

Summary of Water Management Resources for Agriculture in BC

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Disclaimer:

This document was developed as part of the *Knowledge Transfer for Adoption of Water Management Best Practices* for the BC Agriculture & Food Climate Action Initiative. The intention was to develop an understanding of the available resources on water management for farmers and ranchers, relevant to the context of agriculture production in Regional Districts of Bulkley-Nechako and Fraser-Fort George. The links and resources were available as presented as of October 2020. Project partners and authors are not responsible for updating the document.

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1. INTRODUCTION

The *Knowledge Transfer for Adoption of Water Management Best Practices* project was developed by the BC Climate and Agriculture Initiative to address a need for regionally-relevant water management information for producers, as identified in the *Bulkley-Nechako & Fraser-Fort George Adaptation Strategies*.¹ The *Summary of Water Management Resources for Agriculture in BC* document was compiled as part of the process to identify topics to be addressed through extension activities, but upon completion, it was recognized that publishing a document outlining resources related to on-farm water management would be beneficial for producers.

1.1 MINISTRY OF AGRICULTURE CONTACTS

Regional Agrologist for Bulkley-Nechako and Fraser-Fort George:

John Stevenson (*Smithers*) -> John.J.Stevenson@gov.bc.ca 250 847-6379
Karen Tabe (*Vanderhoof*) -> Karen.Tabe@gov.bc.ca 236 409-2004

BC Ministry of Agriculture, Food and Fisheries agrologists and industry specialists in BC:

<https://dir.gov.bc.ca/gtds.cgi?searchString=agrologist>

General agriculture water resources from the Province of BC:

<https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water>

2. LIVESTOCK WATERING SYSTEMS

Livestock Surface Water & Forage Risk Assessment Tool: BC Agriculture & Food Climate Action Initiative - *Cariboo Region Adaptation Strategies*

In 2017, CAI completed an assessment of *Livestock Surface Water and Options in the Cariboo Region*. This project developed maps that would identify areas experiencing reduced surface water availability, and using climate change data, areas that may become vulnerable. From this project came another titled *Livestock Surface Water & Forage Risk Assessment Tool Extension & Engagement*, which used information from the 2017 assessment to establish 3 potential case studies in the Cariboo.

2017 CAI Report: Livestock Surface Water Assessment and Options: A risk assessment and process for planning resilient water developments in a changing climate on crown range in the Cariboo Regional District of British Columbia. Andrew Pantel (M.Sc, P.Ag). <https://www.bcagclimateaction.ca/wp/wp-content/media/CB06-Livestock-Surface-Water-Assessment-2017-report.pdf>

2019 CAI Report: Livestock Surface Water & Forage Risk Assessment Tool Extension & Engagement Project Report: <https://www.bcagclimateaction.ca/wp/wp-content/media/CB11-Livestock-Surface-Water-Forage-2019-report.pdf>

¹ <https://www.bcagclimateaction.ca/regional/rap/bnffg/>

Beef Cattle Research Council (BCRC)

Numerous resources on livestock watering are available through the BCRC website, including:

Webinar: What's In Your Water? Water Quality And The Economics Of Pump Systems:
<http://www.beefresearch.ca/resources/webinars/webinar-detail.cfm?id=2>

Water Systems Calculator: This calculator incorporates producer information of the farm and herd to provide an output on potential weight gain in pumped water vs direct assess. It will also use information on initial costs of the watering systems to provide an overview of the economic results of implementing various water systems. This Calculator is based on information provided in the Economics of Water Systems fact sheet below. <http://www.beefresearch.ca/research/water-systems-calculator.cfm>

Fact Sheet: Economics of Water Systems: Canfax Research Services:
<http://www.canfax.ca/samples/economics%20of%20water%20systems.pdf>

Farmland-Riparian Interface Stewardship Program (FRISP): BC Cattlemen's Association

FRISP will assist in the identification of riparian issues on farms or ranches to protect and enhance water quality, riparian vegetation, and fish habitat. The BC Cattlemen's Association (BCCA), manages and delivers the program to address watershed resource concerns, encouraging sustainable land management practices in support of the agricultural sector. Farmers and ranchers can submit an application through the BCCA office and once approved, technical advisors will assist in project development to support riparian areas.

BCCA Website Link: <https://www.cattlemen.bc.ca/frisp.htm>

2.1 Innovations and Best Practices

Agriculture and Water: Agriculture and Agri-Food Canada

Information on general beneficial management practices for agriculture water management. This includes: Livestock watering, Ponds and dugouts, Watershed protection, and Wells and groundwater.

Agriculture and water quality: <https://www5.agr.gc.ca/eng/science-and-innovation/agricultural-practices/water/watershed-protection/agriculture-and-water-quality/?id=1371491033072>

Agricultural Practices > Water: <https://www5.agr.gc.ca/eng/science-and-innovation/agricultural-practices/water/?id=1187702145201>

Livestock Watering Handbook: BC Ministry of Agriculture

Series of fact sheets on livestock watering information planning and calculations for livestock water systems. Information on: Livestock water requirements, accessing watercourses directly, developing water sources, designing livestock watering systems, pumping livestock water, summer outdoor livestock watering, and winter outdoor livestock watering.

Handbook: <https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/water-supply-conservation/livestock-watering-handbook>

BC Agriculture Water Calculator

The BC Agriculture Water Calculator provides an estimate of the annual irrigation or livestock water demand for a farm. Irrigation water demand estimates are made based on the geographic location of the farm, as well as its soil type, crop type and type of irrigation. Livestock water demand estimates are made for a given number and type of animals. The “irrigation” tab of the calculator estimates the annual irrigation water requirements (See Section 3).

Calculator: <http://www.bcagriculturewatercalculator.ca/>

Watering Systems for Grazing Livestock: Michigan State University Extension

The Great Lakes Basin Grazing Network and Michigan State University Extension developed the Watering Systems for Grazing Livestock booklet, to (1) provide information on setting up water systems, (2) explain the role water systems can play in various parts of agriculture, (3) outline requirements for water sources, livestock and delivery systems, and (4) provide information sources on water systems. The author is Ben Barlett with the Michigan State University Extension District Dairy and Livestock Agent.

Booklet Link:

<https://efotg.sc.egov.usda.gov/references/public/CT/WateringSystemsforGrazingLivestockBook.pdf>

Livestock Watering Fact Sheets: Peace River Forage Association of British Columbia

The Peace River Forage Association of BC has a series of fact sheets called Forage Facts on a range of many agriculture related topics. Visit <http://www.peaceforage.bc.ca/foragefacts.html> for the full list of fact sheets. The five fact sheets below provide a brief outline of different water systems used for cattle in the region, such as solar pumps and nose pumps.

Solar Pumping Systems: Putting the Sun to Work for You:

http://peaceforage.bc.ca/forage_facts_pdfs/FF_7_solar_pumps.pdf

Winter Watering: Kelln Solar System:

http://peaceforage.bc.ca/forage_facts_pdfs/FF_22_KellnSolarSystem.pdf

CAP Winter Water System: Solar Powered:

http://peaceforage.bc.ca/forage_facts_pdfs/FF_21_CAPSolarSystem.pdf

Nose Pumps: Cattle Pump Their Own Water:

http://peaceforage.bc.ca/forage_facts_pdfs/FF_4_nose_pump.pdf

Cow Powered Winter Water Systems: Frost free Nose pump:

http://peaceforage.bc.ca/forage_facts_pdfs/FF_23_%20nosepump2.pdf

2.2 Low-tech Systems

Fact Sheet: Troughs for watering range livestock: Agriculture and Agri-Food Canada

Fact sheet outline information on selecting and sizing of water troughs, livestock watering demands, materials and site selection, and maintenance of putting in a water trough.

Fact Sheet:

[https://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/ba3468a2a8681f69872569d60073fde1/42131e74693dcd01872572df00629626/\\$FILE/wtroughs.pdf](https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/ba3468a2a8681f69872569d60073fde1/42131e74693dcd01872572df00629626/$FILE/wtroughs.pdf)

3. IRRIGATION INFRASTRUCTURE

B.C. Irrigation Management Guide: BC Ministry of Agriculture

The B.C. Irrigation Management Guide assists British Columbia’s farmers and ranchers to optimize water use and has examples for irrigation assessments throughout the publication, as well as blank worksheets for self-evaluation.

Guide: <https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/irrigation/irrigation-management-guide>

B.C. Sprinkler Irrigation Manual: BC Ministry of Agriculture

This manual has applied information on design and implementation of agricultural sprinkler irrigation systems in British Columbia. It provides information on systems such as: wheel line, solid set sprinkler, stationary gun, travelling gun and center pivot systems. It utilizes farm information such as data on soils, crops, and evapotranspiration rates to properly calculate irrigation system water requirements, application rates, set times and irrigation intervals, and gives insight on design information on piping, pumps, screens and water diversions.

Manual: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/irrigation/sprinkler-irrigation-manual/563000-1_web_chapter_3.pdf

BC Agriculture Water Calculator

The BC Agriculture Water Calculator provides an estimate of the annual irrigation or livestock water demand for a farm. The “irrigation” tab of the calculator estimates the annual irrigation water requirements. Irrigation water demand estimates are made based on the geographic location of the farm, as well as its soil type, crop type and type of irrigation. Livestock water demand estimates are made for a given number and type of animals (See Section 2.1).

Calculator: <http://www.bcagriculturewatercalculator.ca/>

Fact Sheets: Irrigation Feasibility Study in the Peace Region: BC Agriculture & Food Climate Action Initiative

A series of fact sheets to summarize overall findings of the Evaluation of Irrigation Potential in the BC Peace Region feasibility study, developed from the CAI Peace Regional Adaptation Strategies.

When Needed Irrigation = Supplemental:

https://www.cattlemen.bc.ca/docs/irrigation_fact_sheet_1_2017-10-17.pdf

Irrigation Site Specifics: https://www.cattlemen.bc.ca/docs/irrigation_fact_sheet_2_site_specifics_2017-09-21.pdf

Irrigation Crop Diversification Corporation Irrigation Economics and Agronomics: Irrigation Crop Diversification Corporation (Saskatchewan)

This document was developed in 2017 for Saskatchewan producers to look at irrigation requirements for commonly irrigated crops in that region. They provide detailed information on economics and agronomics on various crops such as wheat, barley, oats, canola, corn, alfalfa etc.

Report: <http://irrigationsaskatchewan.com/icdc/wp-content/uploads/2017/03/2017-Economics-Agronomics.pdf>

Forage Crop Irrigation Systems and Economics: University of Missouri Extension

This document provides an overview of irrigation set up for forage crops. It covers different types of irrigation systems, crop response, and the economics behind it. They provide a link for a “*Forage Irrigation System Cost Analyzer* (downloadable Excel workbook)” to help work through costs associated with implementing irrigation (Information relative to USA).

Report: <https://extension2.missouri.edu/g1697>

Factors to Consider in Selecting a Farm Irrigation System: University of Georgia Extension

This document provides an overview of various irrigation systems, also addressing the energy for irrigation and water sources.

Report: https://secure.caes.uga.edu/extension/publications/files/pdf/B%20882_4.PDF

3.1 Establishing New/Efficient Infrastructure

Irrigation System Assessment Guide: Environmental Farm Plan (EFP), BC ARDCorp

The Irrigation System Assessment Guide is used to evaluate the effectiveness of water use on the farm. The EFP will assess that the crop is meeting its water needs while preventing water loss. EFP advisors support producers to apply for funding to help implement infrastructure projects that reduce risks identified within the EFP Workbook.

Irrigation System Assessment Guide: <https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/irrigation/irrigation-system-assessment-guide>

Environmental Farm Plan Website: <https://ardcorp.ca/programs/environmental-farm-plan/>

Irrigation Industry Association of BC (IIABC)

The Irrigation Industry Association of BC can provide important support and connections to others in the region that are looking for or have the same information. The association website has a list of certified irrigation professionals across the Province including designers, technicians, contractors and schedulers who have met the education and training standards to provide proper services. The IIABC offers certification courses and annual conventions on irrigation technologies, installation and design, news on events and resources to guides and online tools, such as, the Agricultural Irrigation Scheduling Calculator <See Section 4.2, <https://ag-calc.irrigationbc.com/>>.

Association Site: <https://www.irrigationbc.com/>

3.2 Production Economics for Main Commodities

Fact Sheet: Irrigation Feasibility Study in the Peace Region: BC Agriculture & Food_Climate Action Initiative

The third fact sheet in the irrigation series summarizing the overall findings of the *Evaluation of Irrigation Potential in the BC Peace Region* feasibility study, developed from the *Peace Regional Adaptation Strategies*.

Economics: https://www.cattlemen.bc.ca/docs/irrigation_fact_sheet_3_economics_2017-10-17.pdf

Full Report: Evaluation of Irrigation Potential in the BC Peace Region, Prepared by Kerr Wood Leidal Engineering Consultant. Prepared for the BC Agriculture & Food Climate Action Initiative in partnership with the BC Grain Producers Association. http://www.peaceforageseed.ca/pdf/research_updates/PC05-Evaluation-Irrigation-Potential-Peace-report.pdf

Economic Value of Irrigation in Alberta: Alberta Irrigation Projects Association

This report provides a comprehensive assessment of the Alberta irrigation industry's value to their provincial economy, with a look at future opportunities and challenges due to changing world markets and climatic conditions.

Economic Report: [https://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/irr15523/\\$file/economic-value-irrigation-alberta.pdf](https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr15523/$file/economic-value-irrigation-alberta.pdf)

Pasture / Forage Irrigation Options & Economics: Michigan State University Extension

Presentation by Lyndon Kelly about various types of irrigation systems (pros and cons) and a brief overview of the economics behind them.

Presentation Slides: https://engineering.purdue.edu/ABE/engagement/PastureI_Forage.pdf

Reducing the Cost of Pumping Irrigation Water: University of Nebraska-Lincoln Extension

Report looking at Energy Use in Irrigation and ways to estimate the cost of pumping water and compare energy usages of a well-maintained pumping plant.

Report: <https://www.ksre.k-state.edu/irrigate/oow/p10/Melvin10.pdf>

4. IRRIGATION PRACTICES

The RDFFG is developing a Water Conservation Strategy which will outline conservation strategies for water and waste water systems to ensure that water resources are managed and consumed in a sustainable manner. The BNRD completed an Agricultural Plan in 2012 which has now been updated to the *Food and Agriculture Plan 2020*.

BNRD Food and Agriculture Plan 2020:

[https://www.rdbn.bc.ca/application/files/5815/8705/5888/RDBN Food and Ag Plan Final April 2-2020.pdf](https://www.rdbn.bc.ca/application/files/5815/8705/5888/RDBN_Food_and_Ag_Plan_Final_April_2-2020.pdf)

Okanagan Sustainable Water Strategy

The Okanagan Sustainable Water Strategy was developed by the *Okanagan Water Stewardship Council* to help manage the water resources through the various water requirements across the region, including agriculture and irrigation.

Sustainable Water Strategy Action Plan 1.0: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/okanagan_sustainable_water_strategy_osws_action_plan.pdf

Farming Irrigation Systems: Crop, Soil and Climate: BC Ministry of Agriculture

Developed by Andrew Peterson (Water Management Specialist, Ministry of Agriculture), this handout addresses why we irrigate, how much and how often to irrigate, and if crops make a difference in irrigation intervals.

Handout: http://www.smithersfarmersinstitute.com/uploads/2/8/7/7/28775409/crop_soil_climate.pdf

Farming Irrigation Systems- Sprinkler Irrigation Assessment: BC Ministry of Agriculture

Developed by Andrew Peterson (Water Management Specialist, Ministry of Agriculture), this handout walks through irrigation calculations to determine values such as the system annual water use.

Handout:

http://www.smithersfarmersinstitute.com/uploads/2/8/7/7/28775409/sprinkler_irrigation_assessment.pdf

Webinar: Maintaining the Safety of Fresh Produce by Monitoring the Quality of Irrigation Water: BC Ministry of Agriculture, Webinar Series

An introduction into beneficial practices and sampling techniques to maintain the safety of fresh produce and monitor the microbial quality of agriculture surface water. Presenters: Justin Falardeau, PhD Researcher, UBC Land and Food Systems, Dr. Siyun Wang, Research Supervisor, UBC Land and Food Systems, Elsie Friesen, Food Safety and Education Specialist, Ministry of Agriculture. Recorded: April 18, 2018

Webinar:

<https://www.gotostage.com/channel/7ad0272e1d8143e2b14ee7aee170c4f3/recording/bf8c4f2729b74e568bd97b5bb74f0733/watch>

Fact Sheets: Irrigation Tips to Conserve Water on the Farm: BC Ministry of Agriculture (2015)

Series of fact sheets from Ministry of Agriculture outlining water conservation on farms, specifically in low water or drought conditions. For full list of Drought Factsheets visit:

<https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/drought-in-agriculture?keyword=drought>

Introduction to Irrigation Tips: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/irrigation/500310-1_irrigation_tips_to_conserve_water.pdf

Water Saving Tips: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/irrigation/500310-2_irrigation_water_saving_tips.pdf

Irrigation Management for Forage Crops in Droughts: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-3_forage_crop_and_irrig_mgmt-drought_factsheet_no3.pdf

Irrigation Decisions with Limited Water: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-4_irrigation_decisions_with_limited_water-drought_factsheet_no4.pdf

Drought Impacts: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-7_drought_impacts_-_drought_factsheet_no7.pdf

4.1 Small-scale Horticulture Systems

Webinar: Irrigation on Small Farms: Michigan State University

This webinar was developed for small scale producers with focus on vegetable and fruit production.

Webinar: https://www.canr.msu.edu/resources/irrigation_on_small_farms

Fact Sheet: Drip Irrigation for Vegetable Production: Penn State Extension

Fact sheet outlining advantages, disadvantages and system components for Drip Irrigation.

Drip Irrigation Fact Sheet: <https://extension.psu.edu/drip-irrigation-for-vegetable-production>

Drip-Irrigation Systems for Small Conventional Vegetable Farms and Organic Vegetable Farms:

University of Florida, IFAS Extension

Publication provides overview, components, tips, and maintenance on drip irrigation systems. Includes tables of estimated start-up costs, length of drip line based on flow rate, scheduling recommendations, etc.

Publication on Drip Irrigation Systems: <http://edis.ifas.ufl.edu/pdf/HS/HS38800.pdf>

Irrigation Management: BC Tree Fruit Production Guide

This section of the Tree Fruit Production Guide covers topics on irrigation, how it affects the crops, and soil moisture calculations and considerations, and irrigation systems.

Guide: <https://www.bctfpg.ca/horticulture/irrigation-air-quality/irrigation-management/>

4.2 Irrigation Scheduling

Fact Sheet: Irrigation Scheduling Techniques: BC Ministry of Agriculture (2015)

Fact sheet describes ways to help determine scheduling time for irrigation by measuring soil moisture, analysing meteorological data, or monitoring plant stress.

Irrigation Scheduling Techniques: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/irrigation/577100-1_irrigation_scheduling_techniques.pdf

Agriculture Irrigation Scheduling Calculator

The calculator takes information, such as crop water requirements, soil moisture, the amount of rainfall, and the moisture deficit, to develop an irrigation schedule. By minimizing frequency and maximizing duration of irrigation, the calculator can help create a schedule where irrigation occurs less frequently but will better utilize the water stored in the crop's root zone.

Calculator: <https://ag-calc.irrigationbc.com/>

Agricultural Sprinkler Irrigation Scheduling Calculator User's Guide:

Information from the B.C. Irrigation Management Guide produced by the Irrigation Industry Association of British Columbia has been used as a guide in the preparation of this document. The Irrigation Scheduling Calculator was developed solely by the Ministry of Agriculture and Lands and the Irrigation Industry Association of British Columbia with funding from the Canada British Columbia Water Supply Expansion Program.

User Guide:
http://www.irrigationbc.com/assets/client/File/USER_GUIDE_Agric_Sprinkler_Irrig_Sched_Calc%202009.pdf

Evapotranspiration Calculator: Farmwest

Evapotranspiration refers to the water that is evaporated from the soil and crop surface (evaporation) and the water that is released through the plant, (transpiration). A crop's water requirement or water usage is directly related to ET and the crop's stage of development. The irrigation system can be scheduled using the adjusted ET values.

Calculator: <https://farmwest.com/climate/et>

Irrigation in the Pacific Northwest Calculator

These irrigation calculators will help compute your irrigation needs based on your growing practices, types of soil, and vegetation. Examples: Drip Line Rate, Sprinkler Application Rate, Nozzle Requirements, Pipeline Size/Pressure Loss, etc.

Calculator: <http://irrigation.wsu.edu/Content/Select-Calculators.php>

4.3 Rainwater Capturing

Canadian Association for Rainwater Management

This is a non-profit association that provides information and certification training on Rainwater Management. The certification training is webinar based, with a broad range of educational packages. The group focuses on knowledge transfer and research on best practices for rainwater and storm water management across Canada.

Website: <http://canarm.org/>

Rainwater Harvesting Best Practices Guidebook

Residential Rainwater Harvesting Design and Installation Guidebook developed for homeowners of the Regional District of Nanaimo British Columbia, Canada. Although this guidebook was developed for Nanaimo, many of the best management practices for design, installation and maintenance of residential rainwater harvesting systems are transferrable to other regions, including the RDFFG and the RDBN.

Guidebook: <https://www.rdn.bc.ca/cms/wpattachments/wpID2430atID5059.pdf>

Rainwater Catchment Calculator

Calculate the rainwater collection potential of your home or project. Input the area of your roof (sq. ft) and the inches of rainfall annually to calculate the total potential rainwater collection of the roof.

Calculator: <https://www.watercache.com/resources/rainwater-collection-calculator>

4.4 Water Storage

BC Farm Practices & Climate Change Adaptation: Water Storage: BC Agriculture & Food Climate Action Initiative

This document was developed to address farm practices that have the potential to reduce risk or increase resilience facing climate change. Background on various water storage technologies across BC are outlined with examples of water storage on BC farms.

Water Storage: <https://www.bcagclimateaction.ca/wp/wp-content/media/FarmPractices-WaterStorage.pdf>

Fact Sheet: Farm Water Storage: BC Ministry of Agriculture (2003)

An introduction to dams, dugouts, storage capacity (including equations for calculations) is provided in this fact sheet. *Regulation info will not be relevant with the recent government changes.

Fact Sheet: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/water-supply-conservation/510100-1_farm_water_storage.pdf

Fact Sheet: Wisdom from Watering Holes: Peace River Forage Association of British Columbia

The Peace River Forage Association of BC has a series of fact sheets call Forage Facts on a range of many agriculture related topics. Visit <http://www.peaceforage.bc.ca/foragefacts.html> for the full list of fact sheets. The following fact sheet outlines various on farm water storage methods, emphasizing the transfer of water out of a dugout to a different water container.

Wisdom from Watering Holes: http://peaceforage.bc.ca/forage_facts_pdfs/FF_3_Water_systems.pdf

4.4A DAM SAFETY

B.C. Dam Safety Program: BC Ministry of Environment

Website outlines Dam Safety Regulations, and lists connections to contacts within the BC Dam Safety Program. Key Resources on the website are found below.

Website: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/dam-safety>

Dam Safety Pocketbook (Quick Reference Guide): https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/2_6483_dam_safety_pocket_guide_web.pdf

Inspection and Maintenance of Small Dams Guidelines:
https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/s051025_qp_dam_safety_guidelines_small_dams_text_2_with_cover.pdf

Other Dam Safety Technical Resources: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/dam-safety/technical-resources>

Agricultural Dams Knowledge Transfer Resource in the Cariboo: BC Agriculture & Food Climate Action Initiative

BC Agriculture & Food Climate Action Initiative project in the Cariboo with links to Dam Safety Management Binder and workshop presentation.

Project Outline: <https://www.bcagclimateaction.ca/regional-project/cb07/>

B.C. Dam Safety Self Directed Learning: Government of BC, Environmental Protection & Sustainability

This course is designed to assist dam owners, water license users, and similar stakeholders to better understand dam safety basics in British Columbia. Within the province, there are a large amount of earth-fill embankment dams that are owned and operated by various individuals. Without due diligence from dam owners, these dams pose a substantial safety hazard towards the public and to the environment. Completing this course will provide a general understanding of the dam safety program in British Columbia, basic concepts in dam safety, and broad knowledge of the field.

There are 5 core modules to the course. By the end of this course, you should be able to:

- Understand the importance of dam safety in BC and around the world
- Understand and be able to define basic terminology used in dam safety
- Identify and recognize common deficiencies and problems associated with your dam
- Have a basic overview of the dam safety regulations as well as the requirements for dam owners in BC
- Have an idea of key contacts who can assist you in maintaining, inspecting, operating, and managing a dam
- Be mindful of available resources and other helpful organizations regarding dam safety

<https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/dam-safety/11965/12021>

4.4B DUGOUTS

British Columbia Farm Water Dugouts (2016): BC Ministry of Agriculture

This manual was developed by the Ministry of Agriculture to guide agricultural producers in the proper construction and maintenance of a dugout. It includes sections on BC dugouts (climate, reservoirs), farm water planning, design and construction, equipment, water quality, management, and troubleshooting.

Guide: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/510400-1_british_columbia_farm_water_dugouts_-2016.pdf

Report on Managing Dugouts in Northeast BC (2017): Ministry of Forests Lands and Natural Resource Operations

FLNRORD engaged J. S. Mattison to write a report to explore the legal, policy, and practical challenges of addressing 'the dugouts issue', and to develop recommendations.

Factsheet: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/fs_dugouts_mattison_dec_2017.pdf

Report: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/dugouts_mattison_july_final.pdf

Water Policy Bulletin: BC Ministry of Environment & Climate Change Strategy, Ministry of Forests, Lands, Natural Resource Operations & Rural Development

Authorization requirements for storage and use of water in dugouts (August 2017). This policy bulletin clarifies authorization requirements for water diversion in relation to dugouts under the Water Sustainability Act (WSA) for stream water and groundwater Issued by the Ministry of Environment and Climate Change Strategy and Ministry of Forests, Lands, Natural Resource Operations & Rural Development

Bulletin: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-rights/info_bulletin_-_dugouts_livestock_-_aug_2017.pdf

5. SOIL MOISTURE

Fact Sheets: Peace River Forage Association of British Columbia

The Peace River Forage Association of BC has a series of fact sheets call Forage Facts ranging across many agriculture related topics. Visit <http://www.peaceforage.bc.ca/foragefacts.html> for the full list of fact sheets.

Soil Quality Part I: http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_95_Soil_Quality_Part_I.pdf

Soil Quality Part II: http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_96_Soil_Quality_Part_II.pdf

Soil Water and Resiliency:

http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_107_Soil_Water&Resiliency_aif6.pdf

Soil Moisture:

http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_30_Gettingthemostfromyoursoilmoisture.pdf

Healthy Start for Drought Resistant Forages:

http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_89_Healthy_Start_for_Vigorous_Forages.pdf

Fact Sheet: Cariboo Agricultural Research Alliance (CARA)

The Fact Sheet provides an overview of the use of the Soil Test Kit (as adapted by researchers at the University of Northern BC) in the Peace River and Bulkley Valley, and how it could be adapted for use in the Cariboo Region. To search other documents on the CARA website Research Library follow this link and use the keyword water from the dropdown menu: <https://cariboo-agricultural-research.ca/library/?cat=water&type=all&submit=browse>

Fact Sheet on Soil Test Kit in Cariboo. <https://www.bcagclimateaction.ca/wp/wp-content/media/CB10-2018-factsheet-soil-quality-test-kit.pdf>

Fact Sheet: Soil Water Storage Capacity and Available Soil Moisture: BC Ministry of Agriculture

Water Conservation fact sheet covering water storage in soil, irrigation, terminology, calculations and includes examples.

Soil Water Storage Capacity and Available Soil Moisture: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/soil-nutrients/600-series/619000-1_soil_water_storage_capacity.pdf

Fact Sheet: Drought Impacts on Soil Fertility: BC Ministry of Agriculture

Fact Sheet: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-7_drought_impacts_-_drought_factsheet_no7.pdf

5.1 Soil Moisture Monitoring

Farming Irrigation Systems- Soil Moisture Measurement: BC Ministry of Agriculture

Developed by Andrew Peterson (Water Management Specialist, Ministry of Agriculture), this handout provides background on irrigation, and soil moisture studies.

Handout:

http://www.smithersfarmersinstitute.com/uploads/2/8/7/7/28775409/soil_moisture_measurement.pdf

Methods to Monitor Soil Moisture: University of Wisconsin Extension

Efficient crop irrigation requires an understanding in soil moisture management. This article outlines some equipment/methods that can be used to help determine soil moisture.

Methods to Monitor Soil Moisture:

https://fyi.extension.wisc.edu/cropirrigation/files/2015/03/Methods.to_Monitor.Soil_Moisture.pdf

5.2 Improving Soil Water Retention

Fact Sheet: Tillage, Residue, Management and Their Effect on Soil Moisture: BC Ministry of Agriculture

Drought Management fact sheet provides an overview on management practices and how they affect soil water retention.

Fact Sheet: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-8_tillage_and_residue_management-drought_factsheet_no8.pdf

6. IRRIGATION AND WILDFIRE

Agriculture Wildfire Preparedness and Mitigation Plan: Guide to Completing the Workbook

This guide offers producers a way to develop an *Agriculture Wildfire Preparedness and Mitigation Plan* which is designed to help them protect themselves and prepare for wildfire events. The section on Water Sources outlines information that should be included in a plan in case of emergency fire situations. The Property Risk Reduction section suggests planning for Sprinkler Protection if proper equipment is available.

Guide: <https://www.bcagclimateaction.ca/wp/wp-content/media/OK05-BC-Wildfire-Preparedness-Mitigation-Plan-2018-guide.pdf>

7. OTHER TOPICS

Water Data and Tools: BC Ministry of Environment

Links to information on water rights, tools for monitoring and reporting data, flood and drought information, and mapping and climate tools.

Website link: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools>

Water Licences Query Tool: Water licence query tool helps producers to find information on who has licences on a source, if there are applications on a source or to print a scanned water licence document. http://a100.gov.bc.ca/pub/wtrwhse/water_licences.input

BC Water Tool: map-based water information tool designed to provide find information on water availability, existing water users and monitoring data. <http://www.bcwatertool.ca/>

Groundwater Information: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/groundwater-science-and-data>

Real-Time Water Data: Use the interactive map based tool to display locations of monitoring stations, export data, create & view charts & reports. <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/real-time-water-data-reporting>

Manitoba Forage and Grassland Association - Aquanty Project

Manitoba Forage and Grassland Association's Aquanty Project uses a HydroGeoSphere high-resolution model that looks at water movement and the role of forages and grasslands in times of flood or drought across the Assiniboine River Basin.

MFGA: Aquanty Project:

https://mfgaaquanty.ismcanada.com/arcgis/home/?utm_source=MFGA+eBulletin+-+Oct,+2018&utm_campaign=October+2018+eBulletin&utm_medium=email

Smart Water Use on Your Farm or Ranch: Sustainable Agriculture Research and Education (SARE)

Sustainable Agriculture Research and Education is a group based out of the USA focusing on sustainable best management practices for agriculture. This article on smart water use covers information on: soil management, plant management and water management. Examples of these topics are "managing soil to improve infiltration, selecting drought-tolerant crops and native forages, and designing innovative runoff collection systems."

Website: Provides link to downloadable PDF, <https://www.sare.org/Learning-Center/Bulletins/Smart-Water-Use-on-Your-Farm-or-Ranch>

BC Food Web

Find information on food systems research and other resources, including water and irrigation information. BC Food Web also includes the opportunity to submit a research idea.

Website: <https://bcfoodweb.ca/>

7.1 DRAINAGE

Drainage Management Guide: Environmental Farm Plan (EFP), BC ARDCorp

The Drainage Management Guide provides information on how to develop and implement an Agricultural Drainage Management Plan. EFP advisors can support producers to apply for funding to help implement infrastructure projects on the farm that reduce risks identified within the EFP Workbook.

Drainage Management Guide: <https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/drainage/drainage-management-guide>

Environmental Farm Plan Website: <https://ardcorp.ca/programs/environmental-farm-plan/>

B.C. Agricultural Drainage Manual: Ministry of Agriculture

A general reference that describes accepted drainage practices and principles for British Columbia.

Manual: <https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/drainage/agricultural-drainage-manual>

Climate Change Adaptation & On-Farm Drainage Management in Delta, BC Current Knowledge & Practices: BC Agriculture & Food Climate Action Initiative

UBC and the Delta Farmers' Institute partnered in a project to enhance knowledge for producers on water drainage. This included an on farm research trial, literature review on existing resources and various extension events.

Project Summary: <https://www.bcagclimateaction.ca/wp/wp-content/media/DL09-Delta-Drainage-Sub-irrigation-summary.pdf>

Final Report: <https://www.bcagclimateaction.ca/wp/wp-content/media/FI13-Improving-On-Farm-Drainage-Management-2017-report.pdf>

Drainage: Sustainable Agriculture Research and Education (SARE)

Sustainable Agriculture Research and Education is a group based out of the USA focusing on sustainable best management practices for agriculture. This article on Drainage talks about benefits and concerns of drainage and different drainage system options.

Website: <https://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition/Text-Version/Managing-Water-Irrigation-and-Drainage/Drainage>

Agricultural Drainage: Michigan State University

This extension bulletin provides a few examples of on farm water drainage systems and evaluates pros and cons.

Bulletin: <https://www.canr.msu.edu/agriculture/uploads/files/agriculturaldrainage-2-2-18-web.pdf>

7.2 WHOLE FARM DESIGN

Keyline Water Management

The theory behind the Australia water management technique is to use plow lines or mounds falling slightly off contour to “slow, sink and spread rainwater”. Pore space in compacted soil is opened up and excess water can infiltrate across a broad area. This has potential to work as both a flood and drought mitigation strategy.

Website: <http://crkeyline.ca/what-is-keyline-design/>

Climate Action Initiative Project Summary: Australian Technique Offers Novel Approach to Water Management <https://www.bcagclimateaction.ca/wp/wp-content/media/project-summary-FI09.pdf>

Full Report: <https://www.bcagclimateaction.ca/wp/wp-content/media/FI09-Keyline-Water-Management-CRD-2018-report.pdf>

7.3 USING FODDER INSTEAD OF HAY FOR CATTLE FEED

Fact Sheet: Alternative Feeds for Cattle During Drought: Colorado State University Extension

This fact sheet provides information on alternative feeds for cattle, such as stretching the hay pile, and seasonal planning for forage.

Factsheet: <https://extension.colostate.edu/docs/pubs/livestk/01626.pdf>

Feeding Livestock During Feed Shortages: Government of Saskatchewan

Website has links to information on feed and bedding alternatives, feed testing and ration design, planning for the next shortage and much more on feed and cattle.

Link: <https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/livestock/cattle-poultry-and-other-livestock/cattle/feeding-livestock-during-feed-shortages>

7.4 DROUGHT TOLERANT CROPS AND NATIVE GRASSES

Alberta Forage Manual

The Alberta Forage Manual is a guide designed for producers in Alberta to provide information on tame forage species. This can be used to assist BC producers in evaluating common species between the provinces and apply the information to help species selection in preparation of drought conditions.

Manual: [https://www1.agric.gov.ab.ca/\\$Department/deptdocs.nsf/all/agdex16/\\$FILE/120_20-1_2009.pdf](https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex16/$FILE/120_20-1_2009.pdf)

Fact Sheets: Irrigation Tips to Conserve Water on the Farm: BC Ministry of Agriculture (2015)

Series of fact sheets from Ministry of Agriculture outlining water conservation on farms, specifically in low water or drought conditions. For full list of Drought Factsheets visit:

<https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/drought-in-agriculture?keyword=drought>

Irrigated Alfalfa Management: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-5_irrigated_alfalfa_mgmt_-_drought_factsheet_no5.pdf

Alternate Forage Crops: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/drought/665000-6_alternate_forage_crops_-_drought_factsheet_no6.pdf

Peace Forage Seeding Tool: Peace Region Forage Association of British Columbia

An interactive forage seeding database for the Peace Region.

Main Site: <http://www.peaceforagetool.ca/>

Link to information on Native Grasses: <http://www.peaceforagetool.ca/plant-type/native-grass>

Forage U-Pick: Beef Cattle Research Centre.

An interactive forage species selection tool for Western Canada.

Species Selection Tool: <https://upick.beefresearch.ca/>

British Columbia Rangeland Seeding Manual: BC Ministry of Agriculture

Developed by Allen Dobb and Sandra Burton, this manual provides direction on proper seeding of rangeland for forage production systems for much of the interior regions of BC, as well as management contexts including ecosystem restoration, post-wildfire rehabilitation, and site rehabilitation.

Manual: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/rangelands/bc_rl_seeding_manual_web_single_150dpi0904.pdf

Fact Sheet: Developing improved native and tame forage varieties for Western Canada: Beef Cattle Research Council

The BCRC fact sheet outlines a project that has been built on the breeding work being done by researchers in Swift Current on native forage species under the first Beef Science Cluster.

Fact Sheet: <http://www.beefresearch.ca/fact-sheets/developing-improved-native-and-tame-forage-varieties-for-western-canada.pdf>

Academic Research Paper: Murphy et al (2007).

Surface runoff response of native and introduced grasses under simulated rainfall in southern Alberta. Canadian Journal of Soil Science.

Paper: <https://www.nrcresearchpress.com/doi/pdfplus/10.4141/CJSS07045>

7.5 AGROFORESTRY/SILVOPASTURE

Agroforestry for Landscape Restoration: Food and Agriculture Organization of the United Nations (2017)

Exploring the potential of agroforestry to enhance the sustainability and resilience of degraded landscapes. This report discusses the benefits of using agroforestry as a way of restoring soil and ecosystems. Included is a section on using agroforestry for increased water availability, which is partially achieved due to the increase in organic matter in the soil.

Report: <http://www.fao.org/3/b-i7374e.pdf>

Academic Research Paper: Tiwari et al (2017).

Soil Treatment through Agroforestry: A Review. International Journal of Pure and Applied Bioscience.

Link to Paper: <https://pdfs.semanticscholar.org/73c2/feb0d5dd23ed4e7dcbc319ed16bf41855e54.pdf>

7.6 CROP PROTECTION TECHNOLOGY (BLOCKING WIND, REDUCING EVAPORTRANSPIRATION)

Shelterbelts

Agroforestry Fact Sheet: Windbreaks, Shelterbelts, Timberbelts, Buffers: BC Ministry of Agriculture

Factsheet: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/agroforestry/100100-3_shelterbelts.pdf

Shelterbelts: BC Farm Practices & Climate Change Adaptation: BC Agriculture & Food Climate Action Initiative

This document was developed to address farm practices that have the potential to reduce risk or increase resilience facing climate change. Backgrounds on various shelterbelt technologies across BC are outlined in this report.

Report: <https://www.bcagclimateaction.ca/wp/wp-content/media/FarmPractices-Shelterbelts.pdf>

Field Shelterbelts for Soil Conservation: Government of Alberta (2007)

Benefits, species selection, and management of shelterbelts in fields.

Article: [https://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex2073/\\$file/277_20-3.pdf?](https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex2073/$file/277_20-3.pdf?)

Shelterbelt Planning and Establishment: Government of Canada

Links to information on Shelterbelt planning and design.

Website: <https://www5.agr.gc.ca/eng/science-and-innovation/agricultural-practices/agroforestry/shelterbelt-planning-and-establishment/?id=1344636433852>

7.7 REGULATION

Water Policy Bulletin: BC Ministry of Environment & Climate Change Strategy, Ministry of Forests, Lands, Natural Resource Operations & Rural Development

Authorization requirements for storage and use of water in dugouts (August 2017). This policy bulletin clarifies authorization requirements for water diversion in relation to dugouts under the Water Sustainability Act (WSA) for stream water and groundwater Issued by the Ministry of Environment and Climate Change Strategy and Ministry of Forests, Lands, Natural Resource Operations & Rural Development (See Section 4.4B).

Bulletin: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-rights/info_bulletin_-_dugouts_livestock_-_aug_2017.pdf

Webinar: Groundwater Licensing - What You Need to Know: BC Ministry of Agriculture

FrontCounter BC talks about the Water Sustainability Act, how to apply for your agricultural groundwater licence, and important deadlines. Recorded: January 17, 2018 Presenters: Emily Elsiger, Groundwater Protection officer, Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), Andrei Dmitriev, Natural Resource Specialist, FrontCounter BC, Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD).

Webinar: <https://www.youtube.com/watch?v=16jCr7CeOOA&feature=youtu.be>

BC Agriculture Water Calculator is a water planning tool to estimate theoretical annual irrigation and livestock water requirements in support of groundwater (and surface water) licensing applications (See Section 2): <http://bcwatercalculator.ca/agriculture/welcome>

BC Irrigation Water Use Calculator is a water management tool to estimate actual annual irrigation water usage in support of water use record keeping and reporting. This online tool serves as a free option for farmers (water licence holders) to track actual irrigation water use, so that they do not need to purchase a flow measuring device to meet requirements of their water licence (See Section 3):

<http://bcwatercalculator.ca/irrigation/calculator>

Towards Livestock Watering Regulations: British Columbia's Water Sustainability Act: Government of British Columbia

On July 23, 2020, an update was posted in regards to Livestock Watering Regulation.

Update (2020): <https://engage.gov.bc.ca/app/uploads/sites/71/2020/07/Update-on-Proposed-Livestock-Watering-Policy.pdf>

What We Heard Document: https://engage.gov.bc.ca/app/uploads/sites/71/2019/10/What-We-Heard_public_FINAL4.pdf

2018 Intention Paper:

https://engage.gov.bc.ca/app/uploads/sites/71/2018/01/Livestock_Watering_Regs_intentions_paper.pdf

Water: Environmental Protection & Sustainability: Government of British Columbia

Links to information on current water regulations for British Columbia.

Website: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water>

Living Water Smart: British Columbia's Water Plan: Government of British Columbia

The Water plan provides an overview of the government of BC's vision for sustainable water stewardship. The *Water Sustainability Act* which came into effect on February 29, 2016 was a part of the implementation of the Water Smart plan.

Link to report: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-planning/livingwatersmart_book.pdf

7.8 CLIMATE CHANGE AND WATER

Cultivating Climate Resilience on Farms and Ranches: Sustainable Agriculture Research and Education

Sustainable Agriculture Research and Education (SARE) is a group based out of the USA focusing on sustainable best management practices for agriculture. Although based on USA climate information, the themes of this article are relevant to understanding climate changes and risk in agriculture. It is written in 3 parts: Understanding Climate Risk, Understanding Climate Resilience, Managing Resources for Climate Resilience, and Exploring Your Risk and Assessing Your Options, which brings all of the information together to help work through issues affecting your farm.

Website: <https://www.sare.org/Learning-Center/Bulletins/Cultivating-Climate-Resilience-on-Farms-and-Ranches>

Strengthening BC's Agriculture Sector in the Face of Climate Change: Pacific Institute for Climate Solutions

This white paper developed by Pacific Institute for Climate Solutions (PICS) addresses various climate change issues in regards to agriculture, including sections on proper water management. They suggest promoting water storage, improving irrigation infrastructure and efficiency, improving drainage, and improving soil health.

https://pics.uvic.ca/sites/default/files/uploads/publications/Strengthening%20BC%27s%20Agriculture%20Sector_0.pdf

7.9 PREVIOUS WORKSHOPS ACROSS HIGHWAY 16

1. Smithers Farmers Institute (2016) hosted Andrew Petersen, Water Management Specialist, Ministry of Agriculture, and Dick Ford from Highlands Irrigation shared their expertise on provincial drought patterns, irrigation efficiency and various irrigation systems.

Link to presentation description and resource links: <http://www.smithersfarmersinstitute.com/on-farm-water-management.html>

2. Dam Safety Management Workshops we hosted in 2019 in Northern BC by Kevin Chan, Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

<https://www.bcia.com/sites/default/files/imce/PD/Presentations/3-Flyer-Fort-St-John-Oct-1%281%29.pdf>