GREATER VANCOUVER WATER DISTRICT (GVWD)
BOARD OF DIRECTORS

BOARD MEETING
Friday, March 31, 2023
9:00 am
28th Floor Boardroom, 4515 Central Boulevard, Burnaby, British Columbia
Webstream available at http://www.metrovancouver.org

Membership and Votes

A G E N D A[1]

A. ADOPTION OF THE AGENDA

1. March 31, 2023 Meeting Agenda
That the GVWD Board adopt the agenda for its meeting scheduled for March 31, 2023 as circulated.

B. ADOPTION OF THE MINUTES

1. February 24, 2023 Meeting Minutes *pg. 4*
That the GVWD Board adopt the minutes for its meeting held February 24, 2023 as circulated.

C. DELEGATIONS

D. INVITED PRESENTATIONS

E. CONSENT AGENDA
Note: Directors may adopt in one motion all recommendations appearing on the Consent Agenda or, prior to the vote, request an item be removed from the Consent Agenda for debate or discussion, voting in opposition to a recommendation, or declaring a conflict of interest with an item.

[1] *Note: Recommendation is shown under each item, where applicable. All Directors vote unless otherwise noted.*

1. CLIMATE ACTION COMMITTEE REPORTS

1.1 2023 Water Sustainability Innovation Fund Applications *pg. 9*

That the GVWD Board approve the allocation from the Water Sustainability Innovation Fund of $1,700,000 for the following projects, starting in 2023:

a) Reducing Oxygen Use and Increasing Resiliency at the Coquitlam Water Treatment Plant for $150,000 over two years;
b) Studying the Preliminary Feasibility of Green Hydrogen Production from Hydropower at Cleveland Dam for $250,000 over two years;
c) Evaluation of Biofiltration at the Seymour Capilano Filtration Plant for $300,000 over three years;
d) Next Generation Snowpack Monitoring – Phase 3 for $450,000 over three years;
e) Building the Next Generation of Seasonal Water Supply & Demand Planning Tools for $550,000 over two years.

2. WATER COMMITTEE REPORTS

2.1 Climate Impacts on the Water Supply Areas *pg. 22*

That the GVWD Board receive for information the report dated February 10, 2023, titled "Climate Impacts on the Water Supply Areas".

2.2 Award of Contract Resulting from RFP No. 22-139 Construction of the Coquitlam Main No. 4 South Section Robson Drive to Guildford Way *pg. 60*

That the GVWD Board:

a) approve the award of a contract in the amount of $97,196,248 (exclusive of taxes) to Michels Canada Company resulting from RFP No. 22-139: Construction of Coquitlam Main No. 4 South Section Robson Drive to Guildford Way, subject to final review by the Commissioner; and
b) authorize the Commissioner and Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

F. ITEMS REMOVED FROM THE CONSENT AGENDA

G. REPORTS NOT INCLUDED IN CONSENT AGENDA

H. MOTIONS FOR WHICH NOTICE HAS BEEN GIVEN

I. OTHER BUSINESS

1. GVWD Board Committee Information Items and Delegation Summaries *pg. 66*

J. BUSINESS ARISING FROM DELEGATIONS

K. RESOLUTION TO CLOSE MEETING

Note: The Board must state by resolution the basis under section 90 of the Community Charter on which the meeting is being closed. If a member wishes to add an item, the basis must be included below.

L. ADJOURNMENT/CONCLUSION

That the GVWD Board adjourn/conclude its meeting of March 31, 2023.

GREATER VANCOUVER WATER DISTRICT
BOARD OF DIRECTORS

Minutes of the Regular Meeting of the Greater Vancouver Water District (GVWD) Board of Directors held at 9:52 am on Friday, February 24, 2023, in the 28th Floor Boardroom, 4515 Central Boulevard, Burnaby, British Columbia.

MEMBERS PRESENT:

Delta, Chair, Director George V. Harvie
Anmore, Vice Chair, Director John McEwen
Belcarra, Director Jamie Ross
Burnaby, Director Pietro Calendino
Burnaby, Director Sav Dhaliwal
Burnaby, Director Mike Hurley
Coquitlam, Director Craig Hodge
Coquitlam, Director Teri Towner
Delta, Director Dylan Kruger
Electoral Area A, Director Jen McCutcheon
Langley City, Director Paul Albrecht
Langley Township, Director Eric Woodward
Langley Township, Director Steve Ferguson
Maple Ridge, Director Dan Ruimy
New Westminster, Director Patrick Johnstone
North Vancouver City, Director Linda Buchanan
North Vancouver District, Director Lisa Muri
Port Coquitlam, Director Brad West
Port Moody, Director Meghan Lahti
Richmond, Director Malcolm Brodie
Richmond, Director Bill McNulty
Richmond, Director Chak Au
Surrey, Director Linda Annis
Surrey, Director Harry Bains
Surrey, Director Gordon Hepner
Surrey, Director Pardeep Kooner
Surrey, Director Brenda Locke
Surrey, Director Rob Stutt
Tsawwassen, Chief Laura Cassidy*
Vancouver, Director Rebecca Bligh*
Vancouver, Director Adriane Carr
Vancouver, Director Lisa Dominato
Vancouver, Director Sarah Kirby-Yung*
Vancouver, Director Mike Klassen
Vancouver, Director Ken Sim
Vancouver, Director Lenny Zhou
West Vancouver, Director Mark Sager
Commissioner Jerry W. Dobrovolny
(Non-voting member)

MEMBERS ABSENT:

Pitt Meadows, Director Nicole MacDonald

STAFF PRESENT:

Dorothy Shermer, Corporate Officer
Natalia Melnikov, Legislative Services Coordinator, Board and Information Services

* denotes electronic meeting participation as authorized by Section 3.6.2 of the *Procedure Bylaw*

A. ADOPTION OF THE AGENDA

1. February 24, 2023 Meeting Agenda

It was MOVED and SECONDED
That the GVWD Board adopt the agenda for its meeting scheduled for February 24, 2023 as circulated.

CARRIED

B. ADOPTION OF THE MINUTES

1. January 27, 2023 Meeting Minutes

It was MOVED and SECONDED
That the GVWD Board adopt the minutes for its meeting held January 27, 2023 as circulated.

CARRIED

2. February 3, 2023 Special Joint Meeting Minutes

It was MOVED and SECONDED
That the GVWD Board adopt the minutes for its special joint meeting held February 3, 2023 as circulated.

CARRIED

C. DELEGATIONS

No items presented.

D. INVITED PRESENTATIONS

No items presented.

E. CONSENT AGENDA

It was MOVED and SECONDED
That the GVWD Board adopt the recommendations in the following items as presented in the February 24, 2023 GVWD Board Consent Agenda:

1.1 Coquitlam Sockeye Hatchery Land Use Licence Agreement & Water Use Agreement
1.2 Award of Contract Resulting from Request for Proposals No. 22-380: Construction of Kennedy Newton Main – Phase 3 South Section
1.3 Award of Contract Resulting from Tender No. 21-047: Backup Power Installation of Capilano Raw Water Pump Station

CARRIED

The items and recommendations referred to above are as follows:

1.1 Coquitlam Sockeye Hatchery Land Use Licence Agreement & Water Use Agreement

Report dated January 17, 2023, from Jesse Montgomery, Division Manager, Environmental Management, providing the GVWD Board with information on the Coquitlam Sockeye Hatchery, Land Use Licence Agreement, Water Use Agreement, and associated implications for the GVWD.

Recommendation

That the GVWD Board receive for information the report dated January 17, 2023, titled "Coquitlam Sockeye Hatchery Land Use Licence Agreement and Water Use Agreement".

Adopted on Consent

1.2 Award of Contract Resulting from Request for Proposals No. 22-380: Construction of Kennedy Newton Main – Phase 3 South Section

Report dated January 17, 2023, from Goran Oljaca, Director, Engineering and Construction, Water Services, and George Kavouras, Acting Director, Procurement and Real Estate Services, providing the GVWD Board with the results of RFP No. 22-380: Construction of KNM -Phase 3 South Section and to recommend award of the contract in the amount of $27,914,600 (exclusive of taxes) to B&B Contracting (2012) Ltd.

Recommendation

That the GVWD Board:

a) approve the award of a contract in the amount of $27,914,600 (exclusive of taxes) to B&B Contracting (2012) Ltd. resulting from RFP No. 22-380: Construction of Kennedy Newton Main - Phase 3 South Section, subject to final review by the Commissioner; and

b) authorize the Commissioner and the Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

Adopted on Consent

1.3 Award of Contract Resulting from Tender No. 21-047: Backup Power Installation of Capilano Raw Water Pump Station

Report dated February 13, 2023, from the Water Committee together with the report dated January 25, 2023, from Goran Oljaca, Director, Engineering and Construction, Water Services, and George Kavouras, Acting Director, Procurement and Real Estate Services, providing the GVWD Board with the results of Tender No. 21-047: Backup Power Installation of Capilano Raw Water Pump Station, requesting an increase of $27 million in the capital funding allocated for construction, and recommending award of a contract in the amount of up to $49,454,982 (exclusive of GST) to NAC Constructors Ltd.

Recommendation

That the GVWD Board:

a) authorize an increase of the budget for the Capilano Raw Water Pump Station Backup Power project and the Capilano Watershed Security Gatehouse project in the amount of $27 million; funds to be drawn from known savings on another project, bringing the revised combined budget for these projects to $83 million (exclusive of GST); and
b) approve award of a contract in the amount of up to $49,454,982 (exclusive of GST) to NAC Constructors Ltd. resulting from Tender No. 21-047: Backup Power Installation of Capilano Raw Water Pump Station, subject to final review by the Commissioner; and
c) authorize the Commissioner and the Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

Adopted on Consent

F. ITEMS REMOVED FROM THE CONSENT AGENDA

No items presented.

G. REPORTS NOT INCLUDED IN CONSENT AGENDA

No items presented.

H. MOTIONS FOR WHICH NOTICE HAS BEEN GIVEN

No items presented.

I. OTHER BUSINESS

1. GVWD Board Committee Information Items and Delegation Summaries

It was MOVED and SECONDED

That the GVWD Board receive for information the GVWD Board Committee Information Items and Delegation Summaries.

CARRIED

J. BUSINESS ARISING FROM DELEGATIONS

No items presented.

K. RESOLUTION TO CLOSE MEETING

It was MOVED and SECONDED

That the GVWD Board close its meeting scheduled for February 24, 2023 pursuant to section 226 (1) (a) of the *Local Government Act* and the *Community Charter* provisions as follows:

90 (1) A part of a council meeting may be closed to the public if the subject matter being considered relates to or is one or more of the following:

(e) the acquisition, disposition or expropriation of land or improvements, if the council considers that disclosure could reasonably be expected to harm the interests of the municipality.

CARRIED

L. RISE AND REPORT (Items Released from Closed Meeting)

No items presented.

M. ADJOURNMENT/CONCLUSION

It was MOVED and SECONDED

That the GVWD Board adjourn its meeting of February 24, 2023.

CARRIED

(Time: 9:53 am)

CERTIFIED CORRECT

Dorothy Shermer, Corporate Officer

George V. Harvie, Chair

58349482 FINAL

To: Climate Action Committee

From: Linda Parkinson, Director, Policy, Planning and Analysis
Water Services Department

Date: February 9, 2023 Meeting Date: March 9, 2023

Subject: **2023 Water Sustainability Innovation Fund Applications**

RECOMMENDATION

That the GVWD Board approve the allocation from the Water Sustainability Innovation Fund of $1,700,000 for the following projects, starting in 2023:

a) Reducing Oxygen Use and Increasing Resiliency at the Coquitlam Water Treatment Plant for $150,000 over two years;
b) Studying the Preliminary Feasibility of Green Hydrogen Production from Hydropower at Cleveland Dam for $250,000 over two years;
c) Evaluation of Biofiltration at the Seymour Capilano Filtration Plant for $300,000 over three years;
d) Next Generation Snowpack Monitoring – Phase 3 for $450,000 over three years;
e) Building the Next Generation of Seasonal Water Supply & Demand Planning Tools for $550,000 over two years.

EXECUTIVE SUMMARY

The Climate Action Committee oversees the Sustainability Innovation Funds and makes all funding recommendations to the GWVD Board. Staff assist the Climate Action Committee in reviewing and evaluating all applications that are submitted for consideration. This report presents five applications recommended for funding, totalling $1,700,000 over three years, which will be funded through the Water Sustainability Innovation Fund. The applications cover a range of areas, including water source and supply, water treatment and quality, and sustainable infrastructure. Projects like the Next Generation Snowpack Monitoring – Phase 3 will help Metro Vancouver adapt to the uncertainty of a changing climate, as we will continue to face severe weather events like the reduced snowpack of 2015, the heat dome in 2021, and the extended hot dry summer of 2022 that lasted well into October and required us to extend our watering restrictions to the end of October.

PURPOSE

To present five projects recommended for Sustainability Innovation Funding for the Climate Action Committee and the GVWD Board's consideration.

BACKGROUND

The Water Sustainability Innovation Fund (the Fund) was created by the GVWD Board (the Board) in 2004 to provide financial support to Water applications that contribute to the region's sustainability. The GVWD Board adopted the *Water Sustainability Innovation Fund Policy* in 2014, with further amendments in 2016 and 2021, to guide the use and management of the Fund. The Policy describes the process of generating, submitting, evaluating and recommending applications for funding each year.

The Climate Action Committee is responsible for overseeing the Fund and for making all funding recommendations to the GVWD Board. Staff assist the Climate Action Committee in reviewing and evaluating all applications that are submitted for consideration.

WATER SUSTAINABILITY INNOVATION FUND POLICY

On an annual basis, Water applications are submitted to an internal staff Steering Committee, representing a cross-section of the organization, to evaluate applications and initiatives based on the Fund's evaluation criteria. As defined in the policy, applications need to fulfill the following criteria:

- Be overseen by the GVWD
- Be consistent with the authority and responsibility of the GVWD
- Be consistent with the objectives of the *Drinking Water Management Plan* and/or the *Board Strategic Plan*
- Consider partnerships including, but not limited to, member jurisdictions, academic institutions, non-governmental organizations, and community groups
- Result in a positive contribution, in the form of tangible results and/or measurable benefits, to the sustainability of the region and
- Demonstrate innovation and facilitate action

The Climate Action Committee receives an annual update report on the approved applications from previous years that have become projects supported by the Fund. The update report includes the deliverables, outcomes, and the measurable benefits of these projects to the region's sustainability. A summary of past projects can be found on the Sustainability Innovation Program website (Reference 1).

2023 APPLICATION PROCESS

An internal call for applications closed on November 4, 2022, and five applications from Water Services were considered by the cross-departmental Sustainability Innovation Fund Steering Committee, comprised of representatives from seven different departments within Metro Vancouver.

The Steering Committee evaluated the submissions and determined that five applications strongly align with promoting regional sustainability and innovation. The projects recommended for funding by the Steering Committee are listed in the table below, with additional detail provided in the executive summaries (Attached).

Recommended Allocation from the Water Sustainability Innovation Fund		
Project Title	**Year**	**Amount Requested**
Reducing Oxygen Use and Increasing Resiliency at the Coquitlam Water Treatment Plant	2023-2024	$150,000
Studying the Preliminary Feasibility of Green Hydrogen Production from Hydropower at Cleveland Dam	2023-2024	$250,000
Evaluation of Biofiltration at the Seymour Capilano Filtration Plant	2023-2025	$300,000

Recommended Allocation from the Water Sustainability Innovation Fund		
Project Title	**Year**	**Amount Requested**
Next Generation Snowpack Monitoring – Phase 3	2023-2025	$450,000
Building the Next Generation of Seasonal Water Supply & Demand Planning	2023-2024	$550,000
Total		**$1,700,000**

ALTERNATIVES

1. That the GVWD Board approve the allocation from the Water Sustainability Innovation Fund of $1,700,000 for the following projects, starting in 2023:
   a) Reducing Oxygen Use and Increasing Resiliency at the Coquitlam Water Treatment Plant for $150,000 over two years;
   b) Studying the Preliminary Feasibility of Green Hydrogen Production from Hydropower at Cleveland Dam for $250,000 over two years;
   c) Evaluation of Biofiltration at the Seymour Capilano Filtration Plant for $300,000 over three years;
   d) Next Generation Snowpack Monitoring – Phase 3 for $450,000 over three years;
   e) Building the Next Generation of Seasonal Water Supply & Demand Planning Tools for $550,000 over two years.

2. That the Climate Action Committee receive for information the report dated February 9, 2023, titled "2023 Water Sustainability Innovation Fund Applications" and provide alternate direction to staff.

FINANCIAL IMPLICATIONS

If the Board approves Alternative 1, $1,700,000 for the five applications will be disbursed from the Water Sustainability Innovation Fund over three years. The Fund has sufficient budget to support Alternative 1.

The approved applications will be incorporated into the applicable work plans and budgets.

CONCLUSION

Staff recommend that the Climate Action Committee approve the Steering Committee's recommendations for funding the applications and forward the recommendations to the GVWD Board for consideration. Staff recommendations are presented as Alternative 1. Additional details of each project are provided in the executive summaries (Attached).

Attachment

Water Services Sustainability Innovation Fund – Executive Summaries

References

http://www.metrovancouver.org/services/air-quality/sustainability-innovation-program/Pages/default.aspx

58025873

Sustainability Innovation Fund: Water Services
Executive Summary

Project Name: **Reducing Oxygen Use and Increasing Resiliency at the Coquitlam Water Treatment Plant**

Amount Requested from Sustainability Innovation Fund: $150,000

Purpose:
This project will investigate the feasibility of emerging and innovative technologies to efficiently use oxygen and ozone at the Coquitlam Water Treatment Plant (CWTP) and reduce the current operational costs associated with liquid oxygen supply. This project aims to reduce dependency on a supply chain and transportation network and reduce GHG emissions while increasing the resiliency of critical water supply infrastructure.

Project Objectives:
This project will provide a basis for implementing innovative technologies which will reduce reliance on external oxygen suppliers and substantially reduce recurring oxygen costs. This has the potential to increase overall treatment resilience while reducing operational costs.

Contributions to Regional Sustainability:
Reducing the need for liquid oxygen deliveries will reduce dependency on the supply chain and transportation networks. Transportation of liquid oxygen from across the border will be reduced from approximately 150 trips, resulting in lower GHG emissions. By investigating the feasibility of reduced oxygen use at the CWTP, the project findings will help remove the vulnerability within the oxygen supply chain, and increase the resiliency of critical water supply infrastructure and treatment processes.

Innovation Element:
The two separate technologies for oxygen generation and oxygen recovery are not commonly deployed at water treatment plants. This project will consider integrating these emerging and innovative technologies with the current treatment process and each other. A technology demonstration pilot may be conducted in future phases of the project to validate the findings of this project.

There is the potential to integrate with the Green Hydrogen Project (separate WSIF Application 2023) to utilize some of the oxygen that could potentially be produced using hydropower at the Cleveland Dam.

Tangible Benefits and Outcomes:
This project will provide a roadmap for reducing the overall oxygen use at CWTP. It will also provide Metro Vancouver staff with training and exposure to these emerging technologies.

The final project report will include:

- A life-cycle-cost / benefit analysis of the current technologies available to reduce the dependence on oxygen deliveries at CWTP. This will include an evaluation of the payback period

- An Evaluation of available technologies based on technology maturity, effectiveness, operational complexity and life cycle cost

- A project implementation plan of viable technologies. This could involve additional data collection or a pilot to demonstrate the technology. Later phases could involve conceptual and indicative designs.

Members and other Partners:

An engineering consultant will be retained to conduct the evaluation. Technology suppliers will be engaged to confirm technology maturity, compatibility and capability.

Sustainability Innovation Fund: Water Services
Executive Summary

Project Name: **Studying the Preliminary Feasibility of Green Hydrogen Production from Hydropower at the Cleveland Dam**

Amount Requested from Sustainability Innovation Fund: $250,000

The budget is requested over two years, starting in Q3 of 2023:

- 2023: $100,000
- 2024: $150,000

Purpose:

This SIF project will help determine if hydrogen and oxygen production by electrolysis is a suitable end-use option for potential hydropower at the Cleveland Dam (CLD). Through this project, Metro Vancouver will further its understanding of the potential sustainable end uses for hydropower power that can be produced at the CLD.

Project Objectives:

This preliminary feasibility will investigate the production of green hydrogen and oxygen at the CLD using hydropower and will explore their market potential in the region. The findings will inform future decisions on the next steps toward improving the feasibility of hydropower generation at the CLD while improving downstream fish passage from the Capilano Reservoir to the Capilano River.

Contributions to Regional Sustainability:

The project supports the strategic directions of the *Board Strategic Plan* (2019-2022) for Water Services and Air Quality & Climate Change. It also aligns with the goals and strategies of the *Drinking Water Management Plan, Clean Air Plan, Climate 2050,* and the *Climate 2050 Energy Roadmap*.

The project will identify and assess whether hydrogen production is a possible end-use of hydropower generation. It could be one of the first steps to restoring downstream fish passage and enhancing habitat and sustainable recreation on the Capilano River by providing the necessary justification for proceeding with hydropower generation and associated fish passage enhancements at the CLD.

The province and region have aggressive targets to reduce carbon emissions and anthropogenic environmental impacts. Hydrogen will contribute a significant portion of the anticipated reductions by filling energy gaps that cannot be met by other fuel types or energy storage options.

Innovation Element:

Green hydrogen has significantly lower carbon emissions than hydrogen produced through other means, such as the steam reforming of natural gas (blue hydrogen) that makes up most of the current hydrogen market. If feasible, Metro Vancouver could lead by example, demonstrating to similar organizations how they can contribute to the clean energy sector in new and innovative ways.

Initial estimates indicate that the 50 GWh of potential hydropower at CLD could, in turn, produce approximately 1,000 metric tonnes of hydrogen and 7,900 metric tonnes of oxygen annually. This project will identify uses for this green hydrogen and oxygen within the Metro Vancouver utilities and potential regional markets to capitalize on this rapidly emerging marking opportunity.

Tangible Benefits and Outcomes:

The key outcomes of this project are:

1. To assess if hydrogen and oxygen production by electrolysis is a feasible end-use option for potential hydropower generated at the CLD
2. To determine if and how much revenue could be generated from the sale of hydrogen and/or oxygen, and
3. To use the initial assessment results to develop a scope of work to determine how hydrogen production, hydropower generation, and downstream fish passage at the CLD could co-function and to identify potential benefits of the integrated hydropower and hydrogen technology processes.

The exploration of hydropower end-use will determine if it is feasible to improve downstream fish passage, implement hydropower generation, and subsequently realize the plethora of positive impacts that it would bring to the regional community and environment. This might include:

- Improved fish populations
- Increased recreation on the Capilano River
- Efficient use of spill water at the CLD, and
- Reduction in fossil fuel use and labour related to the Trap and Truck Program.

In addition, if an internal hydrogen customer is found within the Metro Vancouver utilities, it would contribute to the organization's circular economy and may enable low-carbon fuel credits to be claimed.

The project will also illustrate Metro Vancouver's commitment to the environment and support its relationships with stakeholders, such as First Nations communities and salmonid-related interest groups.

Members and other Partners:

Several governmental and non-governmental organizations may support this project by providing information and guidance regarding the various products and services being investigated. These include:

- BC Hydrogen Office
- BC Hydrogen and Fuel Cell Association
- Centre for Innovation and Clean Energy
- Clean Energy Research Centre, and
- Commercial end users

Stakeholders from internal Metro Vancouver utilities will also be further engaged to discuss the potential for internal use of hydrogen. Liquid Waste Services is considering hydrogen injection to increase biogas production in their anaerobic digesters, and Fleet Services is considering a long-term shift to hydrogen fuel cell technology. Within Metro Vancouver, Water Services staff will partner with Invest Vancouver for this project.

Sustainability Innovation Fund: Water Services
Executive Summary

Project Name: **Evaluation of Biofiltration at the Seymour Capilano Filtration Plant**

Amount Requested from Water Sustainability Innovation Fund: $300,000

The budget is requested over three years, starting in Q2 of 2023:

- 2023: $80,000
- 2024: $100,000
- 2025: $120,000

Budget by project phase:

- Phase 1 (2023-2025): $200,000
- Phase 2 (2025, pending the outcome of Phase 1): $100,000

Purpose:

This project will evaluate the implementation of biofiltration at the Seymour Capilano Filtration Plant (SCFP), beginning with a desktop literature review. The advantages, risks, and site-specific considerations for adopting biofiltration at the SCFP will be assessed. A full-scale biofiltration demonstration will then be planned and implemented for at least one year. If the demonstration is successful, a long-term implementation plan for the whole plant will be developed, with operational guidance documentation and processes, to ensure continued, safe and reliable performance.

Project Objectives:

This project will characterize the effects of biofiltration on drinking water quality, operational costs, and maintenance efforts at the SCFP. If biofiltration can be implemented successfully at the plant, it can lead to improvements in drinking water quality across the region through more stable chlorine residuals and lower levels of disinfection by-products (DBPs).

Contributions to Regional Sustainability:

Biofiltration may provide multiple benefits to treated drinking water quality and operational costs with minimal capital investment. By improving treatment at the SCFP, the system can be more resilient to changes in source water quality due to climate change impacts.

Biofiltration involves eliminating the chlorination of filter backwash water. At a minimum, this reduction in chemical consumption will reduce Metro Vancouver's carbon footprint through decreased delivery frequency and trucking requirements.

Other possible environmental benefits depend on the success of biofiltration. For example, there is a potential to reduce energy consumption and wasted water as backwashing cycle frequencies, and intensities, are reduced. These impacts can be determined and quantified after Phase 1.

Innovation Element:

The project capitalizes on an opportunity resulting from recent upgrades to the SCFP infrastructure, mainly the new stainless steel underdrains system. Effective biofiltration and system resiliency can be achieved without considerable capital investment.

While biofiltration is not uncommon in North America, it is practiced at only a few drinking water treatment facilities in British Columbia. By conducting a year-long study with measurable outcomes and tangible results, Metro Vancouver will be well-positioned to assess the implementation of biofiltration at the SCFP and as a provincial leader of the practice. If Phase 2 goes ahead and if biofiltration is implemented at the whole plant scale, the SCFP will be one of the largest biofiltration facilities in North America.

Tangible Benefits and Outcomes:

The primary outcomes of this project and phases will include the following tasks to be carried out by a consultant, and guided by Metro Vancouver Water Services staff :

Phase 1:

1. A literature review of current research will be completed to survey biofiltration impacts on drinking water treatment and outcomes at comparable facilities. The advantages, risks, and site-specific considerations for adopting biofiltration at the SCFP will be assessed.
2. Following desktop assessment, a full-scale demonstration biofiltration study plan will be developed. The demonstration study would run for one year, with technical support from the consultant (including water sampling, data analysis, and monthly updates). A technical report will be prepared, outlining the outcomes of the full-scale study.

Phase 2:

3. If Phase 1 is successful, the plant may be converted to biofiltration operation guided by a long-term implementation plan. The plan's success will be measured by water quality and operational improvement at the SCFP. Other metrics will include monitoring of the drinking water transmission and distribution systems and comparison against past trends.

The drinking water transmission and distribution systems could also see a reduction in cleaning and flushing requirements for Metro Vancouver and member jurisdictions. Initial high-level estimates indicate savings of at least $15,000 per year in operational and chemical costs. More detailed cost savings and outcomes can be determined and quantified after Phase 1.

Members and other Partners:

Metro Vancouver is collaborating with academic partners at Simon Fraser University (SFU) on a separate research project at the SCFP that will provide evidence that biofiltration is being achieved during the full-scale study. These academic partners will be invited to join the project team.

Member jurisdictions will be informed and engaged in Phase 2. Chlorine stability throughout the distribution system is expected to improve with full-scale biofiltration implementation, so jurisdictions with secondary disinfection stations may need to adjust re-chlorination doses and provide water quality monitoring results.

Sustainability Innovation Fund: Water Services
Executive Summary

Project Name: **Next Generation Snowpack Monitoring – Phase 3**

Amount Requested from Water Sustainability Innovation Fund: $450,000

The budget is requested over three years, starting in Q2 of 2023.

- 2023: $150,000
- 2024: $150,000
- 2025: $150,000

Purpose:

Seasonal snow and snow melt on the North Shore Mountains have been considered a significant part of the region's drinking water supply since the early 1900s. This vital resource is also highly vulnerable to changing climate conditions. Snow and stored water in snow are critical to water supply and dam safety planning. However, they are notoriously hard to accurately measure and quantify, especially over complex mountainous terrain in the Metro Vancouver watersheds. This Water Sustainability Innovation Fund (WSIF) project will continue from the earlier Next Generation Snowpack Monitoring (NGSM) phases by adding emerging technology and processes to modernize and operationalize the watershed snowpack monitoring program.

Project Objectives:

This Phase 3 project will look to incorporate the spatial remote sensing tools from the earlier research and development phases into the operational snow monitoring program. If successful, these spatial snow monitoring tools will become an integral part of the watershed snow monitoring program. The aim is to produce validated LiDAR-derived snow depth, and snow water equivalent (SWE) results within one week of data acquisition. These comprehensive, accurate and improved snow distribution data will help inform the development of new hydrological models of the Seymour and Capilano watersheds (WSIF project approved 2022).

These new tools will significantly improve snow data products' accuracy for short- and long-term water supply planning and management.

Contributions to Regional Sustainability:

Accurate and detailed snowpack monitoring data products will help Metro Vancouver manage the watersheds and source water supply more efficiently and confidently. Over time, these data products and spatial analyses will be used in climate change studies and for resiliency planning. The outputs will also inform long and medium-term water plants.

Once remote monitoring processes are fully established and operational, there will be less reliance on manual snow observations. There is potential to lower helicopter transportation time and expenses and to reduce overall program greenhouse gas (GHG) emissions by an estimated 60%.

Collecting LiDAR and satellite data can be helpful for other studies, such as forest health monitoring and landslide analysis and monitoring. The provider of aerial LiDAR and one of the project partners, Kisik Aerial Survey, offsets their emissions, making it carbon neutral and further reducing overall emissions of the snow monitoring program.

Innovation Element:

This project is integrating cutting-edge technology into the existing snow monitoring program. It uses an innovative and balanced approach to monitor and report snow conditions in our watershed areas. Many of the tools proposed have been well-researched but have not been used collectively in an operational snow monitoring program. This work puts Metro Vancouver on the leading technological edge of snowpack monitoring. The tools and experiences gained by integrating these technologies into operations can be shared with other Provincial entities.

Tangible Benefits and Outcomes:

During phases 1 and 2, the most appropriate technologies were identified and studied. The focus has been on remote sensing tools like satellite imagery and light detection and ranging (LiDAR). The work completed in the first two phases has already contributed to improved snowpack measuring methodologies, trials and partial integration of new technology.

The key outcomes for phase 3 include:

- Developing processes and workflows to incorporate remote sensing tools and data products into the operational watershed snowpack monitoring program;
- Combining remote sensing products (airborne LiDAR, Satellite, Remotely Piloted Aerial Systems, drone-based LiDAR) to model snow water equivalent (SWE) in all three water supply areas at varying temporal scales;
- Integrate snow data products into newly developed hydrological models of the Capilano and Seymour watersheds.

Members and other Partners:

Metro Vancouver has worked extensively with Vancouver Island University (VIU) during phases 1 and 2 of the NGSM project. This work has involved the Airborne Coastal Observatory (ACO), a collaboration between VIU, the University of Northern British Columbia, the Hakai Institute (Tula Foundation), Kisik Aerial Survey, BC Hydro, and several regional districts on Vancouver Island. The ACO is a dedicated aircraft with a LiDAR sensor and hyperspectral imager.

For phase 3, we will continue to work with VIU and the ACO to develop procedures and workflows to make LiDAR snow products an operational component of Metro Vancouver's snow monitoring program. This work will benefit other members who are involved with the ACO.

Sustainability Innovation Fund: Water Services
Executive Summary

Project Name: **Building the Next Generation of Seasonal Water Supply & Demand Planning Tools**

Amount Requested from Sustainability Innovation Fund: $550,000

The budget is requested over two years, starting in Q3 of 2023:

- 2023: $150,000
- 2024: $400,000

Purpose:

This project will build the next generation of Metro Vancouver's water supply and demand planning tool and develop a public-facing Drinking Water Stress Index (DWSI) to inform the regional water supply availability.

Project Objectives:

This project will develop a tool to forecast the short-term water supply and demand more accurately and promote evidence-based decisions when managing the region's drinking water supply. It will improve in-house analytical capabilities to make informed decisions about the annual water supply and the watering restrictions. The DWSI will support and strengthen Metro Vancouver's existing communications with member jurisdictions, the media, and the general public by sharing the region's water supply and demand status.

Contributions to Regional Sustainability:

With a faster and more accurate decision-making tool, the project helps build resiliency as changes in climate, demographics, and regulatory requirements impact water availability, supply and demand in the region.

The advanced tool will reduce potential for errors through data-driven decision-making, enhance the timeliness of analysis and results, and improve confidence in the outputs. These will improve source water monitoring, tracking supply and demand changes, and enhance operations and maintenance planning in the water supply system.

The DWSI will act as an additional communication tool to support the public's understanding and awareness of the Metro Vancouver's source water supply and demands. The DWSI would allow the media, member jurisdictions, and the general public to access more public-friendly communication about the level of stress on the regional drinking water supply system.

Innovation Element:

The current Decision Support System (DSS) Model monitors short-term drinking water supply and demand through the annual high water demand period, relying on historic worst-case conditions for

demand and drought. Accurate supply and demand monitoring and forecasting will be crucial in water supply planning for future high-demand periods, given the impacts of climate change. The new tool will use innovative forecasting techniques and climate change scenarios to incorporate additional crucial variables (e.g. temperature, rainfall, snowpack, demographic changes, watering restrictions and operational conditions) to forecast the short-term drinking water supply and demand.

According to the Drinking Water Conservation Plan, water restriction stages are advanced by reviewing various factors, including the outputs of the DSS. The outputs of the new tool will be used to systematically and transparently advance the restrictions of the DWCP.

The possibility of integrating with other SIF project outcomes will be explored, such as the Next Generation Snowpack Monitoring and hydrological model development projects.

Tangible Benefits and Outcomes:

The key outcomes of this project are:

- To develop a decision-making tool which is more accurate in monitoring and forecasting the short-term water supply and demand.
- To develop triggers to create a more systematic process for activating and deactivating the DWCP watering restriction stages.
- To supplement the existing communication tools by developing a DWSI to communicate the status of the water supply to the member jurisdictions, the media and the general public.

Members and Other Partners:

The ability to accurately monitor and accurately forecast the drinking water supply and demand will be crucial to Metro Vancouver's ability to continue to effectively work with the other organizations that also rely on the drinking water source reservoirs, including BC Hydro and DFO. Many organizations rely on Metro Vancouver to provide accurate data and reliable forecasting of the region's short-term supply and demand. In cases where water resources are shared or also required by other organizations, developing the decision-making tool will include their partnership and inputs.

Through improving the ability to communicate the drinking water supply and demand status with the region, Metro Vancouver will remain a trusted partner in maintaining some of the region's most important water bodies.

The Metro Vancouver Corporate Communications team, will determine the requirements of the public-facing DWSI (or equivalent), with the goal of producing a tool that is easily understood by the key stakeholder groups (the public, media, and member jurisdictions).

To: GVWD Board of Directors

From: Water Committee

Date: March 15, 2023 Meeting Date: March 31, 2023

Subject: **Climate Impacts on the Water Supply Areas**

WATER COMMITTEE RECOMMENDATION

That the GVWD Board receive for information the report dated February 10, 2023, titled "Climate Impacts on the Water Supply Areas".

At its March 15, 2023 meeting, the Water Committee considered the attached report titled "Climate Impacts on the Water Supply Areas" dated February 10, 2023.

The Committee subsequently amended the recommendation as presented above in underline style to bring the report forward to the GVWD Board for information.

This matter is now before the Board for its consideration.

Attachment

"Climate Impacts on the Water Supply Areas" dated February 10, 2023.

58826522

To: Water Committee

From: Peter Marshall, Field Hydrologist, Environmental Management, Water Services

Date: February 10, 2023 Meeting Date: March 15, 2023

Subject: **Climate Impacts on the Water Supply Areas**

RECOMMENDATION

That the Water Committee receive for information the report dated February 10, 2023, titled "Climate Impacts on the Water Supply Areas".

EXECUTIVE SUMMARY

Water Services manages a network of automated hydro-meteorological stations, and conducts several annual field sampling programs. Data collected from this monitoring program is used to actively monitor environmental conditions in the Capilano, Seymour, and Coquitlam River Watersheds. This program has become particularly important in the context of climate change, as climate variability increases and historical patterns shift.

Two recent events highlight how quickly our climate is changing: The June 2021 heatwave, and the 2022 fall drought. The infamous 'heat dome' was one of the most anomalous regional extreme heat events to occur anywhere on Earth. The recent fall drought was also unprecedented, and will be discussed in more detail below. These extreme events are occurring more frequently, and are projected to become more normal in the near future. The impacts from these events highlight the importance of comprehensive environmental monitoring, and the need for accurate weather and water supply forecasts.

PURPOSE

This report is intended to provide the Committee with information on weather and climate conditions in the water supply areas, and to highlight how quickly the local climate is changing. Several impactful local weather events from 2022 are also summarized. The report is prepared to share data with Metro Vancouver staff, and to help inform decision-making with regards to regional planning and climate change initiatives.

BACKGROUND

Water Services' monitoring programs provide reliable and timely information on source water quality and quantity, stream flow, and wildfire risk in the water supply areas. This information assists in managing source reservoirs and optimizing water treatment, which helps minimize risks to drinking water quality. The annual Watershed Climate Report summarizes key parameters including air temperature, precipitation, snowpack, stream flow, and wildfire conditions. It is an opportune time to update the Committee with the notable climate and weather-related changes within the region.

WEATHER AND CLIMATE HIGHLIGHTS

Climate Change Projections

Climate Projections for Metro Vancouver (2016) describes expected changes in temperature, precipitation, and other parameters in the Metro Vancouver region by 2050 and 2080. This report used existing climate model outcomes to provide a best estimate on how conditions will change in the region. All models from these projections show an increase in daytime high and nighttime low temperatures, with the greatest increase in the summer months. Warmer temperatures will greatly reduce peak spring snowpack levels, which in turn, will reduce summer and early-fall river inflows. For precipitation, the region can expect more intense and more frequent rainfall events in the fall and winter months. Longer summer dry spells extending into fall droughts are also more likely in the future. Recent years have given a glimpse of what conditions will be consistently like in the coming decades. These conditions illustrate how quickly the climate is changing, and how hard it is becoming to predict the severity of weather events based on historical conditions.

2022 Weather Summary

The past year brought significant weather extremes from season to season. The year 2022 will be remembered primarily for the extended summer-fall drought and extreme heat in early fall, but there were other notable events worth highlighting.

The spring was persistently cool and wet. April and May were both approximately two degrees cooler than average. Precipitation fell on 63 of 82 days between April 1 and June 21 (77%). These conditions were beneficial for the mountain snowpack, which grew from near-normal levels on April 1, to over 180% of normal in mid-June. This late-season snow accumulation was pivotal for the summer and fall water supply.

Warm and dry weather arrived in July. The summer months (June-July-August) were the second hottest on record, and August was the first month ever with mean monthly temperatures over 20°C[1]. The most exceptional period came in the first three weeks of October where new high temperature records were set on 14 of the first 17 days of the month. October averaged almost four degrees warmer than normal, despite seeing cool temperatures for the last week of the month. The water supply areas only received 48 millimeter (mm) of precipitation between July 21 and October 21, which included a 27-day long dry spell in late September and October.

The drought came to a quick conclusion at the end of October and early November as a series of atmospheric rivers targeted the south coast. These weather systems delivered over 400 mm of precipitation in just two weeks. November and December saw cool temperatures and low-elevation snowfall events, which made travel throughout the Metro Vancouver region very challenging. The end of the year experienced extreme weather including a substantial snow storm, freezing rain, and prolonged heavy rainfall. A new high water level was recorded at the Point Atkinson Tidal Monitoring Station in West Vancouver on December 27 when heavy rains and high river levels combined with a king tide.

[1] Data from the Lower Capilano fire weather station on the east side of the Capilano Reservoir. Similar conditions were observed at other weather stations within the water supply areas.

Notable Events

Seasonal drought was severe in the Lower Mainland in 2022. Persistent hot and dry weather pushed the Lower Mainland basin to provincial drought level 4 by mid-September, and level 5 for the first three weeks of October. Under drought level 5, conditions are exceptionally dry and adverse socio-economic and ecosystem impacts are almost certain. It should be noted that Metro Vancouver remained at the Stage 1 water restriction level of the *Drinking Water Conservation Plan* throughout the 2022 peak demand period. Stage 1 restrictions were extended by two weeks from October 15 to October 30 with the goal of reducing non-essential drinking water use during the extended drought. Mean monthly river inflows in September were the lowest for any month in our recorded history (c. 1914).

Hot and dry conditions also resulted in several local and regional wildfires at the tail end of the wildfire season. Most notable, the Minnekhada Regional Park fire sparked on October 1 under summer-like weather conditions. This fire grew to 14 hectares and took crews several weeks to fully extinguish. Wildfire smoke also flooded into the Lower Mainland several times in 2022, resulting in smoke-related air quality advisories for 18 days. This was the seventh year since 2015 that the region was inundated with wildfire smoke.

The Coquitlam Glacier, the last remaining glacier in the water supply areas, was surveyed in late 2022. The results show that this small glacier has decreased in area by 20% since 2014, and has lost an average depth of just over 10 metres. As glaciers get smaller their melt rate tends to increase; however, the Coquitlam Glacier has seen a five-fold increase in melt rates since 2018, which is much greater than normal. This glacier will likely disappear completely within the next 20 to 30 years. It is not a significant source of drinking water, but it is a symbol of climate change impacts in the region. Rising air temperatures, longer snow free seasons, and deposits of ash from wildfire smoke are all factors increasing the melt rate of glaciers like this.

ALTERNATIVES

This is an information report. No alternatives are presented.

FINANCIAL IMPLICATIONS

Data collected and used in this report is funded by the Watersheds & Environment program budget as well as through partnerships with other organizations. Upgrades to snow monitoring methodologies and technologies have been funded by the GVWD Sustainability Innovation Fund.

CLIMATE RESILIENCE

Population growth and climate change will continue to impact the regional drinking water source supply and transmission system, and Water Services is planning for the future with these in mind. Short and long-term plans focus on promoting conservation, improving transmission, and expanding supply.

Water Services' monitoring program is focused on collecting valuable information on environmental conditions in the water supply areas, which is used to inform decision-making. This program has adopted emerging new technologies in recent years that have enhanced the program as well as reduced greenhouse gas emissions by minimizing helicopter travel for field-based sampling.

CONCLUSION

The weather in 2022 was erratic and exhibited some of the conditions expected for the coming years based on regional climate change projections. The climate is changing rapidly, making it difficult to predict conditions based on historical averages and extremes. There is an extensive monitoring program in the water supply areas, which collects essential environmental data to support short and long-term decision making. A complete understanding of conditions in the water supply areas, and how these conditions are changing, allows Metro Vancouver to deliver high-quality drinking water and ensure the system's resilience in the face of the variable impacts of climate change from year-to-year.

Attachment

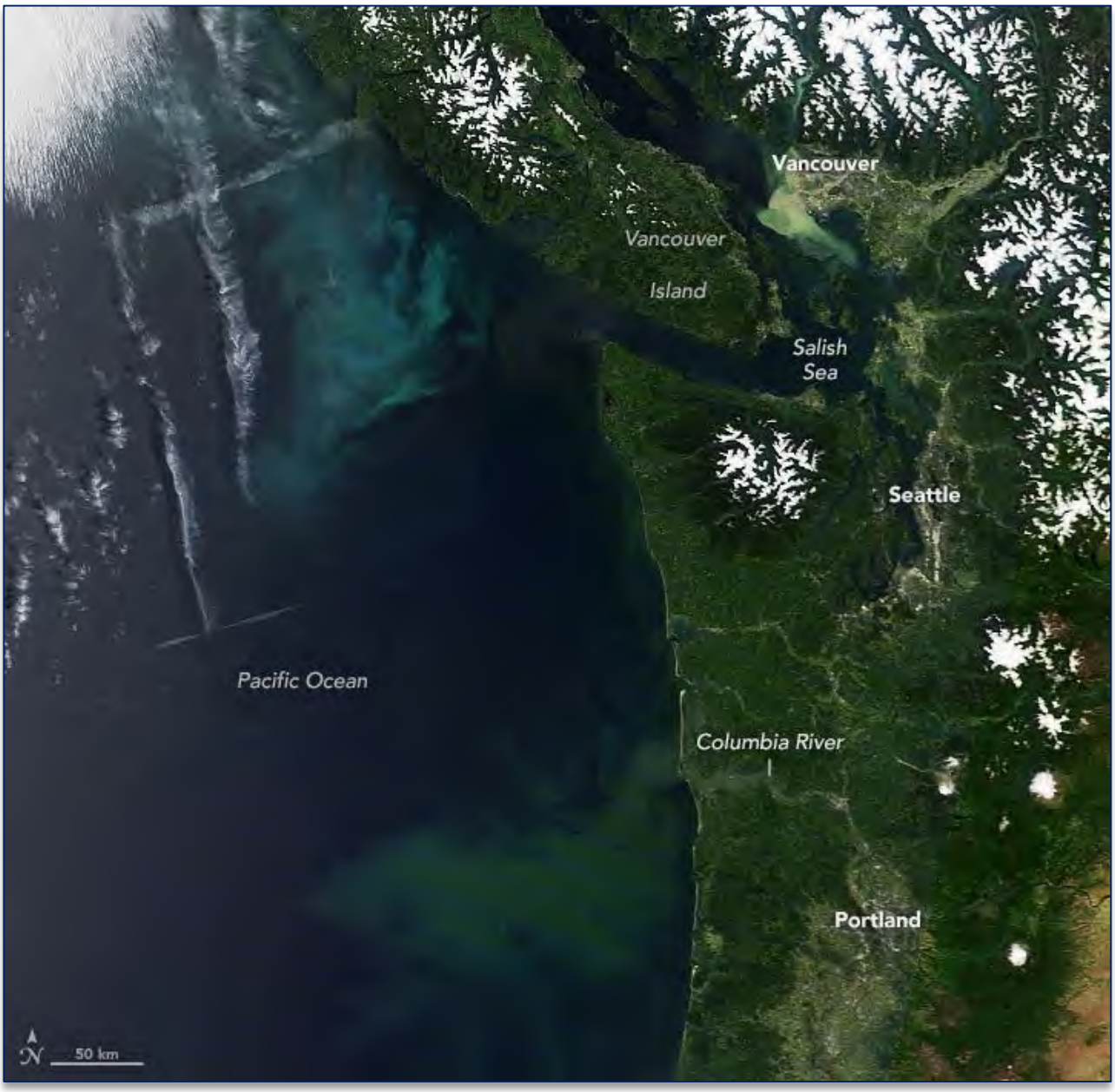
"Watershed Climate Report", dated, January 17, 2023

Reference

Climate Projections for Metro Vancouver (2016)

57804972

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION



Watershed Climate Report

2022 Annual Weather and Climate Summary

Watershed Climate Summary

Prepared by

Peter Marshall

Water Services

Watersheds and Environment

Environmental Management

Metro Vancouver Regional District

4515 Central Blvd.

Burnaby, BC V5H 0C6

January 17, 2023

Cover image: Phytoplankton bloom in the northeast Pacific and freshet in the Fraser River on June 26, 2022. Plenty of snow is still visible on the Coast Mountains at this time. (MODIS Satellite, Nasa Worldview)

Table of Contents

1.0 INTRODUCTION

1.1. Report Overview

This report summarizes the weather and water supply conditions in Metro Vancouver's Capilano, Seymour, and Coquitlam water supply areas (WSAs) during 2022. It also highlights some of the most impactful local and regional weather events of the year. Data for this report were collected from the network of weather and hydrometric stations in all three WSAs, supplemented by data from Environment and Climate Change Canada (ECCC), BC Hydro, and the BC Ministries of Environment Climate Change Strategy (ENV) and Transportation and Infrastructure (MoTI).

1.2. How Data Are Used

Metro Vancouver's Watersheds and Environment group operates an extensive monitoring program in the WSA's. This program integrates ground-based data, satellite observations, and forecast models to monitor and forecast changes in the weather and climate. Automated stations monitor temperature, precipitation, stream flow, snowpack, and many other parameters. Data records for these stations vary from 10 years to over 100 years. The better the information available, the more the climate can be understood and the more accurately future conditions can be assessed. This has become particularly important in the context of climate change, as climate variability increases and historical patterns shift.

Data from this monitoring program are used to inform operations, and support short and long term planning. Population growth and climate change will have continued impacts on our drinking water supply and system, and we are planning for the future with these in mind. Our short and long-term plans focus on promoting conservation, improving transmission and expanding supply. Real-time and historical climate data from the WSA's will help to ensure the system's resilience in the face of unpredictable annual impacts of climate change

2.0 WEATHER AT A GLANCE

Air Temperature

- 2022 was the 16th warmest year in Metro Vancouver since 1900.
- The summer (Jun-Aug) was the second hottest on record.
- The first 3 weeks of October were exceptionally hot.
- An Arctic outbreak in late December led to several cold temperature records.

Precipitation

- Only 48 mm of rain fell between July 21 and October 21 resulting in significant and prolonged drought.
- Over 400 mm of rain fell between October 22 and November 8 as a series of atmospheric rivers arrived.
- 350-550 mm of precipitation fell between December 24 and 31.

Snowpack

- The snowpack was near-normal on April 1st, but increased to around 180% of normal by the middle of June.
- Cool and wet spring weather delayed snow melt by around three weeks.
- The relatively deep snowpack melted gradually and kept reservoirs topped up until almost the end of July.

Streamflow

- The spring freshet was delayed by a few weeks and reservoirs stopped spilling later than average on around July 23.
- Late summer and fall inflows were at very low levels (historically low at times) right through until late December.

Lake Temperatures

- Reservoir surface water temperatures were cooler than average throughout the spring.
- Temperatures climbed above average in July, and record warm temperatures persisted until the third week of October during the stretch of very warm and dry weather.

Wildfire & Smoke

- The watersheds saw 62 days with fire danger at high or extreme (7 days at extreme). Far more than the average of 32 days per year.
- Once again, wildfire smoke drifted into Metro Vancouver on several occasions resulting in air quality advisories for 18 days of the year.
- Notable local wildfire: Minnekhada Regional Park in October.

3.0 LOCATION AND CLIMATE OVERVIEW

Metro Vancouver's WSA's are located in the steep mountains north of Vancouver, BC. Commonly referred to as the 'North Shore Mountains', this area is actually a small sub-range of the Coast Mountains which extend far to the north and east of Vancouver. The WSA's are bounded by Burrard Inlet to south, Howe Sound to the west, and Pitt Lake to the east. The terrain here is characterized by rounded ridge crests and horn shaped peaks, surrounded by deep glacier-cut and densely forested valleys draining into long inlets. Elevations range from 150m to 1750m.

Figure 1: Location of the Water Supply Areas and Lower Seymour Conservation Area

The North Shore Mountains are in a maritime climate zone, characterized by relatively mild winters and cool summers. The WSA's typically receive two to four times the annual precipitation of nearby urban areas in Metro Vancouver. Severe storms are common in the fall and winter months. Atmospheric rivers can deliver vast amounts of precipitation over a 1 to 3-day period. These storms can cause landslides or debris flow events within the WSA's. Temperatures are relatively mild in the WSA's, with an average annual temperature of approximately 9°C; however, the area has seen exceptionally hot temperatures during the past two summers.

4.0 CLIMATE CHANGE PROJECTIONS

Global temperatures have been warming at an accelerated rate for the past few decades. The top ten warmest years on record have all occurred since 2010. A similar pattern is evident in British Columbia and Metro Vancouver. The graphic below shows the average annual air temperature for Vancouver since 1900. Each bar represents a year and the colors show the mean annual air temperature. This paints a very clear picture of warming!

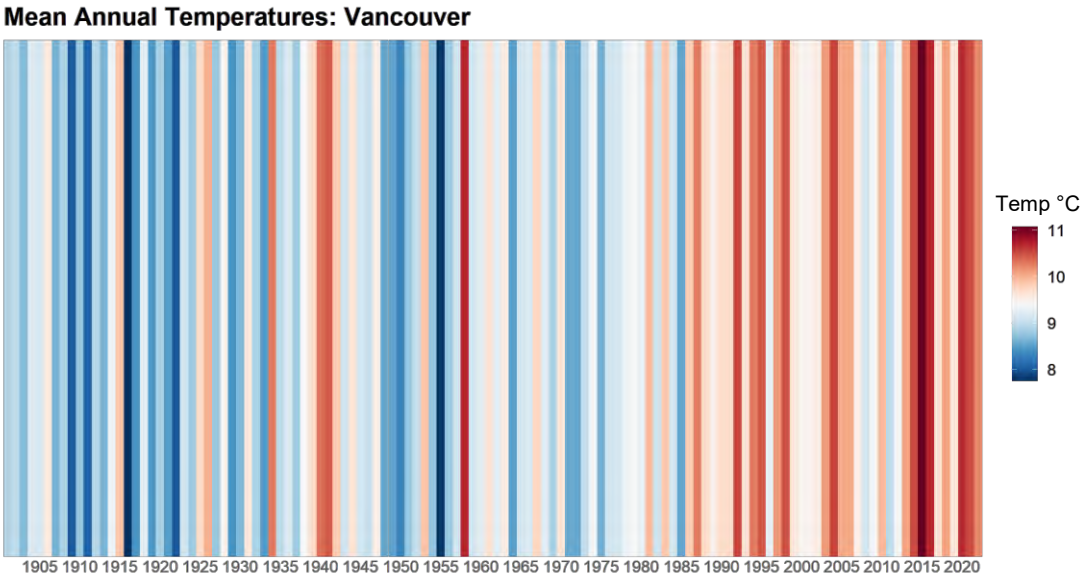


Figure 2: Warming stripes graphic showing mean annual air temperature for Vancouver from 1900-2022

Climate Projections for Metro Vancouver (2016) outlines probable impacts of climate change that we will likely experience in our region in the coming decades. This outlook describes warmer temperatures, a decrease in snowpack, longer summer dry spells, higher precipitation in fall, winter and spring, and more intense storm events. This report describes weather conditions we experienced in 2022, and as you will see, conditions this year are very similar to the long range projections in many respects. Our climate is changing quickly! This highlights the need to plan and adapt to our changing climate to increase our resilience.

5.0 CLIMATE DRIVERS

Our weather varies from season to season in response to certain climate drivers. Most people have heard mention of the El Niño–Southern Oscillation (ENSO). Those who enjoy recreating in the snow on the North Shore Mountains probably pay attention to whether experts are forecasting an El Niño or La Niña winter. This section will give a brief introduction to two of the primary climate drivers influencing the weather in western Canada, both of which impact our air temperatures, precipitation, snowpack, and stream flow.

5.1. El Niño–Southern Oscillation

The El Niño-Southern Oscillation (ENSO) is a climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean. Sea surface temperatures warm or cool by up to

three degrees Celsius over periods ranging from three to five years. El Niño is the warm phase of this oscillating pattern, and La Niña is the cool phase. At times sea surface temperatures are near-normal, which is considered to be ENSO-neutral.

During El Niño seasons, western Canada commonly sees above average air temperatures. Warmer temperatures often equate to below average snowpack, particularly at lower elevations, and lower summer river inflows. Cooler La Niña seasons can result in deeper than average snowpacks in the North Shore Mountains. ENSO is arguably the most important driver of local climate conditions. It is also possible to forecast ENSO patterns well in advance.

5.2. Pacific Decadal Oscillation

The Pacific Decadal Oscillation (PDO) is not as well-known as ENSO, but may be an equally important climate driver for western Canada. The PDO is commonly described as a long-lived El Niño-like pattern in the northeast Pacific Ocean; however, warm or cool phases tend to last 20-30 years. In the warm PDO phase, the sea surface temperatures in the central and western Pacific become cooler than normal, and the waters close to the west coast of North America warm. The opposite pattern occurs during the cool phase.

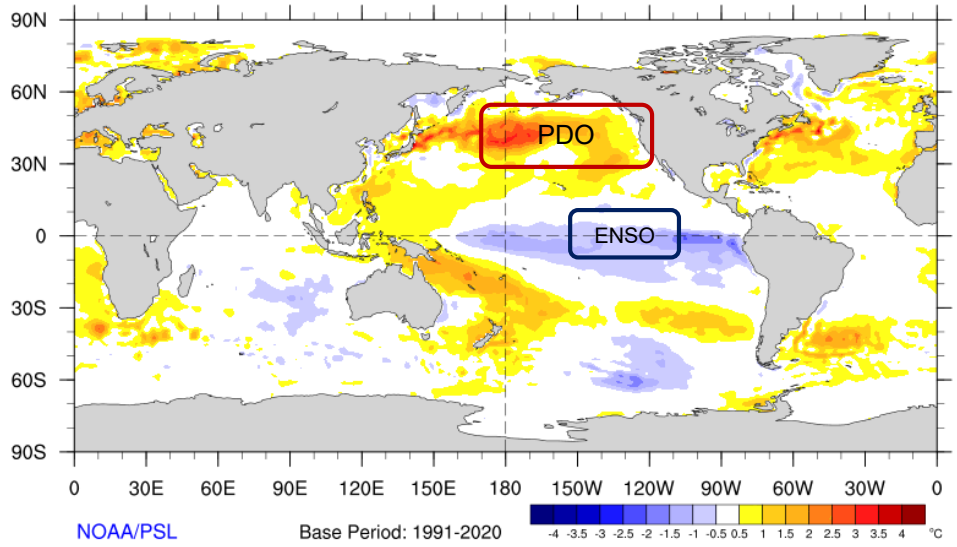


Figure 3: Map showing PDO and ENSO regions in the Pacific Ocean

The PDO has similar large-scale effects on the climate of western Canada. During the warm phase, air temperatures are typically warmer, which can result in lower snowpack and lower river inflows in the spring and summer. Temperatures are generally cooler during the PDO cool phase, which can result in deeper than normal snowpacks. The PDO can also enhance or diminish the effects of ENSO.

Weather Variable	ENSO/PDO Positive	ENSO/PDO Negative
Temperature	Warmer than normal	Cooler than normal
Precipitation	Drier than normal	Wetter than normal
Streamflow	Lower spring/summer flows	Higher spring/summer flows
Snowpack	Shallower snowpack	Deeper snowpack

Table 1: Effects of ENSO/PDO on western Canada

The major PDO regime shifts in the past 100 years occurred in 1924/25 (to warm phase), 1945/46 (to cool phase), 1976/77 (to warm phase), and 1997/98 (to cool phase). There was a brief change to warm phase between 2014 and 2016, which combined with strong El Niño conditions to produce the warmest years on record, both globally and locally.

Understanding these climate drivers and their influence on regional climate variability is important for water supply planning and operations. Of course, it's also important to consider the effects of anthropogenic climate change on these ocean-atmosphere patterns and regional conditions.

5.3. Climate Drivers in 2022

Moderate La Niña conditions were present throughout 2022. This was the second consecutive La Niña winter. The PDO has also been predominantly since 1998, and strongly negative since 2020. As mentioned, combined cool ENSO and PDO phases typically result in below normal temperatures in western Canada. How did the year actually play out? We will look more closely at how these climate drivers may have influenced our weather in 2022.

6.0 WEATHER VARIABLES

This section describes the temperature, precipitation, snowpack, and stream flow conditions in the WSA's in 2022. Below are some highlighted values from within the watershed areas.

Parameter	Value	Location	Date
Hottest temperature	36.0°C	Lower Capilano, 250m	July 26
Coldest temperature	-18.7°C	Loch Lomond, 1070m	December 19
Deepest measured snow	745 cm	Loch Lomond area, 1500m	April 7
Strongest wind (gust)	135 km/h	Lower Capilano, 250m	December 28
First frost day	-0.3°C	Lower Capilano, 250m	November 3
Highest river inflow	385 m^3/s	Capilano River at Lakehead	December 26
Highest river inflow	132 m^3/s	Seymour River at Lakehead	December 26
Greatest 24-hr rainfall	165 mm	Lower Seymour, 210m	December 24
Greatest 48-hr rainfall	262 mm	Palisade Lake, 900m	December 26-27
Highest hourly rainfall	21.4 mm	Palisade Lake, 900m	December 27
Longest dry spell	27 days	Lower Capilano, 250m	Sept 25-Oct 22
Longest wet spell	21 days	Lower Capilano, 250m	April 30-May 20

Table 2: Highlighted weather values from within the watersheds in 2022.

It was another active weather year with numerous weather warnings issued by Environment and Climate Change Canada (ECCC). In total, there were 23 weather warnings issued (versus 29 in 2021), with the majority occurring in the last two months of the year. There was a very active period in late October and early November, and another during the last two weeks of December. Click here for the criteria for public weather warnings in Canada.

Date	Warning Type	Observed Values
Jan 1-2, 2022	Snowfall Warning	~15 cm at valley bottoms
Jan 4, 2022	Snowfall Warning	30-35 cm at mountaintops
Jan 7, 2022	Wind/Winter Storm Warning	139 mm Lower Capilano
Jan 10-13, 2022	Rainfall Warning	120 mm Lower Capilano
Jan 29-31, 2022	Rainfall Warning	62 mm Lower Capilano
Mar 13-15, 2022	Rainfall Warning	91 mm Lower Capilano
Apr 3-4, 2022	Rainfall Warning	97 mm Lower Capilano
Jul 25 – Aug 2, 2022	Heat Warning	36.2°C (July 26), Lower Capilano
Aug 16-19, 2022	Heat Warning	33.2°C (Aug 17), Lower Capilano
Oct 26-28, 2022	Rainfall Warning/ High Streamflow Advisory	107 mm Lower Capilano
Oct 29-31, 2022	Rainfall Warning/ High Streamflow Advisory	110 mm Lower Capilano
Nov 3-5, 2022	Rainfall Warning / High Streamflow Advisory	57 mm Lower Capilano
Nov 5, 2022	Wind Warning	32 km/h, Capilano Reservoir
Nov 29-30, 2022	Snowfall/ Wind Warnings	10-20 cm at valley bottoms
Dec 17-20, 2022	Snowfall Warnings	20-40 cm at valley bottoms
Dec 20-21, 2022	Arctic Outflow Warning	-12.9°C (Dec 21), Lower Capilano
Dec 22-24, 2022	Winter Storm Warning/ Rainfall Warning	150 mm Lower Capilano
Dec 25-28, 2022	Rainfall and Wind Warnings, Flood Watch	71 mm Lower Capilano

Table 3: Weather and streamflow warnings for the North Shore issued by Environment and Climate Change Canada (ECCC) and the BC River Forecast Centre in 2022.

The figure below summarizes the weather of 2022 in the lower Capilano WSA. It shows mean air temperatures (bubbles), precipitation amounts (bubble size), and type of weather (bubble colour). In total, there were 139 days with measurable precipitation, 82 cloudy or foggy days, and 144 sunny days. There was snowfall on 11 days in 2022. This figure also shows the sudden change in air temperatures in late October.

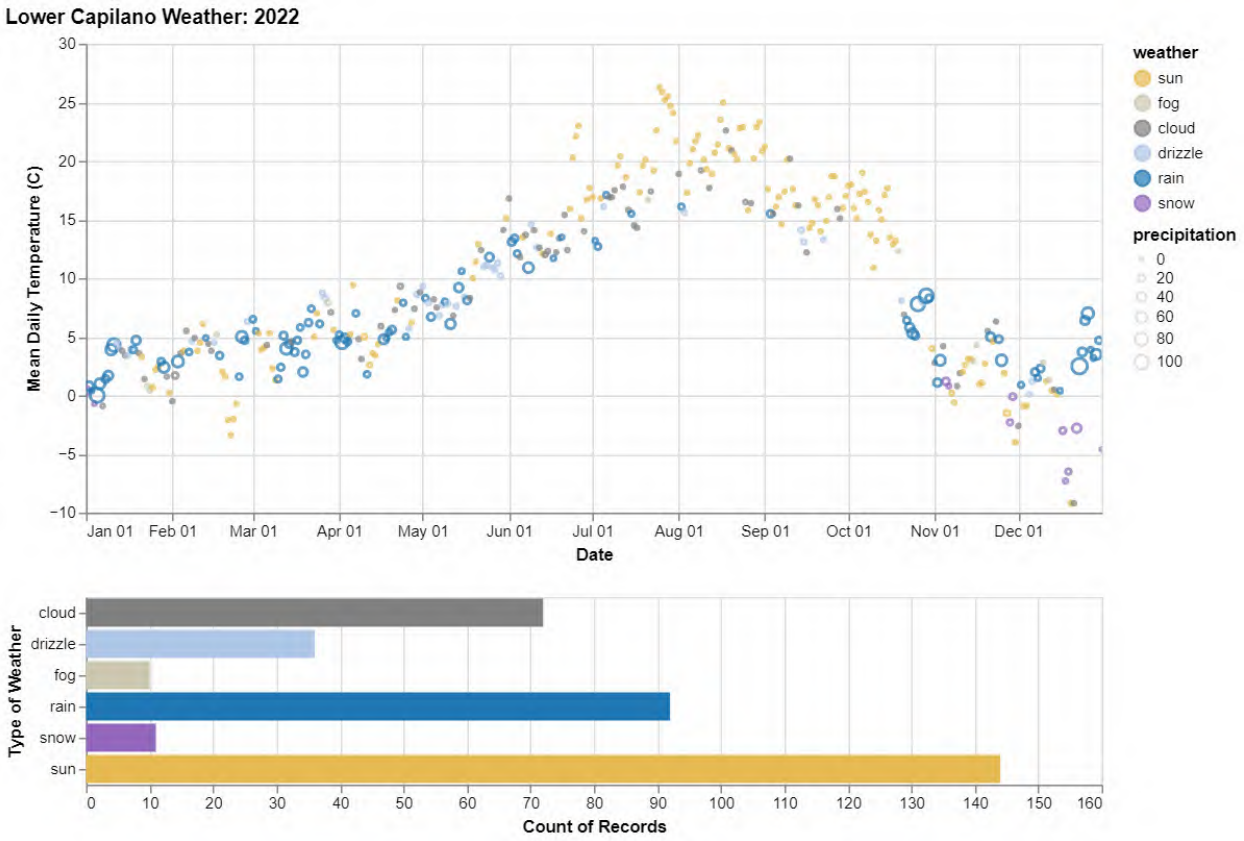


Figure 4: Summary of weather conditions in the lower Capilano WSA in 2022

6.1. Summary Map

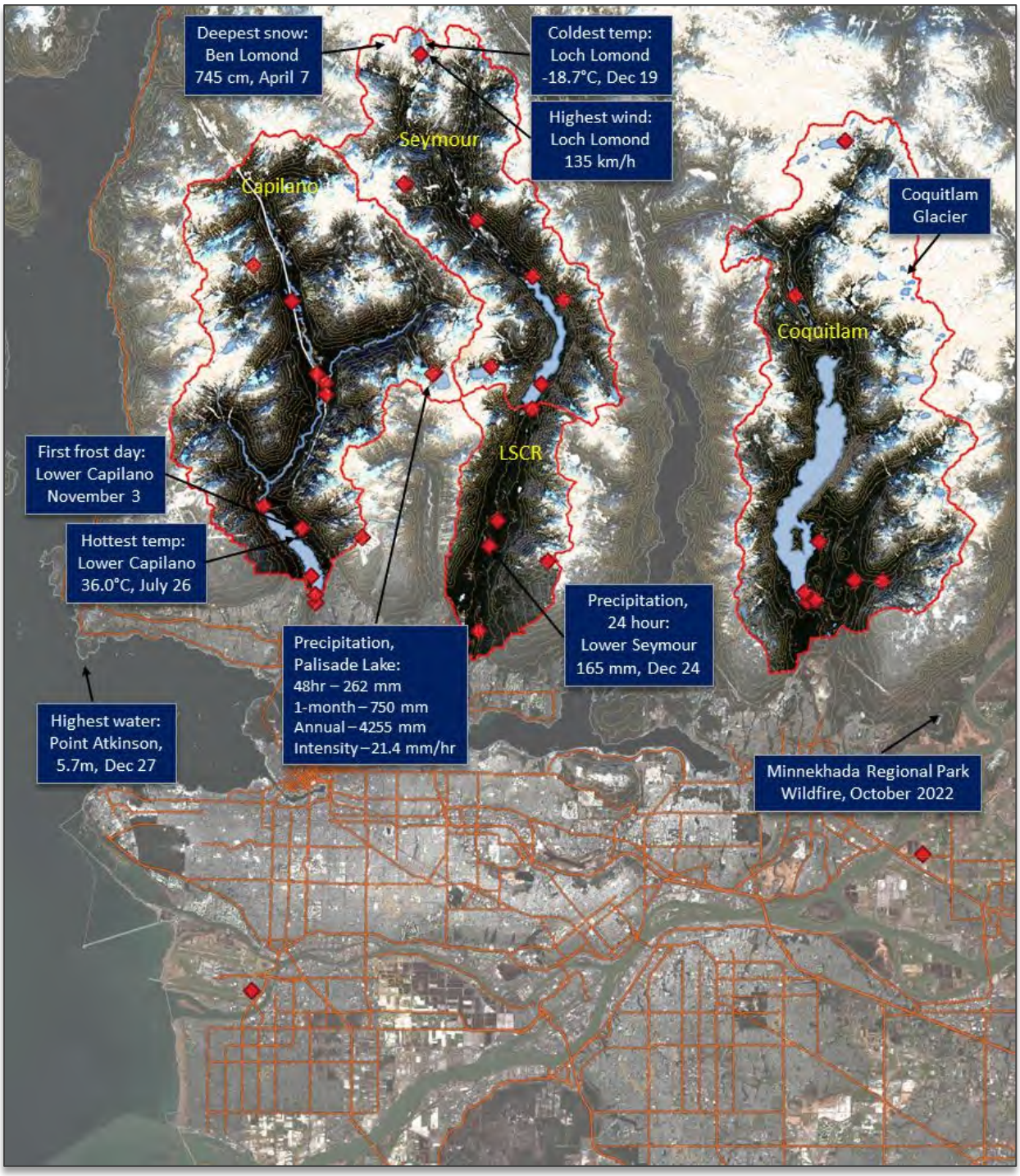


Figure 5: Metro Vancouver map with some weather-related highlights from 2022

6.2. Air Temperature

The annual average air temperature in the watersheds for 2022 was very close to the average of the past 20 years. At the Vancouver Airport, this was the 16th warmest year since 1900 with a mean temperature of 10.2°C. The warming trend of the last several decades is clear to see in the *warming stripes* graphic below (figure 8).

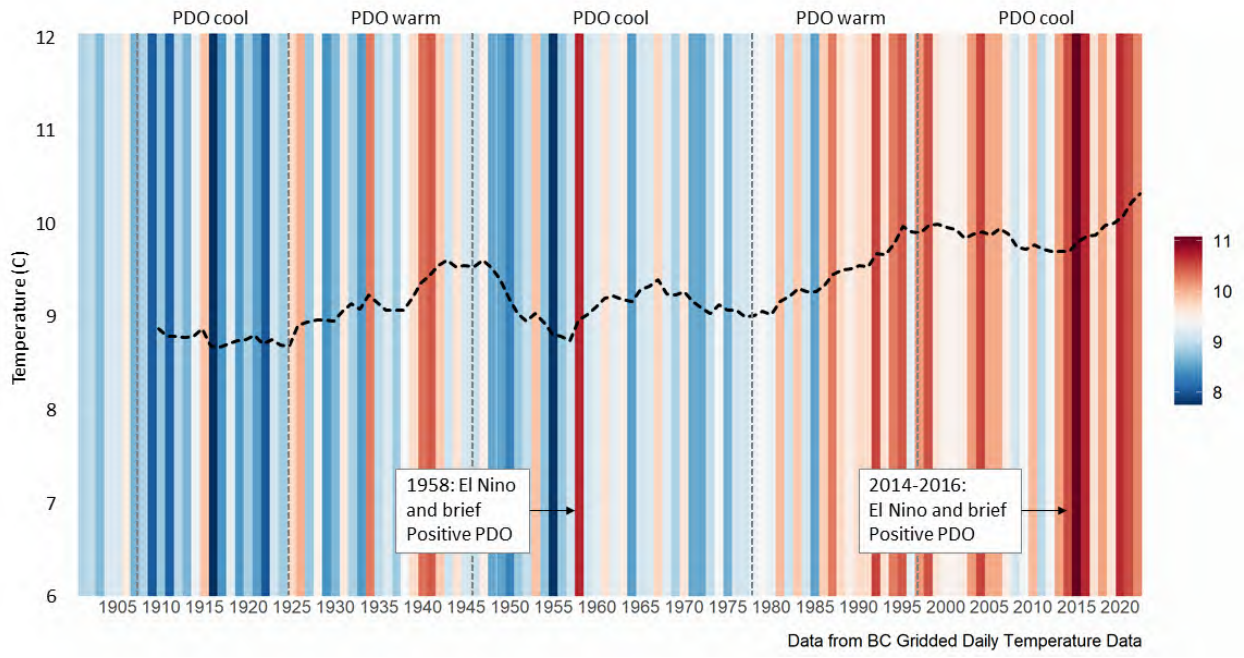


Figure 6: Mean annual air temperatures for Vancouver from 1900-2022 with the 10-year moving average.

Winter temperatures in 2022 were below normal, and considerably cooler than last winter. The summer months (Jun-Jul-Aug) were the second warmest on record behind 2021. Average air temperatures exceeded 20°C in the watersheds for the month of August, making this the hottest month ever in Vancouver. Abnormally warm temperatures continued right through until the third week of October. This extended summer resulted in prolonged seasonal drought, a late wildfire season, and periods of poor air quality during the fall months. Temperatures shifted abruptly near the end of October and fell to well below normal for November and most of December. In fact, this November was the coldest since 2003. The coldest temperatures of the year came just before Christmas as Arctic air surged south.

The table below (table 4) shows the average monthly temperature for each month in 2022 compared to the historical average for the 20-year period. The temperature anomaly and rank are also shown. Both the table and figure below show the extreme swings we experienced this year.

Month	2022 Temp (°C)	Average Temp (°C)	Temp Anomaly (°C)	2022 Rank (hot→cold)
January	2.0	3.1	-1.1	12
February	2.8	3.6	-0.8	12
March	5.0	5.2	-0.2	9
April	5.5	7.6	-2.1	18
May	9.4	11.3	-1.9	19
June	14.3	14.3	**0.0**	10
July	18.7	17.9	+0.8	5
August	20.2	17.7	+2.5	1
September	16.4	14.0	+2.4	1
October	12.5	8.7	+3.8	1
November	2.3	4.8	-2.5	20
December	0.1	2.0	-1.9	16
Annual	**9.15**	**9.07**	**+0.07**	**9**

Table 4: 2022 monthly mean temperatures for the lower Capilano Watershed (data from Lower Capilano fire weather station near the base of Grouse Mountain - 2003-2022).

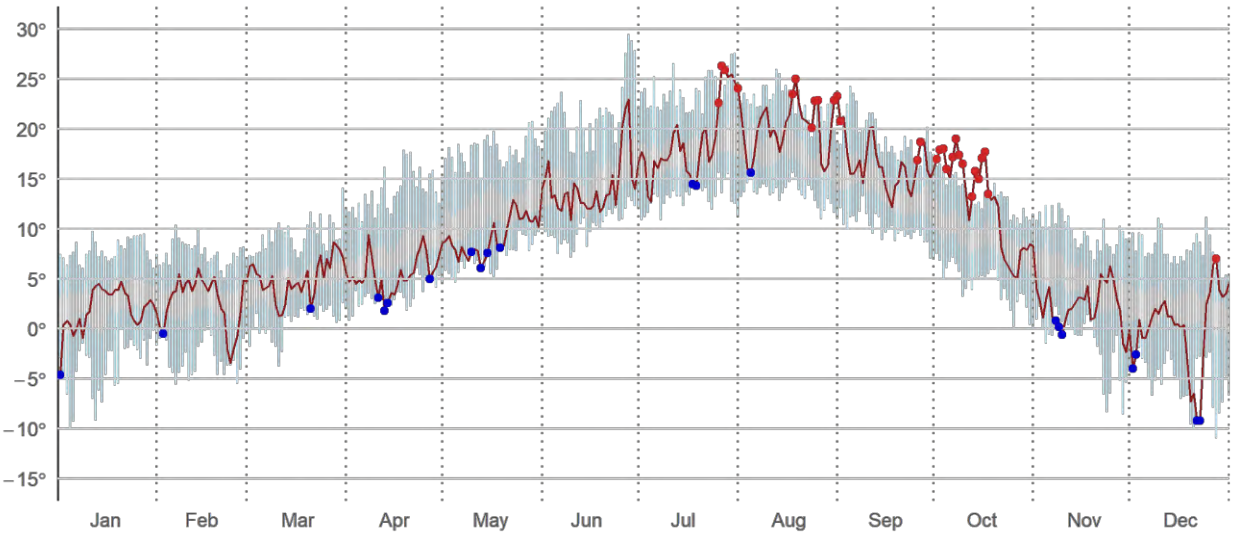


Figure 7: Mean daily air temperatures with range of normal and min/max for the lower Capilano Watershed in 2022. The red and blue dots highlight new record high or low temperatures for that day.

6.2.1. Daily Temperature Records in 2022

New high temperatures records were set on 29 days this year, and low temperature records were set on 21 days. The highest temperature recorded was 36.0°C, which occurred on July 26. This fell well short of the all-time high temperature of 41.0°C set last year. The coldest temperatures of the year were -12.9°C at the Lower Capilano fire weather station (December 21), and -18.7°C at Loch Lomond (December 19).

The table below highlights mean daily temperature records in 2022. The new high temperature records set in October stand out as being truly exceptional. The low temperature records set in December also stand out. Interestingly, these cold days coincided with very heavy snowfall in Metro Vancouver, which is unusual for the BC south coast.

Mean Daily High Temperatures (°C)			Mean Daily Low Temperatures (°C)		
Date	New High	Previous High	Date	New Low	Previous Low
2022-07-25	22.6	22.5	2022-01-01	-4.6	-2.9
2022-07-26	26.3	22.5	2022-02-02	-0.5	-0.3
2022-07-27	25.9	24.4	2022-03-20	2	2.3
2022-07-31	24.1	23.6	2022-04-10	3.1	3.4
2022-08-17	23.5	23.3	2022-04-12	1.8	2.6
2022-08-18	25	21.5	2022-04-13	2.6	3.1
2022-08-23	20.1	19.2	2022-04-26	5	6.4
2022-08-24	22.8	20.3	2022-05-09	7.7	8
2022-08-25	22.9	22.4	2022-05-12	6.1	6.9
2022-08-30	22.9	20	2022-05-14	7.6	8.1
2022-08-31	23.3	18.7	2022-05-18	8.1	8.5
2022-09-01	20.8	18.5	2022-07-17	14.5	14.9
2022-09-25	16.9	16.1	2022-07-18	14.3	15.2
2022-09-26	18.7	16.3	2022-08-04	15.6	15.8
2022-10-01	17	16.3	2022-11-07	0.8	2.2
2022-10-02	17.9	16.5	2022-11-08	0.2	1.4
2022-10-03	18	15.7	2022-11-09	-0.6	0.7
2022-10-04	16	14.4	2022-12-01	-4	-2.6
2022-10-06	17.2	15.4	2022-12-02	-2.6	-1.9
2022-10-07	19	15.7	2022-12-21	-9.2	-3
2022-10-08	17.4	14.3	2022-12-22	-9.2	-2.8
2022-10-09	16.5	14.5			
2022-10-12	13.2	12.4			
2022-10-13	15.8	12.5			
2022-10-14	15	12.7			
2022-10-15	17.1	12			
2022-10-16	17.7	13.6			
2022-10-17	13.5	13.4			
2022-12-27	7	6.1			

Table 5: Mean daily temperature records at the Lower Capilano weather station. The colour shading shows how significant the new temperature record was.

6.3. Precipitation

The year 2022 saw slightly below average annual precipitation; however, the bulk of this precipitation came in a few short periods. The spring months were exceptionally wet compared to normal. Conditions finally dried out in July and remained very dry, in fact historically dry, right through to the final week of October. A series of atmospheric river events at the end of October and early November dropped over 400 mm of rain in less than two weeks. In mid-November the region enjoyed one of longest November dry spells on record. Relatively dry conditions continued until December 24, when a series of weather systems dropped almost 350 mm of precipitation in only one week.

Month	2022 Precip (mm)	Average Precip (mm)	Percent of Normal	2022 Rank (dry→wet)
January	515	450	115	15
February	193	228	85	6
March	314	343	92	10
April	279	198	**141**	16
May	219	127	**172**	19
June	121	96	**126**	15
July	40	57	**70**	9
August	17.5	55	**32**	5
September	30.7	171	**18**	2
October	311	328	95	11
November	225	461	**49**	1
December	454	369	**123**	15
Annual	2719	**2883**	**94**	**6**

Table 6: 2022 monthly precipitation totals at the Lower Capilano fire weather station (Data from 2003-2022).

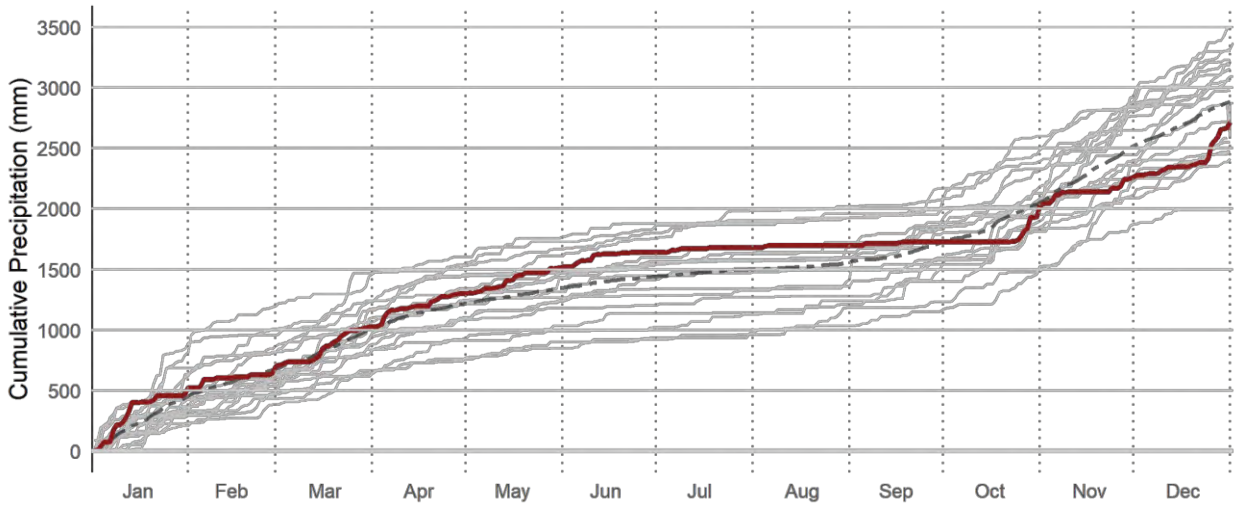
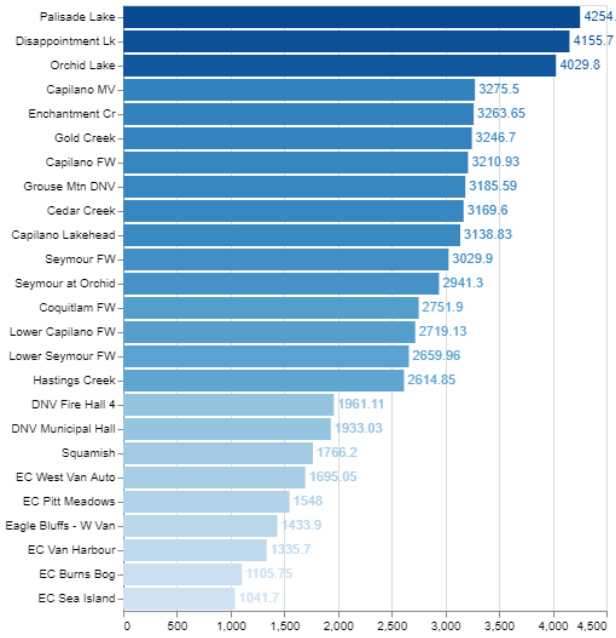
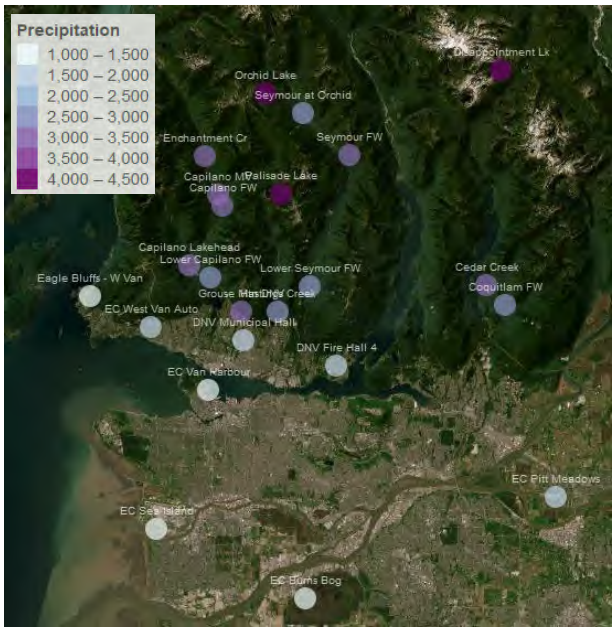


Figure 8: Accumulated precipitation at the Lower Capilano fire weather station in 2022 (red line) compared to mean (dashed line) and each year from 2003-2022 (gray lines).

The wettest areas in the region are the higher elevation sites within the watersheds. Palisade Lake (900m) is typically the wettest gauged site. This location led the way with 4255 mm for the year, which pales in comparison to last year's whopping 6372 mm. Palisade Lake also had the wettest month (December) with a total of 750 mm precipitation, most of which fell during the last week of the month. The largest single storm event occurred on December 26-27 where Palisade recorded 262 mm in just 48 hours.





6.4. Snowpack

Both ENSO and PDO have very noticeable effects on the North Shore mountain snowpack. As seen earlier, average winter temperatures are strongly influenced by ENSO. As a result, warmer El Niño winters tend to see less snow, while cooler La Niña winters see more snow. The same is true for the PDO. Snow depth on April 1 at Grouse Mountain averages 220 cm during positive PDO years, and 310 cm during negative PDO years. That is a significant difference, especially considering that the last warm PDO year was 25 years ago!

Snow began to accumulate in earnest on November 5, 2021. By the beginning of January, the snowpack had climbed to 110-115% of normal. Peak snow depth occurred on April 5th, with peak snow water equivalent occurring a couple weeks later. At the beginning of April, the snowpack was at near-normal levels, but grew in the early spring thanks to cool and wet conditions. By mid-June, the snowpack was at 180% of normal. The snowpack did not really start melting until May 20th, which is much later than normal.

All snow monitoring sites were snow free by July 21, and the snow season lasted approximately 257 days (duration of snow on the ground at 1150 m). This was approximately three weeks longer than historical average. The snow season duration is typically longer during La Niña seasons and the cool PDO phase.

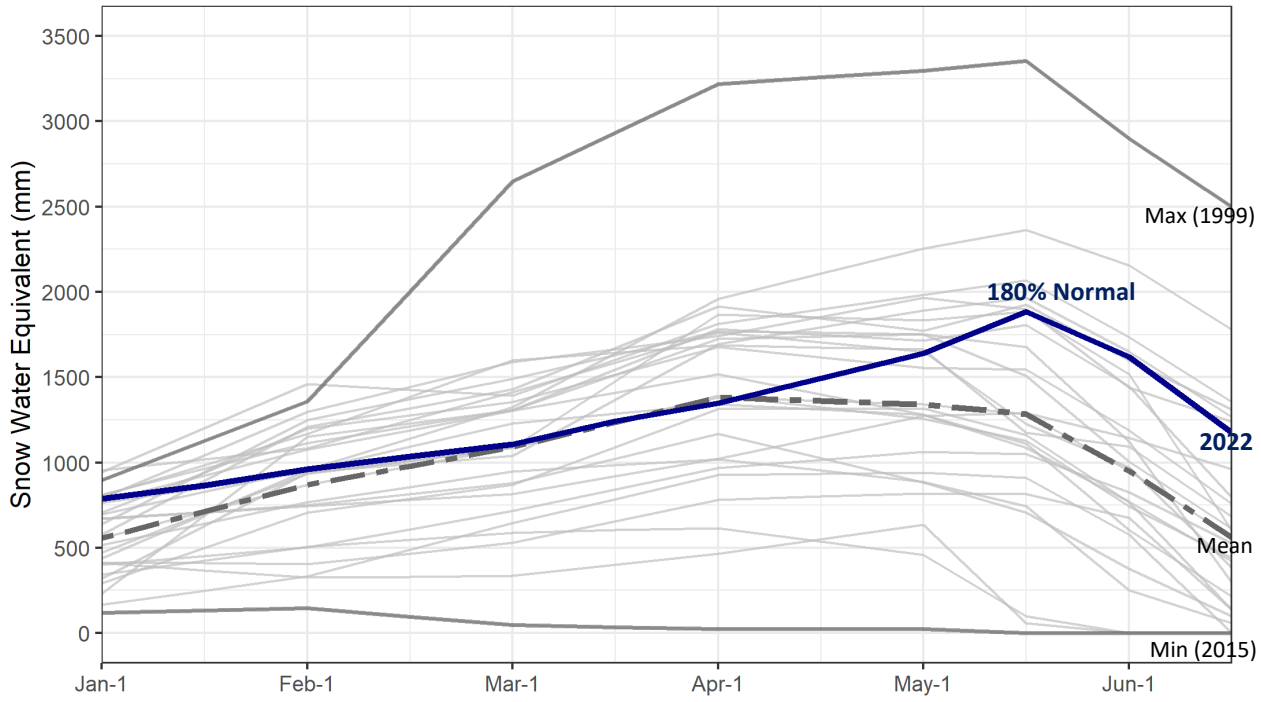


Figure 10: Snow water equivalent in 2022 (blue line) compared to the min, max and average of the 25-year period.

Above average snow conditions and delayed snow melt helped get the region through a significant drought. You can read more about this anomalous drought in the notable weather events section that follows. Source water supply would be of much greater concern during the fall drought if the winter snowpack was below average or melted very quickly.

Figure 11: Crews measuring snowpack above Loch Lomond in the Seymour Watershed (Photo: Peter Marshall).

La Niña and cool-phase PDO winters tend to see more snow in the North Shore Mountains and our WSA's. Snow depth on April 1 at Grouse Mountain averages 220 cm during positive (warm) PDO years, and 310 cm during negative (cool) PDO years. That is a significant difference, especially considering that the last warm PDO year was 25 years ago! The deepest snow season on record occurred in 1999, which was the start of the current cool PDO phase, combined with strong La Niña conditions.

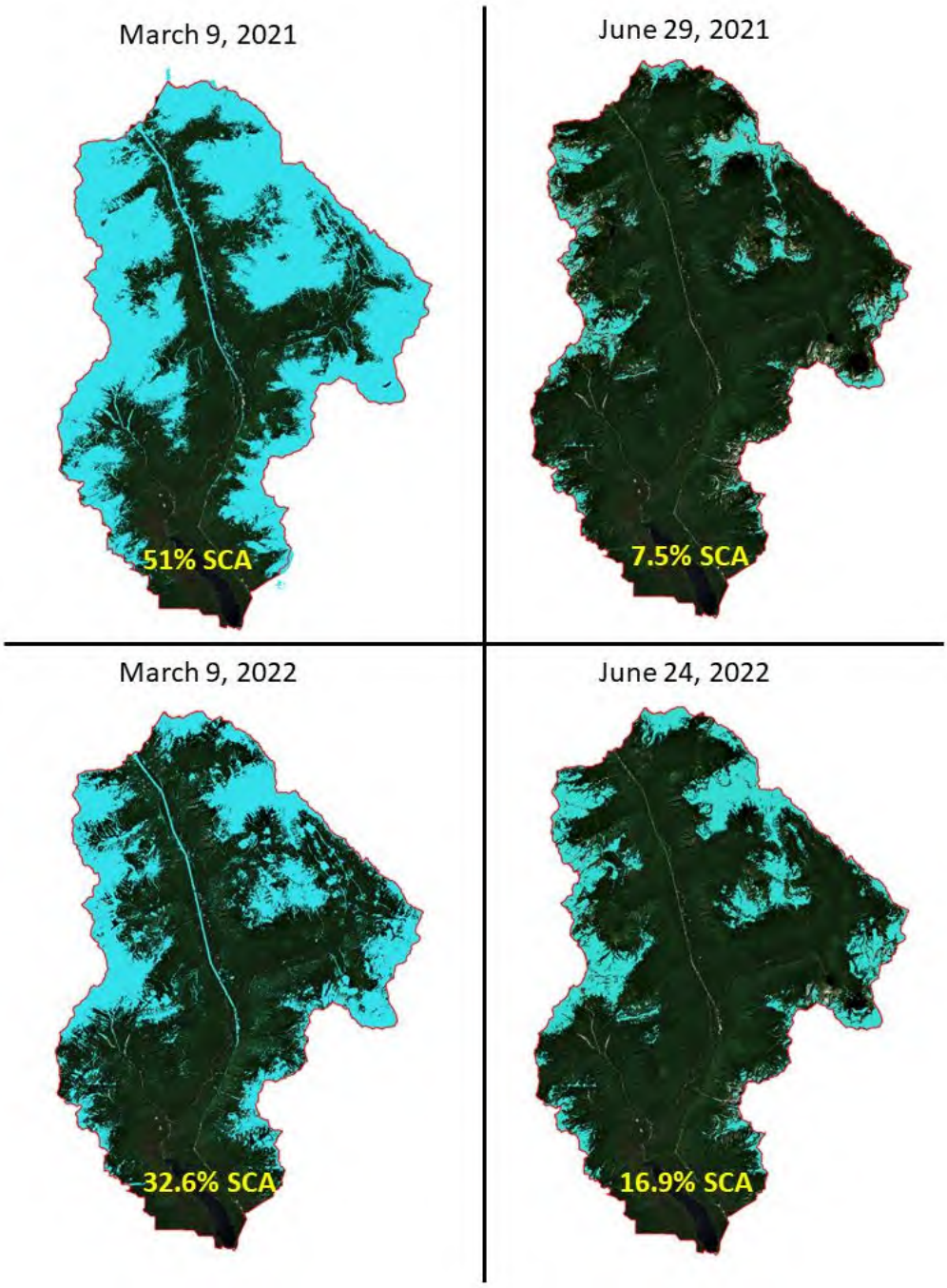


Figure 12: Snow covered area (SCA) in the Capilano Watershed in 2021 and 2022 (Data: ESA-Sentinel 2).

6.5. Streamflow and Water Temperatures

6.5.1. Streamflow

The average annual river inflow at Capilano Lakehead in 2022 was approximately 75% of the historical average from 1914-2022. The only month with significantly higher inflows than normal was June. This was due to above average snow conditions, delayed snowmelt, and relatively wet weather. This may be the most important month of the year for river inflows in order to fill primary reservoirs and keep them topped up for as long as possible into the drier summer months.

Inflows were notably below average from July through to December. Average monthly inflows in September were the lowest for any single month for the entire data record. Palisade Lake dam was opened in late September and helped increase the very low flows in Capilano River during the first few weeks of October. Wet weather finally arrived on October 24th and river inflow increased for a couple weeks; however, cold and dry conditions from mid-November until almost Christmas dropped inflows well below normal once again.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	22.8	20.1	19.0	22.6	28.6	23.4	11.9	5.8	9.4	23.4	29.9	26.3
Min	2.94	1.14	4.11	9.22	4.73	1.34	2.12	1.19	1.43	1.53	3.35	4.74
Max	61.4	57.3	48.5	42.1	43.5	49.5	36.5	29.6	50.0	69.1	67.1	63.0
2021	34.2	10.5	14.2	17.6	24.5	28.4	4.05	4.11	24.9	53.2	63.8	16.6
2022	**23.1**	**10.3**	**19.6**	**14.7**	**25.9**	**33.6**	**9.87**	**1.52**	**1.06**	**11.4**	**9.17**	**23.6**
%norm	101.2	51.3	102.9	65.1	90.6	143.7	82.7	26.1	11.3	48.8	30.7	89.6

Table 7: Mean monthly inflows for Capilano Lakehead compared to historical values (1914-2022). The percent of normal for each month is shown in the bottom row. The average annual inflow at this station is 20.3 m^3/s.

There is a relationship between both the ENSO and PDO conditions with reservoir inflows for the June to September period. Lowest flows during this period are typically associated with warm or neutral ENSO and warm-phase PDO. This is typically because we see warmer air temperatures and shallower snowpacks under these conditions. In other words, there is less snow in the mountains to melt and runoff into the drinking water reservoirs.

The Cleveland Dam (CLD) stopped spilling on July 23, which was slightly later than average thanks to a healthy spring snowpack and cool and wet spring conditions. It started spilling again on October 28, approximately two weeks later than the mean start-spill date. The duration of the reservoir drawdown was around 98 days this year, which is well above average. Previous research showed the mean reservoir drawdown during warm ENSO and PDO events was 83 days, and during cold ENSO and PDO events is was only 55 days. During combine cool ENSO and PDO years, the average drawdown duration was only 45 days.

Despite a healthy spring snowpack, river inflows were quite out of character in the late summer and fall. That being said, the cold and wet spring and late snowmelt helped get the region through a very severe seasonal drought. Source water storage remained within the normal range throughout the year.

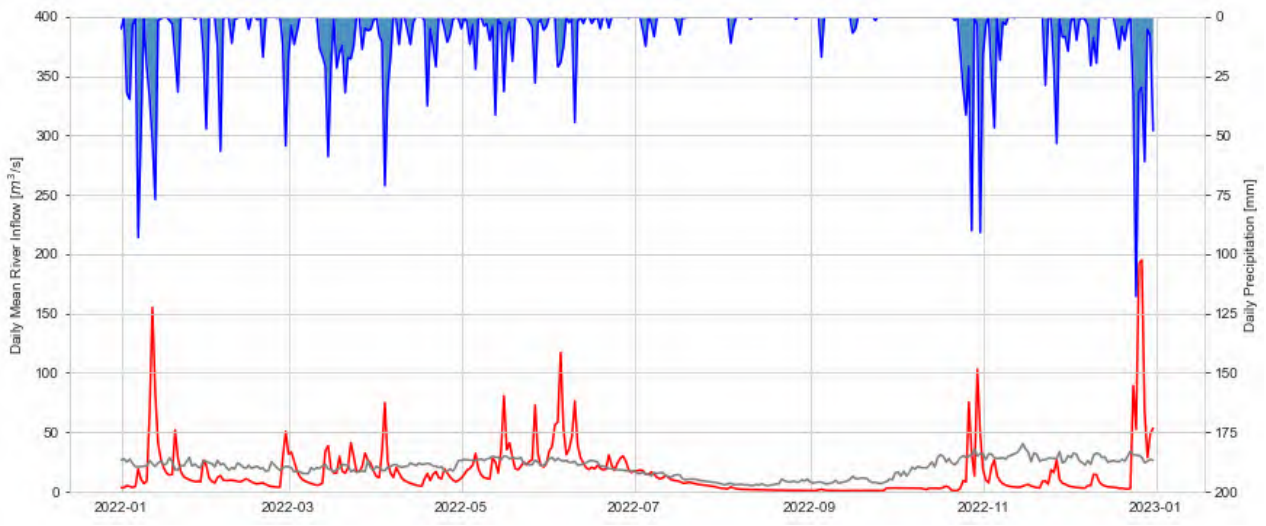


Figure 13: Mean daily river inflows at Capilano Lakehead in 2022 (red line) with mean daily values (gray line) and daily accumulated precipitation at the Lower Capilano fire weather station (blue area).

6.5.2. Reservoir Temperatures

Reservoir surface water temperatures remained cooler than normal throughout the spring due to cool and wet weather and delayed snow melt. Temperatures rose sharply in mid-July when the heat finally arrived and remained at record warm levels from the beginning of August until the middle of October.

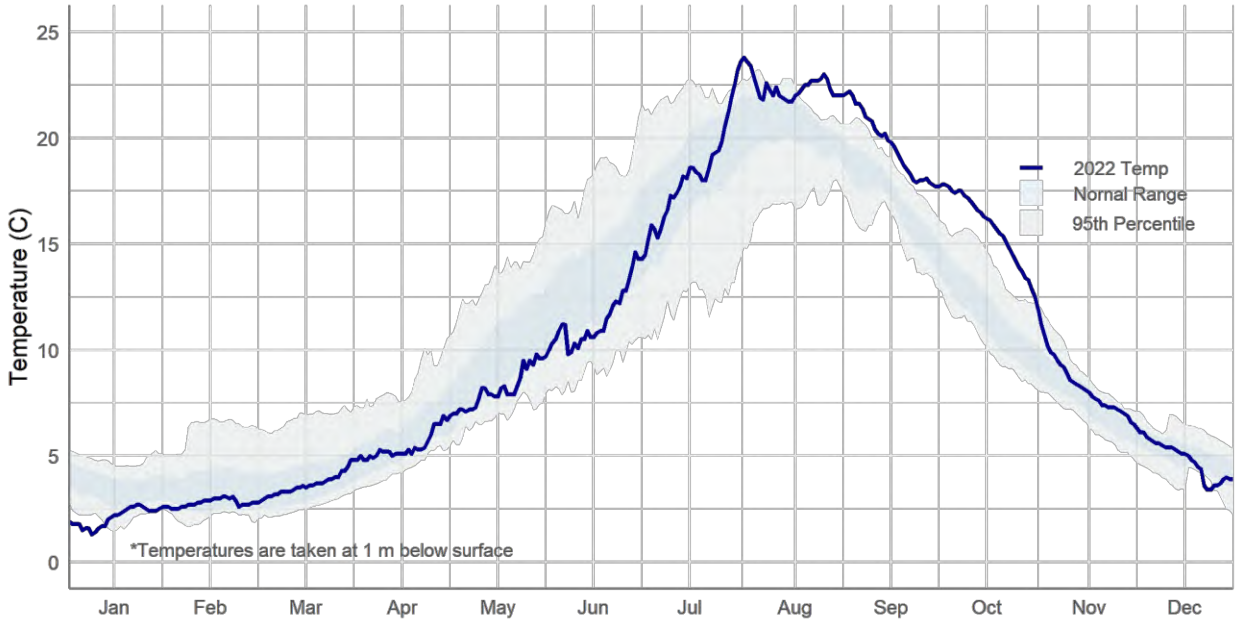


Figure 14: Capilano Reservoir surface temperatures for 2022 compared to the normal range and 95th percentile values (data from 2011 to 2022).

Capilano Reservoir started to drawdown at the end of July and reached its lowest elevation in late October. Stratification became evident in June as air temperatures started to increase, and ended

abruptly with the first fall storms at the end of October. Water temperatures were very warm in the top 20 m during the late summer and early fall.

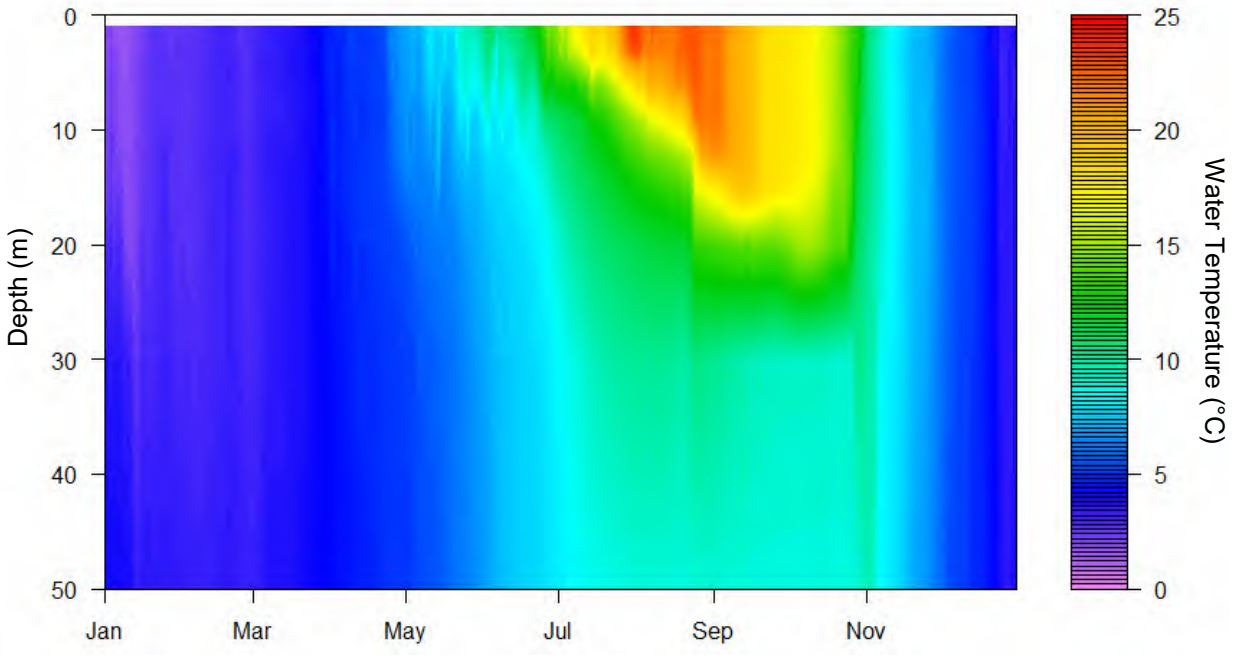


Figure 15: Annual Capilano Reservoir water temperatures by depth

Reservoirs reached their lowest levels on October 25th: 133.7 m Capilano, 143.5 m Coquitlam, and 208.5 m Seymour. Lower than normal lake levels made reservoir operations challenging for watershed staff. Levels rose quickly at the end of October after the first few major storms of the fall moved through.

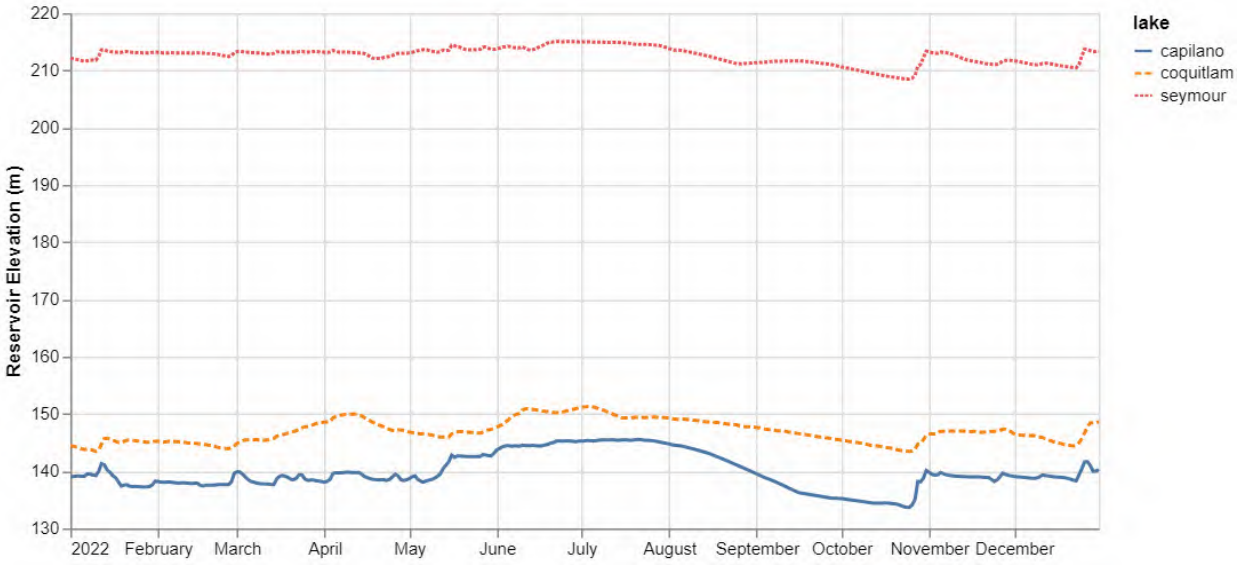


Figure 16: Reservoir elevations in 2022

6.6. Wildfires

Provincially, the BC Wildfire Service detected 1758 wildfires resulting in approximately 133,437 hectares of area burned. For the same period in 2021, there were fewer fires (1610), but over 868,000 hectares of forest burned. The Coastal Fire Centre reported 281 fires and 21,779 hectares burned in 2022.

Figure 17: Late season fires and smoke over the Pacific Northwest and the BC South Coast on October 11, 2022 (MODIS Satellite, Nasa Worldview).

The provincial and local forest fire seasons were late to arrive this year. Significant wildfires did not really start popping up until the third week of July. Watershed Protection crews were called into action in the Fraser zone, battling a number of fires in the Fraser Canyon, eastern Fraser Valley, and near Manning Park.

The season seemed to be tapering off by mid-August, but historically warm and dry conditions in September and October reignited the season. Unseasonably dry conditions kept forest fire danger high-to-extreme right into October. Forest fire danger was rated high or extreme for 62 days in Metro Vancouver, which is 10 days more than last summer and almost double the average of the past 25 years. Fire weather indices that reflect long-term drying reached record highs in the fall. The build-up index (BUI), which is a value rating the total amount of fuel available for combustion, reached 217 in Langley on October 20th, eclipsing the previous high mark set in 2015.

On October 1, a fire sparked on the High Knoll in Minnekhada Regional Park in Coquitlam. This fire quickly grew to around 14 hectares due to unusually warm and dry conditions, and steep and challenging terrain. Watershed Protection staff joined forces with the BC Wildfire Service, MV Regional Parks, and municipal fire departments to tackle this challenging fire over the course of three weeks.

Date	Temp	RH	Wind	Rain	FFMC	DMC	DC	ISI	BUI	FWI	Danger
Oct 1	26.4	40	5.5	0	87.7	71.1	570.2	4.1	108.4	17.5	HIGH
Oct 2	26.6	41	4.7	0	88.8	73.2	575.2	4.4	111.1	18.6	HIGH
Oct 3	27.5	36	4.7	0	89.2	75.4	580.5	4.8	113.8	20.1	HIGH

Table 8: Fire indices at the Coquitlam Fire Weather station at the beginning of October when the Minnekhada Park fire sparked. These were new record high temperatures, and fire codes were very high for this time of year. Click here for information about the Canadian Forest Fire Weather Index System.

Figure 18: Wildfire at Minnekhada Regional Park on October 1, 2022 (Photo: Metro Vancouver)

Once again, wildfire smoke blanketed the Lower Mainland periodically during the summer and fall, resulting in very poor air quality. Smoke and poor air quality has been an issue almost every summer since 2015. Wildfire smoke has significant adverse environmental, human health, and socio-economic impacts. The health concerns are quite clear, but some of the environmental impacts may be overlooked. We'll discuss how smoke and ash impact glaciers in the upcoming *notable weather events* section.

Date	Air Quality Advisory
July 26 - August 1, 2022	Ground-level ozone
September 10-15, 2022	Smoke – PM2.5
October 4-7, 2022	Smoke – PM2.5
October 13-21, 2022	Smoke – PM2.5
TOTAL DAYS WITH AQ WARNINGS IN PLACE:	25

Table 9: Air Quality Advisories issued by Metro Vancouver in 2022

7.0 NOTABLE EVENTS AND WEATHER STORIES

7.1. Late Season Snow and Delayed Freshet

Wintry conditions persisted on BC's south coast right up until the first official day of summer. The spring was wet, cold, and truly uninspiring. April and May were both around 2 degrees cooler than normal. Several new cold temperature records were set in the middle of April. April, May, and June all saw 130-155% of normal precipitation. Rain fell on 63 of 82 days (77%) between April 1 and June 21. It was a gloomy and bleak spring to say the least!

The cool and wet spring conditions had a very positive effect on the seasonal snowpack. The mountain snowpack was near normal on April 1, but by mid-June it had blossomed to around 180% of normal. Snow melt and freshet were delayed by approximately three weeks. The reservoir stop-spill dates were also delayed to the third week of July. Our regional water supply would have been more stressed in the late summer and fall if we had not received significant spring snowfall.

The unusual spring weather also delayed the forest fire season and affected the timing and duration of the smolt outmigration in the watersheds. The late freshet also increased the risk of flooding in the Fraser Valley. Watershed Protection crews were tasked with filling sandbags on Barnston Island in late June to mitigate imminent flooding. Fortunately, really hot temperatures did not arrive until the third week of July, which allowed snow to gradually melt and minimized flooding impacts.

Figure 19: Watershed Protection staff filling a sea of sandbags on Barnston Island (Photo: Watershed Protection)

7.2. Endless Summer and Prolonged Seasonal Drought

The unprecedented warm and dry late summer and early fall led to very significant and prolonged drought on the BC south coast, and in many other parts of British Columbia. Typically, the south coast sees seasonal drought that ends abruptly with the first large fall rain events in September or early October. This was not the case in 2022.

Little to no rain for most of September and the first three weeks of October pushed the Lower Mainland basin to drought level 4 in mid-September, and drought level 5 for the first three weeks of October. Under drought level 5, conditions are exceptionally dry and adverse socio-economic and ecosystem impacts are almost certain. There was some relief at the end of October as a series of atmospheric rivers arrived, but dry conditions in mid-November pushed the Lower Mainland back to drought level 4 by November 24th.

Figure 20: North end of Capilano Reservoir in the fall of 2022. This season saw a significant natural drawdown of the source water reservoirs (Photo: Metro Vancouver).

As mentioned previously, the healthy seasonal snowpack kept reservoirs topped up until the third week of July, keeping total source water storage at the high end of normal throughout the summer months. By the third week of October, source water storage had dropped to less than 40% of the maximum, but still within the normal range. Many other locations on the BC south coast struggled more with water supply than Metro Vancouver. A state of emergency was issued on the Sunshine Coast as their reservoirs dropped to extreme low levels. Water scarcity led to stringent water restrictions, which were in place well into the fall.

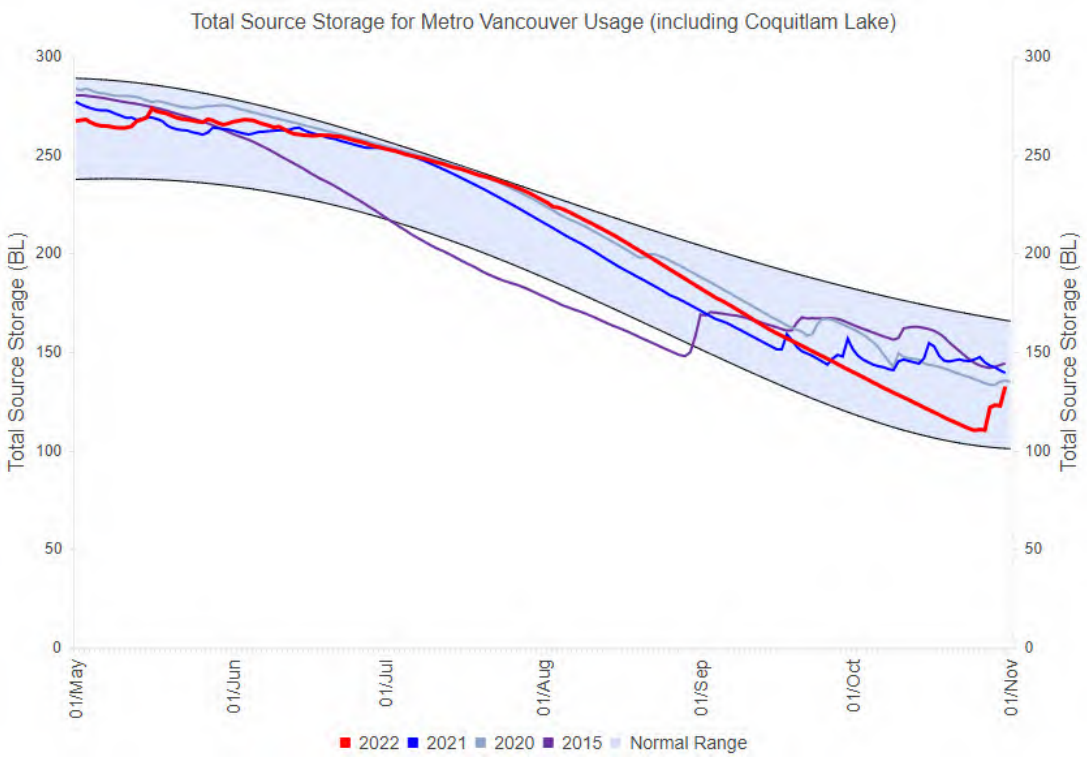


Figure 21: Total source water storage for Metro Vancouver in 2022. The previous two seasons are shown, as well as 2015, which saw very low water levels during the summer due to almost no mountain snowpack.

The plot below shows soil moisture values in the Capilano and Seymour WSA's during the summer and fall. These values are derived and modelled from satellite imagery and weather model data. Soils gradually dried out in the early summer and remained very dry until the first storms arrived on October 23rd.

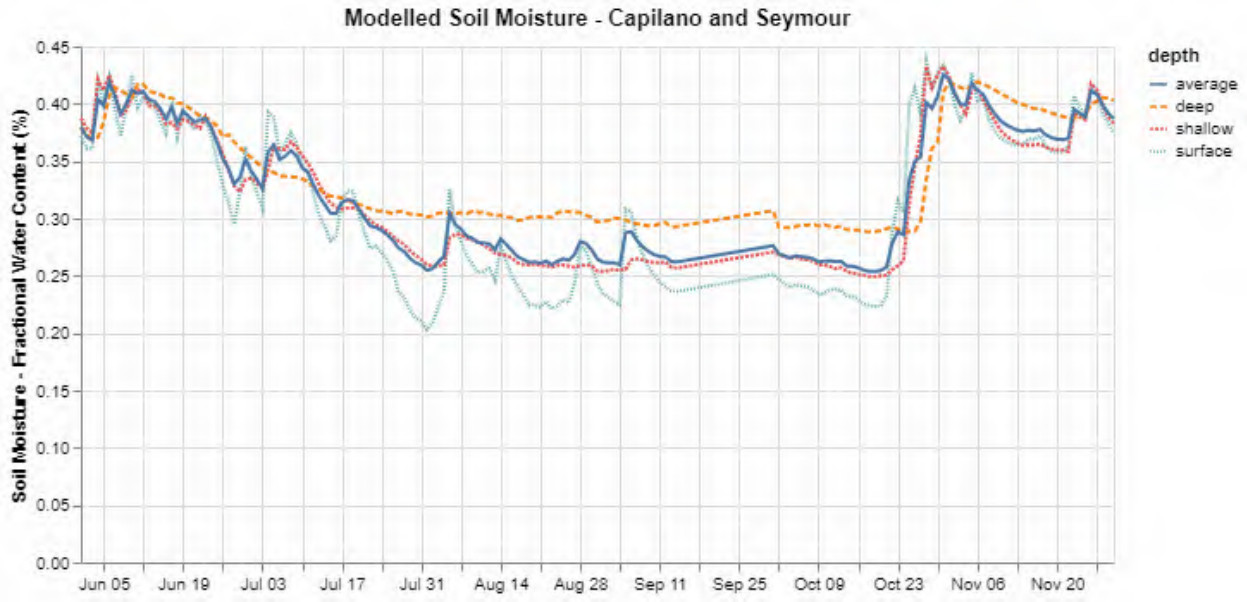


Figure 22: Soil moisture values for the Capilano and Seymour Watersheds derived from satellite imagery (Data: WeGaw).

7.3. The Demise of Metro Vancouver's Last Glacier

A small pocket of glacier ice clings to life in a narrow north-facing basin on the northeast edge of the Coquitlam Watershed. At the end of the little ice age (mid-19th century) Metro Vancouver's water supply areas were home to 5-10 small glaciers, but this is now the last remaining glacier, and it is disappearing quickly.

Light detection and ranging (LiDAR) has been used to measure the height of the glacier in 2015, 2018, and again in October 2022. This repeat-pass LiDAR allows us to see how much the glacier has changed in just seven years. We're also able to compare aerial imagery of the glacier to air photos from as early as 1979. These photos show us how the extent of the glacier has changed over the past 40 years.

The glacier has shrunk from approximately 30 hectares in 1979, to 18 hectares in 2022. In 2014 the small lake (tarn) at the toe of the upper glacier was not visible in aerial imagery, but is now clearly visible. Based on the LiDAR surveys, we can see that the glacier decreased in height by an average of 0.47 m per year between late 2015 and late 2018 (~1.4 m drop in three years). Over the next four years it shriveled by 2.2 m per year, almost a five-fold increase in melt rate after 2018. The glacier has dropped by an average of 10.2 m since our first LiDAR survey in the summer of 2015.

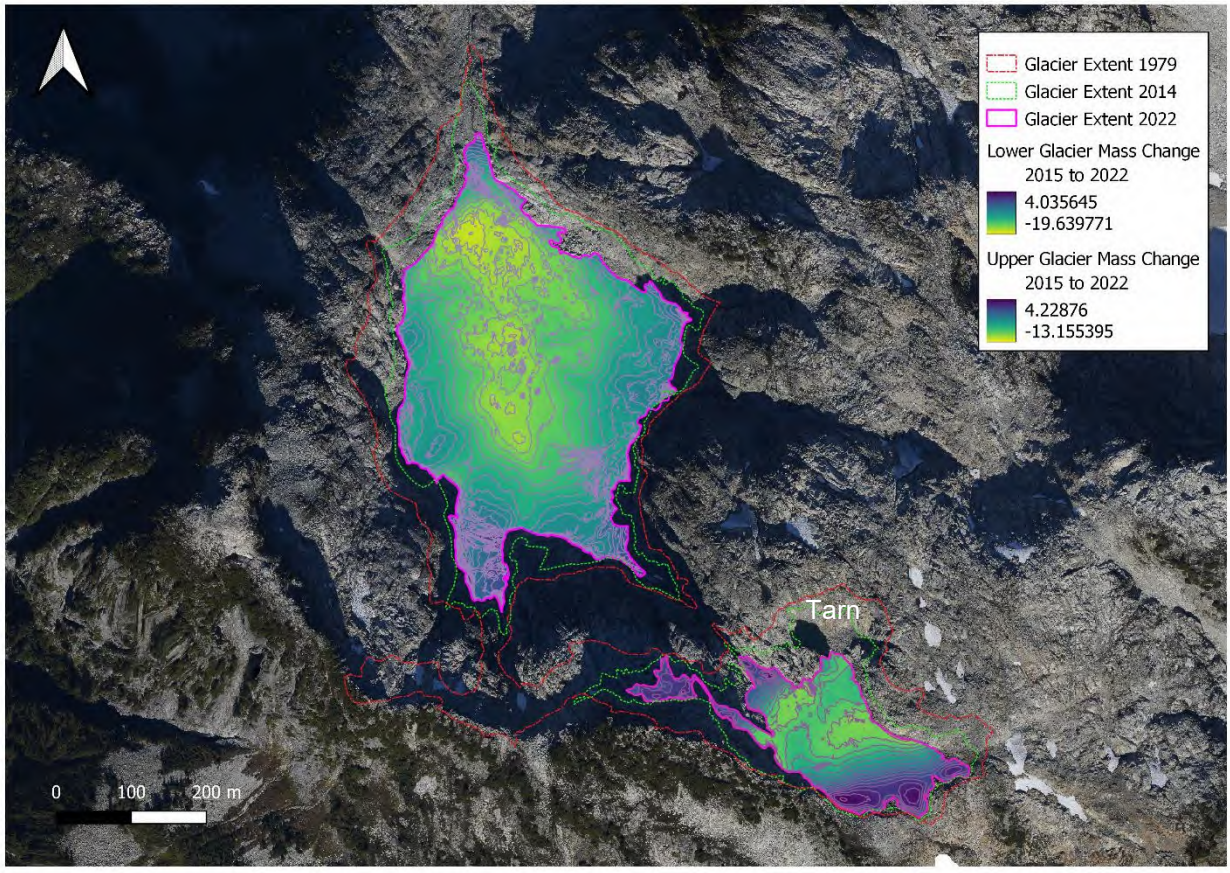


Figure 23: Map of the Coquitlam glacier showing the change in elevation between August 2015 and October 2022. The extent of the glacier is highlighted for 1979, 2014, and 2022 (Data: Airborne Coastal Observatory).

What has caused these increased melt rates over the past several years? Well, there's no doubt that the smaller the glacier becomes, the faster it will melt, but there is probably more at play here. Most

winters since 2015 have seen above average winter snowpacks, which should be beneficial for glacier because it stays covered in a blanket of seasonal snow later into the summer. Air temperatures are certainly a factor. The last two summers were the hottest on record in the watersheds, and this past summer was hotter and drier for much longer than usual.

Another factor that is likely having a significant impact on this glacier, and most glaciers in western Canada, is the deposit of ash on the glacier's surface from wildfire smoke. Our region has been affected by wildfire smoke almost every summer since 2015. The ash has darkened the ice surface considerably, making it absorb more heat, which in turn increases melt. This little glacier is not long for this world! And sadly, it will only be one of many that disappear this century. A recent study shows that up to 80% of the world's glacier may be gone by 2100 (Rounce et al., 2023).

Figure 24: Coquitlam glacier – October 2022 (photo: Metro Vancouver).

7.4. Bitter Cold, Winter Storms, and Atmospheric Rivers

The year ended in a flurry of intense weather. Most of North America was hammered by severe weather during the Christmas break, which led to complete travel chaos across the continent.

On December 17th, a cold Arctic air mass descended on western Canada. The Arctic front pushed south of the US border, leaving the BC south coast with very cold temperatures (-10 to -20°C on Dec 19). On December 20th a low pressure system moved onshore and slammed into the entrenched cold air, blanketing Metro Vancouver in cold, dry snow. Some areas received almost 40 cm of snow with this system!

Figure 25: Metro Vancouver under a blanket of snow on December 21st, 2022 (Photo: CBC)

Cold temperatures persisted for a couple more days after the big snowfall, but a major weather pattern change was brewing in the Pacific. A moist Pacific frontal system made landfall late on December 23rd. This system was forecasted to deliver significant snowfall, followed by prolonged freezing rain, then a lengthy period of heavy rain. Snowfall amounts ended up being less than expected, but freezing rain caused major travel challenges and resulted in power outages across the south coast. The Alex Fraser and Port Mann bridges were closed for over a day due to the risk of falling snow and ice. Ferries were cancelled, and Vancouver airport was almost completed shuttered.

Snow had changed to heavy rain by Christmas Eve and continued throughout the holidays as an atmospheric river targeted the coast. Heavy rains and high river flows coincided with king tides on December 26th and 27th. A new high water level of 5.70 m was recorded at Point Atkinson (West Vancouver) on December 27th, breaking the previous record of 5.61 m set in 1981. Heavy rain, melting snow, and high tides resulted in localized flooding throughout the Lower Mainland.

Figure 26: King tide and flooding on the Seawall in Kitsilano on December 27th, 2022 (Photo: CBC)

Watershed areas recorded 350-550 mm of precipitation by the end of the year, which is essentially equivalent to the average monthly precipitation for December. Low elevation snow disappeared very quickly as temperatures shot up at the end of the month. In fact, a new high temperature record was set in the watersheds on December 27th with an average daily temperature of 7 degrees. Quite a change in only one week

8.0 REFERENCES

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To: Water Committee

From: George Kavouras, Acting Director, Procurement and Real Estate Services
Bob Cheng, Director, Major Projects, Project Delivery

Date: March 7, 2023 Meeting Date: March 15, 2023

Subject: **Award of Contract Resulting from RFP No. 22-139 Construction of the Coquitlam Main No. 4 South Section Robson Drive to Guildford Way**

RECOMMENDATION

That the GVWD Board:

a) approve the award of a contract in the amount of $97,196,248 (exclusive of taxes) to Michels Canada Company resulting from RFP No. 22-139: Construction of Coquitlam Main No. 4 South Section Robson Drive to Guildford Way, subject to final review by the Commissioner; and
b) authorize the Commissioner and Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

EXECUTIVE SUMMARY

This report is to recommend the award of a contract in the amount of $97,196,248 (exclusive of taxes) to Michels Canada Company (Michels), the highest ranked contractor and lowest overall cost, for RFP No. 22-139: Construction of Coquitlam Main No. 4 South Section Robson Drive to Guildford Way.

To address a current shortfall in the Coquitlam source transmission system and to meet the growing demand for drinking water in the region, construction of Coquitlam Main No. 4 is targeted for completion by 2029. The overall Coquitlam Main No. 4 program includes four sections, namely Central Section, South Section (Robson Drive to Guildford Way), Tunnel Section, and Cape Horn Section. The South Section is the first of the four sections to be constructed.

PURPOSE

This report is to advise the GVWD Board of the results of RFP No. 22-139: Construction of the Coquitlam Main No. 4 South Section Robson Drive to Guildford Way and to recommend award of the contract in the amount of $97,196,248 (exclusive of taxes) to Michels.

BACKGROUND

Pursuant to the *GVWD Officers and Delegation Bylaw No. 247, 2014 (Bylaw)* and the *Procurement and Real Property Contracting Authority Policy (Policy)*, procurement contracts which exceed a value of $5 million require the approval of the GVWD Board of Directors.

This report is being brought forward to the Water Committee to consider a recommendation to the GVWD Board to authorize the award of a contract for the Construction of the Coquitlam Main No. 4 South Section Robson Drive to Guildford Way.

PROJECT DESCRIPTION

The current GVWD Coquitlam transmission mains have a capacity shortfall that does not permit the full design capacity of the existing Coquitlam Water Treatment Plant to be conveyed. Furthermore, a key goal in the 2019 to 2022 *Board Strategic Plan* is to develop and secure additional long-term water supply capacity from the Coquitlam source. In order to meet the region's water supply needs and keep pace with regional population growth, an upgrade to the Coquitlam transmission system is required by 2029 to avoid impacting delivery of water to the southern and eastern areas of the region.

Coquitlam Main No. 4 is a critical component in the upgrade. The overall Coquitlam Main No. 4 program includes Central Section, South Section (Robson Drive to Guildford Way), Tunnel Section, and Cape Horn Section (see Attachment 1 for overall alignment). Design of the 1.5-kilometer (km) long, 3.2 metres (m) diameter, South Section is first to be completed with construction slated to start later this year (see Attachment 2 for South Section route) in advance of the City of Coquitlam's Pipeline Road Widening Project on Pipeline Road from David Avenue to Guildford Way to reduce construction impacts to the neighbourhood. When fully built out, Coquitlam Main No. 4 will be roughly 12 km long with nominal diameters ranging from 2.2 m to 3.5 m and will ultimately connect into the Coquitlam source.

RFP No. 22-139 Evaluation and Award Recommendation

RFQ No. 21-221 was issued in 2021 to prequalify contractors to participate in RFP No. 22-139 Construction of the Coquitlam Main No. 4 South Section Robson Drive to Guildford Way. Five experienced contractors were shortlisted and invited to respond to RFP No. 22-139 as follows:

1. Michels Canada Company
2. Aecon Infrastructure Management Inc. (Aecon)
3. Matcon Civil Constructors
4. JJM Construction Limited
5. Sandpiper Contracting LLP

RFP No. 22-139 was issued on July 11, 2022 and closed on January 13, 2023. Two proponents, Michels and Aecon submitted proposals. Evaluation resulted in Michels ranking first with the highest overall technical score and the lowest proposed fee of $97,196,248 (excluding taxes) and Aecon ranking second with a proposed fee of $116,333,567 (excluding taxes).

The construction cost estimate was updated just prior to the issuance of RFP No. 22-139. Furthermore, the project team met with all five prequalified contracting firms to solicit feedback on the project requirements to better inform the design of the RFP and to gauge their interest in submitting proposals for the project. Ultimately, two out of the five proponents submitted proposals and the rest did inform us that they did not have the capacity to take on the work at this time.

Michels' proposed fee of $97,196,248 exceeds the Engineer's estimate of $75 million. The higher than anticipated costs are largely due to significant price escalations in the construction industry

and a saturated construction market. The pent up demand for infrastructure spending coupled with ongoing supply chain issues have impacted material availability and price stability. As well, sky high energy prices and labour shortages together with rising interest rates have created price escalations. In addition, the overall construction cost was difficult to accurately estimate given the complexities associated with a 3 m diameter water main installation in an urban setting and the current volatility of the construction market.

Negotiations with the highest ranked contractor, Michels, were completed on February 17, 2023 and the terms of the contract were agreed to and finalized. The contract value agreed to is $97,196,248 (exclusive of taxes).

ALTERNATIVES

1. That the GVWD Board:
   a) approve the award of a contract in the amount of $97,196,248 (exclusive of taxes) to Michels Canada Company resulting from RFP No. 22-139: Construction of Coquitlam Main No. 4 South Section Robson Drive to Guildford Way, subject to final review by the Commissioner; and
   b) authorize the Commissioner and the Corporate Officer to execute the required documentation once the Commissioner is satisfied that the award should proceed.

2. That the GVWD Board terminate RFP No. 22-139: Construction of Coquitlam Main No. 4 South Section Robson Drive to Guildford Way and direct staff to report back to the GVWD Board with options for an alternate course of action.

FINANCIAL IMPLICATIONS

If the GVWD Board approves Alternative 1, a contract will be awarded to Michels in the amount of $97,196,248 (exclusive of taxes) for Construction of the Coquitlam Main No. 4 South Section Robson Drive to Guildford Way. The proposal submitted by Michels was identified as the highest ranked and offered the lowest proposal cost.

There are sufficient funds in the overall Coquitlam Main No. 4 program to award this construction contract to Michels, however the proposal cost is above the Engineer's estimate. Award of this section of work requires the use of the remaining project contingency.

The GVWD Board has the choice not to proceed with Alternative 1, but staff will need further direction in relation to the project. Alternative 2 will result in delays to the project schedule that may impact the ability to meet the region's water supply needs, particularly in the southern and eastern areas of the region. Furthermore, the City of Coquitlam's Pipeline Road Upgrade Project may be delayed as well.

CONCLUSION

Coquitlam Main No. 4, consisting of the Central, South, Tunnel, and Cape Horn Sections, addresses a current shortfall in capacity from the Coquitlam source and will provide additional transmission capacity from the future expansion of Coquitlam source under the Coquitlam Lake Water Supply

Project. The water main needs to be constructed by 2029 to avoid impacting delivery of water to meet the region's water supply needs, particularly in the southern and eastern areas of the region, and the City of Coquitlam's Pipeline Road Upgrade Project.

Michels' proposal is highest ranked and offers the lowest price. It is recommended that the GVWD Board authorize the Commissioner and the Corporate Officer to award and execute the contract in the amount of $97,196,248 (exclusive of taxes) to Michels for Construction of Coquitlam Main No. 4 South Section Robson Drive to Guildford Way.

Attachments

1. Coquitlam Main No. 4 – Overall Map
2. Coquitlam Main No. 4 – South Section Robson to Guildford Way Map

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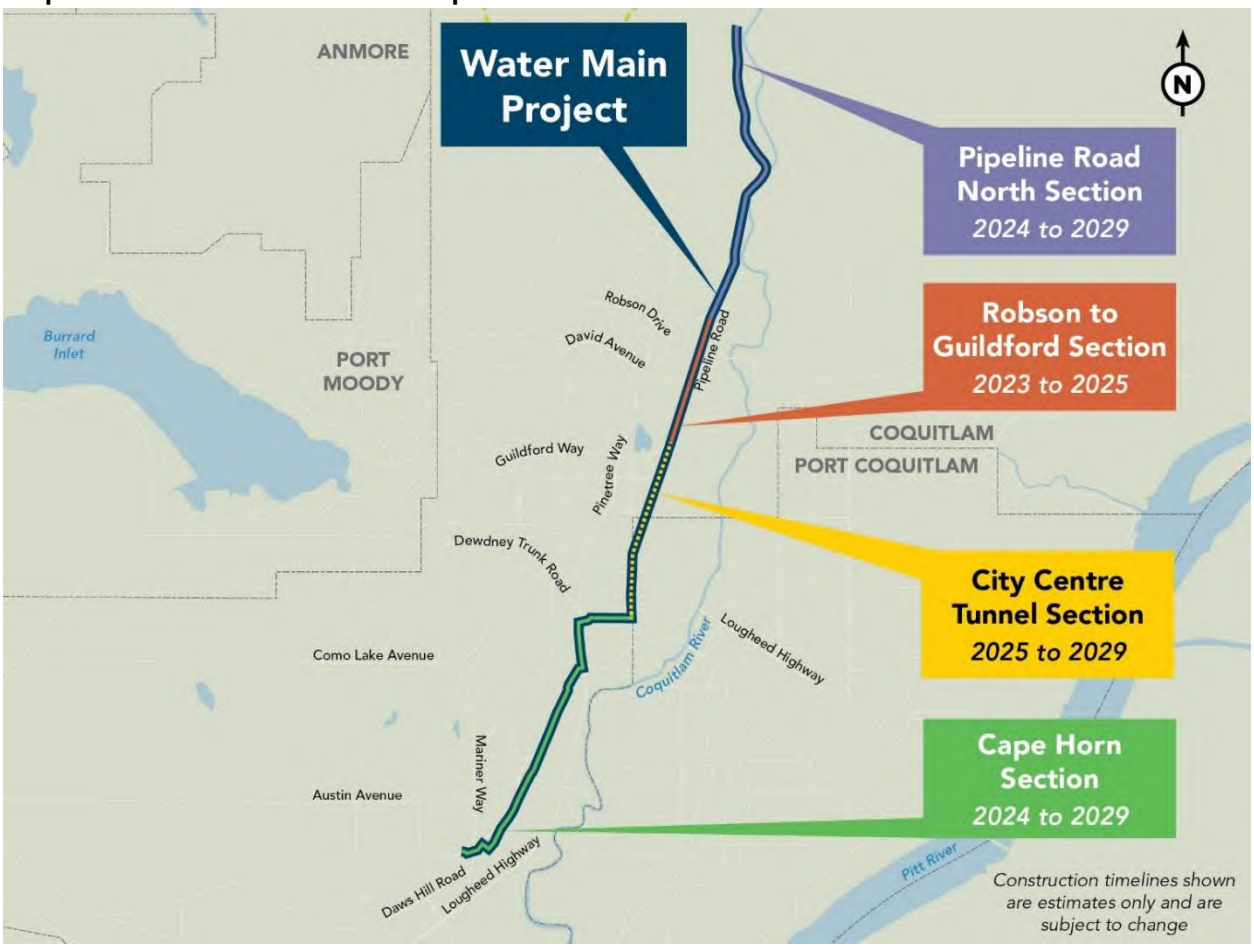
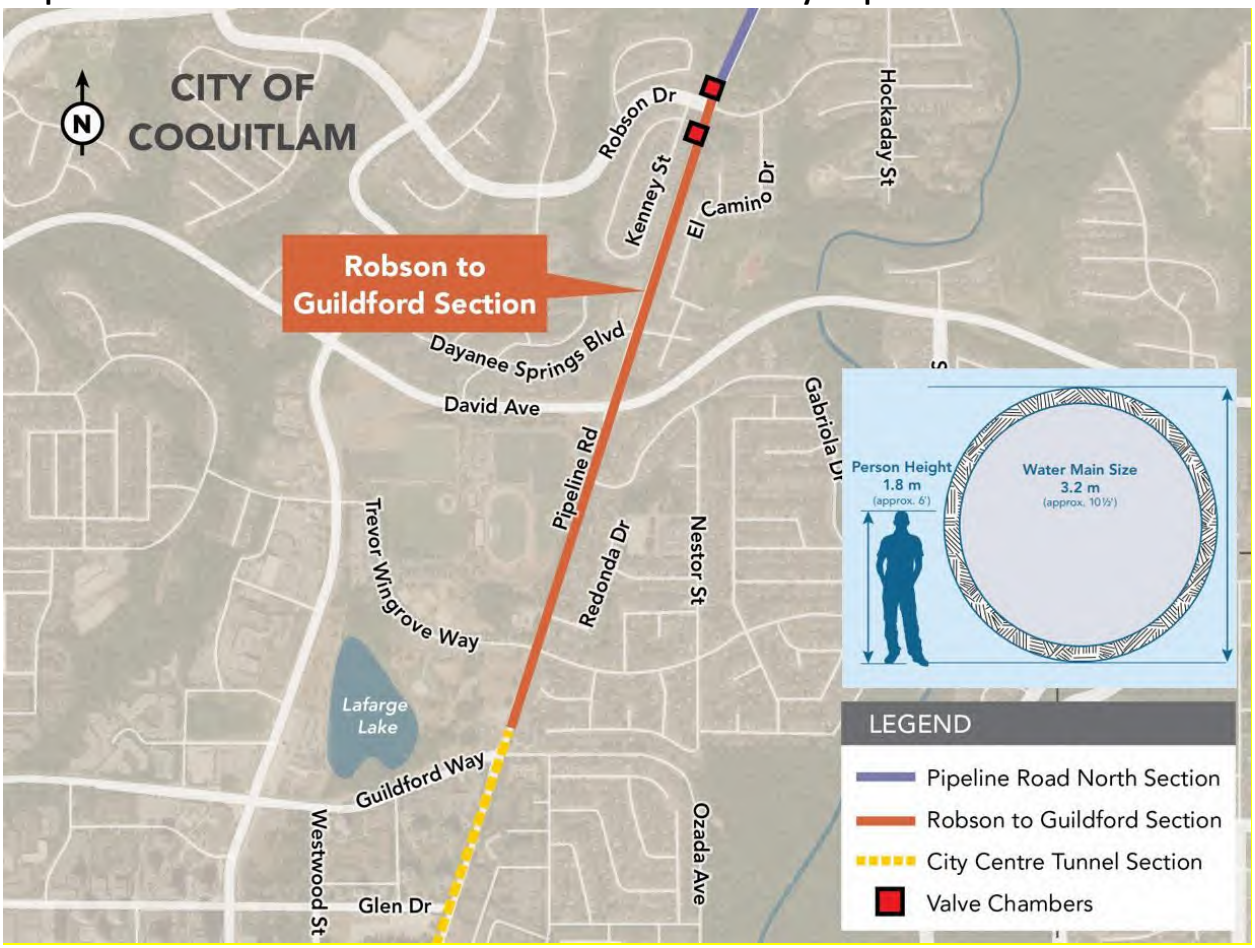
Coquitlam Main No. 4 – Overall Map



Coquitlam Main No. 4 – South Section Robson to Guildford Way Map



COMMITTEE INFORMATION ITEMS AND DELEGATION SUMMARIES

Greater Vancouver Water District
Board Meeting Date – Friday, March 31, 2023

This information item, listing recent information received by committee, is provided for the GVWD Board's information. Please access a complete PDF package here.

Water Committee – March 15, 2023

Delegations:
No delegations presented

Information Items:
5.2 Drinking Water Conservation Plan Summer Support Program – 2022 Results and 2023 Update

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