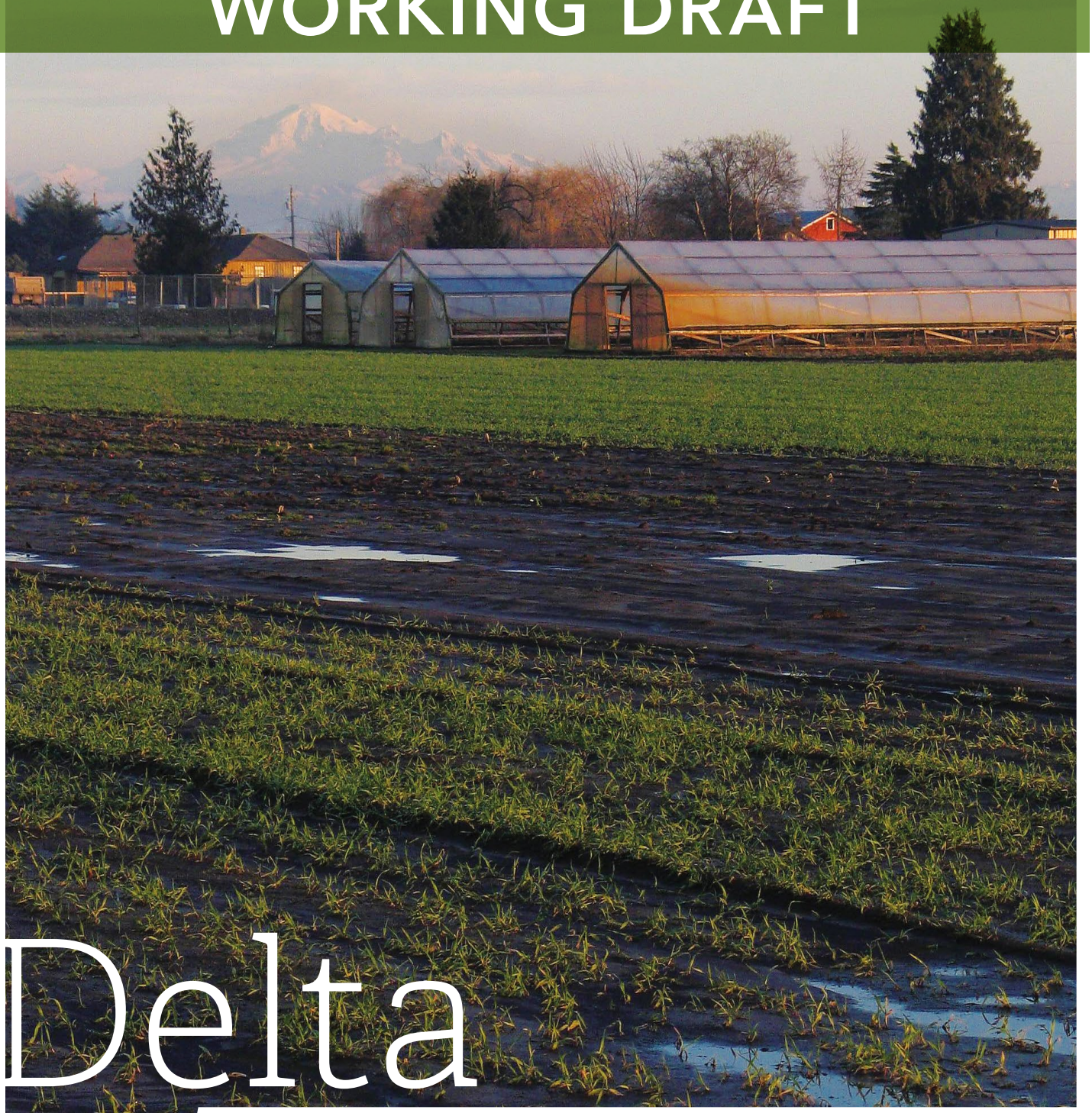
Climate Action Initiative
BC AGRICULTURE & FOOD

WORKING DRAFT



Delta

BC Agriculture & Climate Change
Regional Adaptation Strategies series

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Cover photograph from Delta by Gord McKenna.

Contents

Introduction

In the coming years, climate change will impact the agriculture sector in British Columbia in a range of different ways.

While agricultural producers are accustomed to adjusting their practices to manage through difficult conditions, the scope and scale of climate change is anticipated to exceed anything previously experienced. Adaptation will enhance the sector's resilience and capacity to manage through challenging conditions in both the immediate and long term.

In 2012, an assessment of climate change-related risks and opportunities was conducted with the agriculture sector across BC.[1] The assessment evaluated the potential impacts of climate change on agricultural production in five key regions, and explored the sector's capacity to adapt. The province-wide assessment made evident that, because of British Columbia's diversity (with respect to agriculture, ecology and climate), a regional approach to climate change adaptation is required. In addition, while some adaptation will occur at the farm level, the context beyond the farm is critical for supporting agricultural adaptation. In particular, broader collaboration is required for land use, infrastructure and resource-related decision-making and action.

Building on these findings, the *BC Agriculture & Climate Change Regional Adaptation Strategies* pilot project has brought local governments and producers together to develop priority strategies and actions to facilitate agricultural adaptation. Producers, local governments and provincial government staff in each of three areas of BC — the Peace region, the Cowichan Valley region and Delta — participated in the pilot project.

The intent of the pilot project is to develop both clear actions suited to the specifics of the local context, and to encourage the integration of agricultural climate change adaptation priorities into decision-making and planning across multiple agencies and organizations. A set of agricultural adaptation strategies has been developed in each pilot area.

Project Delivery

An Advisory Committee for Delta was formed to provide input throughout the project. This committee included staff from the Corporation of Delta and the BC Ministry of Agriculture and volunteer representatives of Delta Committees and the agriculture sector. The agricultural producer participants volunteered their time throughout the project, representing both local production systems and agricultural organizations. The Corporation of Delta provided a written commitment to partner, providing staff in-kind (time and expertise) and covering local workshop costs. With funding from the BC Ministry of Agriculture and the Pacific Institute for Climate Solutions, the BC Agriculture and Food Climate Action Initiative provided core management and human resources for project delivery. Please see Acknowledgements for more details.

Project Methodology

The development of the Strategies involved three key stages:

- ***Project Development***
  Background research was conducted and a project plan was drafted. Two initial meetings were held with the local Advisory Committee to receive input on the project outline and the proposed approach for the first workshop.

- ***Workshops***
  Two workshops were held. The first workshop focused on reviewing climate projections, discussing the associated agricultural impacts and identifying the priority impact areas. Developing strategies and actions for adapting to these priority impact areas then became the focus of the second workshop. Prior to the second workshop, in each location, a series of overarching goals, as well as possible strategies and actions, were drafted and reviewed by the Advisory Committee. These materials then helped to guide workshop discussions that focused on action planning (with local priorities, context and resources in mind).

- ***Draft Strategies Document***
  Following the completion of the two workshops, background research and workshop results were compiled into a set of draft strategies and actions. These drafts were then refined and finalized, based on feedback from the Advisory Committee.

photo by Gord McKenna, Delta

Local Context

The proximity of Delta's agricultural production to the ocean and to the mouth of the Fraser River creates a growing environment with particular benefits and challenges. The ocean has a moderating effect on summer and winter temperatures and Delta has higher light levels than other agricultural areas in the Lower Mainland, making it particularly favourable for greenhouse production.[2]

Delta has highly productive agricultural land with predominantly lowland soils formed from deltaic deposits of the Fraser River.[3] Unimproved agricultural land capability ratings are generally Classes 3 and 4[4] and with improvements most of Delta's agricultural soils are Classes 2 and 3.[5] Soils tend to hold water and are prone to ponding in the winter and therefore, necessary improvements often include drainage and water table control. Aridity can be a challenge in summer and some of Delta's soils are also prone to salinity.

The ecological significance of the Fraser River delta area has led to creative partnerships — such as the Delta Farmland and Wildlife Trust — between agricultural producers and others wishing to protect wildlife (particularly migratory bird populations) and habitat.[6] Because the birds cause damage to crops and farmland, these relationships exist in a delicate balance. At the same time, Delta producers are also in very close proximity to the urban population of Vancouver, to Deltaport and to the US border. This location provides the advantages of market access and the disadvantages of the constant pressures of urban development.

According to the 2011 Census of Agriculture, the total number of farms in Delta was 202 (up from 180 farms in 2005).[7] In 2010, there were about 9,400 hectares (23,228 acres) in the Agricultural Land Reserve (ALR) in Delta — 52% of the municipal land base. The BC Ministry of Agriculture's Land Use Inventory for Delta found that about 80% of the ALR land (7,515 hectares) is associated with agricultural activities and another 10% is available, but not currently cultivated.[8]

Agriculture is a substantial contributor to the economy of Delta with total gross farm receipts of almost $170 million in 2010 (down from $190 million in 2005).[9] In 2005, Delta was home to 3.3% of the farms and 6.4% of the total agricultural land base in the Lower Mainland.[10] However, Delta farms earned 11.5% of this area's gross farm revenues and a relatively high proportion of BC's total gross farm receipts. In addition, about 50% of the province's potato acres, 50% of the greenhouse vegetable area and 25% of the field vegetable acres are located in Delta.[11]

Despite its prominence, in recent years the agricultural land base of Delta has been under pressure, becoming increasingly fragmented. Residential development is only one contributing factor. A number of other kinds of development, including the Deltaport expansion and the South Fraser Perimeter Road (Gateway Project) have had (and will continue to have) substantial impacts on agriculture in Delta. Mitigation for loss of farmland associated with the South Fraser Perimeter Road included improvements to the agricultural water supply infrastructure.

Agricultural production in Delta is diverse and has undergone some transition over the past 20 years. The most significant shift has been the growth of the greenhouse sector, which despite its relatively small land base (1.4% of Delta's ALR land) is a large contributor to gross farm revenues in Delta.[12] More recent trends in production include substantial expansion of blueberry production, while field vegetable and dairy operations remain relatively stable elements of agricultural production in Delta.

Delta producers that specialize in particular commodities are likely to be members of commodity organizations such as the BC Greenhouse Growers Association or the BC Blueberry Council. However, Delta does retain geographically-based agricultural organizations such as the Delta Farmers' Institute and the Delta Agricultural Society. These organizations include producers with a range of production types, and provide an opportunity to work collectively on issues of common concern.

To support its local agricultural sector, the Corporation of Delta recently completed an Agricultural Plan, adopted by Delta Council in October of 2011.[13] An Agricultural Advisory Committee is in place in Delta and its role is "to provide advice to Council on all matters relating to agriculture in Delta."[14] The Corporation of Delta has also taken an active interest in climate change adaptation, partnering on related research projects and signing on as a pilot community with ICLEI's (Local Governments for Sustainability) adaptation planning work.[15] A comprehensive climate change adaptation plan, which will be informed by these agriculture-specific adaptation strategies, is currently being developed by the Corporation of Delta.

Regional Climate Science

Accessing the best possible information about climate change is a first step in determining the options for action. For many years, climate scientists have been improving and refining climate models to produce more accurate future projections. These models have now been validated against observed climate records. The resolution of the data and models continues to increase, enabling the kinds of regional projections that follow. The Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre at the University of Victoria that provides practical information on the physical impacts of climate variability and change, in support of long-term planning.[16] PCIC is a key partner developing this pilot project, assisting in the production of the agriculturally relevant, regional climate projections for the 2020s and 2050s that are presented.

Additional information about regional climate projections, maps, and related definitions may be found in Appendix B.

Temperature Projections

- Annual average is 1°C warmer in 2020s (+1.7°C by 2050s)
- 13 more frost free days annually in 2020s (+22 days by 2050s)
- 225 more growing degree-days annually in 2020s (+415 days by 2050s)

Delta (Metro Vancouver) Climate Projections: 2020s to 2050s

Key climate projections for the Delta area (Metro Vancouver) in the 2020s to 2050s are summarized below. Projections are derived from PCIC's online tool, "Plan2Adapt."[17] Numbers provided are the median of all model runs (black line in the graphs), and the shaded area on the graphs shows the range of projected possible future conditions.[18]

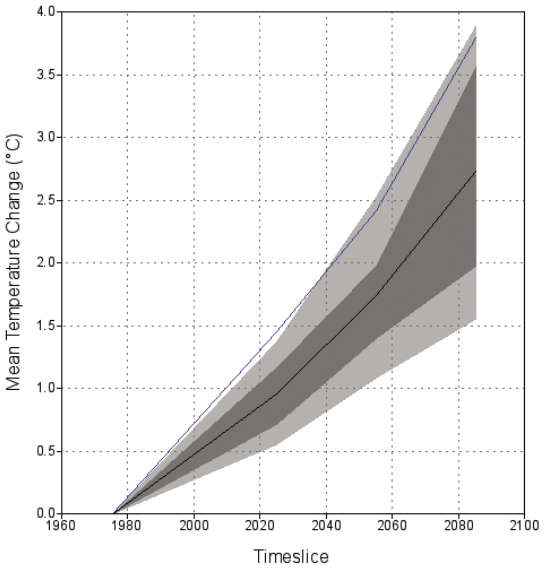

FIGURE 1 Mean Annual Temperature change, 1960-2080s

Temperature

Projections for temperature variables show a strong increasing trend,with all models projecting warming in all seasons (see Figure 1, previous page), which is consistent with recent historical trends in the Delta area.

Precipitation

While models show the possibility for both increasing and decreasing future annual precipitation, the median trend indicates a slight increase. Precipitation projections for seasonal conditions indicate drier summers and wetter winters.

The Corporation of Delta is fairly uniform geographically and as such, sees little variation in temperature or precipitation across the municipality (see map in Figure 4). The proximity to the Georgia Strait moderates temperature to some degree, so lands adjacent to the water may see very slightly higher average annual temperatures than inland areas.

Precipitation Projections

- Annual precipitation: +4% (may increase) in 2020s (+7% by 2050s)
- Summer: –7% (may decrease) in 2020s (–15% by 2050s)
- Winter: +3% (may increase) in 2020s (+6% by 2050s)
- Snowfall: –22% decrease in winter in 2020s (–36% by 2050s)

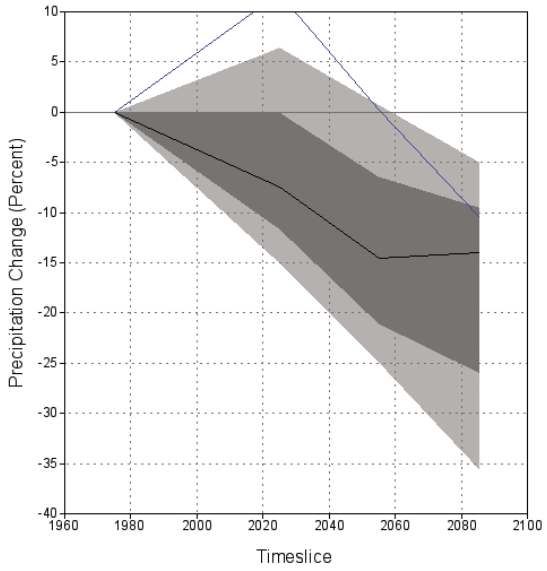

FIGURE 2 Summer Precipitation, 1960–2080s

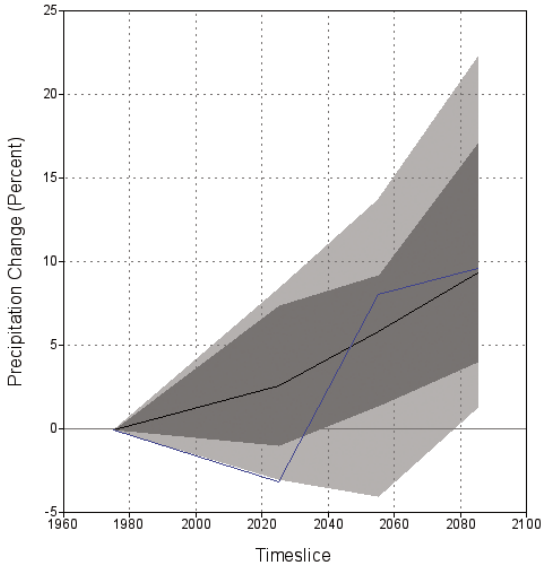

FIGURE 3 Winter Precipitation, 1960–2080s

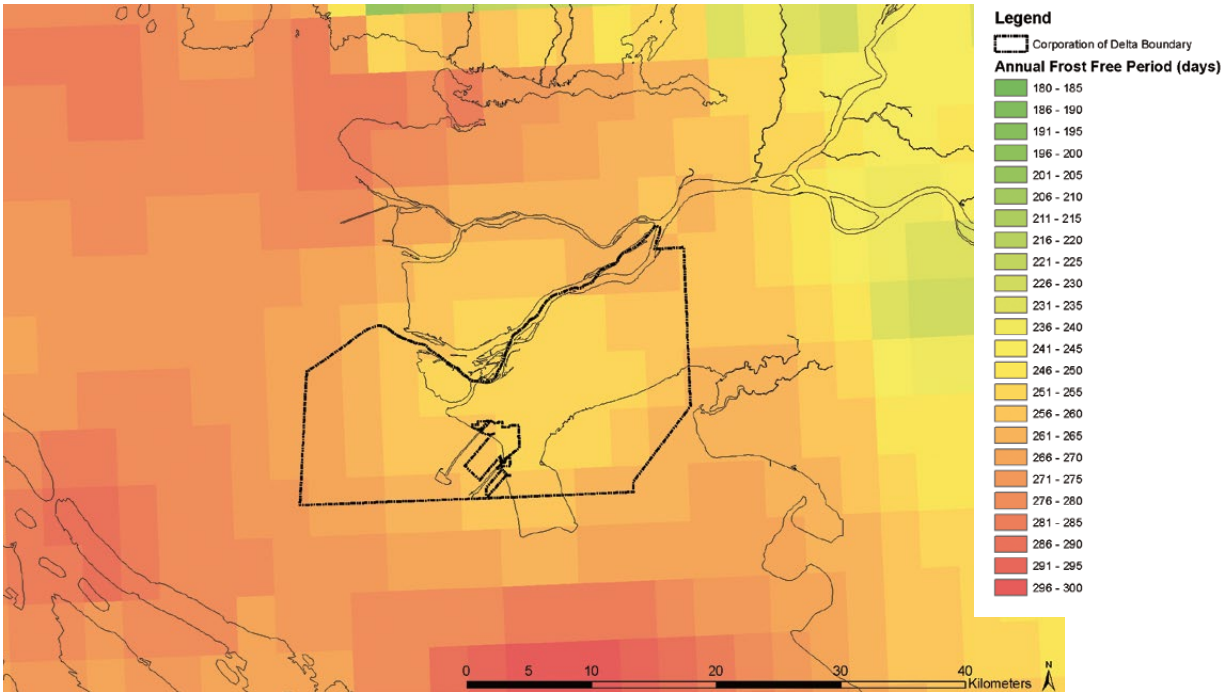

FIGURE 4 Delta Frost-Free Period Map: 2050s[19]
Map indicates the fairly uniform temperature conditions across the Corporation of Delta (heavy black outline).

Related Effects

Climate change is also projected to increase the magnitude, frequency and intensity of extreme events in Delta, for both temperature and rainfall events.

Hydrological modelling for the Fraser River system shows an increase in annual runoff and that the peak of spring runoff will occur earlier in the season as temperatures warm, leading to increasing spring flows and decreasing flows (and therefore water availability) in summer.[20] Global climate change, coupled with local subsidence (gradual sinking of the Delta land mass) contribute to a projected sea level rise of 1.2 metres by 2100.[21] This sea level rise also forces salt water farther up the Fraser River and has the potential to raise Delta's water table, and contribute to increasing soil salinity.

Extremes

- → Double the number of summer "warm days"
- → Increasing extremely hot days
- → Increasing intensity and magnitude of extreme rainfall
- → Drier conditions in the summer

Source for all the above: *Georgia Basin: Projected Climate Change, Extremes, and Historical Analysis*
— Pacific Climate Impacts Consortium.

Hydrology

- → Increasing annual runoff in Fraser River at Hope
- → Increasing river flows in spring, decreasing flows in summer
- → Potential sea-level rise of 1.2 metres above mean sea level by 2100[1]
- → Migration of salt wedge upstream
- → Increasing water table and soil salinity

[1]Source: *Projected sea level changes for British Columbia in the 21st century* — B. Bornhold, 2008.

photo by Gord McKenna, Delta

Agricultural Impacts

The changes in climate projected for Delta would have a range of potential impacts on agricultural production, summarized in the table below.[22]

TABLE 1 Potential impacts on agricultural production in the Detla area

Projected Climate Changes	Effects	Potential Agricultural Impacts
▪ Increasing temperatures ▪ Decrease in snowfall in Fraser River basin ▪ Decrease in summer precipitation ▪ Rising sea level	▪ Changing hydrology - Earlier river peak flows - Salt wedge moves upstream earlier - Earlier salination of Fraser River water at intake points - Rising water table and soil salinity	▪ *Challenging agricultural impacts:* - Limited water supply at time of dry conditions in late summer, fall - Increase in management complexity and costs - Increased demand for irrigation water - Decrease in productivity and quality of crops and livestock under water stress
▪ Increasing growing degree days and frost free days ▪ Increasing annual and seasonal temperature ▪ Shifting precipitation patterns ▪ Variable timing of frost	▪ Increase in variability of growing season conditions	▪ *Challenging agricultural impacts:* - Inconsistent productivity, quality & therefore prices - Challenges aligning production with processing schedules - Decrease in suitability for some crops ▪ *Potential opportunities:* - Increase in suitability for new varieties of forage and field vegetable crops - Increase in suitability of new crop types - Decrease in heating costs
▪ Increase in extreme weather events ▪ Increasing extreme rainfall events	▪ Increasing intensity/ frequency of extreme conditions	▪ *Challenging agricultural impacts:* - Decrease in productivity and crop quality; crop losses - Increase in building maintenance and damage costs - Increase in cooling and ventilation costs (crop storage, livestock) - Interruptions to regional infrastructure and supply lines

table continued on next page →

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▪ Increasing precipitation ▪ Increasing variability of precipitation and extreme rainfall events (especially in spring & fall)	▪ Increase in excessive moisture on fields ▪ Increase in site-specific flood risk ▪ Interruptions to pollination ▪ Decrease in light levels (cloudiness)	▪ *Challenging agricultural impacts:* - Crop damage or loss - Interruptions to planting, input application and harvesting (can't get equipment on fields) - Lower prices for product if it has to be picked at wrong time - Inability to pump water off at high tide - Increase in nutrient and input leaching - Increase in pressure on drainage and water management - Increase in management complexity (including labour availability; conflicts with neighbours)
▪ Increasing average temperatures ▪ Rising sea level ▪ Increasing annual precipitation and decreasing snowfall in the Fraser River Basin ▪ Increasing extreme rain events	▪ Increasing coastal flood risk - Increase in risk of inundation at high tide (dike breach or overtopping) - Increasing annual river flow - Increasing storm surge levels	▪ *Challenging agricultural impacts:* - Increase in crop and infrastructure damage and loss - Relocation or loss of livestock - Interruptions to supply lines - Salination of soils, and time lag for recovery
▪ Increasing winter temperature and seasonal temperatures ▪ Increasing spring precipitation and extreme rain events ▪ Decreasing summer precipitation	▪ Changes in pests, diseases and pollinators: - Increase in winter survival rates - Increase in number of cycles in a year - Introduction of new pests and diseases	▪ *Challenging agricultural impacts:* - Increase in existing and new pests and diseases - Increase in management costs, complexity, uncertainty - Increase in delays and/or prevention of pollination in spring
▪ Climate change in other growing regions	▪ Variability of global agricultural production	▪ *Challenging agricultural impacts:* - Increase in feed, seed or other input costs ▪ *Potential opportunities:* - Increase in demand for food production / local food - Increase in prices
▪ Decreasing precipitation as snow ▪ Increasing temperatures	▪ Possible increase in overwintering water fowl	▪ *Challenging agricultural impacts:* - Increase in crop damage and losses ▪ *Potential opportunities:* - Possible benefits for cleaning up blueberry fields

This set of "impact areas" (grouping of projected climate changes and their associated effects and agricultural impacts) formed the basis for discussions at the first of two workshops. These impact areas were explored in detail with participants, and ranked in order of importance for both the individual farm and regional level. A separate risk and adaptive capacity analysis was also conducted to evaluate impact areas. This analysis considered each impact area with respect to its level of risk (likelihood & consequence) and the current ability to manage and adapt to the associated agricultural impacts.[23]

Based on these analyses, the highest priorities were identified and some impact areas in the table above were excluded from consideration at the second workshop. Those impacts that were excluded may prove to be problematic or advantageous for agriculture in Delta in the future, and should continue to be monitored (particularly changes in pest, disease, weed and pollinator populations). Adaptation strategies may still be needed for agriculture to address these excluded impact areas.

photo by Gord McKenna, Delta

Priority Impact Areas, Strategies & Actions

The following four impact areas were identified as the highest priorities with respect to agricultural adaptation in Delta:

- **Impact Area 1**
  Increasing coastal flood risk
- **Impact Area 2**
  Changing hydrology (effects on water supply & salinity levels)
- **Impact Area 3**
  Increasing amount & variability of precipitation (excess winter & spring moisture)
- **Impact Area 4**
  Increasing variability & extreme conditions

For each of the priority impact areas, background description and adaptation goals are included. Following the description are the strategies and actions to support Delta agricultural producers with adapting to climate change.

The strategies and actions presented were developed to:

- → Address the highest priority impact areas;
- → Reduce vulnerability to these impacts, and/or build capacity to adapt and respond to these impacts; and
- → Define practical steps forward that address gaps and build on existing assets in the Delta context.

For each strategy, potential partners are identified in an accompanying text box, with possible "lead organizations" in ***bold italics***. Potential partners were identified through workshops and subsequent draft development, but there has been no formal dialogue with potential partners, or commitment, regarding their roles in various strategies and actions. Continued development of partnerships is an important element of next steps.

Potential Partners [LEGEND]

- ***possible lead organization***
- other potential partner

Following the strategies and actions, the final section outlines a plan for implementation and monitoring including immediate next steps and delivery.

Impact Area 1
Increasing coastal flood risk

By 2100, it is predicted that sea level will rise by 1.2 metres within the Georgia Basin due to climate change. This rise in sea level, particularly in combination with high tide and storm surge events, has the capacity to overwhelm a dike system built to today's standards. Most of Delta's agricultural lands are less than 2 metres above sea level, placing agricultural operations at comparatively greater risk than higher elevation areas of Tsawwassen and North Delta.

Inundation of agricultural land would have substantial and immediate consequences to crops, livestock and infrastructure, and would likely lead to longer-term challenges with agricultural viability due to soil salinity impacts.

Delta is protected from coastal flooding by a system of dikes, seawalls and pumping stations, designed to manage for current conditions and maintained by the Corporation of Delta. The Corporation of Delta is in the process of revising their flood management strategy to include sea level rise, and anticipates taking a phased approach to raising the dikes. A number of studies have been completed to investigate the risks and potential consequences of coastal flooding resulting from overtopping or breach of the dikes.[24] However, these studies have not specifically evaluated potential impacts for agriculture.

At present, the formal linkage between the Corporation of Delta and the agriculture sector regarding dikes occurs through the Dikes and Drainage Advisory Committee (DDAC). This is a multi-stakeholder committee of Delta Council that includes a representative from the Delta Farmers' Institute. The DDAC advises the Corporation on flood management, including dike maintenance and upgrades.[25]

Because dike improvements are very costly, they require prioritization and support from all levels of government.[26] Agriculture is just one sector that would benefit from upgraded dikes, but upgrades are likely to be critical to the future viability of agriculture in areas at risk of sea level rise impacts. Because of the potential for sea level rise to affect high value and highly productive agricultural land, it is important to elevate the visibility of this impact with the public and all levels of government.

The strategies and actions in this section address the following **two adaptation goals**:

- ***Prevent the flooding of Delta's agricultural lands***
- ***Prepare for the mitigation of flooding impacts to Delta farms***

Incorporate agricultural issues into decision-making processes regarding sea level rise & diking

Despite the role of the multi-stakeholder Dikes and Drainage Advisory Committee (DDAC), there is still strong interest within the broader agricultural producer community in learning more about diking challenges, activities and plans. Increasing the information exchange between the Corporation of Delta and Delta's agricultural producers would build understanding and help to support future action in this area.

In addition to information exchange, a more comprehensive analysis of the agricultural impacts (both economic and physical) of sea level rise is critical to decision-making at all levels. Building on existing studies, an evaluation of agricultural risks and costs in the case of inundation, would be a logical next step.[27] If the study also included vulnerable agricultural areas of neighbouring communities (Surrey and Richmond), it would enhance clarity about the implications of sea level rise for the province's food production capacity and agricultural land base.

Potential Partners

- ***Agricultural organizations***
- ***BC Ministry of Agriculture***
- City of Richmond
- City of Surrey
- ***Corporation of Delta***
- Delta Agricultural Advisory Committee
- ***Delta Farmers' Institute***
- Delta Farmland and Wildlife Trust
- Dikes and Drainage Advisory Committee
- Metro Vancouver

ACTION 1.1A **Facilitate information exchange (between producers and Delta) regarding sea level rise projections, risks and current plans and processes**	ACTION 1.1B **Evaluate the economic and food security implications of sea level rise and inundation for Delta's agricultural land base**
i Corporation of Delta presentations and information exchange about diking at industry association meetings (include mechanisms for feedback to DDAC) ii Convene a broader forum for information exchange regarding sea level rise and flood protection (crossing commodity groups)	i Approach local governments, regional government, agriculture groups (in Delta/ Richmond/Surrey) to conduct a joint project ii Identify parameters of study (e.g., land base, agricultural assets, secondary economic losses, impacts to ecological goods and services, migratory waterfowl) iii Source funding iv Undertake evaluation

Undertake dike improvements & raise dike levels to address sea level rise

Dike improvements are substantial and costly infrastructure projects. A recent study, for the entire Lower Mainland area, estimated the cost of improving the existing dike system (to protect against sea-level rise and seismic events) at over nine billion dollars.[28] Funding for these necessary improvements remains perhaps the largest obstacle to taking action. Traditionally, such works have been funded by grants from higher levels of government and future improvements will require cooperation across all levels of government.

However, the Corporation of Delta can act now by creating a reserve fund to match future funding when it becomes available. This will help to ensure that the municipality is able to act quickly when opportunities arise. To do this, the Corporation requires local taxpayer support, which could be bolstered through increasing communication regarding sea level rise risks.

Potential Partners

- Agricultural organizations
- ***Corporation of Delta***
- Delta Chamber of Commerce
- Delta Farmland and Wildlife Trust
- Delta School Board
- ***Dikes and Drainage Advisory Committee (DDAC)***
- Fraser Health Authority
- ***BC Ministry of FLNRO—Water Management Branch***
- Port Metro Vancouver
- Tsawwassen First Nation
- UBC-CALP

As flooding has the potential to impact much more than agricultural land in Delta (e.g., schools and hospitals, local businesses, regional transportation arteries, areas with environmental significance), there may be opportunities to leverage funding from non-traditional sources. Opportunities for alternate funding sources could be explored to supplement government funds as needed.

The Corporation of Delta oversees dike maintenance activities and upgrades and ensures that Delta's dike network meets the provincial Inspector of Dikes requirements. Strengthening mechanisms for producers to provide feedback regarding dike conditions, and areas of concern, would strengthen collaborative approaches.

ACTION 1.2A **Increase communication regarding maintenance and upgrading of existing dikes (as an interim step)**	ACTION 1.2B **Create a reserve fund for the Corporation of Delta to fund dike and drainage upgrades**	ACTION 1.2C **Partner with non-traditional funders for dike improvements**
i Invite feedback from producers to DDAC on maintenance priorities ii Review existing dike maintenance plan and priorities with producers; receive feedback from producers regarding areas of concern iii Confirm and communicate incremental upgrading plan for dike infrastructure to producers iv Create biennial mechanism for receiving producer input	i Explore mechanisms and options available to Delta to contribute to a dike and drainage reserve fund ii Present options to Mayor and Council	i Identify potential non-traditional funders[29] ii Bring potential funders together to explore potential for partnerships

Improve flooding impact mitigation measures

Although the Corporation of Delta is committed to maintaining and upgrading the dike system as a primary flood protection strategy, some level of flood risk is inevitable. Therefore, even with dike improvements, secondary measures are needed to increase preparedness and resilience amongst producers in the event of a dike failure.

Potential Partners

- ***Agricultural organizations***
- ***BC Ministry of Agriculture***
- Corporation of Delta
- ***Corporation of Delta's Emergency Program Office***
- ***Delta Farmers' Institute***
- Provincial Emergency Preparedness Program

Emergency planning for the Delta agricultural sector, and for agricultural operations at risk of flooding, is an important and relatively straightforward action. Opportunities to improve emergency planning include revising the Livestock Inventory and Livestock Evacuation Plan for the Corporation of Delta's community emergency plans. In addition, despite the risk of inundation in the event of a dike failure, most producers in Delta do not currently have farm-level emergency plans. Developing emergency planning information and resources for farms would help to increase the level of preparedness.

In addition to emergency planning, there are some practical farm level measures that producers might take to improve resilience to flooding. These measures could include: constructing small scale berms around buildings and installing pumps inside bermed areas, implementing flood proofing techniques to better seal buildings, or raising areas for crop, feed and fertilizer storage. Identifying and supporting implementation of these types of actions will reduce vulnerability to *some* of the impacts associated with flooding

ACTION 1.3A **Enhance community and farm-level emergency planning for agricultural operations at risk of inundation**	ACTION 1.3B **Provide information regarding site-specific flood mitigation measures to producers**
i Update Livestock Inventory and Evacuation Plans ii Identify emergency response needs for agricultural operations at the community level so they may be incorporated into existing Corporation of Delta emergency response plans iii Develop materials to assist with farm-level emergency plans	i Identify practical measures to increase on-farm resilience in flooding ii Prepare communications materials regarding these measures iii Distribute these materials to producers in vulnerable areas

Impact Area 2
Changing hydrology (effects on water supply & salinity levels)

In Delta, water supply and salinity are twin management challenges. A combination of sea level rise, earlier peak flows in the Fraser River, and drier summers are likely to lead to increasing challenges with the surface water supply for agricultural use in Delta.

Currently, 4,236 hectares (10,467 acres) of agricultural land are irrigated in Delta, translating into an estimated current irrigation water demand of 19.5 million cubic metres.[30] Climate model runs show an increase in demand by the 2050s (due to higher average temperatures and higher rates of evapotranspiration) but further analysis is needed to provide conclusive estimates.[31]

Irrigation water in-takes in the Fraser River are affected by the migration of the "salt wedge" (where ocean water meets river water) up the river. At times of lower river flows the salt wedge moves farther upstream. This situation is expected to be exacerbated as climate change results in higher river flows earlier in the irrigation season, and lower river flows during the peak irrigation demand later in the season. Sea level rise will also contribute to an increasing quantity of saline water pushing up the river.

Salinity of soils resulting from both saltwater intrusion and application of saline irrigation water are existing challenges in Delta. The effects of climate change on these conditions are unclear, but these challenges may become more pronounced with climate change-induced shifts in hydrology, precipitation and sea level rise.

Relevant Climate Change Effects

- → Sea level rise of 1.2 metres by 2100
- → Earlier peak flows in the Fraser River
- → Lower river levels in late summer and fall
- → Warmer & drier summer/fall
- → Increasing variability of precipitation

The Delta Irrigation Enhancement Project (DIEP) is scheduled to be operational in 2013. The associated upgrades to the irrigation system and intake are designed to address some of the current challenges with accessing an adequate surface water supply across the seasons. The Delta Farmers' Institute, agricultural producers, and the Corporation of Delta continue to work together for efficient operation and management of the irrigation system. Its functioning depends on ongoing cooperation and maintenance of the irrigation and drainage ditch system by the Corporation of Delta.

The strategies and actions in this section address the following **three adaptation goals**:

- ***Increase agricultural water supply and access***
- ***Enhance efficiency of agricultural water use***
- ***Minimize and manage salinity of agricultural soils***

Monitor & enhance irrigation infrastructure to manage during times of low water supply

The Delta Irrigation Enhancement Project (DIEP) is intended to reduce the introduction of saline water into the irrigation system with an upgrade of the current intake at 80th Street. Improvements are scheduled for completion in 2013, followed by 3 years of monitoring for salinity and mechanical issues. The new system is intended to achieve the best possible outcome for current conditions, but changes in the climate will continue and the irrigation system should be monitored in anticipation of the associated impacts.

Much of the Delta agricultural land base is served by a network of irrigation ditches. However, a few areas (such as Westham Island, 56th & 18th, and 64th and 104th streets) have challenges associated with summer irrigation supply. The DIEP improvements are expected to address some of these challenges (for example, a new lift station will help the 64th and 104th Street issues). Some areas (e.g., Westham Island) will not be served by DIEP and strategic improvements could be made to service remaining under-served areas.

Potential Partners

- Agricultural organizations
- BC Ministry of Transportation & Infrastructure
- ***Corporation of Delta***
- ***Delta Agricultural Advisory Committee***
- ***Delta Farmers' Institute***
- Port Metro Vancouver
- Province of BC
- ***Westham Island producers***

ACTION 2.1A **Monitor the effectiveness of the new irrigation intake and communicate results with producers**	ACTION 2.1B **Identify options, opportunities and partners for expanding irrigation infrastructure onto Westham Island**
i Develop and communicate a clear process for producers to inform the Corporation of Delta about changes or issues with the irrigation intake and system ii Make available (e.g., on the Corporation's website) real-time monitoring data or updates regarding salinity levels iii Periodically review the intake performance and new climate change data to consider the need for adjustments over time. Share findings with the Agricultural Advisory Committee and Delta Farmers' Institute.	i Undertake an options analysis for developing Westham Island irrigation infrastructure. Integrate the results of the sea level rise and flooding impacts study (Action 1.1b). ii Work with government and other partners to pursue funding for irrigation infrastructure as compensation for agricultural impacts of development projects in Delta iii Investigate and pursue other funding opportunities

Assess & enable implementation of agricultural water storage options in Delta

As noted above, climate change is expected to exacerbate water supply and salinity issues for water drawn from the Fraser River. Water storage could provide an alternate source of fresh water for farm use. Storage of precipitation and building runoff is already relatively common for greenhouse growers in Delta, and some cranberry growers store water for late season use.

Potential Partners

- ***Agricultural organizations***
- ***BC Ministry of Agriculture***
- Corporation of Delta
- ***Delta Farmers' Institute***
- Delta Farmland and Wildlife Trust
- Port Metro Vancouver

Due to the quantity of water required, storage for irrigation is likely impractical in Delta. A key limitation is the land base required for water storage and Delta's valuable agricultural land base. However, there may be potential for storage as a supplementary or emergency (end of season) water source, and for small-scale or specialty farm uses that are currently served using municipal water. By adding to the available quality water supply, water storage contributes to overall resilience. Further assessment is required to determine in what cases water storage might be a beneficial option in Delta, and whether there is (non-agricultural) land available for this purpose.

ACTION 2.2A **Undertake cost-benefit analysis of agricultural water storage options in Delta (including cooperative and individual storage systems)**	ACTION 2.2B **Develop communications materials and (potentially) explore funding/co-funding options**
i Conduct a cost-benefit study of water storage options for agricultural use in Delta, including: - Costs and benefits for community, sector and farm levels - Design considerations for resilience to climate change impacts - Funding models, with consideration of relative cost-benefit distribution and ability to pay	i Produce communications materials aimed at producers that outline: - Climate change impacts for the agricultural water supply in Delta - Cost-benefit findings for various water storage options ii Communicate results of the (above) study broadly to build awareness and—where appropriate—seek partnerships for funding and/or implementation

Disseminate existing information & tools for irrigation & salinity management

Existing farm practices such as salinity monitoring, subsurface drainage and the "flushing" of salts help to manage salt levels in agricultural soils. Increasing producer access to information about beneficial practices, monitoring and soil management techniques will improve the overall capacity to control salt levels.

Potential Partners

- ***Agricultural organizations***
- ***BC Ministry of Agriculture***
- Corporation of Delta
- ***Delta Farmers' Institute***

For producers in Delta that already experience seasonal challenges in obtaining quality water, improved efficiency and cooperation will contribute toward ensuring that the supply of agricultural water is adequate. Maximizing water use efficiency would improve overall resilience to the projected climate change impacts on freshwater availability. There are already many supporting resources available (see text box for examples). Despite some investment by producers to date, many opportunities remain for maximizing efficiency and optimizing irrigation practices.

The Irrigation Industry Association of BC's website (*www.irrigationbc.com*) has many irrigation guides and manuals to help producers optimize their irrigation systems and practices. The IIABC also offers irrigation courses.

The Irrigation Scheduling Calculator is also available on the website. This tool enables farmers to input their crop type, spacing, soil, irrigation system, and location information, and uses real-time evapotranspiration and weather data to recommend an optimal irrigation schedule.

Other resources of interest can be found at Waterbucket (*www.waterbucket.ca*) and FarmWest (*www.farmwest.com*).

ACTION 2.3A **Disseminate existing information and tools on irrigation management through locally effective means**	ACTION 2.3B **Disseminate relevant information to support producers with salinity monitoring and management**
i Identify and implement the most effective options for producers to access irrigation efficiency resources (e.g., workshops, meetings, newsletters) ii Develop a strategy for communicating with producers about how the Delta irrigation system works, with the goal of harmonizing demand with system supply	i Develop and provide information to support producers with monitoring and managing salinity levels on-farm (e.g., web-based, written, workshops, direct extension) ii Create opportunities for producers to share knowledge about practices and technologies used for salinity management

Pilot & demonstrate technologies, practices & crops for managing salinity

In addition to disseminating existing information and tools, research and demonstration of technologies, practices and crops suitable for changing water supply and salt level conditions will be needed to inform ongoing adaptation. Options may already exist in other locations that have potential for application in the Delta context. In addition, new options could be developed and tested for this area.

Potential Partners

- ***Agriculture and Agri-Food Canada***
- Agricultural organizations
- ***BC Ministry of Agriculture***
- Corporation of Delta
- ***Delta Farmers' Institute***
- ***Local universities and colleges***

While elimination or control of soil salination is necessary to maintain the agricultural viability of Delta, there may be specific contexts in which more salt tolerant crops will help to reduce the risk of crop damage. If economically viable crops are identified, this could enable production in areas where it becomes more difficult to manage saline conditions (or less feasible to minimize salinity). Trials could begin in areas currently dealing with salinity issues.

ACTION 2.4A **Develop research and demonstration projects with a focus on salinity reduction and management (Also see Strategies 3.2 and 4.1)**	ACTION 2.4B **Conduct agronomic and economic viability scan for more salt-tolerant crops**	ACTION 2.4C **Investigate effects of rising (salt) water table**
i Convene potential partners to identify priority options and funding sources ii Determine whether some plots can be linked into existing research trials iii Implement research and collect necessary data to share with producers iv Host field days and share information through producer groups	i Conduct a scan for agronomically and economically suitable salt tolerant crops ii Establish partnerships (local universities, other agricultural organizations, agriculture departments); identify and secure funding iii Identify any similar areas doing work on salt tolerant crops, practices and technologies and coordinate to share knowledge across these regions	i Conduct a study of climate change impacts for soil salinity, including: - Current causes of soil salinity, its extent and change over time - Potential impacts of climate change, including sea level rise, for soil salinity - Recommendations for how to monitor and respond to changes, if necessary

Impact Area 3
Increasing amount & variability of precipitation (excess winter & spring moisture)

Effective drainage of agricultural lands is an important contributor to the agricultural viability of Delta. Virtually all of the soil types present in Delta are significantly improved by drainage.[32] Most agricultural producers in Delta have invested in at least one type of drainage infrastructure, including subsurface (drain tiles) and surface (laser leveling) options. Privately installed drainage connects into Delta's collective system of drainage and irrigation ditches.

The Corporation of Delta invests in upgrades and maintenance of its drainage and pumping system annually. The recently completed Delta Irrigation Enhancement Project upgrades should also support improved drainage through installation of additional lift stations and control structures and approximately 19 kilometres of enhanced ditching and culverts.[33] In addition, the agriculture industry is represented as part of the Dikes and Drainage Advisory Committee, which has the mandate to improve understanding of drainage issues in the community, and to provide advice to Council and staff about flooding and stormwater management.[34] Despite these mechanisms, drainage remains a challenge for some agricultural land in Delta and is likely to become more problematic with climate change.[35]

The additional precipitation anticipated with climate change, particularly through single events, will exacerbate existing drainage problems and may create additional difficulties with managing stormwater.

Relevant Climate Change Effects

- → Increasing annual precipitation
- → Increasing precipitation in fall, winter and spring
- → Increase in magnitude and frequency of intense rainfall events (1.6–2.5 times more frequent by 2050)

Moving excess water off the agricultural land base is particularly important in the spring and fall when interruption of narrow planting and harvesting windows can have serious impacts for productivity and profit for producers.

The strategies and actions in this section address the following **adaptation goal**:

- ***Minimize (precipitation-associated) flooding/ excess moisture on farmland***

Impact Area 3 > Strategy 3.1
Pilot the development of a holistic approach to stormwater & drainage issues across the agricultural land base

Taking a holistic approach to stormwater and drainage issues across the agricultural land base would support producers with managing the challenges associated with increasing precipitation and extreme precipitation events. Ideally, this approach would be watershed based and would acknowledge the relationship between the built and natural environments (as with urban Integrated Stormwater Planning processes).[36]

Potential Partners

- Delta Agricultural Advisory Committee
- ***Agricultural organizations***
- ***BC Ministry of Agriculture***
- ***Corporation of Delta***
- ***Delta Farmers' Institute***
- Metro Vancouver

Utilizing a holistic approach across the agricultural land base would be an innovative way of bringing agriculture, the Province, and local government together to identify stormwater management issues and solutions. Contemplating how climate change will alter stormwater management requirements — how challenges may be increased by intensified rain events — will be an important aspect of this process. A holistic and integrated approach would also include, for example, management of reed canary grass in the ditches and incoming and outgoing water quality. Collaboration with producers throughout the development and implementation of the planning process will build on, and strengthen, relationships for future water management in Delta.

ACTION 3.1A **Develop the planning process**	ACTION 3.1B **Undertake collaborative stormwater management planning**	ACTION 3.1C **Undertake recommended actions**
i Convene potential partners to develop roles and responsibilities ii Collaborate with an agricultural organization to determine an integrated approach suitable to the agricultural land base	i Identify participants including representatives of a cross-section of landowners, agricultural organizations and commodities in Delta ii Conduct a technical review of current stormwater management practices by producers, organizations (e.g., DFWT), Delta and the Province iii Undertake planning process that integrates current practices, infrastructure and weather data, with climate change projections iv Communicate results	i Develop an implementation and a monitoring strategy that allows for system feedback and new information (e.g., about climate change projections and impacts) to inform actions over time

Increase availability of technical information & incentives for farm level stormwater & drainage management (planning, installation & upgrades)

With the climate change impacts outlined above, existing farm drainage infrastructure may be insufficient and upgrades or integration of additional approaches is likely necessary. At present, the Delta Farmland and Wildlife Trust offers cost-share assistance with implementation of laser leveling and the Environmental Farm Plan Program has (in the past) provided assistance with drainage planning. A more fully integrated set of supports for on-site management of stormwater and drainage on agricultural lands would be valuable. This would include strengthening the knowledge base (through research/pilots) for managing excess water in the context of climate change. Planning, technical and implementation support would also help to ensure that management is suitable for future conditions.

Potential Partners

- ***Agricultural organizations***
- ***Agriculture & Agri-Food Canada***
- ***BC Ministry of Agriculture***
- ***Delta Farmers' Institute***
- Delta Farmland & Wildlife Trust

ACTION 3.2A **Pilot and demonstrate drainage management options (Also see Strategies 2.4 and 4.1)**	ACTION 3.2B **Support stormwater and drainage management planning for Delta farms**	ACTION 3.2C **Provide cost-share supports for implementation of farm storm-water management/drainage infrastructure**
i Convene partners to identify priority pilot options and funding/implementation plan ii Pilot and demonstrate management approaches in Delta (research plots or with willing producer partners)	i Integrate climate change considerations, including salinity management, into drainage planning manuals and extension supports ii Actively promote farm stormwater and drainage planning through workshops, programming, agricultural organizations	i Enhance cost-share supports for stormwater/drainage implementation (informed by above)

Impact Area 4
Increasing variability & extreme conditions

In evaluating the risks associated with climate change, BC producers consistently identify extreme events and increasing variability in conditions as the most challenging for adaptation.[37] The uncertainty in the timing, extent and frequency of variable and extreme conditions makes it difficult for producers to plan for particular conditions; requiring instead that they maximize their ability to respond to the broad range of projected changes.

One of the most pivotal strategies for adapting is implementation of technologies and practices that buffer production systems from a variety of potential conditions. This also means evaluating practices in a more integrated way — how they exist within farming systems and their specific environment and how climate change will shift the parameters for management.[38]

At the same time, the broader context for agricultural production strongly influences the degree of flexibility and resilience that agricultural operations are able to achieve. During the course of the workshops, producers in Delta frequently commented on the extent to which agriculture is marginalized and how important it is to improve communication with the surrounding community and beyond. Strengthening the urban population's understanding of agriculture is imperative to increasing the sector's resilience.

Relevant Climate Change Effects

- → Doubling in number of summer "warm days"
- → Increasing extremely hot days (2–3 times more often in 2050s)
- → Increasing intensity and magnitude of extreme rainfall
- → Extreme rainfall events 1.6–2.5 times more frequent by 2050
- → Drier conditions in summer

The strategies and actions in this section address the following **adaptation goal:**

- ***Increase overall resilience and flexibility of agricultural systems to manage projected variable conditions***

Pilot & demonstrate practices and technologies for managing challenging & variable conditions

Piloting and demonstrating management practices and technologies is an important element of supporting innovation and adaptation in agriculture. Applied research can be conducted through trials that mimic field conditions, or within a working farm. In either case, designating resources for testing practices and technologies helps to spread the risk of trying new things, encourage innovation, and support more efficient adoption (because producers can see the results).

Potential Partners

- ***Agricultural organizations***
- Agriculture and Agri-Food Canada
- ***BC Ministry of Agriculture***
- ***Delta Farmers' Institute***
- Delta Farmland & Wildlife Trust
- ***Post-secondary institutions***

Some practices/technologies that could be piloted within the Delta context include:

- → Crop protection and season extension technologies
- → Alternative drainage management practices/technologies
- → Irrigation efficiency, water storage and water reuse technologies
- → Salinity management practices
- → Nutrient management practices and adaptation (i.e., contemplating nutrient management with climate change impacts such as increased precipitation and soil salinity in mind)

ACTION 4.1A **Identify partners and priorities (Also see Strategies 2.4 and 3.1)**	ACTION 4.1B **Pilot and demonstrate management approaches in Delta (research plots or with willing producer partners)**
i Convene potential partners to identify priority pilot options and funding sources ii Identify whether pilots can, in some cases, be linked into existing trials (e.g., potato trials)	i Undertake pilots and collect necessary data to share with producers ii Host field days and share information through agricultural organizations

Develop a collaborative communications strategy highlighting the potential impacts of climate change to the food system & the value of local agriculture

Maintaining a productive and viable agricultural land base is an important aspect of climate change adaptation. For British Columbia, with its very limited arable land base that is under constant pressure, maintaining agricultural land along with a resilient agriculture sector will require the commitment of the broader population.

In contemplating climate change impacts, producers in Delta express concern that many residents of Delta (and the greater Vancouver area more generally) do not understand agriculture or its issues. Consequently, there is also little understanding of the implications of climate change for food production locally and globally.

Potential Partners

- Agricultural organizations
- BC Ministry of Agriculture
- Corporation of Delta
- ***Delta Farmers' Institute***
- ***Delta Farmland & Wildlife Trust***
- ***Direct farm marketing organizations***
- ***Local consumer education / food security groups***

Improving the knowledge of the urban populace would go some distance toward assisting producers to manage the challenges that lie ahead. There will be public involvement in future decisions around infrastructure investment and resource allocation, and the future of agriculture in the province depends on a fuller understanding from those removed from agriculture's daily realities.

With its close proximity of farms and residential areas, Delta offers an excellent opportunity to pilot a communications strategy to build bridges between producers and their neighbours about climate change impacts and the value of local agriculture.

ACTION 4.2A **Initiate a collaborative communications strategy**	ACTION 4.2B **Develop and implement a collaborative communications strategy**
i Invite potential partner organizations to meet and discuss the options for a collaborative communications initiative ii Identify common objectives and an underlying approach iii Identify and seek out possible sources of funding	i Incorporate a range of mechanisms for reaching the local public, such as: - Mail-outs, news media, brochures - Video spots for TV/internet - Public events/workshops

Implementation & Monitoring

While all of the actions in this document are important for the agriculture sector to adapt to climate change, the actions below are identified as "next steps" both due to their importance and/or to the relative ease of implementing them (see text box). Building momentum and capacity for collective action, and addressing the most important issues, will help to ensure implementation of all of the identified actions.

Implementation considerations are identified for each of these next steps, outlined below.[39]

The Climate Action Initiative and local partners intend to form a joint steering committee to oversee the implementation of the strategies. While it is understood that many partners will be involved in delivering various actions, this steering committee will play a key role in monitoring and taking an adaptive management approach over time (see below).

Initial Communications

The strategies and actions in this document have been developed collaboratively by agricultural producers, Corporation of Delta staff and committee representatives, provincial government staff and the Climate Action Initiative. Formation of a steering committee and implementation of this suite of actions will require on-going cooperation and commitment across these and other partners.

The first step towards furthering this collaboration will be to communicate the results of this process back to the potential partners and decision-makers, such as:

- BC Ministry of Agriculture
- Corporation of Delta
- Delta Farmers' Institute
- Delta Farmland and Wildlife Trust
- Agricultural Commodity organizations

Important actions are those that address the highest priority impacts or critical gaps for building resilience. These may be, but are not necessarily, the most urgent actions.

Ease of implementation refers to actions that can be initiated without delay because there is a "window of opportunity," there are clear co-benefits for other actors or programs, or there are minimal barriers to address. These actions, sometimes referred to as "low-hanging fruit," are critical for turning awareness into action.

Formation of a Joint Steering Committee

The Climate Action Initiative will work with local partners to develop a joint steering committee to oversee ongoing communication, implementation and monitoring of the plan.

Monitoring & Adaptive Management

In addition to building the capacity for collective action, climate change adaptation requires the ability to reflect, learn and adjust course in response to developing knowledge and conditions (this is known as "adaptive management" — see Appendix D). To achieve this, regular monitoring of the plan, new knowledge and evolving conditions should be undertaken. It is suggested that this be conducted annually and include:

- Updates on climate projections and potential impacts to agriculture
- Discussion of climate-related impacts being experienced currently
- Review of progress, and barriers to progress, on plan implementation
- Revisiting priorities for action

Next Steps

Action 1.1a

Facilitate information exchange regarding sea level rise projections, risks and current plans/processes

Key roles	Corporation of Delta, Delta Farmers' Institute, other agricultural organizations
Timeframe	Short-term (< 2 years)
Cost	Low (< $25,000)
Existing assets	Delta staff knowledge
Key barriers	None

Action 1.1b

Evaluate (the economic and food security) implications of sea level rise and inundation for Delta's agricultural land base

Key roles	BC Ministry of Agriculture, Corporation of Delta, City of Richmond, City of Surrey, agricultural organizations, Delta Farmland and Wildlife Trust
Timeframe	Short-term (< 2 years)
Cost	Low (< $25,000) to Medium ($25,000–200,000)
Existing assets	Shared interests with Richmond and Surrey; agricultural land use inventory and flood modelling data in the region
Key barriers	Secure funding

Action 1.2b
Create a reserve fund for the Corporation of Delta to fund dike and drainage upgrades

Key roles	Corporation of Delta
Timeframe	Mid-term (2–5 years)
Cost	High (> $200,000)
Existing assets	Planning and technical work to determine best flood management options for Delta; public awareness; broad benefit
Key barriers	Public support, cost

Action 1.3a
Enhance community and farm-level emergency planning for agricultural operations at risk of inundation

Key roles	BC Ministry of Agriculture, Corporation of Delta Emergency Program Office, agricultural organizations, Delta Farmers' Institute
Timeframe	Short-term (< 2 years)
Cost	Low (< $25,000)
Existing assets	Emergency program in Delta; BC Flood Response plan; benefit to individual landowners
Key barriers	Responsibility distributed across agencies — no clear leader

Action 2.1b
Identify options, opportunities and partners for expanding irrigation infrastructure onto Westham Island

Key roles	Corporation of Delta, Delta AAC, Westham Island producers, Delta Farmers' Institute
Timeframe	Mid-term (2–5 years)
Cost	Low (< $25,000); implementation cost is High (> $200,000)
Existing assets	Development projects in Delta could be a source of funds
Key barriers	Cost, technical challenges, benefits are restricted to one area

Action 3.1b
Undertake collaborative stormwater management planning

Key roles	BC Ministry of Agriculture, agricultural organizations, Corporation of Delta, Delta Farmers' Institute
Timeframe	Mid-term (2–5 years)
Cost	Medium ($25,000–200,000)
Existing assets	Existing knowledge and relationships re: drainage in Delta
Key barriers	Requires broad participation and cross-jurisdictional coordination, cost

Action 3.2a
Pilot and demonstrate drainage management options

Key roles	BC Ministry of Agriculture, commodity organizations, Delta Farmers' Institute, Agriculture and Agri-Food Canada
Timeframe	Short-term (< 2 years)
Cost	Medium ($25,000–200,000)
Existing assets	Trials and research plots run by commodity organizations; existing drainage information resources
Key barriers	Communicating the importance of drainage in the BC agriculture context

Action 4.2a
Initiate a collaborative communications strategy

Key roles	Delta Farmers' Institute, Delta Farmland and Wildlife Trust, local consumer education / food security groups, direct farm marketing organizations
Timeframe	Short-term (< 2 years)
Cost	Low (< $25,000) to Medium ($25,000–200,000)
Existing assets	Communications knowledge of various partners; recognizable need and benefit across partners
Key barriers	Collaboration across organizations that don't often partner

Appendix A
Weather, Climate & Variability

Weather is what happens on a particular day at a particular location. Farmers are continually required to adapt to weather conditions to effectively plan and manage their businesses. In contrast, climate refers to long-term trends, patterns and averages over time. These are more difficult to notice through day-to-day or year-to-year experiences, or short-term records of weather. However, over a period of decades, recorded observations can characterize the climate and identify changes.

Anyone who pays close attention to weather forecasts appreciates that predictions of weather are often limited in their accuracy. This is partly because of the many factors that impact weather. Turning to longer, climate-related timescales, in BC we are familiar with the 3–7 year cycles of El Niño and La Niña ("ENSO"), which dramatically impact the climate of individual seasons and years (see Figure 2). Compared to La Niña years, conditions in BC during El Niño years are typically warmer and drier in winter and spring, and less stormy in southern BC.

Adding to the complexity, the Pacific Decadal Oscillation (PDO) is a known pattern that shifts over longer time periods (20 to 30 years) and this is associated with different temperature and precipitation conditions here in BC. It also has a warm and cool phase, and so it can either enhance or dampen the impacts of El Niño and La Niña conditions in a given year.

Figure 6 shows the difference between climate variability, oscillations, and climate change. The many factors that impact the weather create significant variation in what we experience from year to year. However, we are still able to chart averages over long periods of time.

For additional resources see *BC Agriculture Climate Change Adaptation Risk and Opportunity Assessment Series* (*www.bcagclimateaction.ca/adapt/risk-opportunity*) and *Regional Agricultural Adaptation Strategies Technical Report* (*www.bcagclimateaction.ca/adapt/regional-strategies*).

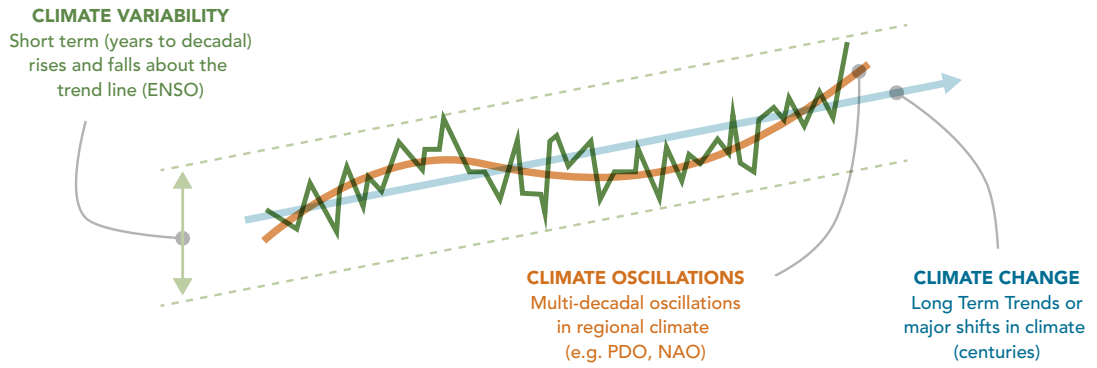


FIGURE 5 Climate Variability, Oscillations & Change

Diagram showing difference between climate variability, oscillations, and climate change. Adapted from original, courtesy of Pacific Climate Impacts Consortium, www.pacificclimate.org

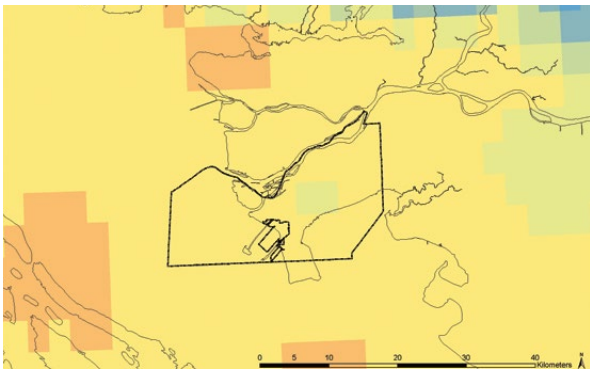
Appendix B
Future Projections: Climate Maps & Full PCIC Tables

TABLE 2 Metro Vancouver Climate Projections — 2020s

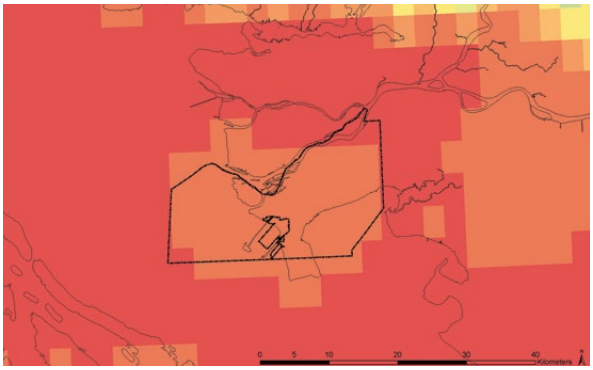
Climate Variable	Time of Year	Projected Change from 1961–1990 Baseline		
		Delta (Range)	**Delta (Average)**	**BC (Average)**
Mean Temperature (°C)	Annual	+0.5 °C to +1.4 °C	+1.0 °C	+1.0 °C
Precipitation (%)	Annual	–2% to +8%	+4%	+4%
	Summer	–16% to +8%	–7%	+0%
	Winter	–3% to +9%	+3%	+4%
Snowfall (%)	Winter	–42% to –5%	–22%	–2%
	Spring	-62% to -4%	–31%	–30%
Growing Degree Days (degree days)	Annual	+104 to +314 degree days	+225 degree days	+153 degree days
Heating Degree Days (degree days)	Annual	–479 to –171 degree days	–334 degree days	–354 degree days
Frost-Free Days (days)	Annual	+6 to +20 days	+13 days	+10 days

TABLE 3 Metro Vancouver Climate Projections — 2050s

Climate Variable	Time of Year	Projected Change from 1961–1990 Baseline		
		Delta (Range)	**Delta (Average)**	**BC (Average)**
Mean Temperature (°C)	Annual	+1.0 °C to +2.5 °C	+1.7 °C	+1.8 °C
Precipitation (%)	Annual	–2% to +11%	+7%	+6%
	Summer	–25% to +3%	–15%	–1%
	Winter	–4% to +15%	+6%	+8%
Snowfall (%)	Winter	–56% to –19%	–36%	–10%
	Spring	–73% to –17%	–56%	–58%
Growing Degree Days (degree days)	Annual	+250 to +609 degree days	+415 degree days	+283 degree days
Heating Degree Days (degree days)	Annual	–853 to –360 degree days	–589 degree days	–648 degree days
Frost-Free Days (days)	Annual	+14 to +33 days	+22 days	+20 days

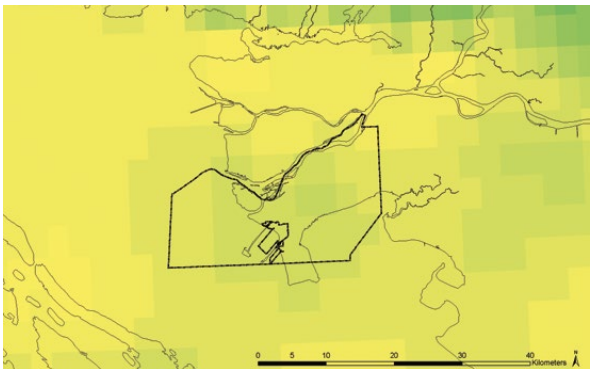


1961–1990 Baseline

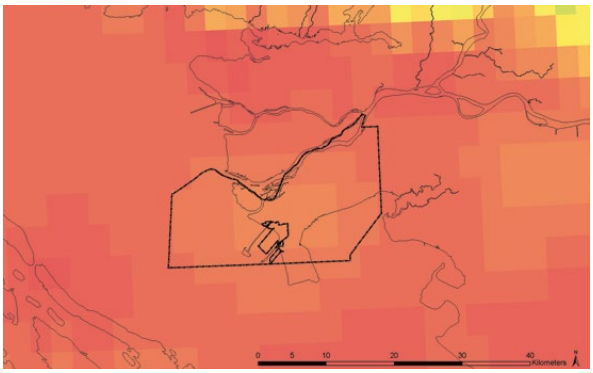


2050s

FIGURE 6 Mean Annual Temperature, Baseline and 2050s [40]

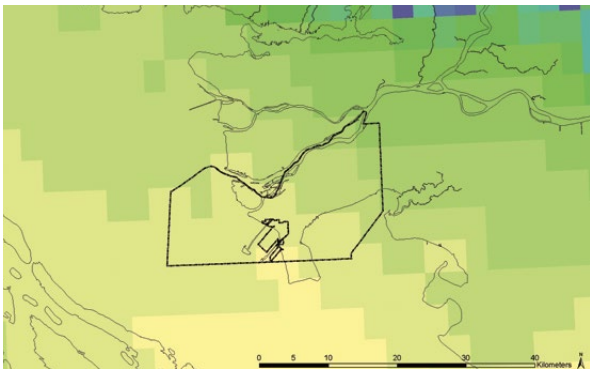


1961–1990 Baseline

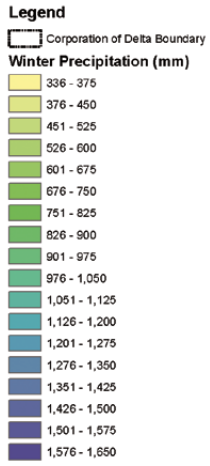


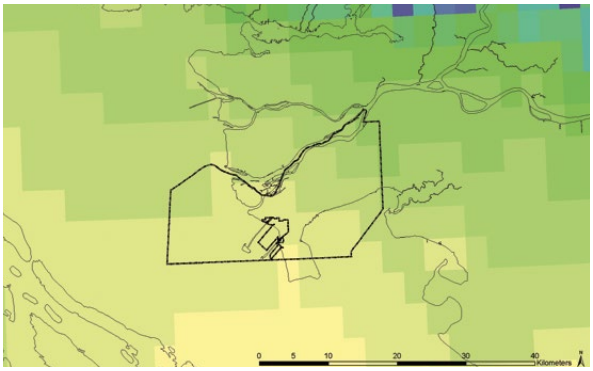
2050s

FIGURE 7 Growing Degree-Days, Baseline and 2050s[41]

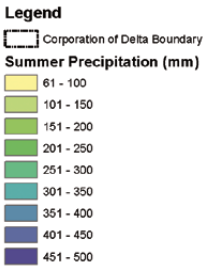


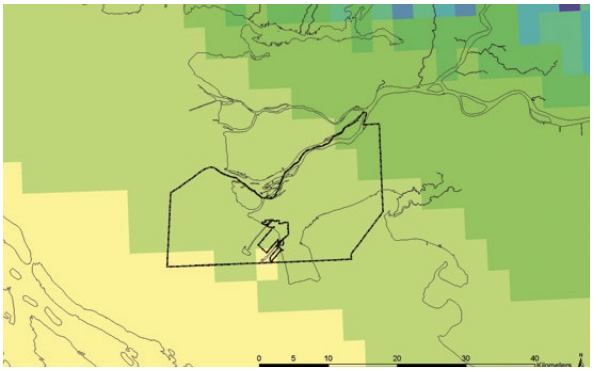
Winter 1961–1990 Baseline



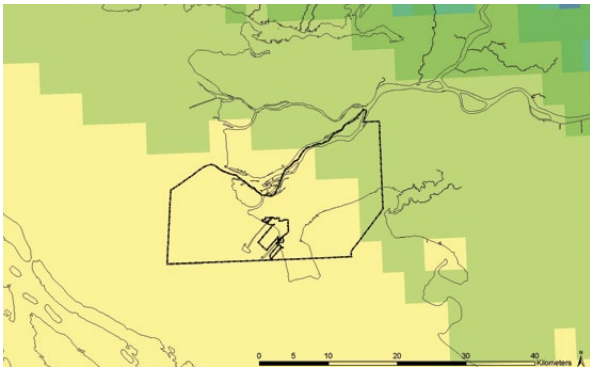


Winter 2050s





Summer 1961–1990 Baseline



Summer 2050s

FIGURE 8 Seasonal Precipitation, Baseline and 2050s[42]

Note that for legibility, winter and summer use different legends and so cannot be directly compared.

Appendix C
Definitions

Growing Degree-Days (GDD) are a measure of heat accumulation, and represent the cumulative number of degrees that the average daily temperature is above a base temperature of 5 degrees, for all days of the year.

Frost Free Days (FFD) are the number of days the temperature is above freezing.

Frost Free Period (FFP) is the consecutive number of days between first frost in fall and last frost in spring.

Heating Degree-Days are a measure of energy demand, and represent the cumulative number of degrees that the average daily temperature is below a base temperature of 18 degrees (when heating is required), for all days of the year.

Cooling Degree-Days represent the cumulative number of degrees above a base temperature of 18 degrees (when cooling is required), and is the opposite of Heating Degree-Days.

Appendix D
Adaptive Management of Climate Change Impacts

Climate change adaptation decision-making is an inherently complex task that requires ongoing learning and reflection to adjust to changing information, events and conditions. As learning progresses, new solutions as well as new challenges will be identified. The following questions are provided as tools for navigating this evolving landscape and determining priorities for action.

Additional considerations when determining how to implement priority actions would include:

- Barriers (e.g., legislation, lack of working relationships)
- Assets/Enablers (e.g., leadership, integrating into existing plans/programs)
- Implementation costs
- Operation and maintenance costs
- Financing and resources
- Timeframe

Table 4 Developing & Prioritizing Adaptation Actions

Effectiveness	To what degree does this action reduce risk/vulnerability, and/or enhance resilience?
Adaptability	Can this action (and resources dedicated to it) be changed or redirected as conditions change?
Urgency	When does action need to be taken on this issue, in order to be effective by the time an impact is projected to occur?
Gaps & Assets	How does this action address identified gaps or barriers? How can it build on existing assets and resources?
Co-benefits ("no-regrets")	What other benefits would this action have, even if climate change impacts do not occur as projected?
Consequences	What could be the unintended and/or undesirable effects of taking this action? Can these be avoided or mitigated?
Extent	Do the benefits apply broadly in the region, or to specific individuals?
Relevance	Does this action have the support of the agricultural community?

Endnotes

1 Crawford, Erica and Emily MacNair. BC *Agriculture Climate Change Adaptation Risk & Opportunity Assessment.* BC Agriculture & Food Climate Action Initiative. March 2012. *http://www.bcagclimateaction.ca*

2 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 153.

3 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 69.

4 Land capability ratings (Classes) are determined by climatic and soil characteristics. Agricultural capability of soils can become greater through improvements like installation of irrigation or drainage. Classes 1, 2 and 3 are the highest capability levels — as the class number increases, agricultural capability is more limited.

5 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 69.

6 Delta Farmland and Wildlife Trust. *http://www.deltafarmland.ca/*

7 Statistics Canada. 2011 Census of Agriculture: 2011 Farm and farm operator data. *http://www29.statcan.gc.ca/ceag-web/eng/community-agriculture-profile-profil-agricole?geoId=590215011&dataType=1*

8 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 74. *http://www.corp.delta.bc.ca/assets/CPD/PDF/DeltaAgriculturalProfileFinal_20110610.pdf*

9 Statistics Canada. 2011 Census of Agriculture: 2011 Farm and farm operator data. *http://www29.statcan.gc.ca/ceag-web/eng/community-agriculture-profile-profil-agricole?geoId=590215011&dataType=1*

10 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 158. *http://www.corp.delta.bc.ca/assets/CPD/PDF/DeltaAgriculturalProfileFinal_20110610.pdf*

11 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 158. *http://www.corp.delta.bc.ca/assets/CPD/PDF/DeltaAgriculturalProfileFinal_20110610.pdf*

12 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan: Phase 1: Delta Agricultural Profile.* Corporation of Delta. June 2011. P. 154. *http://www.corp.delta.bc.ca/assets/CPD/PDF/DeltaAgriculturalProfileFinal_20110610.pdf*

13 *http://www.corp.delta.bc.ca/EN/main/municipal/323/27003/agriculturalplan.html*

14 *http://www.corp.delta.bc.ca/EN/main/mayor/346/aac.html*

15 *http://www.icleicanada.org/*

16 *http://www.pacificclimate.org*

17 *http://pacificclimate.org/tools-and-data/plan2adapt.* In the graphs, the black line indicates the midpoint of all model runs, grey shading indicates the range.

18 For more explanation of model outputs and ranges, see *http://www.plan2adapt.ca*, and the accompanying technical report to this document.

19 Data from Wang, T., A. Hamann, D. L. Spittlehouse, and T. Q. Murdock, 2012: ClimateWNA—High-Resolution Spatial Climate Data for Western North America. *Journal of Applied Meteorology and Climatology*, 51, 16–29, doi:10.1175/JAMC-D-11-043.1.

20 Shrestha, R.R., M.A. Schnorbus, A.T. Werner, A.J. Berland. 2012. *Modelling spatial and temporal variability of hydrologic impacts of climate change in the Fraser River basin, British Columbia, Canada.* Hydrological Processes 26, 1840-1860, doi: 10.1002/hyp.9283

21 Bornhold, B. *Projected Sea Level Changes for British Columbia in the 21st Century*. November 2008. *http://www.env.gov.bc.ca/cas/pdfs/sea-level-changes-08.pdf*

22 Crawford, Erica and Emily MacNair. BC *Agriculture Climate Change Adaptation Risk & Opportunity Assessment.* BC Agriculture & Food Climate Action Initiative. March 2012. *http://www.bcagclimateaction.ca*

23 For more detailed information on the risk analysis process, see the accompanying technical report.

24 Associated Engineering. Corporation of Delta - Southlands Area - Coastal Flood Modelling and Flood Construction Level Assessment. October 2012. *http://www.corp.delta.bc.ca/assets/CPD/PDF/Southlands%20Coastal%20Flood%20Modeling%20and%20Flood%20Costruction%20Level%20Assessment%20-%20Revised.pdf*
Barron, S., D Flanders, K. Tatebe, E. Pond, G. Canete, J. Carmichael, S. Muir Owen, S.R.J. Sheppard. Delta – RAC Sea Level rise Adaptation Project Policy Report. 2012. *http://www.fraserbasin.bc.ca/programs/bcrac/documents/Delta-RAC_Sea_Level_Study-policy_2012.pdf*
Delcan-DHV Consultants. Delta Flood Risk and Consequence Study. March 2010. *http://www.corp.delta.bc.ca/downloads/*

FloodRiskStudy/Delta%20Flood%20Risk%20and%20Consequence%20Study.pdf
Delcan - DHV Consultants. Sea Level Rise Dike Breach Analysis. January 7, 2010.
Flanders, David., S. Barron, J. Carmichael, G. Canete, S. Cohen, E. Pond, S. Sheppard and K. Tatebe. Sea Level Rise Adaptation Visioning Study - Technical Report. March 2011. *http://www.delta-adaptation-bc.ca/documents/120430_delta-rac_technical_final_small/*
Kerr-Wood-Leidal Consultants. Delta Flood Management Study. May 2007. *http://www.kwl.ca/projects/delta-flood-management-study-corporation-delta*

25 Dikes and Drainage Advisory Committee: *http://www.delta.ca/EN/main/mayor/346/ddac.html*

26 A recent study found the region-wide cost of upgrading dikes for sea level rise to be approximately 9 billion dollars. BC Ministry of Forests, Lands, and Natural Resource Operations. *Cost of Adaptation: Sea Dikes and Alternative Strategies.* October 2012. *http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/cost_of_adaptation-final_report_oct2012.pdf*

27 see sources in endote 25 above, as well as: BC Ministry of Agriculture. Delta Land Use Inventory Report. April 2010. *http://www.al.gov.bc.ca/resmgmt/sf/gis/lui_reports/Delta2010_ALUIReport.pdf*

28 BC Ministry of Forests, Lands, and Natural Resource Operations. *Cost of Adaptation: Sea Dikes and Alternative Strategies.* October 2012. *http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/cost_of_adaptation-final_report_oct2012.pdf*

29 Some examples of potential partners/funders include: Chamber of Commerce, Port Metro Vancouver, local industry and businesses, BC Ferries, conservation organizations etc.

30 van der Gulik, T., D. Neilsen, R. Fretwell, S. Tam. 2013. *Agriculture Water Demand Model – Report for the Cowichan Valley*.

31 van der Gulik, T., D. Neilsen, R. Fretwell, S. Tam. 2013. *Agriculture Water Demand Model – Report for the Cowichan Valley*.

32 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan, Phase 1: Delta Agriculture Profile.* "Soil Capability for Agriculture," Corporation of Delta. June 2011. pp.68-72. *http://www.corp.delta.bc.ca/assets/CPD/PDF/delta_agricultural_plan_final_oct2011.pdf*

33 Delta Irrigation Enhancement Project Update: *https://delta.civicweb.net/Documents/DocumentDisplay.aspx?Id=58805*

34 Dikes and Drainage Advisory Committee: *http://www.delta.ca/EN/main/mayor/346/ddac.html*

35 Zbeetnoff Agro-Environmental Consulting & Quadra Planning Consultants. *Delta Agricultural Plan, Phase 3 Report: Agricultural Plan*. Corporation of Delta. October 2011. P. 8. *http://www.corp.delta.bc.ca/assets/CPD/PDF/delta_agricultural_plan_final_oct2011.pdf*

36 *Stormwater Planning: A Guidebook For British Columbia*. May 2002. P.3-1. *http://www.env.gov.bc.ca/epd/mun-waste/waste-liquid/stormwater/guidebook/pdfs/chapter3.pdf*

37 Crawford, Erica and Emily MacNair. *BC Agriculture Climate Change Adptation Risk & Opportunity Assessment: Executive Summary.* 2012. *http://www.bcagclimateaction.ca/wp/wp-content/media/AdaptROseries-ExecSummary.pdf*

38 A new set of documents exploring linkages between farm practices and climate change adaptation — the *BC Farm Practices & Climate Change Adaptation Series* — will be available on the BC Agriculture & Food Climate Action Initiative website in spring of 2013: *http://ww.bcagclimateaction.ca/adapt/farm-practices*

39 These details apply to completing this specific action only, not to actions that may develop as a result. For example, if the action is to conduct a feasibility study, the details do not include what would be necessary to implement the preferred options identified in the study.

40 Data from Wang, T., A. Hamann, D. L. Spittlehouse, and T. Q. Murdock, 2012: ClimateWNA—High-Resolution Spatial Climate Data for Western North America. *Journal of Applied Meteorology and Climatology*, 51, 16–29, doi:10.1175/JAMC-D-11-043.1.

41 Data from Wang, T., A. Hamann, D. L. Spittlehouse, and T. Q. Murdock, 2012: ClimateWNA—High-Resolution Spatial Climate Data for Western North America. *Journal of Applied Meteorology and Climatology*, 51, 16–29, doi:10.1175/JAMC-D-11-043.1.

42 Data from Wang, T., A. Hamann, D. L. Spittlehouse, and T. Q. Murdock, 2012: ClimateWNA—High-Resolution Spatial Climate Data for Western North America. *Journal of Applied Meteorology and Climatology*, 51, 16–29, doi:10.1175/JAMC-D-11-043.1.