Climate Action Initiative
BC AGRICULTURE & FOOD

Fraser Valley Climate Adaptive Drainage Management Forum

ENHANCING RUNOFF AND DRAINAGE MANAGEMENT IN THE FRASER VALLEY AGRICULTURAL SECTOR

Final Report

Prepared For

The BC Blueberry Council in partnership with the BC Agriculture & Food Climate Action Initiative

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STATEMENT OF LIMITATIONS

This report has been prepared by Tim Wilson and Eco-Logical Resolutions for the exclusive use and benefit of the BC Agriculture & Food Climate Action Initiative (CAI), the Fraser Valley Agricultural Adaptation Working Group and project partners. This document represents the best judgement of Tim Wilson and Eco-Logical Resolutions, based on the information available at the time of its completion, and as appropriate for the scope of work. Services were performed according to normal professional standards in a similar context and for a similar scope of work.

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The Fraser Valley Climate Adaptive Drainage Management Forum project was directed by a Project Management Committee (PMC) selected from the Fraser Valley Agricultural Adaptation Working Group. PMC members include:

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Chris Elder	Long Range Planner, Whatcom County Planning & Development Services
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Stephanie Tam	Water Management Engineer, Drainage, Ministry of Agriculture
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Ted van der Gulik	President, Partnership for Water Sustainability in British Columbia

The Forum benefited from presentations given by the following guest speakers:

Chris Elder	Long Range Planner, Whatcom County Planning and Development Services
Jennifer Prive	Professional Biologist, Environmental Dynamics Inc.
Ted van der Gulik	President, Partnership for Water Sustainability in British Columbia
Trevor Murdock	Climate Scientist, Pacific Climate Impacts Consortium

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LIST OF ACRONYMS

ARDSA	Agricultural and Rural Development Subsidiary Agreement
BCUC	BC Utilities Commission
BMP	Best management practice
CAI	BC Agriculture & Food Climate Action Initiative
CREP	Conservation Reserve Enhancement Program
CTD	Controlled tile drainage
DDI	Dyking, Drainage, and Irrigation Committee
DFO	Department of Fisheries and Oceans (or Fisheries and Oceans Canada)
DID	Drainage Improvement District
DMP	Drainage Management Plan
ECCC	Environment & Climate Change Canada
ESI	Ecological Service Initiative
FLNRORD	BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
FRISP	Farmland-Riparian Interface Stewardship Program
FVRD	Fraser Valley Regional District
GCM	Global Climate Model
IAFBC	Investment Agriculture Foundation of British Columbia
IPCC	Intergovernmental Panel on Climate Change
ISMP	Integrated Stormwater Management Plan
MAG	BC Ministry of Agriculture
NGO	Non-Governmental Organization
PCIC	Pacific Climate Impacts Consortium
QEP	Qualified Environmental Professional
RCP8.5	Representative Concentration Pathway 8.5
ROI	Return on Investment
WID	Watershed Improvement District

EXECUTIVE SUMMARY

The Fraser Valley Climate Adaptive Drainage Management Forum project was initiated to generate and share the best available precipitation projections for the Fraser Valley; research collaborative climate adaptive drainage management strategies adopted in comparable settings; and host a Forum between producers, local government and agency staff, researchers and agricultural association representatives to deliberate preferred drainage management strategies to address local runoff and drainage challenges.

Implications of climate change for drainage management

Drainage remains one of the primary limiting criteria for agricultural production in the Fraser Valley, yet changing climate and additional drainage demands are reducing the effectiveness of existing drainage infrastructure. The climate projections indicate that **changes in Fraser Valley precipitation patterns will considerably increase the agricultural drainage burden**. Compared to past climate (1971 – 2000) in the region, average values for the following precipitation indicators are projected to increase by ~2050 as follows:

- Compared to the rest of the year, increases in total precipitation and maximum storm precipitation amounts will be largest during Spring (March, April, May) and Fall (September, October, December) when field trafficability is particularly important.
- The precipitation amount for the ARDSA growing season extreme design storm is projected to increase by about 20%, although in any given year it could increase by 40% or more.
- The precipitation amount for the ARDSA dormant season extreme design storm is projected to increase by about 10%, although in any given year it could increase by 20% or more.
- Considerably more precipitation (about 20%) is expected to fall during extremely wet days (1-in-20 wettest day) in the future. Expressed differently, extremely wet days that used to occur once every 20 years are projected to occur once every 10 years.
- The wettest periods in the region are projected to become even wetter (by about 35%), and the wettest days of the year are projected to occur more closely together.

Given these projections, and with parts of the region already not meeting the ARDSA criteria (KWL, 2017), the **probability of increased crop losses and localized flooding is likely to rise** without incremental intervention and investment in improved drainage management and infrastructure.

Preferred drainage management strategies

Deliberation amongst participants of the Forum workshop revealed broad support and preference for pursuing producer-led drainage area management planning; and improving drainage management and maintenance knowledge and capacity. Potential action items arising from the Forum include:

Action 1. Pilot development of drainage area management planning

Action 1a: Create producer-led agricultural drainage planning group.

Action 1b: Inventory, characterize and assess a pilot drainage area including identification of drainage (and irrigation) enhancement opportunities.

Action 1c: Pilot a multi-stakeholder, multi-objective drainage area planning process, with the intention of embedding individual actions within a broader plan and securing funding for upgrades.

Action 2: Improve drainage management and maintenance knowledge and capacity

Action 2a: Establish an online, map-based decision support tool to support watercourse permit applications and the selection and application of watercourse management and maintenance Best Management Practices.

Action 2b: Increase the professional support available to producers through improved access to qualified professionals (create new training opportunities and prequalification and promotion options for trained individuals).

Action 2c: Improve knowledge transfer to producers, potentially through a liaison role, via workshops, field days and streamlined information for/to producers.

Several agency staff felt that updating watercourse classifications within current operations could be pursued as an early Forum outcome. Depending on upcoming programming and budget decisions, there may be an opportunity for the Climate Action Initiative to work with local partners in the Fraser Valley to advance next steps on select preferred strategies.

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1 INTRODUCTION

1.1 Project Motivation

In the Fraser Valley, climate change is projected to result in a significant increase in annual precipitation with much of this falling as rain (and less as snow) during the winter, spring and autumn. Rain will also be concentrated in more frequent and intense precipitation events, resulting in greater challenges with managing runoff (both onto and off) the predominantly low-lying agricultural land base.

Beginning in 2014, the Fraser Valley Adaptation Strategies planning process brought together agricultural producers and local and provincial government partners to evaluate climate change impacts on local agricultural production, and to develop strategies and actions to address the associated challenges. With respect to agricultural drainage, actions to "develop a coordinated cross-agency approach to agricultural ditch and drainage management" and "identify, pilot & evaluate mechanisms to reduce runoff onto and off agricultural lands" were prioritized. (CAI, 2015)

As a first collaborative step to implement these actions, the Enhanced Collaboration for Drainage & Ditch Management project, completed in Spring 2017, identified a number of areas for further consideration and action. One of the most significant gaps identified was around planning for drainage systems that are adapted for a changing climate. The study noted that: "In many areas, the drainage system capacity has not been assessed for future climate scenarios. Therefore, regulatory and funding requirements to address climate change impacts are not well understood." (KWL, 2017)

Building forward from the previous work, this new project was initiated in the autumn of 2017 with the intention of generating and sharing the best available precipitation projections for the Fraser Valley. The project also includes a multi-jurisdictional scan because planning and managing for the potential changes in frequency and intensity of extreme precipitation is a challenge facing many jurisdictions. While the Fraser Valley will require its own locally suitable approaches, examples of innovative upland runoff and lowland drainage can help to inform "climate adaptive drainage."

The final element of the new project was a Forum – hosted in January of 2018 – to support a dialogue between producers, local government and key agency staff and other specialists about how the projected precipitation changes impact planning, decision-making, research and farm level management. The Forum was also intended to generate a sub-set of favoured potential projects or solutions to support improved drainage and runoff management.

1.2 Project Objectives

The *Fraser Valley Climate Adaptive Drainage Management Forum* ("Forum") project was initiated to:

1 Develop more specific and detailed indicators for projected precipitation changes;
2 Research collaborative climate adaptive drainage management strategies adopted in comparable settings; and,

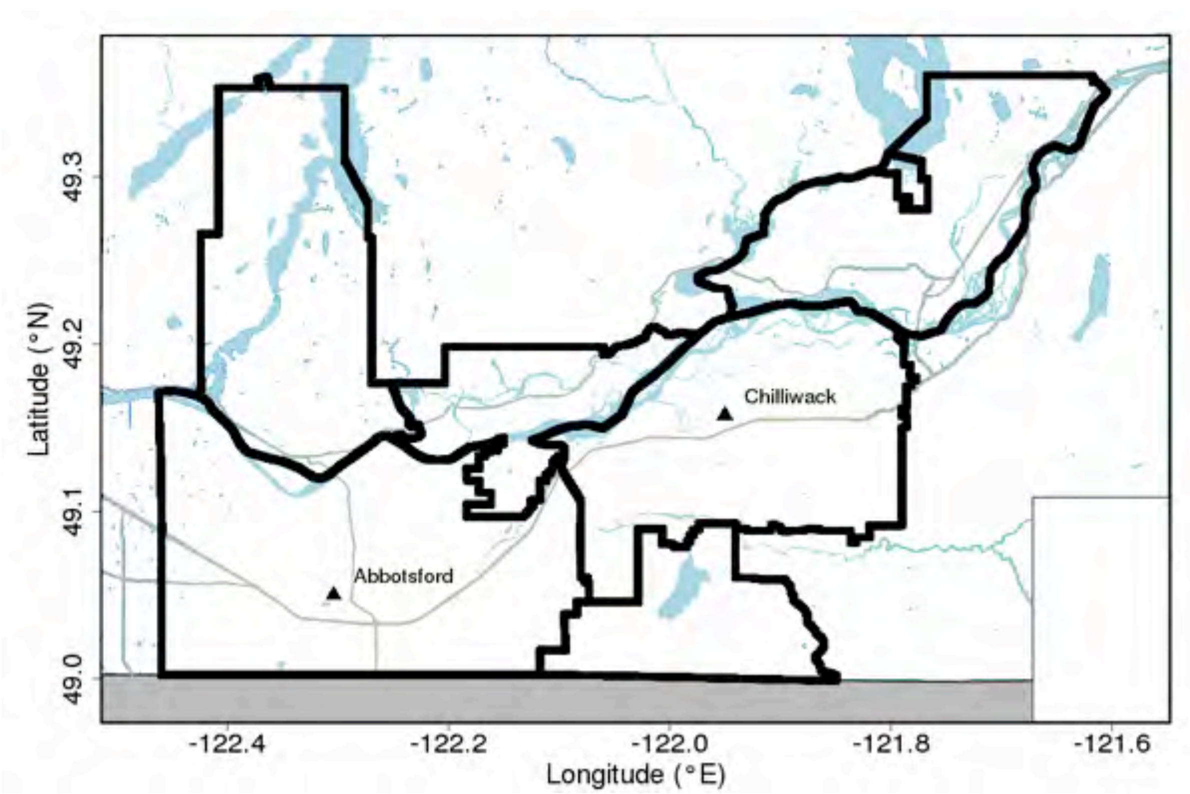
3 Host a Forum between producers, local government and agency staff, researchers and agricultural association representatives to discuss the implications of increased precipitation for agricultural drainage in the Fraser Valley, and to deliberate preferred feasible and effective strategies to advance in the region.

1.3 Project Methods

1.3.1 Precipitation Projections

The Pacific Climate Impacts Consortium (PCIC) developed updated climate/precipitation projections for the Fraser Valley using standard, well-established analytical methods and models that have been used for other BC jurisdictions such as Metro Vancouver. The study area (Figure 1), established by the Project Management Committee (PMC), includes the municipalities of Abbotsford and Chilliwack, the Districts of Mission and Kent, and Electoral Areas G (Nicomen Island/Deroche/Dewdney/Hatzic Island) and H (Cultus Lake/Columbia Valley/Lindell Beach) of the Fraser Valley Regional District (FVRD).

Figure 1 | Study Area (combined municipal areas outlined in black, thickened for emphasis)



1.3.2 Research Scan

The previously completed project – *Enhanced Collaboration for Drainage & Ditch Management* – engaged representatives of local governments, regulatory agencies, producers, and specialists to assess and summarize key issues facing runoff and drainage management in the Fraser Valley, as well as several management strategies for further consideration and action.

Using this earlier work as the basis for researching collaborative climate adaptive drainage management strategies for consideration at the Forum, interviews were conducted with knowledge experts identified by the PMC plus those discovered through the research itself. For some options, case studies were developed to highlight their benefits and outline implementation considerations learned from other jurisdictions. The results of Research Scan, including lists of interviewees, references and website resources, are provided as appendices to this report.

1.3.3 Forum Workshop

The Forum objectives and workshop design were developed in conjunction with the PMC. The objectives included:

- Establish a shared understanding of new precipitation projections to 2050 and their implications for drainage requirements in the Fraser Valley;
- Discuss and evaluate collaborative approaches for climate adaptive runoff and drainage management;
- Discuss early opportunities to advance preferred Climate Adaptive Drainage Management initiatives.

Thirty-one participants attended the event, including 10 producers (Dairy, Berry, Poultry, Vegetable and Nursery sectors); 6 Agency staff (BC Ministry of Agriculture and Ministry of Forests, Lands, Natural Resource Operations & Rural Development); 8 Local Government staff (Fraser Valley Regional District, District of Kent, City of Chilliwack, District of Mission, and City of Abbotsford); 4 NGO representatives (Stewardship Centre for BC, ARDCorp, Partnership for Water Sustainability in British Columbia, and Climate Action Initiative); and 4 Researchers/Consultants (UBC, Environmental Dynamics Ltd). A list of participants is provided in APPENDIX 1 Forum Participants.

The Forum included plenary presentations and discussion of the following topics:

- Agricultural drainage for multiple values – revisiting infrastructure requirements and funding - Ted van der Gulik, Partnership for Water Sustainability in British Columbia (PWSBC).
- Future climate information for agricultural drainage - Trevor Murdock, Pacific Climate Impacts Consortium (PCIC).
- Collaborative regional runoff and drainage management approaches in Whatcom County, Washington - Chris Elder, Planner, Whatcom County Agriculture Program.
- Updates to the Environmental Farm Plan (EFP) Drainage Management Guide - Jennifer Prive, Environmental Dynamics Inc.

Potential management strategies to address existing and future management challenges for the Fraser Valley were presented for discussion within small groups, and to inform a priority ranking exercise for individual participants. After identifying any important overlooked issues and strategies, participants assessed each strategy according to (1) Effectiveness, (2) Commonality (applicability across the region and to different sectors), and (3) Feasibility; and in terms of which strategies they would prefer to be implemented in the near and long term.

The Forum concluded with a brief discussion of the value of continued Forum-style workshops and potential next steps.

2 FRASER VALLEY RUNOFF AND DRAINAGE MANAGEMENT CHALLENGES

2.1 Existing Issues

The Fraser Valley is facing numerous management challenges (issues) with respect to maintaining and adapting agricultural drainage. These issues pertain to increasing physical runoff volumes and duration which will also exacerbate existing challenges with complex/lengthy regulatory processes and funding and knowledge gaps.

For the most part, higher runoff volume and duration is due to climate change and increased upstream development; lengthier and more complex regulatory processes are due to increasing habitat requirements and reduced capacity of regulatory agencies; funding gaps are as a result of increased infrastructure requirements coupled with declining government drainage financing programs; and knowledge gaps are attributable to insufficient and/or disparate knowledge and training resources available to producers and specialists supporting the sector.

2.2 Current agricultural drainage criteria

The agriculture drainage criteria established for BC is based on the Agricultural and Rural Development Subsidiary Agreement (ARDSA) criteria originally developed in the 1960/70s. The ARDSA criteria describe the level of drainage required to allow for good on-farm drainage while achieving a positive agronomic return on drainage investment. The criteria accepted some risk, since more stringent criteria would be too costly for projects to proceed. (van der Gulik, 2017a)

In terms of extreme precipitation events, the design storms were established as:

1. Remove the runoff from a 10-year, 5-day storm, within 5 days in the dormant period (November 1 to February 28);
2. Remove the runoff from a 10-year, 2-day storm, within 2 days in the growing period (March 1 to October 31).

In between storm events and in periods when drainage is required, the base flow in channels is to be maintained at 1.2 m below field elevation; and for both peak and base flows, the conveyance system must be sized appropriately.

Drainage remains one of the primary limiting criteria for agricultural production in the Fraser Valley. (van der Gulik 2017b) Effective drainage supports crop health and productivity as well as maintaining field trafficability. Regional drainage requires both adequate regional conveyance *and* effective on-farm drainage management.

However, several changing conditions and pressures are impacting the effectiveness of existing drainage infrastructure, including (van der Gulik, 2018):

- In some cases, farm level drainage systems may not be optimal for several reasons. In general, there is a lack of qualified drainage contractors (anecdotally only one in B.C.); installation costs of tile drainage are high; ongoing maintenance is required to maintain tile drainage function; challenges exist with on-going maintenance of constructed surface ditches due to species habitat requirements and delayed regulatory approvals; and cost-sharing/funding programs available to producers are limited/minimal.
- Local governments are not achieving the current level of ARDSA agriculture drainage criteria for several reasons including high capital costs; challenges with on-going maintenance due to species habitat requirements and delayed regulatory approvals; upland runoff, which was not originally considered within the ARDSA agricultural drainage criteria, is increasing lowland drainage burdens; and storm event rainfall amounts are significantly increasing due to climate change;
- Additional landscape and infrastructure values, which did not exist when the ARDSA agricultural drainage criteria were established, are adding to drainage requirements. This includes fish and other species habitat; housing developments; highways, roads and bridges; water and sewage lines; power transmission lines; and railroads.

2.3 Projected climate changes in the Fraser Valley

Several standard climate change indicators were chosen to characterize climate change effects on precipitation affecting Fraser Valley runoff and drainage management. Added to these were indicators based on the ARDSA criteria design storm events to better support Forum deliberations. Except for the devised ARDSA criteria, the definitions are largely based on those used in the *Climate Projections for Metro Vancouver* study. (Metro Vancouver, 2015)

Each of these indicators are computed using a set of 12 Global Climate Models (GCMs), based on the internationally recognized “business as usual” greenhouse gas emissions scenario (Representative Concentration Pathway 8.5, or RCP8.5), and statistically downscaled to the ~10 km grid of the ANUSPLIN historical dataset (see https://pacificclimate.org/data/statistically-downscaled-climate-scenarios for more information on the GCMs, ANUSPLIN, and the BCCAQ statistical downscaling method). Further bias correction using the high-resolution (~800 m) climatology was performed to produce the maps of each indicator (see https://pacificclimate.org/data/high-resolution-prism-climatology for more information on PRISM). For a more in-depth description of climate modelling, see the Methodology section of the *Climate Projections for Metro Vancouver* study. (Metro Vancouver, 2015)

The resulting precipitation indicators and their baseline/predicted values are shown in Table 1 on page 7. Baseline (1971-2000) values correspond to the historical gridded (~10 km) values inside the Study Area outlined in Figure 1 on page 2. The 2050s change for the same area is based on the difference between the 2041-2070 average and the 1971-2000 baseline for each downscaled projection (following

RCP8.5 emissions). They are generally represented as % change from the baseline value, except for time values where units are expressed in absolute terms. Negative values mean that the change is downward, i.e. reduced in the future compared to the present.

The values are presented using the following convention:

22% (5 to 37%)

where the first value (in this example, 22%) is the average of all 12 runs over the 2041-2070 period. The values in brackets represent the 10th percentile (in this example, 5%) to 90th percentile (in this example, 37%) of results from the 12 runs over the 2041-2070 period. This range reflects both climate model uncertainty as well as natural variability. *It is prudent to plan for the full range of change in the 10th to 90th percentile, not just the mean change.*

The inclusion of the District of Mission was tested to see whether its greater proportion of high-elevation areas skewed the regional averages shown in in Table 1. This effect was not observed (Murdock, 2018).

The results for several indicators are also shown spatially across the Study Area. For example, Figure 2 shows the change in 1-in-20 wettest day storm events by the 2050s for the average of 12 GCMs (following RCP8.5 emissions). Per the indicator projections in Table 1, it represents a 22% increase in the intensity of the event over the entire Study Area outlined in black on the map. Additional spatial representations for select indicators are available in APPENDIX 2.

Figure 2 | Projected Change in 1-in-20 Wettest Day Precipitation by 2050s

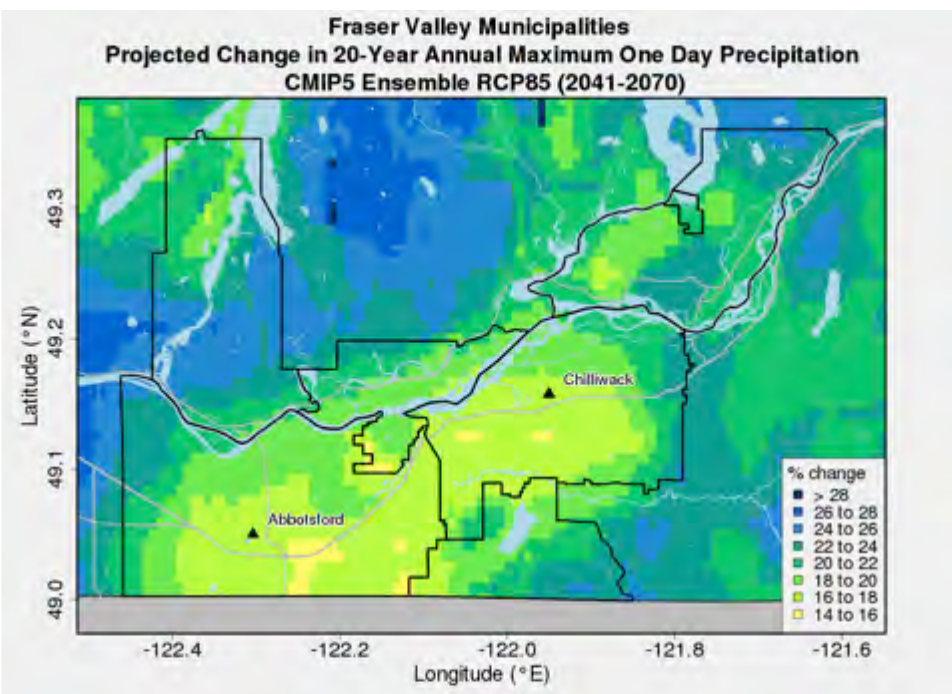


Table 1 | Climate change projections[1]

Indicator	Definition	Baseline value (1971-2000)	Projected change from baseline by 2050s	Interpretation
1-in-20 wettest day precipitation	A day so wet that it has only a one-in-twenty chance of occurring in a given year. That is, there is a 5% chance in any year that a one-day rainfall event of this magnitude will occur. This indicator points to what we can expect in terms of extreme one-day precipitation events in the region.	114 mm	**22**% (5 to 37%)	Considerably more precipitation (about 20% on average) is expected to fall during the 1-in-20 extreme one-day precipitation events in the future.
	The 1-in-20 wettest day can be expressed as a *Return Interval*, which indicates how frequently the Baseline 1-in-20 wettest day precipitation amount (114 mm) is projected to occur.	20 years	**10** years (4 to 19 years)	Extremely wet days (1-in-20 wettest day) that used to occur once every 20 years are projected to occur about twice as often by the 2050s.
Growing season storm	Corresponds to the ARDSA growing season extreme design storm. This describes the amount of precipitation that falls within a 2-day storm event, during the period Mar 1 to Oct 31, that has a 1-in-10 chance per year of occurring.	91 mm	**18**% (-1 to 44%)	The precipitation amount for the ARDSA growing season extreme design storm is projected to increase by about 20% on average, although in any given year it could increase by 40% or more.

[1] All values averaged over the 12 climate model runs for the RCP 8.5 emission scenario.

Indicator	Definition		Baseline value (1971-2000)	Projected change from baseline by 2050s	Interpretation
Dormant season storm	Corresponds to the ARDSA dormant season extreme precipitation design storm. This describes the amount of precipitation that falls within a 5-day storm event, during the period Nov 1 to Feb 28, that has a 1-in-10 chance per year of occurring.		216 mm	**10** (-2 to 23) %	The precipitation amount for the ARDSA dormant season extreme design storm is projected to increase by about 10% on average, although in any given year it could increase by 20% or more.
Total precipitation	All precipitation summed over a season or year, including rain and snow water equivalent. This is a high-level indicator of how precipitation patterns are projected to change. Seasons are defined as Winter (December-February), Spring (March-May), Summer (June-August) and Fall (September-November).				Projections indicate that the Fraser Valley will experience an increase in total annual precipitation of a modest 5% by the 2050s. While this is a relatively small difference from the past, the increase will be distributed unevenly over the seasons. While most rain will continue to fall over the winter months, the largest percentage increase in rainfall will occur in the Spring and Fall (about 10% more by the 2050s). Summer, already the region's driest season, will experience a decline of about 20% by the 2050s. While the models indicate a range of possible change, they mostly agree about the direction of change for each season.
		Winter(DJF)	663 mm	**5**% (-3 to 12%)	
		Spring(MAM)	423 mm	**9**% (-4 to 19%)	
		Summer(JJA)	223 mm	**-19**% (-40 to 1%)	
		Fall(SON)	556 mm	**11**% (-2 to 26%)	
		Annual	1888 mm	**5**% (-1 to 10%)	

Indicator	Definition	Baseline value (1971-2000)	Projected change from baseline by 2050s	Interpretation
Single-day maximum precipitation	Describes the largest amount of rain that falls on any single day in the year. This value is used to understand how extreme precipitation will change over time. Results are summed for each season and year.			Despite the slight increase noted above in total annual precipitation by the 2050s, the increases are projected to be more concentrated within the wettest days in the Fall, Spring and Winter seasons.
	Winter(DJF)	58 mm	**15**% (2 to 31%)	
	Spring(MAM)	38 mm	**16**% (-1 to 33%)	
	Summer(JJA)	32 mm	**-1**% (-24 to 24%)	
	Fall(SON)	59 mm	**19**% (-3 to 52%)	
	Annual	72 mm	**18**% (6 to 34%)	
Five-day maximum precipitation	Describes the largest amount of rain that falls over a period of 5 consecutive days in the year. Results are summed for each season and year.			Like the single-day maximum precipitation, increases are projected to be more concentrated within the wettest days in the Fall, Spring and Winter.
	Winter(DJF)	136 mm	**9**% (3 to 24%)	
	Spring(MAM)	87 mm	**12**% (-3 to 23%)	
	Summer(JJA)	63 mm	**-3**% (-25 to 21%)	
	Fall(SON)	135 mm	**15**% (-3 to 40%)	
	Annual	161 mm	**14**% (6 to 27%)	

Indicator	Definition	Baseline value (1971-2000)	Projected change from baseline by 2050s	Interpretation
Precipitation during wet days	Total annual precipitation that occurs on *days that are wetter than 95% of days on which precipitation occurs* ("R95p wet days").	406 mm	**34**% (3 to 64%)	The wettest periods in the region are projected to become even wetter. The wettest days that exceed the baseline 95th percentile threshold will produce about a third more rain by the 2050s.
Annual wet days within 5 days	The number of times per given year that *R95p wet days* occur within 5 days of each other.	4 times	**6** times (4 to 7 times)	The wettest days of the year are projected to occur close together more frequently
Dormant season - duration between wet days	The average duration between *R95p wet days* within the ARDSA dormant season (Nov 1 to Feb 28).	25 days	**20** days (17 to 23 days)	The wettest days of the ARDSA dormant season are projected to occur more closely together.
Dry spell duration	Number of consecutive days with daily precipitation is less than 1 mm. The value denotes the longest stretch of dry days in a year, typically in summer. This number does not indicate extreme droughts, as it is averaged over the 30-year period	20 days	**25** days (22 to 29 days)	Dry spells are expected to increase in length by about 25% by the 2050s.
Growing season length	An annual measure that counts the number of days between the first span of at least 6 days with a daily average temperature greater than 5°C, and first span after July 1 of 6 days with a temperature less than 5°C. It indicates the length of the growing season for typical plants or crops in our region.	272 days	**324** days (310 to 329 days)	In the past, the Fraser Valley had an average of 272 days in the growing season. By the 2050s, about 50 days will be added, resulting in an almost year-round growing season (roughly 90% of the year on average).

Indicator	Definition	Baseline value (1971-2000)	Projected change from baseline by 2050s	Interpretation
Growing degree days	A measure of heat accumulation that is useful for agriculture and horticulture. Growing degree days are calculated in this region by how much warmer daily temperatures are compared to a base temperature of 5°C (although different base temperatures may be useful for different crops). For example, if a day had an average temperature of 11°C, that day would have a value of 6 growing degree days. Annual growing degree days are accumulated this way for each day of the year and then summed. This measure is a useful indicator of opportunities for agriculture, as well as the potential for invasive species to thrive.	1957 degree-days	**2857** degree-days (2446 to 3229 degree-days)	Growing degree days are projected to significantly increase by the 2050s, rising by about 50% on average.
Frost days	Represents the annual count of days with a night-time low temperature below 0°C.	60 days	**24** days (14 to 39 days)	Future projections indicate conditions where the "new normal" would be a regional climate that is almost entirely frost-free. The number of frost fee days in the region is projected to decline from 60 days on average to about 25 days by the 2050s.

2.4 Implications of climate change for drainage management

The climate projections indicate that **changes in Fraser Valley precipitation patterns will considerably increase the agricultural drainage burden**. Compared to past climate (1971 – 2000) in the region, average values for the following precipitation indicators are projected to increase by ~2050 as follows:

- Compared to the rest of the year, increases in total precipitation and maximum storm precipitation amounts will be largest during Spring (March, April, May) and Fall (September, October, December) when field trafficability is particularly important.
- The precipitation amount for the ARDSA growing season extreme design storm is projected to increase by about 20%, although in any given year it could increase by 40% or more.
- The precipitation amount for the ARDSA dormant season extreme design storm is projected to increase by about 10%, although in any given year it could increase by 20% or more.
- Considerably more precipitation (about 20%) is expected to fall during extremely wet days (1-in-20 wettest day) in the future. Extremely wet days that used to occur once every 20 years are projected to occur once every 10 years.
- The wettest periods in the region are projected to become even wetter (by about 35%), and the wettest days of the year are projected to occur more closely together.

Given these projections, and with parts of the region already not meeting the ARDSA criteria (KWL, 2017), the **probability of increased crop losses and localized flooding is likely to rise** without incremental intervention and investment in improved drainage management and infrastructure.

3 CLIMATE ADAPTIVE DRAINAGE MANAGEMENT – POTENTIAL COLLABORATIVE STRATEGIES

3.1 Whatcom County – An Illustrative Example

The Research Scan highlights several case studies of jurisdictions outside of the Fraser Valley that have pursued various planning approaches, practices and technologies to address runoff and drainage management challenges in the face of climate change. Of these, Whatcom County, located just south of the Fraser Valley in the State of Washington, offers the most illustrative example of how collaborative strategies can help to address drainage management challenges associated with climate change, endangered species, and upland development. See APPENDIX 2 for the remaining case studies.

To meet such challenges Whatcom farmers and government agencies established several collaborative entities and initiatives to proactively assess, plan, and implement Drainage Management Plans (DMPs). Stakeholders participate through several coordinating bodies, including the *Whatcom Conservation District* and *Watershed Improvement Districts*.

Established in 1948, the Whatcom Conservation District is a non-regulatory agency that offers free farm planning services to providers and acts as a liaison between producers, improvement districts, and various levels of governments and agencies. It has several valuable resources that producers and drainage contractors can access.

Watershed Improvement Districts, founded under Washington State law, are "farmer-led" district bodies that represent the needs of the agriculture community. A WID is a type of special purpose district, governed by landowners, that is apart from any city or county, with its own governance (producer Boards), staff and assessment authority. While WIDs are legally organized as an "irrigation" district under Washington state law, they have statutory authority to work on a variety of issues – including water supply, water quality, drainage, and habitat restoration. (SVPA, 2015)

Addressing drainage on a systematic basis, rather than parcel by parcel, was one of the key reasons WIDs were formed. A WID addresses drainage by working with agency partners to evaluate drainage problems, design solutions, and identify funding sources as part of developing and implementing DMPs (see below). In addition, the WID approach allows for the management of species habitat in ways that can fit with agricultural drainage needs and permits solutions in response to distinct farming types in different areas. (Elder, 2018)

The WIDs are additionally organized together into the Ag Water Board [sic] with the goals of:

- jointly cooperating on organizational, administrative, legal, engineering, and other services for all WIDs in a manner that provides cost savings and efficiencies;
- representing the collective interests of the WIDs in project and policy efforts with other interests and agencies;
- ensuring transparency and accountability in the operation of WIDs by establishing uniform procedures, education, and training opportunities for WIDs.

Each of the six Whatcom County WIDs has developed a **Drainage Management Plan** (DMP) to achieve (Boggs, 2009):

- Better knowledge of drainage system infrastructure based on reach by reach assessments.
- Easier permitting using agreed upon Best Management Practices (BMPs).
- Certainty of permit requirements based upon watercourse classification.
- Cost savings from using new or different drainage management techniques.
- Easier budgeting once maintenance needs are assessed.
- Potential for funding once enhanced drainage opportunities are identified and prioritized.
- Directing five-year workplans.

The DMPs were developed collaboratively between local WIDs/landowners, conservation districts, local government and state agencies and regulators. Included in the DMP planning process are the following steps (Boggs, 2009):

Step 1 - Prepare a general overview of the drainage basin
Step 2 - Map and classify watercourses
Step 3 - Inventory and map other infrastructure

Step 4 - Map significant natural resources
Step 5 - Identify maintained watercourses and divide into reaches
Step 6 - Schedule drainage maintenance work by reach
Step 7 - Adopt Best Management Practices
Step 8 - Identify habitat improvement projects and set goals
Step 9 - Adopt monitoring, reporting and Adaptive Management Plans

An approved DMP, when combined with appropriate permit applications, results in a "shovel ready" five-year work plan. A guide for developing DMPs and a list of completed plans is available online at: http://www.whatcomcd.org/sites/default/files/publications/dmg/DMG_Final.pdf

Several management strategies employed in developing and implementing the Whatcom DMPs are readily transferrable to the Fraser Valley. They include:

Long-term / area-wide permitting. As within the Fraser Valley, the regulatory process to apply and receive ditch maintenance approvals is considerably complex due to the existence of multiple management objectives amongst different regulatory agencies. To increase the efficiency and timeliness of ditch maintenance permitting, the DMPs implement longer term (5-year) and/or area-wide permitting plans in collaboration with regulatory agencies (Elder, 2017). This reduces individual permitting efforts for producers, local governments and regulators alike.

Regional opportunity assessments. One of the first steps in developing a DMP is to conduct a region wide assessment of drainage enhancement opportunities in a systematic way. Local and on-farm level action can then be focused within the context of a larger scale plan; and the larger scale plan can help to identify priorities and potential funding for rewarding local and on-farm projects. While the process has shown exciting potential to assist in management of runoff and drainage, it requires increased outreach and communication with the producers to achieve full benefits. (Elder, 2017)

Standardized management prescriptions by watercourse. Like watercourse classifications in BC, watercourses have been identified and classified under a regional scheme. The classifications include *constructed*, *modified* and *natural* watercourse. Each classification has predetermined activities and BMPs prescribed to them (Figure 3). To ensure that the benefits of the classification system are realised extensive outreach is needed with producers so that they understand activities associated with the classification system. (Elder, 2017)

Figure 3: Example Water Course Classification Mapping

Cost-sharing arrangements. Several financing strategies have been adopted to encourage habitat protection and BMPs by landowners. Strategies include sharing costs between neighbouring landowners that are managing/protecting the same waterway and a leasing model whereby producers who convert farmland to riparian buffers receive long-term (15-year term, renewable to 30-years) government lease payments to offset capital and maintenance costs and any associated loss of farm revenues.

Extension initiatives to improve BMPs. Whatcom County has undertaken several studies in conjunction with universities to examine BMPs for enhancing watershed function at the agricultural level. In one study, they found that narrow (5'to 15' wide) densely planted riparian buffers are as effective as wider (35'-180' wide) buffers with respect to reducing air temperature and creating shade. Experiments were conducted to identify which riparian plant types were most appropriate for different conditions and help to reduce weeds and pests (Benedict et al., 2012).

Knowledge Transfer – Online Tools. The Ag Water Board has implemented an online "story map" that serves as an effective tool for "giving farmers a voice" and sharing agriculture and watershed knowledge and project activities with farmers, regulators and the public. It is available online at: http://www.agwaterboard.com/storymap

3.2 Potential Strategies for the Fraser Valley

Table 2 provides a succinct list of collaborative management strategies (options) that were identified through research and Forum deliberation as potentially useful to address the Fraser Valley drainage management challenges. Note that the list is not considered exhaustive; its purpose was to distill the most relevant approaches into a list suitable for discussion at the Forum.

Forum participants evaluated these strategies as part of group discussion and individual ranking. Those strategies that generally ranked higher in terms of effectiveness, feasibility, and commonality; and were favoured to begin in the near term (in several cases, likely due to being easier and faster to achieve) and/or to be pursued over the long term (in several cases, likely due being more complex/harder to achieve yet still beneficial enough to be worth the additional effort) are highlighted in **green** in Table 2. In addition, a few strategies generally ranked near the bottom because of perceived limited application/benefit across the region – these are highlighted in **red**.

Group discussion identified some additional concerns and/or potential strategies that are not shown in this list. These include:

- Collaborating with local First Nations;
- Irrigation and water quality requirements are also important considerations for coordinated water basin management and planning; and
- Investigating potential solutions for farms on leased land where investment in subsurface tile drainage is complicated by the ownership/leasing structure.

Table 2 | Potential Collaborative Runoff and Drainage Management Strategies[2]

Category	Issue	Potential Collaborative Strategy
Coordinated Management and Planning	Lack of communication and coordination between government agencies, First Nations, and agricultural stakeholders.	**Implement / rejuvenate producer-led agricultural water management councils** to give producers a voice, offer training and cost-sharing services, and find collaborative solutions.
		Conduct a region-wide assessment of collaboration opportunities to identify primary management options at a landscape level. The assessment could include advising on the suitability of different soil and hydrological profiles to support certain crop types versus others, as well as identify projects that could serve overall drainage basin objectives with corresponding funding opportunities.
	Expanding objectives, requirements and uses/beneficiaries of drainage networks.	**Pilot a multi-stakeholder, multi-objective drainage basin planning process** with representation from producer associations, relevant agencies, First Nations, regional and local governments, and related interests. Planning would need to consider both urban and rural activities on water management schemes.
	Permitting and maintenance is delayed and/or difficult to conduct when critical habitat associated with species at risk and biodiversity are associated with a watercourse. In some cases, the species requirements are not well understood or defined.	**Classify watercourses by habitat requirements and prescribed management activities**. Update landscape level surveys to determine the most suitable and effective activities that can be applied at the farm level to help with runoff and drainage. In Whatcom County, agreements on maps have helped to increase the level of management certainty for all parties. (Elder 2017)

[2] Strategies highlighted in green were generally ranked higher by Forum participants in terms of effectiveness, feasibility, and commonality, and were favoured to begin in the near term and/or to be pursued over the long term. Strategies highlighted in red were generally ranked near the bottom.

Category	Issue	Potential Collaborative Strategy
	Lack of clarity and agreement regarding suitability of existing ARDSA criteria in a changing climate and for different crop types over time.	**Revisit and update agricultural drainage criteria** considering the full suite of uses and values at risk, risk tolerance and funding availability, and evolving crop types. Given the greater volumes of upland and on-farm runoff anticipated with climate change, the increased costs of drainage infrastructure and changing agronomics and economics for agriculture, and evolving and widening risk tolerance across the region, a review of criteria with updated risk assessment and cost-benefit analysis is likely warranted.
	Differing and/or uncertain application level of design criteria across the region; increasing need for summer irrigation due to climate change; increasing water quality objectives.	**Conduct a region-wide assessment of drainage/water management requirements and gaps.**
Infrastructure Requirements	Undersized agriculture drainage capacity to meet increased volume and duration of water flows arising from increasing extreme rainfall events and additional upland stormwater contributions.	**Increase watercourse, culvert, pump and/or flood box capacities.**
		Reduce duration and peak volume of urban stormwater inflows by minimizing impervious areas in the watershed and improving watershed hydrologic function through retention and infiltration of rainwater.
		Investigate the return on investment (ROI) of controlled tile drainage to reduce peak runoff into conveyance systems; reduce drainage conveyance maintenance, improve groundwater levels in droughts and improve nutrient retention.

Category	Issue	Potential Collaborative Strategy
		Investigate the ROI and funding opportunities of retention ponds in low lying areas where excess water can infiltrate groundwater or otherwise delay release into the conveyance network. Retention ponds additionally reduce sediment runoff which when captured can be periodically harvested. A major consideration is the opportunity cost associated with alienating productive crop land. High land values in the Fraser Valley may reduce the economic return of this strategy to unacceptable values (Lapen, 2017). They are currently being piloted in agricultural areas within Whatcom County.
Operation & Maintenance	Complex regulatory processes preventing or delaying drainage maintenance.	**Increase the adoption of multi-year, area-wide permitting to improve timeliness and efficiency of permit applications and approvals.** Efficiencies benefit all parties involved, including producers, local governments, and regulators. Examples exist in Abbotsford, Chilliwack, and the District of Kent (Barrett, 2017).
	Lack of local and experienced Qualified Environmental Professionals (QEP) and drainage contractors.	**Investigate incentives to increase the number of locally knowledgeable QEPs** (Qualified Environmental Professionals)

Category	Issue	Potential Collaborative Strategy
	Unrealized use of on-farm drainage best management practices (BMPs) to minimize watercourse capacity and maintenance requirements	**Investigate the synergistic effects and ROI of on-farm BMPs**, including: • Enhancing soil organic matter to improve water holding capacity and improve winter water dynamics for infiltration and retention. Soil which has more organic content to retain water longer, as well as provide associated benefits including nutrient cycling and carbon storage (Smukler, 2017). • Maintaining bank and forest vegetation to slow or reduce runoff and reduce ditch maintenance. Additional potential agronomic and ecological benefits can include maintaining bank stability and water quality, shading water and providing habitat for fish and aquatic species, controlling sediment, nutrient, and bank erosion, and shading out Reed canary grass. Potential disadvantages include attract or encouraging noxious weeds and pests such as insects, birds, rodents, ungulates and predators such as coyotes. • Use of buffers and berms or raised ground between watercourse banks and crop lands. This helps to reduce sediment losses and decrease the amount of ditch maintenance needed. It also improves infiltration and has added benefits to the environment. • Seasonal crop cover, including grasses, clover and herbaceous plants, in rainy and windy seasons to reduce unprotected soils and enhance soil organic matter. It reduces the need for ditch maintenance as well as improves infiltration and holding capacity of water in soils (Bradbeer, 2012).
Financing and Affordability	Financing of infrastructure upgrades.	**Investigate new or expanded local government drainage financing**, including utility models, local area service taxes, user fees, development cost charges (DCC), habitat leases and insurance sector investment.
		Investigate potential infrastructure improvement grants from federal and provincial governments and municipal associations.
		Educate local councillors, MLAs and MPs and public about the importance of adequate and effective Agricultural drainage;

Category	Issue	Potential Collaborative Strategy
	Feasibility and affordability of on-farm investments.	**Investigate the addition or expansion of drainage management cost sharing services** for on-farm runoff and drainage design, installation, and maintenance. This could be associated with producer-led agricultural water management councils.
		Investigate potential grants for regional and on-farm improvements and adaptations to climate change, e.g. Farmland Advantage, FRISP, and IAFBC.
Knowledge Transfer	Ineffective or hard to access education materials regarding drainage requirements, regulations, and best management practices.	**Compile relevant research and information resources**, including knowledge held by retiring/retired agency staff.
		Develop an on-line drainage management decision support tool to help inform and determine required and/or cost-effective BMPs at the farm level. This could include map-based inventories and communication.
		Modernize web and print materials, including delivery in multiple languages.
	Inefficient or insufficient working relationships between regulators and ditch maintenance authorities, contractors and/or producers.	**Investigate the creation of a drainage management liaison role** to assist producers with design and maintenance of surface and subsurface drainage. The position could be associated with existing producer associations with financial assistance from government.
		Increase the availability and knowledge of drainage contractors, especially given their intermediary role between authorities and clients. As a key knowledge group dealing with ditch and drainage maintenance, drainage contractors could be targeted for additional training on issues such as species at risk and tile maintenance.
		Increase stakeholder collaboration through regular workshops.

4 ADVANCING FRASER VALLEY CLIMATE ADAPTIVE DRAINAGE MANAGEMENT

4.1 Potential Action Projects

The strategies that were preferred by Forum participants are mainly related to Coordinated Management and Planning, Financing, and Knowledge Transfer. In group discussion it was generally recognized that many of the preferred strategies are inter-dependent and/or would likely be best pursued as a suite of step-wise strategies. For example, securing government financing would likely first require, or be more successful with, a clear assessment and plan that justifies investment in drainage infrastructure. As such, first efforts could begin with Action Projects focused on Coordinated Management and Planning and Knowledge Transfer strategies.

4.1.1 Coordinated Management and Planning

Based on the supported strategies, pilot planning actions could proceed in a step-wise fashion to result in a Drainage Management Plan that, when combined with appropriate permit applications, results in a "shovel ready" five-year work plan.

Action 1a: **Create a producer-led agricultural drainage planning group**. Like the Whatcom County WIDs, for a pilot drainage basin (area) where agriculture remains a/the dominant land use, producers could lead the development of planning group that represents the needs of the agriculture community.

Action 1b: **Inventory, characterize and assess a pilot drainage area.** Under the direction of the agriculture planning group, prepare an overview of the pilot drainage area, including irrigation; map and classify watercourses by habitat requirements and prescribed management activities; inventory and map other infrastructure and drainage users/uses; map significant natural resources and habitats; identify maintained watercourses and divide into reaches; identify relevant planning and management legislation and regulations; identify planning stakeholders; audit the application and suitability of existing agricultural drainage criteria; conduct hydrological modelling of drainage flow volumes and rates for existing and future climate change scenarios; and investigate funding opportunities and requirements.

Action 1c: **Pilot a Drainage Management Plan planning process for the pilot drainage area**. With representation from the agriculture planning group, First Nations and local government, and supported by input from regulatory staff, establish a pilot DMP planning process for the pilot drainage area. Planning could identify drainage infrastructure investment priorities; collaborative project opportunities to incrementally improve on-farm drainage and irrigation, conveyance networks, and habitat condition; outline Best Management Practices by reach; schedule drainage maintenance work by reach; and outline monitoring, reporting and adaptive management procedures.

4.1.2 Drainage Management Knowledge/Capacity

Several near-term actions could be pursued to improve the general level of understanding, knowledge and capacity for maintaining effective drainage in the Fraser Valley. These actions would be most effective if considered (and potentially undertaken) as a group. Particularly 2b and 2c would have greater value if undertaken consecutively or simultaneously. Action 2a requires further investigation as it may be very complex and challenging to develop a sufficiently accurate and supportive on-line tool and more producers from direct professional support and knowledge transfer (versus a digital tool).

Potential actions include:

Action 2a: **Establish an online, map-based decision support tool** to support watercourse permit applications and the selection and application of watercourse management and maintenance Best Management Practices.

Action 2b: **Increase the professional support available to producers through improved access to qualified professionals.** This could most effectively be accomplished by creating new training materials and opportunities for individuals to become trained in agricultural drainage management. This would require general agreement of the level of qualification required and then development and delivery of suitable training support. Individuals could be encouraged/incentivized to seek training through a chance to become part of prequalification lists and possibly more direction promotion with producers to seek out those with the proper training/qualification.

Action 2c: **Improve knowledge transfer to producers, potentially through a liaison role, via workshops, field days and streamlined information for/to producers.** Several different types of knowledge transfer supports could be made available to assist producers with drainage management planning and decisions. This information could span the regulatory context through the best management practices. This could include a series of field days or workshops – more direct and “hands-on” knowledge transfer – as well as new fact sheets or streamlined written materials. There is also strong interest in a funded “field person” to provide drainage management extension or decision support to producers.

4.2 Early Opportunities

Several agency staff felt that updating the watercourse classifications within current operations could be pursued as an early Forum outcome.

Emily MacNair of the BC Agriculture & Food Climate Action Initiative indicated that, depending on upcoming budget decisions, there may be an opportunity for CAI to work with local partners in the Fraser Valley to support drainage basin planning and coordination and/or knowledge transfer initiatives.

95% of the Forum participants indicated that they would be interested in participating in ongoing dialogue, whether through an annual workshop or potentially through project working groups.

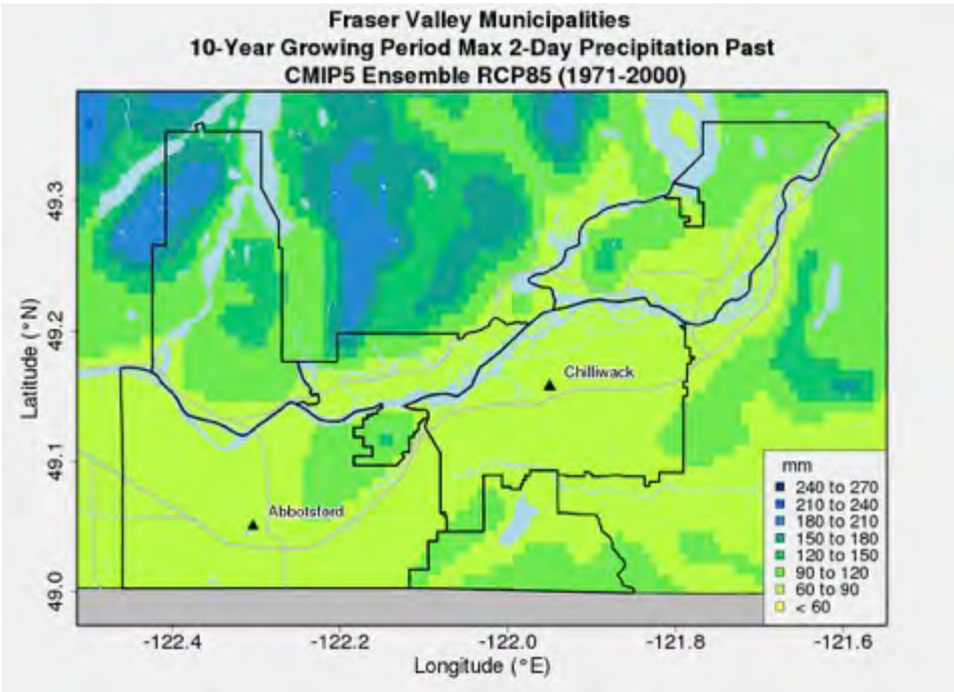
APPENDIX 1 FORUM PARTICIPANTS

Name	Organization
Alison Stewart	Manager of Strategic Planning, Fraser Valley Regional District
Allen James	Sweetbriar Poultry Farm, Chilliwack | BC Agriculture Council and BC Poultry Association Board Member | CAI Chair
Bronwen Welch	Planning & Development Services, District of Kent
Darrell Zbeetnoff	Biologist, Environmental Dynamics Inc.
Dave Dyck	Odessa Farm, Chilliwack
Dave Maljaars	Berry Bounty Farms, Chilliwack | Raspberry Industry Development Council
David Trotter	Agroforesty Specialist, Sector Development Branch, Ministry of Agriculture
DG Blair	Executive Director, Stewardship Centre for BC
Dr. Sean Smukler	Assistant Professor, Applied Biology & Soil Science, Faculty of Land and Food Systems, UBC
Duane Post	Woodside Farms, Kent | Agassiz-Harrison Mills Drainage Committee | Councillor, District of Kent
Emily MacNair	Manager, Adaptation Programming, Climate Action Initiative
Frank Keis	Member, Abbotsford Dyking, Drainage and Irrigation Advisory Committee (ADDIAC)
Frank Van Nynatten	Assistant Manager of Environmental Services, City of Chilliwack
Geoff Hughes-Games	Program Manager, Environmental Farm Plan, ARDCorp
Hirod Gill	Manager of Engineering Planning and Design, District of Mission
Holger Schwichtenberg	Holberg Farm, Kent | BC Dairy Association and Mainland Milk Producers | CAI Board Member
Jacquelyn Shrimer	Authorizations Specialist, Resource Authorizations - South Coast, BC Forests, Lands, Natural Resources and Rural Development (FLNRORD)
Jason Smith	Fraser Berry Farms, Matsqui Prairie | PIER Management and Consulting| BC Blueberry Council |CAI Board Member
Jennifer Prive	Senior Biologist, Environmental Dynamics Inc.
Kendra Morgan	Ecosystems Biologist, Fish and Aquatic Wildlife Resources, Resource Management - South Coast, FLNRORD
Kim Sutherland	Regional Agrologist, Fraser Valley East, Ministry of Agriculture

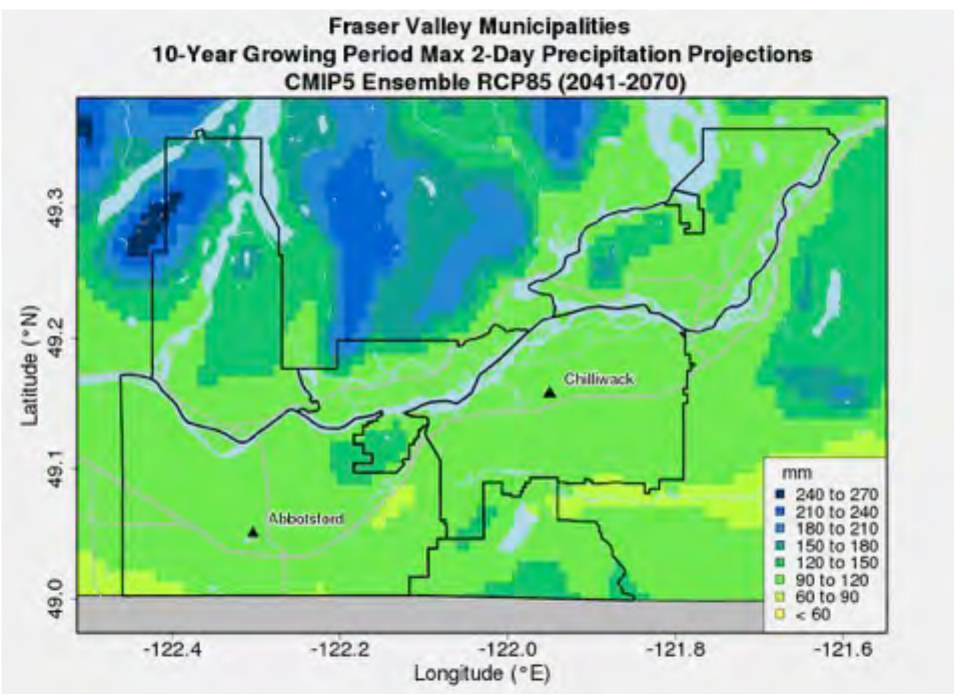
Name	Organization
Kyle St Amour	Drainage Technician, Engineering Department, City of Chilliwack
Len Smit	Kato's Nursery, Abbotsford | BC Landscape and Nursery Association
Matthew Connolly	Environmental and Engineering Services Coordinator, District of Kent
Naomi Sands	Biologist, Environmental Dynamics Inc.
Peter Reus	Van Eekelen Farms, Abbotsford
Rhys Francis	Engineering Technologist, City of Abbotsford
Stephanie Tam	Water Management Engineer, Drainage, Ministry of Agriculture
Tareq Islam	Director of Engineering & Community Services, Fraser Valley Regional District
Ted Dejong	Rose Gate Farm, Abbotsford
Ted van der Gulik	President, Partnership for Water Sustainability in BC

APPENDIX 2 CLIMATE CHANGE PROJECTION FIGURES

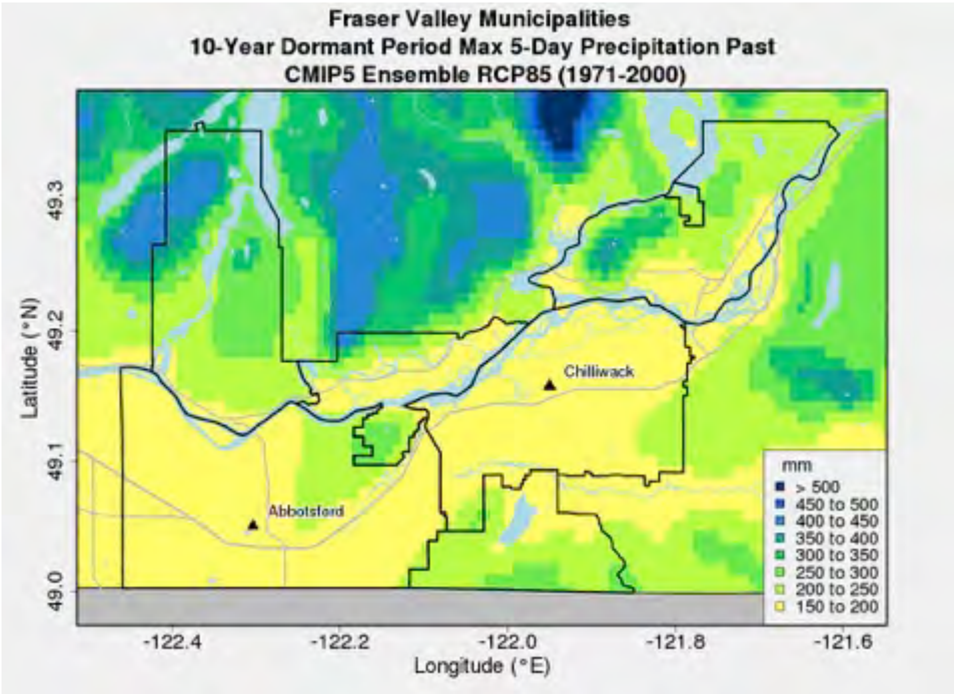
Growing Season Storm – Baseline Reference



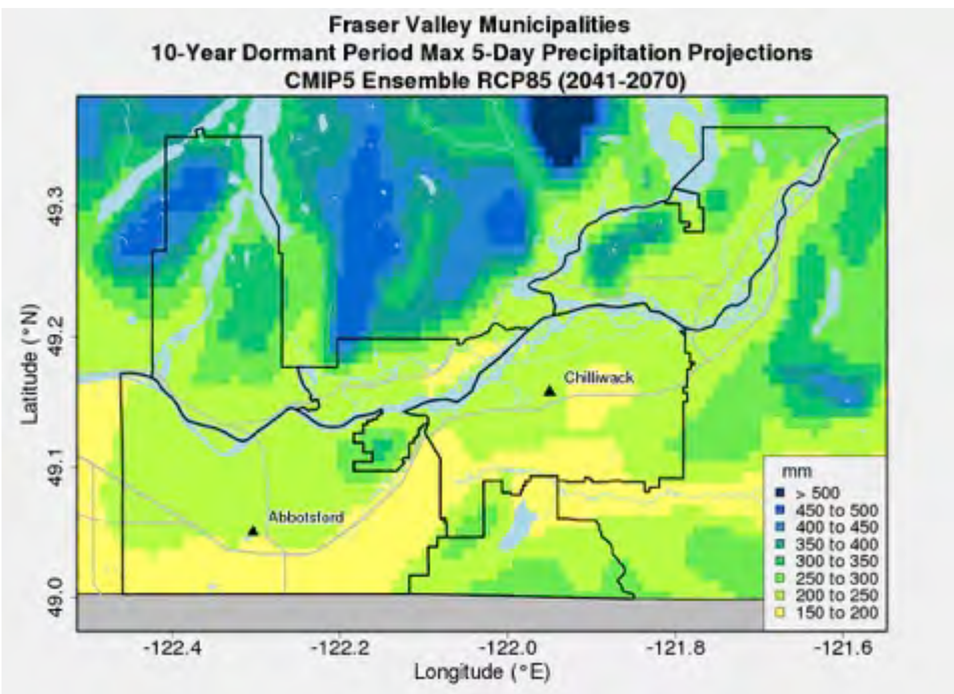
Growing Season Storm – Projected Values by 2050s



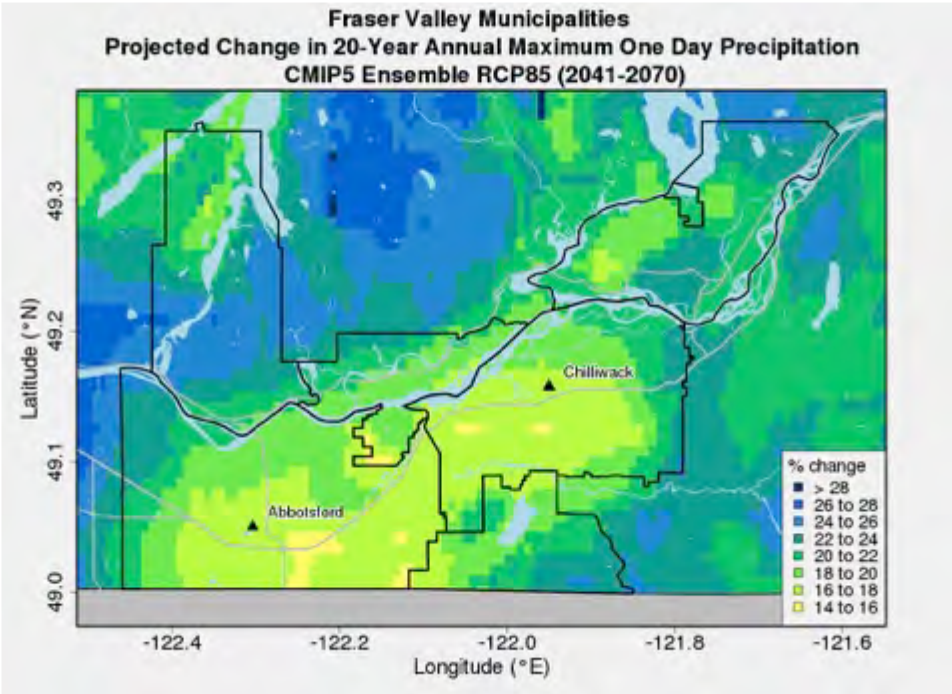
Dormant Season Storm - Baseline Reference



Dormant Season Storm - Projected Values by 2050s



Projected Change in 1-in-20 Wettest Day Precipitation by 2050s



APPENDIX 3 ADDITIONAL CLIMATE ADAPTIVE DRAINAGE MANAGEMENT CASE STUDIES

Metro Vancouver – Using Integrated Stormwater Management Plans to reduce peak stormwater volumes

Comparable context

In general, the anticipated climate change patterns for Metro Vancouver are representative of those expected for the Fraser Valley. Increased runoff from urban areas in Metro Vancouver has the effect of placing greater pressure on drainage infrastructure as well as often having adverse effects on the environment of receiving lands and waters. This prompted Metro Vancouver to mandate that municipalities each develop Integrated Stormwater Management Plans (ISMP) to control urban storm water runoff. In the Fraser Valley, agricultural lands receive much of the storm water that is generated on upland urban developments within the Fraser Valley Regional District (FVRD). Such infiltration significant factor compounding the effects of climate change on storm events in lower lying agricultural areas (van der Gulik, 2017a).

Demonstrated management options

Integrated Planning. Approximately 25 (ISMPs), representing approximately half the watersheds, have been completed or are underway in Metro Vancouver (NRCAN, 2014). Municipalities have adopted such measures as on-site rainfall retention (through infiltration and detention infrastructure); re-exposure and naturalisation of culverted or buried streams; and in most cases established reduction targets for total impervious area.

Surface water infiltration. Physical works are implemented to increase surface water infiltration and retention to reduce water quantities entering drainage networks. Design and engineering strategies include shallow infiltration facilities (e.g. raingardens, bioswales); deeper infiltration facilities (e.g. rock pits, dry wells, underground chambers); street side infiltration and treatment facilities (e.g. silva cells or equivalent); absorbent landscaped areas; intensive and extensive green roofs; and rainwater harvesting.

Ontario – Using controlled tile drainage to moderate water levels

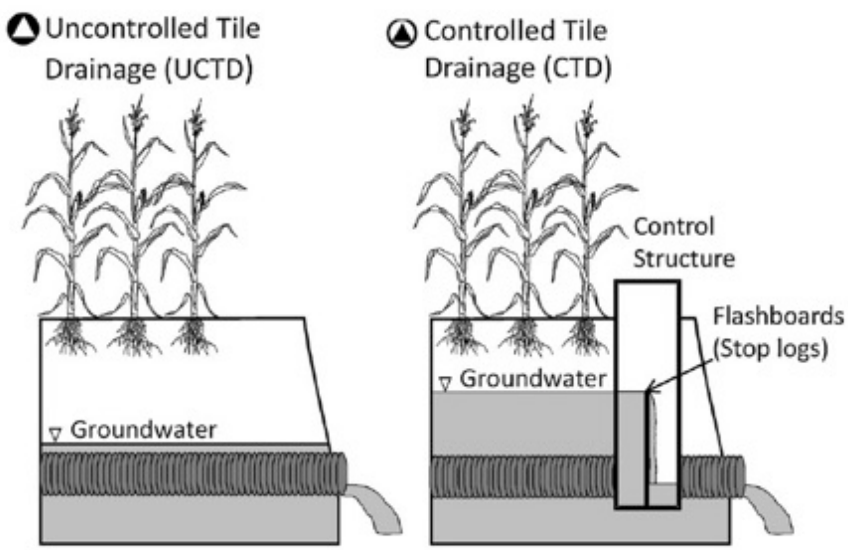
Comparable context

Ontario is anticipated to experience increased droughts in summer periods and greater flooding events over the autumn and spring. Also, under the Great Lakes pollution protocol, sources of nutrient pollution from agriculture are to be reduced (Rudy, 2017).

Demonstrated management options

Controlled tile drainage. Over the last several decades, controlled tile drainage (CTD) has emerged in Ontario as an on-farm best management practice (BMP) that helps to mitigate agricultural runoff while providing agronomic and economic benefits to Producers. CTD has proven beneficial for controlling peak runoff and drainage flows as well as maintaining higher groundwater levels in times of drought (Lapen, 2017; Rudy, 2017) by storing water for longer in the soil (see figure below). The additional storage time also increases the adherence of nutrients to soil particles and organic matter, thereby reducing nutrient runoff into rivers and lakes that is of significant management concern in Ontario (Sunohara et al., 2015; Sunohara et al., 2016). The experience in Ontario is particularly relevant as they have studied retroactively fitting the control devices in areas which already have drain tiles (Lapen, 2017; Sunohara et al., 2015).

Schematic of uncontrolled tile drainage and CTD during a water outflow event (Sunohara *et al.,* 2016).



Studies conducted in Ontario documented increases in corn and soybean crop yields of 3%-4% for retrofitted CTD systems, with an investment payback period of 3-11 years depending on the individual farm scenario (Kitchen et al., 2017). As the per hectare value of crops in the Fraser Valley is significantly higher than the areas studied in Ontario, the returns could be even higher than experienced in Ontario (Lapen, 2017).

Education and Extension. Despite the documented improvements and financial benefits associated with CTD, the technology was initially resisted by Producers due to concerns about increased farm labor, lack of extension services and financial support, and limited data on costs and benefits (Dring et al., 2016). Through a combination of peer interaction and communication from drainage contractors, who are key knowledge providers of drainage regulations, practices and options in Ontario, and education of

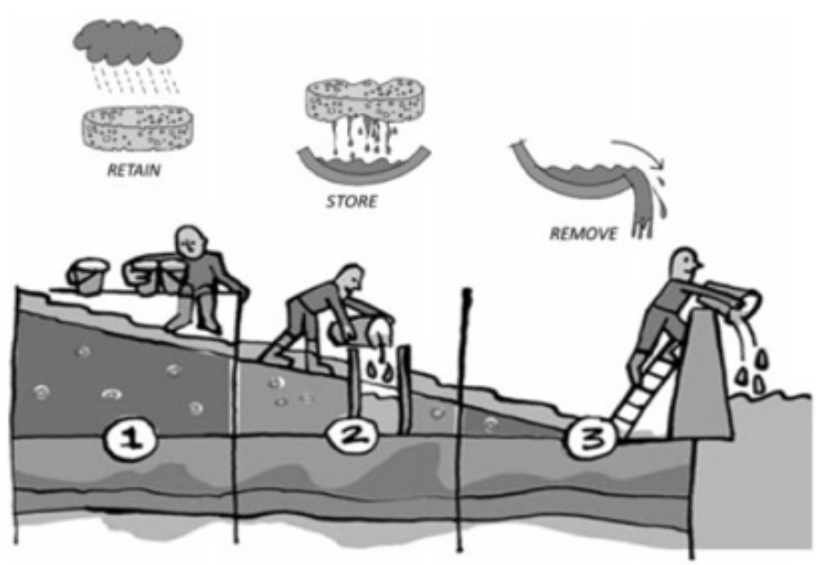
Producers on the benefits of CTD to manage environmental concerns; CTD adoption has steadily increased over time. (Dring, 2017; Rudy, 2017).

Netherlands – Using controlled tile drainage to retain and store water

Comparable context

Much of the Netherlands is flat and either below or close to sea level. Like the Fraser Valley they practice intensive agriculture and husbandry and have a long history in addressing challenges such as inundation, nutrient management, and salination. Traditionally increased drainage requirements were addressed by increasing pump capacity at drainage outlets. Yet the combined problems of climate change, sea level rise, subsidence and urbanization has led to systemic change in drainage management whereby water is increasingly stored within each agricultural plot (Bartholomeus et al., 2017; van den Eertwegh, 2017). In February 2001, the National Government, the Association of Provincial Authorities, the Association of Water Boards (Rijkswaterstaat) and the Association of Dutch Municipalities agreed on a paradigm shift in the water management approach (Delta Committee 2008*). Instead of increasing pumping and drainage capacities, runoff itself is controlled* in a three-step approach of decreasing priority: (1) retention of excess rainfall in the soil, (2) storage of remaining excess water in the field or the [field] drainage system and (3) controlled removal (see figure below) (Ritzema et al., 2015). The principal focus is therefore to use the fields themselves for water retention.

Climate Adaptive Management using a "retain, store and control" management approach (Ritzema et al., 2015)

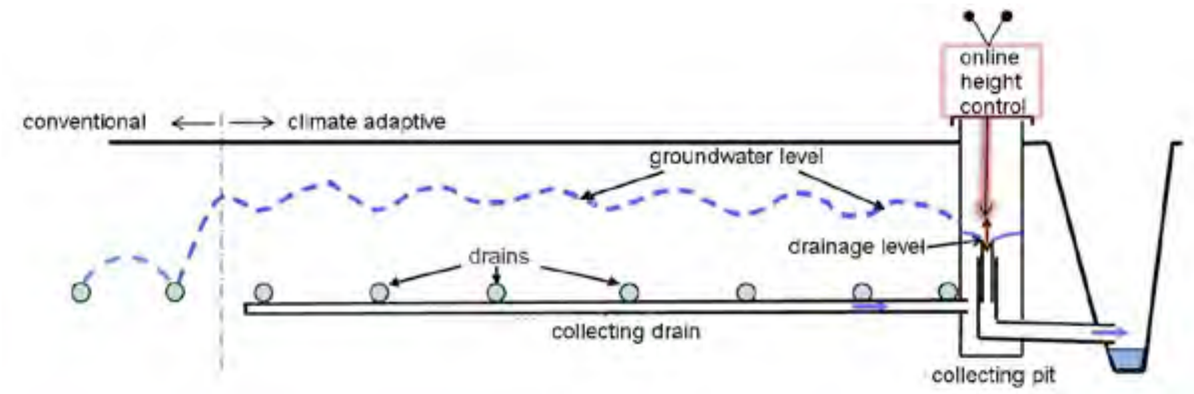


Demonstrated management options

Controlled tile drainage. As with Ontario, outlet systems control the water draining from the drainage tiles, with the difference that the design focuses on handling excess water and addressing flood control

(Eertwegh, 2017). The soils themselves, acting as a sponge, are used to provide the water retention system. The water retention capacity of the soils is improved by increasing soil health (Smukler, 2017).

Controlled tile drainage (KnowH2O, 2016)



The technology has been applied in different agricultural areas and in different soil types such as clay, sandy loam, and peaty zones. Demonstrated benefits have included:

- increased in-field storage resulting in delayed need for removal,
- better control of the groundwater level to ensure root zones are protected,
- improved controlled outflow and lower peak discharges,
- better use of water and nutrients, and reduced loss of nutrients (Ritzema et al., 2015).

Integrated Climate Adaptive Water Planning. On-farm solutions, like CTD, combined with regional planning under the "Live with Water Program" for urban, transport and water development are being used to address future climate impacts. There is an acknowledgement at the regional level that there is no single solution, rather that multi-sector planning is needed to address the climate change. The Rijkswaterstaat (Regional Water Boards) are assigned to implement national water policies, and so are the key facilitators in water planning tasks with the other sectors (van der Eetrwegh, 2017). The difference between Ontario and the Netherlands is not so much in the CTD technology per se, but rather its integrated application in the Netherlands as part of a wider strategy.

APPENDIX 4 POTENTIAL FUNDING MECHANISMS

Potential funding mechanisms to support improved runoff and drainage management and infrastructure in the Fraser Valley may take a variety of possible mechanisms depending on the nature of the option.

Pilot projects in Ontario for CDT have relied on provincial grants to undertake studies and the involvement of Producers who have a special interest in developing more appropriate water management solutions.

In the Netherlands funding for improved drainage management initiatives comes from Regional Water Board grants as well as government incentives for farmers. In addition, major conveyance and drainage outlet infrastructure is financed as part of Water Board budgets. The Water Boards obtain funding from municipal taxes as well as a national fund for water management.

Alternative Funding Models

Service Cost-Sharing Model. The agriculture sector has a long history in establishing cost sharing models whereby Producers pool their resources to make services and production more affordable. The Delta Farmland & Wildlife Trust provides a local example of offering programs for the benefit of introducing on-farm practices that are beneficial to the environment as well as the farmers. The Trust helps fund, or split the cost, of many beneficial practices such as laser levelling to avoid water pooling and establishing grass margins beside ditch banks to reduce the need for ditch maintenance through sediment trapping.

Drainage Utility Model. A utility model can be employed to share the costs of runoff and drainage management between all those benefiting from the service, while also protecting rate payers through the oversight of the BC Utilities Commission (BCUC). For example, the City of Surrey has established a Drainage Utility which collects $400/property/year regardless of the size of the property or impermeable area. (van der Gulik, 2017). Ratepayers are assured of regulated rates by the BCUC to assess and assure value for fees collected.

Voluntary Riparian Habitat Lease Model. In Whatcom County a Conservation Reserve Enhancement Program (CREP) exists to pay volunteer landowners rent, a signing bonus and the costs for establishing buffers along creeks, ditches and wetlands. CREP pays to remove invasive plants such as reed canarygrass and Himalayan blackberry and may also pay to fence livestock out of the buffer and for off-channel livestock watering alternatives. In addition to habitat benefits, buffers of native vegetation help to reduce drainage maintenance requirements by stabilizing stream banks and reducing erosion. Participant landowners receive annual rental payments in return for land that is removed from production and grazing, under a 10 or 15-year agreement. The program is administered by United States Department of Agriculture Farm Service Agency while the Whatcom Conservation District, under Washington State funding, provides the technical support and project planning.

Ecosystem Services Payment Model. Several initiatives such as Farmland Advantage, Ecological Service Initiatives (ESI) pilot projects in BC, and Whatcom County Ag-Watershed Pilot Project are investigating the feasibility of implementing ecosystem service financial accounting in support of a "Natural Resources Marketplace Approach" for implementing certain BMPs.

Potential Funding Sources for Pilot Projects

The following serves to illustrate the range of possible funding mechanisms depending on the nature of the project. It does not purport to be an exhaustive list of potential sources.

Farmland-Riparian Interface Stewardship Program. The Farmland-Riparian Interface Stewardship Program (FRISP) was designed to assist agricultural Producers in their efforts to protect and enhance water quality, riparian vegetation, and fish habitat. The BC Cattlemen's Association (BCCA) manages and delivers the program through a directed common goal approach to address watershed resource concerns, encouraging sustainable land management practices in support of the agricultural sector.

Farmland Advantage. Farmland Advantage is a research and development project that works with farmers to protect and conserve critical, natural values in British Columbia. The project helps farmers identify the natural values which can be protected and enhanced and develops recommendations and plans to preserve them. These plans can include actions such as water or stream setbacks, strategic fencing, reforestation, or rangeland enhancement. Farmers then carry out the recommendations, and Farmland Advantage helps to provide compensation based on successful implementation. It has also conducted pilot projects with Producers across BC to look at implementing BMPs and setting up a payment for ecosystem services model.

Investment Agriculture Foundation of British Columbia (IAFBC). IAFBC has funding for several relevant initiatives including the *Agricultural Area Planning* funding program which supports projects that enable the development of agricultural area plans within British Columbia municipalities and regional districts. The funding can develop agriculture strategies such as developing options and BMPs at a landscape level; funding is for 50% of total cost up to $45,000.

Environment & Climate Change Canada (ECCC). ECCC funds several potential opportunities related to runoff and drainage and climate change adaptation, including:

- *EcoAction Community Funding Program* supports action to address clean air, clean water, climate change and nature issues, and to build the capacity of communities to sustain these activities into the future. The fund is for non-profits, so perhaps an agricultural non-profit group.
- *The Habitat Stewardship Program* allocates funds to projects that conserve and protect species at risk and their habitats and help to preserve biodiversity. This is open to NGO's as well as Provincial, territorial and municipal governments. Up to 100,000/year with matching funds.

APPENDIX 5 RESEARCH CONTACTS

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APPENDIX 6 WEB RESOURCES

The following websites provide valuable information on the topics of runoff and drainage management, regional climate change projections, and funding mechanisms and sources that are applicable to the Fraser Valley context.

Topic: Runoff and Drainage Management

BC Government> Farming, Natural Resources & Industry>Agriculture & Seafood> Agricultural Land & Environment> Water> Drainage

City of Abbotsford> Diking and Drainage

Dewdney Area Improvement District

Farm Credit Canada> Tile drainage: The ultimate risk-management investment

Manitoba Agriculture> Environment> Soil And Water Management> Soil Management Guide> Drainage Management

Ontario Soil and Crop Improvement Association (OSCIA)> Controlled Drainage Benefits Investigated by New OSCIA Partnership

Salish Sea Restoration> Delta Flood and Drainage

Salish Sea Restoration> Lowland Watersheds> Riparian Buffer Function

Whatcom Conservation District> Landowner Tools> Agricultural Drainage

Whatcom County> Whatcom County Ag-Watershed Pilot Project> Identifying Opportunities to Strengthen Agriculture & Watershed Systems in Whatcom County

Whatcom County> Whatcom Family Farmers > Frequently asked questions about WIDS

Topic: Regional Climate Change Projections

Metro Vancouver> Climate Change Programs> Regional Climate Projections and Adaptation

Topic: Financing Mechanisms and Sources

British Columbia Cattlemen's Association> Farmland-Riparian Interface Stewardship Program (FRISP)

Delta Farmland & Wildlife Trust

Farmland Advantage

Government of Canada> Environment and natural resources> Environmental conservation and protection> Environmental funding> Environment and Climate Change Canada funding programs

Investment Agriculture Foundation of British Columbia> Area Agricultural Area Planning Program

Whatcom Conservation District > Conservation Reserve Enhancement Program

Whatcom County Ag-Watershed Pilot Project

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