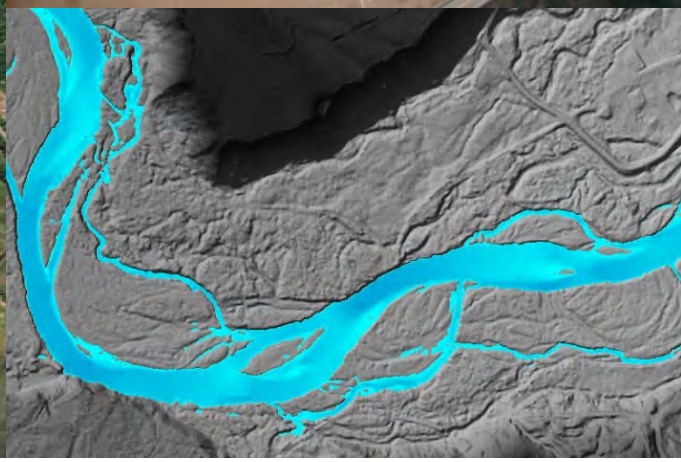
Salmon & White Rivers Flood Risk Assessment

Project # 2221-49200 | Revision 0 | April 4, 2019



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April 5, 2019

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Attention: Shaun Koopman

SALMON & WHITE RIVERS – FLOOD RISK ASSESSMENT

McElhanney Consulting Services Ltd. is pleased to provide a copy of the draft flood risk assessment for the Salmon and White Rivers for your review. The report provides a summary of the analysis completed during the study.

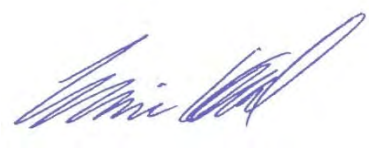
This report should be read in conjunction with the Risk Assessment Template (RAIT), as well as the map figures which have also been prepared as part of this project.

This report was prepared as part of the SRD's funding for the National Disaster Mitigation Program (NDMP), Stream 1. As part of this project, we would be pleased to assist the SRD in compiling a funding application for the next phase of Stream 2. Stream 2 involves detailed mapping & hydraulic modelling of the river to develop new flood maps for the area of interest.

We appreciate the opportunity to work with the Strathcona Regional District and look forward to working with the SRD again in the future.

Yours truly,
McELHANNEY CONSULTING SERVICES LTD.

Prepared by:



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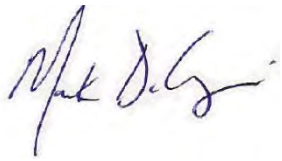

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CONTENTS

TABLES

FIGURES

See attached Map sheets.

1. INTRODUCTION

McElhanney Limited was retained by the Strathcona Regional District (the District) to complete a flood risk assessment for the Salmon and White Rivers. The report has been developed to meet the requirements of the National Disaster Mitigation Program (NDMP), Stream 1. Specifically, the report is structured around gathering the necessary information to fill out the Risk Assessment Information Template (RAIT) and meet the requirements to pursue NDMP Stream 2 funding. In addition to the NDMP requirements, it is also intended that this report can be used to support the District when developing their own initiatives including emergency preparedness planning, input into GIS systems, budgeting for future investigations or mitigation and land use planning.

1.1. SCOPE OF WORK

This project was completed utilizing funding from National Disaster Mitigation Program (NDMP). In recognition of increasing disaster risks and costs, the Government of Canada is investing $200 million over five years for the NDMP. The NDMP addresses flood risks and costs and builds the foundation for informed mitigation investments that could reduce the effects of flood events in the future. Public Safety Canada established the NDMP in April 2015 to build a body of knowledge on flood risks in Canada and invest in foundational flood mitigation activities. Activities include developing a wider understanding of flood risks and employing effective mitigation strategies to reduce the impacts of flooding.

Funding for the NDMP is allocated to recipients via four streams:

Stream 1 (Risk Assessments) provides funding for the completion of risk assessments to inform flood risks. Risk assessments are the foundational step in disaster mitigation. These risk assessments will identify flood hazards, potential impacts, and community and infrastructure vulnerabilities, as well as the overall flood risk profile for the area.

Stream 2 (Flood Mapping) provides funding for the development and/or modernization of flood maps. A flood map identifies the boundaries of a potential flood event based on type and likelihood and can be used to help identify the specific impacts of a flood event on structures, people and assets.

Stream 3 (Mitigation Planning) provides funding for the development and/or modernization of mitigation plans to address flood risks. A comprehensive mitigation plan allows applicants to develop realistic and sustainable mitigation solutions by clearly outlining the plan's objectives, key activities, expected outputs, timelines, and roles and responsibilities.

Stream 4 (Non-structural and Small-Scale Structural Mitigation Projects) provides funding for other non-structural and small-scale structural disaster mitigation projects. Eligible projects would include actions such as the replacement of storm culverts, or projects that improve flood resilience by proactively preventing or mitigating damages and losses.

The Scope of Work for this assignment represents Stream 1 funded work. This report summaries the work that was basis for the completed RAIT and Stream 2 application. The completed RAIT is included in Appendix A.

2. BACKGROUND INFORMATION COLLECTION AND REVIEW

2.1. INFORMATION REVIEWED

The risk assessment relies on existing information, including anecdotal and record information on historic flooding within the community. This information is combined with other existing information such as GIS base mapping, current 200-year floodplain mapping, Ministry of Environment historical records, building information, and infrastructure databases to determine the risk of flooding to the community.

Floodplain modelling for the 200-year event was undertaken in 1980. This modelling does not extend to cover the Village of Sayward but covers the Sayward valley immediately upstream of the village. The basis for this assessment and the completion of the RAIT has therefore been historical flooding based on anecdotal information from the District and community members.

The Regional District have previously mapped an approximate extent for the 2016 flood event which was also used in the analysis of flood risk.

2.2. PUBLIC CONSULTATION

Community engagement sessions were held on 4 and 10 December 2018 to engage with members of the public regarding flooding that has been experienced in the past.

A total of approximately 20 residents attended between the two sessions, with feedback provided across the study area. Residents and members of the community identified areas that have previously flooded, as well as the impacts of this flooding as shown on the attached maps (Appendix B). Community members were asked to provide details on the dates and extents of flooding that had been experienced as per the questionnaire in Appendix C.

Members of the public provided information on their own flooding experiences, with flood events in 1975, 1990, 2008, 2011, 2014 and 2018 specifically highlighted. A common theme in the discussion with members of the community was the concern around emergency access during flood events as well as specific property level flood risk. This presents a significant health and safety risk and is discussed later in this report.

It was apparent from the discussions with the public that the level of snow on the adjacent mountains and the speed at which it melts, followed by heavy rainfall causes a concern with public perception of flood risk, as well as changing land use in the surrounding area. Many residents also made reference to the impact of “King tides” on the level of flooding that has been experienced.

Some residents have witnessed contamination of flood water such as oil and sewage and there were many references to fast flowing water during flooding. These issues present both an environmental and health and safety concern, which is discussed later in this report.

In addition to sharing their experiences of flooding, members of the public provided input into potential mitigation to mitigate against/reduce the impact of potential flooding and these options will be assessed and reviewed as part of the later stages of work outside the scope of this report.

2.3. HISTORICAL RECORDS OF FLOODING

Review of a Ministry of Environment document “Flooding and Landslide Events Southern British Columbia 1808-2006” by D.Septer makes reference to flooding in the Sayward area in 1867, when a member of the Slocan band was referenced in the Daily Colonist on June 23, 1894 as having experienced flooding where river levels in the Pend d’Oreille River, near Sayward reached levels some 30ft above the high water mark reached during the 1894 flood.

The same report references a Louis Merigner, a Colville Valley farmer in the same newspaper as refencing flooding in 1877 in the Pend d’Oreille River, near Sayward, where water levels were as high as the 1882 level. The report references the 1882 event in the Sayward area. The 1882 event occurred in June 7-14 1882. The report details that the 1867, 1877 and 1882 floods were all as a result of spring runoff.

The report highlights flooding experienced December 30- January 3, 1927, when rain on snow resulted in widespread flooding in the area, specifically on January 4, warm rain melting snow in the mountains resulted in heavy flooding, with the Sayward Valley experiencing a severe flood after the Salmon River overflowed its banks.

One flood of particular note that the report details is in 1949 (November 26 – December 3) when a Sayward resident was drowned in a raging creek (unspecified name).

Additionally at the public consultation, there were anecdotal reports, photos & newsprint articles regarding flood events in 1975, 1990, 2008, 2011, 2014 and 2018.The public consultation highlighted that these historical flooding events are not restricted to forgotten “history” , with flooding occurring on a semi-regular basis, with most residents able to recall several flood events which had personally affected either their properties, or their access in and out of the Sayward valley.

2.4. METEOROLOGICAL AND SEASONAL CONDITIONS

From the public consultation and the information provided by members of the community it is apparent that many of the flooding incidents that have occurred are as a result of heavy rain following a period of high snowmelt and “King tides” or a combination of both.

Although snowpack data for the flood events was not available at the time of this study, it is reasonable to conclude that snowmelt provides a large contributing factor to the risk of flooding in the study area and it is recommended that a regional hydrologic analysis is undertaken as part of the hydraulic modelling, including analyzing the risk from the potential impacts of climate change. Engineers and Geoscientists of British Columbia and Provincial Jurisdictions such as The Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Ministry of Transportation and Infrastructure and Ministry of Environment and Climate Change Strategy require that the potential effects of climate change be considered in a design. To understand the changes to climatic conditions anticipated by 2080, it is recommended that the Plan2Adapt tool that was developed and maintained by the Pacific Climate Impacts Consortium (PCIC) is utilized. This tool generates maps, graphs, and data describing projected future climate conditions for various regions within British Columbia. These are drawn from a set of 30 Global Climate Model (GCM) projections based on 15 different GCMs, each driven by two different greenhouse gas emissions scenarios. The emissions scenarios are the A2 (high) and B1 (low), which predict atmospheric concentrations of greenhouse gases in the year 2100 of approximately 1250 ppm and 600 ppm, respectively. The Plan2Adapt tool presents the median changes predicted by this ensemble of model projections. The ensemble will predict a range of possible outcomes; the median is a robust estimate of the central tendency of the ensemble members.

For the Salmon River watershed, it is estimated that precipitation as rainfall will increase due to climate change for the Fall/Winter/Spring seasons by approximately 10% by the year 2080. Due to an increase in winter temperatures, snowpack is expected to drastically decrease during this time. Due to the rain-on-snow, or rainfall during freshet flooding which sometimes occurs, it is difficult to predict exactly how climate change may affect flooding in this area.

However, it is likely that flooding will become more unpredictable, and may manifest as shorter, more intense rain storms and flooding events. See Appendix D for details regarding the estimated changes in precipitation for this region due to climate changes impacts.

3. RISK ASSESSMENT

3.1. RISK VS HAZARD

The EGBC guidelines on Flood Mapping in BC define Inundation Maps as “Topographic maps showing the extent of floodwater in plan, under defined flood events”; Flood Hazard Maps as “Maps that go beyond inundation maps by providing information on the hazards associated with defined flood events, such as water depth, velocity and duration of flooding”; and Flood Risk Maps as “Maps that reflect the potential damages that could occur as a result of a range of flood probabilities, by identifying populations, buildings, infrastructure, residences and the environment, cultural and other assets that could be damaged or destroyed.”.

This report considers flood hazard only; detailing modelling and risk analysis is proposed as part of the next stages of the project, should funding be received.

The mapping produced as part of this report used the District’s base GIS data and the flood mapping data for the 200-year flood event which was completed by the Provincial government in 1980. The information obtained from the public consultation was also mapped onto the GIS base to identify trends and clusters of flooding which have been used in the flood risk assessment below.

3.2. RISK THRESHOLD

This section reviews the type of flood risk to Sayward resulting from periods of heavy rainfall and/or high snowmelt. The most likely flooding is due to heavy local rainfall in the fall, winter or spring. This leads to a rapid onset of increased water levels in the Salmon and White Rivers, and potential surcharging in local drainage systems. A similar likely cause is a large freshet event in combination with a rainfall event, which could cause already high river levels to flood beyond the river banks. However, it is estimated that climate change impacts over the coming decades will drastically reduce the snowpack in this watershed, and therefore flooding will be more likely to occur due to short, intense rainfall events.

BC has not adopted a formal Flood Risk tolerance criteria and risk tolerance must be viewed over varying spatial scales. For example, significant flood damage to a single home in an extreme flood may be tolerable to society, as this constitutes hardship mainly to the homeowner and may not have a significant effect on society at large. However, if many homes are impacted, losses are increasingly deferred to taxpayers. The 200-year event, along with a review of historical flooding has been used as a basis for hazard assessment and this scenario will be examined in the risk assessment as part of this study. However, the District is encouraged to consider establishing a tolerable limit for flood safety (which would be standard-based and/or Risk based) for future development in the area.

Due to the limited level of hydraulic modelling that has been undertaken, the anecdotal historical evidence provided by members of the public, combined with the approximate 2016 flood event mapped by the District and the 200-year floodplain extent modelling were used as a basis for the impacts/consequence assessment. Should funding be received to undertake hydraulic modelling, an assessment should be undertaken to identify the impacts of the smaller, more frequent storm events versus the larger, less frequent storm events to identify the flood events to be modelled. It is likely that the larger storms may only have slightly higher consequences and therefore the smaller storm events that cause frequent flooding may have a greater impact. It is therefore recommended that the 5-year, 10-year and 100-year events are modelled in addition to any others identified.

3.3. IMPACTS/CONSEQUENCES ASSESSMENT

The area of inundation from the existing modelling does not extend to the centre of the Village of Sayward but includes many residential areas including associated infrastructure. The study area includes residential and commercial development, with associated infrastructure and roads. There are also schools, a hospital, conservation areas, municipal buildings, library, campground, parks, and trails within the study area, many of which were highlighted in the public consultation as having been affected by flooding.

The attached maps show the areas that could be at risk during the 200-year event based on current modelling and identify key infrastructure within Sayward that has been included in the flood risk assessment.

The risk assessment included a review of the following impact categories within 5 impact classes as presented by the National Disaster Mitigation Program:

- People and Societal Impacts
    - Fatalities
    - Injuries
    - Displacement
- Environmental Impacts
- Local Economic Impacts
- Local Infrastructure Impacts
    - Transportation
    - Energy and Utilities
    - Information and Communications Technology
    - Health, Food, and Water
    - Safety and Security
- Public Sensitivity Impacts

Each of these impacts has been assessed in the sections below, along with an explanation of the risk rating as assigned in the RAIT.

3.3.1. People and Societal Impacts

It is a priority at the municipal, provincial and federal levels to protect the health and safety of Canadians. Impacts on people are therefore considered pertinent in the assessment process given that natural hazards, such as the flooding experienced in Sayward, can result in societal disruptions such as evacuations as well as injuries.

There are only 2 road accesses into the Village of Sayward and discussion with the District and community members indicate that members of the community were stranded during the flooding experienced in 1975, with members of public needing to be evacuated by helicopter from farm roofs and their homes, as well as in 1990 on Ryans Rd where people were unable to get out of the area. In addition, community members explained that there are ongoing localized areas becoming cut off for 1-3 days at extremely high water (Sayward Road and bridge) as roads became flooded. The potential for road flooding presents a large concern for emergency access during times of flooding.

The public consultation also identified that when flooding does occur the water is often fast flowing, which presents a danger to members of the public. People are at risk of suffering death or serious injury when flooding occurs, People are unable to stand in deep or fast flowing floodwater. Once they are unable to stand there is a risk of death or serious injury.

Given the type of flooding that is likely to occur in the study area, warning time may be more limited, and as evacuation routes are cut off the chances of death and serious injury occurs. Lack of evacuation also poses a risk of fatalities from non-flooding related medical emergencies due to emergency responders unable to access patients etc. The risk rating for fatalities has therefore been set as 2 (could result in 1-4 fatalities)

Injuries could occur before, during and after the flood and may be a direct result of flood waters, such as drowning, or otherwise induced by the event, such as an accident during cleanup activities, post-flood depression, and sleep disorders. It is therefore recommended that residents within the proximity of areas identified as at risk of flooding are encouraged to make their own specific emergency response plans. An information session should be considered to provide these residents with information on the specific dangers associated with flooding.

The existing modelled area for the 200-year flood event does not extend to the area where the hospital is located. However, given its proximity to Salmon Bay, there is a chance that it could be affected in a higher order event. That coupled with the difficulties faced due to inaccessible access routes and the potential fast flowing water means that there is a risk of injuries that could not be addressed by local or regional healthcare resources and additional support or intervention may be required from other regions and supplementary support may be required from the province. The risk rating has therefore been assigned as 3.

The Federal Emergency Management Agency (FEMA) estimate a recovery time equating to 45 days per 30cm of water. Although the flood depths have not been modelled at this time, discussion with local community members indicates that flood depths have in the past been as high as the mailbox, and in some areas up to 5ft. It is therefore likely that flood recovery time could extend beyond 6 months in some localized areas.

There are only 2 road options into the Village of Sayward and given the risk of inaccessibility of these potential routes, it is likely that more than 15% of the total local population could be affected. The risk rating has therefore been set at 5 for the percentage of displaced individuals and 4 for the duration of displacement.

3.3.2. Environmental Impacts

Another priority for municipal, provincial and federal governments is to protect Canada's natural environment for current and future generations. Therefore, environmental impacts are included in the assessment to measure the risk event in relation to the degree of damage and predicted scope of clean up and restoration needed following an event.

McElhanney conducted a review of the area within the modelled 200-year floodplain to determine areas where contamination could be mobilized into flood waters and summarize the potential effects of this contamination.

The following specific tasks were undertaken for this review:

- Completion of an ERIS database search that includes online searches of available Federal and Provincial databases that may contain information of environmental concern. A total of 53 databases were searched with a search area of 10-kilometer radius centered on the intersection of Sayward Road and Highway 19. The search included databases that were determined to be most relevant to this study; the Provincial Site Registry (SREG), Environmental Monitoring Locations (EM - Provincial Permits), the Water Well Information System (WWIS) and the Federal Contaminated Sites Inventory (FCS);
- Examination of the Google Earth aerial photographs for indications of landfilled areas, ponds/lagoons, industrial and commercial sites and other indications of potential environmental concern. These aerial photos are generally current within approximately 2 years;
- Completion of a site visit to review areas noted by the searches and the Google Earth examination, and identify any other areas that could be seen from publicly accessible locations; and
- Preparation of this section of the assessment.

Sampling and analysis of environmental media (soil, groundwater, surface water, or soil vapour) was not undertaken as part of this assessment.

The ERIS database search noted 143 entries. Nine entries were noted in the SREG data, 16 in the EM data, 57 in the WWIS data and 6 in the FCS data. All the 143 entries were evaluated for relevance to the assessment and in conjunction with the Google Earth examination, targets were determined for examination during the site visit.

The site visit consisted of driving the Sayward Valley bottom from the Village to a few kilometers southeast of the Sayward Road/Highway 19 intersection in the developed area of the Valley. Each of the targets identified were assessed from the roadway or publicly accessible area. There was no access onto private properties.

Based on the information gathered and observations on the ground the following point-source Potential Flood Environmental Hazards (PFEH) were identified:

Table 1: Potential Flood Environmental Hazards

Potential Flood Environmental Hazard #	Description and Location	Hazard Description
1	Co-op Gas Station at intersection of Sayward Road and Highway 19.	Underground fuel storage tanks and related dispensing facilities. Potential mobilization of fuel contamination in water.
2	Sayward's White River Resort on Sayward Road 0.5 km south of Highway 19 at Salmon River Bridge.	Underground fuel storage tanks and related dispensing facilities. Potential mobilization of fuel contamination in water.
3	Western Forest Products yard on Salmon River Road 0.5 km southwest of Highway 19 intersection.	4 above-ground fuel storage tanks and related dispensing facilities. Potential mobilization of fuel contamination in water.
4	Former Sayward municipal landfill and MacMillan Bloedel ash landfill northeast of Salmon River Road bridge over Highway 19.	Landfilling of municipal waste and industrial wood ash. Potential mobilization of metals and volatile organic contamination in water.

Additionally, it was also concluded that virtually all the houses, industrial and commercial operations up the Sayward Valley to the east of the Village are on septic fields for sewage treatment. The septic fields are potential sources of both chemical (nitrate/nitrite, ammonia) and biological (coliform) water contamination. Many of these sites will also have a well for water supply as evidenced from the 57 hits in the WWIS database. The wells are not a source of water contamination but may provide a conduit for contamination to enter the underlying aquifer. The general proximity of each well to a septic field makes them significantly susceptible to contamination during a flood.

It is also noted that residences in the area may have heating fuel oil tanks, likely of the above-ground type. These tanks constitute a potential source of water contamination and should be sealed and secured if possible, to prevent flood waters from displacing the contents. Ideally, new tanks should be placed on a stand if they can be kept above flood level on a site-specific basis.

Potential actions that can be pro-actively taken to minimize contamination issues include contamination source control that can be undertaken for point sources such as the Underground Storage Tanks (USTs) identified in Table 1. This may include ensuring that fuelling systems have appropriate shutoff systems, proper securing measures are present (tie-downs, weighting) to keep partially empty tanks from floating, water-tight seals on filling ports and ventilation

systems that terminate above the potential flood water level to prevent water inflow. Some ASTs, such as some of those in the Western Forest Products Yard, may be moveable to above the flood level, however a contingency plan may be required due to the heavy equipment required to conduct such a move. The landfill identified as PFEH #4 in Table 1 appears to be just on the edge of the potential flood area (based on existing modelling) and has been closed for many years. Final covering is in place and vegetation is growing on the cover. Further study of this area is recommended as part of an NDMP Stream 2 and/or 3 stage of work, should funding be received to determine the magnitude of the risk, if any. It is possible that if a minor to moderate risk does exist in this area then a simple solution such as constructing a low-permeability berm may be appropriate.

Wellhead protection is also a critical component of flood planning since there are sources such as the septic fields that are not amenable to source-controls and additionally, source control at the other PFEHs may fail under extreme conditions. Recently installed wells will likely have good wellhead protection measures in place, while older wells may be susceptible due to non-existent wellhead protection or deterioration of the equipment in place due to age. It is recommended that the Regional District conduct a detailed survey of the drinking water wells in the Sayward Valley to determine well locations, their condition and develop measures via policy and/or bylaws to enhance well protection if necessary. Ministry of Health should be consulted in such a process since they have jurisdiction over drinking water well permitting.

Given the explanation provided above, the risk rating for Environmental Impacts has been set as 4.

3.3.3. Local Economic Impacts

The NDMP identifies that there may be local economic impacts as a result of the flood risk occurring. This is therefore included as an item in the risk assessment to capture the damage or losses to locally economic productive assets, as well as disruptions to the normal functioning of the community's local economic system.

The existing floodplain modelling does not extend to the commercial centre of Sayward, however, the impact to commercial properties extends beyond the impact of floodwater within the properties. The potential impact of inaccessible roads has the potential to cause widescale economic disruption to local businesses, as well as cost implications for recovery.

Further hydraulic modelling is required to determine the economic impact of flooding at a property level, but many of the community members interviewed at the public consultation spoke of economic damages to their property, with some discussing the length of time taken for them to receive financial support and the impact that this had on them. These impacts would increase under more severe flooding events. Each flood event results in damages that need repair, time off work to manage flooding and post flood cleanup, as well as disruption of local services due to flooding over roads.

In addition to the time and costs related to building restoration and repairs, there are likely to be local economic impacts relating to responding to the flood during the flood event. This would include requirements for RCMP to provide security if buildings are evacuated as well as support for evacuees and government response, all of which could have impacts on local taxation.

Although the Village of Sayward has a small local population of approximately 300, the area does benefit from day tourism, with some overnight and multiple day tourism from users of the campground attracted by the abundance of natural recreational opportunities in the area. Although the population is declining, the Economic Strategy identifies that the harbor remains strategically located for multiple sectors from aquaculture to tourism, and the community is centrally located to support forestry in the surrounding region.

Given the far-reaching impacts of road disruption on the entire community, the risk rating has been assigned a risk rating of 5, more than 15% of the local economy impacted.

3.3.4. Local Infrastructure Impacts

It is recognized that there are several local infrastructure components, that are fundamental to the viability and sustainability of a community. The NDMP therefore includes local infrastructure in the assessment process to identify components that may be at risk that would have a wider impact on the community. The area includes infrastructure such as roads, storm water infrastructure, and sanitary system infrastructure.

Transportation Routes & Emergency Access

Sayward Road is the main access into the Village of Sayward from the Island Highway. There exists only one alternate access, the Salmon River Main, which generally runs on the opposite side of the Sayward Valley. Based on review of the existing 200-year floodplain extent & discussion with residents, there are indications that both these roads are at risk of flooding and have flooded during past flood events. This can result in the village being completely cut-off from road access.

In addition to the Salmon River Main, the Island Highway itself is also shown to be at risk in the 200-year extent. This is a vital north-south transportation corridor for Vancouver Island, and is the only road link for the Southern island to Sayward and the rest of Northern Vancouver Island. Although the Island Highway itself does not flood as often as Sayward Rd / Salmon River Main, it likely would be at risk during a large (200-year) flood event.

A common theme throughout all of the public consultation was the risk of people being cut off or roads becoming inaccessible. Insufficient emergency access presents a great risk for emergency response purposes, as well as economic impacts as discussed above. The public consultation identified a number of bridges that have also experienced flooding, and in some cases, structural damage. These bridges are highlighted in red on the attached maps.

Alternative access & evacuation plans should be considered by the SRD. Although anecdotal evidence from residents is that past (recent) flooding events have only resulted in short-term road blockages of hours, a larger flood event could restrict or cut-off access due to high water for days. If bridges are damaged/washed-out, this could extend to weeks. Alternative access/evacuation possibilities are water access or helicopter access.

Given the far reaching and wide-scale disruption caused to the local infrastructure, the risk rating for transportation has been assigned as 5, the highest level as it is felt that this is the greatest risk to the local community.

Communications, Energy & Utility Infrastructure

During flood events there may be energy and utility disruption at an individual property level as service connections become flooded, although these impacts are likely to be restricted to the properties directly affected by the flooding. Based on anecdotal evidence from the public consultation there has been limited impact on energy and utilities during previous flooding. However, as there are likely to be energy and utility infrastructure within the affected area, we would estimate that although local activity may be disrupted for a short time, there is a potential that roads would also be flooded and hence access may be difficult for energy and utility providers to access properties to undertake repairs. The risk rating for energy and utility disruption has therefore been set as 2, duration of impact 13-24 hours.

Any disruption to Information and Communications Technology (ICT) is likely to be at the property level, as individual property services become flooded. Wider impacts are not anticipated, therefore the risk assessment for impacts to ICT has been set as 1.

The potential effect of contamination of floodwaters was previously discussed. It was highlighted during the public consultation that some properties that have been affected by flooding have onsite sewage disposal systems which are at risk of breaching into the floodwaters. This is in addition to the direct health impacts of the flooding listed above. As previously discussed, there have been incidents when people have been unable to evacuate due to inaccessible roads

which poses a great risk to the health of the local community. Lack of safe emergency access and egress is the area of greatest concern for the community and the risk rating for health, food and water has therefore been set as 5, the highest rating, with greater than 20% of the local population impacted.

The Village's sewage lagoon is located on the foreshore of the ocean immediately adjacent to the village center. A large flood event within the river is not likely to affect water levels at the lagoon, as it would be dependent on the level of the tides. However, a large flood event could cause erosion or damage to the berm which contains the sewage lagoon. Similarly, a large storm-surge event in combination with a large "King tide" event could cause seawater to inundate or overtop the lagoon. Each of these scenarios could temporarily or permanently damage the sewage lagoon, depending on the severity of the event.

No intelligence or defense assets are identified within the study area, hence there is considered to be no risk to safety and security on a regional level, although there is a direct risk to the properties that are affected as houses are left unoccupied during times of evacuation. The safety and security risk have therefore been assigned a risk rating of 2.

3.3.5. Public Sensitivity Impacts

Public sensitivity impacts were included in the NDMP given that the credibility of governments is founded on the public's trust that all levels of government will respond effectively to a disaster event.

The potential disruption to the roads and the lack of safe emergency access and egress poses a large risk to the community. Given the wide-scale disruption that this would cause (and had caused in the past) at a local level, this could result in loss of reputation for the Regional District.

It is evident from the level of input that was provided by some of the residents at the public consultation meetings that flooding is a very emotional subject for the community, with some people having experienced flooding on numerous occasions. The long-term mental health impacts of flooding cannot be calculated but it is evident that members of the community are suffering from the fear of flooding with each extreme weather event. There is an expectation from the community that the Regional District act to mitigate against the risk of flooding to the community. The risk rating has therefore been assigned a value of 4.

4. CONCLUSION & RECOMMENDATIONS

4.1. SUMMARY

The flood risk assessment for the Salmon and White Rivers through the Village of Sayward, which was commissioned by the Strathcona Regional District, was prepared using available information, including flooding locations and photographs. Historical information was used as a baseline for the assessment. It is clear from this anecdotal evidence that the greatest risk posed is a lack of safe emergency access and egress during flood events. This lack of access has the potential to impact most of the community, with previous incidents of evacuation from roofs required by helicopter. There is a perception from the community that action is needed to mitigate against these risks.

Anecdotal evidence provided by residents indicates that the more frequent, smaller storm events cause frequent, localized flooding within the community. It is these events that appear to have the most impact. Larger storms are likely to have higher consequence; however, the information and analysis is not available to accurately quantify these risks.

The risk assessment included a review of the 12 impact categories within 5 impact classes as presented in the RAIT, with a rating of 1 (least impacts) to 5 (greatest impacts) assigned as per the descriptions in the RAIT. The RAIT is provided in Appendix A.

4.2. NEXT STEPS

The regional District should take the following actions to progress this risk assessment into a more detailed study that can be used to identify potential mitigation options:

- Undertake flood mapping to assess how the area would be affected by flooding events. This would identify the geographical boundaries of several potential flooding events based on the type and likelihood of flooding. An application for Stream 2 NDMP funding can be prepared to undertake this.
    - As part of this exercise, update and extend existing floodplain modelling, to include the interaction with tidal flooding. This help with planning for flood mitigation and also provides a tool for planning purposes when assessing future development.
- Review Sea Level Rise (SLR) estimates, gather estimates of storm surge and/or wave run-up, and compare against the height around the sewage lagoon to determine the potential vulnerability to ocean inundation or damage from storm events (independent from large flood events within the river);
- Use the updated flood mapping to identify structures, people and assets that are within the flood zone that are most likely to be impacted by the flood event and development site-specific response plans, targeted information campaigns, etc.
- Update this risk assessment with data from flood mapping to identify and classify potential hazards and economic impacts of flooding.
- Conduct a detailed assessment of the fuel storage tank locations, including residential fuel oil tanks, determine what flooding safeguards are in place and what improvements, if any, are feasible.
- Conduct a groundwater well location and condition survey to identify locations where the aquifer is vulnerable to contamination via surface water intrusion.

- Conduct a detailed assessment of the former Sayward Municipal / Macmillan Bloedel ash landfill location to determine the extent of vulnerability to floodwater intrusion and determine whether additional protection is needed for this location.
- Use updated flood modelling to identify safe emergency access and egress routes.
- Liaise with external stakeholders, to discuss the potential flood risk.
- Use the updated risk assessment to identify mitigation goals (Stream 3 funding from NDMP can be applied for to undertake this). Identify objectives and strategies to meet these goals, including the identification of specific mitigation projects.
- A review of mitigation options should also consider the options for providing warning systems to alert residents to potential upcoming flooding and provide information on evacuation routes.
- Provide mapping to the public identifying evacuation routes, with the potential to provide this a “live” system with real-time updates on road conditions and flooding levels.
- Undertake a Return on Investment (ROI) analysis for proposed mitigation measures to identify preferred option/s.
- Undertake a public consultation on the proposed mitigation option/s.
- Identify required geotechnical investigation to evaluate the soils conditions in the area and the potential impact of this on flooding and proposed mitigation options.
- Review potential funding sources (including Stream 4 NDMP) to implement preferred mitigation option/s.

5. DISCLAIMER

This report is prepared for the sole use of Strathcona Regional District. No representations of any kind are made by McElhanney Consulting Services Ltd. or its employees to any party not affiliated with Strathcona Regional District. The information provided in this report represents McElhanney's best professional judgement in light of the knowledge available to McElhanney during the time of preparation

APPENDIX A

RISK ASSESSMENT INFORMATION TEMPLATE (RAIT)

Public Safety Canada | Sécurité publique Canada
Ottawa, Canada
K1A 0P8

National Disaster Mitigation Program (NDMP)
Risk Assessment Information Template

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 01/01/1975	End Date: 01/01/2018
Severity of the Risk Event	Provide details about the risk, including: • Speed of onset and duration of event; • Level and type of damaged caused; • Insurable and non-insurable losses; and • Other details, as appropriate.	The risk event is not based on any one historical flood event. Instead it is a combination of anecdotal information, photos, etc. from past flooding events which have been combined to form the basis of the risk event for this assessment. Flooding includes events in 1975, 1990, 2008, 2011, 2014 and 2018, as well as flooding that is experienced annually. Review of historical records indicate that flooding was experienced in the Sayward area back to 1867. Further analysis is required to determine the exact causes of the flooding that is experienced. The risk event tends to be due to heavy local rainfall, potentially in combination with a freshet event. This would lead to a rapid onset of increased water levels and velocities in the rivers. The risk event would result in local transportation and access disruptions, which is the main concern for the local community, with previous evacuation issues having been experienced and residents requiring evacuation by helicopter from roof tops. In addition to evacuation concerns, residents have reported that they have experienced damage to property, particularly of driveways and in basements and crawl spaces and loss of materials that are washed away during flood events. The previous flooding that has been experienced has also resulted in mobilization of contaminants, with residents reporting that they witnessed oil and sewage in flood waters.	
Response During the Risk Event	Provide details on how the defined geographic area continued its essential operations while responding to the event.	Major disruption has been experienced to the road network. There are only 2 main roads that connect Sayward to the surrounding area and flooding has been experienced on both at different times. Some areas of the community have been completely cut off with residents needing air evacuation from roof tops. Local road closures have been needed and traffic detours put in place. Residents have reported that bridges were inaccessible and some community members were evacuated as there was concern that other routes would become inaccessible. In some cases, roads have been inaccessible for up to three days and telephone connections have been disrupted.	

Recovery Method for the Risk Event	Provide details on how the defined geographic area recovered.	Anecdotal evidence from public consultation indicates that residents have experienced local recovery at a property level., with repairs needed to damaged property. Residents have indicated that access in and out of the Town was cut-off for up to 3 days, and smaller detours were required for longer. Repairs to damaged roads were required as well as clearance of debris from roads and properties.
Recovery Costs Related to the Risk Event	Provide details on the costs, in dollars, associated with implementing recovery strategies following the event.	Anecdotal evidence from public consultation indicates that while local residents have received grant to cover some of the property level recovery costs, it has taken significant time for these grants to be received, leading to economic impacts for some residents.
Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.	Recovery times for previous flooding events are unknown, although residents have reported that access in and out of the Town was cut-off for up to 3 days, and smaller detours were required for longer.

Risk Event Identification and Overview	
Provide a qualitative description of the defined geographic area, including: • Watershed/community/region name(s); • Province/Territory; • Area type (i.e., city, township, watershed, organization, etc.); • Population size; • Population variances (e.g., significant change in population between summer and winter months); • Main economic areas of interest; • Special consideration areas (e.g., historical, cultural and natural resource areas); and an • Estimate of the annual operating budget of the area.	Salmon and White Rivers Watercourses Village of Sayward, BC Population of Sayward - approx 340. Minimal population variance, with some tourism limited to day use Main economic area of interest is logging, with tourism a growing economy, with plans to expand the tourism industry in the town. A tourism plan was developed for Sayward in 2016 to promote the town as a destination for recreational and heritage activities.
Methodolgies, processes and analyses	

Provide the year in which the following processes/analyses were last completed and state the methodology(ies) used: • Hazard identification; • Vulnerability analysis; • Likelihood assessment; • Impact assessment; • Risk assessment; • Resiliency assessment; and/or • Climate change impact and/or adaptation assessment. Note: It is recognized that many of the processes/analyses mentioned above may be included within one methodology.	There has been no defined flood risk or hazard assessments undertaken for the community prior to the preparation of the report prepared as part of this NDMP Stream 1 project. Floodplain mapping for the 200 year event was undertaken by the BC Provincial Government in 1980 which was reviewed as part of this analysis. The analysis undertaken as part of this project included a review of anecdotal historical flooding records collected from members of the public through 2 public consultation meetings. The forum of the data collection was an open meeting where community members were encouraged to complete questionnaires and mark up maps to identify and record the flooding that they had witnesses. These records were then mapped using GIS software to identofy any "clusters" of flooding as well as the proximity of the historical flooding to key pieces of infrastructure such as healthcare facilities and schools. No detailed hydraulic modelling has been undertaken to date and will be undertaken at future stages of this program, should funding be received. This modelling will include an assessment of potential climate change impacts. For the purposes of this study the impact and consequences assessment was undertaken from a vidual review of the historical records detailed above and the available 200 year floodplain extent as well as a review of surrounding topography.

Hazard Mapping

To complete this section:
- Obtain a map of the area that clearly indicates general land uses, neighbourhoods, landmarks, etc. For clarity throughout this exercise, it may be beneficial to omit any non-essential information from the map intended for use. Controlled photographs (e.g. aerial photography) can be used in place of or in addition to existing maps to avoid the cost of producing new maps.
- Place a grid over the maps/photographs of the area and assign row and column identifiers. This will help identify the specific area(s) that may be impacted, as well as additional information on the characteristics within and affecting the area.
- Identify where and how flood hazards may affect the defined geographic area.
- Identify the mapped areas that are most likely to be impacted by the identified flood hazard.

Map(s)/photograph(s) can also be used, where appropriate, to visually represent the information/prioritization being provided as part of this template.

Hazard identification and prioritization

List known or likely flood hazards to the defined geographic area in order of proposed priority. For example: (1) dyke breach overland flooding; (2) urban storm surge flooding ; and so on.	1) Overland flooding due to elevated water levels in Salmon river caused by extended rainfall and/or snowmelt 2) Flooding caused by high tides / storm surge

Provide a rationale for each prioritization and the key information sources supporting this rationale.	From review of 200 year flood plain extent and anecdotal evidence provided from members of the public and Regional District staff as well as review of previous historical records dating back to the 1800s.
Risk Event Title	
Identify the name/title of the risk. An example of a risk event name or title is: "A one-in-one hundred year flood following an extreme rain event."	Return period unknown but recent flooding experienced in 1975, 1990, 2008, 2011, 2014 and 2018. It is therefore assumed that the flooding occurs approximately during a one in five year event or greater, typically following extreme rainfall during the fall/spring.
Type of Flood Hazard	
Identify the type of flood hazard being described (e.g., riverine flooding, coastal inundation, urban run-off, etc.)	Freshet/rainfall induced flooding within the Salmon River, causing elevated water levels which flood the mostly unconstrained natural floodplain area.

Secondary hazards	
Describe any secondary effects resulting from the risk event (e.g., flooding that occurs following a hurricane).	Secondary risk of flooding from High Tides.
Primary and secondary organizations for response	
Identify the primary organization(s) with a mandate related to a key element of a natural disaster emergency, and any supporting organization(s) that provide general or specialized assistance in response to a natural disaster emergency.	Strathcona Regional District will co-ordinate emergency response, with support from local emergency responders. The Regional District has an Emergency response team that provides leadership to all emergency operations centre, Emergency Social Services and Ground Search and Rescue volunteer and staff teams in the region who would be called upon during an emergency event.

Risk Event Description

Description of risk event, including risk statement and cause(s) of the event	
Provide a baseline description of the risk event, including: • Risk statement; • Context of the risk event; • Nature and scale of the risk event; • Lead-up to the risk event, including underlying cause and trigger/stimulus of the risk event; and • Any factors that could affect future events. Note: The description entered here must be plausible in that factual information would support such a risk event.	Risk is based on freshet induced or large rainfall event flooding within Salmon River. Therefore the antecedent weather conditions which could help predict or impact flooding are: spring snowpack, temperatures, and precipitation. Climate change could have an impact on these climate/weather conditions and will be studied further as part of further NDMP Streams.

Location	
Provide details regarding the area impacted by the risk event such as: • Province(s)/territory(ies); • Region(s) or watershed(s); • Municipality(ies); • Community(ies); and so on.	British Columbia Salmon & White Rivers watershed Village of Sayward Strathcona Regional District
Natural environment considerations	
Document relevant physical or environmental characteristics of the defined geographic area.	The village of Sayward is located on the coast of Vancouver Island, north of Campbell River. It has a small population of 340, with access to the coastal waters through a harbour located in the north of the community. Sayward has 2 main access roads that link it to Highway 19, the main highway through Vancouver Island, and provide its link to other communities on the island. The village itself is located on a area of low-lying flat land, with mountainous areas to the south, east and west, and the Johnstone Strait to the north.
Meteorological conditions	
Identify the relevant meteorological conditions that may influence the outcome of the risk event.	Intense rainfall in the upper watershed can lead to brief, high-flow events. Typically occuring Fall, Winter or Spring.

Seasonal conditions	
Identify the relevant seasonal changes that may influence the outcome of the risk assessment of a particular risk event.	Seasonal changes can result in higher levels of flow within the rivers. Freshet period, when snow melt is high can coincide with high rainfall and result in larger flows in the river, as well as flooding for a longer, extended period of time when compared to a Fall season rainfall event. Future hydraulic modelling to be undertaken at later stages of the project (should funding be received) will include an assessment of different seasonal models.
Nature and vulnerability	
Document key elements related to the affected population, including: • Population density; • Vulnerable populations (identify these on the hazard map from step 7); • Degree of urbanization; • Key local infrastructure in the defined geographic area; • Economic and political considerations; and • Other elements, as deemed pertinent to the defined geographic area.	The Village of Sayward has a small population of approximately 340. Population density is low with minimal urbanization. The village is located on the coast of Vancouver Island on the Johnstone strait. The community is therefore at risk of flooding from freshet of the surrounding mountainous areas resulting in high water levels in the Salmon River as well as impacts from high tides. All of the community's infrastructure is located on a low lying flat area adjacent to the river and coast. There are 2 access routes into the community that link to Highway 19, and hence provide the evacuation routes in times of flooding. Both of these routes have experienced flooding in the past and there have been instances when people have had to be evacuated from the roof of buildings by helicopter due to inaccessible evacuation routes. Evacuation is therefore the main concern, with residents have experienced evacuation due to concern that roads may become inaccessible.

Asset inventory	
Identify the asset inventory of the defined geographic area, including: • Critical assets; • Cultural or historical assets; • Commercial assets; and • Other area assets, as applicable to the defined geographic area. Key asset-related information should also be provided, including: • Location on the hazard map (from step 7); • Size; • Structure replacement cost; • Content value; • Displacement costs; • Importance rating and rationale; • Vulnerability rating and reason; and • Average daily cost to operate. A total estimated value of physical assets in the area should also be provided.	The study area covers an area with a low population, however assets within the area include utilities, roads and bridges, campground, fire hall, fuel stations, a hospital, library, municipal buildings and a school. Figure X identifies these key assets in relation to current mapping.
Other assumptions, variability and/or relevant information	
Identify any assumptions made in describing the risk event; define details regarding any areas of uncertainty or unpredictability around the risk event; and supply any supplemental information, as applicable.	The risk event is not based on any one historical flood event. Instead it is a combination of anecdotal information, photos, etc. from past flooding events which have been combined to form the basis of the risk event for this assessment. Flooding includes events in 1975, 1990, 2008, 2011, 2014 and 2018, as well as flooding that is experienced annually.
Existing Risk Treatment Measures	
Identify existing risk treatment measures that are currently in place within the defined geographic area to mitigate the risk event, and describe the sufficiency of these risk treatment measures.	There are currently no flood protection measures in place in the community or any flood risk plans for mitigation. During previous flood events, residents have been evacuated as flood waters rise due to concerns that evacuation routes have the potential to become inaccessible as flood waters continue to rise.

Likelihood Assessment		
Return Period		
Identify the time period during which the risk event might occur. For example, the risk event described is expected to occur once every X number of years. Applicants are asked to provide the X value for the risk event.	Based on flood events in 1975, 1990, 2008, 2011, 2014 and 2018 it is assumed that the flooding described herein is the result of approximately a 1 in 5-year event (or greater).	
Period of interest		
Applicants are asked to determine and identify the likelihood rating (i.e. period of interest) for the risk event described by using the likelihood rating scale within the table below.		
Likelihood Rating	Definition	
5	The event is expected and may be triggered by conditions expected over a 30 year period.	5
4	The event is expected and may be triggered by conditions expected over a 30 - 50 year period.	
3	The event is expected and may be triggered by conditions expected over a 50 - 500 year period.	
2	The event is expected and may be triggered by conditions expected over a 500 - 5000 year period.	
1	The event is possible and may be triggered by conditions exceeding a period of 5000 years.	
Provide any other relevant information, notes or comments relating to the likelihood assessment, as applicable.	Anecdotal evidence indicates that flooding has occurred in 1975, 1990, 2008, 2011, 2014 and 2018 and in some locations flooding occurs annually.	

Impacts/Consequences Assessment

There are 12 impacts categories within 5 impact classes rated on a scale of 1 (least impacts) to 5 (greatest impact). Conduct an assessment of the impacts associated with the risk event, and assign one risk rating for each category. Additional information may be provided for each of the categories in the supplemental fields provided.

A) People and societal impacts

	Risk Rating	Definition	Assigned risk rating
Fatalities	5	Could result in more than 50 fatalities	2
	4	Could result in 10 - 49 fatalities	
	3	Could result in 5 - 9 fatalities	
	2	Could result in 1 - 4 fatalities	
	1	Not likely to result in fatalities	
Supplemental information (optional)	Evacuation routes are often cut off, with historical evidence that members of the community have needed to be airlifted from their homes during flood events. Discussions with members of the community indicate that water is fast flowing, which presents a higher risk of fatalities from drowing if people are knocked off their feet.		
Injuries	5	Injuries, illness and/or psychological disablements cannot be addressed by local, regional, or provincial/territorial healthcare resources; federal support or intervention is required	3
	4	Injuries, illnesses and/or psychological disablements cannot be addressed by local or regional healthcare resources; provincial/territorial healthcare support or intervention is required.	
	3	Injuries, illnesses and/or psychological disablements cannot be addressed by local or regional healthcare resources additional healthcare support or intervention is required from other regions, and supplementary support could be required from the province/territory	
	2	Injuries, illnesses and/or psychological disablements cannot be addressed by local resources through local facilities; healthcare support is required from other areas such as an adjacent area(ies)/municipality(ies) within the region	
	1	Any injuries, illnesses, and/or psychological disablements can be addressed by local resources through local facilities; available resources can meet the demand for care	
Supplemental information (optional)	Evacuation routes cut off, and the hospital is in an area that could be at risk)(further modelling required to confirm this). Air support has previous been required for evacuation.		

		Risk Rating	Definition	Assigned risk rating
Displacement	Percentage of displaced individuals	5	> 15% of total local population	5
		4	10 - 14.9% of total local population	
		3	5 - 9.9% of total local population	
		2	2 - 4.9% of total local population	
		1	0 - 1.9% of total local population	
	Duration of displacement	5	> 26 weeks (6 months)	4
		4	4 weeks - 26 weeks (6 months)	
		3	1 week - 4 weeks	
		2	72 hours - 168 hours (1 week)	
		1	Less than 72 hours	
Supplemental information (optional)		There are only 2 road options into the town of Sayward and given the risk of inaccessibility of these potential routes, the affect of flooding would extend to the majority of the local population. Depths up to 5ft of flooding have previously been experienced and hence recovery time is likely to extend into months, although this is mostly related to infrastructure flooding. A long recovery period is expected because permanent, long-term repairs to roads and bridges generally takes months.		
B) Environmental impacts				
		5	> 75% of flora or fauna impacted or 1 or more ecosystems significantly impaired; Air quality has significantly deteriorated; Water quality is significantly lower than normal or water level is > 3 meters above highest natural level; Soil quality or quantity is significantly lower (i.e., significant soil loss, evidence of lethal soil contamination) than normal; > 15% of local area is affected	4
		4	40 - 74.9% of flora or fauna impacted or 1 or more ecosystems considerably impaired; Air quality has considerably deteriorated; Water quality is considerably lower than normal or water level is 2 - 2.9 meters above highest natural level; Soil quality or quantity is moderately lower than normal; 10 - 14.9% of local area is affected	
		3	10 - 39.9% of flora or fauna impacted or 1 1 or more ecosystems moderately impaired; Air quality has moderately deteriorated; Water quality is moderately lower than normal or water level is 1 - 2 meters above highest natural level; Soil quality is moderately lower than normal; 6 - 9.9 % of area affected	

	2	< 10 % of flora or fauna impacted or little or no impact to any ecosystems; Little to no impact to air quality and/or soil quality or quantity; Water quality is slightly lower than normal, or water level is less than 0.9 meters above highest natural level and increased for less than 24 hours; 3 - 5.9 % of local area is affected	
	1	Little to no impact to flora or fauna, any ecosystems, air quality, water quality or quantity, or to soil quality or quantity; 0 - 2.9 % of local area is affected	
Supplemental information (optional)	The local conservation area is at risk, During times of previous flooding, members of the local community has experienced oil and sewage present in floodwaters. There are log dumps, sewage systems, the Town's sewage lagoon, a gas station, and many other potential sources of contamination present within the floodplain extents. Based on anecdotal evidence of historical flood events, there have not been any catastrophic environmental impacts due to this type of flood event. However, the potential is present and past performance is no indication of future outcomes, especially as infrastructure ages/deteriorates and development continues.		

C) Local economic impacts

	Risk Rating	Definition	Assigned risk rating
	5	> 15 % of local economy impacted	5
	4	10 - 14.9 % of local economy impacted	
	3	6 - 9.9 % of local economy impacted	
	2	3 - 5.9 % of local economy impacted	
	1	0 - 2.9 % of local economy impacted	
Supplemental information (optional)	Disruption to roads is likely to cause large-scale disruption that would affect not only local businesses, but also local residents. Anecdotal evidence indicates that local residents have experienced significant economic damages in previous events. A long recovery period is expected because permanent, long-term repairs to roads and bridges generally takes months.		

D) Local infrastructure impacts			
	Risk Rating	Definition	Assigned risk rating
Transportation	5	Local activity stopped for more than 72 hours; > 20% of local population affected; lost access to local area and/or delivery of crucial service or product; or having an international level impact	5
	4	Local activity stopped for 48 - 71 hours; 10 - 19.9% of local population affected; significantly reduced access to local area and/or delivery of crucial service or product; or having a national level impact	
	3	Local activity stopped for 25 - 47 hours; 5 - 9.9% of local population affected; moderately reduced access to local area and/or delivery of crucial service or product; or having a provincial/territorial level impact	
	2	Local activity stopped for 13 - 24 hours; 2 - 4.9% of local population affected; minor reduction in access to local area and/or delivery of crucial service or product; or having a regional level impact	
	1	Local activity stopped for 0 - 12 hours; 0 - 1.9% of local population affected; little to no reduction in access to local area and/or delivery of crucial service or product	
Supplemental information (optional)	Infrastructure, particularly road access is considered to be the greatest risk to the local community. Roads have previously been totally cut off with residents requiring emergency evacuation by helicopter. The town of Sayward has only 2 access roads to the link it to the local area, both of these routes have experienced flooding previously. In addition, bridges have been identified as having flooded, with some structural damage experienced. Lack of access and egress into and out of the town impacts the entire community, this has therefore been given the highest risk rating possible.		
Energy and Utilities	5	Duration of impacts > 72 hours; > 20% of local population without service or product; or having an international level impact	2
	4	Duration of impact 48 - 71 hours; 10 - 19.9% of local population without service or product; or having a national impact	
	3	Duration of impact 25 - 47 hours; 5 - 9.9% of local population without service or product; or having a provincial/territorial level impact	
	2	Duration of impact 13 - 24 hours; 2 - 4.9% of local population without service or product; or having a regional level impact	
	1	Local activity stopped for 0 - 12 hours; 0 - 1.9% of local population affected; little to no reduction in access to local area and/or delivery of crucial service or product	

Supplemental information (optional)	Anecdotal evidence indicates that there has been limited energy and utility disruption during previous flood events. However, as there are likely to be energy and utility infrastructure within the affected area, we would estimate that local activity may be disrupted for less than 12 hours		
Information and Communications Technology	5	Service unavailable for > 72 hours; > 20 % of local population without service; or having an international level impact	1
	4	Service unavailable for 48 - 71 hours; 10 - 19.9 % of local population without service; or having a national level impact	
	3	Service unavailable for 25 - 47 hours; 5 - 9.9 % of local population without service; or having a provincial/territorial level impact	
	2	Service unavailable for 13 - 24 hours; 2 - 4.9 % of local population without service; or having a regional level impact	
	1	Service unavailable for 0 - 12 hours; 0 - 1.9 % of local population without service	
Supplemental information (optional)	Any impact is likely to be restricted to a property level, with services disrupted for less than 12 hours.		
Health, Food, and Water	5	Inability to access potable water, food, sanitation services, or healthcare services for > 72 hours; non-essential services cancelled; > 20 % of local population impacted; or having an international level impact	5
	4	Inability to access potable water, food, sanitation services, or healthcare services for 48-72 hours; major delays for nonessential services; 10 - 19.9 % of local population impacted; or having a national level impact	
	3	Inability to access potable water, food, sanitation services, or healthcare services for 25-48 hours; moderate delays for nonessential services; 5 - 9.9 % of local population impacted; or having a provincial/territorial level impact	
	2	Inability to access potable water, food, sanitation services, or healthcare services for 13-24 hours; minor delays for nonessential; 2 - 4.9 % of local population impacted; or having a regional level impact	
	1	Inability to access potable water, food, sanitation services, or healthcare services for 0-12 hours; 0 - 1.9 % of local population impacted	

Supplemental information (optional)	Roads inaccessible due to flooding causes a great risk for emergency access and egress. Given the limited accessible routes into the town, emergency access disruption poses a risk to greater than 20% of the population being unable to access healthcare. This has therefore been assigned the highest risk rating.		
Safety and Security	5	> 20 % of local population impacted; loss of intelligence or defence assets or systems for > 72 hours; or having an international level impact	2
	4	10 - 19.9 % of local population impacted; loss of intelligence or defence assets or systems for 48 – 71 hours; or having a national level impact	
	3	5 - 9.9 % of local population impacted; loss of intelligence or defence assets or systems for 25 – 47 hours; or having a provincial/territorial level impact	
	2	2 - 4.9 % of local population impacted; loss of intelligence or defence assets or systems for 13 – 24 hours; or having a regional level impact	
	1	0 - 1.9 % of local population impacted; loss of intelligence or defence assets or systems for 0 – 12 hours	
Supplemental information (optional)	No intelligence or defence assets within the study area, however, during previous flooding residents have been required to evacuate, which poses a security risk at an individual property level, this risk has the potential to impact 2-4.9% of the local population. Anecdotally, many residents report that their access out of town was entirely cut-off for days. However, the vast majority of folks were able to shelter in-place and wait for access to be restored. Only a small percentage of the population required evacuation due to flooding, or due to medical complications which occured during the time when access to hospital or facilities was cut-off.		

E) Public sensitivity impacts			
	Risk Rating	Definition	Assigned risk rating
	5	Sustained, long term loss in reputation/public perception of public institutions and/or sustained, long term loss of trust and confidence in public institutions; or having an international level impact	4
	4	Significant loss in reputation/public perception of public institutions and/or significant loss of trust and confidence in public institutions; significant resistance; or having a national level impact	
	3	Some loss in reputation/public perception of public institutions and/or some loss of trust and confidence in public institutions; escalating resistance	
	2	Isolated/minor, recoverable set-back in reputation, public perception, trust, and/or confidence of public institutions	
	1	No impact on reputation, public perception, trust, and/or confidence of public institutions	
Supplemental information (optional)	Lack of safe emergency access and egress poses a risk to the community and local residents are in fear of flooding with each extreme weather event. Members of the local community provided emotional accounts of flooding that has been experienced and there is an expectation of action from the local community.		

Confidence Assessment

Based on the table below, indicate the level of confidence regarding the information entered in the risk assessment information template in the “Confidence Level Assigned” column. Confidence levels are language-based and range from A to E (A=most confident to E=least confident).

Confidence Level	Definition	Confidence Level Assigned
A	Very high degree of confidence Risk assessment used to inform the risk assessment information template was evidence-based on a thorough knowledge of the natural hazard risk event; leveraged a significant quantity of high-quality data that was quantitative and qualitative in nature; leveraged a wide variety of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a multidisciplinary team with subject matter experts (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a significant number of existing/known mitigation measures	
B	High degree of confidence Risk assessment used to inform the risk assessment information template was evidence-based on a thorough knowledge of the natural hazard risk event; leveraged a significant quantity of data that was quantitative and qualitative in nature; leveraged a wide variety of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a multidisciplinary team with some subject matter expertise (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a significant number of potential mitigation measures	

C	Moderate confidence Risk assessment used to inform the risk assessment information template was moderately evidence-based from a considerable amount of knowledge of the natural hazard risk event; leveraged a considerable quantity of data that was quantitative and/or qualitative in nature; leveraged a considerable amount of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a moderately sized multidisciplinary team, incorporating some subject matter experts (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a large number of potential mitigation measures	C
D	Low confidence Risk assessment used to inform the risk assessment information template was based on a relatively small amount of knowledge of the natural hazard risk event; leveraged a relatively small quantity of quantitative and/or qualitative data that was largely historical in nature; may have leveraged some geospatial information or information from other sources (i.e., databases, key risk and resilience methodologies); and the risk assessment and analysis processes were completed by a small team that may or may not have incorporated subject matter experts (i.e., did not include a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences). Assessment of impacts considered a relatively small number of potential mitigation measures	
E	Very low confidence Risk assessment used to inform the risk assessment information template was not evidence-based; leveraged a small quantity of information and/or data relating to the natural risk hazard and risk event; primary qualitative information used with little to no quantitative data or information; and the risk assessment and analysis processes were completed by an individual or small group of individuals little subject matter expertise (i.e., did not include a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences). Assessment of impacts did not consider existing or potential mitigation measures	

Rationale for level of confidence	
Provide the rationale for the selected confidence level, including any references or sources to support the level assigned.	Assessment is based on anecdotal evidence from previous flooding events, specifically in 1975, 1990, 2008, 2011 and 2014. Although some 200 year floodplain extents were available for the assessment, these did not cover the entire study area and consideration must also be given to the impact with potential risk of tidal flooding. The anecdotal evidence that was provided from the public consultation provides a detailed account of flooding that has been experienced. Geospatial information was provided by Strathcona Regional District, including infrastructure, land use, etc. The assessment was completed by civil engineers, hydrotechnical engineers, environmental engineers (Contaminated Sites specialist) and risk specialists.

Key Information Sources	
Identify all supporting documentation and information sources for qualitative and quantitative data used to identify risk events, develop the risk event description, and assess impacts and likelihood. This ensures credibility and validity of risk information presented as well as enables referencing back to decision points at any point in time. Clearly identify unclassified and classified information.	A public consultation exercise was undertaken to obtain community member accounts of flooding, which included responses to a survey, interview questions and photographs. Regional District staff also provided anecdotal information about historical flooding, as well as approximate mapped flooding extents for the 2016 event.
Description of the risk analysis team	
List and describe the type and level of experience of each individual who was involved with the completion of the risk assessment and risk analysis used to inform the information contained within this risk assessment information template.	Eric Heel, Intermediate Hydrotechnical Engineer completed a field inspection of the potential flood risk areas, met with Strathcona Regional District staff, to form the basis of the risk assessment and the RAIT. Eric is a civil / hydrotechnical engineer with over 8 years' experience on water resources related projects within BC. His expertise lies in open channel flow modelling, floodplain modelling/mapping, and design of in-stream works. Clare Share, PEng undertook the Risk Assessment. Clare is a professional engineer with over 10 years of experience of flood risk assessments in the UK and Canada. Clare was a key member in the production of national legislation relating to storm water management in the UK, including reviewing the impact and risk associated with flooding. In addition Clare was Flood Risk Manager for a major London borough and served as an advisor to the mayor of London authority on flood risk issues. Both Eric and Clare have completed previous flood risk assessments under this programme. Allan Morrison is an engineer and contaminated sites specialist, who provided expertise & input into potential contamination or environmental impacts. Allan has over 15 years' experience in this field in BC.

APPENDIX B
FLOOD VULNERABILTY MAPS

Salmon and White Rivers Flood Vulnerability

Sayward

Secondary Evacuation Route (Salmon River Rd)

Primary Evacuation Route (Sayward Rd)

Sewage Lagoon

Flood Locations (Historic)
- 1975
- 1990
- 2008
- 2011
- 2014
- Annually
- Potential Flood Environmental Hazard

Vulnerable Infrastructure
- Campground
- Firehalls
- Fuel Stations
- Hospitals
- Library
- Municipal
- Schools
- Wharf

- Sanitary Manholes
- Hydrant
- Misc. Watermain
- Valve
- Sewer Outfall
- Forcemains
- Watermains
- Storm Sewer
- Roads
- Bridges

Evacuation Routes
- Primary Route
- Secondary Route

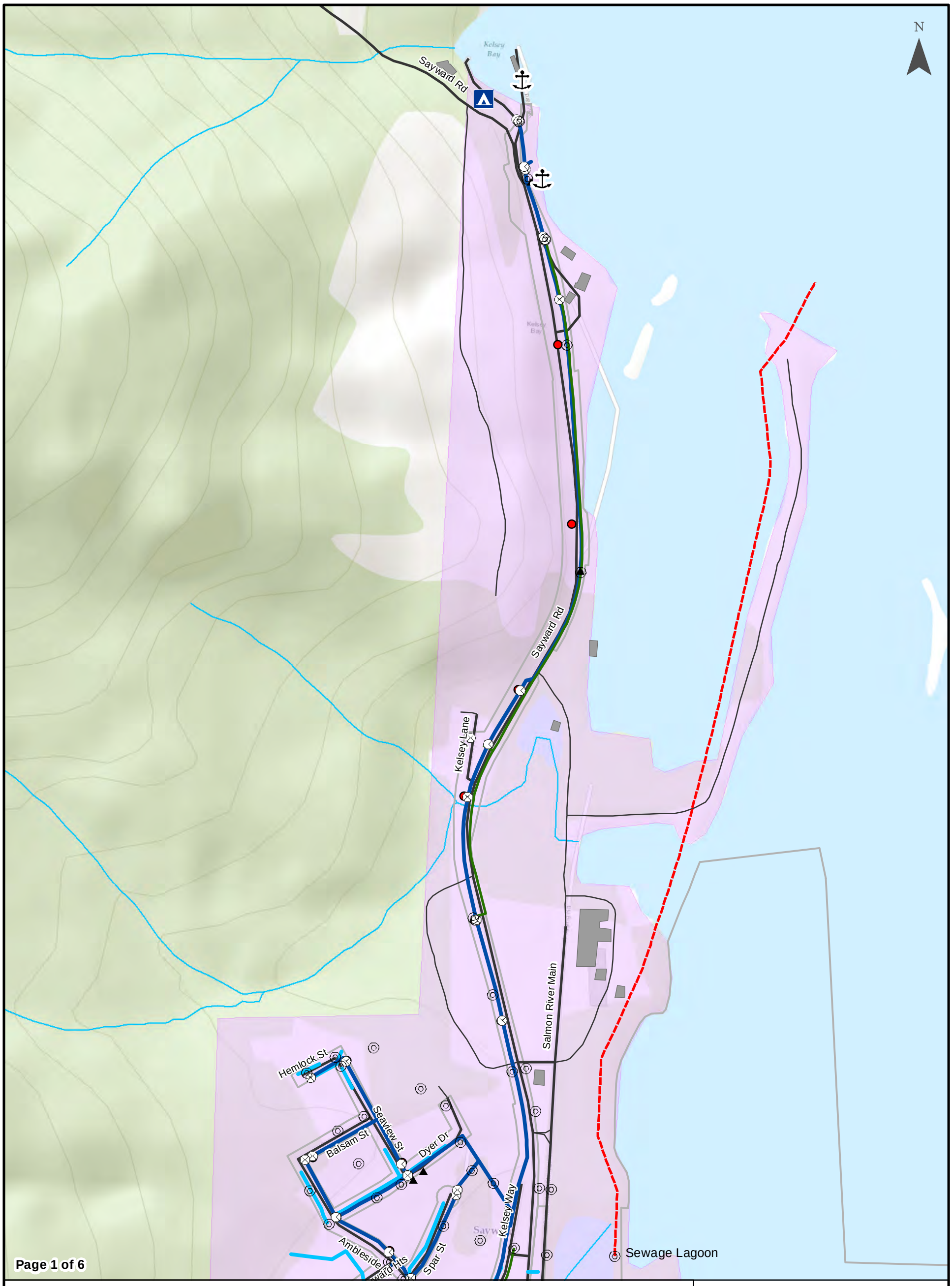
- Flood Event (2016)
- Buildings
- Wetlands
- Sayward
- Conservation Area
- 200-Year Floodplain

1:30,000

0 0.5 1 km

Strathcona Regional District

McElhanney



Salmon and White Rivers Flood Vulnability

Vulnerable Infrastructure
- Campground
- Firehalls
- Fuel Stations
- Hospitals
- Library
- Municipal

- Schools
- Wharf
- Sanitary Manholes
- Hydrant
- Misc. Watermain
- Valve
- Sewer Outfall

- Forcemains
- Watermains
- Storm Sewer
- Roads
- Bridges

Evacuation Routes
- Primary Route
- Secondary Route

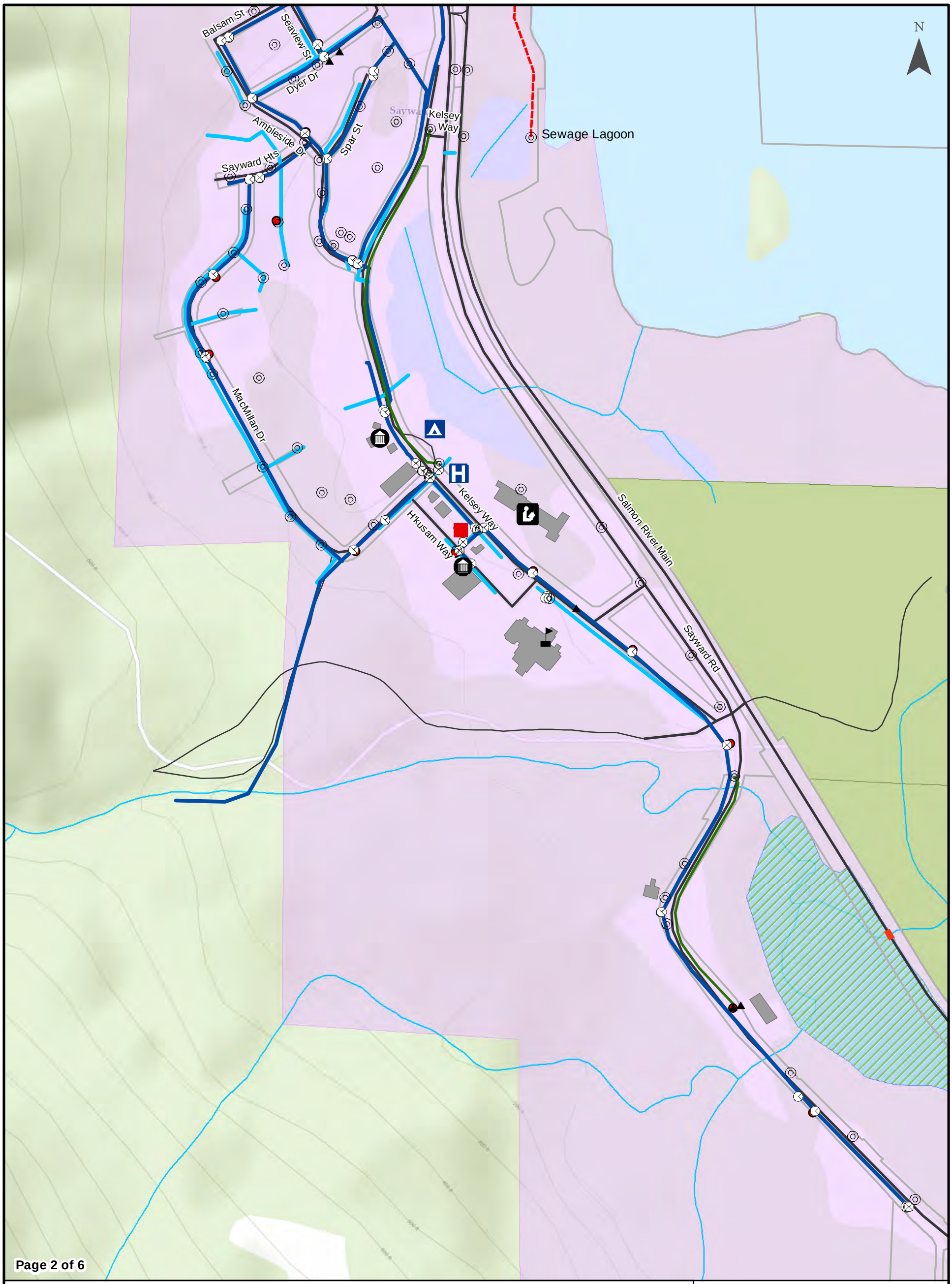
- Buildings
- Wetlands
- Sayward
- Conservation Area
- 200-Year Floodplain
- Parcels

Meters: 0 100 200

Strathcona Regional District

McElhanney

Date: April 05, 2019



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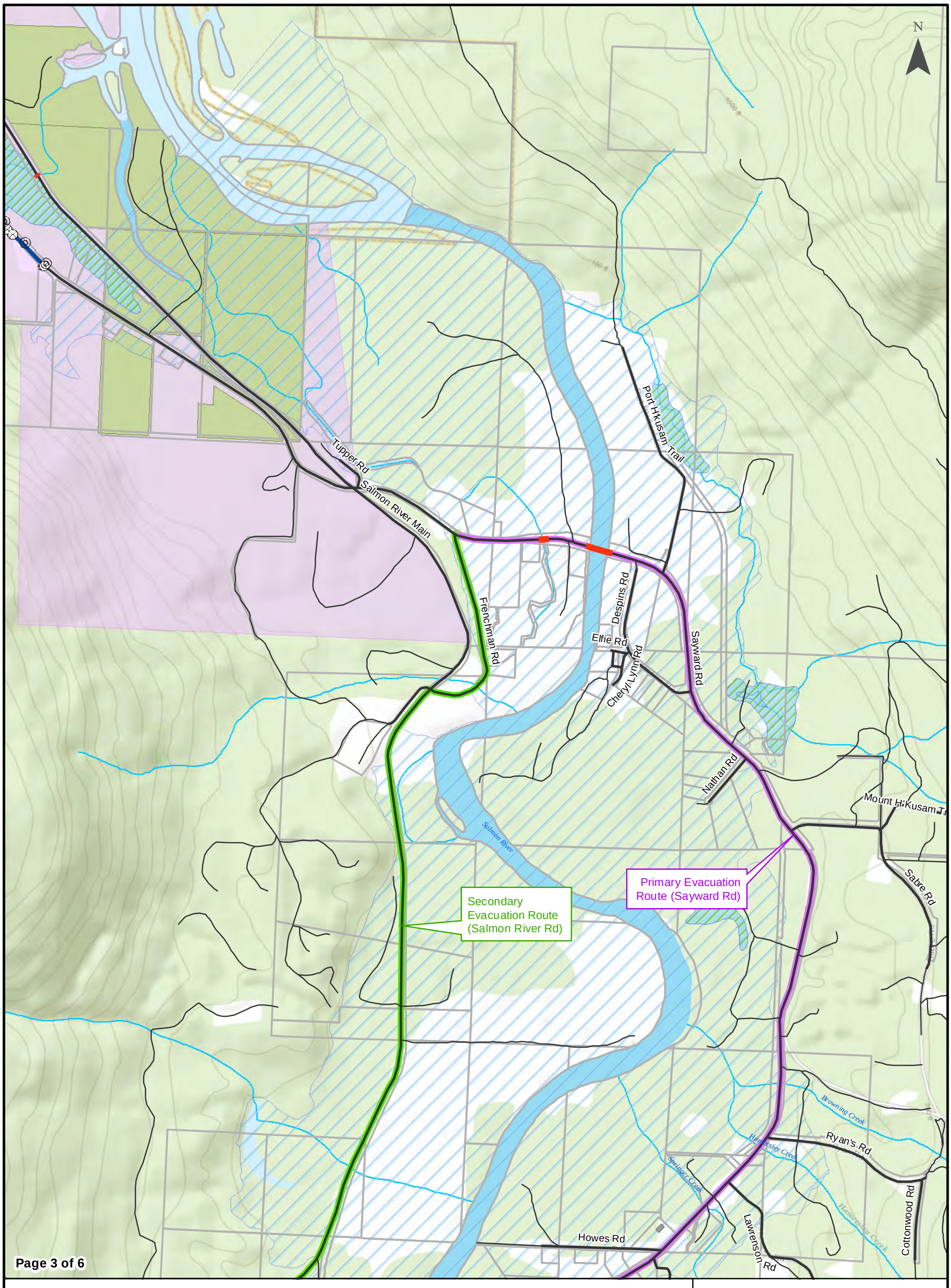

Salmon and White Rivers Flood Vulnability

Vulnerable Infrastructure
- Campground
- Firehalls
- Fuel Stations
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- Bridges

Evacuation Routes
- Primary Route
- Secondary Route

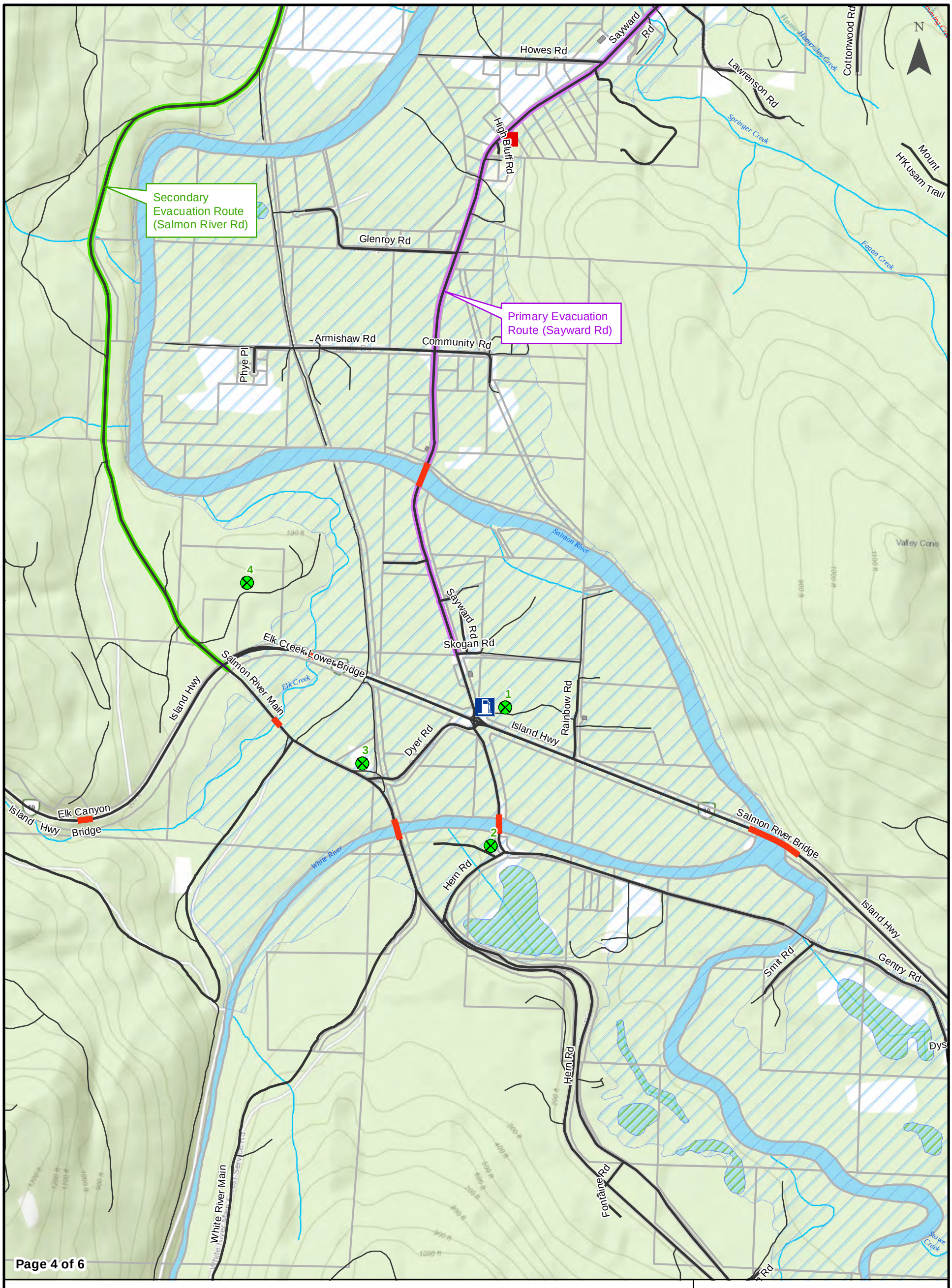
- Buildings
- Wetlands
- Sayward
- Conservation Area
- 200-Year Floodplain
- Parcels

Meters: 0 — 300 — 600

Strathcona Regional District

McElhanney

Date: April 05, 2019



Salmon and White Rivers Flood Vulnability

Vulnerable Infrastructure
- Campground
- Firehalls
- Fuel Stations
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Evacuation Routes
- Primary Route
- Secondary Route

- Buildings
- Wetlands
- Sayward
- Conservation Area
- 200-Year Floodplain
- Parcels

Meters: 0 — 300 — 600

Strathcona Regional District

McElhanney

Date: April 05, 2019

Dyson Rd
Delta Dr
Gentry Rd
Island Hwy
Timber Rd
Stowe Creek Main FSR
Stowe Creek Bridge
Sachts Rd
Ruby Rd
Stowe Creek Rd
Salmon Rd
Sullivan Rd
Mountview Dr
Island Hwy
Stowe Creek
Salmon River
Salmon River Main
C Branch FSR
N

Salmon and White Rivers Flood Vulnability

Vulnerable Infrastructure
- Campground
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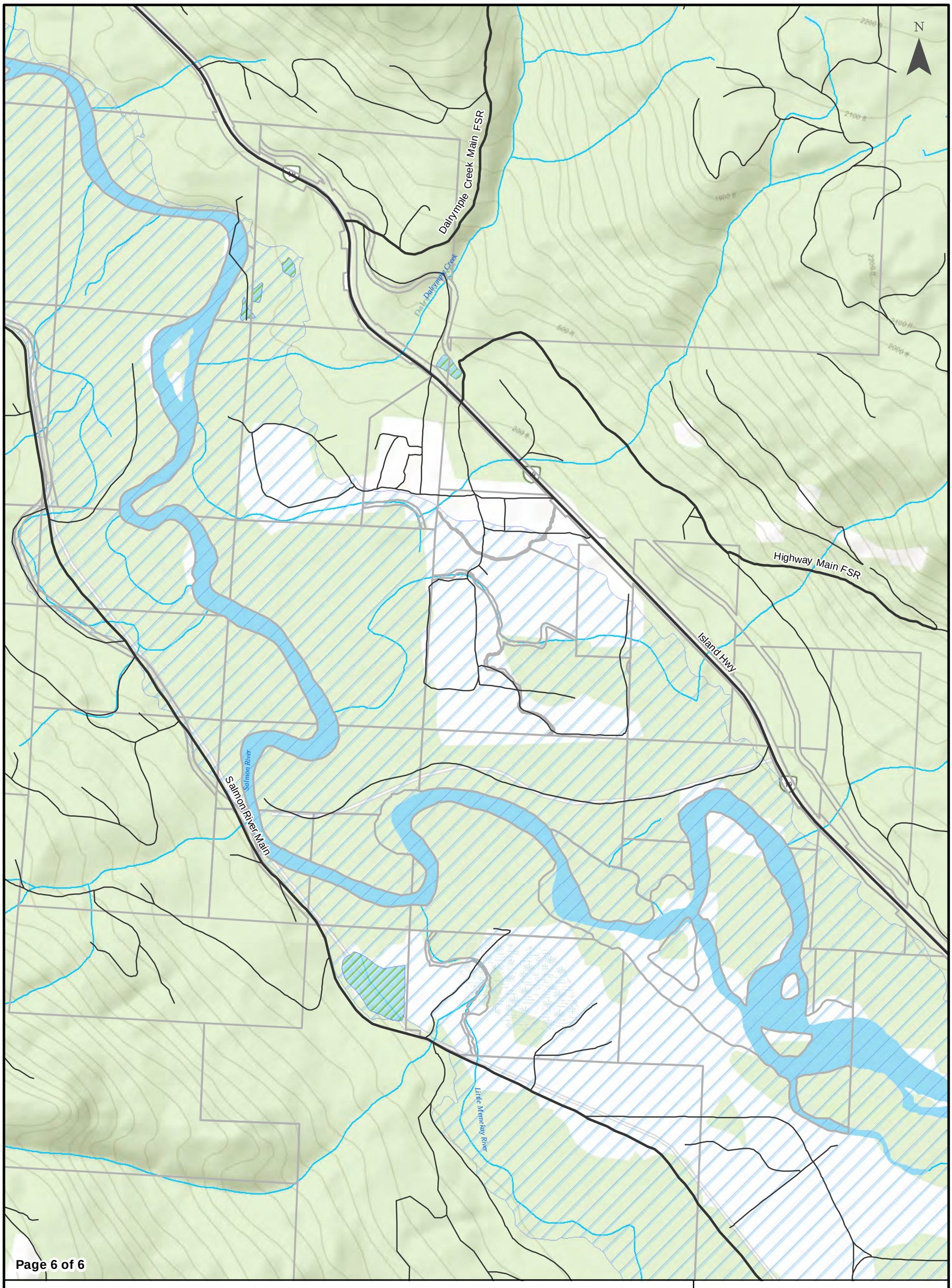
- Conservation Area
- 200-Year Floodplain
- Parcels

Meters
0 300 600

Strathcona Regional District

McElhanney

Date: April 05, 2019



Salmon and White Rivers Flood Vulnability

Vulnerable Infrastructure

- Campground
- Firehalls
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Evacuation Routes

- Primary Route
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- Parcels

Meters: 0 300 600

Strathcona Regional District

McElhanney

Date: April 05, 2019

N

Salmon River

900 ft

1100 ft

Island Hwy

Salmon Lookout Trail

Bigtree Creek

Salmon Brewster Trail

Salmon River

Salmon Brewster Trail

Little Memekay River

Salmon River Main

Memekay River

Big Tree Main S

Salmon and White Rivers Flood Vulnability

Vulnerable Infrastructure

- Campground
- Firehalls
- Fuel Stations
- Hospitals
- Library
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- Sanitary Manholes
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Evacuation Routes

- Primary Route
- Secondary Route
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- Sayward
- Conservation Area
- 200-Year Floodplain
- Parcels

Meters: 0 300 600

Strathcona Regional District

McElhanney

Date: April 05, 2019

APPENDIX C

PUBLIC MEETING QUESTIONNAIRE

Historical Flooding Interview

Name and contact info (optional, for information and follow up only)

When did the flooding occur?

How deep was the water? Estimation compared to person height, local landmarks etc

Was the flood water contaminated with sewage?

What was the weather like prior to the flooding event?

Was the water fast flowing or standing water?

How quickly did the flooding occur?

Was there any property damage caused by the flooding?

What was the cost to repair the damage?

How long were you out of your home during repairs? (if applicable)

Was there any damage to infrastructure as a result of the flooding? Roads, waterlines etc

Was there any injuries or damage to health as a result of the flooding?

Were there any areas of environmental concern that were impacted?

Do you have any photos or videos that you are happy to share?

Any other information about the flooding?

What do you think Is needed to protect against flooding like this?

APPENDIX D

PCIC "PLAN 2 ADAPT" CLIMATE CHANGE INFORMATION

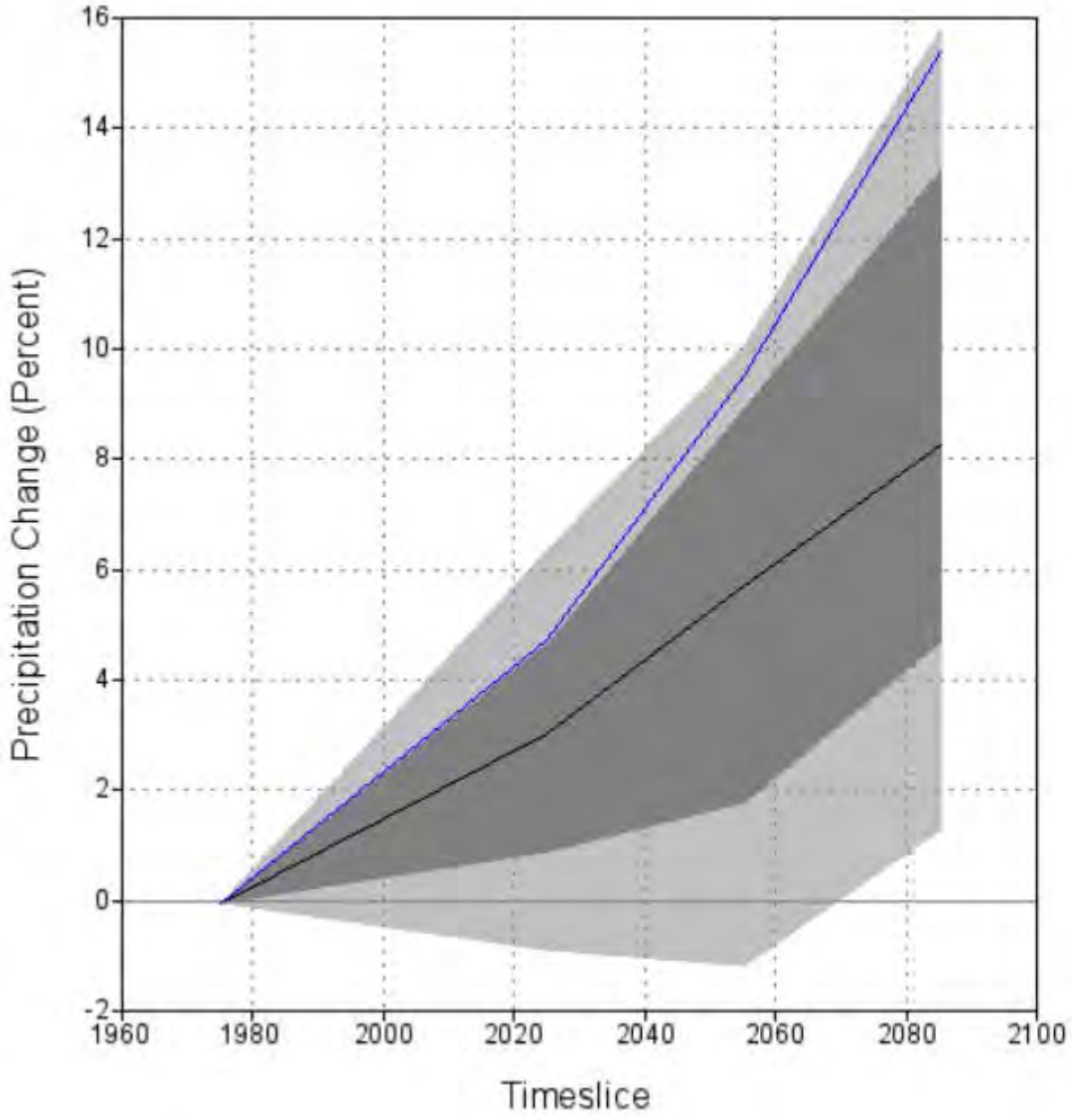
Summary of Climate Change for Strathcona in the 2080s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+2.5 °C	+1.3 °C to +3.7 °C
Precipitation (%)	Annual	+8%	+1% to +16%
	Summer	-12%	-32% to -0%
	Winter	+12%	+1% to +22%
Snowfall* (%)	Winter	-33%	-59% to -13%
	Spring	-72%	-86% to -14%
Growing Degree Days* (degree days)	Annual	+521 degree days	+270 to +832 degree days
Heating Degree Days* (degree days)	Annual	-877 degree days	-1328 to -467 degree days
Frost-Free Days* (days)	Annual	+35 days	+19 to +52 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2080s** for the **Strathcona** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

Plot



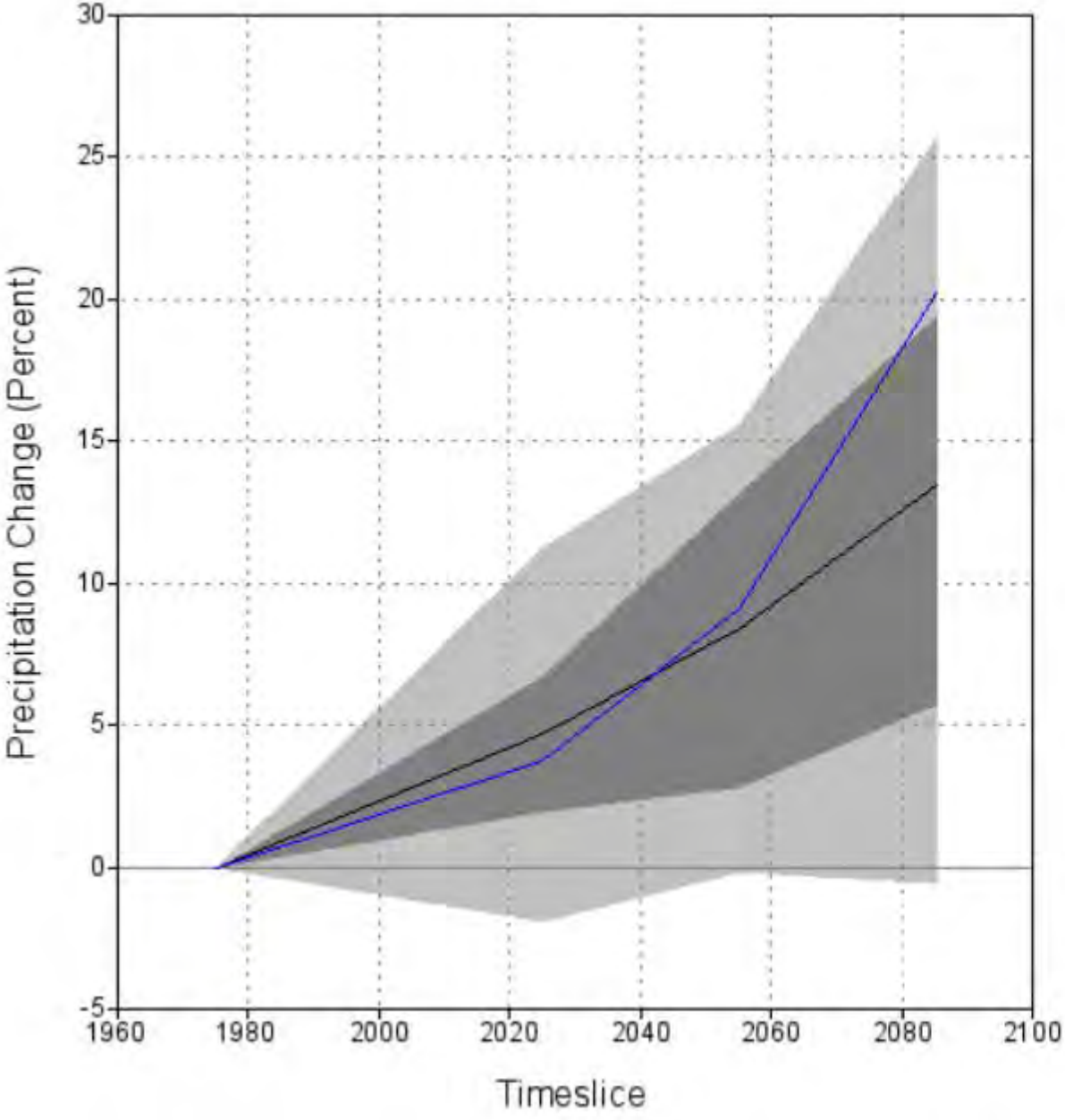
Interpretation

This figure shows the range of projected **Annual** precipitation* (rain plus snow) change (percent), for the **Strathcona** region over three time periods (2020s, 2050s, and 2080s), according to a PCIC-standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set.
- The blue line indicates the model used for display purposes (CGCM3 A2 run 4).
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Plot



Interpretation

This figure shows the range of projected **Fall** - **SON** precipitation* (rain plus snow) change (percent), for the **Strathcona** region over three time periods (2020s, 2050s, and 2080s), according to a PCIC-standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set.
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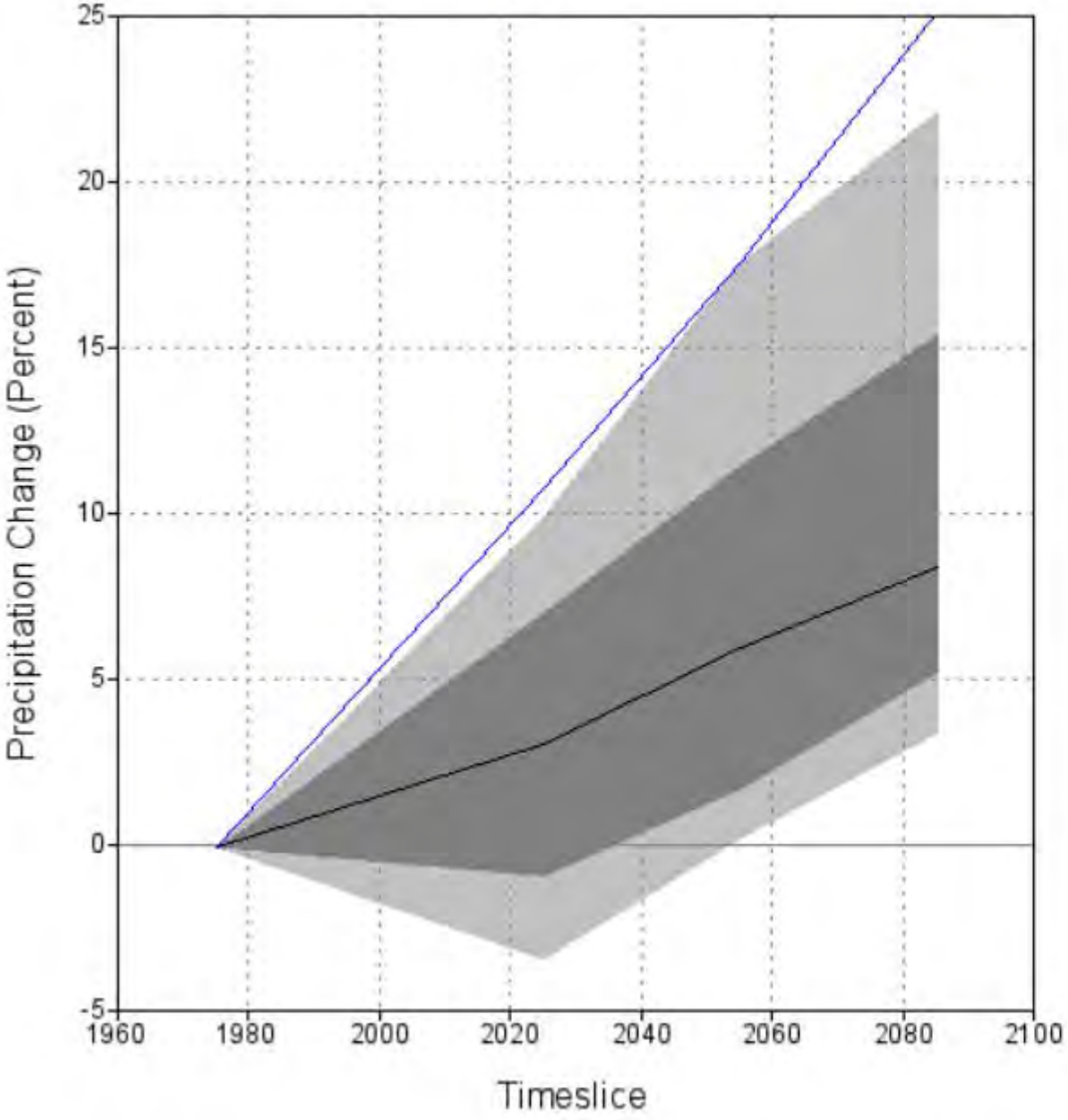
Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Plot



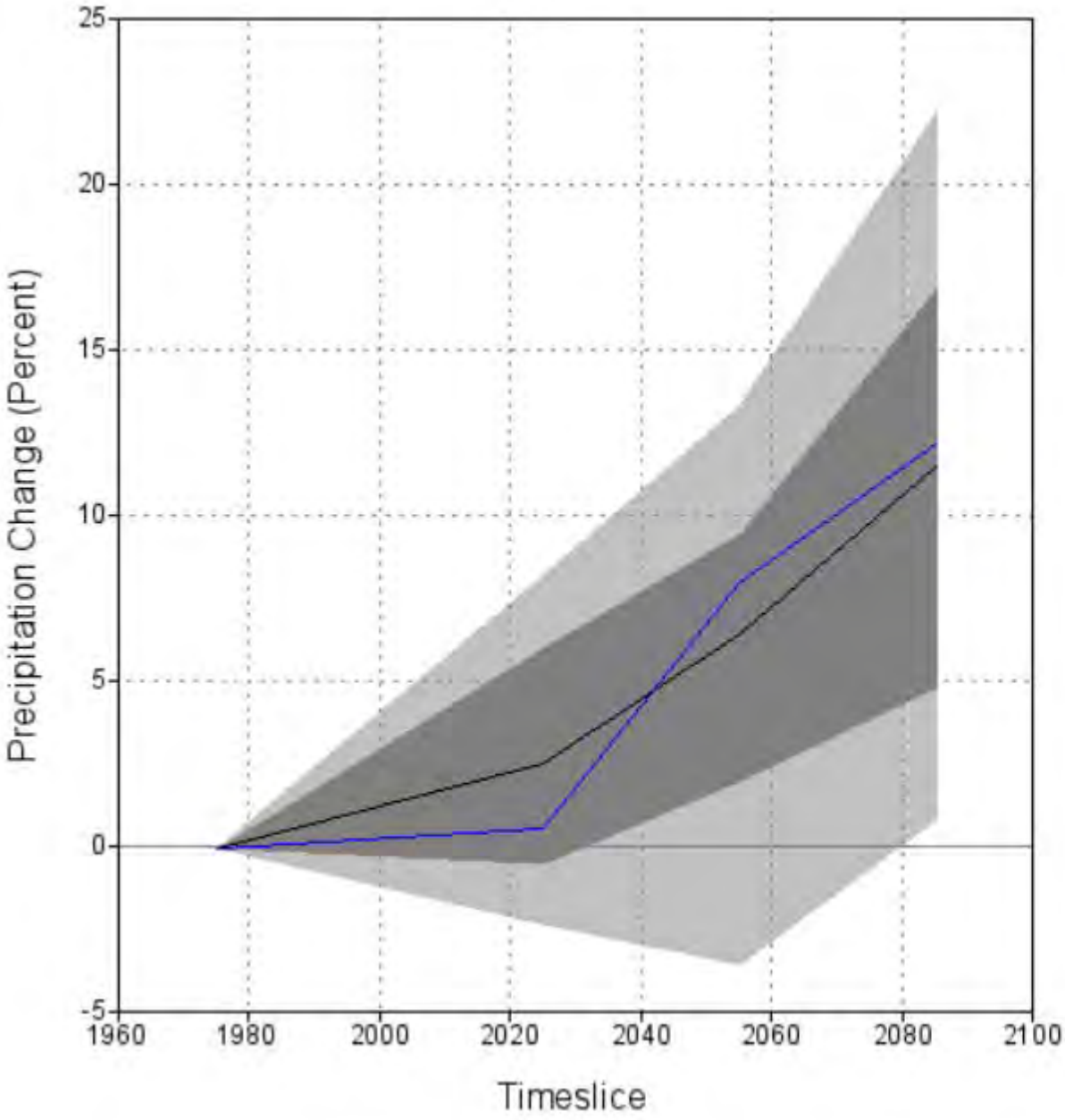
Interpretation

This figure shows the range of projected **Spring** - **MAM** precipitation* (rain plus snow) change (percent), for the **Strathcona** region over three time periods (2020s, 2050s, and 2080s), according to a PCIC-standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set.
- The blue line indicates the model used for display purposes (CGCM3 A2 run 4).
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Plot



Interpretation

This figure shows the range of projected **Winter - DJF** precipitation* (rain plus snow) change (percent), for the **Strathcona** region over three time periods (2020s, 2050s, and 2080s), according to a PCIC-standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set.
- The blue line indicates the model used for display purposes (CGCM3 A2 run 4).
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).