the heart of the Squamish community. Implementation can start slowly: the first step is to acquire and protect an interest in the lands that will eventually be needed to expand the dike. Having plans and agreements in place can also help the District take advantage of federal and provincial cost-sharing programs.

The IFHMP produced a prioritized list of upgrading projects from every flood hazard area. The list includes both short-term (standard dike) and long-term (“super dike”) upgrades to the Squamish River dike and Mamquam River south dike. Prioritizing the list will help District staff reduce risk as quickly and cost-effectively as possible. The prioritized upgrading plan is discussed further in Section 8.3.

Eagle Viewing Area Plan

One part of the Squamish River dike that needs further study is the Eagle Viewing Area reach on the upper floodplain. The Eagle Viewing Area reach extends from Eagle Run Drive in the north to Kewtín (Kowtain) I.R. No. 17 in the south. Specific challenges with this reach of the Squamish River dike include:

- a history of seepage and piping
- deficiencies in the dike cross-section
- poor subsurface conditions
- inadequate freeboard
- impinging river flows and debris impact
- sensitive habitat areas
- encroaching development
- infrastructure on and next to the dike
- heavy recreational use
- shared jurisdiction with Squamish Nation
- private property challenges

The IFHMP recommends that the District and the Skwxwú7mesh Úxwumixw (Squamish Nation) work with other stakeholders to develop a neighbourhood-level plan. The plan should consider flood protection, transportation, internal drainage, sanitary sewers, property issues, parking and public access, existing buildings, and future development. Establishing a neighbourhood plan will allow partners and projects to proceed independently while building toward a shared vision. A more detailed discussion about a neighbourhood-scale plan for the Eagle Viewing Area can be found in Section 8.3 of the River Flood Risk Mitigation Options report.

7.3 Cheakamus River

Section 8 of the IFHMP River Flood Risk Mitigation Options report presents preliminary planning maps for the north and south Cheakamus River Flood Hazard Area. The planning maps have been simplified and aligned with District cadastral information. The limits of Overland Flow Hazard Areas were also updated. The final north and south planning maps are shown in Figure 7-11 and Figure 7-12, respectively.

The IFHMP designates all Cheakamus River Flood Hazard Areas as Restricted Densification Areas. This designation reflects several important factors:

- the rural character of the community;
- high environmental values throughout the Paradise Valley;
- the overlapping flood, debris flood and debris flow hazards; and
- the additional challenge of vulnerable emergency access / egress routes.



The IFHMP also recommends that the District not accept responsibility for new dikes in the Paradise Valley. New diking to support densification would create watershed and environmental challenges, incur significant costs for operation and maintenance, and potentially transfer risk to other parts of the valley.

The minimum FCLs mapped in Figure 3-4 stop near the southern limit of the Culliton Creek debris flow runout zone. The restricted densification area extends farther north to the District boundary. The extension captures areas that may be subject to more hazardous (but unmapped) debris flows and debris floods.

Primary Floodway

There are several dikes along the Cheakamus River. Most are private dikes, some are not continuous, and many will be overtopped during moderate flood events. Unlike other rivers in Squamish, the Cheakamus River dikes do not define an appropriate limit for the Primary Floodway.

Instead, the IFHMP defined the Primary Floodway based on quantitative and qualitative hazard assessments. The entire valley may convey flow during a very large flood, but the primary floodway is the part that is most important for conveyance.

Designating the area as a Primary Floodway should help the District more closely review and manage development that is close to the river. Proper management of development is important due to the lack of standard dikes. Proper management is also important because long distances and vulnerable access routes may limit the District's ability to respond during a major flood.

For many properties in the Primary Floodway, well-sited and responsibly-designed development can still proceed safely. The IFHMP supports careful continued development under existing zoning and in accordance with appropriate conditions. The Cheakamus River Primary Floodway is therefore treated differently from Primary Floodways in other parts of the District (where no new development should be permitted).

Appropriate conditions for allowing development within the Cheakamus River Primary Floodway are listed below. Other IFHMP requirements for development in Flood Hazard Areas would also apply.

Conditions for Development in Cheakamus River Primary Floodway Areas

1. The property must have no land suitable for development outside the Primary Floodway.
2. Proposals must meet (or receive a hardship-based exemption from) FCL, river setback, and dike setback requirements established in the District's new Floodplain Bylaw.
3. The location and design of buildings must maximize conveyance, minimize upstream water level increases, and minimize risk to the structure as well as any adjacent diking infrastructure.
4. Footings and fill must be protected against damage from floods, sediment, and floating debris.
5. The District must not be required to assume responsibility for new structural flood protection works.
6. Private dikes must be designed, built, and documented in accordance with DPA requirements.
7. Qualified professionals must certify that the above conditions can be met.



Access Routes

The Cheakamus River Flood Hazard Area is the most remote part of the District. Access depends on roads and bridges that may not have been designed to provide the same level of service and reliability as the District's larger transportation arteries. Examples include Fergie's Bridge, Paradise Valley Road, and the Paradise Valley Road Bailey Bridge.

The District should identify appropriate levels of service and reliability for access and emergency response routes in Paradise Valley. The Bailey Bridge is a good example of where the District may wish to accept more risk or less risk. The existing bridge is a low, narrow structure with a small opening and limited conveyance capacity. It was washed out in the 2003 flood, cutting off all road access to the upper Paradise Valley. The 2003 peak flow was less than the IFHMP's updated estimate of the updated 200-year return period flood.

Dikes on either side of the Bailey Bridge help to guide flow into and through the bridge opening. The Paradise Valley Road training berm (also known as Dike 5C) protects the north approach to the bridge. It is currently an "orphan" structure, meaning that it is not monitored or maintained by anyone. The IFHMP recommends that the District accept responsibility for Dike 5C. The Bailey Bridge and its adjacent structures should be managed and upgraded together.

Cheekeye Confluence Area Plan

Like the Eagle Viewing Area along the Squamish River, the Cheekeye River confluence area has some unique local challenges and constraints. Examples include:

- potential blockage at Fergie's bridge
- ± 3 m historical variation in river bed levels
- long-term sediment management issues
- existing non-standard dike structures
- transfer of risk between landowners
- environmental risks and opportunities
- Transportation constraints
- Coordination of emergency plans
- proposed dike on Ch'iyákmesh (Cheakamus) I.R. No. 11

The District and the Skwxwú7mesh Úxwumixw (Squamish Nation) should work with community stakeholders to develop a neighbourhood-level plan that will address these issues.

7.4 Stawamus River

Section 8 of the IFHMP River Flood Risk Mitigation Options report presents a preliminary planning map for the Stawamus River. The planning map has been simplified and aligned with District cadastral information. The limits of Overland Flow Hazard Areas were also updated. The final IFHMP planning map is shown in Figure 7-13.

The IFHMP does not recommend any controlled densification areas for the Stawamus River hazard areas. Overland flow in the Valleycliffe neighbourhood would only occur if flooding exceeds the IFHMP's 200-year return period criteria, or if a debris flood fills in or blocks the river channel.

In fact, the IFHMP identified the Valleycliffe neighbourhood as a potential candidate for additional density, provided:

- a secondary access route is maintained for evacuation and emergency response;
- the Stawamus River dike (particularly its erosion protection works) are upgraded to meet the latest provincial standards; and



- general IFHMP policy such as FCLs and setbacks apply to all new development.

Densification of the unconnected coastal Flood Hazard Area adjacent to Mamquam Blind Channel could also be acceptable, excluding lands designated as Primary Floodway. As an unconnected coastal Flood Hazard Area, densification proposals would need to include a site-specific coastal flood risk mitigation strategy. The District should facilitate discussions between the Skwxwú7mesh Úxwumixw (Squamish Nation) and adjacent landowners to align flood mitigation strategies and avoid transfer of risk situations.

Floodways

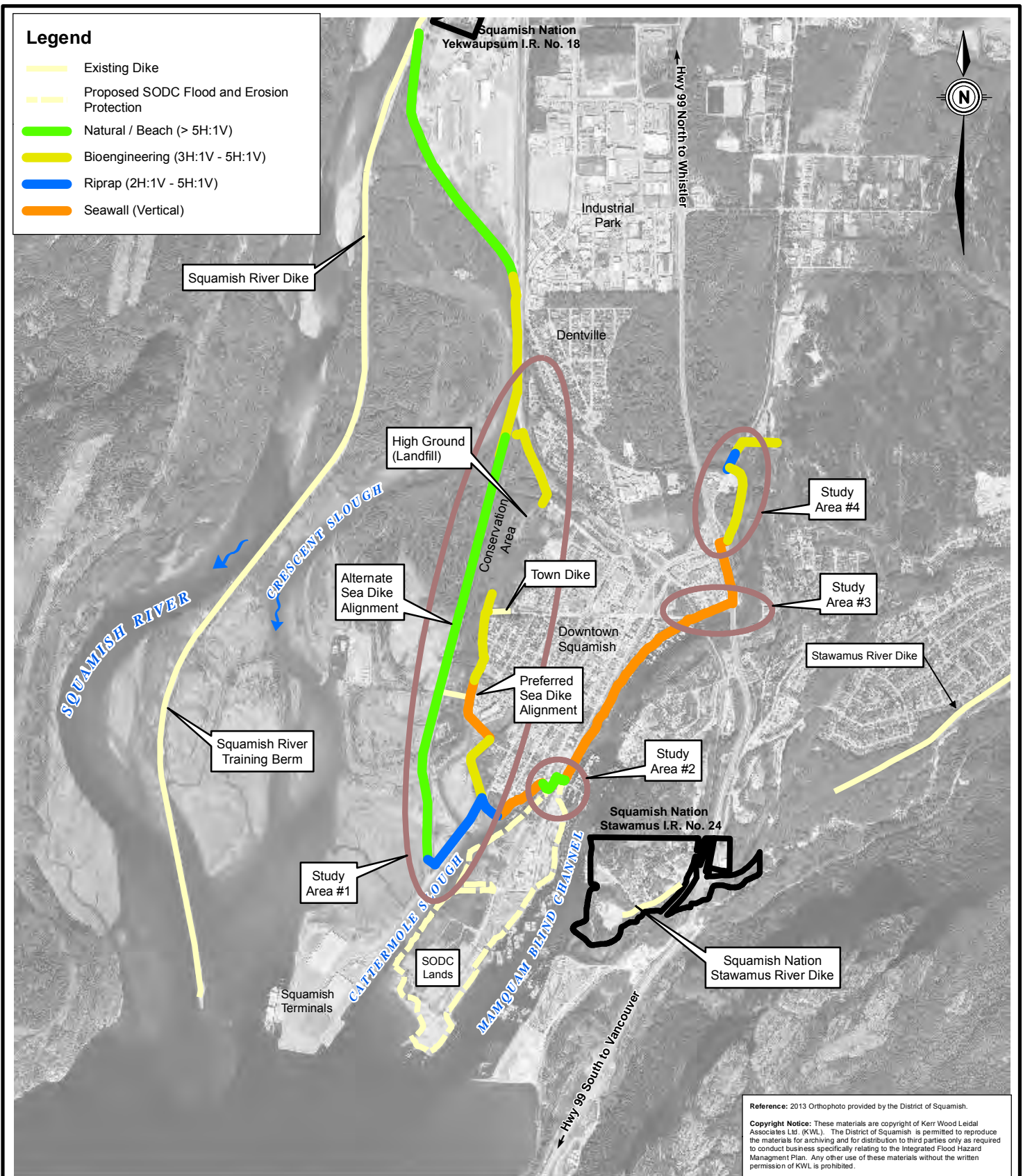
Figure 7-13 identifies Primary Floodway and Secondary Floodway areas. The Primary Floodway includes all lands on the river side of the District's Stawamus River dike as well as the lower estuary. The primary floodway provides essential flood conveyance and should be protected from new development.

Parts of St'á7mes (Stawamus) I.R. No. 24 are shown as "Primary Floodway subject to Squamish Nation review". In these areas, the planning map reflects unmitigated present-day conditions. The Skwxwú7mesh Úxwumixw (Squamish Nation) controls development on St'á7mes (Stawamus) I.R. No. 24 and is reviewing its own flood risk mitigation options. Once finalized, the flood risk plan for St'á7mes (Stawamus) I.R. No. 24 should be incorporated into the IFHMP.

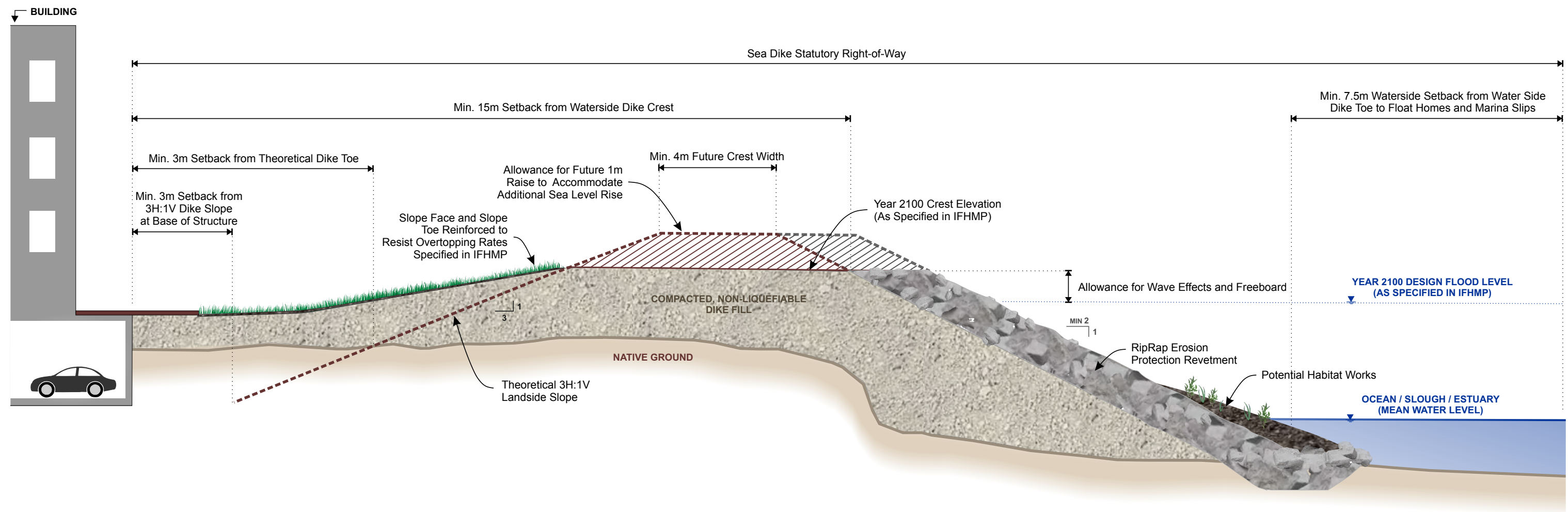
Secondary Floodways through the Valleycliffe neighbourhood are largely limited to the road network and Little Stawamus Creek corridor. The corresponding Secondary Floodway Areas are intended to minimize the impacts of overland flow from a debris flood or bridge blockage.

Upstream Study Limit

The Squamish Nation's 2017 flood hazard assessment improved the IFHMP's understanding of Stawamus River debris flood hazards. Proposals to develop upstream of the IFHMP study limits (shown on Figure 7-13) will need to complete further work to confirm hazards and develop mitigation strategies. At a minimum, the developer should complete the field work program recommended by Thurber Engineering in the Squamish Nation's hazard assessment.



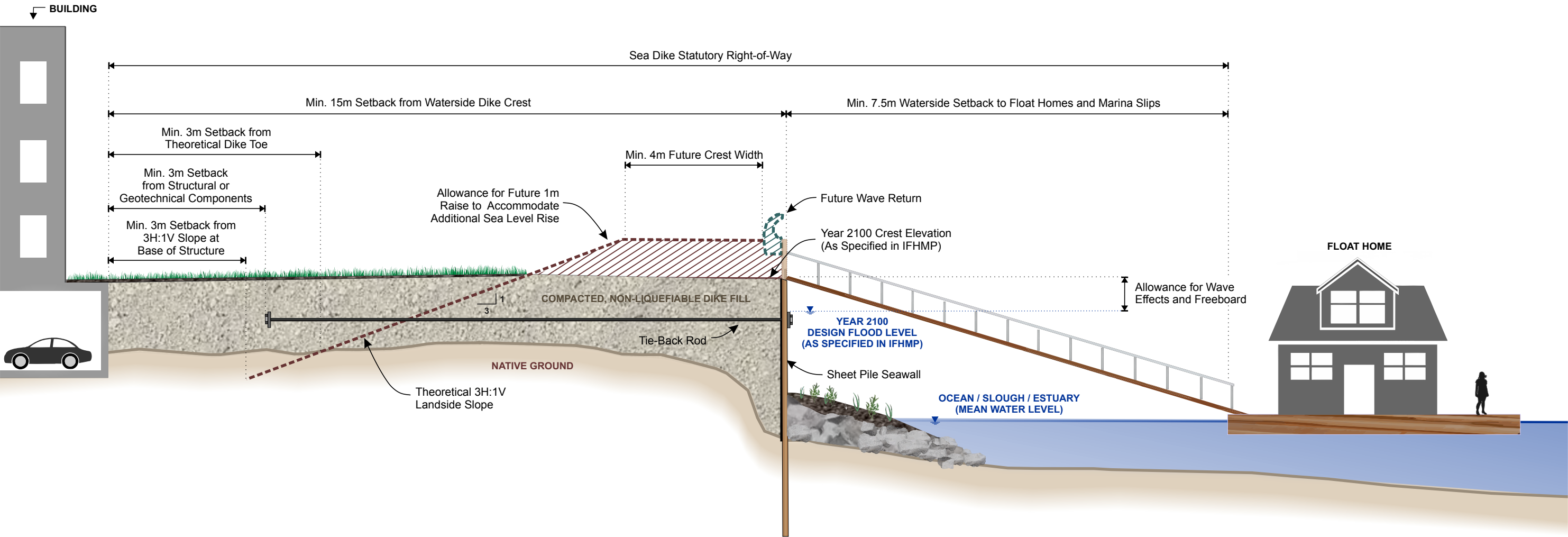
District of Squamish
Integrated Flood Hazard Management Plan



Note:

This dike section illustrates key concepts considered in developing the Squamish IFHMP. It is not intended to form the basis for design. Individual elements must be designed by a qualified professional and will be subject to regulatory review processes.

District of Squamish
Integrated Flood Hazard Management Plan



Note:

This dike section illustrates key concepts considered in developing the Squamish IFHMP. It is not intended to form the basis for design. Individual elements must be designed by a qualified professional and will be subject to regulatory review processes.

Project No. 463-278

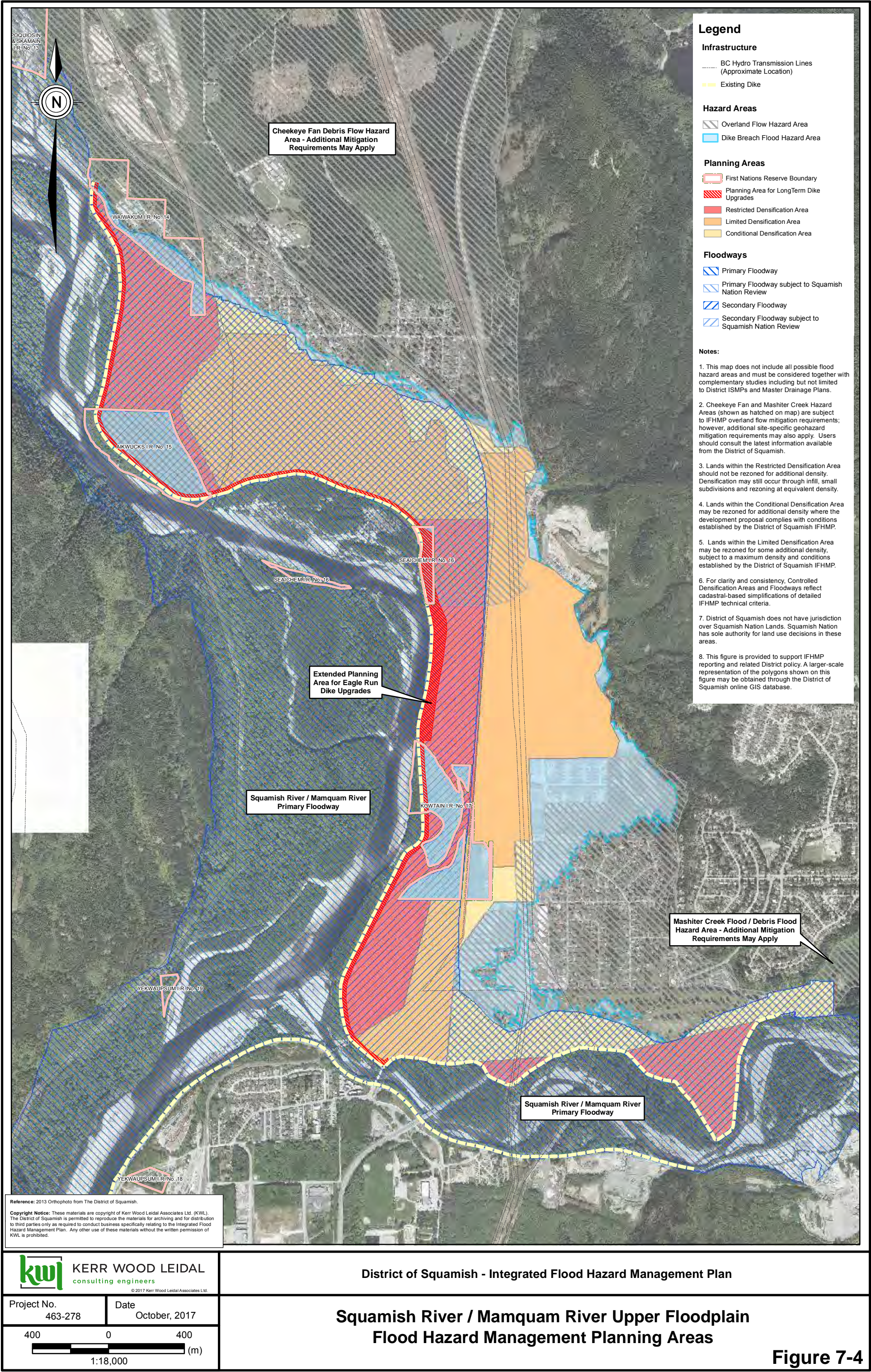
Date October 2017

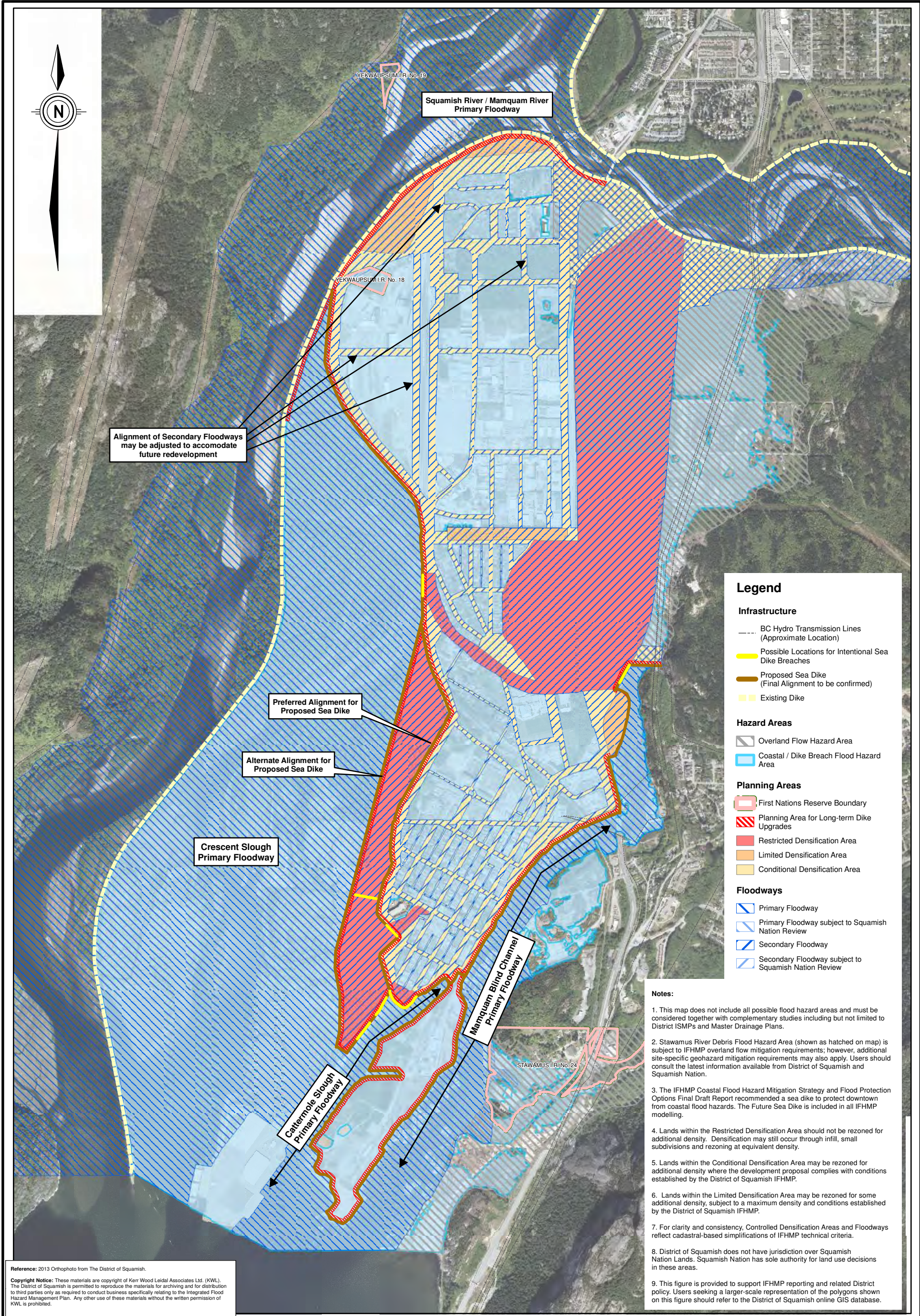
Not to Scale

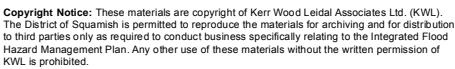
Proposed District of Squamish Sea Dike
Conceptual Cross-Section for Sheet Pile Alternative

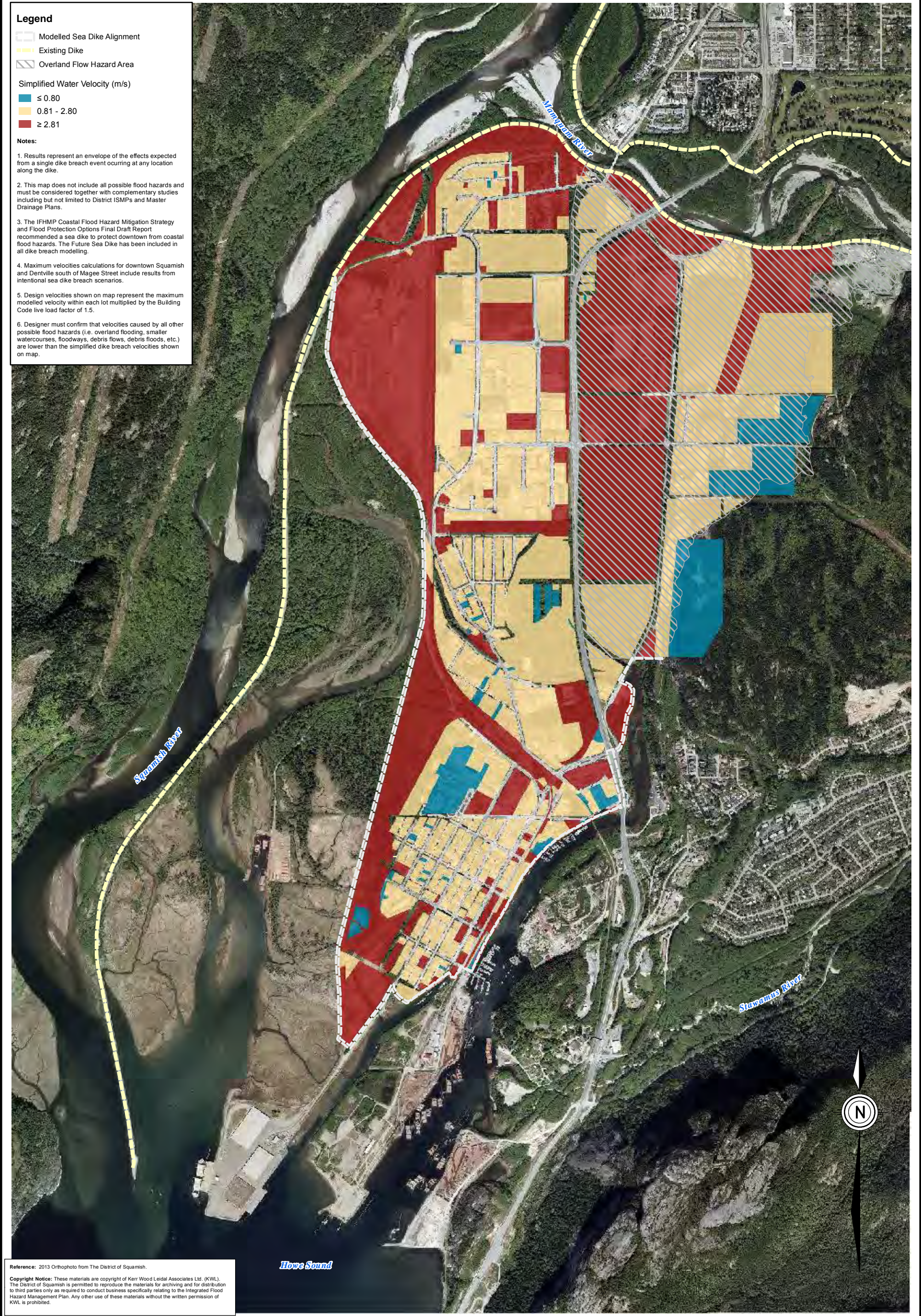
kwj KERR WOOD LEIDAL
consulting engineers

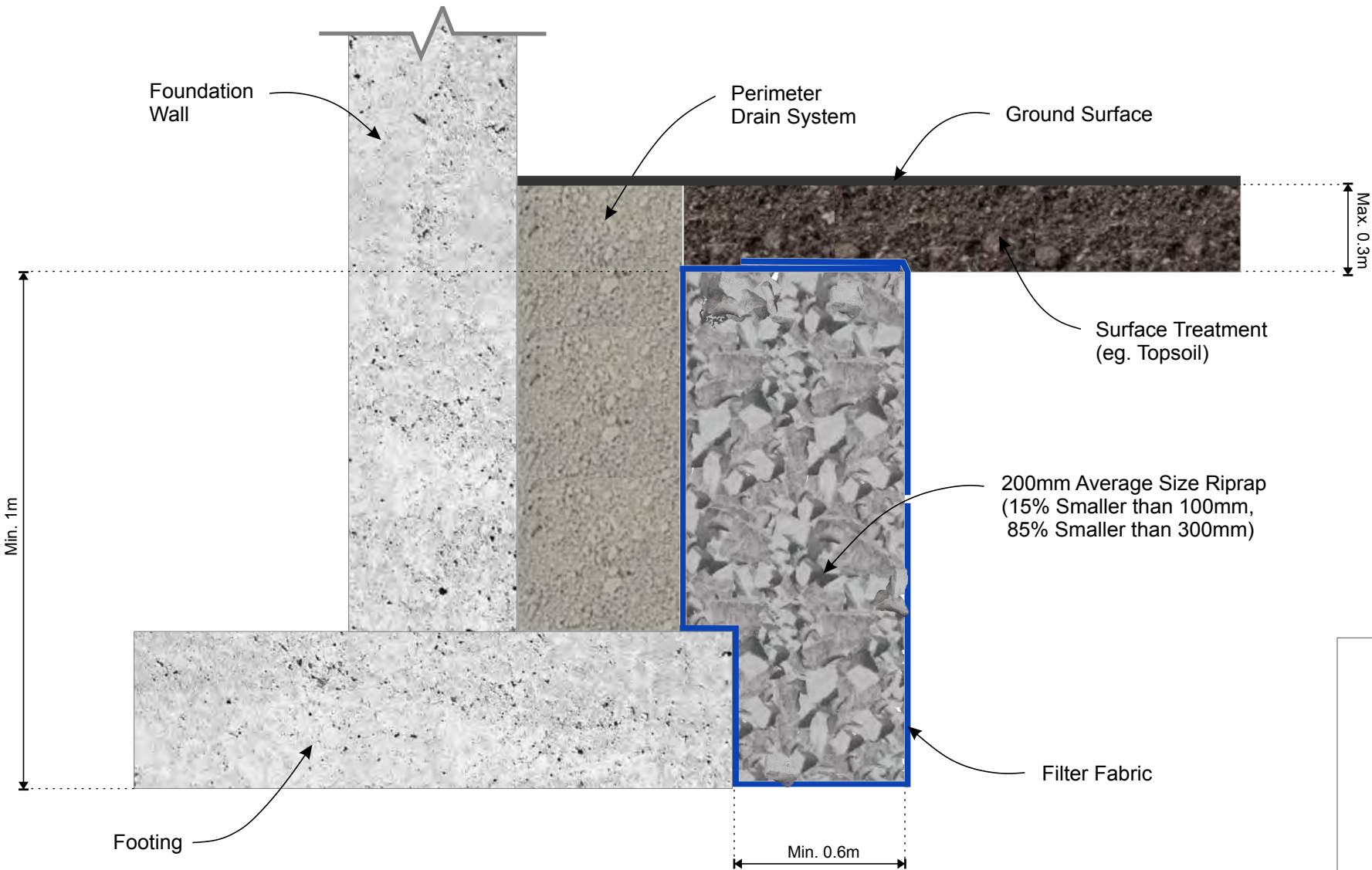
Figure 7-3









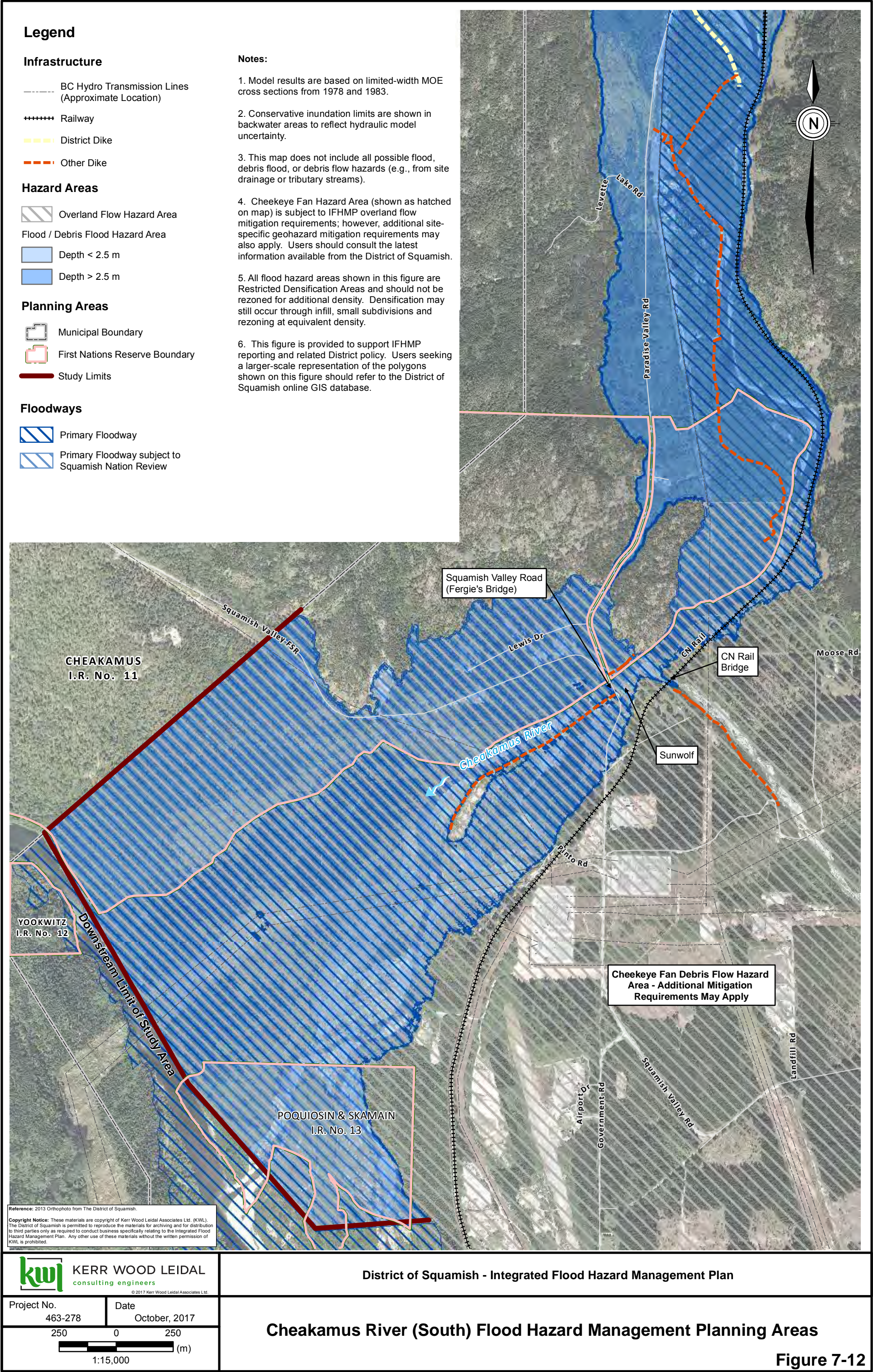


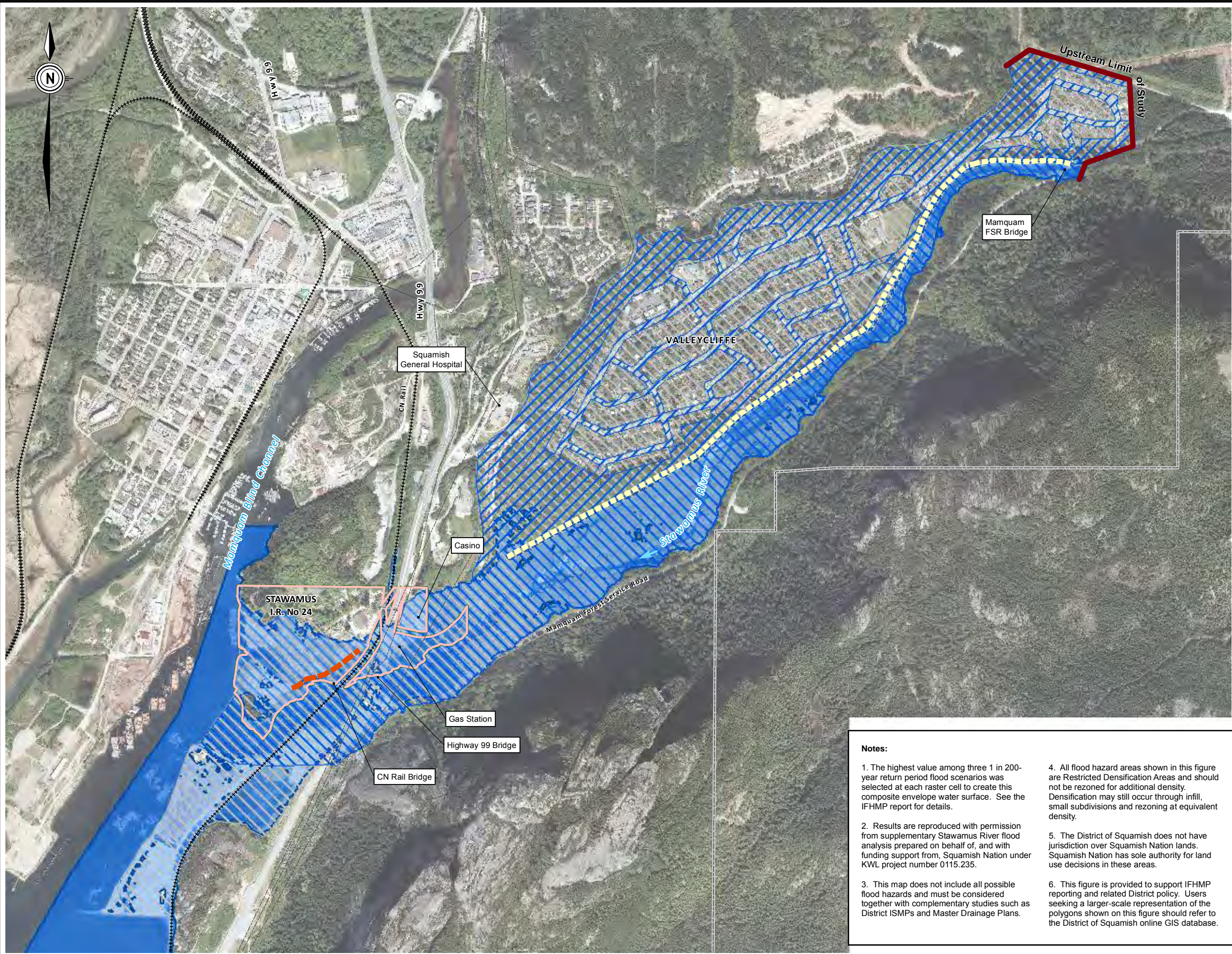
NOTE

Riprap and filter fabric not required if minimum depth from natural (pre-development) grade to top of footing exceeds 2m or if confining fill is protected as per Detail B.

For exclusive use on lots where District of Squamish simplified velocity mapping indicates a maximum velocity of less than 2.8 m/s.







District of Squamish
Integrated Flood
Hazard Management Plan

Legend

Infrastructure

- BC Hydro Transmission Lines (Approximate Location)
- Railway
- District Dike
- Other Dike

Hazard Areas

- Overland Flow Hazard Area
- Flood / Debris Flood Hazard Area
 - Depth < 2.5 m
 - Depth > 2.5 m

Planning Areas

- Municipal Boundary
- First Nations Reserve Boundary
- Study Limits

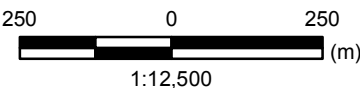
Floodways

- Primary Floodway
- Primary Floodway subject to Squamish Nation Review
- Secondary Floodway

Reference: 2013 Orthophoto from the District of Squamish.



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Project No.	Date
463-278	October 2017

Stawamus River
Flood Hazard Management
Planning Areas

Figure 7-13

Notes:

- The highest value among three 1 in 200-year return period flood scenarios was selected at each raster cell to create this composite envelope water surface. See the IFHMP report for details.
- Results are reproduced with permission from supplementary Stawamus River flood analysis prepared on behalf of, and with funding support from, Squamish Nation under KWL project number 0115.235.
- This map does not include all possible flood hazards and must be considered together with complementary studies such as District ISMPs and Master Drainage Plans.
- All flood hazard areas shown in this figure are Restricted Density Areas and should not be rezoned for additional density. Density may still occur through infill, small subdivisions and rezoning at equivalent density.
- The District of Squamish does not have jurisdiction over Squamish Nation lands. Squamish Nation has sole authority for land use decisions in these areas.
- This figure is provided to support IFHMP reporting and related District policy. Users seeking a larger-scale representation of the polygons shown on this figure should refer to the District of Squamish online GIS database.



8. Implementation

This IFHMP makes over 100 recommendations for flood risk management throughout the District. Section 5.4 of this report presents a framework for grouping recommendations by their content. Section 7 groups recommendations by flood hazard. When discussing implementation, it is most useful to group recommendations by how they will be implemented. Considered in this way, there are four main “types” of IFHMP recommendations:

- **Policy Measures** deal with goals, objectives, and requirements.
- **Operational Measures** affect how the District fulfills its responsibilities.
- **Capital Investments** are construction projects that require large financial investments.
- **Further Studies** will provide more data and analysis to guide future updates.

Some of the IFHMP recommendations should be implemented immediately. Others will take decades to plan and build. Section 5.3 of the River Flood Risk Mitigation Options report describes four different priorities for implementing recommendations:

- **Priority 1** measures should be implemented immediately or at the earliest possible opportunity.
- **Priority 2** measures should be considered in planning decisions and implemented before the next IFHMP update.
- **Priority 3** measures should be considered in planning decisions, but implementation will likely be after the next IFHMP update.
- **Priority 4** measures should be implemented if and when opportunities arise. Priority 4 measures are not strict requirements, but add value to planning, development other decisions.

The sections below summarize implementation issues and comment on general priorities for each of the four categories. More information on specific recommendations can be found in the IFHMP Coastal Flood Risk Mitigation Options report and River Flood Risk Mitigation Options report.

8.1 Policy Measures

Policy measures set out the goals, objectives and requirements for the community's flood risk management program. To be considered “implemented”, policies must be formally adopted by Council. They must also be applied and enforced by District staff.

The IFHMP project team worked closely with District staff to prepare draft policy updates for three main documents:

- The **Official Community Plan** (or OCP) sets targets for acceptable flood risk and guides the development and growth of the community.
- The new **Floodplain Bylaw** establishes FCLs and setback requirements. It also lays out the requirements for exempting a property from FCL or setback requirements.
- A new **Development Permit Area** (or DPA) identifies and protects primary and secondary floodways.

Initial drafts of the three documents were prepared by the IFHMP project team in the Fall of 2016. Development applications received over the winter of 2016/2017 gave District staff a unique opportunity



to “shadow test” the policies by considering how they would apply to real-life situations. The shadow-testing process considerably improved the draft versions that were presented to District Council, and should reduce the number and scope of issues that arise after the new policies are adopted.

Revised versions of the policies were presented to the public, District Council and the Skwxwú7mesh Úxwumixw (Squamish Nation) in spring and early summer 2017. The latest draft OCP policies, development permit guidelines, and Floodplain Bylaw are included as Appendices F, G, and H of this report. The policies will be formally considered by council through the bylaw adoption process. A comprehensive review of the major policies should be completed during the next IFHMP update.

Supporting policy measures are also included in a small number of other bylaws. These measures are particularly well-suited to the scope and intent of each bylaw, and would be difficult to apply within the OCP, Floodplain Bylaw, or DPA. Examples of other bylaws that incorporate IFHMP recommendations include:

- the new **Soil Management Bylaw**, which governs fill within property line setbacks;
- the updated **Subdivision and Development Control Bylaw**, which outlines requirements for design and construction of structural flood protection works proposed or required as part of a development; and
- the **Zoning Bylaw**, which requires restrictive covenants and restricts the height of spaces below the FCL (to deter later conversion from storage to habitable space).

These bylaws are either currently being updated, or scheduled to be updated in the near future.

The final key policy tool is the Comprehensive Emergency Management Plan (CEMP) and its appendices. One of the appendices will be an annex of flood-specific measures. The CEMP is currently being updated by the District's emergency management team. Emergency management staff reviewed and provided feedback on Section 8.5 of the IFHMP River Flood Risk Mitigation Options report, which deals with emergency response tools.

Virtually all policy measures are Priority 1 IFHMP recommendations.

8.2 Operational Measures

Operational measures are actions that District staff take to help look after the community. This type of recommendation is usually up to District staff to implement in the course of their work. Most of these measures do not require any new policies or special council authorizations.

Some IFHMP operational measures have to do with the dike system. For example:

- implementing sustainable vegetation management;
- improving access for dike inspections, maintenance, upgrading and repairs;
- completing a CCTV inspection of culverts; and
- stockpiling materials needed for emergency dike closures.

These operational measures have been identified through the IFHMP and the District's recently completed comprehensive dike inspection. Other recommendations that could be considered operational measures include:

- monitoring of sediment accumulation in the river channels;



- building, testing, maintaining and operating flood risk monitoring and warning systems;
- maintaining and updating the dike breach model (to assess adverse impacts of densified development on conveyance);
- incorporating information from parallel Cheekeye Fan hazard and mitigation studies; and
- communicating flood risk information to the public (e.g., via online tools like GIS maps).

Engineering staff are usually responsible for planning the work. The work itself will usually be completed by Operations staff or contractors. IFHMP operational measures can fall under Priority 1, 2, or 4. Because operational measures are usually implemented as part of regular District operations, their scope is rarely long-term enough to fall under Priority 3.

As discussed in Section 7.2 and noted above, the IFHMP dike breach model can be used to evaluate rezoning applications and other development applications in Secondary Floodway Areas. However, the District will need to maintain an up-to-date version of the dike breach model. This is not a straightforward task. The cost per update will increase considerably if the model is not well documented and up to date. More importantly, the model may reach a point where it can no longer support the evaluation of a proposed development.

A revision control process can be used to help organize and track model updates. A well-designed process will also reduce maintenance effort and cost over the long term. Key recommendations for maintaining an up-to-date dike breach model are summarized below:

- An “official” version of the dike breach model should be maintained and archived in a single, digitally-secure location.
- A filing and documentation structure should be created for logging changes and revisions. Log files should be stored and archived with the model.
- All modelling should be completed by someone familiar with the model structure and assumptions.
- Updates should only be completed by one person or team at a time (to avoid version control issues).
- Individual modellers and/or teams should remain as consistent as possible from one project to the next. Where change is necessary, care should be taken to share all relevant domain knowledge.
- Each new development should be evaluated by creating a new “branch” of the model (or by extending another branch to include other pending developments).
- Changes should be merged back into the “trunk” model only after the project receives final approval from District Council.
- An archive copy of the model should be created each time the “trunk” model is updated.

After initial setup, District staff should be able to incorporate the necessary parts of the revision control process into the scope and budget of each individual assessment.

8.3 Capital Investments

Capital Investments are projects and initiatives that require large financial investments. They will typically, but not exclusively, involve upgrades to the District’s structural flood protection works. Obvious examples include design and construction of the new sea dike as well as upgrades to the various river dikes. Land acquisition is an example of a non-structural capital investment.



Lead times required for engineering design and budgeting make it unrealistic to assign IFHMP Priority 1 to all but the most critical capital investments. An example of a Priority 1 capital investment is upgrading of the Squamish River dike at Judd Slough to meet the latest provincial standards.

It is equally unrealistic to use the District's limited capital for projects that are assigned the "nice to have" status of IFHMP Priority 4. However, Priority 4 may include opportunities to implement other projects in a more advantageous way. For example, requiring developers to upgrade their dike frontage would be a Priority 4 opportunity.

In general, capital investments to address known deficiencies should be assigned IFHMP Priority 1 or Priority 2. This includes raising the sea dike to 4.0 m geodetic elevation and upgrading river dikes to provincial standard status. Capital investments to address future hazards like sea level rise, or to provide significant improvements in flood protection like the Squamish River "super dike", should be assigned IFHMP Priority 3.

While the four IFHMP priorities are useful, the list of structural upgrading projects needed a more detailed assessment. District staff and consultants worked together to assess each project against three criteria:

1. the consequences that could occur if each project was not completed,
2. the likelihood of those consequences occurring (assuming the project was not completed), and
3. an order-of-magnitude cost for each project.

Each criterion was scored from 1 to 6. The three criteria scores for each project were multiplied together to obtain a total project score. The total project scores were used to create an initial ranking of structural upgrading priorities. Project scores were removed from the list prior to final review to allow for subjective adjustments.

Appendix I presents the list of recommended structural upgrades to the dike system, prioritized from most favourable to least favourable. In general, the most favourable projects are low-cost upgrades where failure is relatively likely and consequences would be extreme. The least favourable projects are higher-cost upgrades that address issues of lesser consequence and lower probability.

The prioritized list of recommended structural upgrades to the dike system includes four main themes:

- the proposed sea dike (conceptual cost estimate approximately \$28 million)
- river dike upgrades to meet provincial standards (conceptual cost estimate approximately \$19 million)
- "super dike" upgrades for Squamish River dike (conceptual cost estimate approximately \$35 million)
- a small number of uncoded miscellaneous projects.

The prioritized list of recommended structural upgrades does not include any debris flow mitigation works on the Cheekeye Fan.

While the list of structural upgrades is prioritized, it is not exact. It is intended as a general guide for investment decisions, and need not be completed in strict order. The District may also choose to complete some of the upgrades using internal staff and/or operating budgets.



8.4 Further Studies

The IFHMP recommends a number of further studies. The data and analyses they produce will help the District implement the IFHMP and scope future updates. The Skwxwú7mesh Úxwumixw (Squamish Nation) completed the first of these studies (Stawamus River debris flood assessment) in early 2017 and the results have been incorporated into the IFHMP.

Further studies specifically identified in one or more of the IFHMP technical reports include:

- collection of wind and wave data in Howe Sound
- Culliton Creek debris flow / debris flood hazards
- coastal subsidence / liquefaction assessment
- local area plan for Cheekeye River confluence
- Integrated Stormwater Management Plans
- special study areas for sea dike
- unauthorized fill along District dikes
- seismic dike vulnerability assessment
- local area plan for Eagle Viewing Area
- tsunami hazard assessment

While the above studies are not considered urgent, they should be completed prior to the next IFHMP update. The further studies listed above are therefore assigned IFHMP Priority 2.

In addition to studies specifically recommended by the IFHMP, the District could benefit from further dike breach modelling of the Squamish River floodplain. It would be beneficial to understand dike breach risks under existing (rather than assumed Year 2100) conditions. It would also be beneficial to understand the Year 2100 dike breach risks from floods larger and smaller than the 200-year return period event. Analysis of larger and smaller dike breach events can be combined with the IFHMP results into a Quantitative Risk Assessment.

Further modelling and QRA should be pursued on an opportunistic basis as IFHMP Priority 4.

8.5 Funding

Guiding principles for IFHMP project decisions are outlined in Section 5.1 of this report. The IFHMP also defined guiding principles for funding the recommended capital investments. Four principles were identified:

1. **Be Opportunistic.** Look for cost-effective opportunities to combine upgrades with needed repairs, maintenance, and even emergency response initiatives during a flood event. Costs and cost-effectiveness should be evaluated on a long-term basis.
2. **Build for today, plan for tomorrow.** Take steps now to ensure that the community is protected from today's hazards, but make sure that the works will be easy to upgrade in the future. Make sure that land, legal access, community support and political will are available when the works are needed.
3. **Build partnerships.** Seek stable and secure long-term funding commitments from senior governments. Require lot-by-lot implementation of IFHMP capital projects as part of community renewal and growth.
4. **Share costs equitably within the community.** Extend the principles of equitable impact and benefit to funding capital upgrades for the dike system. Funds may be raised through general revenues, gas tax revenues, or levies applied to special service areas. Care should be taken to prevent developers from committing future owners to disproportionate and unfair funding arrangements.



Funding sources to implement the IFHMP can be characterized for each of the four main “types” of IFHMP recommendations identified at the beginning of this section.

Policy Measures

District staff routinely create, review, and update policy tools in the course of their day-to-day jobs. Costs for this work are funded through the District’s established payroll, which is a fixed part of the operating budget. From time to time, staff effort may be supplemented by consultants. Development application fees provide a limited funding stream that helps the District offset some of the routine internal costs of reviewing development applications.

Some policy measures – such as limits on densification in high-hazard areas – will result in opportunity costs. Opportunity costs are development opportunities (and corresponding future tax revenue) that were not allowed to proceed. Opportunity costs should be offset over the long term by savings on emergency response and recovery.

The only “true” economic costs associated with the implementation of policy measures are borne by developers. Examples of these costs include the cost of floodproofing fill and cost premiums for using flood-resistant materials below the FCL. Developers should incorporate these costs when evaluating the economic viability of a potential development proposal. Government agencies must be prepared to accept similar costs when building or redeveloping institutional structures.

Operational Measures

Funding for operational measures will consist primarily of staff resources and related equipment. These costs are routinely covered through the annual operating budget. The District may receive some funding assistance for Local Authority Emergency Planning through Emergency Management BC.

Staff resources may be supplemented by consultants and contractors from time to time on an as-needed basis. Assistance is typically procured through standing offers, secondment (of staff or equipment), or on a casual (hourly) basis.

Capital Investments

Capital Investments account for the vast majority of funding required to successfully implement the IFHMP. As noted in Section 8.3, most capital investments will consist of construction projects to upgrade the District’s dikes and other structural flood protection works. The District expects to contribute a portion of the required investment, but will need significant financial support from the federal and provincial governments to implement many IFHMP recommendations. District staff will take a lead role in identifying and pursuing appropriate funding opportunities.

Senior Government Cost-Sharing

The multi-billion dollar cost of recent floods in Canada and beyond has raised senior governments’ awareness of flood risks. Federal and provincial cost-sharing programs are expected to continue to provide funding support for the foreseeable future. Billions of dollars for infrastructure improvements will be allocated across Canada over the life of this IFHMP.

Senior government cost-sharing programs and formulas have changed over time. Recent cost-sharing agreements have specified one-third federal, one-third provincial and one-third local government funding. Funding arrangements are often cyclical, and the District cannot control or influence the eligibility criteria. Some previous funding programs have preferred projects that have plans and designs



already in place. The IFHMP, and particularly the prioritized list of structural upgrades, should help the District take advantage of cost-sharing opportunities as they arise.

Local Funding Sources

To take advantage of cost-sharing programs, the District must be prepared to contribute its share of the funding. Sources for District funding contributions could include:

- annual operating budgets (general revenues);
- senior government grants such as the federal gas tax fund;
- development-driven sources; and
- local area levies.

As a small community, the District has correspondingly small tax base. Funding extensive dike upgrades through general revenues is possible, but must be balanced against other funding priorities. The District routinely develops multi-year capital plans that allocate available capital funds across the full spectrum of municipal services. It would be difficult for the District's general tax revenues to support the full list of capital investments recommended by the IFHMP within an appropriate timeframe.

Senior government provides municipal governments with some stable sources of infrastructure funding in the form of grants. For example, the federal gas tax fund provides a relatively predictable source of revenue for Squamish, and periodic opportunities to apply for additional funds through the gas tax Strategic Priorities Fund. Gas tax funding grants must typically be directed toward infrastructure improvements.

The District may also wish to explore setting up flood protection as a separately-funded utility. Raising funds through a utility framework clarifies the linkage between funding and expenditures, but creates additional administrative workload for District staff. The City of Richmond created a dike utility in 2005 to provide a stable source of dedicated funding for dike upgrades.

Development-Driven Funding

Developer-driven funding sources include Development Cost Charges (DCCs) and Community Amenity Contributions (CACs). DCCs are mandatory charges that developers must pay to help fund the off-site costs of new development. The use of DCCs is regulated by the province under the *Local Government Act*. The provincial government has conclusively stated that DCCs may not be used for flood protection. This is true even if a development will significantly increase the consequences of a dike breach.

Like DCCs, CACs are paid by developers to support off-site amenities. While DCCs are imposed by bylaw, CACs must be negotiated for each individual development. The provincial government encourages municipalities to use DCC principles to guide CAC allocation. These principles include:

- a demonstrable link between development and the proportional CAC funding;
- consistency and transparency in setting and using the CACs;
- planning ahead to create estimated schedules and tables of estimated CAC amounts; and
- using CACs to fund capital improvements rather than operation and maintenance expenses.

For some developments, there may be engineering requirements that are considered a pre-requisite for municipal approval. For example, mitigation measures specified in a QP's Flood Hazard Assessment must be implemented before a development can be considered "safe for the intended use".



Investments required to meet engineering requirements are typically considered part of the cost of development, and are not considered a CAC.

CACs may be a potential funding stream for dike upgrades where:

- the dike upgrade will provide a general benefit for the community, but
- the upgrade is not required as a condition of development approval.

Flood protection was not considered in the District's 2015 interim Community Amenity Contribution Targets and Allocations. To be fair and equitable, the District would carefully need to establish CAC durations, geographic areas, and funding targets for each relevant dike upgrade. This would require significant updates to the District's CAC policy.

Local Area Levies

Local area levies require definition of a Local Service Area protected by each dike, and a corresponding tax to support future upgrading (e.g., based on parcel or frontage charges). The District could begin dike upgrades as soon as the Local Service Area is established by borrowing against future revenues.

A local service area ensures that those who benefit most directly from dike protection contribute accordingly. However, this approach has several drawbacks. Taxpayers in the service area would need to vote in favour of setting up the service area (and may have little motivation to do so). Funding through a local service area could also conflict with the principle of sharing costs equitably throughout the community.

This funding approach is often used to fund the operating and maintenance cost of new dikes built to protect new developments. In this case, new dikes are discouraged by the IFHMP, with the exception of the sea dike. A local area levy could be an appropriate mechanism for funding any future operation and maintenance costs within unconnected coastal flood hazard areas.

Recommended Approach for Funding IFHMP Capital Investments

Development protected by the District's dike system benefits the entire community. It is both equitable and reasonable that funding for dike upgrades be drawn from the District's annual capital budget.

While the entire community benefits from dike protection, those who live and operate businesses in the dike-protected floodplain benefit most directly. It is both equitable and reasonable that people with property in the dike breach flood hazard area contribute more than those who have no personal assets at risk.

Lastly, the IFHMP recommends that future developers of riparian properties be required to upgrade their on-site dike frontage as a condition of development. Where upgrades are required to make the land "safe for the intended use", the contribution should be considered an engineering pre-requisite for development approval. However, it would also be equitable and reasonable to seek proportionate contributions from others (e.g., non-riparian developers) who wish to develop in dike-protected areas.

In summary, dike upgrades require extensive capital funding and provide differing levels of benefit across the community. These factors justify consideration of a blended approach to local funding that combines:

- contributions from general revenues and grants, reflecting the benefits that dikes provide for the broader community;
- funding from local service area(s), representing the additional benefit provided to those whose personal assets are protected; and



- developer contributions that recognize the key role of the dike system in supporting ongoing development opportunities throughout the District's floodplain areas.

Each of these opportunities have different logistical challenges. Developing a sustainable funding model will require time and community consultation. Prior to the next IFHMP update, the District should further explore these options and determine an appropriate balance between them. In the meantime, funding to address the IFHMP's most urgent recommendations should be drawn from the District's annual budget, which is expected to be the least controversial of the options listed above.

Further Studies

Funding for the further studies identified in Section 8.4 will typically be drawn from the annual operating budget, although the source of funds may be both general revenues or senior government funding programs. Cost sharing assistance may also be available from senior governments on a project by project basis. The National Disaster Mitigation Program, now entering its fifth intake phase, is an example of one senior government program that funds studies rather than just capital projects.

8.6 Partnerships

The majority of recent flood protection capital projects in Squamish have been either funded by, or cost-shared with, the District's flood protection partners. Examples include the section of sea dike under construction at the Mireau development, Squamish River dike upgrades at North Yards and Judd Slough, and sediment management at the Mamquam River and Cheekeye River confluences.

Partnerships are equally critical for the successful implementation of the IFHMP. All of the organizations listed in Section 1.2 of this report can be partners in flood risk management.

Partnerships will serve a wide variety of purposes and provide a wide variety of benefits. Some critical collaborators like the Skwxwú7mesh Úxwumixw, Indigenous and Northern Affairs Canada, and the B.C. Inspector of Dikes share regulatory jurisdiction on flood risk issues in the local floodplains. The Government of B.C. and the Government of Canada play a key role in funding disaster response efforts. Other partners will share data, information, and capital costs for dike upgrades.

The District works with a number of partners who collect and provide information, in real time when necessary. They include:

- the River Forecast Centre (e.g. flood warnings and advisories, snow survey bulletins);
- BC Hydro (e.g. Daisy Lake Dam spill alert and flood alert notifications);
- Water Survey of Canada (real time hydrometric data);
- StormsurgeBC (e.g. extreme water level bulletins); and
- the National Tsunami Warning Centre.

These partnerships are particularly important to understand how to predict, verify, and monitor emergency conditions.

Successful implementation of the IFHMP requires working with interested members of the public, non-government organizations, developers and other stakeholders. A co-operative approach is recommended for public engagement and education. This includes the use of the District website for public education and may include a continuing role for the technical working group. Other stakeholders involved in public education and engagement include the Fraser Basin Council, BC Real Estate



Association, APEGBC, Union of BC Municipalities (UBCM), BC Branch of the Canadian Water Resources Association, the Climate Action Secretariat of the Ministry of Environment, and the research-oriented Pacific Climate Impacts Consortium based at the University of Victoria.

Partnerships with the insurance industry is an emerging field. The Government of Canada has undertaken a number of steps in this direction through Natural Resources Canada. The intent of all parties is to enable private insurance to play a larger role in flood risk mitigation, which should in turn reduce reliance on Disaster Financial Assistance as an “insurer of last resort”.

8.7 IFHMP Next Steps

Careful thought should be given to the life cycle of an IFHMP. This IFHMP was adopted some 23 years after the 1994 FHMP, and is far more comprehensive. Some challenges should be expected as the community adjusts to the IFHMP's more inclusive approach. Updating the IFHMP more frequently can reduce the extent and impact of changes. More frequent updates can also reduce the learning curve for Council, staff, partners, and consultants.

An IFHMP can also be updated too frequently. Updating an IFHMP too frequently is not cost-effective. There may be little to no change in information, technology or the community. Changes that do occur can “move the goalposts” for development and make the community less attractive for investment.

The District has adopted a target of updating the IFHMP every 10 years. These updates will be comprehensive, and will incorporate new data, new approaches, and new development.

Some parts of the IFHMP may also need to be updated on an interim basis. Major shifts in climate change science, in the community, the river channel, and/or the watershed are all examples of change that could require an interim update.

Planning for the next comprehensive IFHMP update should start two to three years in advance. This lead time is needed to allow District staff to scope the project, secure funding, and confirm that all required information is available.

The next IFHMP update should incorporate the findings of studies noted in Section 8.4 as well as:

- new climate change research and hydrologic records;
- the latest version of the Squamish River dike breach model;
- the latest information available on Cheekeye Fan debris flow hazards and mitigation;
- long-term plans for the Squamish River training berm; and
- flood risk mitigation plans prepared by the Skwxwú7mesh Úxwumixw (e.g., St'á7mes (Stawamus) I.R. No. 24).



9. Summary

The IFHMP represents an important step forward for the District's flood risk management program. The process has confirmed that there are no easy or inexpensive ways to reduce and manage flood risk in a growing community where so many hazards overlap. Successful implementation of the IFHMP will demand significant and ongoing financial, policy and administrative commitment from District Council, staff and partners.

However, once implemented, the community-supported solutions of the IFHMP will help the District achieve its goal of remaining a liveable, sustainable community. In achieving these goals, the District will demonstrate how proactive communities can adapt and respond to the challenges of natural hazards and climate change.

This section provides a bulleted summary of the main points described in this report. Sub-headings correspond to report sections.

Introduction

1. In 2014, the District began preparation for a new Integrated Flood Hazard Management Plan (IFHMP). The IFHMP has been developed to better respond to the changes in the Squamish community and reflect advancements in the field of flood hazard management.
2. District and Skwxwú7mesh Úxwumixw (Squamish Nation) lands share the floodplain and are protected by a common dike. As a result, the District and Nation share an interest in flood risk management. The District recognizes the contributions of the Squamish Nation to the IFHMP process.
3. The IFHMP was developed by District staff and consultants, with input from District Council, the Squamish Nation, a Technical Working Group, community stakeholder groups, and the public.
4. The term "integrated" was added to the District's IFHMP because it takes an integrated or systems-oriented approach to achieving its four primary objectives. The four IFHMP objectives are to:
 - equitably reduce and share flood risks;
 - identify compatible opportunities for growth and development;
 - make sustainable decisions with a long-term focus; and
 - adopt and implement community-supported solutions.
5. Development of the IFHMP has consisted of four main phases: a background analysis, a strategy for coastal flood risk mitigation, a strategy for river flood risk mitigation, and a final plan tying all these elements together. Each phase is summarized in an IFHMP project report.
6. This document is the final report for the IFHMP, summarizing all major findings, recommendations and decisions to date.

Background

7. The District of Squamish is located at the head of Howe Sound where five fast flowing mountain rivers reach gently sloping valley bottomlands. Such areas have historically been viewed as the most suitable for human settlement, agricultural and transportation.



8. Flooding is a well-documented risk in the Squamish area. There are written accounts of numerous local floods since the late nineteenth century as well as the oral history of the Skwxwú7mesh Úxwumixw (Squamish Nation).
9. The District's natural hazards include
 - flood hazards from the Squamish, Mamquam, Cheakamus and Stawamus Rivers;
 - flood and debris flow hazards from the Cheekeye River and several smaller creeks; and
 - coastal flood and tsunami hazards from Howe Sound.
10. Prior to the IFHMP, the District's flood hazard management program consisted of a series of policy and planning measures as well as extensive structural flood protection works.
11. Policy tools included floodproofing and avoidance measures reflected in the District's 2009 Official Community Plan and regulated through the Zoning Bylaw. The IFHMP's review of the District's policy-based flood hazard mitigation tools identified a need to better plan for climate change, particularly Sea Level Rise, as well as the need for a Floodplain Bylaw and flood hazard Development Permit Areas.
12. The District's structural protection works consist of dikes, riprap erosion protection revetments and related structures. These works are regulated under the provincial *Dike Maintenance Act*.
13. The integrated Squamish River and Mamquam River dike system is about 20 km long and is the most important part of the District's dike system. Other District dikes are located in the Paradise Valley (Cheakamus River), along the Cheekeye River upstream of Highway 99, and along the Stawamus River adjacent to the Valleycliffe neighbourhood.
14. Coastal flood protection is currently provided by low, non-standard works around the downtown. The District lacks a comprehensive system of dedicated coastal flood defences.
15. In addition to the District's dike system, there are a number of unregulated Squamish Nation and privately-owned dikes and training berms located throughout the local floodplains.

Flood Hazard Assessment

16. The IFHMP addresses several types of flood-related hazards for Squamish, including coastal floods (and sea level rise due to climate change), river floods, dike breaches, and erosion hazards. Related hazards not addressed in the IFHMP include urban stormwater flooding and groundwater flooding.
17. The District is addressing debris flow risks on the Cheekeye Fan through a separate but parallel process. Results of the Cheekeye Fan Debris Flow mitigation are intended to be co-ordinated with the IFHMP River Flood Risk Mitigation Options to ensure an effective overall mitigation of flood debris and flow risks.
18. The IFHMP carried out hazard and consequence assessments to help the community develop a vision for flood risk management. Flood hazards can be reduced (or "mitigated") by:
 - reducing the probability that flooding will affect the community, and/or
 - reducing the consequences of flooding should it occur.



19. To make good long-term mitigation strategies and decisions, the IFHMP considers the conditions that might exist when today's buildings and developments reach the end of their service life. A modelling horizon of the Year 2100 was adopted.
20. The following assumptions about how hazards and development will change between now and 2100 have been incorporated in the IFHMP's flood hazard and consequence assessments:
 - Sea levels will be 1 metre higher than they are today.
 - Peak flows for river floods will be 10% larger than they are today.
 - Development will gradually fill in to the maximum density allowed under the current Zoning Bylaw.
 - By Year 2100, all lots and buildings will be floodproofed. The amount of floodproofing fill assumed for each lot varies based on the lot's current zoning.
 - Key floodway corridors will be maintained at present-day elevations.

Coastal Flood Hazards

21. A coastal flood occurs due to an extreme combination of tide, storm surge, wind, and waves.
22. Much of downtown Squamish is presently at risk of inundation from coastal floods. The risk from coastal floods is expected to increase significantly over time due to sea level rise.
23. For the IFHMP, District Council decided to focus on a coastal flood that has a 1 in 200 (or 0.5%) chance of occurring in any given year. This is also called the 200-year return period event, and is the provincial standard for flood protection in most areas of B.C.
24. The 200-year return period still-water coastal flood level is 4.59 metres geodetic elevation, including a freeboard allowance of 0.6 m to account for uncertainty. This is called the "Designated Coastal Flood Level" for Squamish, and is a minimum value for the coastal Flood Construction Level.
25. Additional allowances for waves and wind setup must be added to the still-water coastal flood to safely design buildings and coastal flood protection structures. Different allowances are needed for different sites along the District coastline.

Squamish River / Mamquam River Flood Hazards

26. IFHMP models show that the District's existing dikes may not provide their intended level of protection against the 200-year return period flood on local rivers.
27. The IFHMP identifies other deficiencies on the local river and flood protection systems such as the hydraulic capacity of bridges, evidence of dike seepage and piping in past floods, potential for overland flooding in undiked areas, and limited extents for erosion protection revetments.
28. The District has not yet completed a comprehensive seismic assessment of the dike system. Based on available data, some dikes may not meet the province's current seismic design guidelines.
29. The IFHMP modelled flooding that could result from dike breaches along the Squamish River / Mamquam River dikes both north and south of the Mamquam River. Water levels from the dike breach model were adopted as minimum Flood Construction Levels (FCLs) for the Squamish River / Mamquam River floodplain.
30. In the event of a dike breach north of the Mamquam River, the IFHMP estimates economic losses at \$190 million. A dike breach south of the Mamquam River could result in economic losses reaching



\$257 million. If dike breaches occur concurrently on both floodplains, the IFHMP estimates total losses at \$447 million.

31. In the event of a dike breach north of the Mamquam River, the IFHMP estimates that approximately 7,000 people could be displaced. A dike breach south of the Mamquam River could displace about 3,400. If dike breaches occur concurrently on both floodplains, the IFHMP estimates a total displaced population of 10,400.
32. A dike breach on either floodplain could flood potential evacuation centres and interrupt critical municipal services such as fire protection and sewage treatment. This could force evacuation of additional areas not directly affected by flooding.

Cheakamus River Flood Hazards

33. Cheakamus River hazards include clear-water flooding, channel erosion, and sediment aggradation. Hazards also include backwater floods and outburst debris floods resulting from the creation and subsequent failure of landslide dams.
34. The most important consequence of Cheakamus River flooding is the potential loss of key access routes like Fergie's Bridge, Paradise Valley Road, and the Bailey Bridge. Loss of these routes would make it more difficult to share warnings, evacuate residents, and respond to emergencies.
35. Other consequences include the inundation of rural communities, loss of land to erosion, damage to an extensive network of spawning channels and disruption to local business operations.

Stawamus River Flood Hazards

36. The primary hazards for the Stawamus River include floods, debris floods, the possibility of avulsion or lateral erosion, and sediment or debris deposition in the lower reaches and estuary. Peak flow from a debris flood could be larger than a comparable 'clear water' flood.
37. Key consequences of flooding from the Stawamus River include compromised access to, and inundation of, St'á7mes (Stawamus) I.R. No. 24 at the mouth of the Stawamus River, potential damage to regionally-significant bridge infrastructure at Highway 99 and the CN mainline, loss of land to erosion, and disruption or damage to local businesses.

Community Engagement

38. Community engagement is important to make sure that the IFHMP reflects the values and priorities of the community.
39. The IFHMP community engagement plan included consultation with the community (via digital media, social media and conventional open houses), dialogue with a Technical Working Group, and bi-lateral discussions with the Skwxwú7mesh Úxwumixw (Squamish Nation). The community engagement plan also specified key milestones where input the IFHMP would require input from District Council.
40. Community feedback determined that the District should use all practical approaches to mitigate flood hazards. Since some strategies are not always practical, the IFHMP uses different combinations of flood hazard mitigation strategies in different flood hazard areas.



Mitigation Approaches

41. The primary goal of the IFHMP is to produce new tools to manage and mitigate flood hazards. To meet the initial four objectives, the IFHMP project team used guiding principles to help make difficult decisions. Key principles guiding the development of the IFHMP include:
- Build a safe, sustainable, resilient community
 - Take a multi-generational view
 - Engage the public but respect project limitations
 - Protect existing development
 - Allow for community growth
 - Equitably share risks, costs and benefits
 - Work within natural constraints
 - Accept that there will be residual risk
42. The IFHMP recommends a wide variety of flood risk mitigation tools for the Squamish community. Some recommendations apply to the entire community. Others apply to specific areas.

Community-wide Mitigation Measures

43. **Land use planning** tools recommended by the IFHMP include:
- an updated OCP that defines risk mitigation objectives and encourages growth in areas of lower flood risk;
 - a new Floodplain Bylaw that establishes Flood Construction Levels and setbacks for buildings; and
 - A new Development Permit Area that protects and preserves floodway capacity.
44. **Site-specific** tools recommended by the IFHMP include:
- FCLs specific to each flood hazard area;
 - corresponding minimum setbacks from potential hazards and flood protection works;
 - Restrictive Covenants attached to the legal title of at-risk properties to inform future owners of the hazard, impose any site-specific requirements, and indemnify the District from claims for future flood damages;
 - typical designs for protecting foundations and floodproofing fill against erosion and scour hazards;
 - a process to guide the District's evaluation of site-specific exemption requests; and
 - the selective use of land acquisition where there is no other option to protect floodways or upgrade flood protection works.
45. **Structural flood protection** tools recommended by the IFHMP include:
- a new sea dike to protect Downtown Squamish from coastal floods;
 - upgrades to river dikes to meet or exceed provincial guidelines;
 - obtaining continuous access along the crest of all District dikes; and
 - a policy of not accepting responsibility for new dikes to protect new development.



46. **Watershed and river management** tools recommended by the IFHMP include:
- protecting river corridors from development to preserve flood conveyance and minimize environmental impacts;
 - monitoring and, if necessary, managing sediment and debris;
 - planning to “Build Back Better” following a disaster; and
 - continuing to advocate for re-forestation and other sustainable land use practices throughout the watershed.
47. **Emergency planning** tools recommended by the IFHMP include measures to deal with “what if” scenarios that cannot be mitigated. The District is in the process of updating the Flood Annex to its Comprehensive Emergency Management Plan (CEMP).
48. **Public outreach and education** tools recommended by the IFHMP will help increase community awareness of flood risks and the District’s risk mitigation program. The District expects that this IFHMP report will become a key tool for public outreach and education.
49. **Flood Insurance** tools recommended by the IFHMP include encouraging businesses, strata corporations, and single-family residences to obtain overland flood insurance where such insurance is available.

Area-specific Flood Mitigation Measures

50. In addition to a new sea dike, the IFHMP recommends FCLs for Downtown Squamish. District Council decided to continue the historical exemption allowing non-residential development to proceed below the FCL. Development under the historical exemption must still meet other mitigation requirements such as using flood-resistant building materials.
51. Continuation of the historic exemption should be supported by a plan to intentionally breach the proposed sea dike if an upstream river dike breaches.
52. There are several “unconnected” coastal flood hazard areas located outside the protection of the proposed sea dike. FCLs for unconnected coastal flood hazard areas should be determined on a case-by-case basis.
53. Future growth through densification should be restricted in the highest-hazard parts of the Squamish River / Mamquam River floodplain.
54. Council chose to control, rather than restrict, growth through densification in other parts of the Squamish River / Mamquam River flood hazard area. The IFHMP recommends conditions that each application should meet before being approved. Some areas are subject to a maximum density for residential units.
55. Secondary floodways should be designated and protected on the Squamish River / Mamquam River floodplain and in Valleycliffe to avoid adverse impacts on floodway conveyance.
56. The Squamish River floodplain is the heart of the community and is exposed to some of the highest hazards, so Council decided that dikes protecting these areas should be higher, wider, and stronger than the provincial standard.
57. Future growth through densification should be restricted in the Cheakamus River floodplain (Paradise Valley) due to its rural character, remote location, and significant hazards.



58. The District should identify appropriate levels of service and reliability for access and emergency response routes in the Paradise Valley. This will help determine the appropriate scope and priority of any required improvements.
59. Further study is recommended to address difficult challenges along the Squamish River dike at the Eagle Viewing Area and at the Cheakamus River / Cheekeye River confluence.

Implementation

60. The IFHMP makes over 100 recommendations for flood hazard management throughout the District. The recommended tools can be categorised into four main types including:
 - policy measures that set out the goals, objectives and requirements for the community's flood hazard management program;
 - operational actions that District staff take to help look after the community;
 - capital investments to support larger construction projects; and
 - further studies that will provide the data and analysis necessary to guide future updates.
61. Some of the IFHMP recommendations should be implemented immediately. Others will take decades to plan and build. There are four different priorities for implementing the IFHMP recommendations:
 - Priority 1 – to be implemented immediately or at the earliest possible opportunity.
 - Priority 2 – to be considered in planning and implemented before the next IFHMP update.
 - Priority 3 – to be considered in planning, but implemented after the next IFHMP update.
 - Priority 4 – to be implemented if and when opportunities arise. Priority 4 measures are not strict requirements, but add value to planning, development other decisions.
62. Draft policy has been prepared for three main documents: an updated OCP, a new Floodplain Bylaw and a new Development Permit Area. Supporting policy measures are also included in a small number of other bylaws.
63. Most policy measures are Priority 1 IFHMP recommendations. To be considered “implemented”, policies must be formally adopted by Council and enforced by District staff.
64. District staff routinely create, review, and update policy tools in the course of their day-to-day jobs, with implementation costs being a fixed part of the operating budget. From time to time, staff effort may be supplemented by consultants.
65. Most operational measures do not require any new policies or special Council authorizations. Examples include improving access for dike inspections, maintenance and repairs, or monitoring sediment accumulation within local river channels. Incorporating information from parallel studies and communicating flood risk information to the public are also operational measures.
66. The District will need to maintain an evolving “official” version of the dike breach model to help determine whether complex rezoning proposals in Controlled Densification Areas will have adverse impacts on flood risk.
67. Most operational measures fall under IFHMP Priorities 1, 2, or 4.



68. Funding for operational measures (staff resources and related equipment) are routinely covered through the annual operating budget. The District may receive some funding assistance for Local Authority Emergency Planning through Emergency Management BC.
69. Capital investments will typically involve upgrades to the District's structural flood protection works, including design and construction of a new sea dike, upgrades of various river dikes to meet the Provincial standard, and "super dike" upgrades for the Squamish River dike. Land acquisition is an example of non-structural capital investment.
70. Due to the high costs, only the most important capital investments are assigned IFHMP Priority 1. Most are Priority 2 or 3. A few capital investment opportunities are assigned IFHMP Priority 4 for opportunistic implementation, such as asking riparian developers to upgrade their dike frontage.
71. Capital Investments account for the vast majority of funding required to successfully implement the IFHMP. The IFHMP's prioritized list of recommended structural upgrades has a conceptual cost estimate of over \$82 million and will take decades to complete. Successful implementation will require senior government support through funding grants and cost-sharing programs.
72. The District has several options for funding the local government share of capital investments: its own annual budget (through general revenues or grants), developer contributions, and local area levies.
73. Four principles were identified to guide funding decisions:
 - Be opportunistic and take advantage of cost-effective opportunities to complete upgrades.
 - Build for today, but plan for tomorrow.
 - Seek out partners who can commit to stable and secure long-term funding.
 - Share costs equitably within the community.
74. In keeping with these funding decisions, particularly the equitable sharing of costs within the community, the IFHMP acknowledges that an equitable approach to funding capital investments should consider all of the funding sources mentioned above:
 - general revenues, to reflect the benefits that the whole community gains from dike protection of commercial, institutional, and recreational areas located in the floodplain;
 - developer contributions, to reflect the role of the dike in supporting profitable development opportunities; and
 - local area levies, to reflect the additional benefit provided to those whose personal assets are located in a flood hazard area.
75. Some of these measures may be more difficult to implement than others. The District recommends additional study to determine the optimal balance between them. In the interim, funding for the highest priority upgrades should be drawn from the District's annual budget.
76. The IFHMP recommends a number of further technical studies. These studies focus on filling the remaining data and knowledge gaps identified by the IFHMP. They are generally assigned IFHMP Priority 2 so that results will be available to support the next IFHMP update.
77. Funding for the further studies will come from a variety of potential sources including general revenues, senior government funding programs, other stakeholders and developers.



78. Partnerships have been critical for the development of the IFHMP and will be equally critical for the successful implementation of the IFHMP, including cost-sharing, regulation, data collection, monitoring and ongoing stakeholder engagement and communication.
79. The District has adopted a target of updating the IFHMP every 10 years. The 10-year updates are intended to include a comprehensive review that will incorporate new data, innovative approaches, and new development.



10. Report Submission

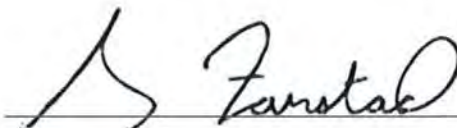
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Revision History

Revision #	Date	Status	Revision	Author
0	31 October 2017	FINAL	Incorporates final District comments from staff and Council	DR





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Appendix A

Glossary of Technical Terms



Appendix A – Glossary of Technical Terms

Flood risk management can be very complex. Experts often use technical words, or use ordinary words with very specific meanings, to describe flood hazards, consequences, risks, and mitigation measures. The definitions below are provided to help everyone understand and use the Squamish IFHMP.

aggradation	Deposition of sediment within a stream or river channel.
alluvial fan	A fan-shaped geologic feature made up of sediment deposited by a stream when it transitions from a steeper, confined reach (valley) to a flatter, less-confined valley bottom or <i>floodplain</i> .
climate	Long-term or typical <i>weather</i> patterns for a given area.
climate change	Long-term changes in typical <i>weather</i> patterns, typically occurring slowly over time.
coastal flood	A <i>flood</i> caused by extreme combination of <i>tide</i> , <i>storm surge</i> , and/or <i>waves</i> where water from the sea inundates land that is usually dry.
consequence	An outcome or potential outcome arising from the occurrence of a <i>flood</i> , expressed qualitatively or quantitatively and usually in terms of loss, disadvantage, damage, injury, or loss of life.
conveyance	The transportation of water (verb), or the capacity to transport water (noun), downstream through a channel, conduit or floodplain.
debris flood	A rapid flow of water, mud, sediment and debris that shares some characteristics with both a <i>Debris Flow</i> and a <i>Flood</i> .
debris flow	An extremely destructive mass of water-laden soil, fragmented rock, trees and other organic debris that flows rapidly down a steep channel under the influence of gravity.
Designated Flood	A flood of a specified magnitude or <i>return period</i> established by government policy as the basis for flood hazard and flood risk management.
Designated Flood Level	The highest water level that would be experienced during the <i>Designated Flood</i> . The <i>IFHMP</i> uses the term <i>Designated Flood Level</i> to refer specifically to corresponding to the still (or “static”) water level for the designated <i>coastal flood</i> , which does not include an allowance for <i>freeboard</i> .
dike	An embankment, wall, fill, piling, or other structure that is built to prevent the flooding of land. Related structures like pump stations and floodboxes are considered an integral part of the adjacent <i>dike</i> .
dike breach	Failure of a <i>dike</i> during a <i>flood</i> that allows water to flow into a protected <i>floodplain</i> area.
erosion	Rapid or gradual loss of land or bed material due to action of flowing water or waves.



Appendix A – Glossary of Technical Terms

estuary	The final reach of a river before it meets the ocean, where fresh water from the river meets and mixes with salt water. Flow slows down, and tides affect the water level.
fan	See <i>Alluvial Fan</i> .
FCL	See <i>Flood Construction Level</i> .
fjord	A long, narrow and deep inlet of the sea, carved by a glacier and bordered by steep slopes above the water line.
Flood Hazard Management Plan (FHMP)	An assessment considering the effects of <i>floods</i> on the community and the environment, and recommending guidelines and best practices for <i>flood risk</i> reduction. Specifically for the IFHMP, the term <i>Flood Hazard Management Plan</i> refers to the District's 1994 FHMP.
flood	An event where water rises above normally-occurring levels to spill out of a channel or ocean and inundate land that is not normally under water.
Flood Construction Level (FCL)	The flood construction level is determined using freeboard along with observed or calculated water surface elevation for the designated flood.
flood hazard area	A protected (diked) or unprotected area where the land elevation makes the area susceptible to flooding from a stream or body of water. When used with lower case letters, it refers generally to one or more areas that are potentially subject to flood hazards. Use of the term with initial capitals ("Flood Hazard Area") refers to one or more flood hazard areas specifically designated by the District of Squamish.
flood hazard assessment	A report prepared by a Qualified Professional that identifies flood characteristics, determines whether a development is safe for the intended use, and specifies any corresponding flood mitigation measures.
"flood-resistant" materials	Materials that can withstand direct and prolonged inundation without sustaining significant damage. Any parts of a building below the FCL should be build with "flood-resistant" materials.
flood risk Management	Managing the risk of flooding by reducing the probability that flooding will affect a community, by reducing the consequences that could result from flooding, or both. Also called Flood Risk Mitigation.
floodplain	An area of land adjacent to a stream that is regularly or periodically inundated during a <i>flood</i> .



Appendix A – Glossary of Technical Terms

<i>floodplain setback</i>	The required minimum distance from a reference line, point, or natural feature that must remain free of fill, structures and obstructions. <i>Floodplain Setbacks</i> provide space for dike maintenance and emergency response, maintain <i>Secondary Floodways</i> , reduce exposure to flood hazards, and allow for potential land erosion.
<i>floodproofing</i>	The alteration of land or structures either physically, or in use, to reduce or eliminate flood damage. Floodproofing incorporates the use of <i>FCLs</i> , building specifications and/or <i>floodplain setbacks</i> .
<i>floodway</i>	A channel or route that conveys or is intended to convey water during a <i>flood</i> .
<i>foreshore</i>	The area of land next to the ocean that is located between low-water and high-water marks.
<i>freeboard</i>	A vertical distance added to a flood level to accommodate uncertainty and allow for unexpected waves, surges or other natural phenomena.
<i>freshet</i>	A period of high flow on a river, most often referring to the period of high flow in the spring that results from snowmelt.
<i>geodetic elevation</i>	An elevation relative to a specified geodetic datum, typically one that approximates mean sea level. Geodetic elevations for the IFHMP refer to the Canadian Geodetic Vertical Datum of 1928, or CGVD28. This is in the process of being replaced by a new vertical datum for Canada, CGVD2013.
<i>hazard</i>	An event or situation that could cause damage or harm people, land or structures.
<i>Integrated Flood Hazard Management Plan</i>	A plan that adopts a holistic and comprehensive systems-based approach to understanding, assessing, and managing <i>flood hazards</i> and <i>flood risks</i> . For this project, the term <i>Integrated Flood Hazard Management Plan</i> refers specifically to this document.
<i>IFHMP</i>	See <i>Integrated Flood Hazard Management Plan</i> .
<i>landslide</i>	A rapid sliding movement of rock or debris down a slope.
<i>local effects</i>	Local wind, wave and surge effects that can contribute to sustained high coastal water levels and increase the likelihood of coastal flooding.
<i>minimum ponding elevation</i>	A minimum elevation for construction that is intended to reduce flood damage caused by the ponding of local runoff or overland flow.
<i>natural boundary</i>	The visible normal high water mark along any river, coastal foreshore, or other body of water.
<i>non-standard dike</i>	A <i>dike</i> that does not protect against the 200-year <i>return period flood</i> and/or does not meet standards and guidelines established by the BC Inspector of Dikes.



Appendix A – Glossary of Technical Terms

overbank	The higher, flat part of a <i>floodplain</i> adjacent to the river channel that is normally dry but conveys water during a <i>flood</i> . Named <i>overbank</i> because it is created by sediment deposited when flow in a river spills over the river banks. In Squamish, the term <i>overbank</i> is often used to refer to the area between a river and an adjacent dike.
overland flow hazard area	An area where shallow water may flow during a flood event, but where water is not expected to rise to a significant depth. <i>Overland flow hazard areas</i> include those areas designated on District maps as well as any area less than 1.5 metres above the <i>Natural Boundary</i> of an adjacent or nearby stream.
peak flow	The highest flow that occurs during a river or creek flood event or within a specified period of time (for example, annual <i>peak flow</i>).
primary floodway	A river corridor or undiked <i>floodplain</i> area that is or may reasonably be required to convey flow safely during the <i>Designated Flood</i> .
Professional Engineer	A person who is registered or licensed in the practice of engineering under the <i>Engineers and Geoscientists Act</i> .
Professional Geoscientist	A person who is registered or licensed in the practice of geoscience under the <i>Engineers and Geoscientists Act</i> .
protective works	Any embankment, wall, or structure constructed for the purposes of protecting an area, structure or development from the effects of <i>floods</i> , <i>debris flows</i> , <i>debris floods</i> , or <i>erosion</i> .
QP	See <i>Qualified Professional</i> .
QRA	See <i>Quantitative Risk Assessment</i> .
Qualified Professional	A <i>Professional Engineer</i> or <i>Professional Geoscientist</i> with the education, training and experience needed to conduct flood assessments in accordance with APEGBC guidelines.
Quantitative Risk Assessment	An assessment that develops a numerical relationship between the probability and magnitude of expected losses for various hazard scenarios.
return period	The inverse of annual probability of occurrence for a <i>flood</i> or other extreme event. For example, a 200-year <i>return period flood</i> has a 1 in 200 chance of occurring in any given year. Over a very, very long time period, events of this magnitude would occur on average every 200 years. However, it is possible to have multiple 200-year return period events in any shorter period, and the 200-year <i>return period</i> event may occur two years in a row.
risk	<i>Risk</i> is a measure of the potential for harm or damage that combines the probability of a <i>hazard</i> and its related <i>consequences</i> with the severity of the resulting impacts.



Appendix A – Glossary of Technical Terms

riprap	Angular rocks or boulders used to reduce or prevent <i>erosion</i> along a river bank or <i>foreshore</i> .
runoff	Water from rainfall or snowmelt that flows off a property or area and eventually into a creek, stream, river, lake or ocean. Runoff may flow on or below the ground surface.
sea dike	An existing or future dike built to protect against coastal <i>floods</i> and <i>sea level rise</i> .
sea level rise	The rise of sea levels due to warmer ocean temperatures and the melting of polar and glacial ice. Provincial guidelines recommend planning for 1 m of sea level rise by the year 2100 and 2.0 metres by the year 2200.
secondary floodway	An area within a diked floodplain that is expected to convey water during a <i>dike breach flood</i> .
setback	Minimum distances that structures must be located from rivers, shorelines, dikes, or property boundaries. Also see <i>floodplain setback</i> .
setup	The increase in water level due to energy transferred by wind and waves. Wind energy is transferred from wind stressed on the surface of the water. Wave energy is transferred from the momentum of breaking waves.
standard dike	<p>A <i>dike</i> considered by the BC Inspector of Dikes to meet minimum provincial standards including:</p> <ul style="list-style-type: none">• design and construction to contain the designated flood;• design and construction that meets minimum geometric and geotechnical specifications;• design and construction completed under the supervision of a qualified Professional Engineer;• an effective dike management and maintenance program by a local diking authority (typically local government); and• legal access (rights of way or land ownership) for the diking authority to maintain the dike.
storm surge	An temporary increase in water level during storm events that is caused by a combination of atmospheric pressure, wind, wave, momentum, ocean currents and/or temperature.
tides	The rise and fall of sea levels due to the gravitational forces of the Moon and the Sun on the Earth.
tsunami	Very large ocean waves (sometimes incorrectly called “tidal waves”) caused by earthquakes, underwater volcanic eruptions or underwater landslides. Wave height is low while in the open ocean, but builds to significant heights upon reaching shallow waters.



Appendix A – Glossary of Technical Terms

<i>tsunami runup elevation</i>	The highest elevation that a specific tsunami is expected to reach when breaking on shore.
<i>wave runup</i>	The vertical distance above the <i>coastal flood</i> level that a wave will reach. The actual distance will depend on wave characteristics and the slope and composition of the foreshore beach, structure, or embankment.
<i>weather</i>	The state of the atmosphere at a particular place and time. Generally given in terms of temperature, wind, clouds and precipitation.
<i>wind waves</i>	Waves generated by a sustained wind over water. Waves have the potential to overtop or breach <i>coastal flood</i> defences and inundate low-lying coastal areas. Waves also present significant erosion hazards.



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Appendix B

IFHMP Open House and Online Survey Summary Report

INTEGRATED FLOOD HAZARD MANAGEMENT PLAN



IFHMP Open House and Online Survey Summary Report



July 2017



Prepared by:

In association with:



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Executive Summary

The final phase of community engagement activities for the District of Squamish Integrated Flood Hazard Management Plan (IFHMP) took place in June-July 2017. An Open House was held at the Squamish Adventure Centre on Monday, June 26, 2017 and was followed by the fourth online questionnaire for the IFHMP, a 15-question survey provided in hard-copy at the Open House and made available online from June 26 through July 17, 2017.

Twenty three members of the public attended the Open House, which was facilitated by District of Squamish staff with assistance from the KWL and Arlington Group project team. The Open House included a presentation, followed by a question and answer session, along with an opportunity for the public to review informative storyboards and speak one-on-one with the project team. Feedback received in the question and answer session and through individual conversations noted by the project team indicated general support for the IFHMP, with some concerns regarding individual properties and a need for ongoing public education programs around emergency management in a flood event.

A total of 57 responses were received for the survey, with 10 collected in hard-copy during the Open House, 1 submitted in hard-copy to the District after the event and another 46 completed online. Most of the questions in the survey sought to gauge the community's agreement with the flood risk mitigation measures proposed by the IFHMP. The majority of responses to all questions were in agreement with the measures or approaches proposed. Ninety percent of respondents also indicated that they believed the IFHMP has done an adequate job of identifying risks, options, and recommended approaches for managing flood risk in Squamish.

1. Introduction

The third Open House for the District of Squamish Integrated Flood Hazard Management Plan (IFHMP) was held at the Squamish Adventure Centre on Monday, June 26, 2017. The Open House was held to provide information and gather public input concerning the Draft IFHMP. It summarized the identified flood hazards for the District of Squamish, the proposed flood mitigation options (both policy-based and structural), the recommended funding and implementation strategies. This report serves to document how the Open House was organized and record comments that were provided by the public during the Open House and through an online questionnaire.

1.1 Open House Agenda

The June 26, 2017 Open House took place from 6:00 pm to 8:00 pm. The facilitation was led by David Roulston, Matt Gunn and Chris Wyckham (District of Squamish), and assisted by David Roche (KWL), and Graham Farstad, Cathy Forbes and Caroline Rouxel (Arlington Group).

Attendees were invited to sign in at the door and indicate the neighbourhood in which they live (Appendix A – Open House Attendance Sheet). They were then provided with a handout of the questionnaire (Appendix B – Questionnaire). In addition to printed copies provided at the Open House, the questionnaire was also made available online.

For this third Open House, the District included presentation of the IFHMP followed by a question and answer session. Following the question and answer session, participants were invited to review the storyboards and meet with project team members individually.

Attendees were encouraged to complete and submit a hard-copy of the questionnaire before leaving or complete the questionnaire online by July 14, 2017. Ten completed questionnaires were received at the Open House. The Open House concluded shortly before 8:00 pm.

1.2 Attendance

The Open House sign-in sheet indicated a total attendance of 23 persons. Nearly all participants signed in order to provide a public record. Participants were asked to indicate their residential neighbourhood. As with previous IFHMP Open House sessions, neighbourhoods located within river floodplain areas showed a greater participation rate than those less affected by river flooding. Brackendale was the best-represented neighbourhood at the Open House, representing just under 50% of attendees (Table 1).

Neighbourhood	Number of Attendees	Proportion (%)
Garibaldi Estates	1	4.3%
Garibaldi Highlands	1	4.3%
Brackendale	11	48%
Valleycliffe	4	17%
Hospital Hill	2	9%
Squamish Terminals	1	4.3%
Other/Not Identified	3	13%
TOTAL	23	100%

Table 1: Open house attendees' neighbourhood of residence.

2. Open House Activities

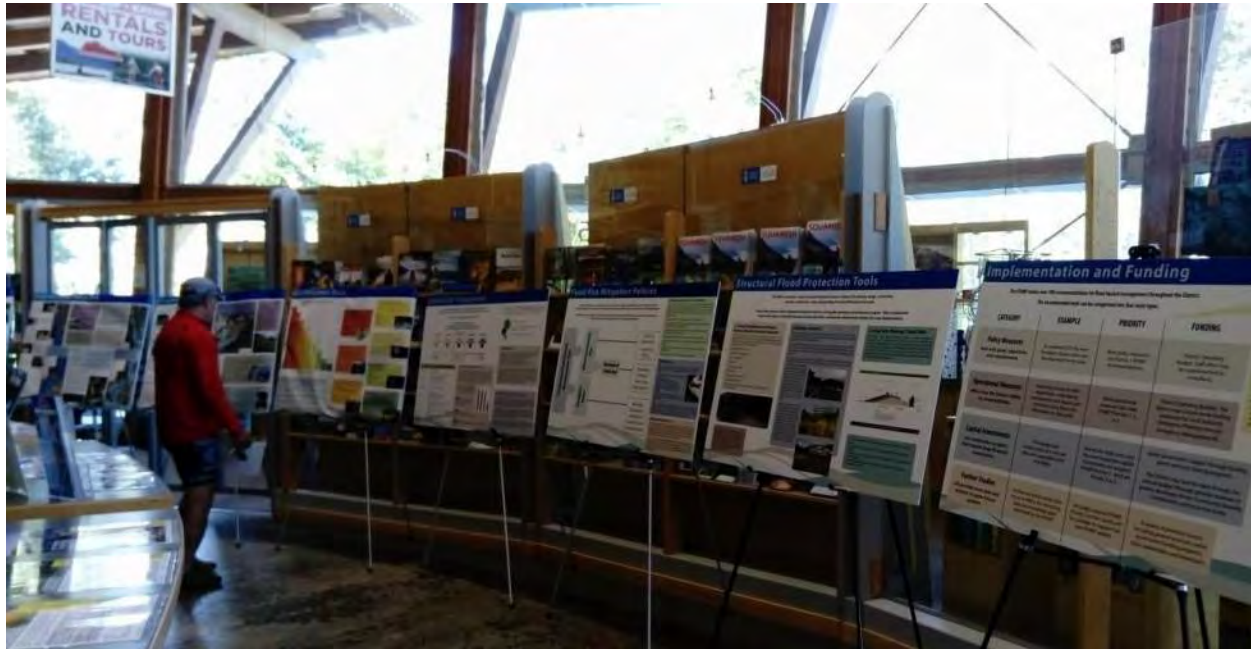
2.1 Presentation and Q&A Session

A presentation took place in the Adventure Centre Theatre starting at 6:15 pm. The presentation to 20 members of the public was provided by the Municipal Engineer for the IFHMP, David Roulston, supplemented by a PowerPoint highlighting key elements. This presentation covered all key elements of the Squamish IFHMP and was followed by a question and answer session. Questions were raised on a wide variety of aspects of the project and the process. They included what education measures will be taken following adoption of the IFHMP, the location of safe refuge areas, funding for dike improvements, the rationale for the three different controlled densification measures, elaboration of opportunistic measures to be considered, and the role of public consultation including whether it resulted in any changes to recommended actions. Several speakers complimented the District for its comprehensive process. The presentation and question and answer session took approximately one hour.

2.2 Revisited Storyboards

A display of 16 storyboards was provided in the north hallway of the Adventure Centre (see Figure 1). They included a series of key storyboards from the first and second Open Houses. These storyboards provided background information on the IFHMP including the major floods over the past century, documentation of the types of flood hazards facing Squamish from the Squamish, Cheakamus, Cheekeye, Mamquam and Stawamus Rivers as well as storm surges and other coastal events. Proposed mitigation measures for these flood hazards were also identified from the first two Open Houses.

Figure 1: Storyboards displayed around the north hallway of the Squamish Adventure Centre.



2.3 New Storyboards

Six new storyboards were prepared for this Open House. These storyboards provided an updated timeline of the IFHMP process and information of about the community engagement strategy through to the completion of the draft IFHMP. The storyboards also summarized key information from the draft IFHMP, including primary policy-based flood mitigation tools (OCP, Flood Bylaw and Development Permit Area) and predominant structural flood mitigation tools (dike upgrades, building a sea dike and planning for a “Super-Dike”). A summary of implementation and funding mechanisms, organized in terms of policy measures, operational measures, capital investments and further studies was displayed. Images of all the storyboards that were displayed are included in Appendix C – Storyboards.

3. Questionnaire – Open House and Online

3.1 Overview

The survey consisted of 15 questions inviting yes/no answers, multiple-choice responses and open-ended comments. The survey was provided in hard-copy for the Open House and made available online on the

District's website. The online survey was advertised as open until July 14 and was closed on July 17. A copy of the survey is provided in Appendix B – Questionnaire. The responses are included in Appendix D – Survey Responses.

3.2 Questionnaire Response - Open House and Online

10 survey responses were submitted during the Open House, with 1 additional hard-copy survey submitted to the District after the event. 46 online responses were received over the following 3 weeks resulting in a total of 57 responses from all sources. Hard copy responses were added to the electronic Survey Monkey results to enable comprehensive documentation and analysis of all responses. Less than half of those attending the Open House filled out the questionnaire. Since nearly all Open House attendees were at the presentation and Q&A session, many may have felt their questions and comments were addressed without the need to fill out the questionnaire. Others may have provided an online response.

It should also be noted that neither the paper or online survey required all questions to be answered. As a result, the response rate in 3.3 below varied considerably depending on the particular question.

3.3 Response Summary

The questions asked and the responses received are summarized below. Respondents were not required to answer all questions and were free to skip questions they did not wish to answer. As a result, the number of responses to each question varied.

Q1. The updated Official Community Plan (OCP) will carefully control but not eliminate growth in areas of higher flood risk. It also says how much risk the community is willing to accept, and encourages growth in areas of lower flood risk. Do you think the OCP updates are a good approach for managing flood risk in Squamish?

A total of 57 responses were received for Question 1. 44 respondents (77%) agreed that the OCP updates are a good approach for managing flood risk. 14 comments were received, with several commenters reinforcing the need for the OCP policies to be clear and consistently enforced for the OCP to be an effective mechanism to manage flood risk. Other comments expressed concerns about limitations on building in certain areas.

Q2. A new Floodplain Bylaw will establish building regulations for new buildings including minimum elevations for future and minimum distances from creeks, rivers, and dikes. Do you think the new Floodplain Bylaw is a good approach for managing flood risk in Squamish?

A total of 48 responses were received for Question 2. 40 respondents (83%) agreed that the new Floodplain Bylaw is a good approach for managing flood risk in Squamish. Of the ten comments received, six related to the need for the bylaw to be realistically balanced with maintaining reasonable costs for developers and builders.

Q3. A new Development Permit Area (DPA) will require future developments to leave space to let water pass safely through the community to avoid transferring risk or increasing flood levels over time. No

development will be allowed outside the District's dikes ("Primary Floodways"). Future development in designated dike-protected corridors called "Secondary Floodways" will have to meet specific conditions to avoid making the consequences of a flood worse for others. Do you think the new DPA is a good approach for managing flood risk in Squamish?

46 respondents answered Question 3, with 39 agreeing (85%) that the new DPA is a good approach to managing flood risk in Squamish. The eight comments received largely reinforced agreement with the DPA. Some comments expressed concern about the effect of this type of regulation on construction costs and subsequently housing affordability, as well as decisions to allow housing to be built on the east side of Loggers Lane.

Q4. The IFHMP recommends a balanced approach to diking that considers different needs in different parts of the community. The IFHMP recommends: Building a new sea dike to protect Downtown Squamish from coastal floods that will get worse as climate change causes sea levels to rise. Making the dikes that protect the heart of the community (Brackendale, Eagle Run / Highway 99, Garibaldi Estates, North Yards, Industrial Park, Dentville, and Downtown Squamish) higher, wider and stronger. These improvements will reduce the likelihood of dike failures that could cause up to \$450 million in damages and displace 60% of the community's population Maintaining the Provincial standards for dike protection for the Valleycliffe neighbourhood. Avoiding building new dikes in rural and relatively remote areas like the Paradise Valley. Do you agree with the IFHMP approach to dike protection for managing flood risk in Squamish?

Of the 45 responses received for Question 4, 41 agreed (91%) with the IFHMP approach to dike protection for managing flood risk in Squamish. The ten comments received mainly focused on concerns that the design standard for the dikes are excessive and objections to spending taxpayer money on building dikes. One comment suggested that the extra cost to build dikes should be recognized in the same manner as the costs of sewer and water when building on the hillsides.

Q5. The IFHMP recommends a prioritized list of dike upgrades. Some upgrades will be expensive and may take several decades to build. Building and paying for the upgrades may be a challenge, so the District must start planning immediately. The District can raise the necessary funds in different ways. Please tell us which funding approaches you agree with for flood risk management in Squamish (check all that apply):

Answer Choices	Responses (# and %)
Grants from the federal and provincial governments	39 (85%)
Cost-sharing agreements between the District and federal/provincial governments	37 (80%)
Taxes that apply to everyone in the District (since everyone uses services in the floodplain)	24 (52%)
Taxes or fees that only apply to people who own property in dike-protected areas	10 (22%)
Fees charged to developers who will profit from new developments located in the floodplain	39 (85%)

Table 2: Choices and responses to Question 5.

There were 46 responses to Question 5. Three approaches received support from 80% or more respondents. The most popular funding approaches to flood risk management was to use grants from the

federal and provincial governments, take advantage of cost sharing programs, and to charge fees to developers who will profit from new developments located in the floodplain.

Q6. The IFHMP recommends site-specific requirements for new developments. They include new Flood Construction Levels, setbacks from creeks and rivers, erosion protection for foundations and floodproofing fill, and a restrictive covenant on property title. These 'on-site' measures are designed to reduce the consequences of flooding for new development. Do you agree with these on-site measures for managing flood risk in Squamish?

Of the 45 responses received for Question 6, 40 (or 89%) agreed with the proposed on-site measures for managing flood risk in Squamish. The nine comments received demonstrated a variety of general views, including a call for fewer restrictions on landowners, a need to manage these on-site measures and ensure clarity and minimise additional cost to developers, and to ensure these measures don't transfer risk to existing developments or properties.

Q7. Downtown Squamish is a very important business hub for the community. The District has historically allowed non-residential development (e.g., stores, restaurants and warehouses) to build at ground level (below the flood construction level) within the downtown area. The IFHMP continues the historical flood construction level exemption for non-residential development. However, new developments will need to use flood-resistant building materials and a restrictive covenant will be required on title to ensure that future owners understand the risks. Do you agree with this approach for non-residential development?

Of the 46 responses received for Question 7, 39 (85%) agreed with the proposed approach for managing flood risk in non-residential development in Downtown Squamish. Nine comments were received that included concerns around compliance, upgrades and the impact on small business.

Q8. The IFHMP recommends that densification (i.e., rezoning) be controlled at three different levels: Properties located in Restricted Densification Areas (coloured red) should not be rezoned for additional density. Growth may still occur through infill development. Rezoning that concentrates the density allowed under existing zoning into a smaller part of the lot is also acceptable. Properties located in Conditional Densification Areas (coloured yellow) can be rezoned for additional density if the development proposal complies with a list of conditions established by the IFHMP. Properties located in Limited Densification Areas (coloured brown) may be rezoned up to a maximum density of 29 units per hectare (RS-2 Duplex Zoning). Development proposals must also meet all requirements for Conditional Densification Areas. The intention of this recommendation is to limit an increase in flood risk over time, while supporting growth that enhances the ongoing livability of Squamish. Do you agree with this approach?

44 respondents provided answers to Question 8. Nearly all agreed (37 or 84%) agreed with the controlled densification approach to growth in Squamish. A total of ten comments were received, several of which reinforced agreement with this approach. Others expressed concern about how to balance these needs with smart growth principles and pointed out potential discrepancies in the decision to control densification in some areas but not others, for example in Loggers Lane.

Q9. Do you think that the IFHMP has done an adequate job of identifying risks, options, and recommended approaches for managing flood risk in Squamish?

Ninety percent (37 out of 41) of responses to Question 9 agreed that the IFHMP has done an adequate job of identifying risks, options and recommended approaches for managing flood risk in Squamish. Seven comments displayed a range of views, from agreements that the plan is very detailed to a belief that the approaches are too risk averse.

Q10. Do you have any comments about the proposed mitigation plan for the following areas: (check applicable area)

Answer Choices	Comment Summary
Downtown Squamish/ Dentville 2 responses	<ul style="list-style-type: none"> - Concerns about dike breaches - Concerns about storm water management in the Downtown area once the sea dike is built
Garibaldi Estates/Eagle Run/Brackendale 5 responses	<ul style="list-style-type: none"> - Concerns about dike breaches - Reinforcement of the need for planning in the Brackendale due to the risks faced by the area - A request for no rezoning changes for properties adjacent to the Brackendale dikes, to better protect the inner-community
Paradise Valley	No comments
Valleycliffe 1 response	<ul style="list-style-type: none"> - Call to prioritize flood protection measures in Valleycliffe due to the growing population in the area and the limited access to the community
Other area (specify) 6 responses	<ul style="list-style-type: none"> - Question about the level of protection for the Scott Crescent development and Waterfront Landing - General comment stating that the proposed mitigation plan should ensure that existing structures do not become subject to increased risk - Three comments questioning why housing is being supported in the Loggers Lane area

Table 3: Answer choices and comment summary of Question 10.

Q11. Please provide any other general comments you may have about the IFHMP.

15 general comments were received for Question 15 and can be classified into 5 main categories, in no particular order:

1. Praise for the IFHMP and the community engagement process.
2. Specific requests for more information, including evacuation plans.
3. Questions about the IFHMP including how it will be kept current through its duration and how it will be realistically and incrementally implemented.
4. General suggestions for further considerations, including looking at international examples for flood hazard management and supporting the natural courses of the Squamish waterways.
5. Concerns that the plan is too risk averse and will have undesirable cost impacts and effects on housing supply and local businesses.

Q12. Where do you live?

39 responses were given to this question. The largest number live in Brackendale, followed by Garibaldi Highlands and Valleycliffe/Plateau. This includes both Open House and online responses. Nearly one third did not indicate the particular neighbourhood where they live.

Answer Choices	Responses
Downtown Squamish	3
Dentville	3
Finch Drive/Loggers Lane	1
North Yards	4
Garibaldi Estates/Eagle Run	1
Tantalus/Newport Ridge	2
Garibaldi Highlands	5
Brackendale	12
Valleycliffe/Plateau	5
Hospital Hill	4
Paradise Valley	0
Other location in Squamish (specify)	0
Outside Squamish (specify)	1
Total	39

Table 4: Answer choices and responses to Question 12.

Q13. Do you own property in the floodplain?

Of the 43 responses received for Question 13, 20 stated they owned property in the floodplain, 17 did not own property in the floodplain and 6 were not sure.

Questions 14 and 15 asked for contact information and specific questions that respondents wished to have answered.

15 respondents provided contact details to be added to the District's contact database and will be included in future updates. Two specific questions were received, one asking for clarification of the Restricted Densification Area adjacent to Judd Creek and another inquiring about how to protect a home from flood risk and who to contact for help in the event of a flood. These questions and the appropriate contact details were supplied to District staff for follow up.

3.4 Response Analysis

Questions 1 through 8 in the questionnaire sought to gauge the community's agreement with the IFHMP's identification and determination of the level of flood risk to the community, the measures and mechanisms proposed by the IFHMP to mitigate flood risks, and the types of funding approaches that could be used to pay for required flood risk management measures. A majority of responses to all these questions were in agreement with the measures or approaches proposed.

The comments received in this block of questions represented a balance of respondents reinforcing their support, with certain caveats, and respondents justifying their disagreement with the measures and approaches proposed. Comments regarding policy measures tended to cite concerns that the regulations would not be consistently enforced, or that the measures would impose excessive limitations to development. Comments regarding the structural diking measures tended to express concerns with the proposed design standards, suggesting that they are too extensive and would be too costly.

In terms of costing and funding mechanisms, responses to Question 5, as well as general comments received in other questions, indicated that the community was in favour of flood hazard management measures being funded by grants from the federal and provincial governments, or paid for through fees charged to developers who will profit from new developments located in the floodplain, rather than being funded by local taxpayers.

Question nine asked whether the respondents agreed that the IFHMP adequately identified the risks, options and recommended approaches for managing flood risk in Squamish. The majority of respondents (90%) replied positively to this question, indicating that the IFHMP has been generally well received in its level of risk management and approach to risk mitigation.

Respondents were offered opportunity to provide directed comments about the proposed mitigation plan for select areas. The comments received reflected general concerns and minimal scrutiny of specific technical recommendations. The comments received reinforced the importance of ongoing community education and information sharing around the flood risks faced by individual neighbourhoods.

The final five questions asked allowed for general comments to be made and asked for information on the respondents, including where they live and whether they own property in the flood plain. An opportunity to provide contact information and specific questions that the respondent would like answered was also provided. The information collected showed that the largest percentage of respondents came from the Brackendale area and just under 50% of respondents own property in the floodplain.

It should be noted that the attendance at the Open House and participation in the online survey represented a small proportion of the Squamish community or those neighbourhoods subject to flood hazards. However, much of the information at this final Open House had been previously made available on the District of Squamish website or through the Official Community Plan updating process. Previous consultation had also taken place at two other Open Houses, numerous Council meetings, meetings with the Squamish Nation and meetings with highly affected landowners. The Open House and online responses were quite similar. While the numbers were modest, the opportunities provided and responses received from interested members of the community indicate general support for the IFHMP.

Appendix A – Open House Attendance Sheet

Integrated Flood Hazard Management Plan
Public Open House
June 26th, 2017
Sign-in Sheet

Name	Neighbourhood
Jeffrey & Lisa Jenkins	40813 90th Rd.
Dorey Hackett	Squamish Terminals Ltd.
Maureen Payette	1840 Garden Pl. Sq.
Joan Hainer	Brackendale
Ellis Munro	
Sarah Wilson	Karibaldi Estates
Earth Tube	BRACKENDALE
Murray Journey	Crumpt Wood
Greg McDougall	Brackendale
Ingrid McDougall	Brackendale
Steph Wright	Brackendale
Steve Thompson	
DOUG HAMILTON	BRACKENDALE
JESS HERMAN	Highlands.
Steve Payne	Crumpt Woods
Andy Trachsel	Brackendale
Eric Andersen	Hospital Hill (safest place !)
Astrid Andersen	
KEVIN HABERL	Brackendale

Appendix B – Questionnaire (Hand-out and Online)

Squamish Integrated Flood Hazard Management Plan (IFHMP) Questionnaire

Introduction

The Squamish community faces an unusually broad range of flood-related hazards. The District has responded by developing a detailed flood management plan that provides the community with policy, planning and structural protection tools. In 2014, the District began an extensive update to its 1994 Flood Hazard Management Plan. A new Integrated Flood Hazard Management Plan (IFHMP) has been developed to better respond to the changes in the Squamish community.

The IFHMP recommends over 100 specific tools for mitigating flood risk. Recommendations address land use, new building regulations, dike upgrades, river management, emergency response, public education, and flood insurance. Some tools apply to the entire community, such as updates to the OCP and adopting a new Floodplain Bylaw. Other tools apply to specific Flood Hazard Areas.

Some IFHMP recommendations should be implemented immediately. Others will take decades to plan and build. Some of the most important recommendations will require significant long-term financial commitments.

To help us plan and prioritize actions for the future, we want to hear your thoughts on some of the key flood mitigation tools proposed by the IFHMP.

Questionnaire

The IFHMP recommends three key policy tools (Official Community Plan update, new Development Permit Area, new Floodplain Bylaw) that will help the District reduce flood risk. District staff will consider these new policies when evaluating applications for new development throughout the community. The three following questions invite your thoughts on these tools.

- 1 The updated Official Community Plan (OCP) will carefully control but not eliminate growth in areas of higher flood risk. It also says how much risk the community is willing to accept, and encourages growth in areas of lower flood risk.

Do you think the OCP updates are a good approach for managing flood risk in Squamish?

☐ Yes

☐ No

Comments

2

A new Floodplain Bylaw will establish building regulations for new buildings including minimum elevations for future and minimum distances from creeks, rivers, and dikes.

Do you think the new Floodplain Bylaw is a good approach for managing flood risk in Squamish?

☐ Yes

☐ No

Comments

3

A new Development Permit Area (DPA) will require future developments to leave space to let water pass safely through the community to avoid transferring risk or increasing flood levels over time. No development will be allowed outside the District's dikes ("Primary Floodways"). Future development in designated dike-protected corridors called "Secondary Floodways" will have to meet specific conditions to avoid making the consequences of a flood worse for others.

Do you think the new DPA is a good approach for managing flood risk in Squamish?

☐ Yes

☐ No

Comments

Dikes can greatly reduce the potential for flooding. However, they can also promote more development in high-risk areas, which increases the consequences of a dike failure. Dikes can also create a false sense of safety, and people may forget they live in a floodplain.

4

The IFHMP recommends a balanced approach to diking that considers different needs in different parts of the community. The IFHMP recommends:

- Building a new sea dike to protect Downtown Squamish from coastal floods that will get worse as climate change causes sea levels to rise.
- Making the dikes that protect the heart of the community (Brackendale, Eagle Run / Highway 99, Garibaldi Estates, North Yards, Industrial Park, Dentville, and Downtown Squamish) higher, wider and stronger. These improvements will reduce the likelihood of dike failures that could cause up to \$450 million in damages and displace 60% of the community's population
- Maintaining the Provincial standards for dike protection for the Valleycliffe neighbourhood.
- Avoiding building new dikes in rural and relatively remote areas like the Paradise Valley.

Do you agree with the IFHMP approach to dike protection for managing flood risk in Squamish?

☐ Yes

☐ No

Comments

5

The IFHMP recommends a prioritized list of dike upgrades. Some upgrades will be expensive and may take several decades to build. Building and paying for the upgrades may be a challenge, so the District must start planning immediately. The District can raise the necessary funds in different ways.

Please tell us which funding approaches you agree with for flood risk management in Squamish (check all that apply):

- ☐ Grants from the federal and provincial governments
- ☐ Cost-sharing agreements between the District and federal / provincial governments
- ☐ Taxes that apply to everyone in the District (since everyone uses services in the floodplain)
- ☐ Taxes or fees that only apply to people who own property in dike-protected areas
- ☐ Fees charged to developers who will profit from new developments located in the floodplain

6

The IFHMP recommends site-specific requirements for new developments. They include new Flood Construction Levels, setbacks from creeks and rivers, erosion protection for foundations and floodproofing fill, and a restrictive covenant on property title. These 'on-site' measures are designed to reduce the consequences of flooding for new development.

Do you agree with these on-site measures for managing flood risk in Squamish?

- ☐ Yes
- ☐ No

Comments

7

Downtown Squamish is a very important business hub for the community. The District has historically allowed non-residential development (e.g., stores, restaurants and warehouses) to build at ground level (below the flood construction level) within the downtown area. The IFHMP continues the historical flood construction level exemption for non-residential development. However, new developments will need to use flood-resistant building materials and a restrictive covenant will be required on title to ensure that future owners understand the risks.

Do you agree with this approach for non-residential development?

- ☐ Yes
- ☐ No

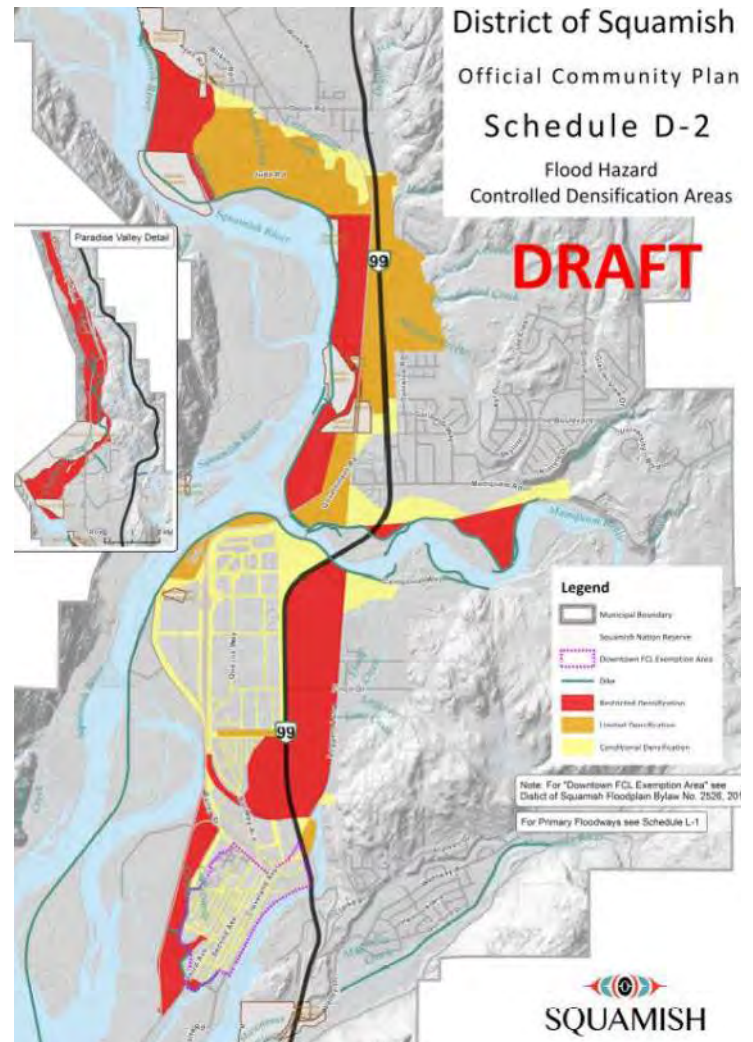
Comments

8

The IFHMP recommends that densification (i.e., rezoning) be controlled at three different levels:

- Properties located in **Restricted Densification Areas** (coloured red) should not be rezoned for additional density. Growth may still occur through infill development. Rezoning that concentrates the density allowed under existing zoning into a smaller part of the lot is also acceptable.
- Properties located in **Conditional Densification Areas** (coloured yellow) can be rezoned for additional density if the development proposal complies with a list of conditions established by the IFHMP.
- Properties located in **Limited Densification Areas** (coloured brown) may be rezoned up to a maximum density of 29 units per hectare (RS-2 Duplex Zoning). Development proposals must also meet all requirements for Conditional Densification Areas.

The intention of this recommendation is to limit an increase in flood risk over time, while supporting growth that enhances the ongoing livability of Squamish.



Do you agree with this approach?

☐ Yes

☐ No

Comments

9

Do you think that the IFHMP has done an adequate job of identifying risks, options, and recommended approaches for managing flood risk in Squamish?

☐ Yes

☐ No

Comments

10

**Do you have any comments about the proposed mitigation plan for the following areas:
(Check applicable area)**

- ☐ Downtown Squamish/ Dentville
- ☐ Garibaldi Estates/Eagle Run/Brackendale
- ☐ Paradise Valley
- ☐ Valleycliffe
- ☐ Other area (specify)

Comments

11

Please provide any other general comments you may have about the IFHMP.

Comments

Please tell us a little about yourself.

12 Where do you live?

- ☐ Downtown Squamish
 - ☐ Dentville
 - ☐ Finch Drive/Loggers Lane
 - ☐ North Yards
 - ☐ Garibaldi Estates/Eagle Run
 - ☐ Tantalus/Newport Ridge
 - ☐ Garibaldi Highlands
 - ☐ Brackendale
 - ☐ Valleycliffe/Plateau
 - ☐ Hospital Hill
 - ☐ Paradise Valley
 - ☐ Other location in Squamish (specify) _____
 - ☐ Outside Squamish (specify) _____
-

13 Do you own property in the floodplain?

- ☐ Yes
- ☐ No
- ☐ I own property in Squamish but am not sure if it is in the floodplain.

14 I would like to learn more. My email address is:

15 Please have someone contact me about the following (I understand I may not receive an immediate reply):

Thank you for completing the IFHMP Questionnaire!

Appendix C – Storyboards

Squamish Integrated Flood Hazard Management Plan



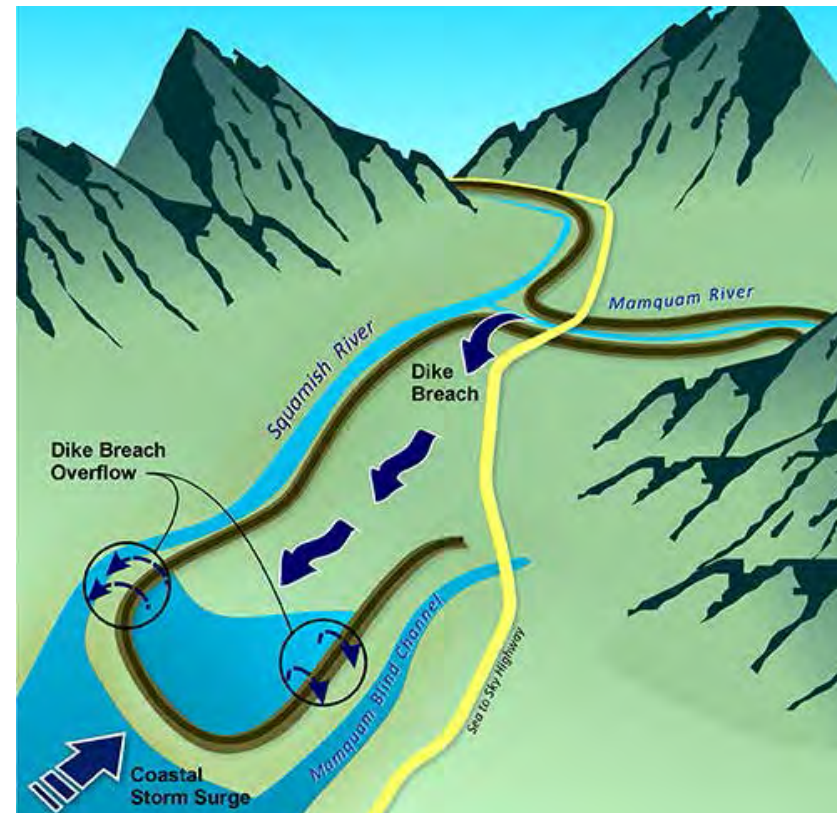
In 1994, the District of Squamish completed its first Flood Hazard Management Plan (FHMP) to manage and mitigate the flood risk for the District.

A generation after its adoption, the FHMP now needs to be revisited and updated. The update process will take into account:

- Growing population
- Legislative and regulatory changes
- New professional standards
- Provincial guidance
- Flood hazard assessment best practices
- Climate change

WHAT IS AN INTEGRATED FLOOD HAZARD MANAGEMENT PLAN?

- The 1994 Flood Hazard Management Plan for Squamish is being updated.
- The new plan will be called the Integrated Flood Hazard Management Plan (IFHMP).
- The IFHMP will guide development and land use in Squamish for years to come. The IFHMP process provides an opportunity for Squamish to maintain its commitment to livability and sustainability by incorporating the latest flood management guidelines, new engineering modeling tools and techniques, and best planning practices.
- An effective IFHMP will depend on community engagement and public support.
- A financially-responsible budget, reflecting the size of the community, will further support the implementation of the IFHMP.



WHAT MAKES UP AN IFHMP?

Phase 1: Flood Mitigation Background Analysis

This first step is designed to summarize the existing information surrounding Squamish's:

- Hydrology
- Geohazards
- Anticipated climate change
- Future coastal water levels
- Extent and condition of existing flood protection
- Existing policy tools that manage flood hazards

Phase 2: Coastal Flood Hazard Mitigation Options

Several coastal flood defence options have been developed and are presented at this first Open House for your input on the options, risks, consequences, and potential mitigation measures.

Phase 3: River Floodplain Modelling and Risk Analysis

Technical risk assessments will be conducted on the Squamish and Mamquam Rivers followed by the Cheakamus, Cheekeye and Stawamus Rivers. Results will be presented at the second Open House in the fall of 2015.

Phase 4: Integrated Flood Hazard Management Plan

The final phase of the IFHMP involves the preparation of the Integrated Flood Hazard Management Plan, which will recommend both technical and policy solutions. The Draft IFHMP will be presented at the third Open House – Winter 2015/16 – and to Council in the winter of 2016.

IFHMP Timeline

Integrated Flood Hazard Management Plan (IFHMP) Public Consultation Schedule




SQUAMISH
PROJECT TEAM

 **KERR WOOD LEIDAL**
consulting engineers

 **CASCADE ENVIRONMENTAL**
RESOURCE GROUP LTD.

 **the Arlington Group**
Planning + Architecture Inc.

 **SNC • LAVALIN**

 **THURBER ENGINEERING LTD.**

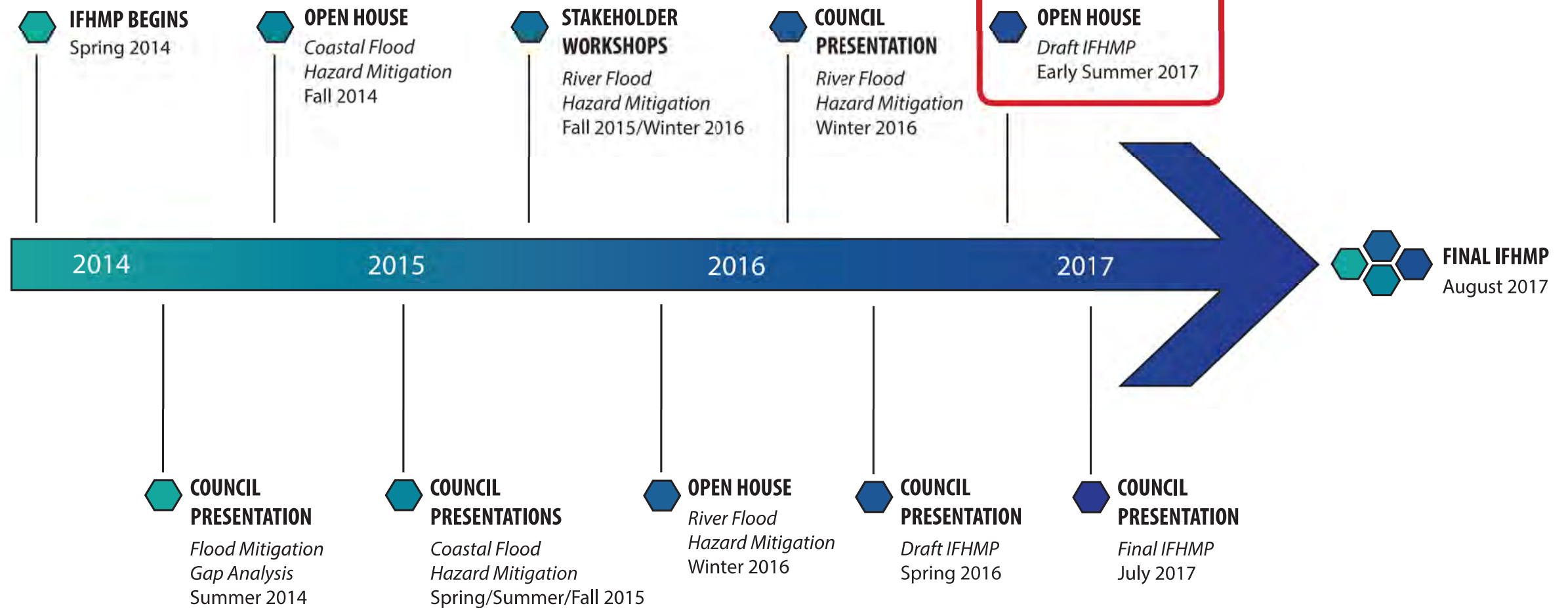
STAKEHOLDERS



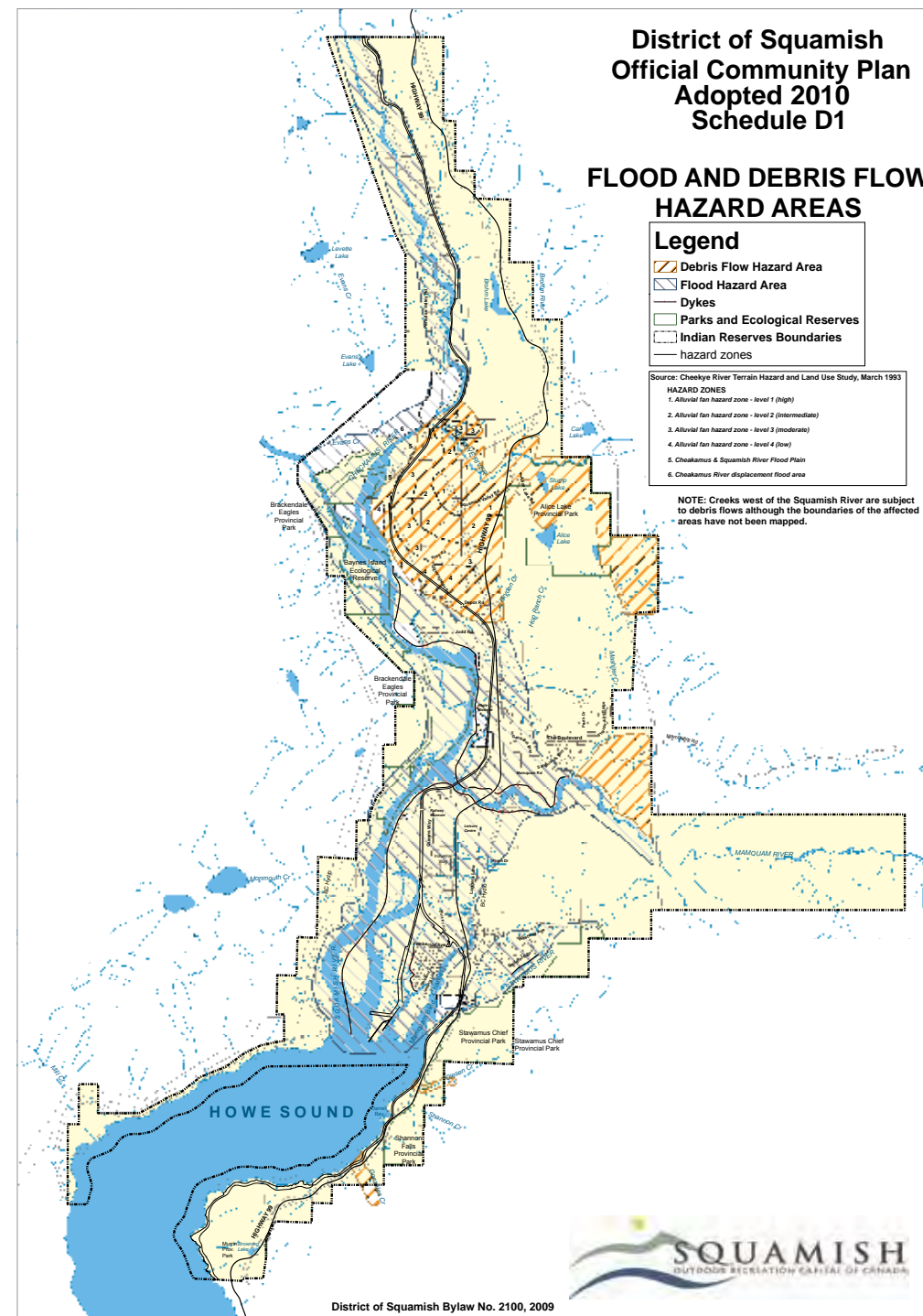
PUBLIC



**TECHNICAL WORKING GROUP &
SKWxwú7MESH úxwumíxw
(SQUAMISH NATION)**



Keep up to date and provide feedback on the IFHMP at www.squamish.ca/floodhazard



Where the Rivers Meet the Sea

The District of Squamish is located at the head of Howe Sound where 5 rivers converge. These mountain rivers, fed by glaciers, snowmelt and precipitation, descend from their steep mountain tops carrying water, sediment, and on occasion, rocks and other debris. When these fast flowing rivers reach the gently sloping valley, they tend to slow down and spread out, and leave sediment behind. The terms alluvial fan and floodplain are used to describe the riparian areas along these lower river reaches.

Skwxwú7mesh Úxwumixw Oral History - The Flood

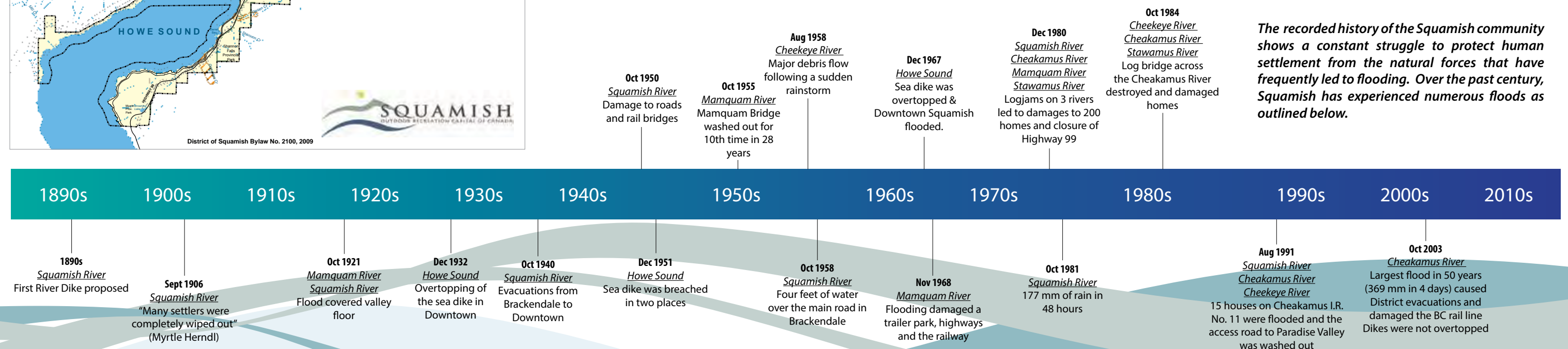
The oral history of the Skwxwú7mesh Úxwumixw (Squamish Nation) has a legend called the Flood. According to the legend, when the people began to forget their old ways and failed to listen to their elders, the game began to disappear and then the fish and the berries. People became hungry and began to quarrel. Still they wouldn't listen to their elders and change their ways. Then the rains came. The waters rose and the people had to anchor their canoes to Nch'kay' (Mt. Garibaldi). When the waters receded, the people who survived came to their senses and listened to their elders. Then the game and the fish and the berries returned in abundance.

Lessons from the Past

Several conclusions can be drawn from the flood history in Squamish:

- 1. All the rivers in Squamish pose a risk of flooding. All have caused multiple and damaging floods in the past.**
- 2. Damaging floods have also occurred as a result of coastal inundation.**
- 3. The flood risk in Squamish has strong seasonal variations. Most flooding has taken place between October and December. Major floods have also taken place in August.**
- 4. Contrary to other B.C. communities, the freshet (typically in late May, June and early July) has not been a major cause of flooding on local rivers.**
- 5. The frequency of flood damages over the past 30 years has decreased compared to earlier time periods. This is attributed to investments in structural flood protection (i.e. dikes).**
- 6. Extreme precipitation (rain and snow) has occurred on at least 5 occasions since 1980. These continue to test the limits of flood protection structures.**

In addition to the 5 major rivers and their tributaries, the District's land area also includes numerous small, steep creeks that can present flood, debris flow, sedimentation, and erosion hazards.



Coastal Flood Hazard

Coastal Flood Hazard

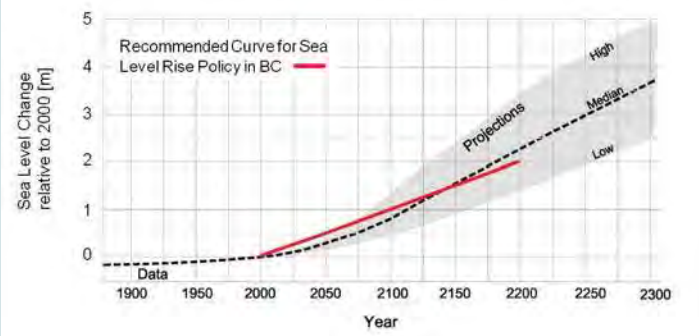
Coastal flood hazards in Squamish are affected by the combination of:

- tides
- storm surge
- local wind and wave effects
- wave impacts on the shoreline

Engineering assessments have concluded that large tsunamis are unlikely to affect Squamish. Tsunami hazards are beyond the scope of the IFHMP.

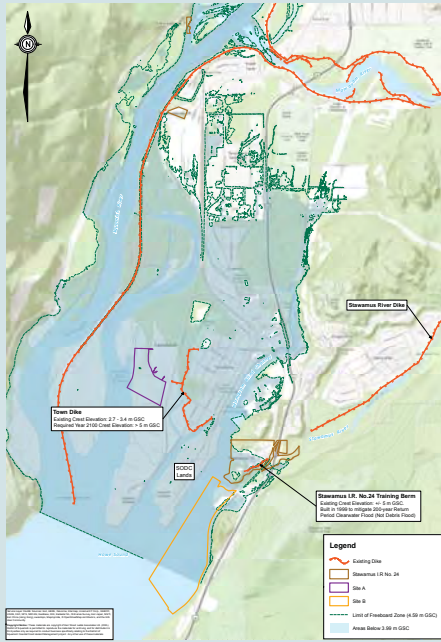
Sea Level Rise

One of the most important climate change impacts is sea level rise due to warmer ocean temperatures and melting of ice. Provincial Guidance anticipates sea level rise by 1.0 metre by the year 2100 and 2.0 metres by the year 2200. This is illustrated on the graph below.



Squamish at Risk

The District's Howe Sound coastline extends from Watts Point to Woodfibre. The foreshore is relatively steep and undeveloped except at Woodfibre and from Crescent Slough to Stawamus I.R. No. 24. In this area, river estuaries and sloughs allow coastal hazards to penetrate deep into the community.



Coastal Flood Risk Mitigation

In October 2015, District Council adopted a coastal flood risk mitigation strategy.

Connected Floodplain Areas

“Connected” floodplain areas (such as the downtown Squamish peninsula) encompass many different properties and land uses. Effective risk reduction requires unified and consistent approach. Key strategies for connected coastal floodplain areas are described below.

- **Protect** existing and proposed development against coastal floods including Sea Level Rise to Year 2100
- **Accommodate** coastal flood hazards through land use restrictions, designated floodways, appropriate FCLs, and restrictive covenants.
- **Retreat** critical facilities out of the coastal floodplain as they reach the end of their development life cycle

Unconnected Floodplain Areas

“Unconnected” floodplain areas are also vulnerable to coastal flood hazards. Flooding in one area is not “connected” to flooding in another area, so each site can define its own independent approach for reducing flood risk. Examples of unconnected coastal floodplain areas:

- Scott Crescent Development
- Waterfront Landing
- Stawamus I.R. No. 24
- Site A
- Site B
- Squamish Terminals and
- Woodfibre

Mitigation Options Include the Following Examples

Avoid/Retreat

- Reclaim area to natural state as community amenity
- Possible locations - intertidal areas, Squamish Estuary

Accomodate

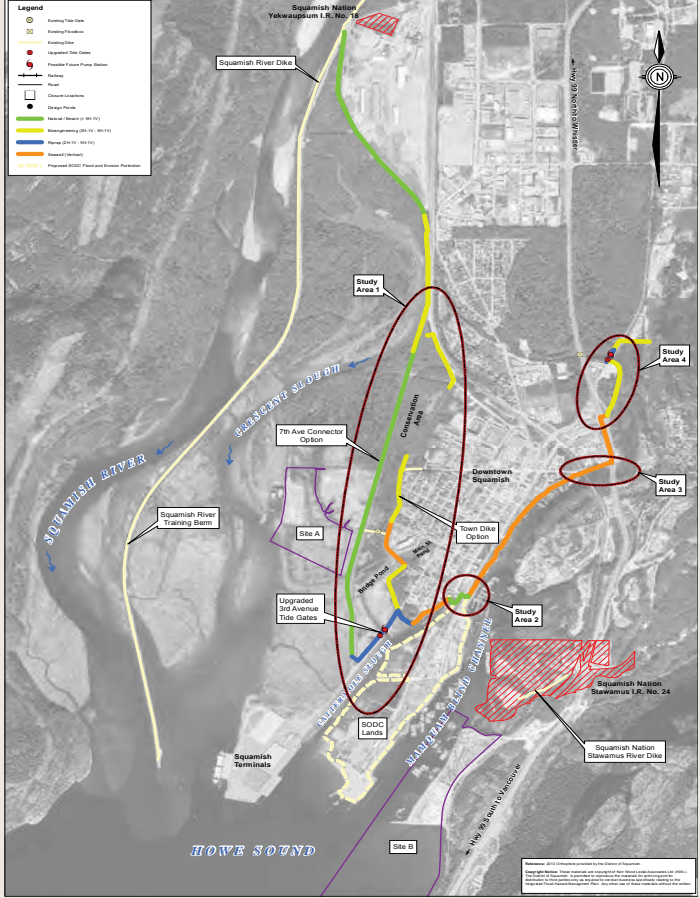
- Raise elevation of habitable space above flood levels
- Use flood resistant building materials below the FCL
- Allow water dependant industrial uses (e.g. log sort)

Protect

- Raise land elevation with structural fill
- Construct offshore defenses (e.g. breakwaters)
- Construct perimeter defences (e.g. sea dike or seawall).

Future Sea Dike Alignment

District Council approved the future sea dike but some questions must still be addressed in special “study areas”.



Different colours in the figure show different types of shoreline treatment:

- Natural or Beach Slopes (Green)
- Riprap (Blue)
- Bioengineered (Yellow)
- Seawall (Orange)

Special Study Areas

Special Study Area #1 will determine whether the dike should follow the CN Rail tracks or the existing Town Dike.

- If the District proceeds with the 7th Ave Connector the dike should be incorporated into the truck route.
- If the 7th Ave Connector does not proceed, the Town Dike alignment may be more favourable.

Special Study Area #2 will decide how the dike should tie in with SODC and Squamish Yacht Club boat ramp.

Special Study Area #3 will accommodate bike and foot traffic flow between the railway bridge and Highway 99.

Special Study Area #4 will integrate the sea dike with Rose Park, the proposed Sea to Sky Forestry Centre, and a possible future pump station at Loggers Lane.

Balancing FCLs and Overtopping

If the sea dike is built too low, waves will overtop the dike into downtown. The District of Sechelt has this problem at Trail Bay.



In Squamish, too much overtopping would overwhelm the stormwater system. But, If the sea dike is built too high, it will trap more water during a river dike breach and increase MBEs.

The District selected an overtopping rates of 10 L/s per metre of dike. Higher overtopping rates are unsafe.

Sea Dike Crest Elevations

Different types of shorelines are proposed in different areas.

- Natural beach shoreline is preferred.
- Areas with less space need riprap or bioengineering.
- A seawall is required along Mamquam Blind Channel.

The preliminary elevation for the sea dike crest is 4.7 m above mean sea level. This is on average about 2-3 m above natural ground in Downtown Squamish.

Sea Dike Implementation

The IFHMP recommends phased implementation as per the table below:

ACTION	TIMING
Raise to 3.3 m elevation with standard cross-section	Immediate
Raise to Year 2100 elevation with ongoing redevelopment	Ongoing
Raise to minimum elevation 4.0 m at final dike width.	As funding permits
Raise to Year 2100 (1 m SLR) crest elevation	When justified by sea level rise

The first section of sea dike is already under construction as part of the Mireau development on Mamquam Blind Channel.



Upper Squamish/Mamquam Flood Hazard

7

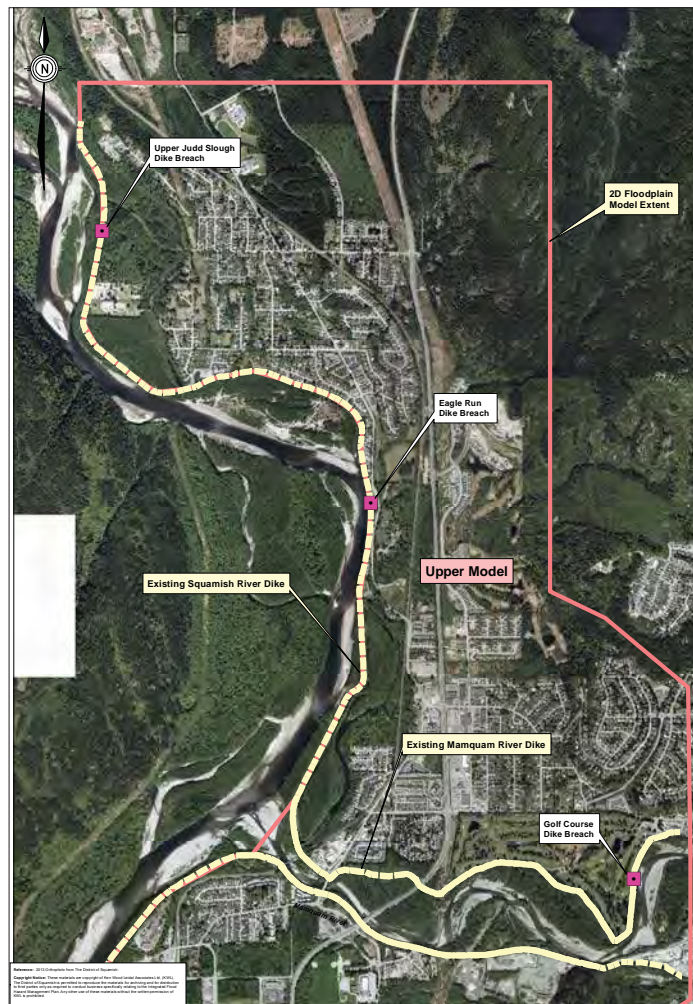
The Mamquam River naturally divides the Squamish River Floodplain into “upper” and “lower” areas. The Upper and Lower floodplain areas were modeled separately.

IFHMP modeling incorporates state of the art technology, updated hydrology, new data and climate change considerations.

Dike Breach Modeling

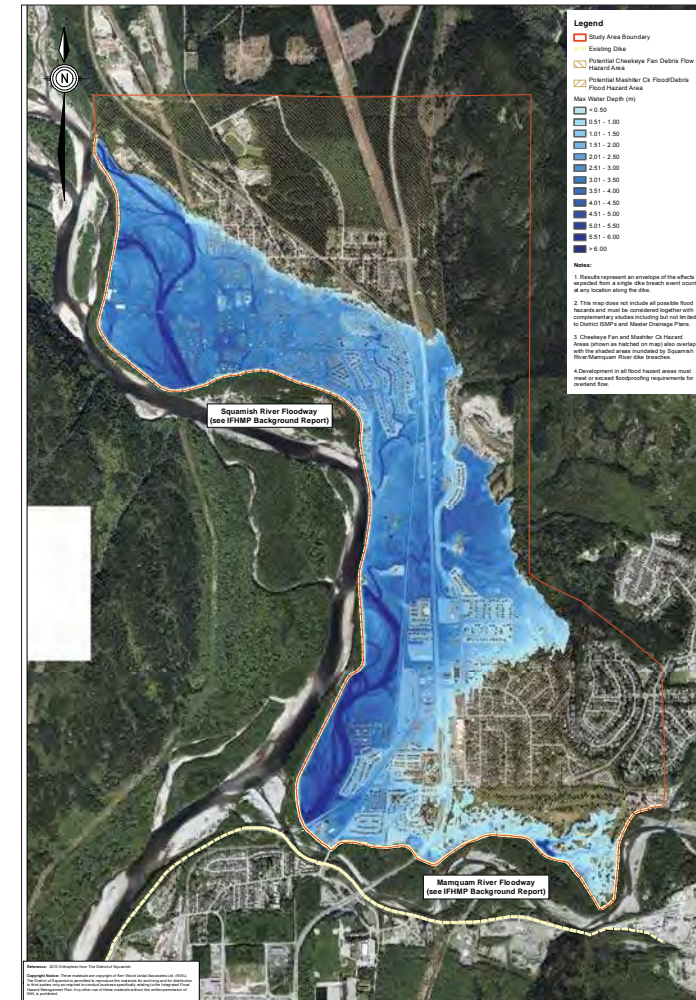
A dike breach could occur at any location. The IFHMP modelled three dike breaches: at Judd Slough, Eagle Run, and the Golf Course.

Modeled Dike Breach Locations



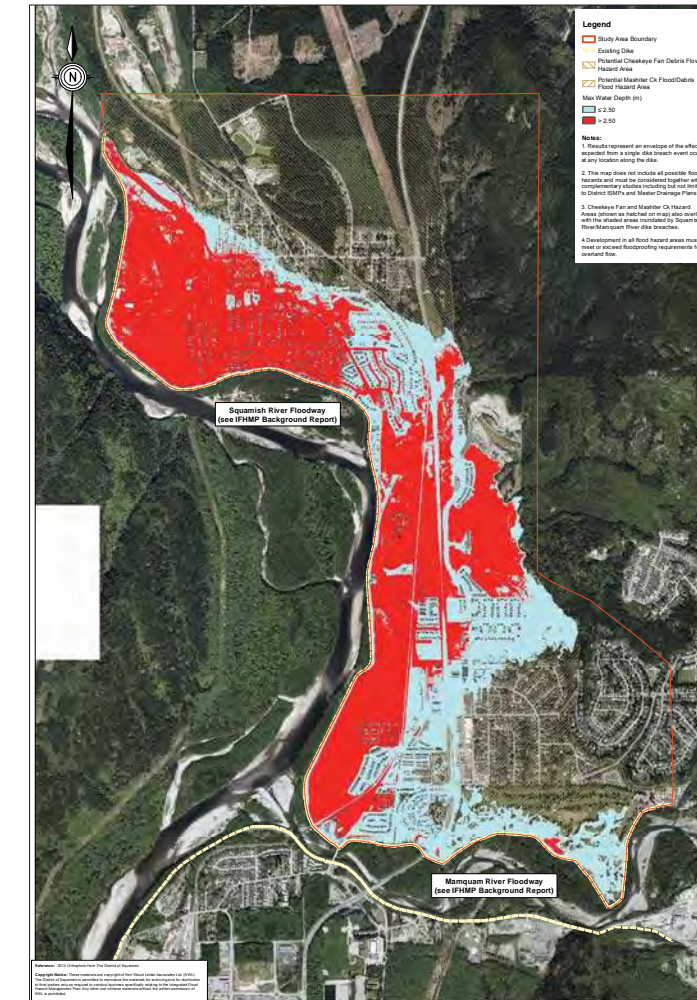
Results from these three simulations were generalized to show “worst case” results for all parts of the floodplain, assuming that the dike breach could happen anywhere. The maps on this board are planning tools and do not represent any specific dike breach scenario.

Floodplain Extent



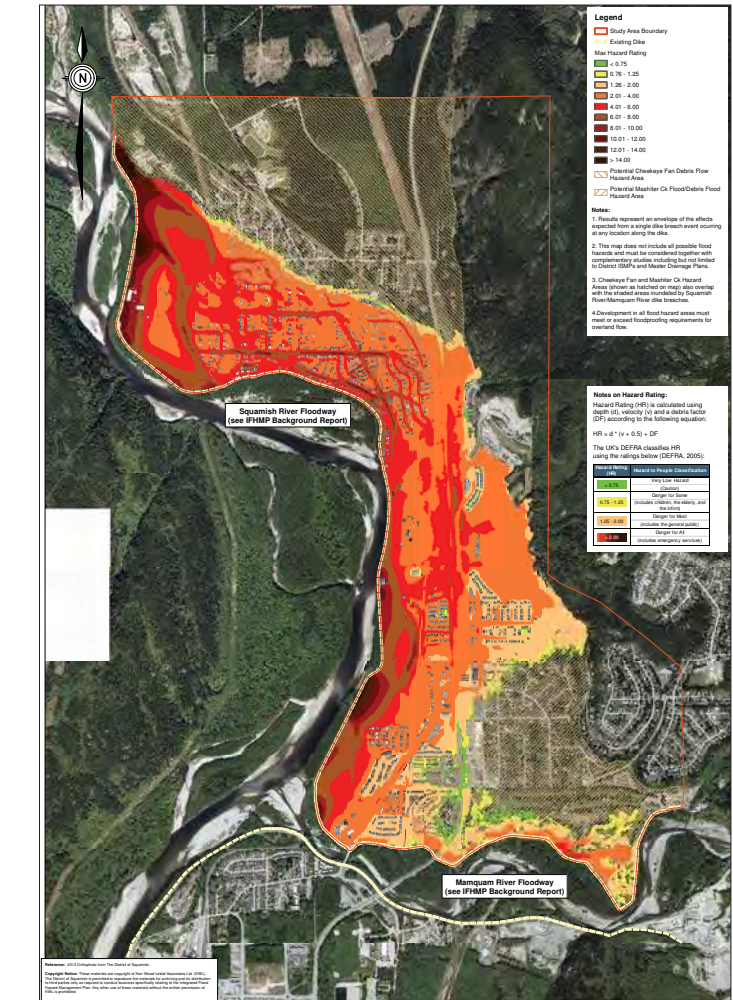
This map shows the maximum extent of flooding expected if a dike breach occurs during the 1:200 year river flood. It also shows water depth above assumed Year 2100 ground level. Darker blue (deeper water) reveals old river levels, channels and local creeks cut off from the river by diking.

Flood Depth > 2.5 m



The red areas on this map show where flood depths would exceed 2.5 m. Provincial guidance recommends 2.5 m flood depth as a basis for identifying particularly high-hazard areas. The areas shown in red were used to help define the limited densification areas shown on board 9.

Physical Hazard



Flooding can be dangerous when water gets deep or flows quickly. It is most dangerous where both happen together. **Hazard Rating** is a measure of how dangerous conditions could get during a dike breach. Darker colours are very dangerous, even for properly trained and equipped emergency personnel.

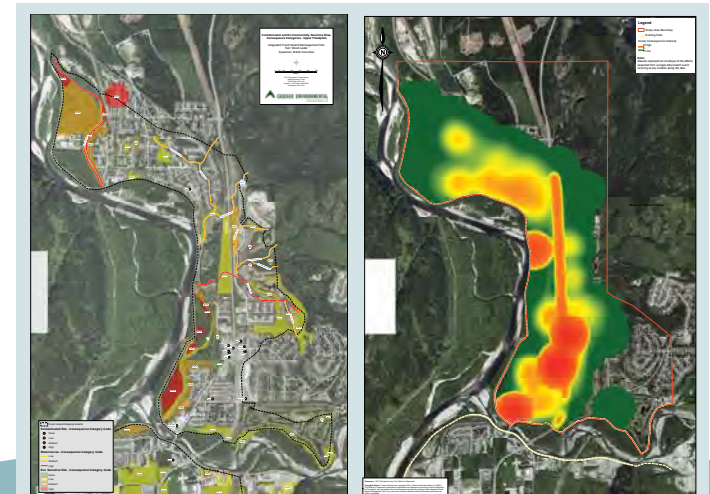
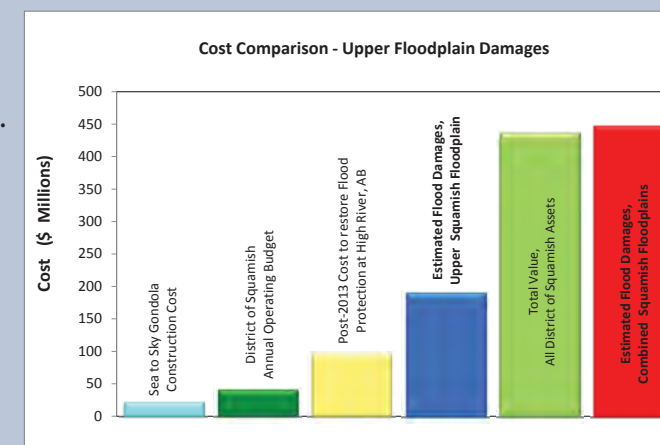
Economic Damages of a Dike Breach

The IFHMP used HAZUS software and Geographic Information Systems (GIS) data to estimate the economic damages resulting from a dike breach flood.

For the upper floodplain:

- Economic losses would total \$190 Million (in 2014 dollars)
- 7,000 people could be displaced
- 21,000 tons of debris could be produced.

The HAZUS study cannot account for all possible losses, and is considered a low estimate of damage.



The IFHMP also assessed social and environmental consequences, see the River Flood Risk Mitigation report.

Lower Squamish/Mamquam Flood Hazard 8

The Mamquam River naturally divides the Squamish River Floodplain into “upper” and “lower” areas. The Upper and Lower floodplain areas were modeled separately.

IFHMP modeling incorporates state of the art technology, updated hydrology, new data and climate change considerations.

Dike Breach Modeling

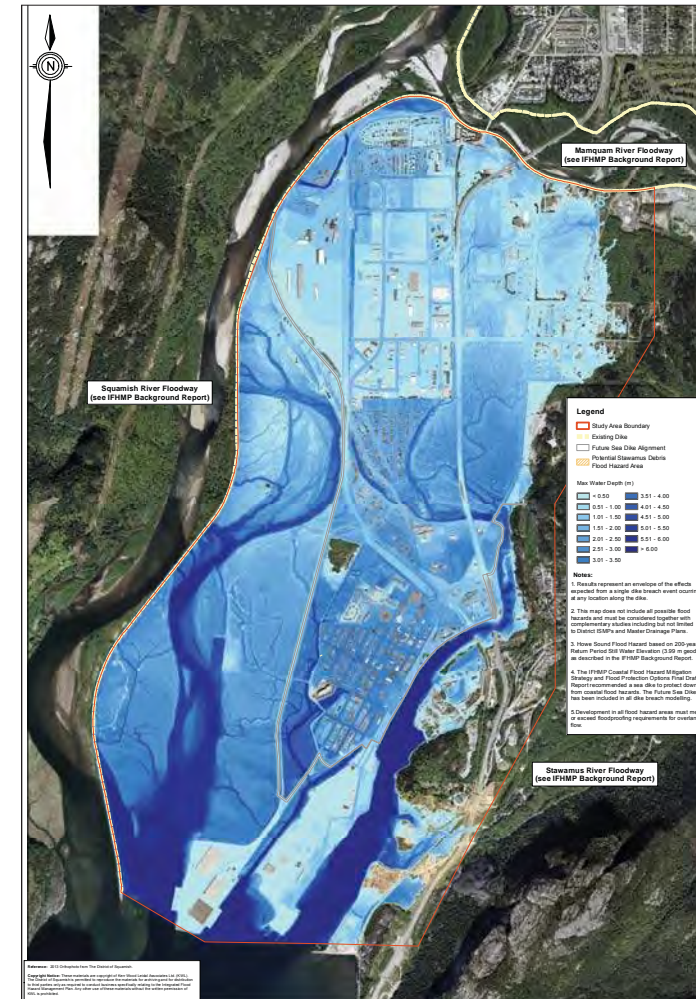
A dike breach could occur at any location. The IFHMP modelled four dike breaches: at Whittaker Slough, CN Railway, Loggers Lane, and the Brennan Channel.

Modeled Dike Breach Locations



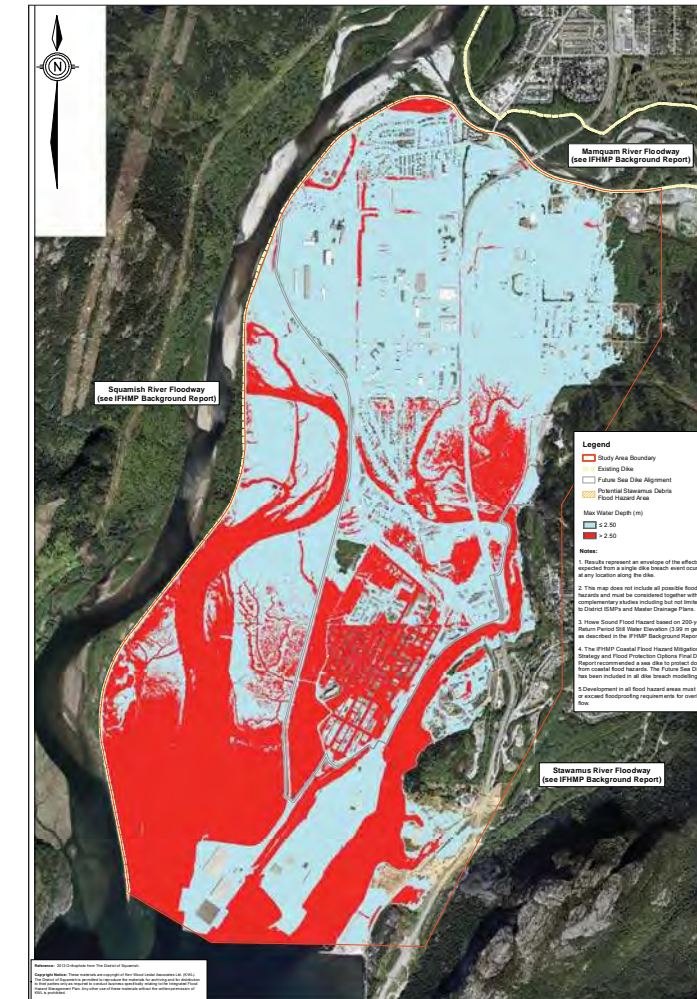
Results from these three simulations were generalized to show “worst case” results for all parts of the floodplain, assuming that the dike breach could happen anywhere. The maps on this board are planning tools and do not represent any specific dike breach scenario.

Floodplain Extent



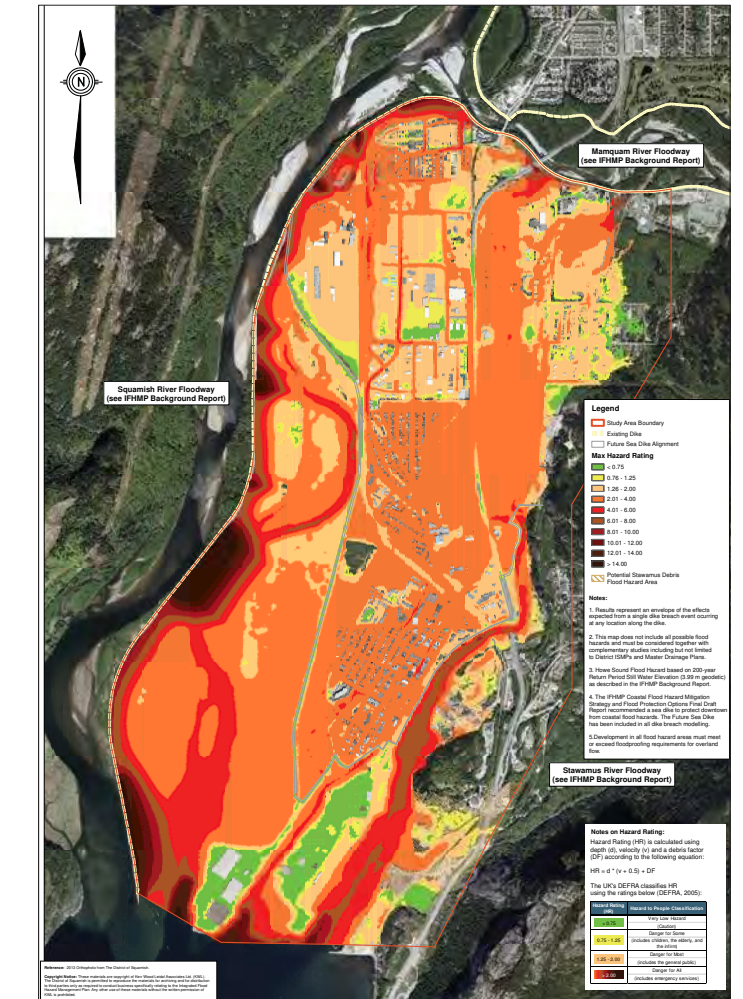
This map shows the maximum extent of flooding expected if a dike breach occurs during the 1:200 year river flood. It also shows water depth above assumed Year 2100 ground level. Darker blue (deeper water) reveals old river levels, channels and local creeks cut off from the river by diking.

Flood Depth > 2.5 m



The red areas on this map show where flood depths would exceed 2.5 m. Provincial guidance recommends 2.5 m flood depth as a basis for identifying particularly high-hazard areas. The areas shown in red were used to help define the limited densification areas shown on board 9.

Physical Hazard



Flooding can be dangerous when water gets deep or flows quickly. It is most dangerous where both happen together. **Hazard Rating** is a measure of how dangerous conditions could get during a dike breach. Darker colours are very dangerous, even for properly trained and equipped emergency personnel.

Economic Damages of a Dike Breach

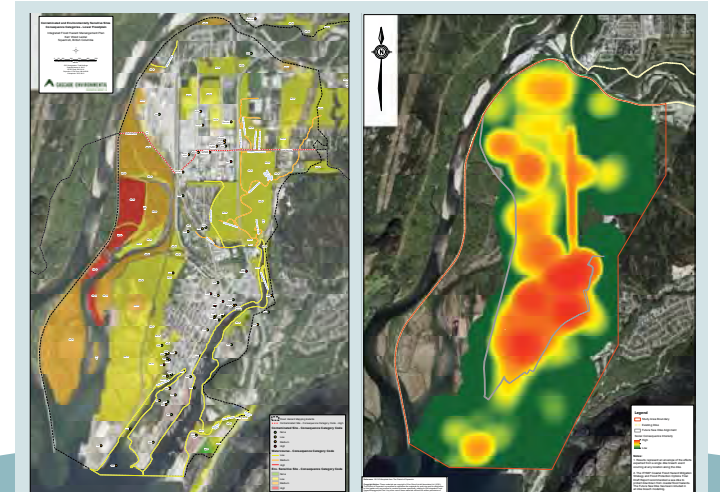
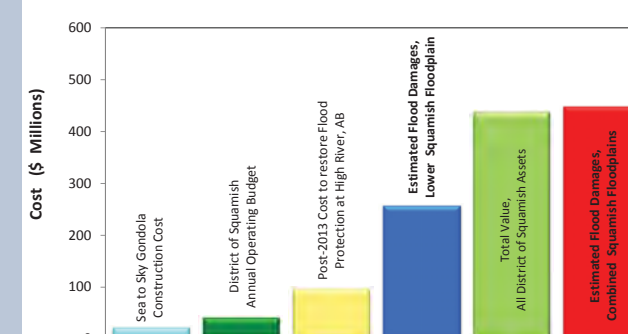
The IFHMP used HAZUS software and Geographic Information Systems (GIS) data to estimate the economic damages resulting from a dike breach flood.

For the lower floodplain:

- Economic losses would total \$257 Million (in 2014 dollars)
- 3,400 people could be displaced
- 17,000 tons of debris could be produced.

The HAZUS study cannot account for all possible losses, and is considered a low estimate of damage.

Cost Comparison - Lower Floodplain Damages



The IFHMP also assessed social and environmental consequences, see the River Flood Risk Mitigation report.

Stawamus River Flood Risk

11

The Stawamus River drains a heavily-forested glacially-carved watershed that extends from Sky Pilot Mountain to Howe Sound. The river flows through Valleycliffe and Stawamus I.R. No. 24.



Hazard Overview

The primary hazard on Stawamus River is flooding and the possibility of lateral erosion in the higher-elevation areas (e.g. Valleycliffe) and deposition in the lower reaches and estuary.

The Stawamus River is a steep mountain river with typically high rates of wood and sediment transport. Over time, gravel deposited on Mamquam Blind Channel can affect navigation.



Landslide dam-breach debris floods may be possible in the Stawamus River watershed. These events typically have much larger peak discharges and carry much more wood and sediment than a comparable return period 'clear water' flood.

Finally, the Stawamus River estuary is also subject to coastal backwater flooding from Howe Sound.

Areas at Risk

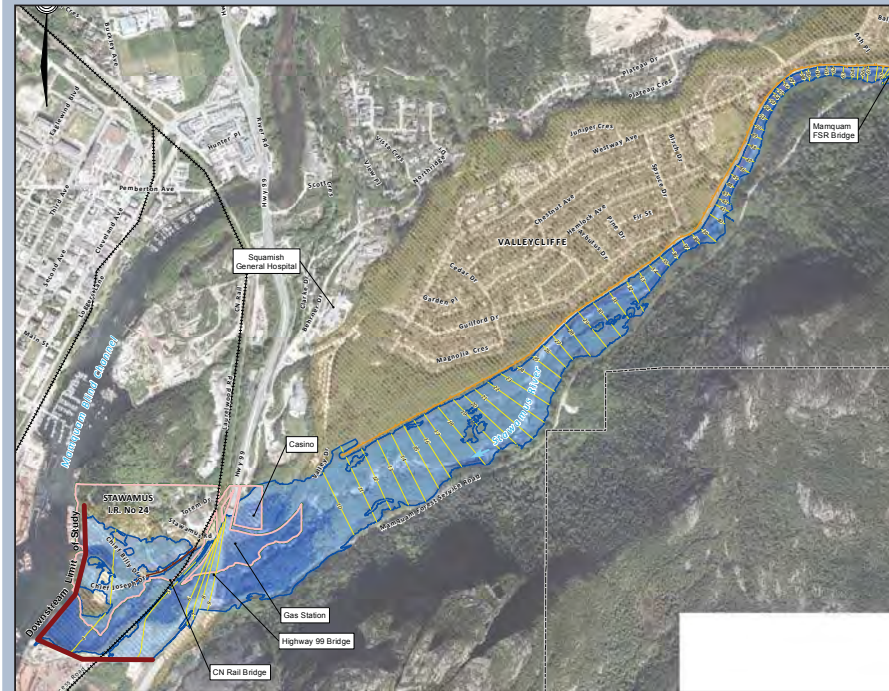
Areas at risk of flooding from Stawamus River include:

- the Valleycliffe neighborhood, including residential and commercial properties as well as Valleycliffe Elementary School,
- low-lying areas surrounding the of Little Stawamus Creek confluence, and
- low-lying areas of Squamish Nation I.R. No. 24.

Key infrastructure includes Highway 99, Valley Drive and the CN Rail mainline and the Mamquam Forest Service Road. The Squamish Nation gas station and Chances Squamish (casino) are located adjacent to the river immediately upstream of the Highway 99 Bridge.

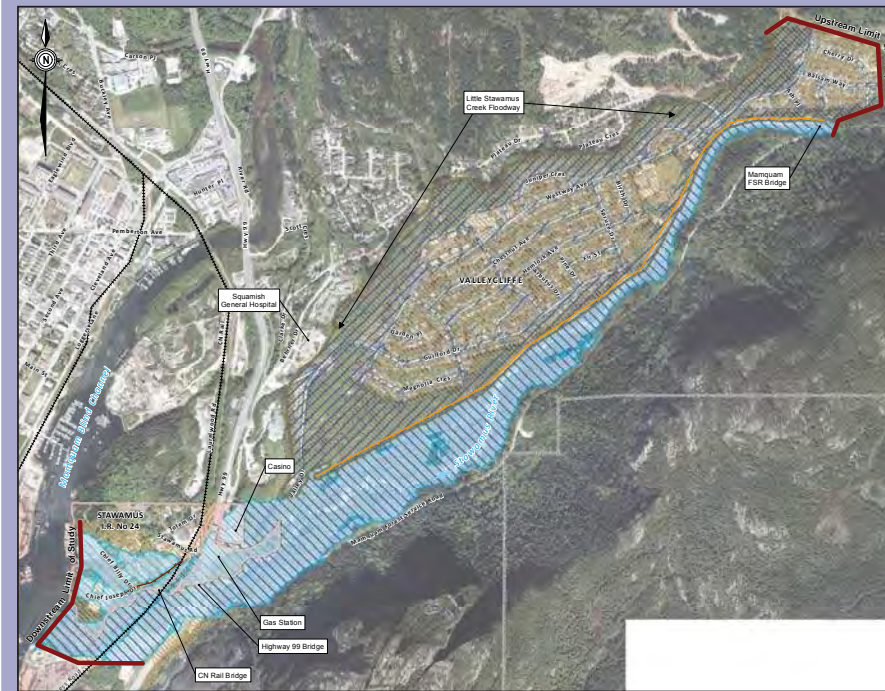
Flood Extents

This map shows the Stawamus River 1:200 year debris flood hazard area. The floodplain consists of the valley corridor generally between the Stawamus River and Little Stawamus Creek. The area at risk extends along the right bank of the Stawamus River from approximately the Mamquam Forest Service Road Bridge to approximately 50 metres upstream of Little Stawamus Creek and about 600 metres upstream from Highway 99.



Land Use Planning - Valleycliffe

The focus for Stawamus River flood risk management is to contain the flood hazard area outside the existing dike. Development under existing zoning should accommodate overland flow by elevating buildings to the FCL and ensuring the street network can serve as secondary floodways in the event of a bridge blockage. These measures are recommended as precautionary and are not expected to be onerous for developers.



Structural Flood Protection Works

- Future studies should consider whether the existing dike crest contains the modelled flood profile along most of its length.
- Upgrades to erosion protection works are recommended.
- Upgrade or extend at the upstream end of the Stawamus River dike could help mitigate debris flood hazards and further reduce the potential for overland flow through Valleycliffe.



Strategy Overview

Protect

is recommended as the primary flood mitigation strategy for the Valleycliffe flood hazard area.

Accept

rather than protect against avulsion and overland flow hazards.

Accommodate

overland flood hazards through floodproofing and internal floodways. Accommodate measures are particularly important in the undiked area between the main Valleycliffe community and Stawamus I.R. No. 24.

Retreat and **Avoid** strategies are not recommended for the Valleycliffe area, except as related to the protection and preservation of secondary floodways. Valleycliffe is an example of an area that can accommodate growth.

Consequences of Flooding: Valleycliffe

- Flooding of Valley Drive and the Mamquam Forest Service Road could isolate some areas.
- Erosion could threaten the District's backup water intake or damage a water main.
- Dikes confine 1:200 year flow but bridge blockages could cause an avulsion through Valleycliffe.
- An avulsion could damage buildings and create hazards to people.

Consequences of Flooding: I.R. No. 24

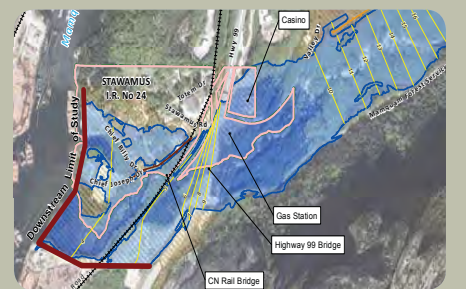
- Sediment deposition could limit channel capacity.
- Several buildings (including homes), the heritage Shaker Church, and a community wastewater treatment system are located in the flood hazard area.
- Bridge blockages at Highway 99 and CN Rail are possible and would exacerbate flood hazards.
- Highway 99 and CN Rail could be closed to traffic if water overtops highway or railway.
- Entire Sea to Sky corridor cut off from Metro Vancouver.

Stawamus I.R. No 24

The Squamish Nation is responsible for identifying and implementing appropriate flood risk mitigation strategies and tools on all reserve lands. The reserve is subject to coastal floods as well as floods and debris floods on the Stawamus River.

In parallel with the District's IFHMP, the Squamish Nation is developing a long-term vision for Stawamus I.R. No. 24 that will integrate development, flood protection and environmental objectives.

The IFHMP project team expects that the final vision will likely incorporate elements of all flood risk mitigation strategies: protect, accommodate, Avoid, and Retreat of specific buildings in the highest hazard areas.



Bridges and Access Roads

- Valley Drive east of Highway 99 floods regularly. The District can raise the low point, but it should remain below Highway 99.
- A short length of the Mamquam FSR may also be flooded. The District should work with other stakeholders to raise the road.
- The old concrete bridge abutments remain in place below the new Highway 99 bridge deck (top photo). This constricts the channel and increases the potential for woody debris to be trapped by the bridge.
- The CN Rail bridge opening has limited hydraulic capacity (photo) and could be overtopped during a major flood.

The District should work with partners and stakeholders to identify opportunities to address these issues.



Cheakamus River Flood Risk

10

The Cheakamus River flows through the District from Culliton Creek to the Squamish River at the edge of the Cheekeye Fan. BC Hydro operates a dam at Daisy Lake that diverts water through a tunnel from Cheakamus River to Squamish River.



Hazard Overview



Hazards on the Cheakamus River include normal “clear-water” floods. The 2003 flood was a clear-water flood.

Debris flows on Culliton Creek or the Cheekeye River can reach the Cheakamus River. Small Cheekeye River debris flows partially blocked the Cheakamus River in 2009 (see photo) and 2013.



If a large debris flow blocks the river, the river will back up, spill over, and wash out the blockage. The debris flood that results release a higher peak flow and more sediment than a “clear water” flood. (Photo: Britannia Creek, 1991)

The Cheekeye River can also produce much larger debris flows. Debris flows can occur with little warning. When they “run out” into developed areas, they can buildings and kill people. (Alberta Creek, 1983)



The District is studying debris flow mitigation on the Cheekeye Fan separately from the IFHMP.

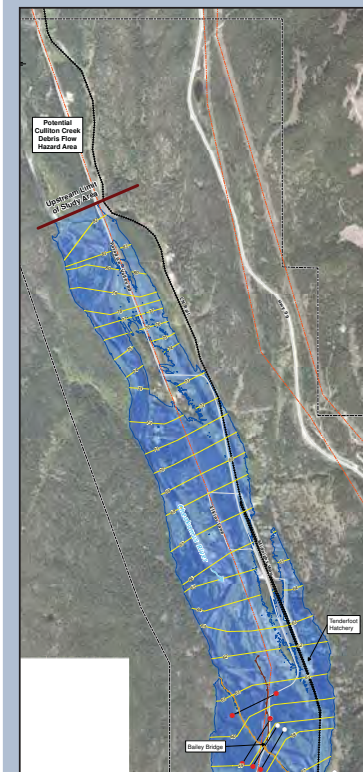
Areas at Risk

Areas at risk of flooding from the Cheakamus River include:

- Paradise Valley, including the Cheakamus Centre and the Bailey Bridge
- Squamish Nation communities at Cheekeye and Moodyville on Cheakamus I.R. No. 11
- The edge of the Cheekeye Fan near the Cheekeye River confluence, including Sunwolf and Fergie’s Bridge

Fergie’s Bridge and the Bailey Bridge are important links in the only road access to the community. The access route may be vulnerable to flooding.

Flood Extents



Protect Access

- Review the existing and desired level of flood resilience for emergency response routes. Develop a plan for long-term upgrades.
- Work with community partners to take advantage of opportunities to raise Paradise Valley Road.

- Work with Squamish Nation to incorporate the planned Cheekeye dike into a long-term flood resilience strategy at Fergie’s Bridge.



- Evaluate dike upgrading options for all river training structures as part of any upgrading plan for the Bailey Bridge

Accommodate Development

- Continue to require restrictive covenants.
- Designate flood hazard areas and minimum Flood Construction Levels based on 1:200 year flood extents.
- Maintain riparian (environmental) and flood protection building setbacks

Limit Diking

- No new District dikes to support new development.
- Ensure new private dikes do not create a transfer of risk.
- Accept responsibility for all river training structures at the Bailey Bridge and incorporate into dike maintenance operations.
- Support landowners who are upgrading or repairing private dikes by sharing emergency response protocols, flood hazard management information, and dike maintenance experience.

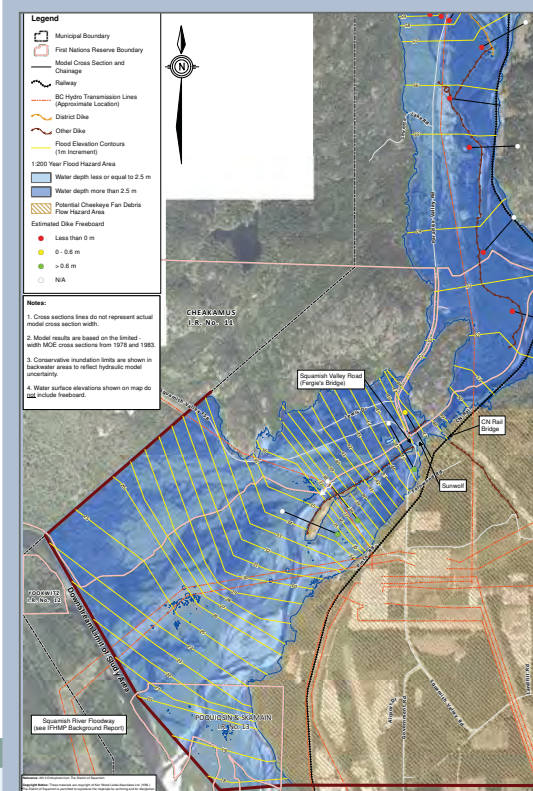
Other Measures

- Develop evacuation plans, signage and safe refuge areas. Share with the community through outreach and signage.
- Work with BC Hydro and the BC River Forecast Centre to maintain and enhance flood warning systems
- Complete comprehensive debris flow / debris flood hazards and mitigation studies for Cheekeye River and Culliton Creek.

Land Use Planning



These maps show “clear-water” 1:200-year flood hazard areas. The conservative results acceptable for the IFHMP, which must account for other uncertainties like future development patterns and debris floods.



Strategy Overview

Avoid

further densification of the floodplain by restricting infill development to today’s zoning levels. This will help to keep the low density feel of the area.

Accommodate

flood hazards by establishing new FCLs and maximizing building setbacks to give the river space to move.

Protect

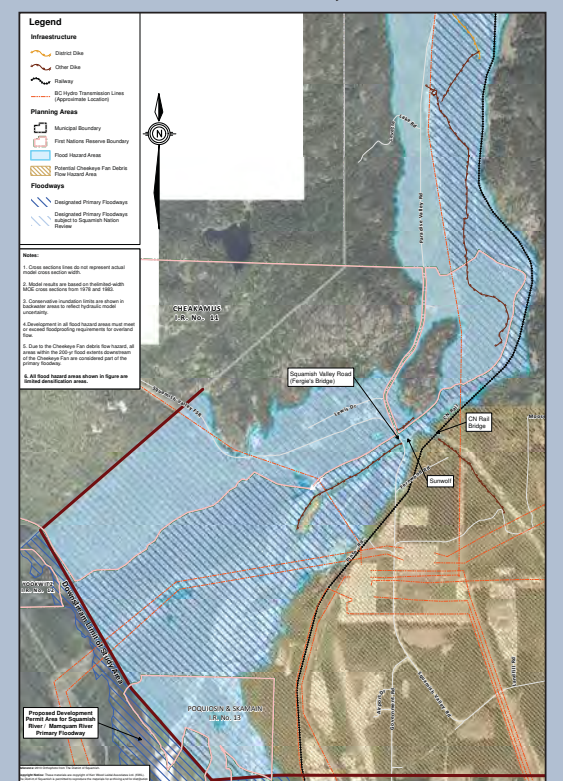
key access routes, but preserve the river corridor. Do not build new District dikes to support new development. Help private dike owners make sustainable decisions.

Potential Consequences of Flooding

- Private dikes overtop and probably fail.
- Damage to buildings and hazards to people may increase in a debris flood.
- Paradise Valley Road is cut off, creating evacuation and emergency response challenges.
- Fergie’s Bridge and the Bailey Bridge are considered particularly high risk structures.
- “Backdoor flow” into Cheekeye community during large events.
- Damage and service interruption for BC Hydro, CN Rail, Cheakamus Centre, Sunwolf and other local businesses.
- Erosion of reserve land is of particular concern for the Squamish Nation.



Cheakamus River flood risk management focuses on maintaining the natural system by limiting densification through rezoning in all flood hazard areas. Development under existing zoning should be raised to the FCL and minimize footprint areas within the floodway.

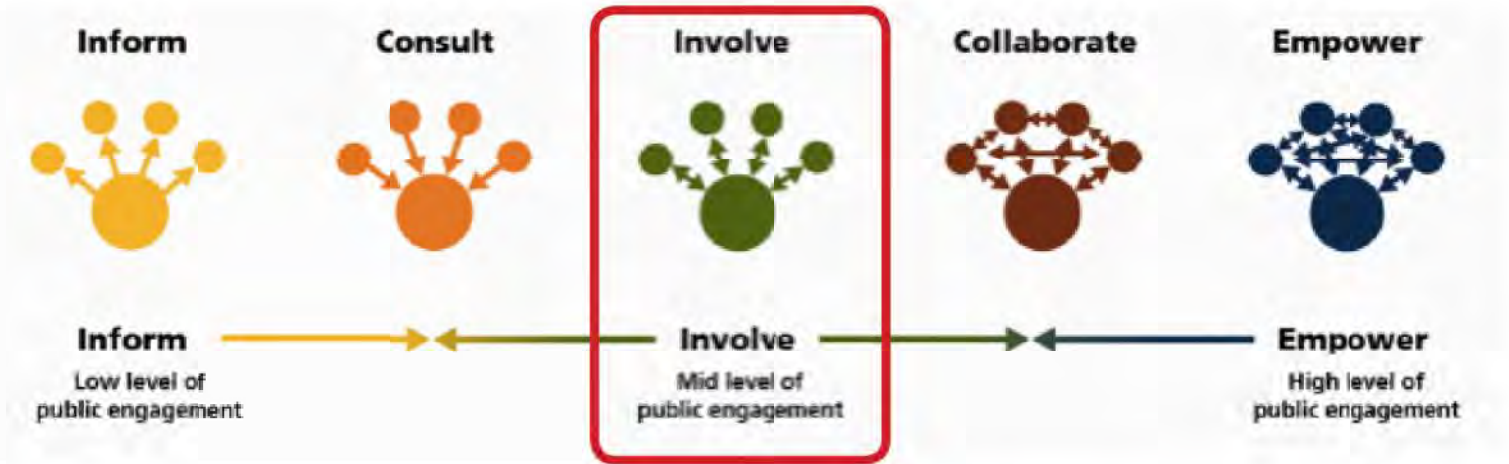


Community Engagement

Developing a Flood Mitigation Strategy involves challenging tradeoffs and difficult decisions. Recognizing this, in October 2015, Council approved a public engagement plan targeted at the 'Involve' level.

At the 'Involve' level of engagement, the District committed to:

- Listen to the public's concerns and values.
- Consider their input when developing and choosing alternatives.
- Provide feedback on how public input influenced the decision process.



Month	Community Engagment Activity
October 2014	Open House #1 Online Survey #1
November 2015	Highly Affected Stakeholders Workshop Squamish Nation Workshop Community Stakeholders Workshop Online Survey #2
December 2015	IFHMP Project Team Workshops
February 2016	Open House #2 Community Stakeholders Workshop Technical Working Group Meeting District Council Presentation
March 2016	Squamish Nation Chiefs and Council Presentation Stakeholder follow-up discussions Online Survey #3
April - July 2016	Council meetings & Commitees of the whole District Staff Meetings
June 2017	Open House #3
Summer 2017	Online Survey #4 Final presentation to Chiefs and Council

Open House & Online Survey #1 October 2014

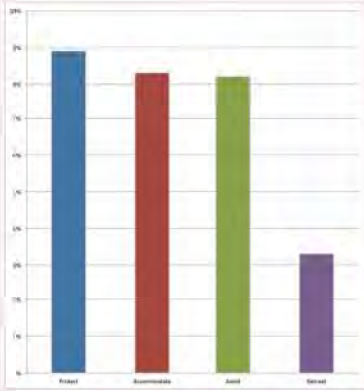
The first Open House was held in Squamish on October 23, 2014. The Open House provided general information on flood risks in Squamish and collected feedback on long-term coastal flood protection options. Approximately 70 members of the community attended this event. Following the Open House, an online survey was prepared to gain public input on risk tolerance, evaluation criteria and competing priorities. 117 responses were received.

Overall, the results indicate strong support for protect (89%), accommodate (83%) and avoid (82%) strategies. Retreat did not receive the same level of support (33%).

95% considered reducing the risk of injury or death to be the most important objective.

91% supported using all practical approaches to mitigate flood risk.

82% supported discouraging development in high risk flood plain areas.



The online survey questions **simplified very complex issues**. This was done to help respondents gain an appreciation of the **difficult decisions facing the District**. The survey asked the public to rate difficult decisions between competing objectives, with results showing clear preferences between four objectives, as shown below:

- 1 Protecting the environment
- 2 Avoiding social, cultural and community impacts
Minimizing costs to taxpayers
- 3 Providing development opportunities

Stakeholder Feedback

Over the course of the IFHMP, District staff organized several meetings with key stakeholder groups. Meetings included the following groups and dates:

- Squamish Estuary Management Committee – February 19, 2015
- Highly-Affected Landowners – November 16, 2015
- Residents and Community Stakeholders – November 23, 2015
- Cheakamus River / Paradise Valley Stakeholders – February 1, 2016

Generally, all groups supported improving diking infrastructure and adopting a higher standard of protection. The majority of stakeholders also supported accommodating flood hazard through the use of flood construction levels and allowing passage of floodwaters during a dike breach. There was support for limiting development in the highest hazard areas by the Stakeholders Group while the Highly Affected Landowners Group preferred to see the lands developed using dike protection and flood construction levels for mitigation.

Open House & Online Survey #2 February/March 2016

A second Open House was held on February 24, 2016. The Open House provided information on river flood hazards and mitigation opportunities. It also asked attendees to provide feedback on what they considered to be an acceptable level of flood risk. Approximately 35 people attended the event.

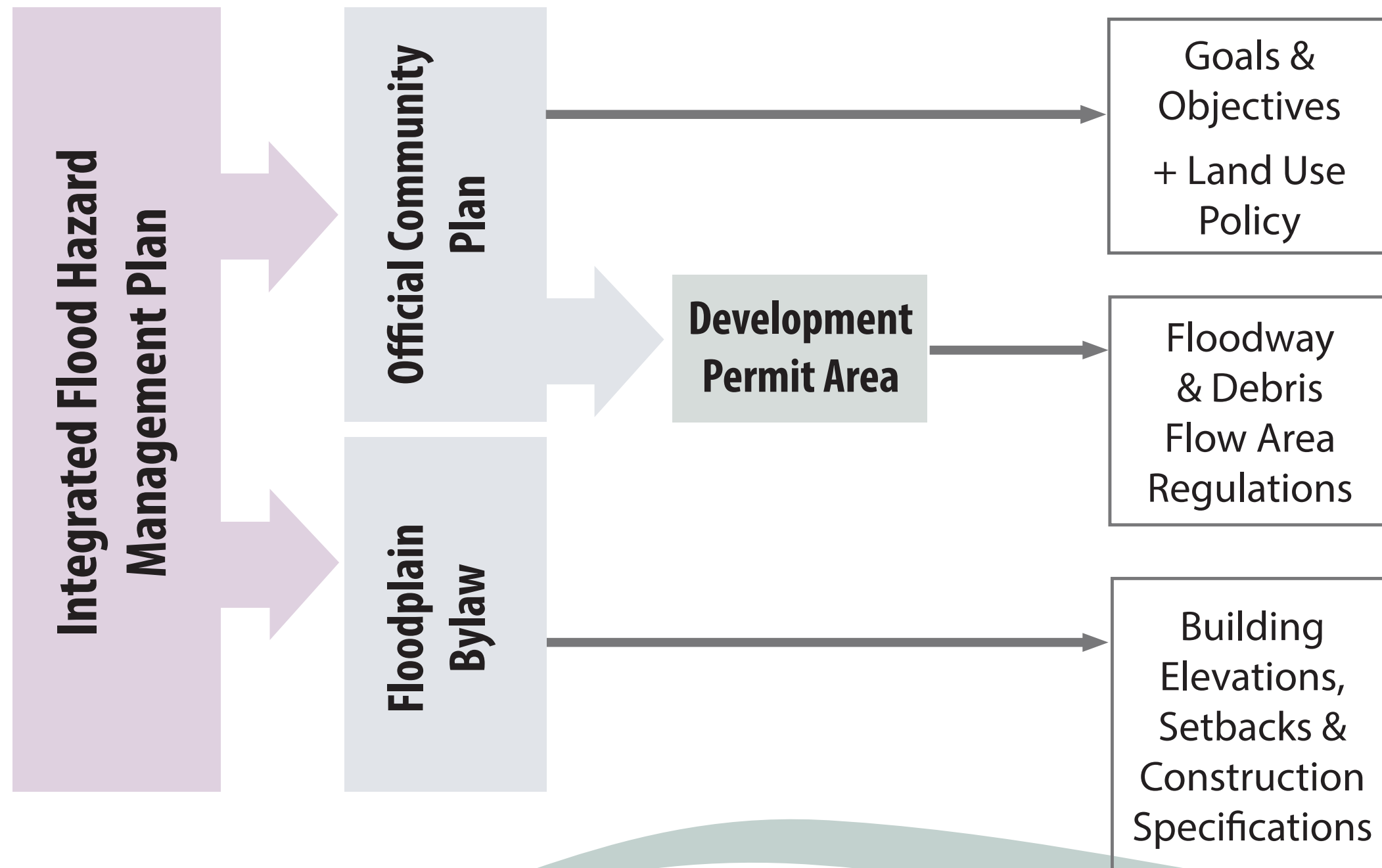
Following the Open House, an online survey was prepared to gain public input on strategies and tools proposed by the IFHMP to help manage river flood risks. Some questions related to general flood hazard management in Squamish. Other questions were specific to each neighbourhood.

There were 38 responses to Survey #2, including 11 received from Open House #2. The response rate to the technical questions was low, which suggests that some people were not comfortable commenting on these very complex issues.

Flood Risk Mitigation Policies

The IFHMP recommends a range of policy measures that set out the goals, objectives and requirements for the community's flood risk management program. The most important land use planning tools focus on the need for updates to the District's flood risk mitigation policies.

The IFHMP project team has worked closely with District Staff to prepare policy updates for the three main policy documents, including the Official Community Plan, the Floodplain Bylaw and a new Development Permit Area.



OCP Smart Growth & Areas for Densification

The OCP sets out the District's vision for the future and guides the growth of the community. The District's Official Community Plan supports smart growth principles, like sustainable design and land use practices. Smart Growth should be updated to incorporate the mitigation of flood risk. Examples include:

- Directing growth away from areas subject to high flood risk.
- Buildings with ground level parking and storage and living areas above the Flood Construction Levels (FCLs).

Areas of Squamish with no flood risk which are suitable for densification from a hazard perspective include:

- Garibaldi Highlands, Quest University and part of Garibaldi Estates

Areas in the floodplain with lower risk and where densification is possible include:

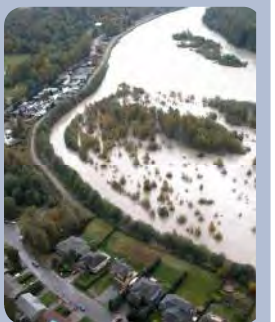
- Valleycliffe, Downtown, Dentville, East of Brennan Park, and Squamish Industrial Park

All other areas will include infill development opportunities.

Floodplain Bylaw

A new Floodplain Bylaw incorporates most of the recommended flood protection measures in a single comprehensive framework with:

- Maps showing FCLs for different areas subject to flood hazard areas
- Available floodproofing measures
- Setbacks from watercourses and dikes
- Permissible use of space below the FCL
- Exemptions for maintenance, repair and additions
- Location of electrical panels and HVAC
- Conditions where a Qualified Professional may be required



The *Local Government Act* limits what regulations a Floodplain Bylaw can establish. For instance a Floodplain Bylaw can not impose development conditions within a primary floodway (main river corridor). The IFHMP recommends a new Development Permit Area for this purpose.

Development Permit Area

A new Development Permit Area (DPA) for flood hazard areas and debris flow natural hazard areas was recommended to clarify requirements for developers and help guide District review of development applications. The DPA captures any important IFHMP policy recommendations that can't be implemented through the OCP or Floodplain Bylaw.

One of the most important regulations of the DPA is to restrict development in primary floodways (with exceptions for the Cheakamus River) and impose regulations for development within secondary floodways (areas within dike-protected corridors critical for conveying floodwaters in the event of a dike breach).

Structural Flood Protection Tools

The IFHMP recommends a range of tools and mitigation measures relating to the planning, design, construction, operation, maintenance, repair, and upgrading of structural flood protection works.

Some of these measures will be implemented through the District's existing dike operations and maintenance program. Other recommended measures will require considerable planning and preparation effort, and may have indeterminate timelines for actual implementation.

1. Fixing Dike Deficiencies/Bringing Existing Dikes to Provincial Standards

The District has spent over \$4M on dike upgrades since 2012. Some sections are still too low or too narrow, have substandard bank protection, allow too much seepage, or lack formal land tenure. Addressing these issues is a high priority for the District.

Existing deficiencies include:

- Dike below 1:200 year level
- Lack of land tenure
- No access
- Oversteepened slopes
- Too narrow
- Missing erosion protection
- Overgrown vegetation

Other infrastructure in areas like Eagle Run (below) make upgrades more challenging.



The District will support landowners who are upgrading or repairing private dikes by sharing emergency response protocols, flood hazard management information, and dike maintenance experience. The District will also ensure new private dikes do not create a transfer of risk.

2. Building a Sea Dike

The most important tool for coastal flood risk mitigation is a new District sea dike. The District's sea dike does not meet provincial standards, and Downtown Squamish is presently at risk from coastal floods.

By Year 2100, the sea dike will need to be much longer, higher, and more reliable than it is now. The sea dike will need to start at the Squamish River dike near North Yards, wrap around downtown, and tie into high ground north of Mamquam Blind Channel.

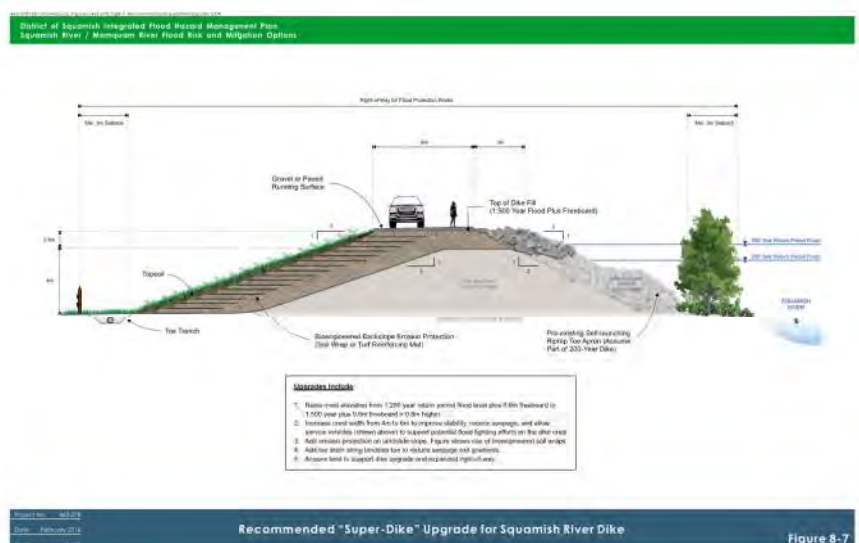
The preliminary crest elevation is 4.7 m geodetic for the majority of the sea dike, but increases to 4.8 m at the north end of Crescent Slough. Some work on the sea dike should start immediately to protect downtown against present-day coastal floods. However, the full height of the Year 2100 sea dike won't be needed right away. As long as the lower part of the sea dike is built wide enough, the upper part can be added later (once we know more about the rate of sea level rise).

Phasing construction in this way makes the sea dike more affordable by spreading costs over a longer period of time. Regardless of whether the sea dike is built all at once or in phases, by the District or by developers, the District should start planning now to make sure that land and funding for the sea dike is available when it is needed.



3. Long-Term Planning: "Super Dike"

The "super dike" recommendation adopts a higher standard of protection for the Squamish River dike. Significant residential and commercial development in this area equates to higher consequences of a dike breach, justifying a higher design standard for the Squamish River dike. The District should start planning now to make the dike higher, wider, and more robust. It will likely take decades to implement the new "super dike" standard.



- The "super-dike" will increase protection from 1:200yr to 1:500 year level.
- Increasing it to 4m-6m wide will reduce seepage that can lead to failure.
- Adding erosion protection on land side will prevent complete failure if overtopped.
- Improved erosion protection will prevent undermining or debris damaging the dike.

Implementation and Funding

The IFHMP makes over 100 recommendations for flood hazard management throughout the District.

The recommended tools can be categorised into four main types.

CATEGORY	EXAMPLE	PRIORITY	FUNDING
Policy Measures deal with goals, objectives and requirements	An updated OCP, the new Floodplain Bylaw and a new Development Permit Area	Most policy measures are Priority 1 IFHMP recommendations.	District Operating Budget. Staff effort may be supplemented by consultants.
Operational Measures affect how the District fulfills its responsibilities	Improving access for dike inspections, undertaking maintenance and repairs and communicating flood risk information to the public.	Most operational measures fall under IFHMP Priorities 1, 2, or 4.	District Operating Budget. The District may receive some funding assistance for Local Authority Emergency Planning through Emergency Management BC.
Capital Investments are construction projects that require large financial investments	The design and construction of a new sea dike and upgrades to the river dikes.	Due to the high costs, only the most important capital investments are assigned IFHMP Priority 1. Most are Priority 2 or 3.	Senior government support through funding grants and cost-sharing programs. The District may fund its share through the annual budget (through general revenues or grants), developer-driven Community Amenity Contributions, and local area levies.
Further Studies will provide more data and analysis to guide future updates	Further technical studies that focus on filling the remaining data and knowledge gaps identified by the IFHMP.	Generally assigned IFHMP Priority 2 so that results will be available to support the next IFHMP update.	A variety of potential sources including general revenues, senior government funding programs, other stakeholders and developers.

Some of the IFHMP recommendations should be implemented immediately. Others will take decades to plan and build.

- **Priority 1** measures should be implemented immediately or at the earliest possible opportunity.
- **Priority 2** measures should be considered in planning decisions and implemented before the next IFHMP update.
- **Priority 3** measures should be considered in planning decisions, but implementation will likely be after the next IFHMP update.
- **Priority 4** measures should be implemented if and when opportunities arise. Priority 4 measures are not strict requirements, but add value to planning, development and other decisions.

Share Your Views

To help us plan and prioritize actions for the future, we want to hear your thoughts on some of the key flood mitigation tools proposed by the IFHMP.

Please indicate whether you agree or disagree with the specific IFHMP recommendations below:

	YES	NO	COMMENTS
1. The updated Official Community Plan (OCP) will carefully control but not eliminate growth in areas of higher flood risk. It also says how much risk the community is willing to accept, and encourages growth in areas of lower flood risk. Do you think the OCP updates are a good approach for managing flood risk in Squamish?			
2. A new Floodplain Bylaw will establish minimum elevations for new development within the floodplains. It will also require new development to be set back a safe distance from creeks, rivers, and dikes. Do you think the new Floodplain Bylaw is a good approach for managing flood risk in Squamish?			
3. A new Development Permit Area (DPA) will require future developments to leave space to let water pass safely through the community. No development will be allowed outside the District's dikes. Future development in designated corridors called "floodways" will have to meet specific conditions to avoid making the consequences of a flood worse for others. Do you think the new DPA is a good approach for managing flood risk in Squamish?			
4. Dikes can greatly reduce the potential for flooding. However, they can also promote more development in high-risk areas, which increases the consequences of a dike failure. Dikes can also create a false sense of safety, and people may forget they live in a floodplain. The IFHMP recommends a balanced approach to diking that considers different needs in different parts of the community. The IFHMP recommends: <ul style="list-style-type: none">• Building a new sea dike to protect Downtown Squamish from coastal floods that will get worse as climate change causes sea levels to rise.• Making the dikes that protect the heart of the community (Brackendale, Eagle Run / Highway 99, Garibaldi Estates, North Yards, Industrial Park, Dentville, and Downtown Squamish) higher, wider and stronger. These improvements will reduce the likelihood of dike failures that could cause up to \$450 million in damages and displace 60% of the community's population• Maintaining the current standard of dike protection for the Valleycliffe neighbourhood.• Avoiding new dikes in rural and relatively remote areas like the Paradise Valley. Do you agree with the IFHMP approach to dike protection for managing flood risk in Squamish?			
5. The IFHMP recommends site-specific requirements for new development. They include new Flood Construction Levels, setbacks from creeks and rivers, erosion protection for foundations and floodproofing fill, and a restrictive covenant on property title. These on-site measures are designed to reduce the consequences of flooding for new development. Do you agree with these on-site measures for managing flood risk in Squamish?			
6. Downtown Squamish is a very important business hub for the community. The District has historically allowed non-residential development (e.g., stores, restaurants and warehouses) to build at ground level within the downtown area. The IFHMP continues the historical exemption for non-residential development. However, new developments will need to use flood-resistant building materials and a restrictive covenant will be required on title to ensure that future owners understand the risks. Do you agree with this approach for non-residential development?			
7. Some parts of the District have historically developed in very high risk locations. The IFHMP recommends that the District identify key areas where it would be appropriate to "Build Back Better" after a disaster. Do you agree with this approach for managing flood risk in Squamish?			
8. Do you think that the IFHMP has done an adequate job of identifying risks, options, and recommended approaches for managing flood risk in Squamish?			

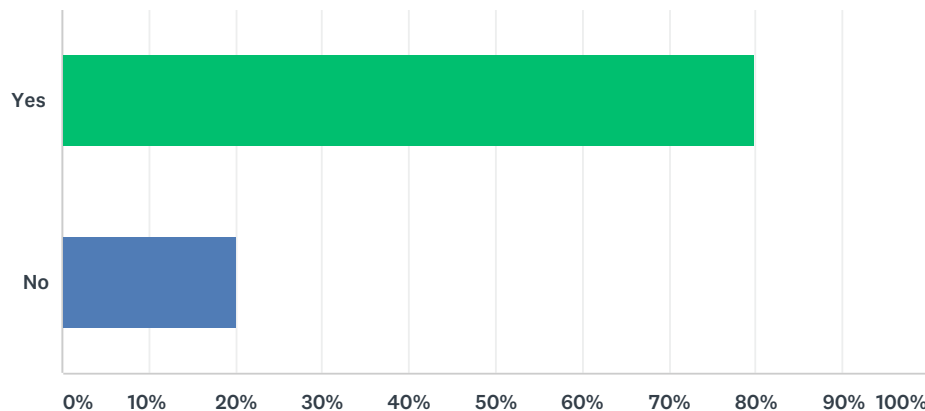
9. The IFHMP recommends a prioritized list of dike upgrades. Some upgrades will be expensive and may take several decades to build. Building and paying for the upgrades may be a challenge, so the District must start planning immediately. The District can raise the necessary funds in different ways. Please tell us which funding approaches you agree with for flood risk management in Squamish (check all that apply):	
Grants from the federal and provincial governments	
Cost-sharing agreements between the District and federal / provincial governments	
Taxes that apply to everyone in the District (since everyone uses services in the floodplain)	
Taxes or fees that only apply to people who own property in dike-protected areas	
Fees charged to developers who will profit from new developments located in the floodplain	

10. Do you have any comments about the proposed mitigation plan for the following areas:	
AREA	COMMENT
Downtown Squamish/Dentville	
Garibaldi Estates/Eagle Run/Brackendale	
Paradise Valley	
Valleycliffe	
Other Area (specify)	

Appendix D – Survey Responses

Q1 The updated Official Community Plan (OCP) will carefully control but not eliminate growth in areas of higher flood risk. It also says how much risk the community is willing to accept, and encourages growth in areas of lower flood risk. Do you think the OCP updates are a good approach for managing flood risk in Squamish?

Answered: 55 Skipped: 2



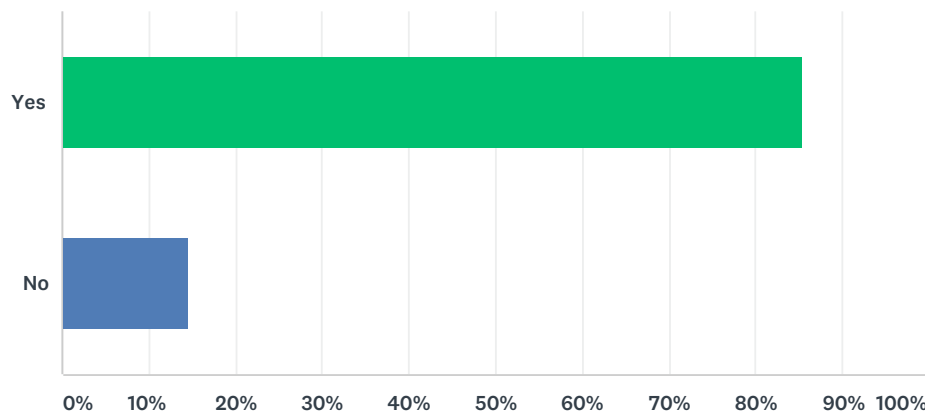
ANSWER CHOICES	RESPONSES
Yes	80.00% 44
No	20.00% 11
TOTAL	55

#	COMMENTS	DATE
1	The OCP Growth Management discourages housing on lots 509-510, 513 and this is wrong -we should build on the hillsides.	9/15/2017 11:03 AM
2	More advertisements needed for upcoming meetings.	9/15/2017 10:46 AM
3	Yes – providing that risk tolerance thresholds are clearly defined and used to inform both strategic and operational planning/policy development.	9/15/2017 10:44 AM
4	New development in high risk/flood susceptible zones should be avoided at all costs and, if new development is to proceed it absolutely cannot be allowed to potentially impact or increase hazard levels on existing development."	9/15/2017 10:40 AM
5	I am concerned about limitations being placed on expanding residential development on the uplands -- for example Lots 509/510 and Lot 513. The valley bottom lands are too important for habitat and transportation and employment and other uses. The costs to protect residential subdivisions in the floodplain are also high. Allowing residential use of the east side of Loggers Lane is a mistake.	7/14/2017 9:01 PM
6	Not everywhere. Only in high-density designated areas. In other areas I believe that individual landowners have the sole right and privilege of choosing how to manage and build on their land (relating to flood mitigation), so the risks and liabilities are theirs, not the District. Using the OCP denotes the District assumes wide area liability which it should not. Protection via building code should reign for individual projects.	7/11/2017 2:53 PM
7	Building in known high risk areas should be avoided.	6/30/2017 3:41 PM
8	Too vague and asking feedback from people who don't understand all the issues	6/27/2017 6:56 PM
9	Potential residents of those areas MUST be made aware of the additional risk.	6/27/2017 4:29 PM

10	The IFHMP is in conflict with many of the other policies within the OCP. This causes significant conflict for developers looking to follow the OCP to act on the District's vision. The IFHMP is also missing flexibility in approaches to mitigating flood risk.	6/27/2017 11:21 AM
11	Just going to change to build where ever they please anyway	6/27/2017 11:18 AM
12	Its good for managing communication. Not the flood plan.	6/27/2017 10:42 AM
13	They are only good if staff and council actually abide by them and do not make amendments as soon as there is development pressure	6/26/2017 5:27 PM
14	I think Dikes will do a lot better job at managing flood risk than an OCP	6/26/2017 3:20 PM

Q2 A new Floodplain Bylaw will establish building regulations for new buildings including minimum elevations for future and minimum distances from creeks, rivers, and dikes. Do you think the new Floodplain Bylaw is a good approach for managing flood risk in Squamish?

Answered: 48 Skipped: 9



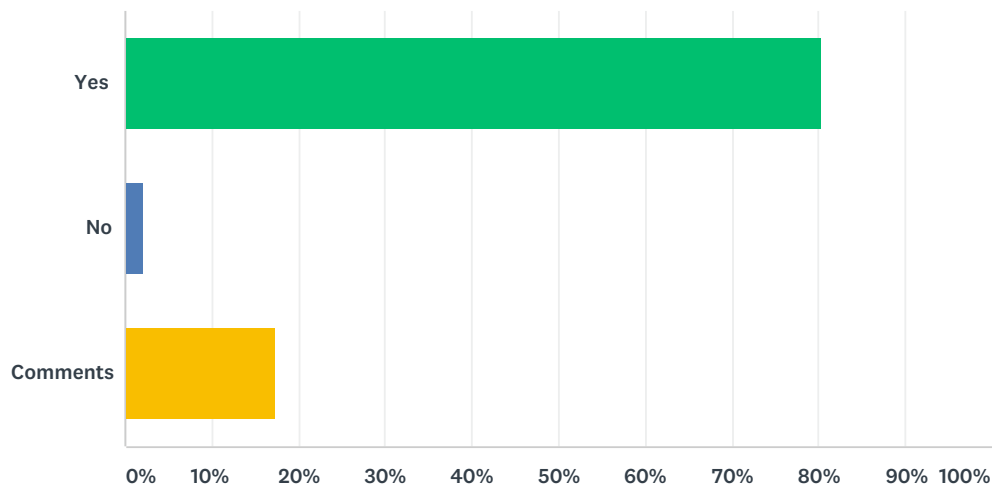
ANSWER CHOICES	RESPONSES	
Yes	85.42%	41
No	14.58%	7
TOTAL		48

#	COMMENTS	DATE
1	Yes, but it does raise costs for employment lands.	9/15/2017 11:04 AM
2	How will builders react and respond to these bylaws!	9/15/2017 10:47 AM
3	The proposed Floodplain bylaw could be based on risk tolerance threshold (damage/loss) or on hazard intensity (depth, velocity). Is there capacity to use a risk-based approach for developing the floodplain bylaw?"	9/15/2017 10:44 AM
4	We need clear and consistent language around setbacks and minimum elevations. At present, houses that are allowed to be developed in hazard zones but have restrictions on living space (i.e. basement and garage zones that may be in a flood way) are a colossal failure as 99% of these homes are lived in and the DOS cannot enforce them. Very important to have realistic and enforceable bylaws ie. garages around town are lived in.	9/15/2017 10:41 AM
5	Yes, it is thoroughly conceived -- BUT might not sufficiently consider the circumstances of industrial lands in the BCR Yards and Business Park. We need jobs, and not extra costs for development of industrial enterprises.	7/14/2017 10:52 PM
6	Only in high density areas where group behaviour actually results in wider benefit	7/11/2017 2:55 PM
7	Not sure	6/27/2017 6:56 PM
8	Some concrete timelines and funding mechanisms need to be integrated into the IFHMP so that were not building housing in the sky that will look out of place in 25 years (?) when the super-dike network is complete. You lose a lot of charm in a town when you remove ground floor commercial. I would like to know the various timelines so that we could rationally look at the risk of lower FCLs over a period of time if the dike system was constructed. Also, asking for developers to construct these super-dikes will create ghettos by making re-development of some of these areas unfeasible.	6/27/2017 11:25 AM

9	Depending on the exact recommendations, its a good idea to have certain bylaws	6/27/2017 10:45 AM
10	This needs to be carefully managed. If the regulations are too stringent - no new development will proceed, and we will not find ourselves any further ahead, especially if we are relying on developments to pay for new dikes, etc.	6/26/2017 5:28 PM

Q3 A new Development Permit Area (DPA) will require future developments to leave space to let water pass safely through the community to avoid transferring risk or increasing flood levels over time. No development will be allowed outside the District's dikes ("Primary Floodways"). Future development in designated dike-protected corridors called "Secondary Floodways" will have to meet specific conditions to avoid making the consequences of a flood worse for others. Do you think the new DPA is a good approach for managing flood risk in Squamish?

Answered: 46 Skipped: 11



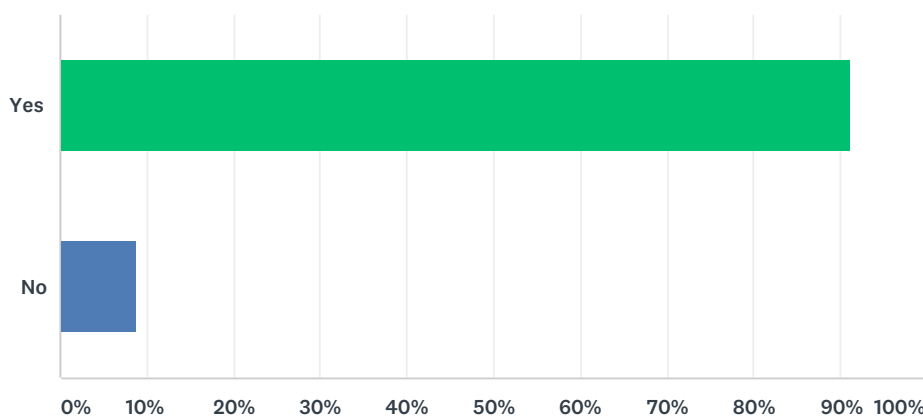
ANSWER CHOICES	RESPONSES	
Yes	80.43%	37
No	2.17%	1
Comments	17.39%	8
TOTAL		46

#	COMMENTS	DATE
1	Yes, but I am concerned over housing being built on the east site of loggerslane which are at the same flood level as the Rec C.	9/15/2017 11:04 AM
2	We need better protection around our existing watercourses (the primary route for most water flows) as well as realistic surface storm water drainage areas, wetlands, such as along Loggers Lane, become even more important during flood events.	9/15/2017 10:41 AM
3	I do not understand why so much housing is being allowed on the east side of Loggers Lane. Does it mean no new community facilities or more expensive community facilities on the west side of Loggers Lane, such a new performing arts centre?	7/14/2017 10:56 PM
4	This is far too much paranoia (and regulations) adding significant construction costs, all for events that happen very rarely. No wonder the affordability of housing is so terrible. People should be warned if they buy a house on a floodplain, then the liability for where they store things is their own business. For the rare occasion when floods happen, things get wet, they dry out, some of it is lost: big deal. Why make contractors rich building protectionary measures for such random and minor trouble like a flood???	7/11/2017 3:03 PM

5	This needs more work. Not opposed or for	6/27/2017 6:57 PM
6	Yes, this is a good policy and one that would be maintained even with improved dike protection.	6/27/2017 11:26 AM
7	Yes. By letting the area flood in its natural progression will help others areas from flooding. Building with space between housing and stable enough to be under water for times of flood. The dyke worsens the floods and need to be minimized. By letting the area flood provides valuable habitat and natural progression of the land. The land area will shift and so will the houses. Anywhere on the flats we should be prepared to move as the river shifts over time.	6/27/2017 10:50 AM
8	See previous comment	6/26/2017 5:29 PM

Q4 The IFHMP recommends a balanced approach to diking that considers different needs in different parts of the community. The IFHMP recommends: Building a new sea dike to protect Downtown Squamish from coastal floods that will get worse as climate change causes sea levels to rise. Making the dikes that protect the heart of the community (Brackendale, Eagle Run / Highway 99, Garibaldi Estates, North Yards, Industrial Park, Dentville, and Downtown Squamish) higher, wider and stronger. These improvements will reduce the likelihood of dike failures that could cause up to \$450 million in damages and displace 60% of the community's population Maintaining the Provincial standards for dike protection for the Valleycliffe neighbourhood. Avoiding building new dikes in rural and relatively remote areas like the Paradise Valley. Do you agree with the IFHMP approach to dike protection for managing flood risk in Squamish?

Answered: 45 Skipped: 12

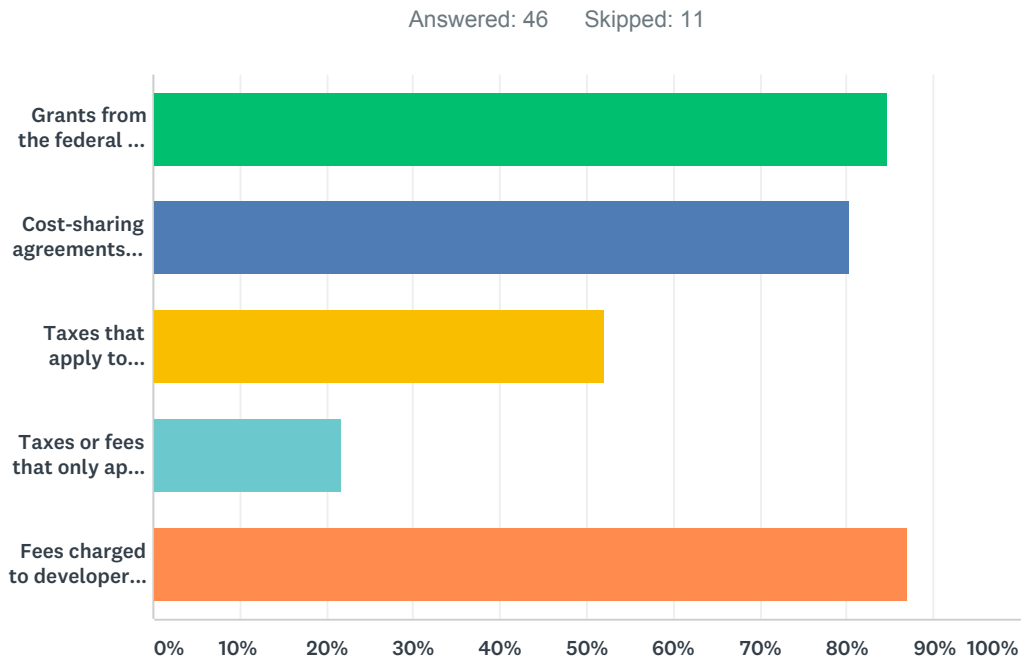


ANSWER CHOICES	RESPONSES	
Yes	91.11%	41
No	8.89%	4
TOTAL		45

#	COMMENTS	DATE
1	Yes but we should recognize the cost of dikes the same way we recognize the extra cost of sewer and water when building on the hillsides.	9/15/2017 11:05 AM
2	What materials will be used in dike construction, Rock, gravel earth, etc will not reduce flooding risk for very long!	9/15/2017 10:47 AM
3	Be always mind full of the danger of climate change and be pro active.	9/15/2017 10:45 AM

4	Dikes are infrastructure just the same as higher cost servicing for upland areas are infrastructure -- to be paid by the taxpayers/ ratepayers. There should be no bias against development on the uplands from the way we consider infrastructure costs. We must reduce the development pressure on the valley bottom.	7/14/2017 11:01 PM
5	No more taxpayer money on dykes. You can't stop natural hazards; or shouldn't try. Buyer beware if they build in the flood plain. DOS should prioritize new development to be in the higher lands if they want blind safety.	7/11/2017 3:07 PM
6	Need to consider business	6/27/2017 6:57 PM
7	However, the DOS Council needs to look at the actual design standard these dikes are proposed to be built to. The size and setbacks proposed are incredibly conservative. They adhere and exceed to Provincial guidelines that other municipalities have balked at because someone in their department understood the value of land vs risk. This plan will significantly sterilize a lot of land. A smarter approach would be to phase the super dike and look at alternative construction methods that consider cost of construction vs land (and tax base) that will be lost.	6/27/2017 11:29 AM
8	Developers need to pay for dike upgrades NOT taxpayers	6/27/2017 11:20 AM
9	Totally agree with less dyke and more focus on building stronger flood worthy buildings. It will flood and it will get our buildings wet. How do we prevent damage from the water is the question. Not preventing the water from coming.	6/27/2017 10:53 AM
10	I don't think we should be spending money upgrading anything BEYOND provincial standards. I think the community as a whole has quite a high risk tolerance.	6/26/2017 5:30 PM

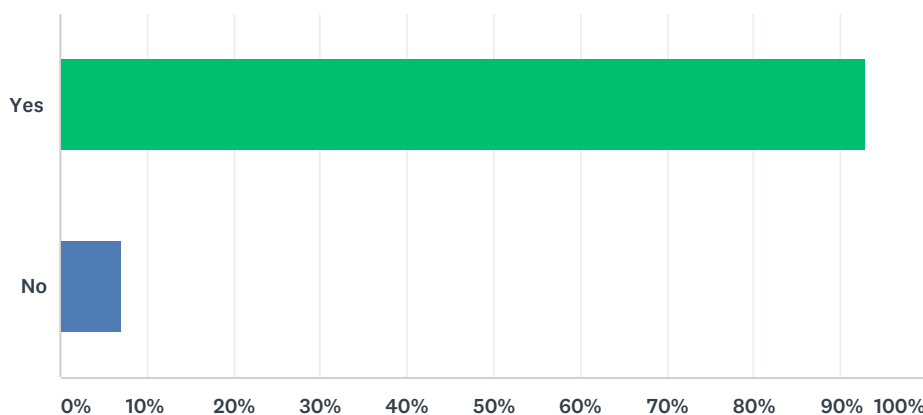
Q5 The IFHMP recommends a prioritized list of dike upgrades. Some upgrades will be expensive and may take several decades to build. Building and paying for the upgrades may be a challenge, so the District must start planning immediately. The District can raise the necessary funds in different ways. Please tell us which funding approaches you agree with for flood risk management in Squamish (check all that apply):



ANSWER CHOICES	RESPONSES	
Grants from the federal and provincial governments	84.78%	39
Cost-sharing agreements between the District and federal / provincial governments	80.43%	37
Taxes that apply to everyone in the District (since everyone uses services in the floodplain)	52.17%	24
Taxes or fees that only apply to people who own property in dike-protected areas	21.74%	10
Fees charged to developers who will profit from new developments located in the floodplain	86.96%	40
Total Respondents: 46		

Q6 The IFHMP recommends site-specific requirements for new developments. They include new Flood Construction Levels, setbacks from creeks and rivers, erosion protection for foundations and floodproofing fill, and a restrictive covenant on property title. These 'on-site' measures are designed to reduce the consequences of flooding for new development. Do you agree with these on-site measures for managing flood risk in Squamish?

Answered: 42 Skipped: 15



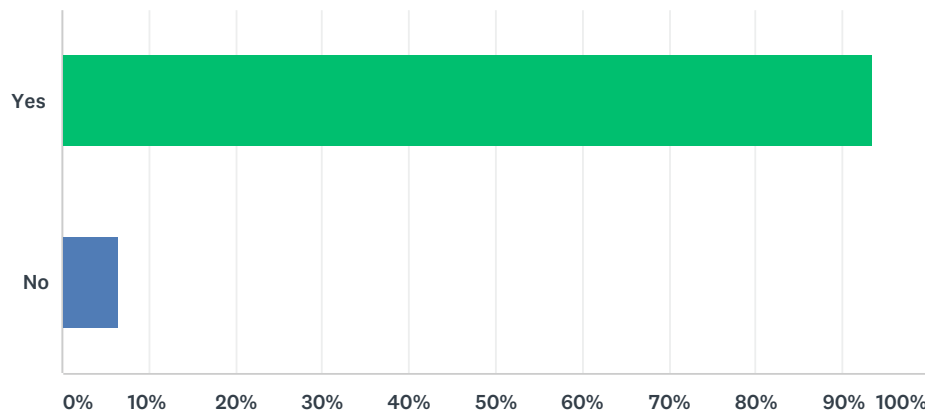
ANSWER CHOICES	RESPONSES	
Yes	92.86%	39
No	7.14%	3
TOTAL		42

#	COMMENTS	DATE
1	Perhaps needs a finer lens applied...	9/15/2017 10:50 AM
2	Covenants are to enforce, caution should be taken in approving any new development in high risk flood zones.	9/15/2017 10:42 AM
3	Yes, but we need to make special consideration of employment/ industrial lands -- not make these lands too expensive for jobs investment.	7/14/2017 11:02 PM
4	Absolutely not! Once again, individual landowners should be well-informed of potential risk, but NOT restricted from doing what they want at their own liability!	7/11/2017 3:10 PM
5	Don't allow new development that is greatly taller than existing homes, it ruins the feel of a neighbourhood and ruins views.	6/27/2017 9:12 PM
6	However, I think there are ethical questions in a third-party owning the model used to analyze these FCLs. Engineering staff within the DOS should be able to manage this information and monitor it in conjunction with the GIS department (which does a tremendous job). This is a lost revenue stream for the DOS which should have the capability to run these models internally.	6/27/2017 11:31 AM

7	We need to focus on the fact that the river will shift naturally. It needs to in order for it to form its path. We need to stay out of the way by taking out the dyked and letting the land shift. If we build we need to consider that land we build on may be in the river some time in the future. The entire basin needs to evolve and let the river snake. Some areas will dissapaeear and other areas will be built up. We need to allow this to happen. Either move squamish above and possible flood or be prepared to shift with the land and river.	6/27/2017 11:02 AM
8	As long as the on site measures don't simply transfer the risk to existing developments/properties	6/27/2017 10:42 AM
9	Yes - however these needs to be carefully managed and balanced. Development in Squamish today is very expensive with all of the fees and charges already imposed. As long as the requirements are well understood at the beginning of a project and don't change throughout, good decision should be able to be made.	6/26/2017 5:32 PM

Q7 Downtown Squamish is a very important business hub for the community. The District has historically allowed non-residential development (e.g., stores, restaurants and warehouses) to build at ground level (below the flood construction level) within the downtown area. The IFHMP continues the historical flood construction level exemption for non-residential development. However, new developments will need to use flood-resistant building materials and a restrictive covenant will be required on title to ensure that future owners understand the risks. Do you agree with this approach for non-residential development?

Answered: 46 Skipped: 11



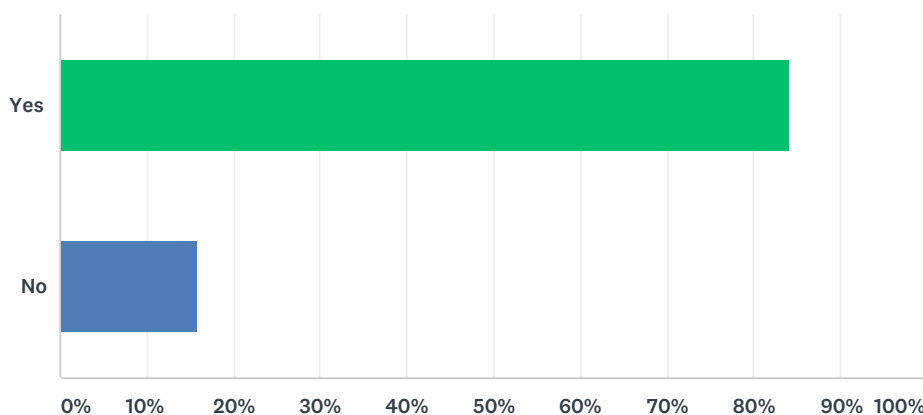
ANSWER CHOICES	RESPONSES	
Yes	93.48%	43
No	6.52%	3
TOTAL		46

#	COMMENTS	DATE
1	Exemption yes, but it should not apply to the Ocean Front.	9/15/2017 11:06 AM
2	What will force landowners to upgrade	9/15/2017 10:53 AM
3	How do you get developers to comply	9/15/2017 10:48 AM
4	Only if other employment lands areas are given similar treatment -- BCR Yards and Business Park.	7/14/2017 11:04 PM
5	This policy should be allowed throughout the community.	7/11/2017 3:12 PM
6	Yes and maybe. I am curious if it could actually reduce the businesses insurance costs by using flood-resistant building materials. Maybe this would soften blow. I am a bit concerned if this would be a deterrent to small businesses that are the heart of the community. I do think the restrictive covenant is a good thing to have.	6/30/2017 3:47 PM

7	This approach should be expanded to some other areas as well, specifically Brackendale, where redevelopment of the commercial areas will have significant negative impacts on that area when they do choose to redevelop. This flexible approach will balance flood risks with human interaction and healthy public spaces.	6/27/2017 11:33 AM
8	Building in the downtown area is a high risk. When the river changes there will be the loss of land mass and access. Building there means that those buildings need to be floatable and not risk contamination of the waters.	6/27/2017 11:06 AM
9	Yes - please do not make new commercial development build 1-2m above the rest of the downtown.	6/26/2017 5:33 PM
10	Not sure the building materials will be flood resistant (electrical primary and distribution, drywall, insulation) but concrete would be preferable.	6/26/2017 3:26 PM
11	restrictive covenants are very hard to uphold and after two or three changes in ownership the details of the covenant often get lost. I think the DOS should take a very aggressive approach towards limiting new development all together in the downtown if these new structures will be posing potential flood risk.	6/26/2017 3:07 PM

Q8 The IFHMP recommends that densification (i.e., rezoning) be controlled at three different levels: Properties located in Restricted Densification Areas (coloured red) should not be rezoned for additional density. Growth may still occur through infill development. Rezoning that concentrates the density allowed under existing zoning into a smaller part of the lot is also acceptable. Properties located in Conditional Densification Areas (coloured yellow) can be rezoned for additional density if the development proposal complies with a list of conditions established by the IFHMP. Properties located in Limited Densification Areas (coloured brown) may be rezoned up to a maximum density of 29 units per hectare (RS-2 Duplex Zoning). Development proposals must also meet all requirements for Conditional Densification Areas. The intention of this recommendation is to limit an increase in flood risk over time, while supporting growth that enhances the ongoing livability of Squamish. Do you agree with this approach?

Answered: 44 Skipped: 13



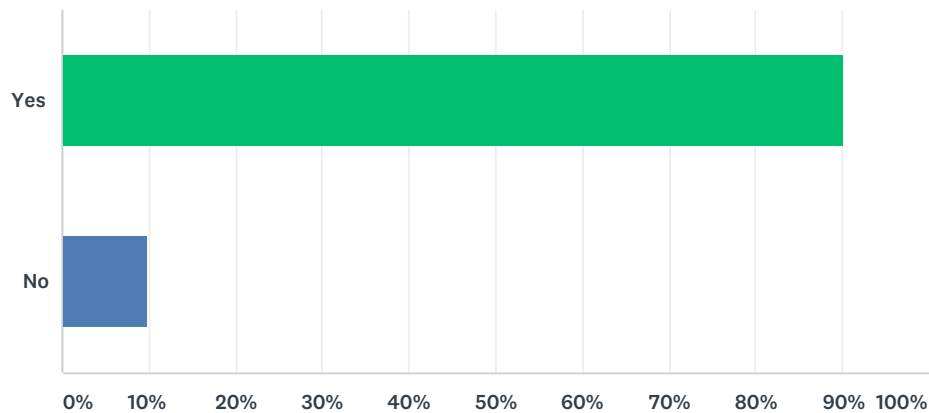
ANSWER CHOICES	RESPONSES	
Yes	84.09%	37
No	15.91%	7
TOTAL		44

#	COMMENTS	DATE
1	Specifically the area of Loggers Lane - why the discrepancy?	9/15/2017 11:06 AM
2	Except for item 1. That encourages disaster if people are allowed to build	9/15/2017 10:48 AM
3	The treatment of Loggers Lane east side and Edgewater in North Yards subdivision seem to suggest favouritism to housing developers. What is the explanation?	7/14/2017 11:05 PM
4	Very proactive.	6/30/2017 3:49 PM

5	This appears to be heavily influenced by active or proposed building developments. The restrictions should follow the evidence based approach and risk filter regardless of planned development	6/28/2017 4:38 PM
6	Encourage higher ground densification, not low lying next to existing less dense neighbourhoods	6/27/2017 9:16 PM
7	Kinda agree... We need to stop trying to prevent the natural course of nature and provide the scenario of how the river system will change in the flood areas. Some areas may now be permanently dry with no future risk of being reclaimed by the river. Those areas we build. The land that is in the natural course of the river movement needs to be used with temporary or left as a natural flood plane. Building in the path of the river movement causes more problems than we are prepared to mitigate. Examples like Brandon Manitoba are likely when you build right in the path of a river. The river needs to move over time and historical and geological indicators will tell us where not to build.	6/27/2017 11:36 AM
8	However, how does this align with smart growth principles and densification within flat, public transport serviced areas? Does this mean the District will be encouraging expansion into areas of higher elevation? How will those areas be developed with steep slope development seeing more and more regulation? What about the ESA's identified in those areas? Which policy takes priority? Some direction MUST be outlined within the IFHMP and OCP otherwise these conflicting statements will cripple the progress of our town.	6/27/2017 11:35 AM
9	yes - however when looking at the community as a whole there are challenges with other areas too. if squamish is planning to grow - where is that happening. floodplain vs. greenfield expansion. there are pros and cons to each but if we too strictly limit floodplain development - we will be left with a sprawling community that has no heart.	6/26/2017 5:35 PM
10	The area along the mamquam river in the North Yards should be a Conditional Densification area not a "limited"	6/26/2017 3:16 PM
11	Limited or no further growth within the red zoned areas should be strictly adhered to in order to prevent future risk	6/26/2017 3:08 PM

Q9 Do you think that the IFHMP has done an adequate job of identifying risks, options, and recommended approaches for managing flood risk in Squamish?

Answered: 41 Skipped: 16

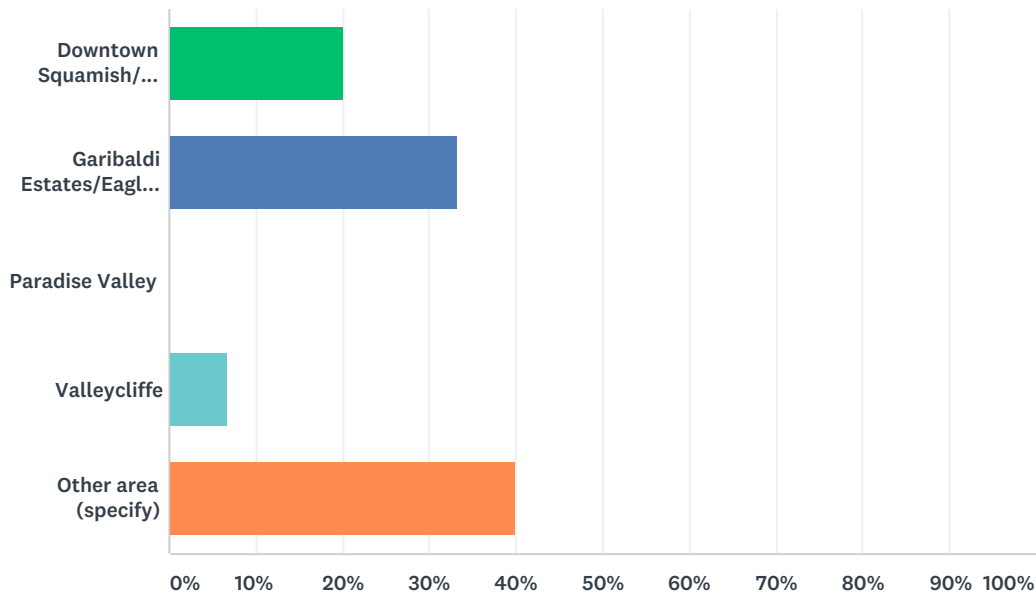


ANSWER CHOICES	RESPONSES	
Yes	90.24%	37
No	9.76%	4
TOTAL		41

#	COMMENTS	DATE
1	The plan is very detailed	9/15/2017 10:54 AM
2	Way overboard. Creating too much paranoia for a very infrequent event and portraying the potential damages as much higher than they actually are. We could do all of the recommendations and still be wiped out by nature. If it happens, it happens. Stop trying to play God so much (on behalf of taxpayers).	7/11/2017 3:18 PM
3	With an asterisk. Seems to be influenced by development community in many places (example: new developments off loggers lane	6/28/2017 4:40 PM
4	Need more consideration for businesses. Seems very risk averse, which I understand in part, but it's too black and white	6/27/2017 7:01 PM
5	I think it has identified the areas of flooding. By trying to protect the buildings with a dyke is just setting up squamish for a disaster in the future and making us pay for a dyke and maintaining it is a band aid solution. Relocation of properties to better no flood locations would be the best long term solution. Legal action aside...I live in the red zone.... And right in the path of where the river should be today. I would be willing to move to higher ground. Perhaps if i was informed of the flood zone or the fact the river will eventually take over my property I would have done that move sooner.	6/27/2017 11:45 AM
6	More than adequate, the IFHMP takes a very conservative approach to risk.	6/27/2017 11:36 AM
7	it is an excellent document. how it is put into practice will be interesting to see.	6/26/2017 5:35 PM

Q10 Do you have any comments about the proposed mitigation plan for the following areas:(check applicable area)

Answered: 15 Skipped: 42



ANSWER CHOICES	RESPONSES	
Downtown Squamish/ Dentville	20.00%	3
Garibaldi Estates/Eagle Run/Brackendale	33.33%	5
Paradise Valley	0.00%	0
Valleycliffe	6.67%	1
Other area (specify)	40.00%	6
TOTAL		15

#	OTHER (PLEASE SPECIFY)	DATE
1	as per no 8 and comments there. At Loggers Lane Brennan Park area - discrepancies east-west	9/15/2017 11:07 AM
2	I'm concerned about the consequences of the Daisy Lake dike breaking in an earthquake and the Judd Road dike condition	9/15/2017 10:52 AM
3	Loggers Lane in Brennan Park area -- don't understand why so much housing is encouraged here.	7/14/2017 11:06 PM
4	Brackendale is particularly vulnerable a breach would Cause large prop damage and loss any development would require proper engineering	6/30/2017 5:50 PM
5	Loggers lane new housing area	6/28/2017 4:41 PM
6	No rezoning changes for properties adjacent to the Brackendale dikes, as this will allow more 'safety' for the community within	6/27/2017 3:16 PM
7	If you build the sea dike downtown as you have proposed, what is the proposal to deal with stormwater and what happens if you have a dike breach off the mamquam? Can you mitigate that?	6/26/2017 3:30 PM
8	My comments are for all the areas and the proposed mitigation plans should respectively ensure no increase in risk to existing structures and proper design and construction to ensure future development is not subject to flood related risks.	6/26/2017 3:09 PM

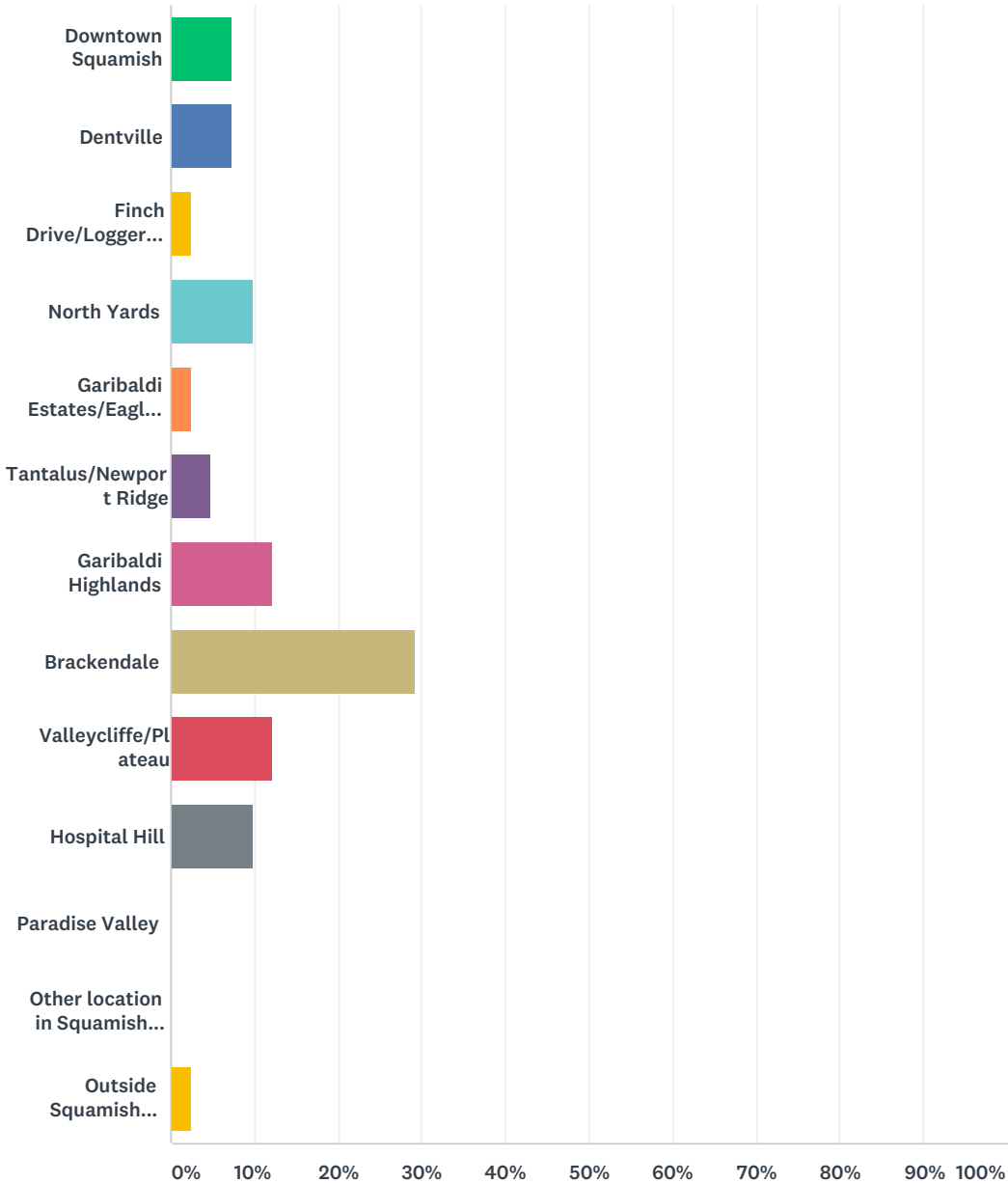
Q11 Please provide any other general comments you may have about the IFHMP.

Answered: 16 Skipped: 41

#	RESPONSES	DATE
1	Yes, the Open House meetings were quite informative	9/15/2017 11:07 AM
2	Very long term plan – how will future knowledge and experience be incorporated	9/15/2017 10:54 AM
3	Where do we evacuate to if there is flooding in my area – Birken Rd	9/15/2017 10:52 AM
4	Excellent work by Engineering Department.	7/14/2017 11:08 PM
5	Did you also look at the approach of the Netherlands for flooding danger? The situation is similar, also rivers and the sea They also made it possible for the water of the rivers to flood in meddows, so that the amount of water reduces. I am not an engeneer but also live in the Netherlands.	7/13/2017 10:48 AM
6	These reports and many other recent engineering requirements are simply insurance driven scams. Now instead of insurance, we pay up front and via massive mortgages. Rare events happen and through history we pick up the pieces and move on. Restricting potential housing supply and adding excessive construction costs (via very rarely used protectionary measures) really needs to be given a second thought and brought back to reality.	7/11/2017 3:25 PM
7	The developments in brackendale would possibly be the hardest impacted So should be properly planned out	6/30/2017 5:51 PM
8	After reading the book "the wave" by Susan Casey, we purposely looked at settling in Hospital Hill due to it being on a hill and not at sea level. I think the IFHMP is in the best interests of this community. Some might not like the suggestions put forward but the reality is that sea levels are rising and we need to have a big, bold approach to make sure that risks are minimized. Thanks for doing this.	6/30/2017 3:53 PM
9	Great work so far. Needs to hold standard absent considerations from special interests	6/28/2017 4:41 PM
10	As densification increases in garibaldi highlands, please consider a new route for south bound access that does not include tantalus / garibaldi way intersection unless a light is put at that intersection.	6/27/2017 9:20 PM
11	I hope you are consulting with the businesses who are directly affected. I also hope you are not being too risk averse. We live in a crazy location and businesses should be able to accept some risk if buildings are not for habitation	6/27/2017 7:02 PM
12	New Development in flood hazard areas that are protected by correctly designed dikes, adequate FCL, etc are safer than existing historic development in these areas and should be encouraged not discouraged. The majority of Squamish is in the flood plain, get used to it and design accordingly.	6/27/2017 3:54 PM
13	The river needs to be let back to its natural course and we need to figure something else out to adjust our way we live and build, not try to alter mother nature. This will actually advance us as a civilization and not keep us stagnant. We need to thi k in other terms of development nomadically and not fixed. This is the correct type.of.start but we need to put the river first and.the possibility of flooding...	6/27/2017 11:48 AM
14	I urge Council, Planning and Engineering to take some sober second thought with this plan. Look at the economic impact of the space required for the various proposed dikes and see where reducing the amount of space required would be justified by the value (taxable base) that land provides.	6/27/2017 11:38 AM
15	please make the recommendations realistic. If the plan is going to cost \$80M - then the likelihood of it being fully implemented is poor. let's take a stepped approach. make it reasonable and doable. just because you have a high standard in writing does not make anyone any safer if nothing gets built...	6/26/2017 5:37 PM
16	I think the District and KWL have done a good job with the IFHMP.	6/26/2017 3:31 PM

Q12 Where do you live?

Answered: 41 Skipped: 16



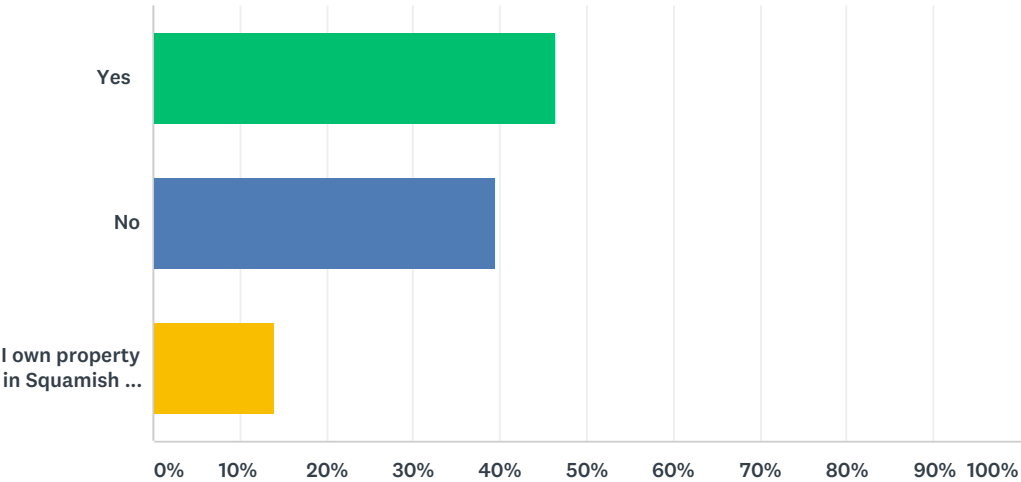
ANSWER CHOICES	RESPONSES	
Downtown Squamish	7.32%	3
Dentville	7.32%	3
Finch Drive/Loggers Lane	2.44%	1
North Yards	9.76%	4
Garibaldi Estates/Eagle Run	2.44%	1
Tantalus/Newport Ridge	4.88%	2

Garibaldi Highlands	12.20%	5
Brackendale	29.27%	12
Valleycliffe/Plateau	12.20%	5
Hospital Hill	9.76%	4
Paradise Valley	0.00%	0
Other location in Squamish (specify)	0.00%	0
Outside Squamish (specify)	2.44%	1
TOTAL		41

#	OTHER (PLEASE SPECIFY)	DATE
1	We have a house in Brackendale and in the Netherlands	7/13/2017 10:49 AM
2	Work in Squamish and hope to live here someday.	6/27/2017 3:55 PM

Q13 Do you own property in the floodplain?

Answered: 43 Skipped: 14



ANSWER CHOICES		RESPONSES	
Yes		46.51%	20
No		39.53%	17
I own property in Squamish but am not sure if it is in the floodplain		13.95%	6
TOTAL			43

Q14 I would like to learn more. My email address is:

Answered: 10 Skipped: 47

#	RESPONSES	DATE
1	m_schoonheim@hotmail.com	7/13/2017 10:50 AM
2	hush_tal@hotmail.com	7/11/2017 3:27 PM
3	mike@mdms.org	7/8/2017 4:09 PM
4	Mike@mdms.org	7/7/2017 10:27 PM
5	wallyolsen@shaw.ca	7/3/2017 7:47 AM
6	Jeff.j.mackey@gmail.com	6/28/2017 4:42 PM
7	Mgb067@telus.net	6/27/2017 6:12 PM
8	Candorequestrian@gmail.com	6/27/2017 3:19 PM
9	allegracairns@gmail.com	6/27/2017 11:59 AM
10	Poburan@hotmail.com	6/27/2017 11:49 AM

Q15 Please have someone contact me about the following (I understand I may not receive an immediate reply):

Answered: 3 Skipped: 54

#	RESPONSES	DATE
1	Clarification of the Restricted Densification Area adjacent to Judd Creek.	7/8/2017 4:09 PM
2	Not necessary	7/3/2017 7:48 AM
3	Yes please via email	6/27/2017 11:55 AM



KERR WOOD LEIDAL
consulting engineers

Appendix C

Skwxwú7mesh Úxwumixw (Squamish Nation) Perspectives

- C1. Letter from Skwxwú7mesh Úxwumixw re: Comments on Draft IFHMP Presentation**
- C2. Transcription of verbal information shared by Xwélxwelacha Siyam (Chief Richard Williams) re: impacts of dikes on the Squamish Nation and its peoples**



To: District of Squamish (DoS)
Re: Integrated Flood Hazard Management Plan – Skwxwú7mesh Úxwumíxw (SN)
Comments on the June 26, 2017 Presentation

On June 26, 2017 the SN was provided with a presentation of the IFHMP by Gary Buxton, Chris Wykam and Dave Roulston, on behalf of the DoS. Below are the comments of the SN to the presentation and the final report.

Historic Consequences of the Current Dike Alignment and Construction Methods

The SN would like to see a statement on the effects the previous dike strategy and work has had on all SN Reserve Lands that have diking infrastructure on or through them. In particular, the Siyí7ch'em (Seaichem) I.R. No. 16, and the cemetery at Wíwk'em (Waiwakum) I.R. No. 14. Further we would like an acknowledgement of how the accepted construction methods of the day impacted fish and other marine animal habitat; specifically the reduced flows in Jimmy Jimmy Slough, the side channels in Kewtin (Kowtain) I.R. No. 17 and Yekw'ápsen, (Yeakwapsem) I.R. No. 18 & I.R. No. 19, the diversion of the Mamquam River, and the reduction of fresh water flow through the estuary.

Right of Way (ROW) Through Reserve Lands, DoS and Public Dike Access

The SN has a no loss of land policy for its Reserve Lands. The SN is not ceding any of its authority on Reserve Lands through the IFHMP.

As noted in the report there is not currently a ROW agreement for the portions of dike that are on Reserve Lands. The SN would like to see the DoS engage in discussions with our Rights and Title Team to further discuss ROW; contact can be made through our Intergovernmental Relations, Natural Resources and Revenue (IRNR&R) Division.

In addition it is noted there is not an agreement for the DoS to access the dikes on Reserve Lands for maintenance, repair, emergency or public access. We would like to enter into further discussion on; maintenance, repair, emergency access and appropriate signage to note these are private lands and accessed at one's own risk. The SN would like to see the DoS engage in discussions with our General Operations Team to develop a working understanding of this access. Contact can be made through Austin Chandler, Manager Community Operations - Squamish Valley Operations.

Projects to Improve/Upgrade the Dike System

The SN acknowledges and understands that the existing dike system is not up to current standards of protection. The SN does not support a super dike concept at this time.





All dike projects will be reviewed on a project by project basis; blanket approval will not be provided. In addition, any scope changes in an approved project will be required to be reapproved by the SN. Final approval for all projects requiring SN approval will be given by SN Chiefs and Council through a Band Council Resolution (BCR). Regarding the design and construction of any upgrades or new dike systems, the SN would like to highlight the following:

On Reserve

To be an equal participant with the DoS in all planning and design work. Further that each project on Reserve Lands have a component of: land recovery, fish habitat creation or revitalization, a limit on public access and additional Reserve Lands protection (i.e. cemetery on Waiwakum). The General Operation Team will be the administrative lead on this and may call on other divisions for assistance.

Crown Lands

For any projects on Crown Lands, that the Rights and Title Team be contacted for review and approval of the crown land use. That the project plans and design work be reviewed by the General Operations Team for comment. In addition, the SN would like to see an agreement developed regarding the scalping/dredging of creeks, streams, rivers and sea water ways/areas. This agreement would start with the Rights and Title team.

Fee Simple and DoS Lands

For any fee simple and DoS lands that the project planning and design work are reviewed by the General Operations Team for comment. Further, where the SN is the owner of the fee simple land, that the appropriate SN authority of the land be contacted for review and comment.

Private Dike Work

The SN would like assurance that the construction of Private Dikes within the DoS will be subject to all required approvals and that there will be enforcement of approval processes and construction standards.

Miscellaneous

The SN would like to see;

The re-establishment of the channel on the west side of the Squamish River Valley across from the Eagle Run area,





That all flood hazard projects have a component of fishery revitalization in them,

That all flood hazard projects have a component of marine species habitat revitalization in them,

That the Blind Channel re-watering project be expanded to increase the flow of water,

That all further development of new material(s) for the IFHMP use Squamish Language place names within it, in addition to the English spelling.

Conclusion

In closing we would like to thank the DOS for the presentation and look forward to a section with the SN comments contained within the IFHMP. If there are any questions about our reply to the presentation please contact the undersigned.

chen kw'enman-túmi

(I thank you)

Skwxwú7mesh Úxwumíxw

CC: General Operations Team





The Effect of Dike Work on Skwxwú7mesh Úxwumixw (Squamish Nation) Lands and Economies from Íkwikws (Aikweks) I.R. No. 15, Siyí7ch'em (Seaichem) I.R. No. 16 and Waiwakum (Wíwk'em) I.R. No. 14

Pre April 1977 – District of Squamish (DoS) / Province Dike Work on the Squamish River

Oral Account by Xwélxwelacha siyam (Chief Richard Williams)

The below is information shared verbally by Chief Richard Williams. Chief Williams is both a hereditary Chief of the Squamish Nation (head of a family) and an elected member of Squamish Nation Council. The information shared is specific to the area from the southern boundary of Seaichem to the northern boundary of Waiwakum. It is presented as a Squamish Nation perspective on what the effects of the construction of the dike had on the Squamish Nation and its' people.

Pre – Squamish River Dike on Aikweks I.R. No. 15 and Seaichem I.R. No. 16
Seaichem

- 68 acres in size
- 7 Long Houses
- Hayfields
- Orchards
- Creek where pump house is now was southern boundary of the reserve

Aikweks

- Descendents of the “Flossy” and Squamish Jim (Sam George as well) families lived on Aikweks
- Fishing site where Jimmy Jimmy slough entered under transmission tower

Waiwakum

- Chief Jimmy Jimmmy slough was freshly watered where is started at the North West end of Waiwakum I.R. No. 14 and a thriving fish habitat area.

Dike Construction and “Improvements”

When the dike was constructed heading north along Judd slough the non rip rap material was excavated from the southern tip of Aikweks down towards toward Seaichem (the access road is now used to access “fisherman’s park” off of the dike). Culverts were originally installed at the northern end of the dike to allow the flow of fresh water through Jimmy Jimmy slough. The “water gate” and pumps were later constructed so that a bath tub effect from increased flow from the slough would not occur, the water could be let out. To further stop the bath tub effect the culverts at the start (northern end) of the slough were removed.





Results of Dike Work

The removal of material created a low area that impacted the river's ability to return to the west side of the valley. This resulted in the river flowing through the centre of the Seaichem reserve and the loss of approximately 58 acres of Reserve Lands. As this is determined by non Nation authorities to be erosion, no compensation for the loss of land was offered despite the actions of the dike construction creating the low area.

The removal of original culverts at the top of the dike created a low/no fresh water flow through Chief Jimmy Jimmy slough. As a result organic material was not able to be flushed out and the spawning areas became covered with leaves, soil and algae. The seepage of water into the slough through the water table does allow some fresh water, but not nearly enough to allow the slough, especially the area inside the dike ("Fisherman's Park" north) to be the salmon habitat area it once was.

Where a portion of the slough entered the Squamish River, immediately south of the water gate and pumps on the dike the Newman and Moody families had a fishing site, this was lost do to the methods used to direct the Squamish River and stop water from coming in behind the dike. The constructed dike stopped before the cemetery on Waiwakum, as such it did not protect the cemetery and the resulting erosion exposed grave sites.

Past Agreements between the DoS and Squamish Nation

For the construction of the dike through Reserve Lands no Squamish Nation approval was received. After the Construction of the Dike the Squamish Nation was appoache by the DoS to approve dike access for municipal workers only for the areas it ran through reserve lands. To date no one has been able to find a document confirming if such an agreement was signed.

The remainder of this page is left blank intentionally





KERR WOOD LEIDAL
consulting engineers

Appendix D

Report to Council for June 20, 2017 Meeting of District of Squamish Committee of the Whole (Excluding RTC Attachments)

REPORT TO: Council
REPORT FROM: Community Planning & Infrastructure
PRESENTED: June 20, 2017
SUBJECT: Final Draft Integrated Flood Hazard Management Plan Review

FOR: COW
FILE:

Recommendation:

That Council approve the following resolution(s):

THAT the Council receive the draft Integrated Flood Hazard Management Plan and associated policies for review and feedback.

1. Objective:

The Integrated Flood Hazard Management Plan (IFHMP) project team wishes to introduce the final draft Integrated Flood Hazard Management Plan for review and receive feedback on the associated policies prior to public engagement.

2. Background:

The District of Squamish is exposed to significant flood hazards from coastal and river flooding due to its location at the head of Howe Sound and the confluence of 5 rivers with mountainous watersheds. In response to significant community development and new flood guidelines issued by the Provincial Government, the District initiated the IFHMP to prepare a comprehensive flood management plan to manage flood risk and guide community development over the next development cycle. The project has been ongoing for the past three years and is now in the final phase of the plan. The phases of the plan include:

- (1) Background/Gap Analysis – reviewed existing diking and policy to evaluate gaps and areas of focus for later stages of the plan.
- (2) Coastal Flood Mitigation Strategy – evaluated coastal flood hazards and prepared plan to mitigate long term flood risk including development of a conceptual sea dike design taking anticipated sea level rise into consideration.
- (3) River Flood Mitigation Strategy – updated floodplain maps for river systems, evaluated consequences of river flooding and prepared plan to mitigate flood risk.
- (4) Integrated Flood Hazard Management Plan – compiles recommendations from first three phases into a final plan highlighted by a prioritized capital plan to upgrade flood protection systems (primarily dikes) and a comprehensive policy framework to guide community development.

The project has broken new ground in British Columbia in terms of flood analysis and policy development and is considered one of the most robust flood management plans in the Province. The project has included extensive community and Council engagement including

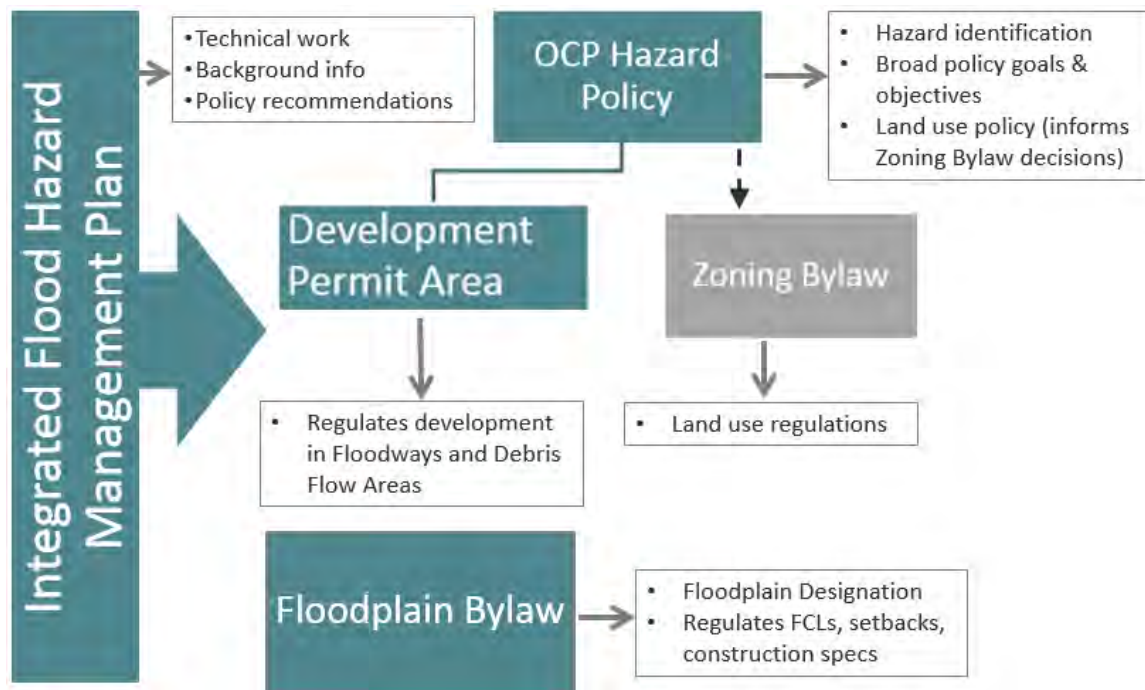
numerous Open Houses, online surveys, Council meetings, stakeholder workshops, bi-lateral meetings with Squamish Nation, and Technical Working Group meetings.

3. **Project Information:**

The project team has prepared a final draft IFHMP based on recommendations from the first three phases of the IFHMP which have been reviewed and accepted by Council. The final plan includes:

- (1) A robust policy framework highlighted by: Integrated Flood Hazard Management Plan, Official Community Plan Hazard Policy, a new Development Permit Area for Protection of Development from Flood-Related Hazards and a new Floodplain Bylaw.
- (2) A detailed and prioritized capital plan laying out long-term priorities for improving the District's flood protection systems.

The final policy framework is summarized by the following figure:



The final draft Integrated Flood Hazard Management Plan, OCP Hazard Policy, Development Permit Area and Floodplain Bylaw are included in Attachments 1-4 respectively.

Flood protection capital priorities have been based on a combination of likelihood of failure, consequence of failure, and cost. A high-level summary of the capital plan is as follows:

- (1) Rectify all existing dike deficiencies to Provincial Standards.
- (2) Extend sea dike to protect against current sea levels as soon as possible, phase further sea dike upgrades as funding permits and based on latest data and science.
- (3) Raise Squamish River Dike to a higher standard (higher, wider, stronger) due to the high consequence of failure.

A detailed, prioritized list of the recommended flood protection upgrades is included in Attachment 5.

Overall, implementation of the recommendations in the IFHMP will reduce community flood risk by reducing the probability of a flood occurring and reducing community consequences in the event of a flood.

4. Implications:

a) Budget:

The IFHMP includes long-term capital projects that are anticipated to take decades to complete and are estimated to cost over \$80M dollars. The IFHMP recommends pursuing senior government funding, including an annual allowance from municipal sources and completing dike upgrades in a phased manner to carry out these upgrades. The IFHMP also recommends evaluating the potential to establish a Flood Protection Utility, have new development fund a portion of dike upgrades with Community Amenity Contributions and implementing a Local Service Area tax that would require floodplain inhabitants to pay for upgrades that benefit them most directly.

The District is in a similar position as many other floodplain communities and the forthcoming Fraser Basin Council Lower Mainland Flood Management Strategy is conducting a detailed review of how Lower Mainland municipalities can fund large flood-related capital projects. The District should consider this and incorporate it into long term financial planning as more information becomes available.

b) Organizational Impact:

Recommended dike upgrades and policy implementation are anticipated to be completed with existing staff resources. Implementation of a new Development Permit Area will create additional review by District staff, however this is anticipated to be offset by reduced review work for standard building permit applications which will follow regulations in the Floodplain Bylaw rather than completing a site-specific hazard review for each application as has been the case for the past 20 years.

Policy:

There are three new policies proposed in the IFHMP as outlined in the report.

c) Environment:

The IFHMP has developed comprehensive mitigation plans with environmental protection and creating sustainable solutions as core guiding principles. There are many specific recommendations in the plan providing environmental protection, some examples include: new policy restricting buildings and fill within primary river corridors, establishing setbacks from watercourses, and constructing a sea dike using a Green Shores approach where environmental values are high.

d) Council Priority and Strategic Plan Alignment:

Priority Areas that are addressed by the IFHMP include: *Healthy Community, Economy and Environment*.

Specific goals and guiding principles within the priority areas above that will be met by this project include:

- a. Air quality, water quality, the environment and land are valued and protected.
- b. Minimizing our collective impact on climate change is considered through adaptation and mitigation strategies.
- c. The District leads the protection of our natural environment by focusing on: (1) Becoming a community that adapts to and mitigates climate change, and (2) Protecting and where possible enhancing natural spaces.
- d. The use of existing infrastructure is maximized.

e) **Citizen Engagement**

The District has undertaken extensive community engagement throughout the IFHMP including numerous Open Houses, online surveys, Council meetings, stakeholder workshops, bi-lateral meetings with Squamish Nation, and Technical Working Group meetings. Further consultation including a final Open House, online survey and meeting with Squamish Nation will be completed in the final phase of the plan.

f) **Implementation**

The District will finalize the IFHMP upon receiving community and Council feedback targeting a July 2017 completion date. The OCP Hazard Policy and Development Permit area will be implemented upon adoption of the new OCP while the new Floodplain Bylaw will be brought forward for readings and adoption following IFHMP finalization.

5. **Attachments:**

1. Final draft Integrated Flood Hazard Management Plan, Kerr Wood Leidal, June 7, 2017
2. Draft Official Community Plan Hazard Lands Policy
3. Draft Development Permit Area 2 – Protection of Development from Flood-Related Hazards
4. Draft Floodplain Bylaw
5. Draft Structural Flood Protection Upgrade – Priorities List

6. **Alternatives to Staff Recommendation:**

N/A

7. **Staff Review**

Prepared By:

David Roulston, P.Eng, Municipal Engineer

Reviewed By:

Chris Wyckham, P. Eng., Director of Engineering

Gary Buxton, General Manager of Community Planning and Infrastructure

Robin Arthurs, General Manager of Corporate Services, Recreation & Culture

CAO Recommendation:

That the recommendation of the Engineering Department be approved.



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Appendix E

Report to Council for October 3, 2017 Meeting of District of Squamish Community Development Standing Committee

(Excluding RTC Attachments)

REPORT TO: Council
REPORT FROM: Community Planning & Infrastructure
PRESENTED: October 3, 2017
SUBJECT: Integrated Flood Hazard Management Plan Adoption

FOR: CDSC

FILE:

Recommendation:

That Council approve the following resolution:

THAT the District of Squamish finalize and adopt the Integrated Flood Hazard Management Plan and begin implementation of the plan.

1. Objective:

To receive Council authorization to finalize and adopt the Integrated Flood Hazard Management Plan (IFHMP) and begin implementation of the plan.

2. Background:

The District of Squamish is exposed to significant flood hazards from coastal and river flooding due to its location at the head of Howe Sound and the confluence of five rivers with mountainous watersheds. In response to significant community development and new flood guidelines issued by the Provincial Government, the District initiated the IFHMP to prepare a comprehensive flood management plan to manage flood risk and guide community development over the next development cycle. The project has been ongoing for the past three years and is now in the final phase of the plan. The phases of the plan include:

- (1) Background/Gap Analysis – reviewed existing diking and policy to evaluate gaps and areas of focus for later stages of the plan.
- (2) Coastal Flood Mitigation Strategy – evaluated coastal flood hazards and prepared a plan to mitigate long term flood risk including development of a conceptual sea dike design taking anticipated sea level rise into consideration.
- (3) River Flood Mitigation Strategy – updated floodplain maps for river systems, evaluated consequences of river flooding and prepared plan to mitigate flood risk.
- (4) Integrated Flood Hazard Management Plan – compiles recommendations from first three phases into a final plan highlighted by a prioritized capital plan to upgrade flood protection systems (primarily dikes) and a comprehensive policy framework to guide community development.

The project has broken new ground in British Columbia in terms of flood analysis and policy development and is considered one of the most robust flood management plans in the Province. The project has included extensive community and Council engagement including numerous Open Houses, online surveys, Council meetings, stakeholder workshops, bi-lateral meetings with Squamish Nation, and Technical Working Group meetings.

The final draft of the IFHMP was presented to Council on June 20, 2017 for feedback. Following the presentation to Council, staff undertook the following engagement activities:

- 1) Presented the plan to a group of Squamish Nation Chiefs and core staff on June 26, 2017 for feedback and received additional written feedback (appended to final IFHMP report);
- 2) Conducted a third Public Open House on June 26, 2017 including a presentation of the plan and open-forum question and answer session; and
- 3) Completed a final online survey.

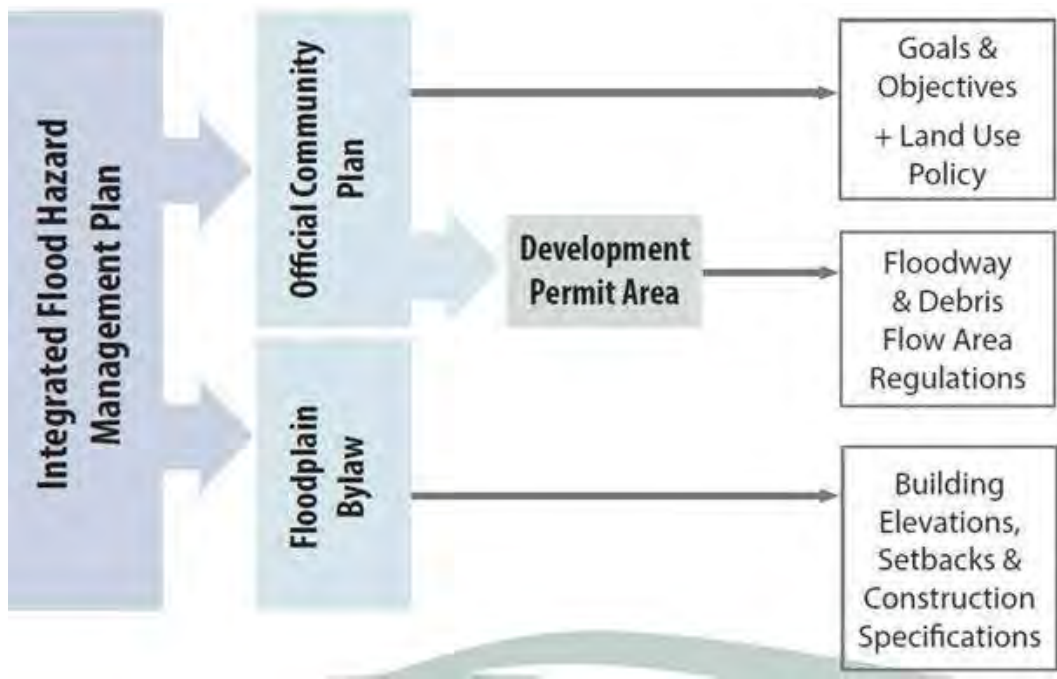
Overall, the final engagement has indicated strong support for the plan. Final feedback received in the engagement items listed above and from Council have been taken into consideration and incorporated into the final IFHMP.

3. Project Information:

The project team has prepared the IFHMP based on recommendations from the first three phases of the IFHMP which have been reviewed and accepted by Council. The final plan includes:

- (1) A robust policy framework highlighted by: Integrated Flood Hazard Management Plan, Official Community Plan Hazard Policy, a new Development Permit Area for Protection of Development from Flood-Related Hazards and a new Floodplain Bylaw (final draft policies included in final IFHMP).
- (2) A detailed and prioritized capital plan laying out long-term priorities for improving the District's flood protection systems.

The final policy framework is summarized by the following figure:



Flood protection capital priorities have been based on a combination of likelihood of failure, consequence of failure, and cost. A high-level summary of the capital plan is as follows:

- (1) Rectify all existing river dike deficiencies to Provincial Standards.
- (2) Extend sea dike to protect against current sea levels as soon as possible, phase further sea dike upgrades as funding permits and based on latest data and science.
- (3) Raise Squamish River Dike to a higher standard (higher, wider, stronger) due to the high consequence of failure.

A detailed, prioritized list of the recommended flood protection upgrades is included in the final IFHMP.

Overall, implementation of the recommendations in the IFHMP will reduce community flood risk by reducing the probability of a flood occurring and reducing community consequences in the event of a flood.

4. Implications:

a. Budget:

The IFHMP includes long-term capital projects that are anticipated to take decades to complete and are estimated to cost over \$80M. The IFHMP recommends pursuing senior government funding, including an annual allowance from municipal sources and completing dike upgrades in a phased manner. The IFHMP also recommends evaluating the potential to establish a Flood Protection Utility, have new development fund a portion of dike upgrades with Community Amenity Contributions and implementing a Local Service Area tax that would require floodplain inhabitants to pay for upgrades that benefit them most directly. These options are not decided with the adoption of the plan and will be reviewed further during the implementation of the IFHMP.

The District is in a similar position as many other floodplain communities and the forthcoming Fraser Basin Council Lower Mainland Flood Management Strategy is conducting a detailed review of how Lower Mainland municipalities can fund large flood-related capital projects. The District should consider this and incorporate it into long term financial planning as more information becomes available.

b. Organizational Impact:

Recommended dike upgrades and policy implementation are anticipated to be completed with existing staff resources. Implementation of a new Development Permit Area will create additional review by District staff, however this is anticipated to be offset by reduced review work for standard building permit applications which will follow regulations in the Floodplain Bylaw rather than completing a site-specific hazard review for each application as has been the case for the past 20 years.

c. Policy:

There are 3 new policies to be implemented following adoption of the IFHMP as follows:

- 1) Official Community Plan (including new Hazard section)

2) Development Permit Area for Flood Hazards

3) Floodplain Bylaw

d. Bylaws:

A new Floodplain Bylaw will be brought to Council for consideration as part of the implementation of the IFHMP.

5. Council Priority Areas

Environment:

The IFHMP aligns with the goals of the Strategic Plan by preparing policies and bylaws that include climate action policies that facilitate climate change adaptation and mitigation actions.

Economic Development

The IFHMP has created a policy framework through extensive community consultation that has identified community and economic development opportunities in conjunction with flood mitigation measures.

Healthy Community

The IFHMP has accomplished a strategic action item in Council's Strategic Plan by developing a climate change adaptation and mitigation strategy in consideration of anticipated sea level rise and more intense precipitation events. The IFHMP also aligns with the goals of the Strategic Plan by preparing policy that will result in Squamish being a more adaptable and resilient community.

Open and Transparent Government

The IFHMP has completed an extensive public engagement campaign at the 'Involve' level of the IAP2 participation spectrum. This has included:

- 3 public open houses
- 4 online surveys
- Several targeted stakeholder workshops
- 5 meetings with a Technical Working Group of regulators
- 12 open council meetings
- 4 workshops with Squamish Nation Chiefs and Council and staff

Further engagement has taken place as part of the Official Community Plan update and further engagement opportunity will be available as part of the proposed adoption of a new Floodplain Bylaw.

a) Implementation

The OCP Hazard Policy and Development Permit area will be implemented upon adoption of the new OCP while the new Floodplain Bylaw will be brought forward for readings and adoption following IFHMP finalization.

6. Attachments:

1. Integrated Flood Hazard Management Plan, Kerr Wood Leidal, September 13, 2017

7. Alternatives to Staff Recommendation:

THAT council provide additional feedback prior to adoption of the IFHMP.

8. Staff Review

Prepared By:

David Roulston, P.Eng. Municipal Engineer

Reviewed By:

Chris Wyckham, P. Eng., Director of Engineering

Gary Buxton, General Manager of Community Planning and Infrastructure

Robin Arthurs, General Manager of Corporate Services, Recreation & Culture

CAO Recommendation:

That the recommendation of the Engineering Department be approved.

Linda Glenday, CAO



KERR WOOD LEIDAL
consulting engineers

Appendix F

Draft District of Squamish Official Community Plan Section 11 – Objectives and Policies for Hazard Lands

11. Hazard Lands

The location, geology and topography of Squamish expose the community to a number of natural hydrological and geological hazards.

Squamish is located in the floodplain of the Squamish, Mamquam, Stawamus, Cheekeye and Cheakamus rivers and the low-lying coastal margin of Howe Sound. Nearly all of the commercial and industrial lands as well as the Downtown core and a majority of residential neighbourhoods are located in areas subject to flood hazards. Extensive diking and pump stations provide a significant level of protection for flood-prone areas of the municipality. The District's Integrated Flood Hazard Management Plan (IFHMP) provides an updated and comprehensive approach to flood management. The IFHMP outlines a combination of strategies to mitigate flood risk including protecting existing development, accommodating hazards for new development, avoiding development in the highest risk areas and encouraging growth in low risk areas. These strategies are depicted in Figure 11.1

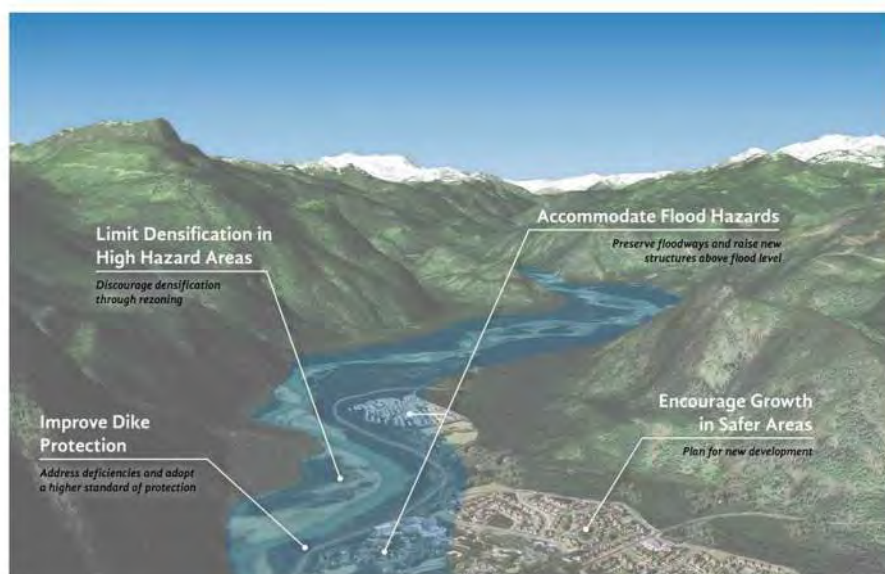


Figure 11-1 Flood Risk Mitigation Strategies

Squamish is situated at the head of North America's southernmost fjord, Howe Sound, and consequently is surrounded by mountainous terrain. Geological hazards faced by the community include debris flows, mass movements from landslides on steep slopes, rock fall and seismic hazards.

Finally, Squamish is surrounded by heavily forested terrain representing the Coastal Western Hemlock biogeoclimatic zone. The proximity of developed lands and forests result in wildfire interface hazard for some areas of the community. A Community Wildfire Protection Plan has been developed for the District. The intent is to create a 'FireSmart' community and to reduce the vulnerability of areas in the District to the threat of wildfires, which may also increase over time as climate change brings longer periods of less precipitation.

In BC, climate change is anticipated to result in increased temperatures, increased forest fire hazard, increased precipitation and more extreme precipitation events; all of which could increase the probability of hazardous events in Squamish. At the same time, continued growth and development will increase the potential consequences of these hazards for the community.

General Natural Hazards and Constraints

11.1 Objectives

- a. Assess and manage the multiple natural hazards in Squamish to maintain these risks within levels acceptable to the public.
- b. Minimize and mitigate the risk of loss of life, property damage and economic impacts from natural hazards, including:
 - i. Flood, erosion and tsunami hazards,
 - ii. Debris flow and debris flood hazards,
 - iii. Slope instability,
 - iv. Rock falls,
 - v. Snow and mud avalanches,
 - vi. Seismic hazards, and
 - vii. Wildfire hazards.
- c. Utilize strategies of protection, accommodation, avoidance and retreat as appropriate to mitigate natural hazards within the District of Squamish.
- d. Encourage growth in areas suitable for new development that are least vulnerable to natural hazards.

11.2 Policies

- a. Mitigate the risk of natural hazards to a level acceptable to the District of Squamish.
- b. Address natural hazards during the development application process for properties located within areas:
 - i. prone to flood and debris flow hazards identified in **Schedule D-1**.
 - ii. where there are steep slopes as identified in **Schedule E** as per the Local Government Act.

- c. Prohibit development in areas subject to unacceptable flood and debris flow hazards, rockfall, landslip, seismic, or other natural hazards as identified in policies within this section of the OCP.
- d. Require a hazard assessment prepared by a Qualified Professional in accordance with the District's 'Terms of Reference for Natural Hazard and/or Risk Assessments' for all land development applications located within a natural hazard area identified in **Schedule D-1** or as deemed necessary by the Building Inspector or Approving Officer.
 - i. Notwithstanding the above, hazard or risk assessments for building permit applications within flood hazard areas shall only be necessary as required by the Floodplain Bylaw, Development Permit Area 2 (DPA2) or as deemed necessary by the Building Inspector.
 - ii. Where a hazard assessment confirms that a development site could reasonably be within a landslide, debris flow, debris flood or rockfall runout area, subsequent risk assessments shall be required in accordance with the framework for flood risk assessments presented in in Appendix F of APEGBC Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC. The determination on whether a Quantitative or Qualitative Risk Assessment is required shall be determined by a Qualified Professional in consultation with the District and APEGBC guidelines and shall consider the type of hazard, size and type of proposed development and local site conditions.
- e. Utilize the following loss of life risk tolerance criteria if a Quantitative Risk Assessment is required as a minimum acceptable threshold for new development in areas subject to landslide, debris flow, debris flood or rockfall:
 - i. For existing development, the individual risk to loss of life per annum shall not exceed 1:10,000; and
 - ii. For new development, the individual risk to loss of life per annum shall not exceed 1:100,000; and
 - iii. Societal (Group) risk for loss of life per annum shall be within the Broadly Acceptable or As Low As Reasonably Practicable (ALARP) zones shown in Figure 11.2: Frequency – Number of Fatalities Diagram; and
 - iv. Where societal risks to life fall within the ALARP zone, the risk assessment report shall explain to the satisfaction of the Approving Officer why the cost of reducing the risk further is considered grossly disproportionate to the benefit gained (as per the definition of ALARP).

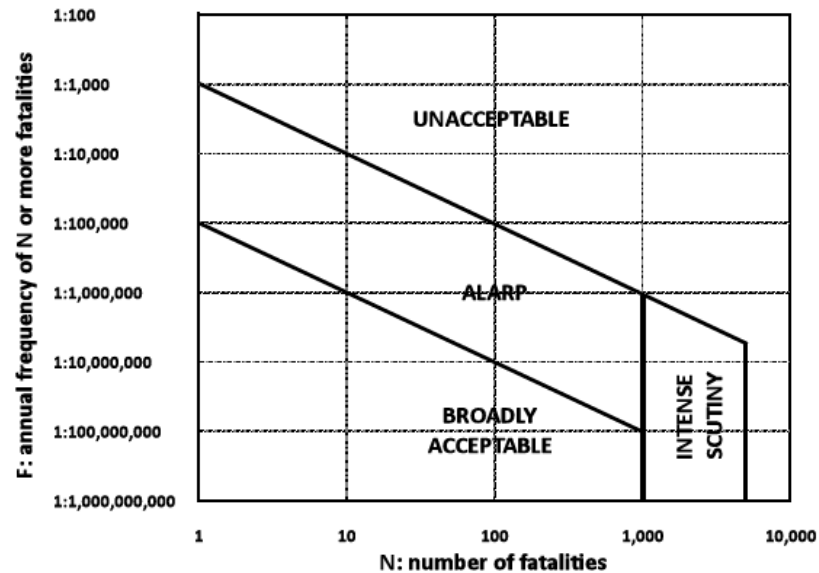


Figure 11.2 Frequency – Number of Fatalities Diagram

- f. Require a 'save harmless' restrictive covenant pursuant to Section 219 of the Land Title Act for any area of the community identified as being subject to natural hazards prior to rezoning, subdivision, development permit or building permit approval.
- g. Prohibit subdivision or rezoning of existing lots where future development requires FCL or Floodplain Setback exemptions under the Floodplain Bylaw.
- h. Update the Integrated Flood Hazard Management Plan (IFHMP) every 10 years to incorporate new information, updated requirements, updates in climate data and analytic tools, ongoing development and changing community priorities. Provide interim updates as necessary to incorporate specific changes in key areas of policy, science, and/or engineering.
- i. Develop and implement a comprehensive public education program concerning natural hazards and natural hazard mitigation, particularly about risks from flooding and wildfire. Simplify and streamline the availability of information for residents and developers.
- j. Decline operation and maintenance responsibility for new dikes not identified in the IFHMP that are proposed to support subdivision or rezoning applications on the basis that new dikes are "not in the public interest" as specified in the Land Title Act due to significant ongoing costs and maintenance responsibilities.
- k. Exempt non-residential uses in the Downtown FCL Exemption Area shown in Figure 11.3 from elevating above the required designated flood construction

level to preserve the historic streetscape, subject to provisions in the Floodplain Bylaw and as certified by a Qualified Professional.



Figure 11-3 Downtown FCL Exemption Area (shaded area)

- l. Designate, protect and acquire legal land tenure required for new dikes and upgrading existing dikes, including the future sea dike and a more robust standard for the Squamish River and Mamquam River south dike as shown in **Schedule B** of the Floodplain Bylaw. Land required for future dike purposes shall be kept free of development and infrastructure.
- m. Discourage the storage of environmentally harmful chemicals within flood hazard areas. To mitigate in circumstances where storage must or may be allowed, a Qualified Professional shall provide recommendations to contain the chemicals in the event of a flood.
- n. Develop a long term strategy for managed retreat from vulnerable areas which includes:

- i. opportunistically retreating existing development to restore adequate flood setbacks from watercourses; and
 - ii. prioritizing the removal of key facilities and critical infrastructure outside of flood hazard areas at the end of their current life cycle.
- o. Avoid siting new critical District facilities in areas with high risk from flood hazards.
- p. Avoid re-building of critical damaged infrastructure in areas inappropriate for the hazard.
- q. Development proposals shall incorporate safe refuge areas and/or secondary road accesses where the District determines that safe evacuation is not a realistic option.

Flood Hazard Management: River and Creek Hazards

11.3 Objectives

- a. Minimize and mitigate the risk of loss of life, property damage and economic impacts from river, debris flood and debris flow hazards.
- b. Reduce the community's vulnerability to flooding and improve community resiliency.

11.4 General Policies

- a. Acknowledge that flooding is the result of processes that occur at a watershed scale and take appropriate steps to monitor and advocate for responsible watershed management.
- b. Adopt dike crest elevations as defined in the IFHMP based on estimated water levels for the 1:200 year return period flood, with provision for freeboard and climate change.

11.5 Controlled Densification Areas Policies

- a. Acknowledge Controlled Densification Areas (Restricted Densification, Limited Densification, or Conditional Densification) as identified in **Schedule D-2**.
- b. Support park, open spaces natural habitat, recreational trail, greenway corridor, barrier-free public recreation, or agricultural uses in Controlled Densification Areas and Primary Floodways in **Schedule L-1** to provide flood relief and encourage permanent designation through a restrictive covenant.

- c. Restricted Densification Areas designated in **Schedule D-2** are not supported for rezoning and OCP amendments that increase development potential, such as an increase to permitted dwelling units, floor area ratio or height.
- d. Conditional Densification Areas designated in **Schedule D-2** are not supported for rezoning and OCP amendments that increase development potential, such as an increase to permitted dwelling units, floor area ratio or height, unless the following criteria are met:
 - i. The development is floodproofed in accordance with the Floodplain Bylaw, without exemptions, using the method deemed most appropriate by the developer's Qualified Professional.
 - ii. A continuous perimeter of erosion and scour protection is provided to prevent loss or damage of floodproofing fill and/or foundations during the design flood event.
 - iii. The increased development potential is confirmed to avoid adverse effects on the conveyance capacity of a Secondary Floodway identified in **Schedule L-1**. Adverse impacts are defined as increasing flood levels by more than 0.10 metres for any individual development and greater than 0.15 metres as the cumulative increase for all future developments as compared with flood modeling completed for the IFHMP.
 - iv. Any lands left at existing grade or intended to provide flood relief must receive permanent designation that prohibits future development or obstruction within those lands.
 - v. Unmitigated environmental impacts are avoided and the development preserves a 30 metre buffer to the natural boundary of all natural watercourses.
 - vi. Development does not create an unmitigated transfer of flood or erosion risk to neighbouring parcels due to re-directing floodwater from a river dike breach and/or changes in local hydrology or drainage patterns.
 - vii. If the development is proposed adjacent to the Squamish or Mamquam River south dike, the dike frontage is upgraded at the applicant's expense and a statutory right of way for the 1 in 500 year return period dike shown in the Floodplain Bylaw is provided.
 - viii. A Qualified Professional and Qualified Environmental Professional certify that the above conditions can be met.
 - ix. An independent third-party peer review on any or all of the above criteria is completed at the District's sole discretion at the applicant's expense.

- e. Limited Densification Areas designated in **Schedule D-2** are not supported for rezoning and OCP amendments that increase development potential, such as an increase to permitted dwelling units, floor area ratio or height, unless the application meets all of the requirements for Conditional Densification Areas listed in Section 11.5.d. and the proposed density does not exceed 29 units/hectare of net development area. To identify net development area:
 - i. Identify the total lot size.
 - ii. Assess the proposed development lot for constraints to identify land that cannot be developed.
 - A. Complete a site bio-inventory, riparian assessment, hazard assessment (excluding flood hazard) and any other review as required to identify any lands that are non-developable (non-development lands).
 - B. Identify any other non-development lands such as dike setbacks and statutory rights of way.
 - iii. Subtract the non-development areas from the total lot area to identify the gross development area.
 - iv. Subtract a 20% road allowance from the gross development area to identify the net development area.
- f. Apply the most restrictive designation to the entire property where all or part of a property falls within one or more Controlled Densification Area.
- g. Defer approval of any rezoning application or subdivision of more than 3 lots located in a Controlled Densification Area until upstream flood protection works meet APEGBC requirements for a 'standard' or 'adequate' dike.

11.6 Floodways Policies

Primary Floodways, illustrated in **Schedule L-1**, are corridors along main stem rivers that are not protected by standard dikes. Secondary Floodways, illustrated in **Schedule L-1**, are designated areas within a dike-protected floodplain that are critical for conveying floodwaters in the event of a dike breach. Development Permit Area 2 contains policies to preserve and protect the function of Primary and Secondary Floodways.

- a. Protect Primary Floodways along rivers identified in **Schedule L-1** to preserve flood conveyance, allow for natural river processes and maximize environmental productivity.

- b. Protect Secondary Floodways identified in **Schedule L-1** to preserve floodway conveyance capacity and avoid increasing hazards in upstream or adjacent areas.
- c. Deny requests for variances and/or site-specific exemptions to the Zoning Bylaw, Floodplain Bylaw and DPA 2 guidelines that could adversely affect floodway conveyance or increase flood levels in adjacent or upstream areas (i.e. by reducing building setback or increasing site coverage).
- d. Allow existing high-risk properties within Primary Floodways identified in **Schedule L-1** to remain privately owned, subject to regulations in the Floodplain Bylaw and Development Permit Area 2 intended to maintain Primary Floodways free of buildings, fill and other infrastructure.
- e. Undertake in-stream sand and gravel extraction when required for flood mitigation purposes in accordance with the Integrated Flood Hazard Management Plan and coordinate extraction activities with Squamish Nation, approving agencies and stewardship groups.

Flood Hazard Management: Coastal Flood Hazards

11.7 Objective

- a. Minimize and mitigate the risk of loss of life, property damage and economic impacts from coastal flood hazards.
- b. Plan for anticipated sea level rise as recommended in the IFHMP in order to minimize adverse impacts, facilitate adaptation to impacts that are already occurring or anticipated to occur and take advantage of new opportunities.

11.8 Policies

- a. Implement recommendations to upgrade existing sea dikes and construct new sea dikes to protect against coastal flooding caused by high tides, storm surge and sea level rise in accordance with the IFHMP Coastal Flood Hazard Mitigation Strategy including adopting the dike crest elevations and acceptable overtopping rates defined by the IFHMP.
- b. Adopt Provincial guideline recommendations to plan for 1 metre of sea level rise by Year 2100 and 2 metres of sea level rise by Year 2200.
- c. Support ongoing information gathering initiatives, including:
 - i. Collect coastal wind and water level data;
 - ii. Complete tsunami, aerial, and submarine landslide studies; and

- iii. Begin to build a Howe Sound Light Detection and Ranging (LiDAR) database.
- d. Update the Coastal Flood Hazard Mitigation Strategy and Flood Construction Levels at least every 10 years or as new information becomes available to reflect updated climate and sea level rise projections and development in the region.
- e. Explore opportunities to use leading-edge approaches like bioengineering erosion protection to safely combine hazard and risk mitigation with environmental stewardship.
- f. Participate in the Lower Mainland Flood Management Strategy to promote a collaborative and learning approach to adapt to sea level rise on BC's south coast.
- g. Employ a precautionary approach for planning in areas vulnerable to SLR by:
 - i. Directing development that is not already contemplated in the Growth Management Section of this plan away from areas vulnerable to sea-level rise and storm surge inundation;
 - ii. Encouraging recreational use and activities without infrastructure in these areas; and
 - iii. Adopting a precautionary approach for new coastal development by adopting and enforcing coastal setbacks in accordance with relevant Provincial guidelines in order to reduce hazard exposure and preserve space for future sea dike construction beyond 1 metre of sea level rise. Setback relaxations should only be considered on lots existing prior to adoption of this OCP in cases of significant hardship where meeting the setbacks would sterilize the land.

Cheekeye Fan Debris Flow Hazard

Existing development within the Cheekeye Fan area is currently exposed to debris flow hazard as identified on **Schedule D-1**. The 2009 OCP included policies to restrict permanent development in high risk zones and to mitigate risk in the remaining areas of the fan. In the process of Council consideration of fan-wide risk mitigation options in 2015, new information emerged regarding the potential extent of Cheekeye Fan hazard.

The Cheekeye Fan is considered a debris flow / debris flood hazard area and has been subject to extensive study. Past municipal policies designating the Cheekeye Special Study Area, restricting permanent development in high risk-zones and establishing other development controls on the remaining areas of the Fan (2009 OCP) have been reviewed and updated following the submission of

two Expert Review Panel reports in 2014 and 2015. The first report established the maximum credible debris flow event that the community should plan for while the second report provided recommendations for loss of life risk tolerance criteria. Both reports concluded that risk to existing development should be mitigated whether or not there is any future development on the Cheekeye Fan. The panels further reiterated that all forms of mitigation including engineered mitigation structures, land use zoning and education should be considered.

Currently, a development application has been submitted for large-scale development in north Brackendale on the Cheekeye Fan proposing funding and construction of area-wide mitigation including a debris flow barrier, sedimentation basin and possible other downstream mitigation measures. This application has been the impetus for considerable study and planning of a debris hazard mitigation structure and neighbourhood planning with associated community engagement and Council consideration. Significant design development and review are required prior to approval of this development and an area-wide mitigation scheme. However, if approved, with area-wide mitigation in place the District should review and update hazard mapping and development control policies to potentially consider further development on the Cheekeye Fan. Consequently, the following policies address objectives, policies and planning requirements for development on the Cheekeye Fan under multiple future scenarios including the status quo with no area wide mitigation in place and in the event that risk mitigation measures are implemented.

The Cheekeye Fan is an alluvial fan, a cone-shaped formation found in mountainous regions where deposits of alluvial (material transported by water) sediment and colluvial (material transported by gravity) material from debris flows and debris floods accumulate over time. Natural hazards common to this type of fan include stream floods, deposition of sediment, erosion of new channels, avulsions (a sudden shift in the channel of a stream or river) and debris floods and debris flows. Areas at risk typically extend well beyond existing river channels and often include the entire fan surface.

11.10 Land Use Policies in the Absence of Area Wide Mitigation

- a. Restrict any land subdivision, habitable space, or permanent buildings and structures within the Cheekeye Fan Debris Hazard Zones C1 and C2, identified in **Schedule D-1**.
- b. Process in-stream development applications for rezoning, subdivision, development permits and building permits, for which the District of Squamish accepted fees for prior to March 24, 2015, located within Debris Hazard Zones C3 or C4 identified in **Schedule D-1** of the OCP following submission of a risk assessment by a Qualified Professional that supports the applications and which meet the requirements outlined in Section 11.10.g.
- c. Process applications received after March 24, 2015 for minor and major repairs, extensions, reconstruction or new buildings and subdivisions up to and including 3 lots or 3 new dwelling units located within Debris Hazard Zones C3, C4 and C5

identified in **Schedule D-1** following submission of a risk assessment by a Qualified Professional that supports the applications and which meet the requirements outlined in Section 11.10.g.

- d. Do not process new applications received after March 24, 2015 for rezoning, and for subdivision greater than 3 lots or 3 dwelling units located within the Debris Hazard Zones C3 or C4 identified in **Schedule D-1** of the OCP until new hazard mapping and appropriate development controls are in place.
- e. Process applications for rezoning, subdivision greater than 3 lots or building permits for greater than 3 new dwelling units located within Debris Hazard Zone C5 identified in **Schedule D-1** following submission of a risk assessment by a Qualified Professional that supports the application and which meets the requirements listed in Section 11.10.g.
- f. Process development applications for open space uses, outdoor recreational uses and *Restricted Industrial* uses on the Cheekeye Fan, following submission of a risk assessment by a Qualified Professional that supports the applications and which meet the requirements listed in Section 11.10.g. New municipal services and permanent buildings are not permitted in association with these uses.
- g. Require that risk assessments by a Qualified Professional to support applications within the Cheekeye Fan meet the District's Terms of Reference for Natural Hazard and/or Risk Assessments and the following minimum requirements:
 - i. The QP must either have prior experience in performing risk assessments, or have had their risk assessment reviewed by another QP who has experience in performing risk assessments.
 - ii. The QP must use the magnitude - cumulative frequency relationship determined by Expert Panel #1.
 - iii. The risk assessment must incorporate multiple hazard events with probabilities up to and including the 1:10,000 year return period, 5.5 million m³ event.
 - iv. The risk assessment must comply with the framework laid out in Appendix F of APEGBC Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC.
 - v. Individual and societal risk to loss of life shall be assessed using Figure 11.2 and shall achieve the risk tolerance criteria in Section 11.2.e. to permit new development.
 - vi. On-site and/or off-site, developer-funded mitigation strategies shall be proposed, as required, to achieve the risk tolerance criteria in Section 11.2.e.

- h. Amend the District of Squamish Zoning Bylaw to implement OCP policies in this section that restrict the development of permanent structures in specific areas of the Cheekeye Fan in the absence of an area wide or partial fan structural mitigation strategy that has been accepted by Council and implemented.
- i. Due to the debris flow hazard exposure level of the Squamish Airport location, in the absence of an area-wide debris flow mitigation strategy that has been accepted by Council and implemented:
 - i. prohibit new land subdivision and long term leases at the Squamish Airport; and
 - ii. consider short-term and reversible approvals for leases and structures at the airport that exclude residential use and overnight accommodations and comply with recommendations of the October 21st, 2015 Kerr Wood Leidal Memorandum titled “Building Permits At Squamish Airport (Cheekeye Fan) Flood Management Approach” or updated Qualified Professional recommendations on the topic solicited by the District.

11.11 Cheekeye Fan Mitigation Objective

- a. Require that proposed area wide or partial fan structural risk mitigation proposals for the Cheekeye Fan debris flow hazard area address appropriate criteria as described in the following section.

11.12 Cheekeye Fan Mitigation Policies

- a. Ensure that a proposed area wide or partial fan mitigation strategy for the Cheekeye Fan debris flow hazard area includes:
 - i. Updated hazard/risk assessment studies and mapping prepared by a Qualified Professional and accepted by the District that clearly identifies areas impacted by the hazard and the baseline risk levels; and
 - ii. Confirmation that the risk tolerance criteria listed in Section 11.2.e. have been achieved.
 - iii. Detailed design of engineering structures by a Qualified Professional Engineer including applicable studies/reports and approvals by the District and all relevant Provincial and Federal agencies.
 - iv. Cost estimates and funding plans for all capital costs, operations and maintenance costs, restoration costs following a major event.
 - v. Land tenure securing operations and maintenance access for mitigation structures.

- vi. Establishing the maintenance authority and operations and maintenance requirements.
 - vii. Development control policies and land use strategies to maintain risk within tolerable levels for existing and proposed development on the Cheekeye Fan.
 - viii. Confirmation that under post-mitigation, post-development conditions, the combination of new mitigation and new development results in a net decrease of total risk to life on the fan.
- b. Require that hazard mitigation strategies associated with a proposed area wide or partial fan structural risk mitigation strategy for the Cheekeye Fan debris flow hazard area are implemented prior to subdivision approval to create three or more new lots of dwelling units within the Cheekeye Fan debris flow hazard area zones C1, C2, C3 and C4 identified in **Schedule D-1**.

11.13 Future Land Use Objective for Area Wide Mitigation Zone

- a. Develop a sub area plan and updated development policy including land use policies for the Cheekeye Fan in the event that Council accepts area wide or partial fan structural risk mitigation to ensure that risk is maintained within tolerable levels for any future proposed development.

11.14 Future Land Use Policies for Area Wide Mitigation Zone

- a. Amend the Cheekeye Fan development control policy framework in the OCP as appropriate if an area wide or partial fan hazard mitigation strategy and updated mapping is accepted by Council. The framework should address risk tolerance levels for new development including identifying a set of compatible land uses and conditions for new development to proceed.
- b. If an area wide or partial fan hazard mitigation strategy in accordance with Section 11.4.4 is accepted by Council for the Cheekeye Fan debris flow hazard area, require adoption of a sub area plan within the Cheekeye Fan debris flow hazard area zones C1, C2, C3 or C4 prior to consideration of applications submitted following the adoption of this OCP to:
 - i. amend OCP land use designations,
 - ii. rezone a property, or
 - iii. subdivide to create three or more new lots of dwelling units.
- c. Develop the sub area plan for land within the Cheekeye Fan debris flow hazard area in consultation with all relevant stakeholders through a collaborative process with the Squamish Nation.

- d. Develop the sub area plan in accordance with the Cheekeye Fan debris flow hazard mitigation strategy, land use policies and associated development controls accepted by Council. In addition to the sub area planning requirements outlined in the OCP the sub area plan should consider:
 - i. employment lands opportunities, including opportunities associated with the Squamish Airport;
 - ii. locations for uses outlined in Section 23.2.b. relating to a Forestry Land Strategy;
 - iii. joint servicing for existing First Nations reserves and other land uses in the area;
 - iv. buffering and development standards to address proximity of the Squamish Airport to First Nations reserves, residential development and employment land uses; and
 - v. changes to the Growth Management Boundary to reflect new development areas.

Steep Slopes

11.15 Objectives

- a. Manage development in steep slope areas in a manner that reduces the risk to life and property, prevents erosion and potential risks to down-slope properties, prevents destabilization of slopes and protects the aesthetics quality of the slopes.

11.16 Policies

- a. Where the natural grade of a slope on or adjacent to a proposed development site is equal to or greater than 25% as identified by **Schedule E** or the District's Building Inspector or Approving Officer, a slope stability assessment report prepared by a Qualified Professional may be required to identify any slope stability hazards, assess the safety of the site and propose any mitigation measures necessary to ensure the safety of the proposed development and existing neighbouring development.
- b. Do not considered lands where the natural grade of a slope on or immediately adjacent to a development site is equal to or greater than 25% for single-family residential development.
- c. Consider multi-family residential applications in areas where the natural grade of development footprints is a slope less than or equal to 40%, subject to a geotechnical assessment and endorsement by a Qualified Professional.

- d. Lands where the natural grade of a slope on or immediately adjacent to a development site is greater than 40% will not be considered for development.
- e. Develop a steep slope development permit area for the District of Squamish in consultation with relevant community partners.

Wildfire Interface Hazard

11.17 Objective

- a. Protect vulnerable areas of the community from existing and potential climate change induced wildfire interface hazard.

11.18 Policies

- a. Finalize the Community Wildfire Protection Plan. Plan for impacts of climate change on wildfire hazard to reflect projected changes to precipitation and temperature
- b. Develop and adopt a Wildfire Hazard Development Permit Area designation for wildland urban interface areas following completion of the Community Wildfire Protection Plan.
- c. In high risk interface areas, incorporate FireSmart guidelines for residential development, particularly with respect to building materials and landscaping requirement within a first priority 10 metre radius zone around structures.
- d. Encourage the provincial government and SLRD to initiate development of a comprehensive regional fire risk mitigation strategy.
- e. Promote a 'FireSmart' community through initiatives developed consultation with wildfire management professionals, Squamish Fire Rescue, developers, builders, and landscape professionals.



SQUAMISH

Official Community Plan

Schedule D-1

Flood & Debris Flow Hazard Areas

DRAFT

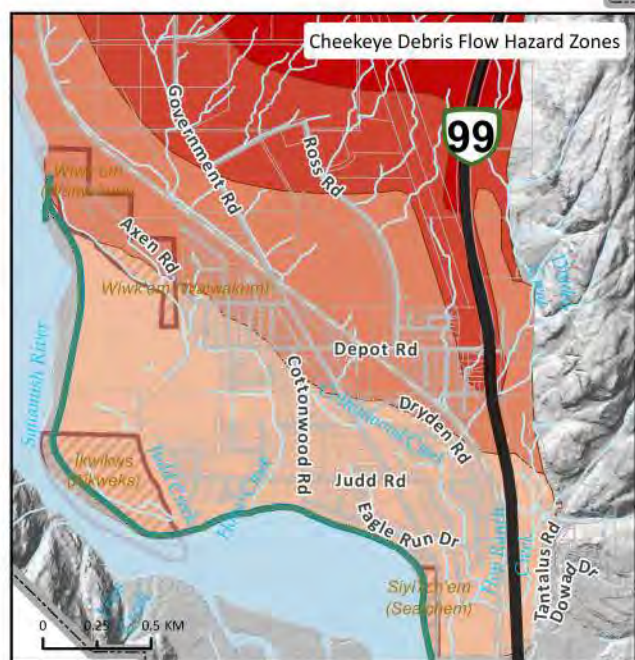
V.2.0 (October 2017)

Legend

- Municipal Boundary
- Squamish Nation Reserve
- Dike
- Debris Flow Hazard Area
- Overland Flow Areas
- Flood Hazard Areas

Debris Flow Hazard Zone

- C1
- C2
- C3
- C4
- C5



Cheekeye Debris Flow Hazard Area is also an Overland Flow Area

Cheekeye Debris Flow Hazard Zone C5 overlaps the Squamish River Flood Hazard Area (see inset for zone boundaries)

- Note:
1. Creeks west of the Squamish River and creeks north of the Cheekeye River may be subject to debris flows but have not been mapped.
 2. Debris flow areas identified have been mapped based on a desktop review. A site-specific hazard assessment prepared in accordance with Provincial legislation may be required for specific development proposals at the discretion of the Building Inspector or Approving Officer in conjunction with specific land development applications.
 3. Overland Flow Areas are areas where shallow water may flow during a flood event but where water is not expected to rise to a significant depth.

#SQUAMISH 2040

Note: consolidations are completed through GIS (www.squamish.ca/maps). Paper maps are not intended to be regularly updated with adopted OCP amendments.

Distict of Squamish Bylaw No. 2500,2016



0 0.5 1 2 Kilometers



SQUAMISH

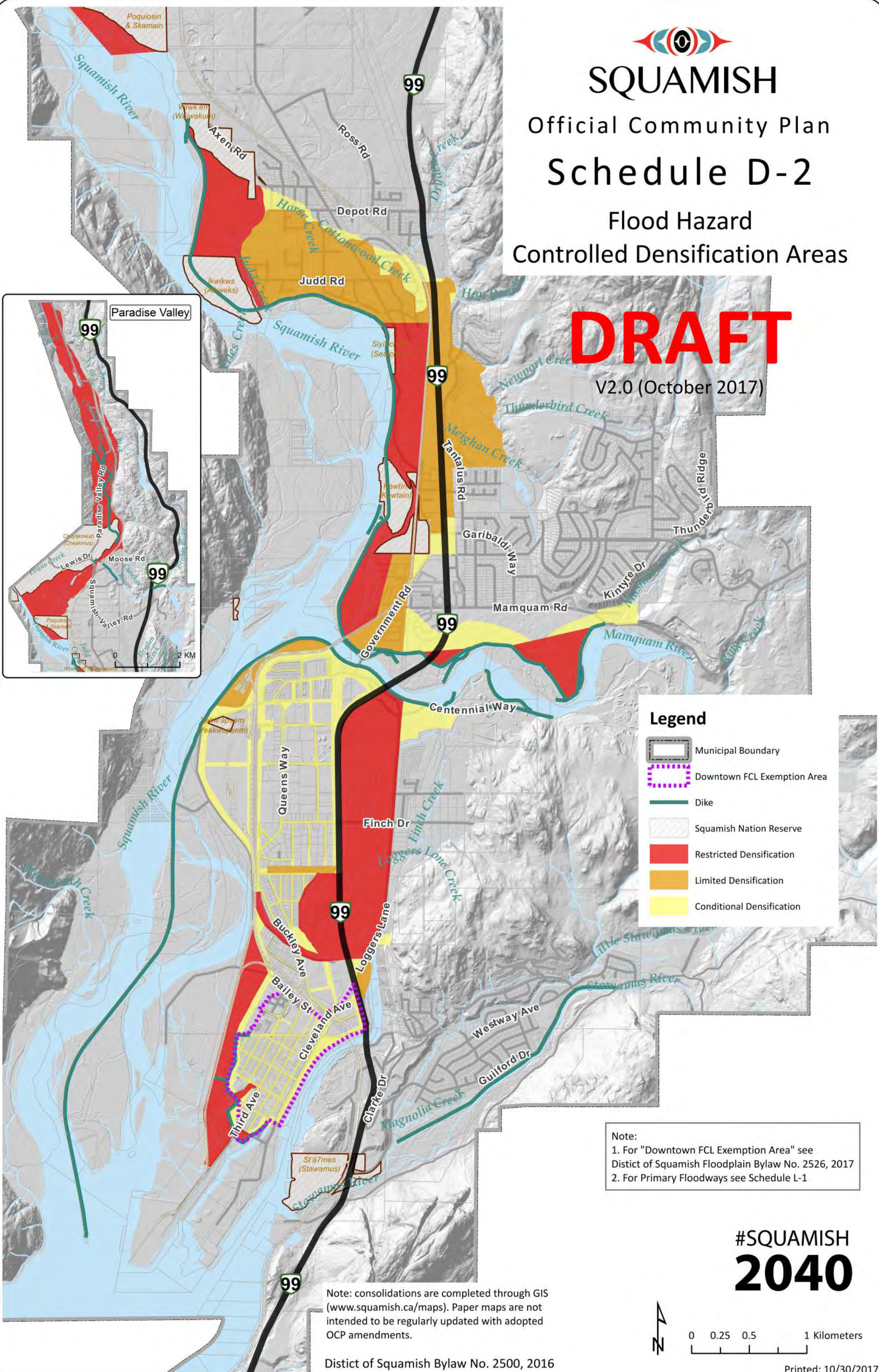
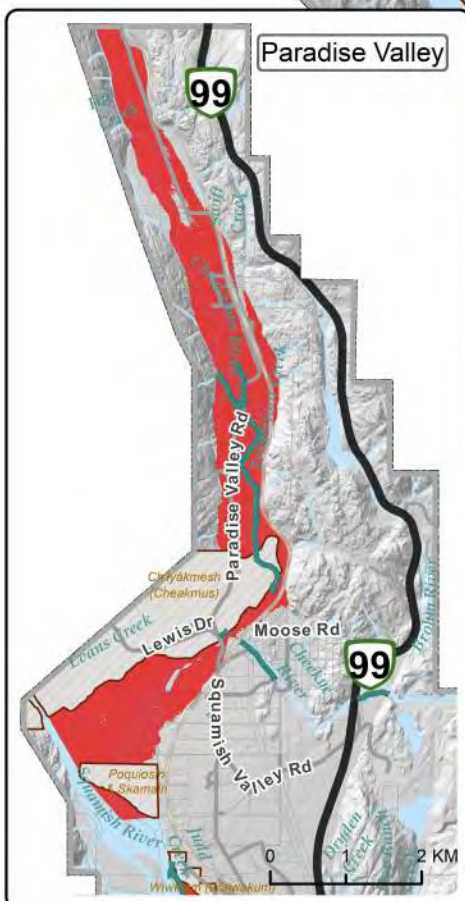
Official Community Plan

Schedule D-2

Flood Hazard
Controlled Density Areas

DRAFT

V2.0 (October 2017)



Legend

- Municipal Boundary
- Downtown FCL Exemption Area
- Dike
- Squamish Nation Reserve
- Restricted Density
- Limited Density
- Conditional Density

Note:
1. For "Downtown FCL Exemption Area" see District of Squamish Floodplain Bylaw No. 2526, 2017
2. For Primary Floodways see Schedule L-1

Note: consolidations are completed through GIS (www.squamish.ca/maps). Paper maps are not intended to be regularly updated with adopted OCP amendments.

District of Squamish Bylaw No. 2500, 2016

#SQUAMISH
2040



0 0.25 0.5 1 Kilometers

Printed: 10/30/2017



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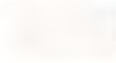





Schedule E

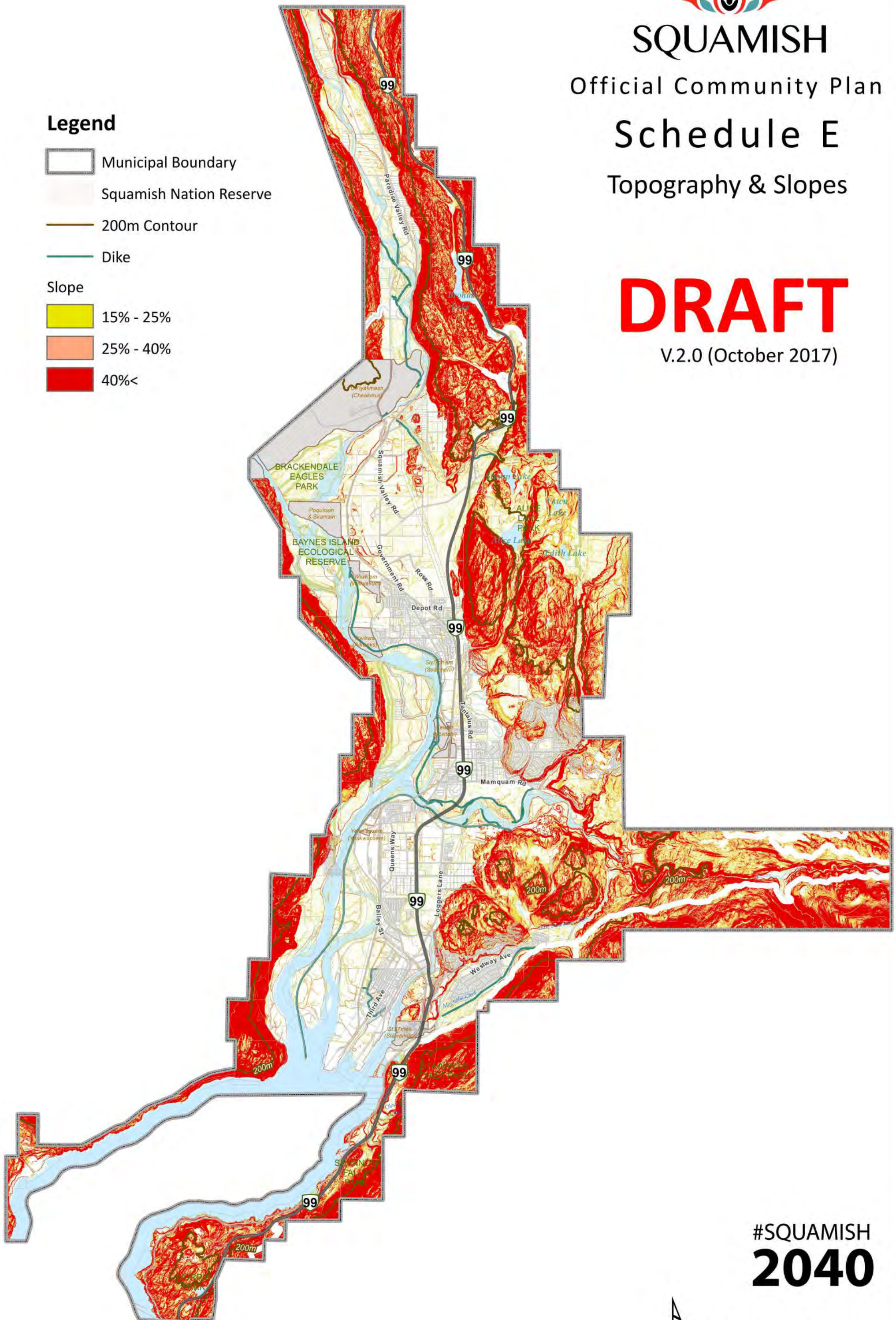
Topography & Slopes

DRAFT

V.2.0 (October 2017)

Legend

-  Municipal Boundary
-  Squamish Nation Reserve
-  200m Contour
-  Dike
- Slope**
 -  15% - 25%
 -  25% - 40%
 -  40%<



#SQUAMISH
2040



0 0.5 1 2 Kilometers



SQUAMISH

Official Community Plan

Schedule L-1

DPA 2: Flood Hazard Development Permit Area

DRAFT

V.1.0 (May 2017)

Legend

- Municipal Boundary
- Squamish Nation Reserve
- Dike
- Proposed Sea Dike
- Primary Floodway Model Boundary
- Debris Flow Hazard Area
- Primary Floodway Subject to Squamish Nation Review
- Primary Floodway
- Secondary Floodway
- Flood Hazard Areas (includes Overland Flow Areas)

Upstream limit of
modelled floodplain

Upstream limit of
modelled floodplain

Lower Squamish

Note:

1. Creeks west of the Squamish River and creeks north of the Cheekye River may be subject to debris flows but have not been mapped.
2. Debris flow areas identified have been mapped based on a desktop review. A site-specific hazard assessment prepared in accordance with Provincial legislation may be required for specific development proposals at the discretion of the Building Inspector or Approving Officer in conjunction with specific land development applications.

Note: For Cheekye Debris Flow Hazard Area please refer to Schedule D-1

#SQUAMISH 2040



0 0.5 1 2 Kilometers



KERR WOOD LEIDAL
consulting engineers

Appendix G

Draft District of Squamish Official Community Plan Section 35 – Development Permit Area 2: Flood Hazard

35. Development Permit Area 2

Protection from Flood Hazards

Background

35.1 Purpose

- a. Development Permit Area 2 is established for the protection of development from hazardous conditions.

35.2 Application

- a. Development Permit Area 2 guidelines apply to lands within areas designated as *Primary Floodways*, *Secondary Floodways* and *Debris Flow Hazard Areas* as shown in **Schedule L-1**. Development Permit Area 2 also applies to all legal parcels abutting areas designated as *Secondary Floodways*.

35.3 Objectives and Justification

- a. The objectives of Development Permit Area 2 are:
 - i. Manage development to mitigate the risk of floods and flood-related hazards and their consequences for development within areas subject to flood hazards;
 - ii. Designate and protect *Primary Floodways* free of buildings, fill and other infrastructure to preserve flood conveyance;
 - iii. Designate and protect *Secondary Floodways* to preserve conveyance and avoid increasing hazards in adjacent or upstream areas in the event of a dike breach;
 - iv. Designate *Debris Flow Hazard Areas* and adopt guidelines to mitigate risk to people, infrastructure and property.
- b. The justifications of Development Permit Area 2 are:
 - i. Significant areas within the District of Squamish are located within the floodplains of the Squamish, Mamquam, Cheakamus and Stawamus River floodplains. Flood modeling has determined appropriate Flood Construction Levels (FCLs) for dikes and future development. Future development that is not in accordance with modeling assumptions may reduce the conveyance capacity of critical floodways and increase flood levels over time thereby transferring risk to existing development.

- ii. Development within and abutting *Primary Floodways* and *Secondary Floodways* will be reviewed against Development Permit Area 2 guidelines to ensure proposed development mitigates adverse impacts on floodway capacity in order to maintain FCLs for existing development.
- iii. Areas within the District of Squamish are located within *Debris Flow Hazard Areas*. Future development, if not situated and designed properly, could expose people and property to significant hazards reducing public safety and community resilience to natural hazards.
- iv. Development within *Debris Flow Hazard Areas* will be reviewed against Development Permit Area 2 guidelines to ensure hazards are mitigated appropriately to reduce the risk to people, infrastructure and property.

35.4 Development Requiring a Permit

- a. A Development Permit is required prior to any development within Development Permit Area 2 as follows:
 - i. Subdivision of land where the number of parcels is increased;
 - ii. Construction of, addition to or alteration of a building or other structure; and
 - iii. Alteration of land, including a change of grade involving the removal, deposit or moving of soil greater than 30 cubic metres.

35.5 Development Permit Area 2 Exemptions

- a. Despite Section 35.4, a development permit is not required for the following:
 - i. Work within the boundaries of an Indian Reserve.
 - ii. Alteration, addition or repair of an existing permanent building or structure, provided the building footprint is not modified or expanded;
 - iii. Replacement or reconstruction of an existing building to its original footprint, provided the existing structure is fully compliant with the District's Zoning Bylaw, Floodplain Bylaw and all other applicable bylaws;
 - iii. Construction or repair of underground services;
 - iv. Park or open space use that does not include:
 - A. construction of a close-sided building; or
 - B. placement of fill or infrastructure that raises grades more than the minimum required to provide site drainage;

- v. Any construction of flood protection works where the District of Squamish will be the owner and maintenance authority and where potential floodway impacts have been considered;
- vi. Any construction or repair of flood protection works authorized under the Emergency Program Act.
- vii. Development proposals or placement of fill on parcels that abut, but do not encroach into *Secondary Floodways*, provided that the owner agrees to enter into a Section 219 Restrictive Covenant to ensure compliance with Sections 35.8.c. and 35.8.e. of these guidelines and where the District of Squamish, at its sole discretion, agrees to exempt the application.
- viii. Structures less than 10 square metres, where the District of Squamish, at its sole discretion, qualitatively concludes that floodway conveyance impacts are not considered significant.
- ix. Fencing, decks and raised patios, except where they are reviewed as part of a larger Development Permit Area 2 application involving any of the activities listed in Section 35.4.

Guidelines

35.6 General

- a. Each development permit application that includes a development proposal wholly or partially within a *Primary Floodway*, *Secondary Floodway* or *Debris Flow Hazard Area* or abutting a *Secondary Floodway* should have a Section 219 restrictive covenant, in a form approved by the District, registered on the title specifying mitigation measures for the development and indemnifying the District.

35.7 Primary Floodways

- a. No building, structure or placement of fill should be permitted in the *Primary Floodway* of the Squamish, Mamquam, or Stawamus Rivers.
- b. No building, structure, or placement of fill should be permitted in a *Primary Floodway* of the Cheakamus River except in accordance with the following conditions:
 - i. The development meets all applicable requirements in the Floodplain Bylaw, including, but not limited to, compliance with the requirements for any site-specific exemption.
 - ii. The District receives and accepts a *Flood Hazard Assessment* report that:

- A. establishes the suitability of the land for development and any required mitigation measures,
 - B. certifies that there is no other suitable development land on the lot outside the *Primary Floodway*,
 - C. certifies that the proposed location, form and orientation of the building, structure or fill maximizes floodway conveyance, minimizes potential increase in water levels in adjacent or upstream areas and mitigates potential risk to the structure and any adjacent diking infrastructure, and
 - D. specifies design of foundations, floodproofing fill and *Protective Works* to ensure that structures are oriented and anchored to minimize the potential impact of flood, sediment and erosion damage.
- iii. The District is not required to take additional operations and maintenance responsibility for flood protection infrastructure including dikes.
 - iv. The design and field review of any *Protective Works* must be:
 - A. Completed by a Professional Engineer,
 - B. Reviewed and accepted by the District, and
 - C. Approved under all applicable statutes including, but not limited to, the *Dike Maintenance Act*, *Water Sustainability Act*, *Fisheries Act* and *Navigation Protection Act*.

35.8 Secondary Floodways

- a. Where the footprint of a new structure, or placement of greater than 30 cubic metres of fill falls wholly or partially within or abuts a *Secondary Floodway*, the proposed location, form and orientation of the structure or fill should be certified by a *Qualified Professional* to maximize floodway conveyance, minimize potential increase in water levels in adjacent or upstream areas and minimize potential risk to the structure. The certifying *Qualified Professional* should give appropriate consideration to existing and approved upstream and downstream developments.
- b. For an existing structure located wholly or partially within a *Secondary Floodway*, expansion of the building footprint and appurtenant fill (e.g., floodproofing fill, driveways and drive aisles) across the floodway flow direction should be avoided unless there is no practicable alternative. If there is no practicable alternative, the proportional expansion of the structure footprint across the floodway flow direction should not exceed the corresponding

increase in gross floor area unless a *Qualified Professional* certifies that the expansion meets the objectives and criteria applied to new structures under Section 35.8.a of this guideline.

- c. In order to minimize structural fill within and abutting *Secondary Floodways*:
- i. New structures should be placed no higher than necessary to meet the requirements of the Floodplain Bylaw and achieve a level foundation.
 - ii. For any part of a lot located within a *Secondary Floodway*, the extent of fill should be limited to the building footprint with an allowance for side slopes no flatter than the ratio of 5 horizontal to 1 vertical. The height of fill should not exceed existing grade at the property line.
 - iii. Fill placed within any property line setback that abuts a *Secondary Floodway* should remain below a line projecting upward from existing grade at the property line along a slope of 5 horizontal to 1 vertical.
 - iv. Where a *Qualified Professional* certifies that the location, form and orientation of on-site walkways, driveways and drive aisles within *Secondary Floodways* meets the requirements and intent of 35.8.a, or where expansion of an existing structure and appurtenant fill meet the requirements of 35.8.b, the District may modify the fill requirements in 35.8.c.ii and 35.8.c.iii for walkways, driveways and drive aisles.
 - v. Where a *Qualified Professional* determines that a permanent, off-site barrier or embankment would impede the function of a floodway within all or part of a lot, the District may modify the fill requirements in 35.8.c.iii, provided the *Qualified Professional* certifies that:
 - A. the modification does not further impede flow;
 - B. the modification is limited to parts of the lot that do not abut a road, lane or green space;
 - C. modified floodproofing fill elevations proposed by the *Qualified Professional* remain at or below the crest of the downstream barrier or embankment; and
 - D. modified floodproofing fill elevations proposed by the *Qualified Professional* remain at least 1.5 metres below the FCL.

- d. Maintain a 30 metre setback from any watercourse within a *Secondary Floodway*. Reductions permitted under the *Riparian Areas Regulation* should not be allowed in *Secondary Floodways*.
- e. The size, form and orientation of linear flow obstructions (e.g. fences, barriers, hedgerows and other vegetation) within *Secondary Floodways*, or within property line setbacks that abut *Secondary Floodways*, should be designed to allow for flood conveyance. New linear obstructions oriented perpendicular to the flow direction should only be approved where an existing upstream or downstream barrier already provides an equal or greater impediment to flood flows.
- f. Any development proposal not meeting guidelines contained in 35.8.a, 35.8.c(3) or 35.8.d(4) should be required to have a *Qualified Professional* certify that flood levels at any upstream or adjacent location will not be increased by more than the criteria below in order to receive a development permit:
 - i. 0.10 metres, when evaluated as an independent proposal, compared to the results obtained from the latest version of the District's flood model; or
 - ii. 0.15 metres, when considered in conjunction with all previously approved development as well as any pending development applications specified by District staff, compared to the original water levels established by the District's Integrated Flood Hazard Management Plan.

35.9 Debris Flow Hazard Areas

- a. New development should be sited to avoid hazards; where it is impossible or impractical to avoid a hazard, mitigation measures may be considered to permit new development subject to the following conditions.
- b. The District must receive a risk assessment report prepared in accordance with the District's Terms of Reference for Natural Hazard and/or Risk Assessments. The determination of whether a Quantitative or Qualitative Risk Assessment is required should be determined by a *Qualified Professional* in consultation with the District and APEGBC Professional Practice Guidelines and in consideration of the scale of hazard, proposed development and local site conditions. The risk assessment must address the following minimum requirements:
 - i. The *Qualified Professional* should certify that no alternative development location is available outside the *Debris Flow Hazard Area* on the lot.

- ii. The *Qualified Professional* should specify any mitigation requirements with respect to the proposed location, form, elevation and orientation of development to reduce hazard exposure.
 - iii. Foundations should be designed and certified by a Professional Engineer to ensure that structures are oriented and anchored to minimize the potential impact of flood, sediment and erosion damage. Footings should be extended appropriately to prevent scour and erosion. At minimum, engineered concrete foundations should extend 1.0 metre above finished grade at all points on the perimeter of the building.
 - iv. The *Qualified Professional* should certify that the risk tolerance criteria in Section 11.2.e of the Official Community Plan have been met.
- c. Off-site *Protective Works* funded by a developer may be allowed as an approach to reduce risk to within acceptable thresholds where the District accepts that the mitigation provides a net positive community benefit after consideration of residual risk, long term maintenance costs and costs for replacement of mitigation. The following conditions should also apply:
- i. The design and field review of any Protective Works must be completed by a Professional Engineer, accepted by the District and approved under all applicable statutes.
 - ii. Provisions for contributing financial support to an ongoing maintenance program should be required as part of the Restrictive Covenant agreement between the District and an owner, or a strata corporation.
 - iii. Easements or rights-of-way to access and maintain the works must be registered in favor of the District, and
 - iv. An Operation and Maintenance manual must be prepared for the District with a copy to the Inspector of Dikes.
 - v. Mitigation must not cause any material adverse impact on other properties without written consent of the land owner(s).

Appendix

35.10 Definitions

Debris Flow Hazard Area means an area exposed to Debris Flow or Debris Flood hazards as shown in Schedule L-1.

Flood Hazard Assessment means a report prepared by a *Qualified Professional*, in accordance with District's Terms of Reference for Natural Hazard and/or Risk

Assessments and Provincial legislation. The assessment identifies flood characteristics, determines whether a development is safe for the intended use and specifies any corresponding flood mitigation measures.

Primary Floodway means a river corridor or un-diked floodplain area that is reasonably required to discharge the flow of a designated flood. *Primary Floodways* are shown in Schedule L-1.

Protective Works means any landfill, embankment, dike, berm, revetment, wall, barrier, flap gate, drainage infrastructure or other structures constructed for the purposes of protecting an area, structure or development from the effects of floods, debris flows, or debris floods.

Qualified Professional means a Professional Engineer or Professional Geoscientist registered or licensed under the provisions of the *Engineers and Geoscientists Act* that is experienced in geotechnical engineering under Section 524(7) of the *Local Government Act* or a person in a class prescribed by the minister under Section 524(9) of the *Local Government Act*. A *Qualified Professional* must meet the requirements outlined in the District's Terms of Reference for Natural Hazard and/or Risk Assessments.

Secondary Floodway means an area within a dike-protected floodplain that is critical for conveying floodwaters in the event of a dike breach to maintain modelled flood levels. *Secondary Floodways* are shown in Schedule L-1.



SQUAMISH

Official Community Plan

Schedule L-1

DPA 2: Flood Hazard
Development Permit Area

DRAFT

V.1.0 (May 2017)

Legend

- Municipal Boundary
- Squamish Nation Reserve
- Dike
- Proposed Sea Dike
- Primary Floodway Model Boundary
- Debris Flow Hazard Area
- Primary Floodway Subject to Squamish Nation Review
- Primary Floodway
- Secondary Floodway
- Flood Hazard Areas (includes Overland Flow Areas)

Upstream limit of
modelled floodplain

Lower Squamish

Upstream limit of
modelled floodplain

Note:

1. Creeks west of the Squamish River and creeks north of the Cheekye River may be subject to debris flows but have not been mapped.
2. Debris flow areas identified have been mapped based on a desktop review. A site-specific hazard assessment prepared in accordance with Provincial legislation may be required for specific development proposals at the discretion of the Building Inspector or Approving Officer in conjunction with specific land development applications.

Note: For Cheekye Debris Flow Hazard Area please refer to Schedule D-1

#SQUAMISH 2040



0 0.5 1 2 Kilometers



KERR WOOD LEIDAL
consulting engineers

Appendix H

District of Squamish Bylaw No. 2526, 2017 (Floodplain Bylaw)

District of Squamish

BYLAW NO. 2526, 2017

A Floodplain Management Bylaw to designate land as floodplain and make provisions in relation to flood management in the District of Squamish

WHEREAS:

It is desirable to minimize the risk of injury, loss of life, and property damage due to flooding,

Council has considered Provincial Guidelines respecting flood control, and

The *Local Government Act*, Section 524, authorizes Council to enact a bylaw to designate floodplains within the District of Squamish and to regulate in relation to flood control, flood hazard management, and development of land that is subject to flooding.

NOW THEREFORE the Council of the District of Squamish, in open meeting assembled, hereby enacts as follows:

1.0 Citation

1.1 This Bylaw may be cited as “District of Squamish Floodplain Management Bylaw 2526, 2017”.

2.0 Interpretation

2.1 In this Bylaw:

APPROVING OFFICER has the meaning defined in the *Land Title Act*.

BUILDING INSPECTOR has the meaning defined in the *Community Charter*.

CARPORT means an open structure that is an accessory building or attached to the principal building for the use of parking of one or more motor vehicles.

COUNCIL means elected Council of the District.

DISTRICT means the District of Squamish.

DESIGNATED FLOOD means a *Flood* resulting in a peak discharge or peak water level that a *Qualified Professional* determines will be equaled or exceeded with an annual probability of 1:200 or 0.5% (i.e., a “1 in 200-year recurrence interval”).

DESIGNATED FLOOD LEVEL means the observed or calculated water surface elevation for the Designated Flood, used in the calculation of the *FCL*.

FCL, see *Flood Construction Level*.

FLOOD means any event in which water, rising significantly above normally occurring levels, spills out of a *Watercourse* or the ocean and inundates areas beyond the associated *Natural Boundary*.

FLOOD CONSTRUCTION LEVEL (FCL) means the required elevation of the underside of a wooden floor system or top of *Pad* to be used for *Habitable Areas* as specified in Section 4.1 of this Bylaw. In the case of a *mobile home*, *FCL* means the ground level or top of *Pad* on which the *mobile home* is located.

FLOOD HAZARD AREA means a protected (diked) or unprotected area, which, by reasons of land elevation is susceptible to flooding from a *Watercourse*, or other body of water as shown in Schedule A1 of this Bylaw.

FLOOD HAZARD ASSESSMENT means a report, prepared by a *Qualified Professional* in accordance with *District's* Terms of Reference for Natural Hazard and/or Risk Assessments and Provincial legislation. The assessment identifies flood characteristics, determines whether a development is safe for the intended use, and specifies any corresponding flood mitigation measures.

FLOOD RESISTANT MATERIALS means the building products, listed in Schedule F, capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage.

FLOODPLAIN means an area designated in Section 3 of this Bylaw.

FLOODPLAIN SETBACK means the required minimum horizontal distance from a reference line, point or natural feature to any landfill, structure, obstruction or structural support required to elevate a floor system or *Pad* above the *FCL*. *Floodplain Setbacks* are specified to provide adequate space for dike operations and maintenance and emergency response, maintain *Secondary Floodways*, reduce exposure to hazards during a flood and/or allow for potential land erosion.

FLOODPROOFING means the alteration of land or structures either physically, or in use, to reduce or eliminate flood damage. Floodproofing incorporates the use of *FCLs*, building specifications and/or *Floodplain Setbacks*.

FREEBOARD means an additional vertical distance added above a *Designated Flood Level* to establish an *FCL*.

GARAGE means a roofed accessory building or portion of a principal building with more than 60% of the perimeter enclosed within walls, the principal use of which is for parking one or more motor vehicles.

HABITABLE AREA means any space or room, including a *mobile home* that can be used for dwelling purposes, business, or the storage of goods susceptible to damage by floodwater.

HEAVY INDUSTRY means and includes manufacturing, processing or shipping of wood and paper products, metal, heavy electrical, non-metallic mineral products, petroleum, hydrocarbon and coal products, industrial chemicals and by-products, and allied products.

INSPECTOR OF DIKES means an official of the Ministry of Forests, Lands and Natural Resource Operations as defined under the *Dike Maintenance Act*.

INTEGRATED FLOOD HAZARD MANAGEMENT PLAN means a plan prepared by the *District* assessing flood hazards and providing information to support flood management in Squamish.

MINIMUM PONDING ELEVATION means a minimum elevation for construction that is intended to reduce possible flood damage from ponding of local drainage. Minimum Ponding Elevation is determined on a site-specific basis based on topography, road elevations and downstream embankments using the criteria specified in Section 4.1.1(ii) of this Bylaw.

MINOR BUILDING means any single-storey building or structure accessory to a residential or farm use which is less than 10 square metres in area and which does not require a building permit under the *District of Squamish Building Bylaw*.

MOBILE HOME means a factory-built single-unit dwelling capable of being moved from place to place on an integrated chassis.

NATURAL BOUNDARY means the visible high watermark of any lake, river, stream, coastal foreshore, or other body of water where the presence and action of the water are so common and usual and so long continued in all ordinary years as to mark upon the soil of the bed of the lake, river, stream, or other body of water a character distinct from that of the banks thereof, in respect to vegetation, as well as in respect to the nature of the soil itself and also includes the edge of dormant side channels of any lake, river, stream, or other body of water.

NATURAL GROUND ELEVATION means the average of the undisturbed, pre-development ground elevations at the four primary corners of a proposed building site.

OVERLAND FLOW HAZARD AREA means an area where shallow water may flow during a flood event, but where water is not expected to rise to a significant depth. *Overland Flow Hazard Areas* include those areas designated as “*Overland Flow Hazard Area*” in Schedule A1 as well as any area less than 1.5 metres above the *Natural Boundary* of an adjacent or nearby stream.

PAD means a surface on which blocks, posts, runners or strip footings are placed for the purposes of supporting a *mobile home*, or a concrete surface for the purposes of supporting a *Habitable Area*.

PRIMARY FLOODWAY means a river corridor or un-diked *Floodplain* area that is reasonably required to discharge the flow of a *Designated Flood*. *Primary Floodways* are shown in Schedule E.

PROFESSIONAL ENGINEER means a person who is registered or licensed in the practice of engineering under the *Engineers and Geoscientists Act*.

PROFESSIONAL GEOSCIENTIST means a person who is registered or licensed in the practice of geoscience under the *Engineers and Geoscientists Act*.

PROTECTIVE WORKS means any landfill, embankment, dike, berm, revetment, wall, barrier, flap gate, drainage infrastructure or other structure constructed exclusively or *inter alia* for the purposes of protecting an area, structure or development from the effects of *Floods*, debris flows, or debris floods.

QUALIFIED PROFESSIONAL means a *Professional Engineer* or *Professional Geoscientist* registered or licensed under the provisions of the *Engineers and Geoscientists Act* that is experienced in geotechnical engineering under Subsection 524(7) of the *Local Government Act* or a person in a class prescribed by the minister under Subsection 524(9) of the *Local Government Act*. A *Qualified Professional* must meet the requirements outlined in the *District’s Terms of Reference* for Natural Hazard and/or Risk Assessments.

SEA DIKE means an existing or future dike shown in Schedule B, that is operated and maintained by the *District* to protect against coastal flooding and sea level rise, with a minimum crest elevation defined in the *Integrated Flood Hazard Management Plan*, meeting Provincial guidelines for design and construction and approved by the *Inspector of Dikes*.

SECONDARY FLOODWAY means an area within a dike-protected *Floodplain* that is critical for conveying floodwaters in the event of a dike breach to maintain modelled flood levels. *Secondary Floodways* are shown in Schedule E.

SECONDARY SUITE means a second, self-contained dwelling unit with private access, its own kitchen and bathroom, and located within a single-unit dwelling, within a detached accessory building, or within a townhouse dwelling complying with the requirements of the Zoning Bylaw.

SETBACK see *Floodplain Setback*.

STANDARD DIKE means a dike shown in Schedule B, built to a minimum crest elevation equal or above the *FCL* and meeting standards of design and construction approved by the *Inspector of Dikes* and maintained by the *District*.

TSUNAMI RUNUP ELEVATION means an elevation that will provide reasonable protection for development against water levels that may be experienced during a tsunami. The *Tsunami Runup Elevation* shall be 4.7 metres geodetic.

UNCONNECTED COASTAL FLOOD HAZARD AREA means any area that is not and will not be protected by the planned *Sea Dike* shown in Schedule B and that is below 5.6 metres geodetic elevation.

WATERCOURSE means any natural or man-made depression with well-defined banks and a bed 0.6 metres or more below the surrounding land serving to give direction to a current of water at least six (6) months of the year or having a drainage area of 2 square kilometres or more upstream of the point of consideration.

- 2.2 Unless otherwise provided in this Bylaw, words and phrases used herein have the same meanings as in the *Local Government Act*, *Community Charter*, or *Land Title Act*, as the context and circumstances may require. A reference to a statute in this Bylaw refers to a statute of the Province of British Columbia unless otherwise indicated, and a reference to any statute, regulation, bylaw or other enactment refers to that enactment as it may be amended or replaced from time to time. In the event of a conflict between this Bylaw and a Provincial enactment, the stricter law prevails. Headings in this Bylaw are for convenience only and must not be construed as defining or limiting its scope or intent. If any part of this Bylaw is held to be invalid by a court of competent jurisdiction, the invalid part is severed and the remainder continues to be valid.
- 2.3 The *District* does not, by the enactment, administration or enforcement of this Bylaw, represent to any person that any building, structure, manufactured home or *Habitable Area* located, constructed or used in accordance with the provisions of this Bylaw, or in accordance with conditions, terms, information, advice, direction or guidance provided by the *District* in the course of administering this Bylaw, will not be damaged by flooding or floodwater.

3.0 Application and Floodplain Designation

- 3.1 This Bylaw shall be applicable within the boundaries of the *District* except within an Indian Reserve.

3.2 Floodplain Designation

The following areas of the *District* are designated as *Floodplain*:

- (i) Any land within a *Flood Hazard Area* and/or *Overland Flow Hazard Area* shown in Schedule A1.
- (ii) Any land within an *Unconnected Coastal Flood Hazard Area*.
- (iii) Any land that is less than 1.5 metres above the *Natural Boundary* of an adjacent *Watercourse*, lake, pond, swamp, marsh area or reservoir.
- (iii) Any land within the *Floodplain Setbacks* specified in Section 4.

4.0 Floodplain Specifications

4.1 Flood Construction Levels

- 4.1.1 Within a designated *Floodplain*, the following elevations are specified as *FCLs*, except where more than one *FCL* is applicable, the higher elevation shall govern:

- (i) The elevation determined by interpolation of *FCLs* shown in Schedule A1.
- (ii) For *Overland Flow Hazard Areas*, the *Minimum Ponding Elevation*, which is determined as the higher elevation of:
 - a. 1.5 metres above the *Natural Boundary* of any adjacent *Watercourse*, lake, pond, marsh or reservoir, whether natural or constructed;
 - b. 0.6 metres above the crest of any downstream road or embankment or other feature that could result in a backwater condition, but specifically excluding the effect of downstream *Standard Dikes* and *Sea Dikes*; and
 - c. 1 metre above the finished grade around the building.
- (iii) For development directly adjacent to the *Sea Dike*, the higher elevation of:
 - a. 0.3 metres above the adjacent crest of the *Sea Dike*; and
 - b. An *FCL* determined by a *Qualified Professional* based on the interaction of any overtopping flows with the proposed structure over its design life.
- (iv) For *Unconnected Coastal Flood Hazard Areas*, an *FCL* determined by a *Qualified Professional* in accordance with Provincial Guidelines as the sum of:
 - a. *Designated Flood Level* established in the *Integrated Flood Hazard Management Plan*,
 - b. Allowance for regional uplift or subsidence to the year 2100,
 - c. Estimated wave effects for a wind event with an annual exceedance probability of 1:200 or 0.5%, and
 - d. A minimum freeboard of 0.6 metres.
- (v) The *Tsunami Runup Elevation*.

4.2 Floodplain Setbacks

4.2.1 *Floodplain Setbacks* shall be as follows, except that where more than one setback is applicable, the greater shall apply.

- (i) 30.0 metres from the *Natural Boundary* of the Squamish, Mamquam, Cheakamus, Cheekeye and Stawamus Rivers.
- (ii) 15.0 metres from the *Natural Boundary* of any other *Watercourse* where the development, structure or improvement are not located within a *Secondary Floodway*.
- (iii) 30.0 metres from the *Natural Boundary* of any *Watercourse*, for developments, structures or improvements located within a *Secondary Floodway*.
- (iv) For areas abutting any dike maintained by the *District*, except the *Sea Dike*, the greater of:
 - a. 7.5 metres from the toe of an actual or theoretical dike cross-section that meets Provincial requirements for a *Standard Dike*,
 - b. 15.0 metres from the toe of any existing dike that does not meet Provincial Requirements for a *Standard Dike*,
 - c. 3.0 metres from the toe of any existing dike that exceeds Provincial Requirements for a standard dike.

- (v) For areas abutting the Squamish River dike or the Mamquam River South dike, 3.0 metres from the minimum future dike shown in Schedule C.
- (vi) 0.0 metres from the boundary (i.e. outside) of any existing right-of-way for *Protective Works*, including but not limited to any existing or future *Standard Dike* or *Sea Dike* shown in Schedule B.
- (vii) For areas abutting the *Sea Dike*, the greater of:
 - a. 15.0 metres from the water side crest of the *Sea Dike* where the sea dike has been designed or built to the Year 2100 standard shown in Schedule D,
 - b. 3.0 metres from any part of the *Sea Dike* as illustrated in Schedule D, including but not limited to:
 - i. the intersection of an actual or theoretical 3H:1V backslope of a dike raised to accommodate 2 metres sea level rise from present day (i.e. anticipated Year 2200 sea level) with the natural (i.e., pre-development) ground elevation,
 - ii. the intersection of the theoretical 3H:1V backslope of a dike raised to accommodate 2 metres sea level rise (i.e. anticipated Year 2200 sea level) with the lowest base elevation of the proposed structure, and
 - iii. any structural or geotechnical component (e.g. cable tieback or soil anchor).
 - c. 30.0 metres from the future natural boundary, including 1 metre of sea level rise, as determined by a *Qualified Professional* in accordance with Provincial Guidelines, where the *Sea Dike* has not been designed or built.
- (viii) For float homes, the greater of:
 - a. 7.5 metres from the water side toe of the existing *Sea Dike*,
 - b. 7.5 metres from the intersection of existing natural grade with the water level at mean high tide, for areas along the planned *Sea Dike* alignment shown in Schedule B where the *Sea Dike* has not yet been built, and
 - c. 7.5 metres from the water side toe of the planned *Sea Dike* shown in Schedule B, where a preliminary design for the planned *Sea Dike* has been completed.
- (ix) For *Unconnected Coastal Flood Hazard Areas*, the greater of:
 - a. 15.0 metres from the future natural boundary, including 1 metre of sea level rise, as determined by a *Qualified Professional* in accordance with Provincial Guidelines,
 - b. The distance to where existing grade, or proposed grade (where the land is proposed to be filled and permanently protected from erosion) intersects with the *FCL* as determined by a *Qualified Professional* in accordance with Provincial Guidelines,
 - c. Such additional distance beyond (a) or (b) where a *Qualified Professional* determines is necessary to accommodate future waves and erosion, and

- d. 15.0 metres from the waterside crest of any *Protective Works* designed to mitigate future erosion.

5.0 Application of Floodplain Specifications

5.1 Within a designated *Floodplain*, the following regulations apply:

- (i) No *Habitable Area* shall be constructed, reconstructed, altered, moved or extended, such that the underside of its floor system or the top of its supporting *Pad* is lower than the *FCL* specified in this Bylaw.
- (ii) No building, structure, *Habitable Area* or fill shall be constructed, reconstructed, altered, moved or extended within the *Floodplain Setback* specified in this Bylaw.
- (iii) Enclosed underground parking is not permitted on any property located within the *Floodplain* that is not protected by a *Standard Dike*.
- (iv) Major fixed equipment including, but not limited to, major electrical switchgear, furnaces, ventilation systems, hot water tanks and hot water heaters that are integral to and necessary for the functioning of a building according to the *BC Building Code* must meet *FCLs* specified in this Bylaw.
- (v) Structural support or compacted landfill or a combination of both may be used to elevate the underside of the floor system or the top of the pad above the *FCL* provided that the structural support or floodproofing fill is adequately protected against scour and erosion from flood flows, wave action, ice and other debris using the following minimum requirements:
 - a. Where Schedule A2 shows that simplified design flood velocity for a specific property is less than 0.8 metres per second, areas shall not be left as bare earth except during construction.
 - b. Within all *Overland Flow Hazard Areas* or where Schedule A2 shows that simplified design flood velocity for a specific property is between 0.8 metres per second and 2.8 metres per second, structural support and floodproofing fill shall be protected using the standard details shown in Schedule G.
 - c. In any other flood hazard area, including but not limited to areas where Schedule A2 shows that simplified design flood velocity for a specific property is greater than 2.8 metres per second, a *Professional Engineer* must specify appropriate erosion and scour protection measures.

5.2 The *Building Inspector* may require that a British Columbia Land Surveyor's certificate be submitted, at the cost of the landowner, to verify compliance with:

- (i) the location of the proposed development site in relation to *Primary Floodway* or *Secondary Floodway* boundaries, and
- (ii) the *FCL* and *Floodplain Setback* specified in this Bylaw.

5.3 Notwithstanding the requirements laid out in this Bylaw, a *Flood Hazard Assessment*, pursuant to the *Community Charter* or the *Land Title Act*, may be required by the *Building Inspector* or *Approving Officer* prior to building permit or subdivision approval where they deem that this Bylaw and/or the *Integrated Flood*

Hazard Management Plan does not resolve concerns for a potential hazard due to flooding.

6.0 General Exemptions

- 6.1 The following types of development are exempt from meeting the *FCL* specified in this Bylaw:
- (i) Farm buildings and open-sided livestock housing,
 - (ii) Public recreation shelters, parks, docks, piers and playgrounds susceptible to only marginal damage by floodwaters,
 - (iii) *Minor Buildings*,
 - (iv) Manure pits,
 - (v) *Heavy Industry* located behind a *Standard Dike*.
- 6.2 The following types of development are exempt from the *FCLs* specified in this Bylaw, subject to the conditions listed for each type of development:
- (i) A renovation to an existing building or structure below *FCL*, provided that:
 - a. there is no increase to the existing floor area below the *FCL*,
 - b. the renovation does not create a new dwelling unit and
 - c. new building materials used below *FCL* consist exclusively of *Flood Resistant Materials*.
 - (ii) An addition to an existing building or structure below the *FCL*, provided that:
 - a. the total floor area added below the *FCL*, after the date of adoption of this Bylaw does not exceed 25 percent of the floor area below *FCL* that exists at the date of adoption of this Bylaw,
 - b. the degree of non-conformity regarding a *Floodplain Setback* is not increased,
 - c. building materials used below *FCL* consist exclusively of *Flood Resistant Materials*,
 - d. structural support or compacted landfill used to elevate *Habitable Area* above the *FCL* is adequately protected against scour and erosion from flood flows, wave action, ice and other debris per the requirements specified in Section 5.1(v), and
 - e. the addition does not involve the creation of a new dwelling unit.
 - (iii) That portion of a building or structure to be used as a parkade or *carport*, or *garage* not exceeding 50 square metres in floor area, or entrance foyer not exceeding 12 square metres in floor area, provided that:
 - a. the underside of a wooden floor system or top of *Pad* is elevated above the higher of the seasonal high water table or 1 metre geodetic elevation,
 - b. building materials used below *FCL* consist exclusively of *Flood Resistant Materials*,
 - c. appropriate signage is installed and maintained notifying users of the flood hazard,
 - d. emergency access/egress is provided, and

- e. no goods damageable by floodwater are stored below the *FCL*.
- (iv) That portion of a building with a ceiling height not exceeding 1.5 metres (e.g. crawl space) provided that building materials used below *FCL* consist exclusively of *Flood Resistant Materials* and no goods damageable by floodwater are stored within the crawl space.
- (v) Electrical circuits not integral to the operation of the building's central and integral systems, provided they are permitted and installed in accordance with BC Safety Authority regulations.
- (vi) Closed-sided livestock housing provided the underside of the wooden floor system or the top of the *Pad* is elevated above the *Minimum Ponding Elevation*.
- (vii) On-loading and off-loading facilities associated with water-oriented industry and portable sawmills, provided the main electrical switchgear is located above the *FCL*.

7.0 Local Area Exemptions

7.1 Within the Downtown FCL Exemption Area identified in Schedule H, non-residential uses may be constructed, reconstructed, moved or extended below the *FCL*, provided that:

- (i) major fixed equipment including major electrical switchgear, furnaces, ventilation systems and hot water tanks that are integral to and necessary for the functioning of a building according to the *BC Building Code* are located above the *FCL*,
- (ii) building materials used below *FCL* consist exclusively of *Flood Resistant Materials*,
- (iii) the floor level is at least 0.15 metres above the crown of road and 0.3 metres above the gutter of any adjacent road,
- (iv) all elevators have an automatic shut-off to prevent occupants from inadvertently descending into an inundated area, and
- (v) a maximum of one level of parking is located below the finished grade with clearly marked and accessible exits to the surface, subject to the parkade elevation remaining above the higher of the seasonal high water table and 1 metre geodetic elevation.

8.0 Site-Specific Exemptions

8.1 The General Manager of Community Planning and Infrastructure may exempt a person from meeting the requirements of this Bylaw in relation to a specific parcel of land or a use, building or other structure on the parcel of land if he/she considers it advisable and subject to all of the following conditions:

- (i) The *District* receives a *Flood Hazard Assessment* completed in accordance with the *District's* Terms of Reference for Natural Hazard and/or Risk Assessments, certifying that:
 - a. the land may be used safely for the use intended without reliance on *Protective Works*,
 - b. a valid hardship exists and no other reasonable option is available,

- c. the proposed *FCL* and *Floodplain Setback* represent the minimum practicable variation from the requirements of this bylaw given the location, configuration, and intended use of the land, specifically without regard to the economic circumstances or siting preferences of the Owner, and
- d. the exemption will not result in a transfer of flood hazard to other lands.

A valid hardship shall only be recognized where the physical characteristics of the lot (e.g. exposed bedrock, steep slope, the presence of a *Watercourse*, etc.) and size of the lot are such that building development proposals consistent with the current land use zoning cannot occur under the requirements of this Bylaw. The economic circumstances or design and siting preferences of the owner shall not be considered as grounds for hardship;

- (ii) The General Manager of Community Planning and Infrastructure considers that the exemption is consistent with Provincial Guidelines;
- (iii) *Habitable Area* is elevated above the *Minimum Ponding Elevation*;
- (iv) *Habitable Area* for residential development is elevated to a minimum 2.5 metres above the *Natural Ground Elevation*;
- (v) Building materials used below *FCL* consist exclusively of *Flood Resistant Materials*;
- (vi) The owner enters into a *Restrictive Covenant* with the *District* in a form approved by the *District*; and
- (vii) Electrical circuits and mechanical systems integral to the operation of the building's central and integral systems are installed above the *FCL* and in accordance with BC Safety Authority regulations.

8.2 Notwithstanding Section 8.1, the General Manager of Community Planning and Infrastructure may exempt a person from meeting the *Floodplain Setbacks* established under Section 4.2 in relation to a setback from an existing dike that does not meet Provincial Standards or a *Sea Dike* that has not been designed or built, where:

- (i) a conceptual design and alignment is prepared by a *Qualified Professional* and submitted to the *District*,
- (ii) the General Manager of Community Planning and Infrastructure and *Inspector of Dikes* consider the exemption advisable and provide written approval, and
- (iii) the works receive approvals under all applicable statutes including, but not limited to, the *Dike Maintenance Act*, *Water Sustainability Act*, *Fisheries Act* and *Navigation Protection Act*.

8.3 Notwithstanding Section 8.1, the General Manager of Community Planning and Infrastructure may exempt a person from meeting the *Floodplain Setbacks* established under Section 4.2 in relation to placing fill within a dike setback, where:

- (i) a *Qualified Professional* certifies that the proposed fill:
 - a. is geotechnically compatible with the abutting dike fill,
 - b. will not decrease the conveyance of a *Secondary Floodway* or result in a transfer of flood hazard to other lands, and

- c. has been constructed in general conformance with the specified design parameters upon completion.
 - (ii) the General Manager of Community Planning and Infrastructure and *Inspector of Dikes* consider it advisable and provide written approval, and
 - (iii) the works receive approvals under all applicable statutes including, but not limited to, the *Dike Maintenance Act*, *Water Sustainability Act*, *Fisheries Act* and *Navigation Protection Act*.
- 8.4 Notwithstanding Section 8.1, the General Manager of Community Planning and Infrastructure may exempt a renovation or addition to a building or structure existing prior to the date of adoption of this bylaw that creates a new *Secondary Suite* below the *FCL*, provided that:
 - (i) the *District* receives a *Flood Hazard Assessment* completed in accordance with the *District's* Terms of Reference for Natural Hazard and/or Risk Assessments, certifying that:
 - a. the land may be used safely for the use intended without reliance on *Protective Works*,
 - b. the exemption will not result in a transfer of flood hazard to other lands, and
 - c. the degree of non-conformity regarding a *Floodplain Setback* is not increased.
 - (ii) the total floor area added below the *FCL* after the date of adoption of this Bylaw does not exceed 25 percent of the non-conforming floor area below *FCL* that exists at the date of adoption of this Bylaw,
 - (iii) the renovation or addition does not result in conversion of a one-unit dwelling to a two-unit dwelling as defined in the Zoning Bylaw,
 - (iv) new building materials used below *FCL* consist exclusively of *Flood Resistant Materials*, and
 - (v) the owner enters into a *Restrictive Covenant* with the *District* in a form approved by the *District*.
- 8.5 Notwithstanding Section 8.1, a *Qualified Professional* who is also a *Professional Engineer* may provide a site-specific *Flood Hazard Assessment* that proposes a different design velocity for erosion protection than is shown on Schedule A2. Where the General Manager of Community Planning and Infrastructure accepts the revised design velocity, the same *Qualified Professional* must complete the design of corresponding site-specific erosion and scour protection measures.

9.0 Offence and Penalty

- 9.1 A person who contravenes a provision of this Bylaw, or who permits, allows or suffers a contravention by another person, commits an offence and in the case of a continuing offence, each day that the offence continues is a separate offence. A person convicted of an offence under this Bylaw is liable to a fine not exceeding ten thousand dollars (\$10,000).

10.0 Enforcement

- 10.1 This Bylaw may be enforced by the General Manager of Community Planning and Infrastructure, Building Inspector, Municipal Engineer or Bylaw Enforcement Officer of the *District*.

11.0 Schedules

11.1 Schedules A through H are attached to and form part of this Bylaw.

READ A FIRST, SECOND AND THIRD time this 17th day of October,
2017.

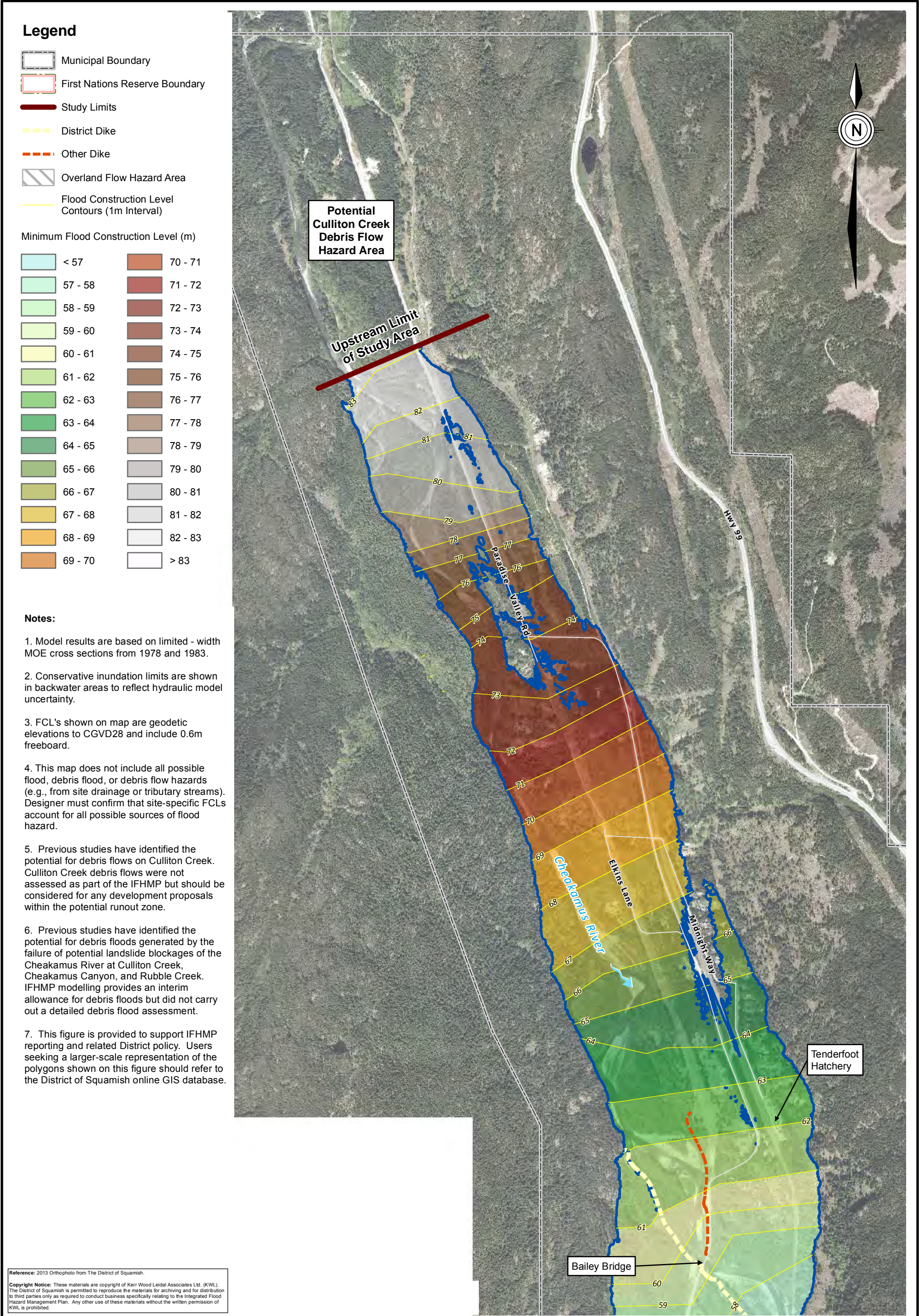
RECONSIDERED AND FINALLY ADOPTED this day of ,
2017.

Patricia Heintzman, Mayor

Robin Arthurs, Corporate Officer

Schedule A1 - Flood Construction Level Maps

Path: O:\0400-0499\463-278\430-GIS\MXD-Rp\Final IFHMP Report\20170424-SchedA1_CheakamusNorth_FCLs.mxd Date Saved: 4/25/2017 3:55:05 PM
Author: jlau



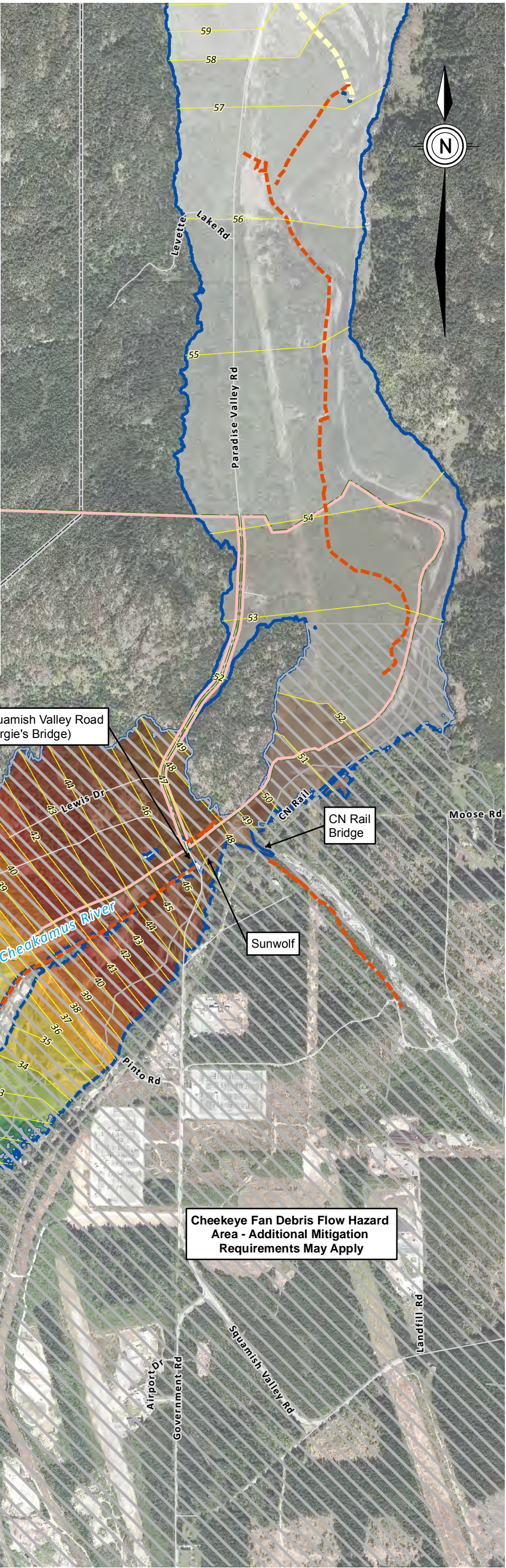
Legend

- Municipal Boundary
- First Nations Reserve Boundary
- Study Limits
- District Dike
- Other Dike
- Overland Flow Hazard Area
- Flood Construction Level Contours (1m Interval)

Minimum Flood Construction Level (m)

< 20	40 - 42
20 - 22	42 - 44
22 - 24	44 - 46
24 - 26	46 - 48
26 - 28	48 - 50
28 - 30	50 - 52
30 - 32	52 - 54
32 - 34	54 - 56
34 - 36	56 - 58
36 - 38	> 58
38 - 40	

- Notes:
- Model results are based on limited-width MOE cross sections from 1978 and 1983.
 - Conservative inundation limits are shown in backwater areas to reflect hydraulic model uncertainty.
 - FCL's shown on map are geodetic elevations to CGVD28 and include 0.6m freeboard.
 - This map does not include all possible flood, debris flood, or debris flow hazards (e.g., from site drainage or tributary streams). Designer must confirm that site-specific FCLs account for all possible sources of flood hazard.
 - Development in Cheekeye Fan debris flow hazard area must meet or exceed floodproofing requirements for overland flow areas.
 - This figure is provided to support IFHMP reporting and related District policy. Users seeking a larger-scale representation of the polygons shown on this figure should refer to the District of Squamish online GIS database.



Reference: 2013 Orthophoto from The District of Squamish.
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Project No.

463-278

Date

April, 2017

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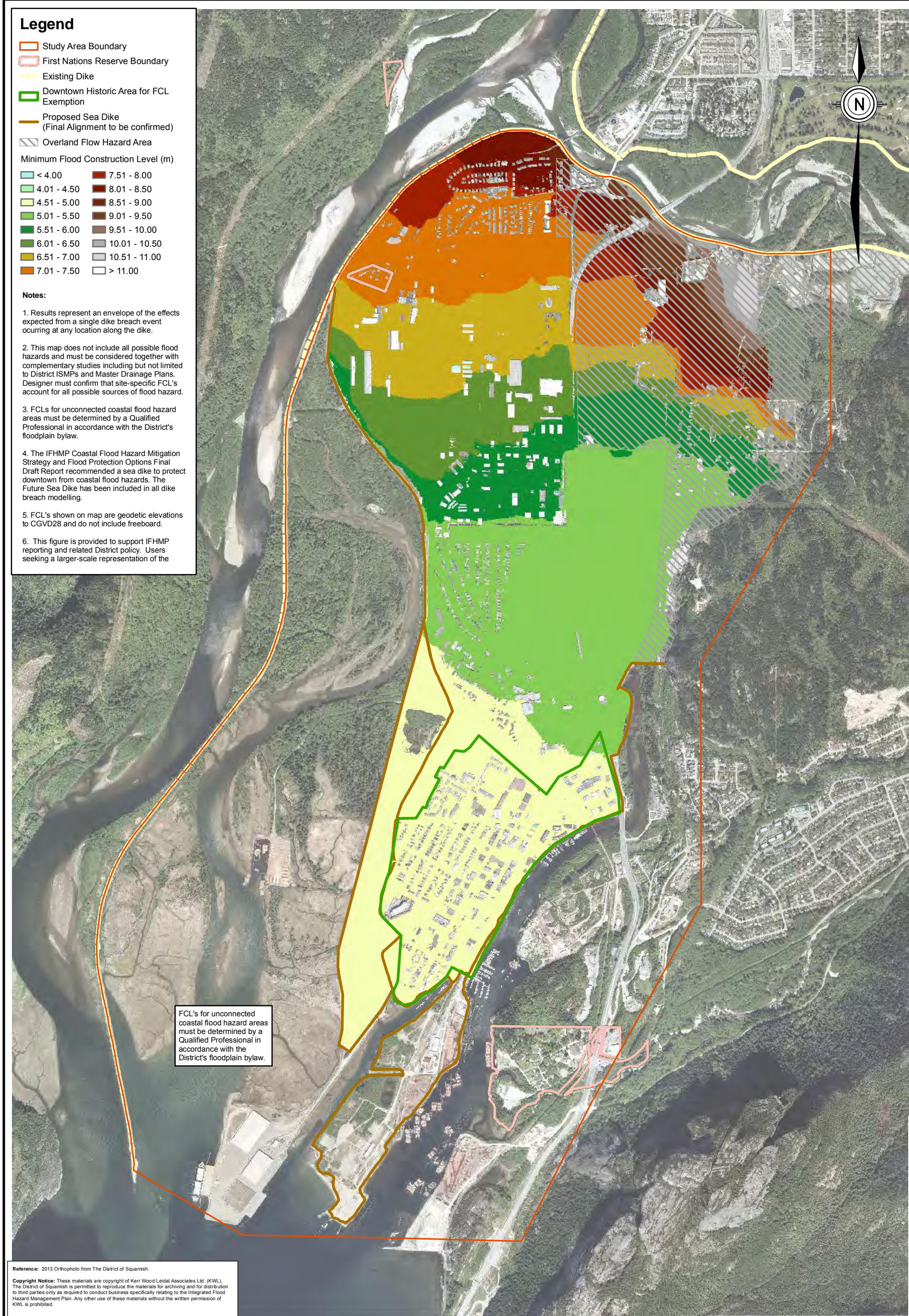
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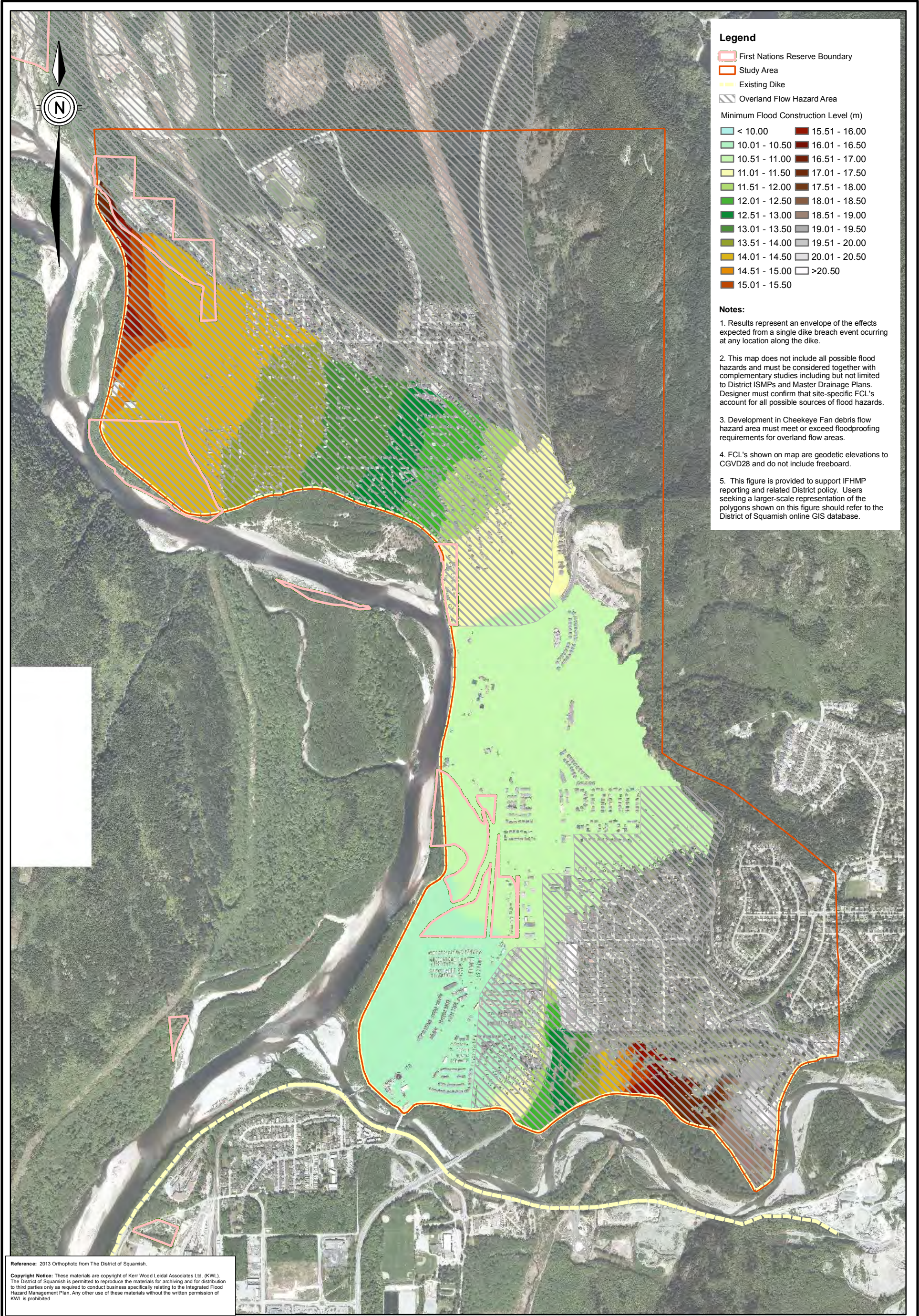
(m)

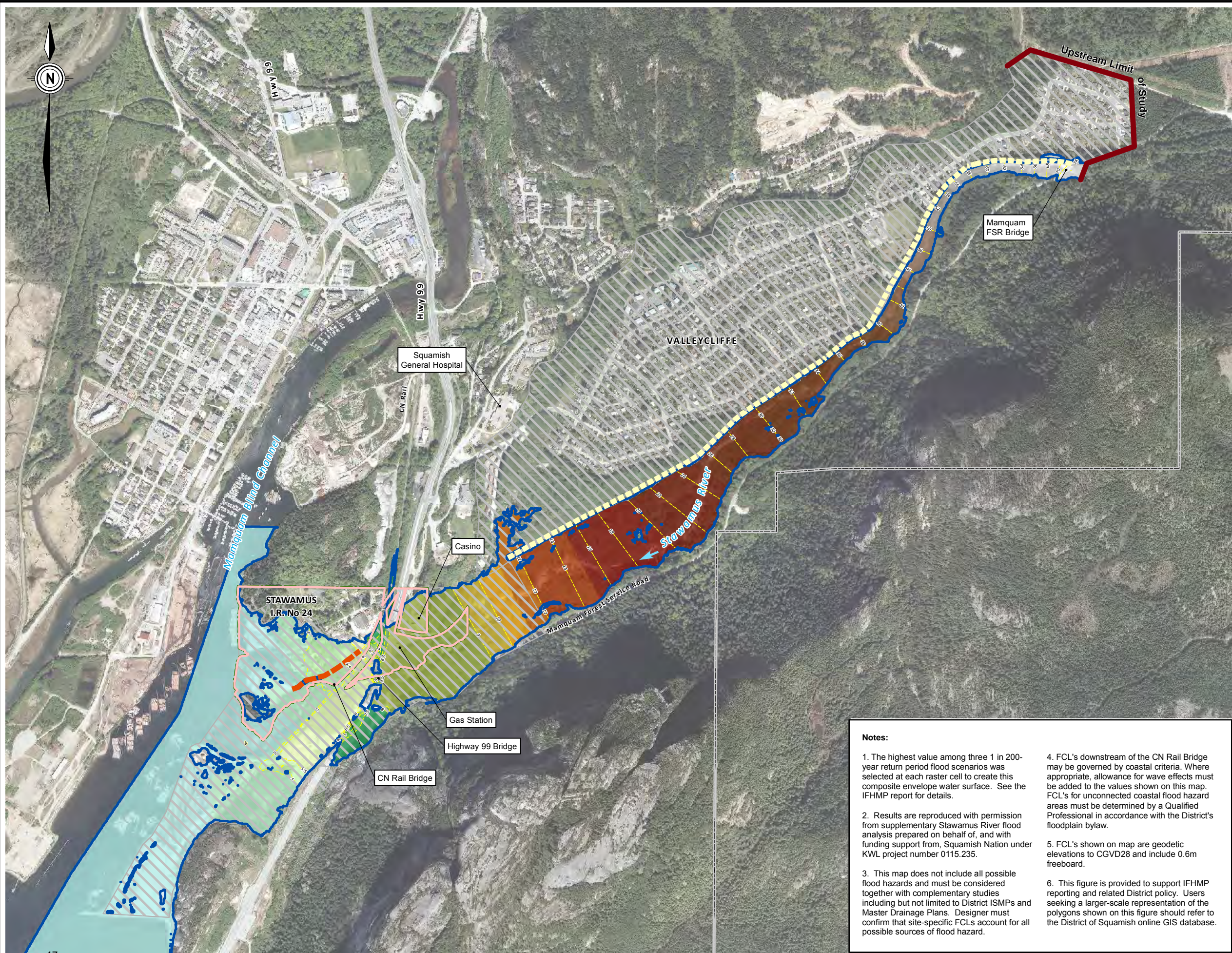
District of Squamish - Integrated Flood Hazard Management Plan

Cheakamus River (South) Minimum Flood Construction Levels

Schedule A1







District of Squamish
Integrated Flood Hazard Management Plan

Legend

- Municipal Boundary
- First Nations Reserve Boundary
- Study Limits
- District Dike
- Other Dike
- Overland Flow Hazard Area
- Flood Construction Level Contours
0.5m Interval Downstream of Hwy 99
2m Interval Upstream of Hwy 99

Minimum Flood Construction Level (m)

< 4.6	12 - 15
4.6 - 5	15 - 20
5 - 5.5	20 - 25
5 - 6	25 - 30
6 - 6.5	30 - 35
6 - 7	35 - 40
7 - 7.5	40 - 45
7.5 - 8	45 - 50
8 - 8.5	50 - 55
8.5 - 9	55 - 60
9 - 10	60 - 65
10 - 11	65 - 70
11 - 12	> 75

Reference: 2013 Orthophoto from the District of Squamish.

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Project No.
463-278

Date
April 2017

Stawamus River
Minimum
Flood Construction Levels

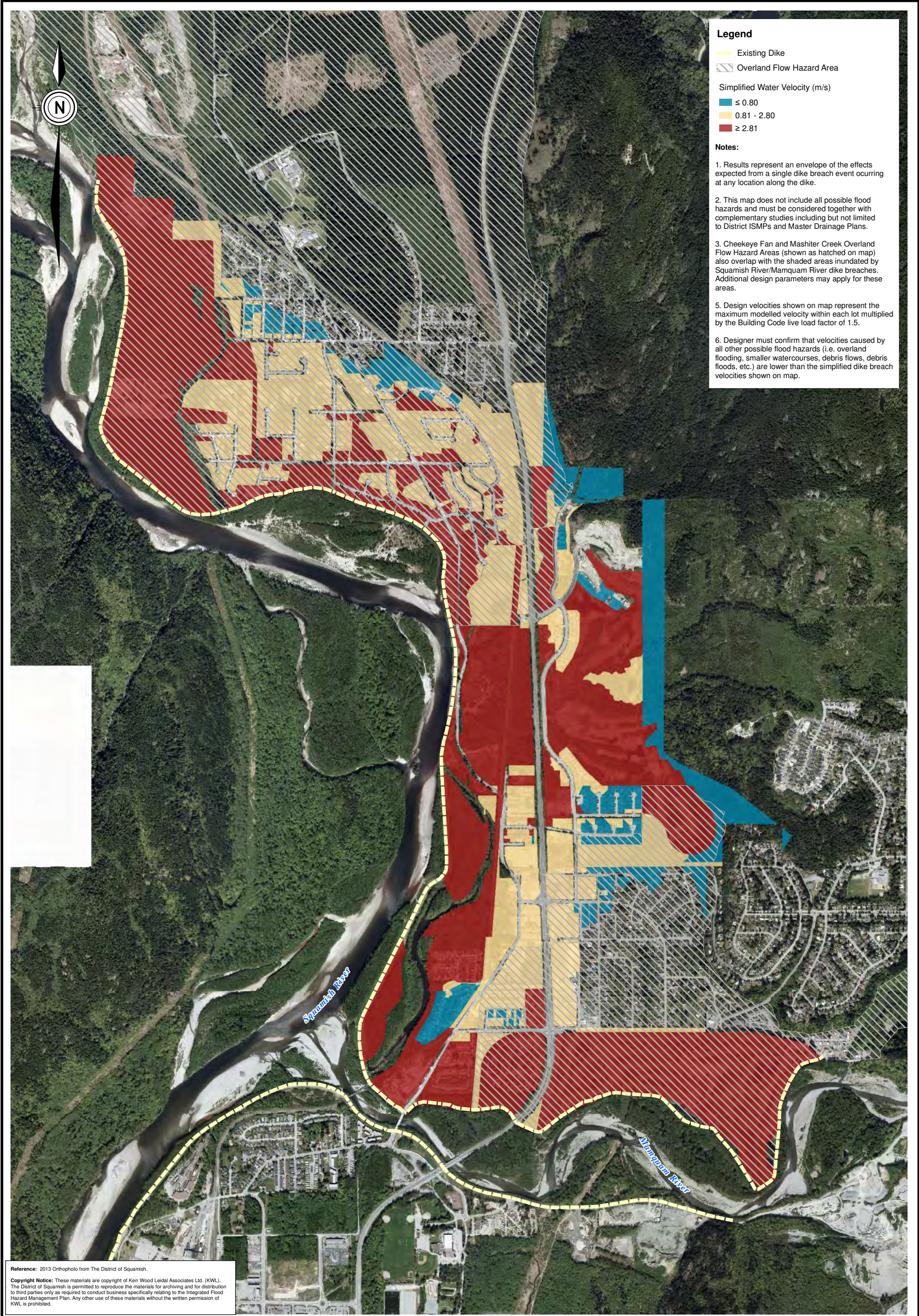
Schedule A1


Notes:

- The highest value among three 1 in 200-year return period flood scenarios was selected at each raster cell to create this composite envelope water surface. See the IFHMP report for details.
- Results are reproduced with permission from supplementary Stawamus River flood analysis prepared on behalf of, and with funding support from, Squamish Nation under KWL project number 0115.235.
- This map does not include all possible flood hazards and must be considered together with complementary studies including but not limited to District ISMPs and Master Drainage Plans. Designer must confirm that site-specific FCLs account for all possible sources of flood hazard.
- FCL's downstream of the CN Rail Bridge may be governed by coastal criteria. Where appropriate, allowance for wave effects must be added to the values shown on this map. FCL's for unconnected coastal flood hazard areas must be determined by a Qualified Professional in accordance with the District's floodplain bylaw.
- FCL's shown on map are geodetic elevations to CGVD28 and include 0.6m freeboard.
- This figure is provided to support IFHMP reporting and related District policy. Users seeking a larger-scale representation of the polygons shown on this figure should refer to the District of Squamish online GIS database.

Schedule A2 - Simplified Design Water Velocity Maps

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Author: DRoche





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Project No.

463-278

Date

March, 2017

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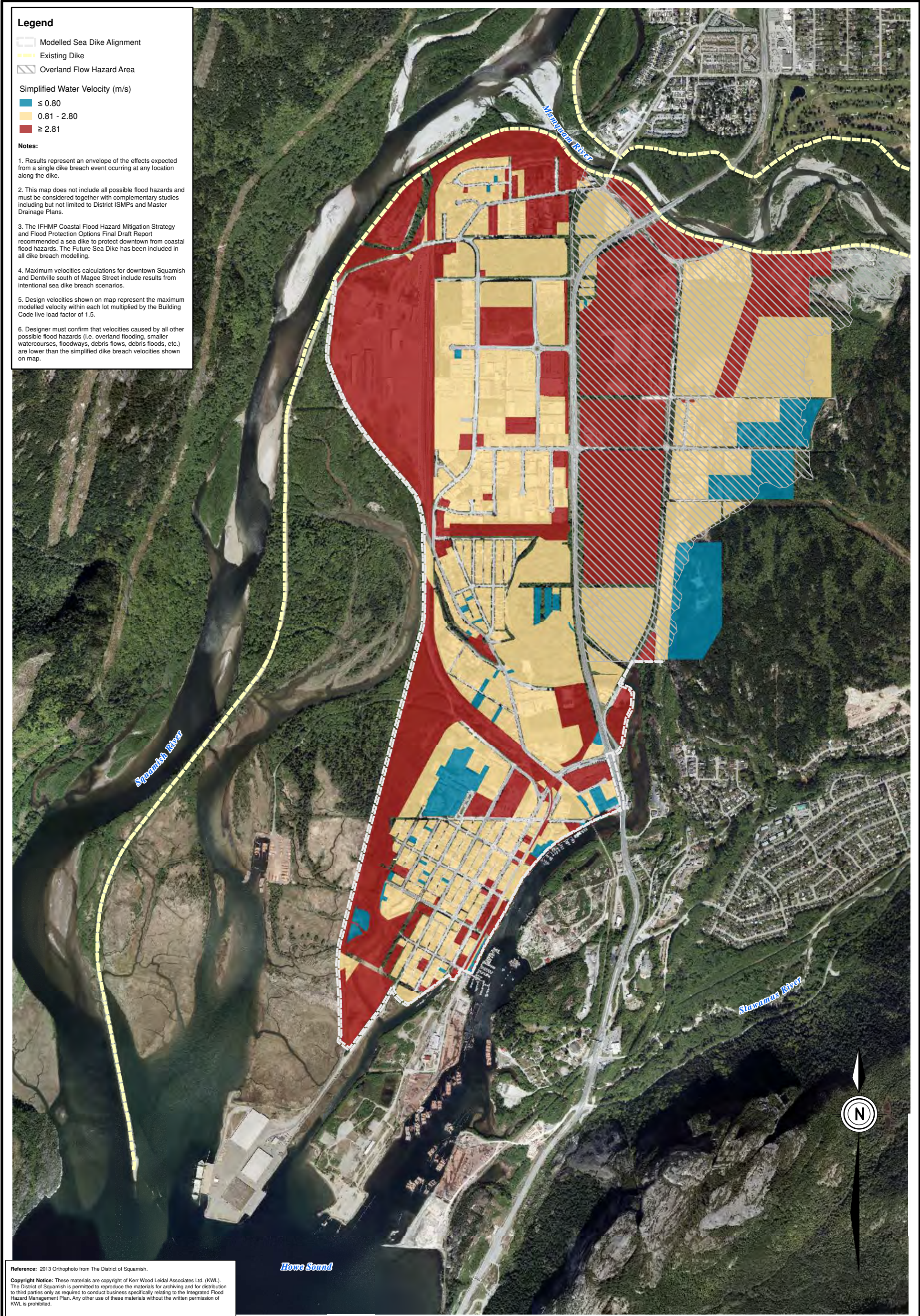
District of Squamish - Integrated Flood Hazard Management Plan

Simplified Design Water Velocities

for Dike Protected Upper Floodplain

Year 2100 200-Year Return Period Flood

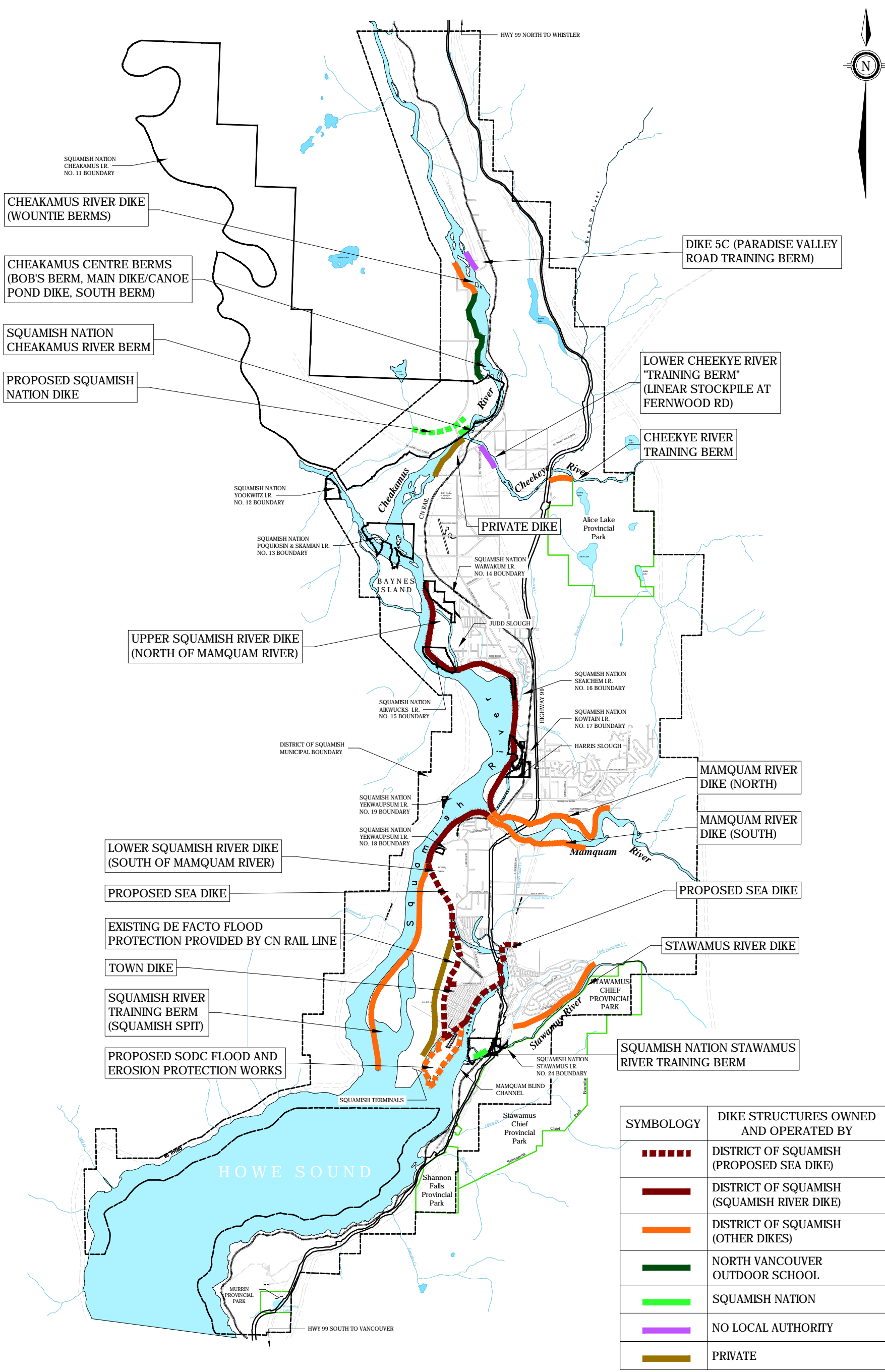
Schedule A2



Schedule B - Structural Flood Protection Works Location Map

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Scale:


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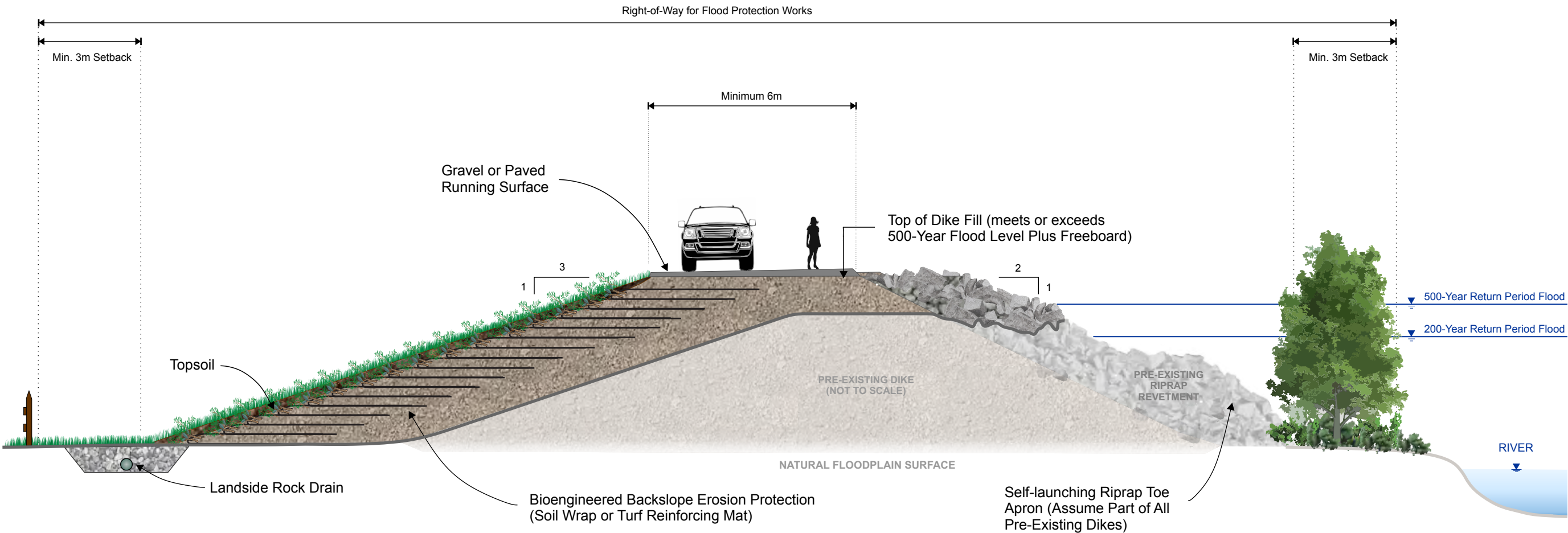
463-278

Date:

April 2017

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District of Squamish
Integrated Flood Hazard Management Plan



Super Dike Upgrades Include:

1. Raise crest elevation to meet or exceed 1:500 year flood level plus 0.6m freeboard
2. Upgrade riprap revetment and self-launching toe apron to protect against erosion and scour during 500-year return period or larger floods. Extend riprap to raised dike crest.
3. Provide minimum crest width of 6m to improve stability, reduce seepage, and allow service vehicles (shown above) to support potential flood fighting efforts on the dike crest.
4. Add erosion protection on landslide slope. Figure shows use of bioengineered soil wraps.
5. Add rock drain along landside toe to reduce seepage exit gradients and prevent toe scour during overtopping.
6. Acquire land to support dike upgrade and expanded statutory right-of-way.

Project No. 463-278

Date September 2017

Scale 1:125

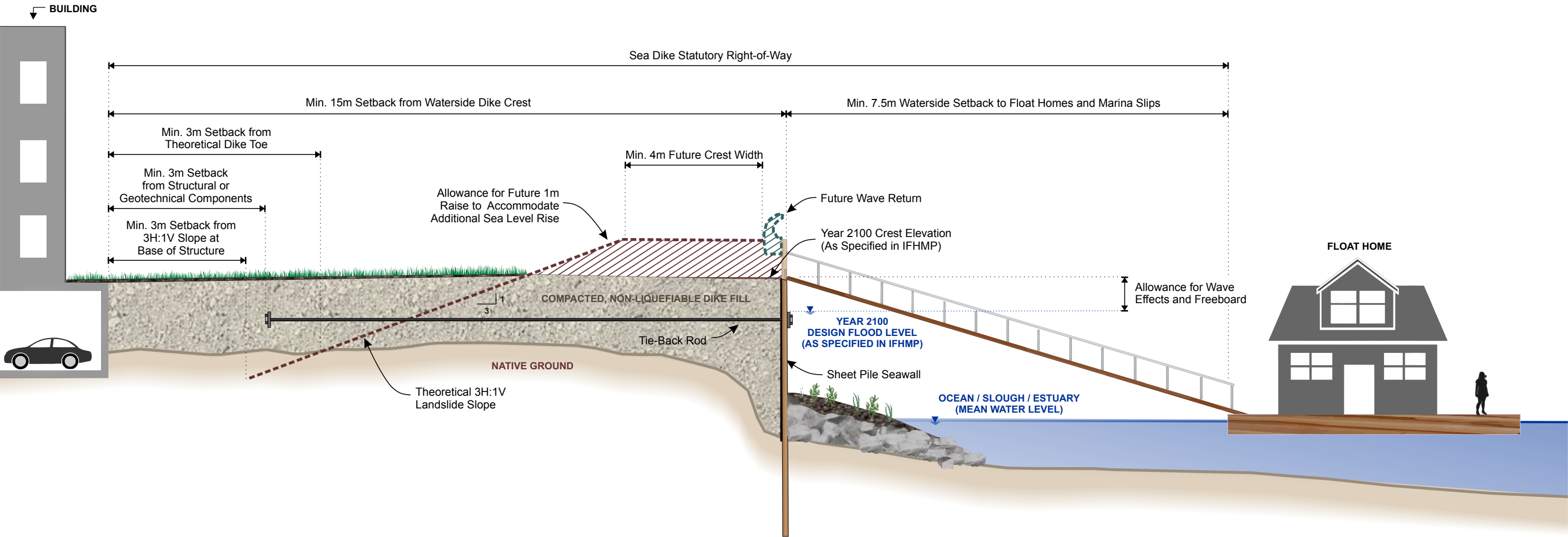
Minimum Future Dike Cross-Section for Squamish River Dike and Mamquam River South Dike

Schedule C

Schedule D - Typical Sea Dike Sections

O:\0400-0499\463-278\501-Drawings\1b_Figures\463278_SeaDikeCrossSections.CDR

District of Squamish
Integrated Flood Hazard Management Plan



Note:

This dike section illustrates key concepts considered in developing the Squamish IFHMP. It is not intended to form the basis for design. Individual elements must be designed by a qualified professional and will be subject to regulatory review processes.

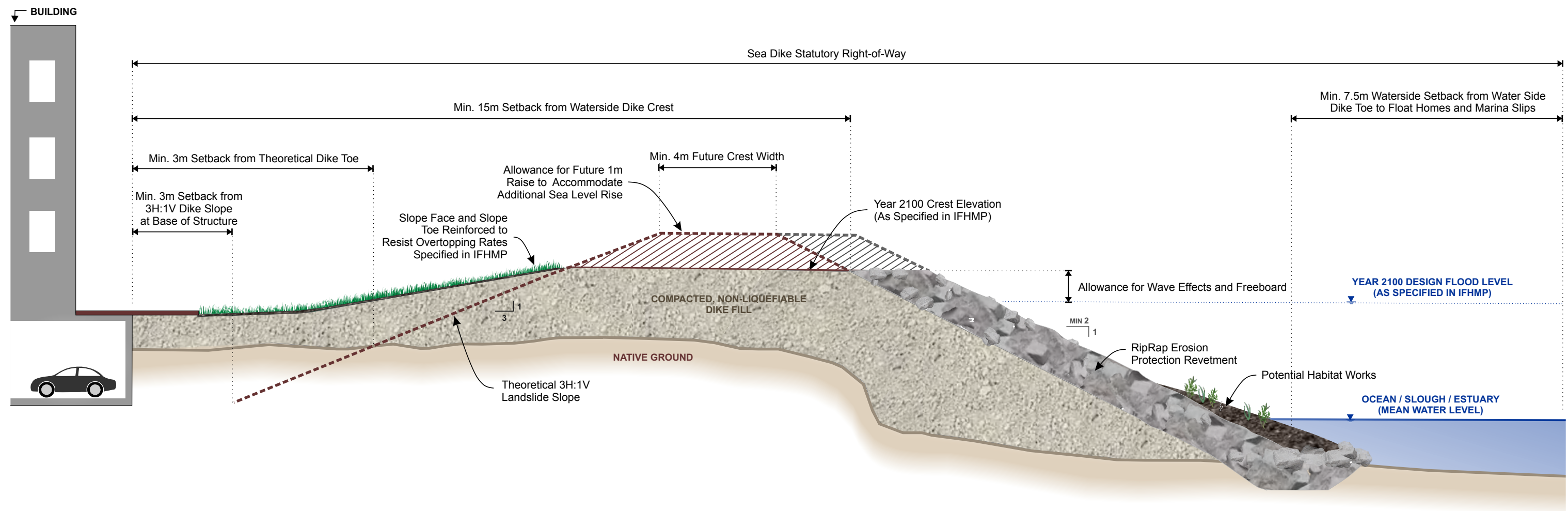
Project No. 463-278

Date February 2017

Not to Scale

Proposed District of Squamish Sea Dike
Conceptual Cross-Section for Sheet Pile Alternative

District of Squamish
Integrated Flood Hazard Management Plan

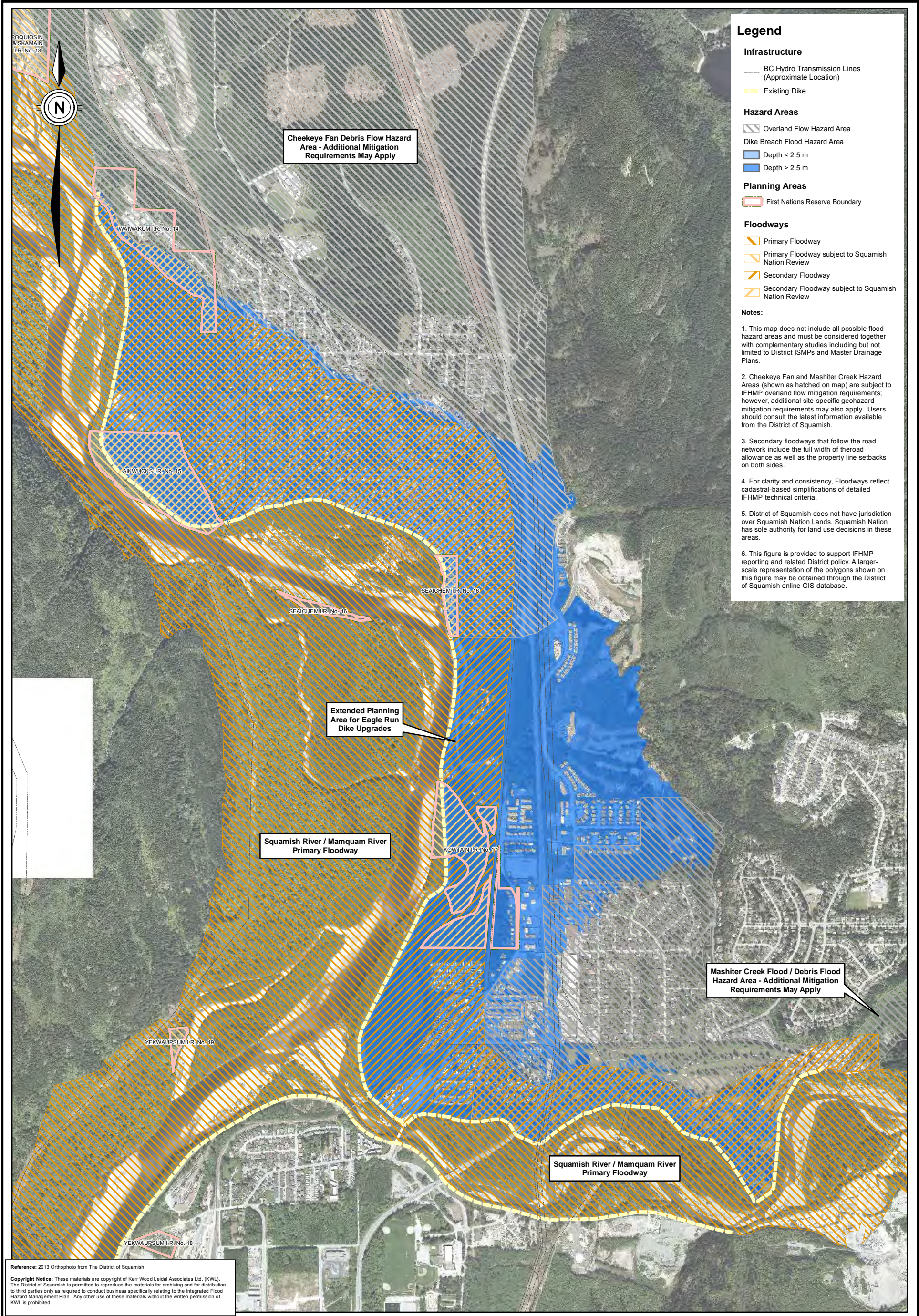



Note:

This dike section illustrates key concepts considered in developing the Squamish IFHMP. It is not intended to form the basis for design. Individual elements must be designed by a qualified professional and will be subject to regulatory review processes.

Schedule E - Floodway Maps

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Author: jlau





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Project No.

463-278

Date

April, 2017

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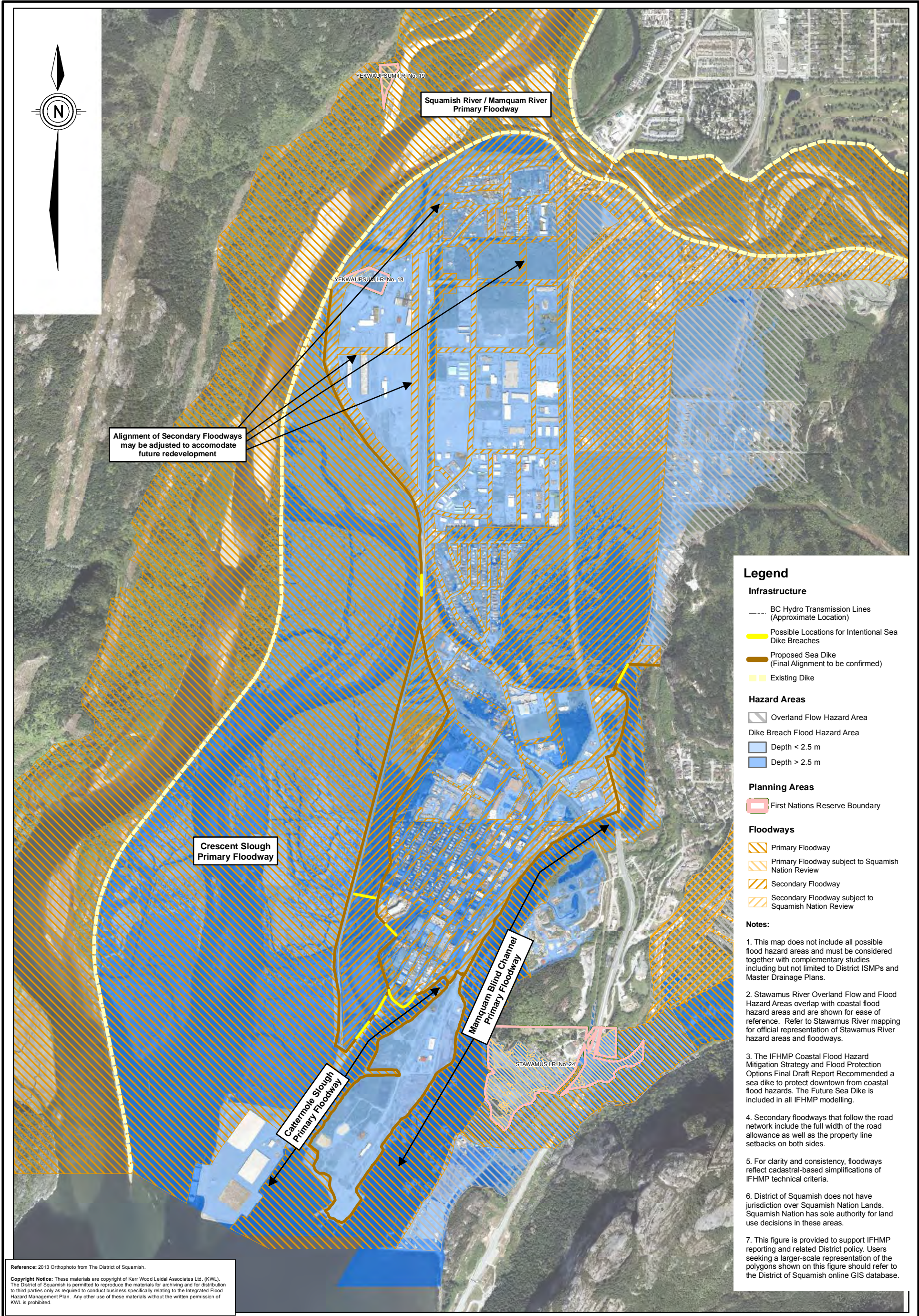
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(m)

District of Squamish - Integrated Flood Hazard Management Plan

Squamish River / Mamquam River Upper Floodplain Floodway Map

Schedule E



Legend

Infrastructure

- BC Hydro Transmission Lines (Approximate Location)
- Railway
- District Dike
- Other Dike

Hazard Areas

- Overland Flow Hazard Area
- Flood / Debris Flood Hazard Area
 - Depth < 2.5 m
 - Depth > 2.5 m

Planning Areas

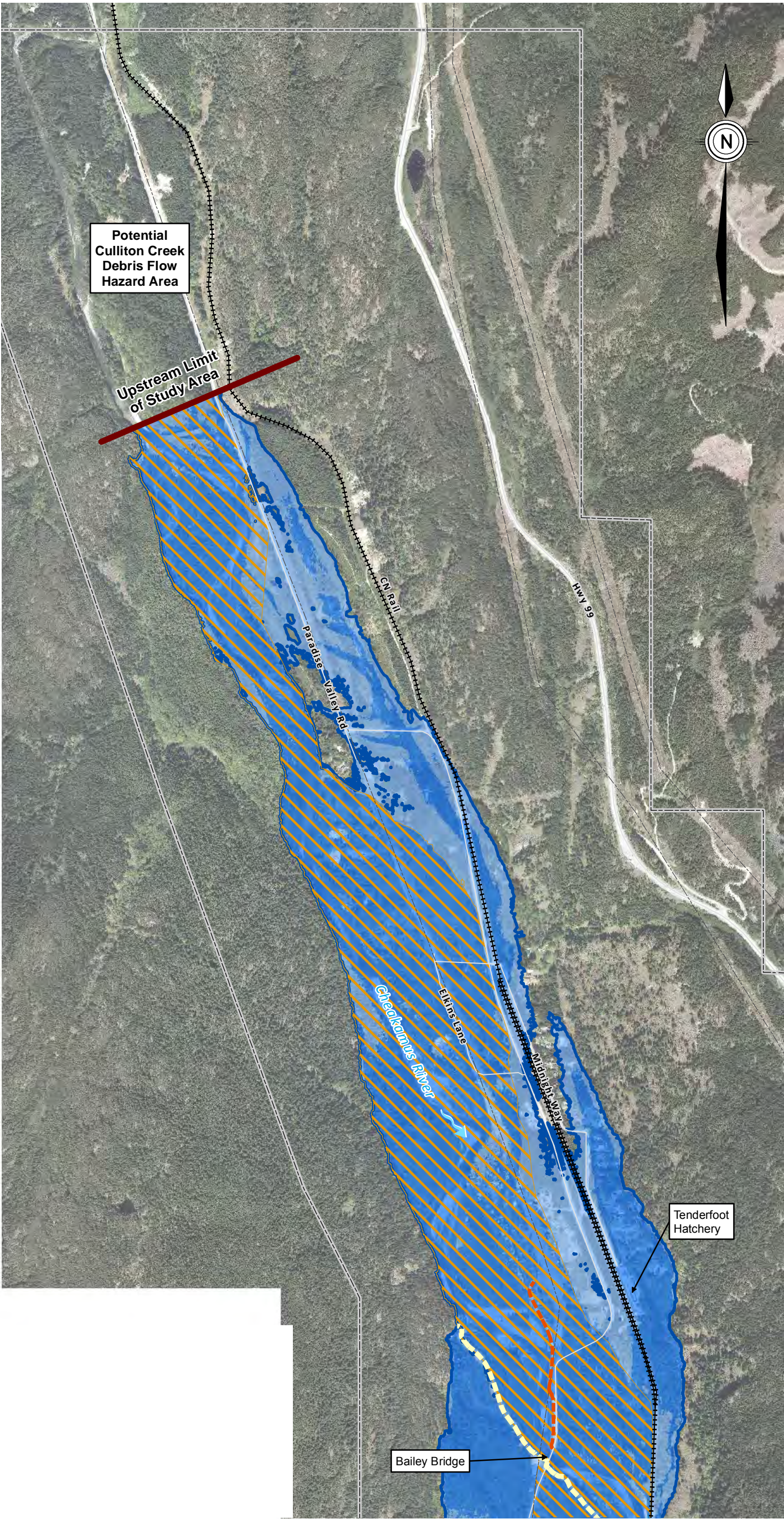
- Municipal Boundary
- First Nations Reserve Boundary
- Study Limits

Floodways

- Primary Floodway
- Primary Floodway subject to Squamish Nation Review

Notes:

- Model results are based on limited - width MOE cross sections from 1978 and 1983.
- Conservative inundation limits are shown in backwater areas to reflect hydraulic model uncertainty.
- This map does not include all possible flood, debris flood, or debris flow hazards (e.g., from site drainage or tributary streams).
- Previous studies have identified the potential for debris flows on Culliton Creek. Culliton Creek debris flows were not assessed as part of the IFHMP but should be considered for any development proposals within the potential runout zone.
- Previous studies have identified the potential for debris floods generated by the failure of potential landslide blockages of the Cheakamus River at Culliton Creek, Cheakamus Canyon, and Rubble Creek. IFHMP modelling provides an interim allowance for debris floods but did not carry out a detailed debris flood assessment.
- This figure is provided to support IFHMP reporting and related District policy. Users seeking a larger-scale representation of the polygons shown on this figure should refer to the District of Squamish online GIS database.



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Project No.

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Date

April, 2017

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(m)

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District of Squamish - Integrated Flood Hazard Management Plan

Cheakamus River (North) Floodway Map

Schedule E

Legend

Infrastructure

- BC Hydro Transmission Lines (Approximate Location)
- Railway
- District Dike
- Other Dike

Hazard Areas

- Overland Flow Hazard Area
- Flood / Debris Flood Hazard Area
 - Depth < 2.5 m
 - Depth > 2.5 m

Planning Areas

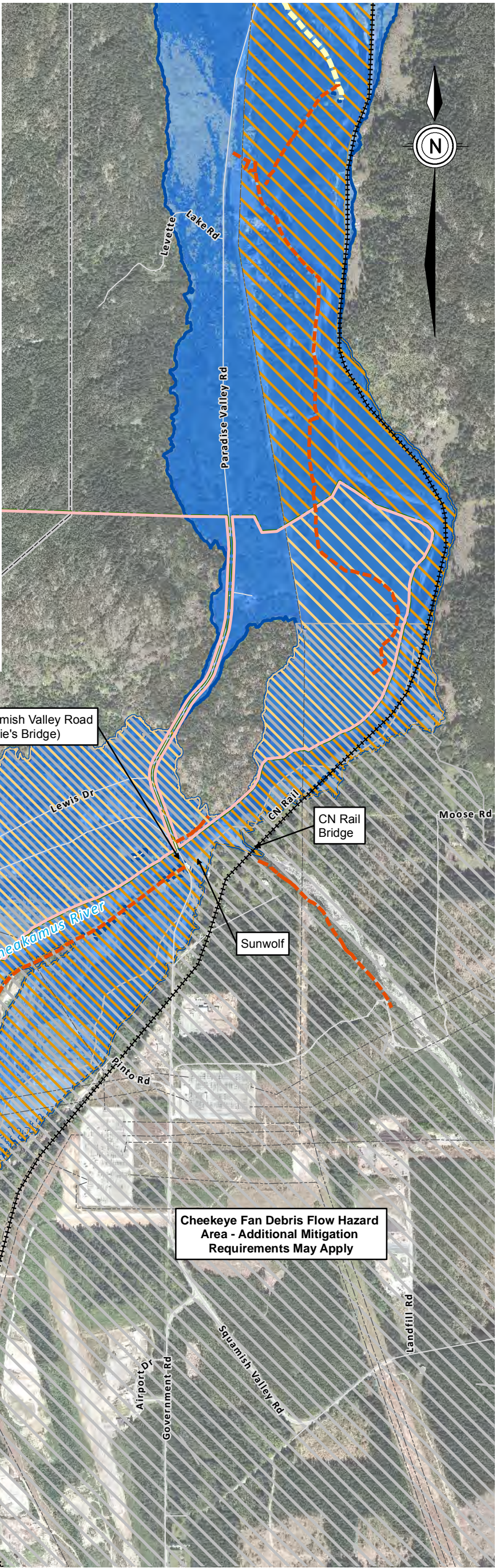
- Municipal Boundary
- First Nations Reserve Boundary
- Study Limits

Floodways

- Primary Floodway
- Primary Floodway subject to Squamish Nation Review

Notes:

- Model results are based on limited-width MOE cross sections from 1978 and 1983.
- Conservative inundation limits are shown in backwater areas to reflect hydraulic model uncertainty.
- This map does not include all possible flood, debris flood, or debris flow hazards (e.g., from site drainage or tributary streams).
- Cheekeye Fan Hazard Area (shown as hatched on map) is subject to IFHMP overland flow mitigation requirements; however, additional site-specific geohazard mitigation requirements may also apply. Users should consult the latest information available from the District of Squamish.
- This figure is provided to support IFHMP reporting and related District policy. Users seeking a larger-scale representation of the polygons shown on this figure should refer to the District of Squamish online GIS database.



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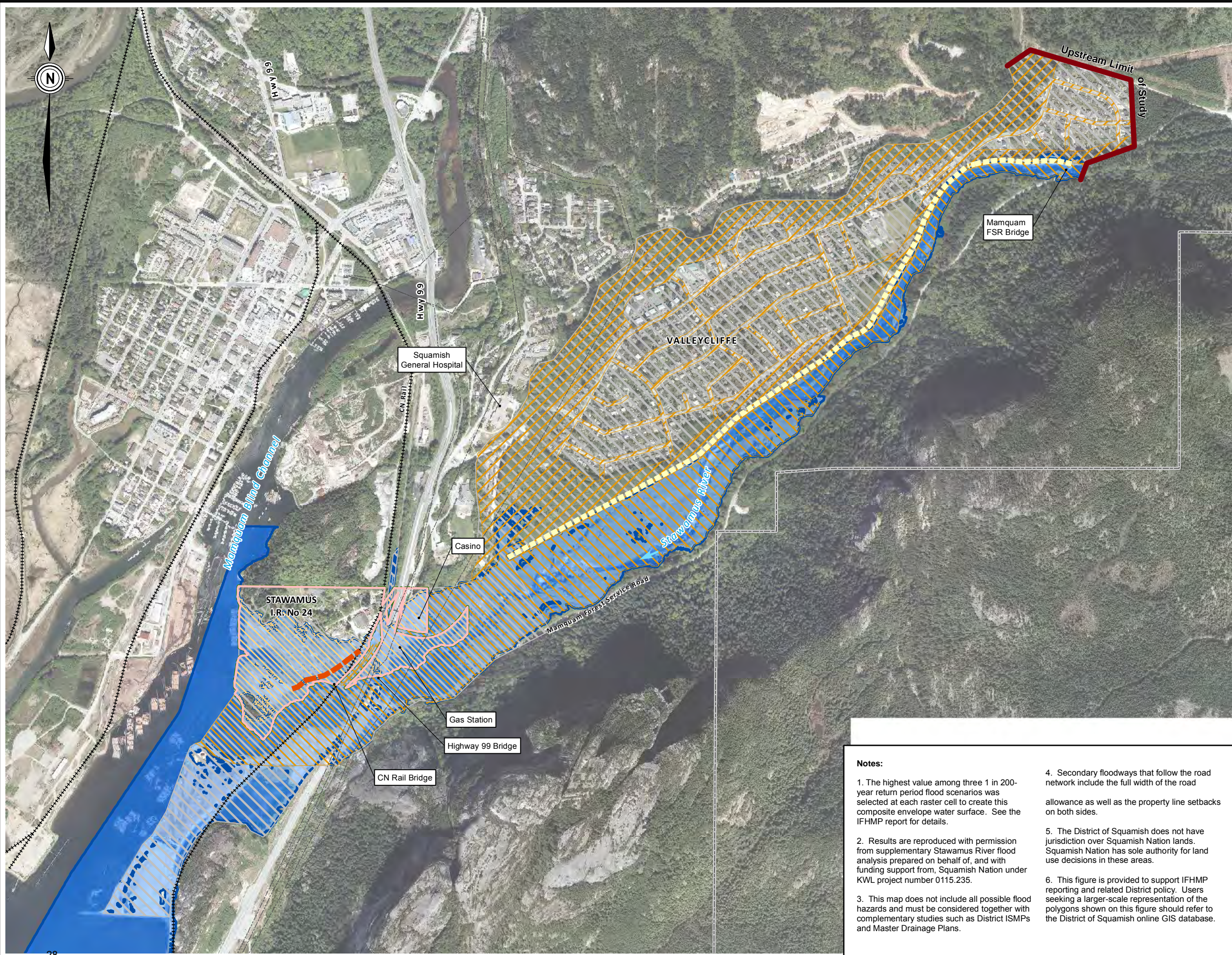
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District of Squamish - Integrated Flood Hazard Management Plan

Cheakamus River (South) Floodway Map

Schedule E



District of Squamish
Integrated Flood Hazard Management Plan

Legend

Infrastructure

- BC Hydro Transmission Lines (Approximate Location)
- Railway
- District Dike
- Other Dike

Hazard Areas

- Overland Flow Hazard Area
- Flood / Debris Flood Hazard Area
- Depth < 2.5 m
- Depth > 2.5 m

Planning Areas

- Municipal Boundary
- First Nations Reserve Boundary
- Study Limits

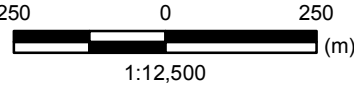
Floodways

- Primary Floodway
- Primary Floodway subject to Squamish Nation Review
- Secondary Floodway

Reference: 2013 Orthophoto from the District of Squamish.



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Project No.
463-278

Date
April 2017

Stawamus River
Floodway Map

Schedule E

Notes:

- The highest value among three 1 in 200-year return period flood scenarios was selected at each raster cell to create this composite envelope water surface. See the IFHMP report for details.
- Results are reproduced with permission from supplementary Stawamus River flood analysis prepared on behalf of, and with funding support from, Squamish Nation under KWL project number 0115.235.
- This map does not include all possible flood hazards and must be considered together with complementary studies such as District ISMPs and Master Drainage Plans.
- Secondary floodways that follow the road network include the full width of the road allowance as well as the property line setbacks on both sides.
- The District of Squamish does not have jurisdiction over Squamish Nation lands. Squamish Nation has sole authority for land use decisions in these areas.
- This figure is provided to support IFHMP reporting and related District policy. Users seeking a larger-scale representation of the polygons shown on this figure should refer to the District of Squamish online GIS database.

Structural Materials (floor slabs, beams, subfloors, framing, and interior/exterior sheathing)

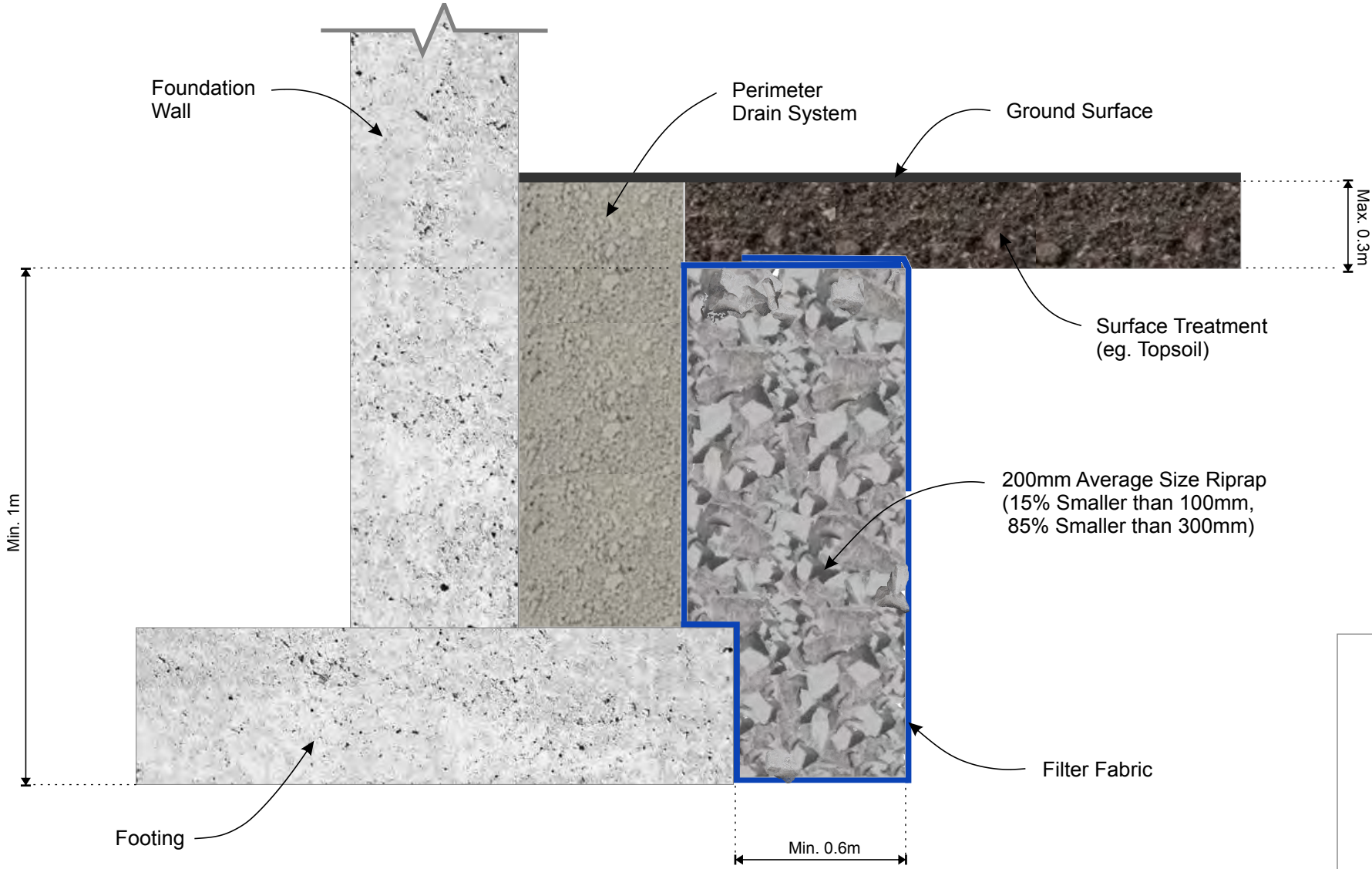
Building Material	Floors	Walls/Ceilings
Asbestos-Cement Board		■
Brick		
Face or glazed		■
Common (clay)		■
Cast Stone (in waterproof mortar)		■
Cement board/fiber-cement board		■
Cement/latex, formed-in-place	■	
Clay tile, structural glazed		■
Concrete, precast or cast-in-place	■	■
Concrete block		■
Gypsum products		
Non paper faced gypsum board		■
Water-resistant, fiber-reinforced gypsum exterior sheathing		■
Plywood		
Marine grade	■	■
Preservative-treated, alkaline copper quaternary (ACQ) or copper azole (C-A)	■	■
Preservative-treated, Borate	■	■
Exterior grade/Exposure11 (WBP – weather and boil proof)	■	■
Recycled plastic lumber (RPL)		
Commingled, with 80-90% polyethylene (PE)	■	
Fiber-reinforced, with glass fiber strands	■	
High-density polyethylene (HDPE), up to 95%	■	
Stone – natural or artificial non-absorbent solid or veneer, waterproof grout	■	■
Structural Building Components		
Floor trusses, wood, solid (2x4s), decay-resistant or preservative-treated	■	■
Floor trusses, steel	■	
Headers and beams, solid (2x4s) or plywood, exterior grade or preservative-treated		■
Headers and beams, steel		■
Wall panels, plywood, exterior grade or preservative-treated		■
Wall panels, steel		■
Wood		
Solid, standard, structural (2x4s)		■
Solid, decay-resistant	■	■
Solid, preservative treated, ACQ, C-A, Borate		■

Finish Materials (floor coverings, wall and ceiling finishes, insulation, cabinets, doors, partitions, and windows)

Building Material	Floors	Walls/Ceilings/Other
Cabinets, built-in		
Metal		■
Ceramic and porcelain tile with mortar set	■	■
Concrete tile with mortar set	■	
Doors		
Metal, hollow		■
Metal, wood core		■
Metal, foam-filled core		■
Fiberglass, wood core		■
Epoxy, formed-in-place	■	
Glass (sheets, colored tiles, panels)		■
Insulation		
Sprayed polyurethane foam (SPUF) or closed-cell plastic foams	■	■
Mastic flooring, formed-in-place	■	
Metals, ferrous		■
Paint		
Polyester-epoxy and other oil-based waterproof types		■
Latex		■
Partitions, folding		
Metal		■
Partitions, stationary (free-standing)		
Wood frame		■
Metal		■
Glass, unreinforced		■
Glass, reinforced		■
Polyurethane, formed-in-place	■	
Rubber		
Moldings and trim with epoxy polyamide adhesive or latex-hydraulic cement		■
Rubber sheets or tiles with chemical-set adhesives	■	
Silicone floor, formed-in-place	■	
Steel (panels, trim, tile) with waterproof adhesives		■
Terrazzo	■	
Vinyl asbestos tile (semi-flexible vinyl) with asphaltic adhesives	■	

District of Squamish
Dike Breach Erosion Protection

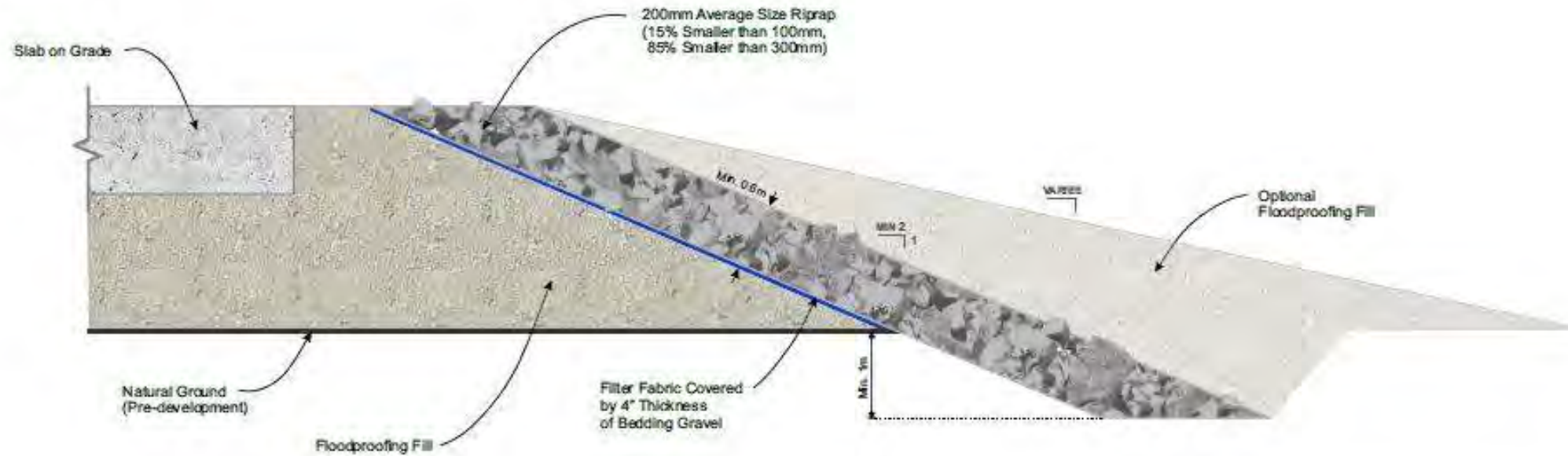
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NOTE

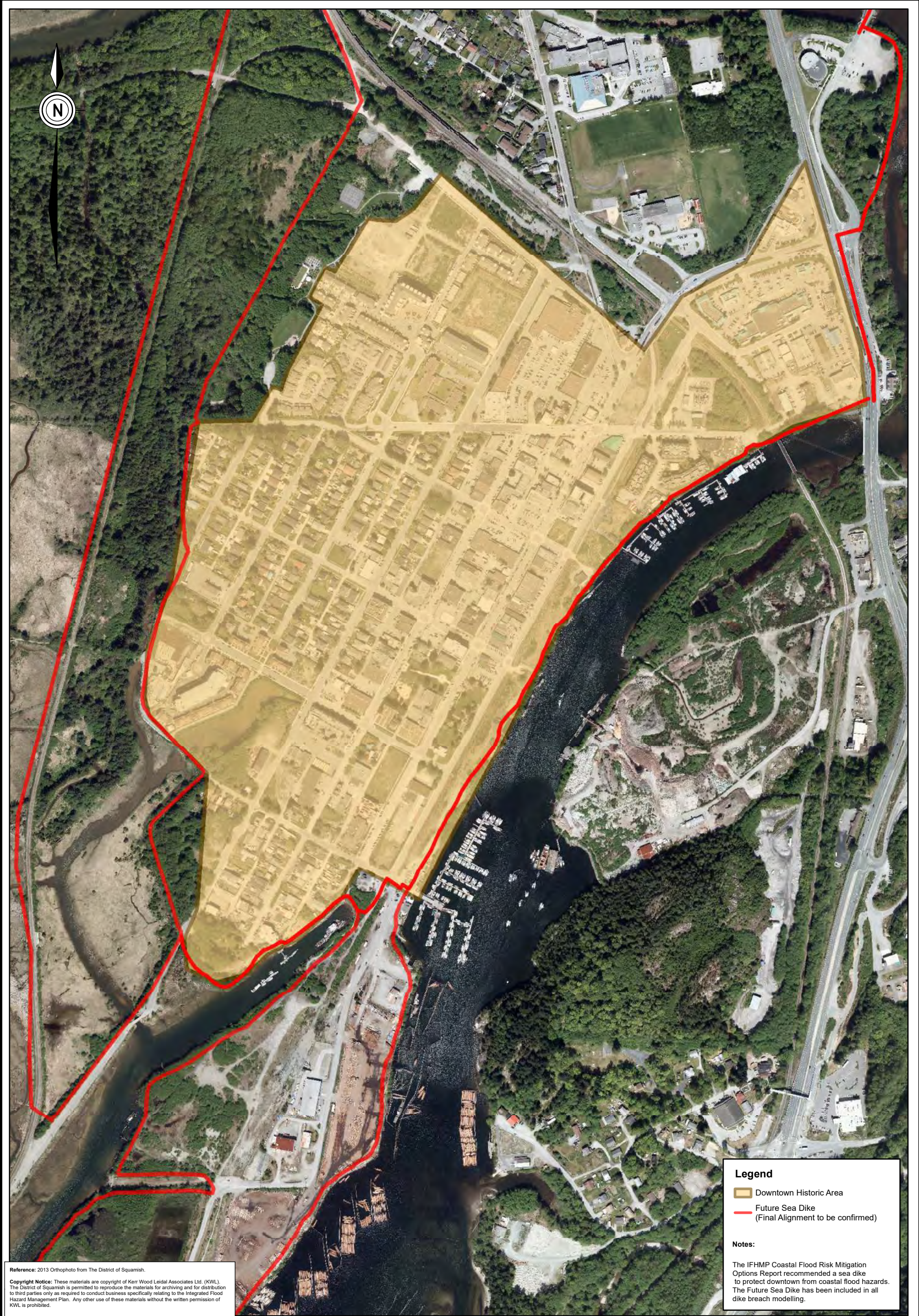
Riprap and filter fabric not required if minimum depth from natural (pre-development) grade to top of footing exceeds 2m or if confining fill is protected as per Detail B.


For exclusive use on lots where District of Squamish simplified velocity mapping indicates a maximum velocity of less than 2.8 m/s.



BASIS

- For exclusive use on lots where District of Squamish simplified velocity mapping indicates a maximum velocity of less than 2.8 m/s.





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Project No.	Date
463-278	May, 2017

100000

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1:6,000

(m)

District of Squamish - Integrated Flood Hazard Management Plan

Designated Downtown Historic Area
for Flood Construction Level (FCL) Exemption

Schedule H



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Appendix I

Upgrading Priorities for Structural Flood Protection Works

Relative Priorities for Recommended Structural Flood Protection Upgrades

Note: The list is organized by relative priorities that reflect the recommended order of implementation. Sub-classes are provided to supplement the IFHMP's four-class priority system.

Priority	External Funding Required?	Dike / Area	Action
1	No	All	Condition inspection for all penetrations and flow control gates, upgrades at priority problem spots
1	No	Mamquam / Downtown	Implement stockpiling and deployment plan for dike closures at CNR, Hwy 99, and sea dike
1	No	All	upgrade / secure penetrations and flapgates identified as high-risk during inspection
1	No	All	Inspect erosion protection and identify priority problem spots (eg u/s Judd Slough PS)
1	Yes	Upper Squamish	Judd Slough standard dike improvements (includes removal of deactivated culvert)
1	No	Lower Squamish	Replace flap gate and CCTV broken culvert on lower Squamish River dike and slipline as required
2A	No	Squamish	Obtain engineering opinion on unauthorized fill
2A	No	Stawamus	Complete riprap to dike crest on upper Stawamus River dike
2A	Yes	Lower Squamish	Widen Squamish River dike at the Fish (standard dike)
2A	Yes	Downtown	temporary sea dike upgrades to 3.3 m on perimeter (Lot 1 downtown plus local areas on reaches 2, 4, 5)
2A	Yes	Upper Squamish	Eagle Run toe berm at Cheema / McIntosh and standard dike improvements
2B	No	All	complete seismic assessment of critical dike sections where a flow slide would require major realignment
2B	No	Upper Squamish	Work with Squamish Nation to re & re gabion backslope on Seaichem I.R. No. 16
2B	Yes	Upper Squamish	Brackendale standard dike upgrades, Judd Slough PS to Seaichem I.R. No. 16 (incl gates and SROW verification)
2B	Yes	Downtown	sea dike to 4.0 m (reaches 3-4-5)
2B	Yes	All	Upgrade riprap protection and add toe at prioritized locations (assume incremental implementation)
3A	Yes	Upper Squamish	Judd Slough superdike upgrades
3A	Yes	Lower Squamish	Raise / widen Squamish River dike from the Fish to the Railway Museum dike access (superdike standard)
3A	Yes	Mamquam	Review Mamquam south dike downstream of Brennan Intake against superdike standard and address deficiencies
3A	Yes	Paradise Valley	Upgrade Bailey Bridge Training Works and accept responsibility for Dike 5C
3A	Yes	Downtown	Implement Reach 2 sea dike to 4.0 m elevation
3A	No	Mamquam	Upgrade Mamquam North dike and riprap upstream of Government Road
3B	No	Mamquam	Mamquam River south standard dike upgrade upstream of Reunion Intake
3B	No	Upper Squamish	Harris Slough standard dike upgrades
3B	Yes	All	upgrade / secure balance of flapgates
3B	Yes	Lower Squamish	Raise / widen Squamish River dike from the Railway Museum dike access to Fortis ROW (superdike standard)
3B	Yes	Upper Squamish	Brackendale superdike upgrades
3B	Yes	Upper Squamish	Eagle Run superdike upgrades
3C	Yes	Stawamus	Stawamus River dike upgrades for debris flood design event (pending debris flood study)
3C	Yes	Mamquam	Mamquam north (golf course) standard dike upgrades
3C	Yes	Upper Squamish	Harris Slough superdike upgrades
3C*	Yes	Downtown	Raise sea dike to Year 2100 elevation (4.7 m / 4.8 m) when SLR exceeds 0.3 m above Year 2014 levels

*If SLR reaches 0.3 m before other tasks are complete, raising the sea dike to Year 2100 elevation should be reprioritized to the top of the 3B category.