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# FLOW MONITORING – EVALUATING INNOVATIVE TECHNOLOGIES AND HYDROLOGICAL PREDICTION IN THE NATIONAL HYDROLOGICAL SERVICES

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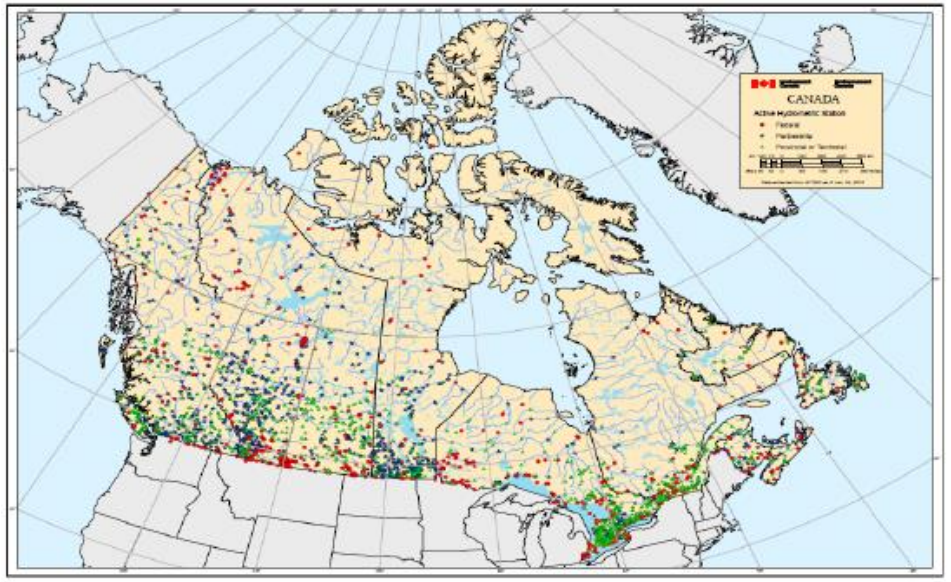
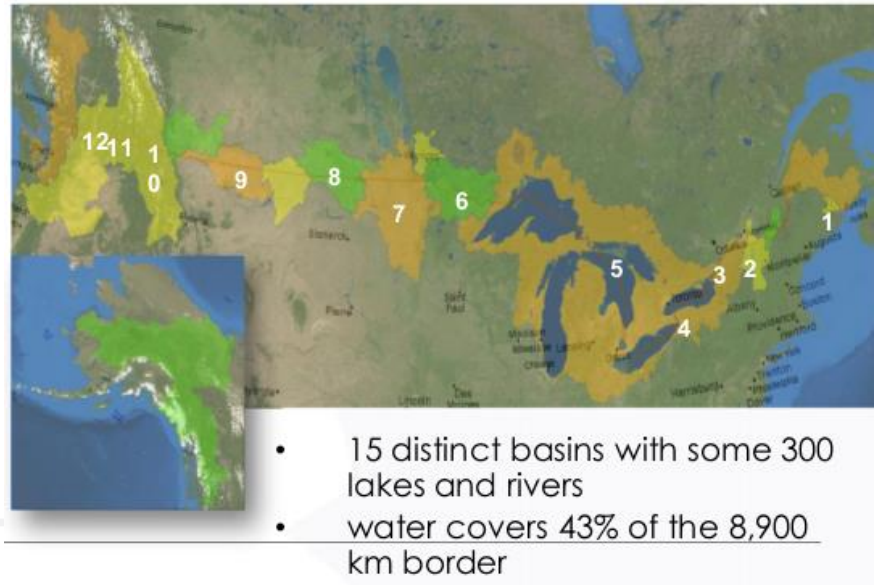
# OVERVIEW

- What do we do?
- The path to solve them
- The innovation component
  - What we are trying to do
  - Projects to get us there
- The prediction component
  - What we are trying to do
  - Projects to get us there

# WHAT IS NHS?

- Two main components to NHS
- Water Survey of Canada
  - Hydrometric monitoring (cost share agreements with PT partners)
  - Operation of some 2200 hydrometric station across Canada most of which are real-time
- Water Management
  - International and Domestic Water Management Boards
  - IJC reference studies
  - Hydrological, hydraulic and eco-hydraulic modelling activities

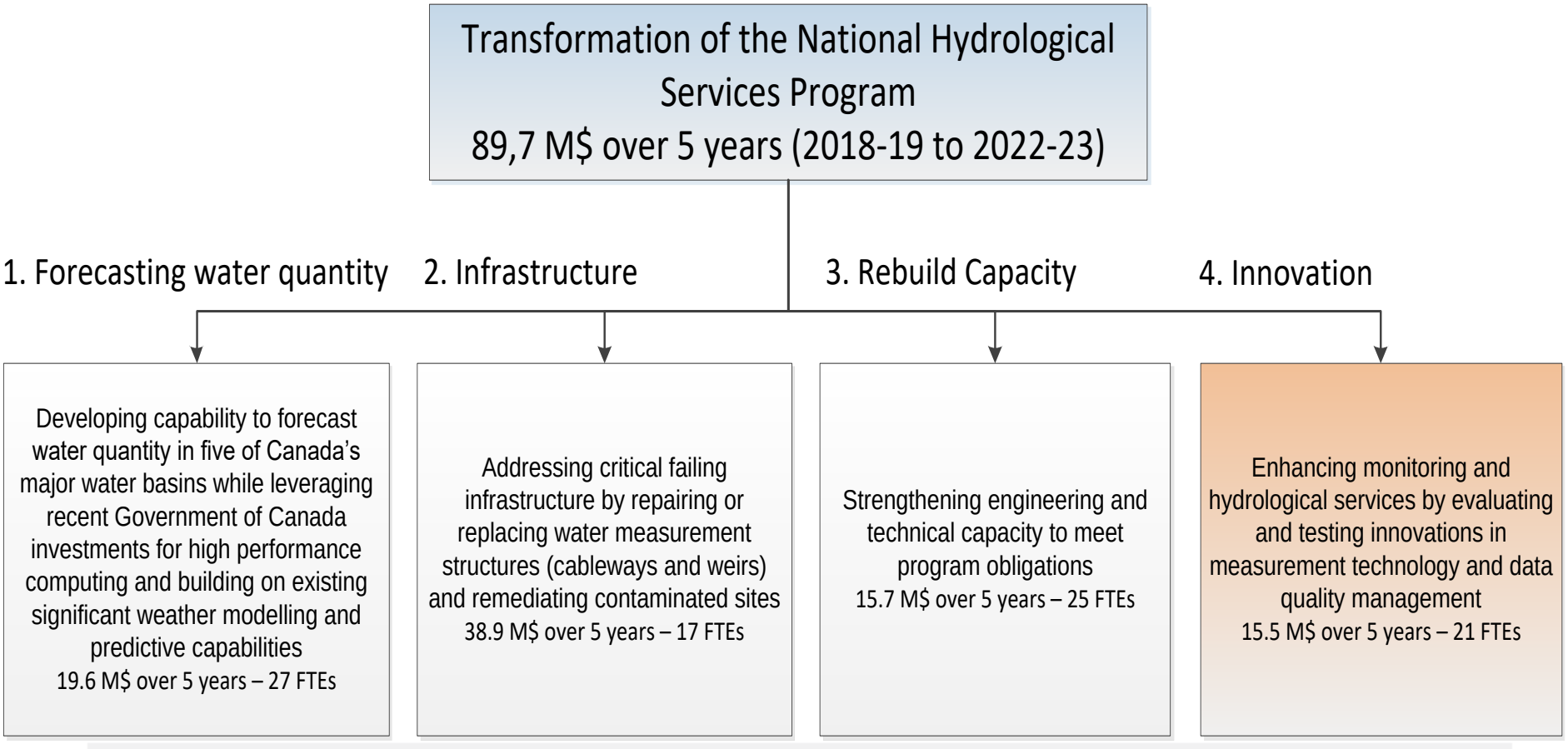


# The issues

- Ageing infrastructure
  - Cableways, Weirs, Wells, etc.
- HR resource issues
  - Staffing below zero-base estimates
  - Challenge in meeting our core water management mandate
- Need to keep up with rapidly evolving technology in all aspects of our business
- Now able to integrate more forecasting products into our operations and product suite
- Address feedback loops between monitoring and modelling

# HYDROMETRIC TREASURY BOARD SUBMISSION IN SHORT…

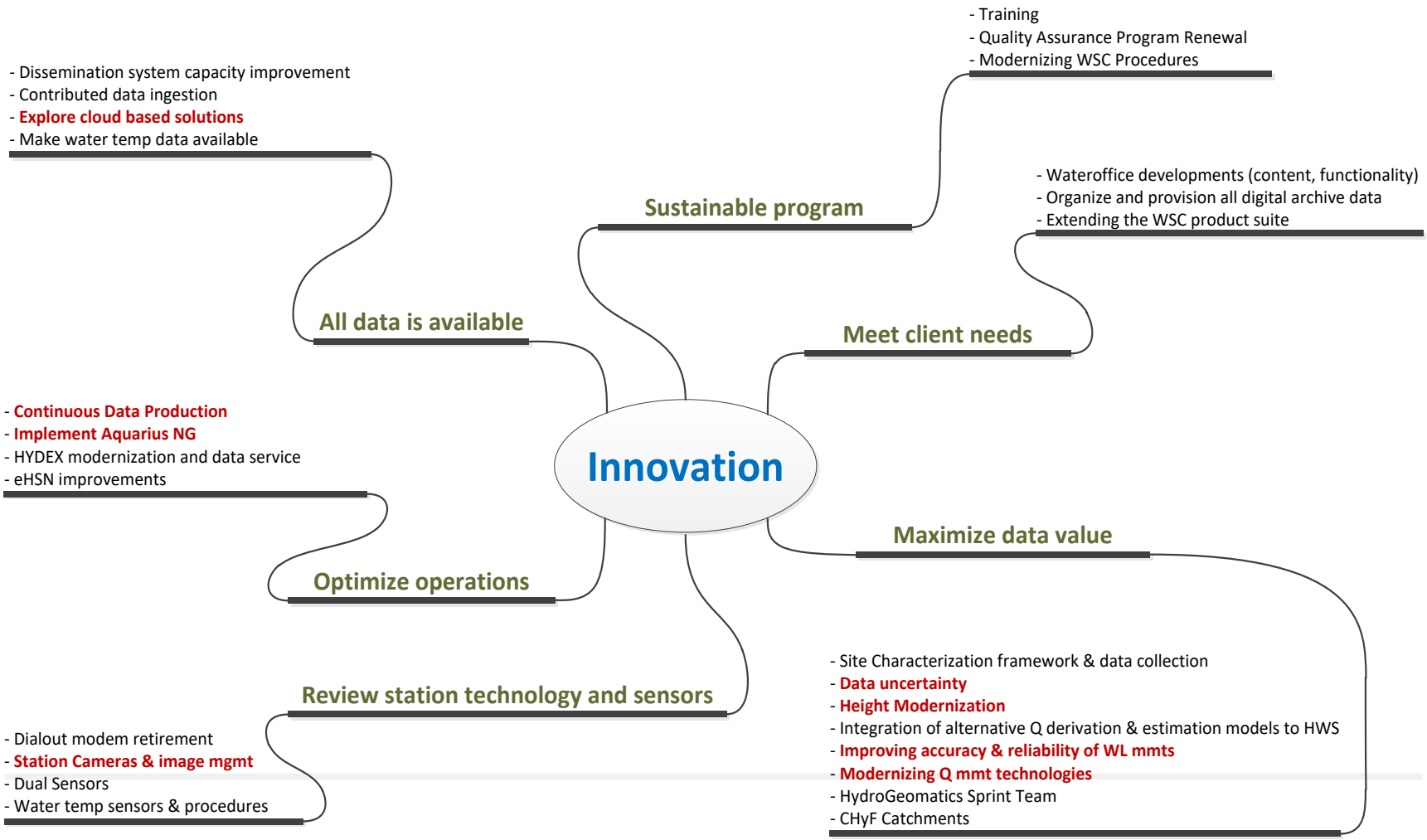


# Evaluate and test innovations in measurement technology and data quality

- The goals of this component are to
  - Strengthen national data systems (Improving system redundancy and 24/7 operations)
  - Test innovative new technologies (field and office)
  - Improve the ability of the NHS to integrate promising new technologies into its operations, and
  - Keep pace and innovate in a rapidly evolving technological environment.
- This includes
  - Implementing the newest generation of hydrometric data production systems
  - Advancing systems performance to meet the real-time needs for water resource management
  - Testing and implementing new technologies to improve the quality and efficacy of data collection
  - Improving the distribution of products and services by employing modern data dissemination platforms.
- In addition, an expanded suite of innovative products will be developed to support decision-making involving water resources made possible through the proposed incremental analytical capacity.

# INNOVATION PROJECTS UNDER 6 THEMES

- 25 plus proposals covering all aspects of our work
- Year 1/2 priority projects in bold red type



# YEAR 1 2018-19

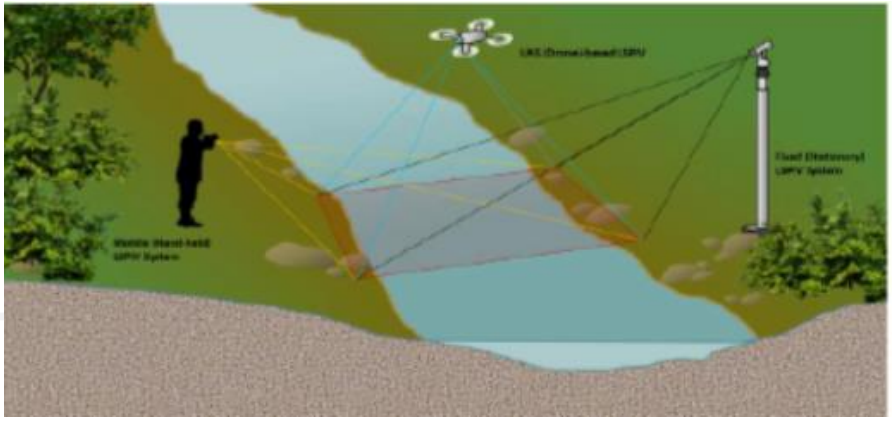
- Year 1 – Partial year
- Essentially ramp up
- Project and costing
- Acquisitions for test sites
  - LSPIV, radar, drone, Discharge App
  - Uplooking ADCP – under ice
  - GNSS systems for height modernization
- Setup of test sites initiated (headquarters)
- Project management and HR
  - Establish innovation committee (Water Survey Management and USGS representative)
- Establish Communication Strategy (Water Survey, OMC-H, NHPCC, NAT)

# YEAR 2 2019-20

- Initial regional staff (East and West) brought on for project with additional hiring to be completed by the end of calendar year 2019
- Implement test sites for Q measurement technologies in regions
  - LSPIV, index-velocity, radar (Ontario Thunder Bay and Atlantic on Sackville River at Bedford)
- Test improvements for at station technologies (WL sensors, cameras)
- Complete continuous data production pilot and begin national implementation
- Implement Aquarius NG into national operations
- Height Modernization (reference all stations to a common vertical datum)
  - Complete the development of a national plan
  - Field work and data analysis as per plan

# LARGE SCALE PARTICLE IMAGE VELOCIMETRY (LSPIV)

- Potential for measuring discharge in flashy and/or remote sties, and when other methods are not possible
- In development and use by other agencies (USGS, France, Argentina), both for fixed and handheld cameras
- WSC progress
  - Developed guideline (and field checklist) for hand-held video collection
  - Testing 3 different fixed-LSPIV set ups at WSC stations in Ottawa area
    - Satellite camera (02KF015)
    - Security camera + RaspberryPi + cell modem (02LB006)
    - 2 camera (stereo) set up, research with Uottawa (02LA004)
    - Testing commercial LSPIV app (DischargeApp) through selected WSC offices
    - Testing of drones for LSPIV testing



**Different LSPIV Options /Configurations WSC is Currently Testing**

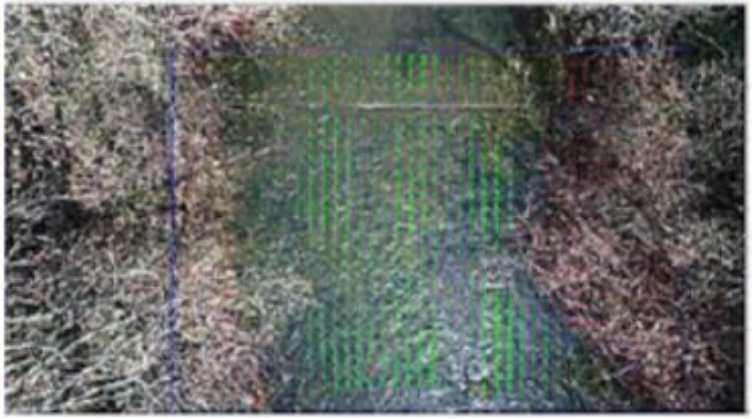
# Fixed-Camera LSPIV System

**Raspberry-based Fixed Camera Setup**

*Station: 02LB006 – Castor River, ON*

# UAS (Drone)-based LSPIV System

***Station:08HB032, BC***



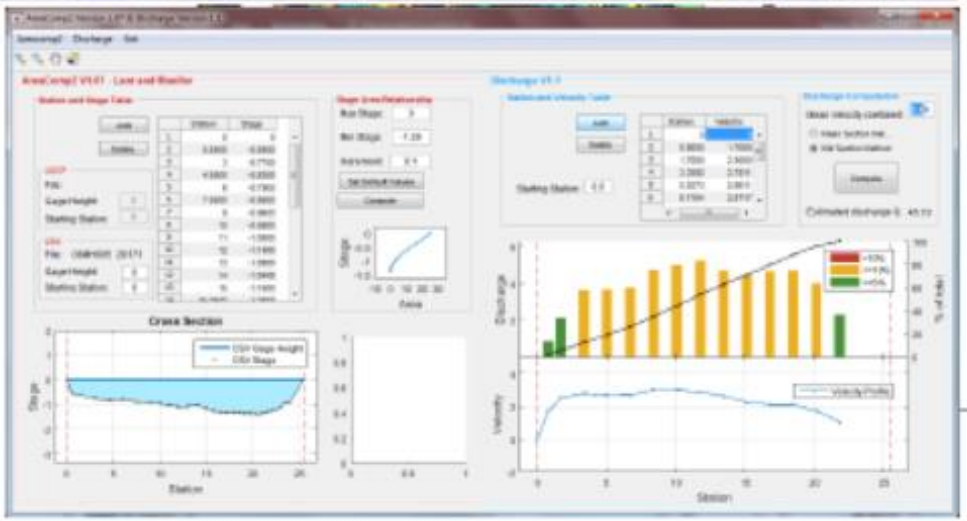
**Phantom-4-Pro**

*(used for LSPIV testing)*

# Mobile (Hand-held) LSPIV System

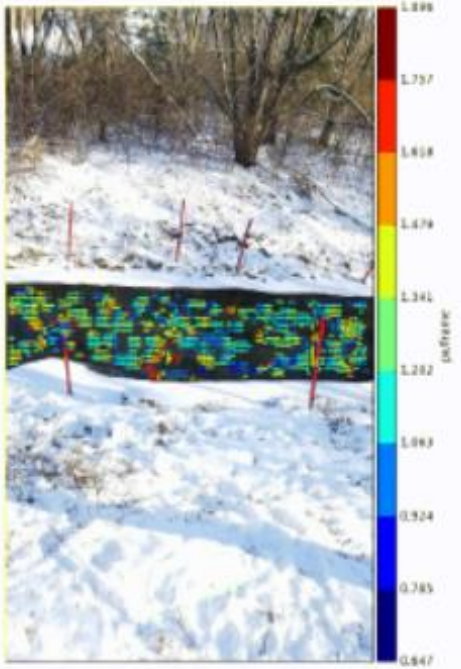
**Mobile (Hand-held) Video**

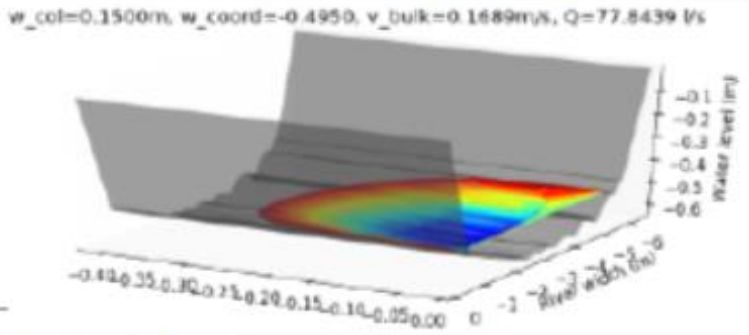
*Station:08MH005-Alouette River Near Haney, BC*



**DischargeApp Test**

*Station:02KF015 – Graham Creek, ON*






*Note: DischargeApp test is at early stage, and the quality of the results show the room for improvement*

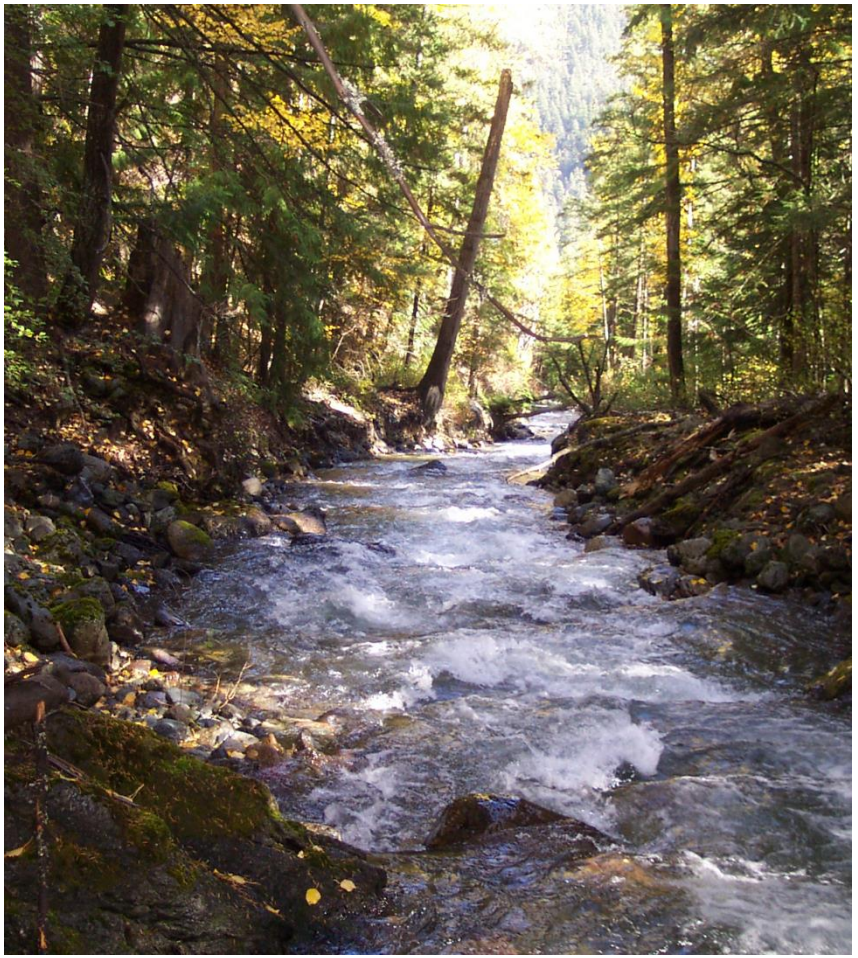
# FIXED LSPIV SYSTEM - *GRAHAM CREEK AT NEPEAN (02KF015)*

- Small, flashy urban creek
- Nupoint satellite camera
- Remote video triggering capabilities and easy measurements

# DILUTION TECHNIQUES

Dilution techniques may be superior to other techniques under the following conditions:

- High velocities or turbulence when other techniques (e.g., Price, ADCP) may fail
- Irregular channel boundaries (e.g., boulders or mobile bed) which make it difficult to use an area-velocity method
- When flow depths and velocities can be too small to be measured accurately



# METHOD

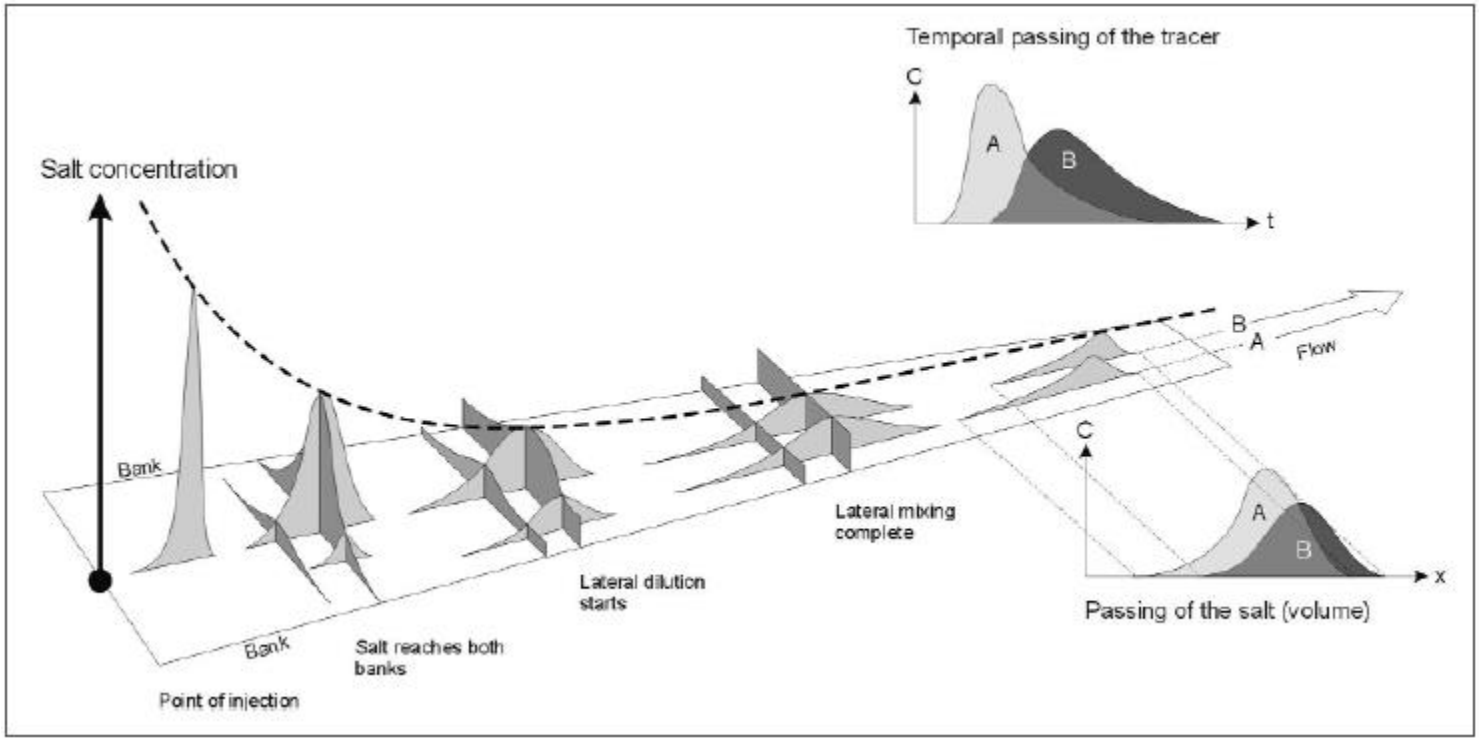
- Method involves injecting a tracer of known mass or concentration into a stream and measuring the “dilution” at a downstream location

- Method relies on:
  - Tracer being conservative and stable (does not degrade/adsorb)
  - Conservation of mass (no tracer lost between injection and measurement location)
  - Tracer well-mixed at downstream measured location

- Common methods: “Slug” and “Constant Rate”

- Common tracers:
  - Ionic – e.g., NaCl (table salt) – up to ca. 30 cms
  - Fluorescent – e.g., Rhodamine WT – 100+ cms

# A Longitudinal Profile of Tracer Concentrations From a Slug Injection




From Merz and Doppmann, 2006

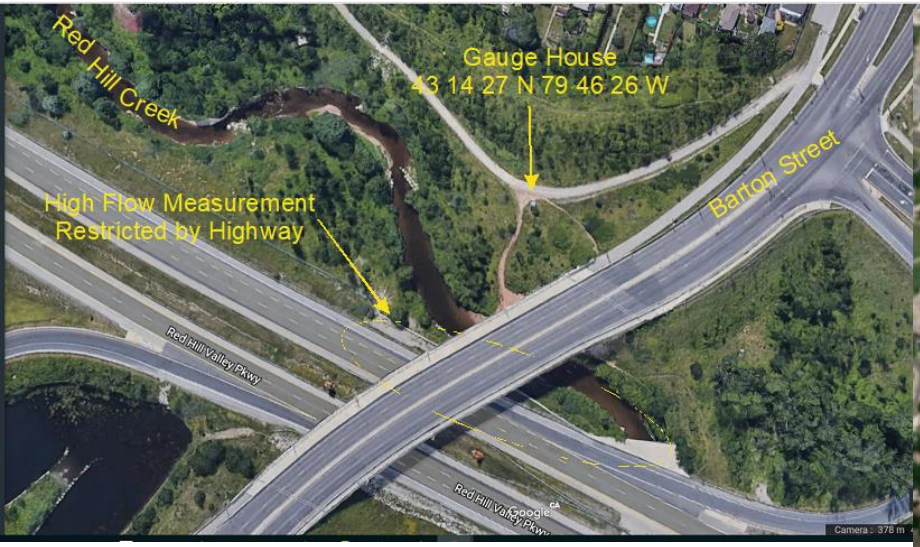

Installation of an automated salt dilution system
Nordic Creek at outlet of Nordic Glacier (08NB020), Selkirk Mountains, BC

Example of poor lateral mixing of Rhodamine WT –
Coquihalla River below Needle Creek (08MF062)

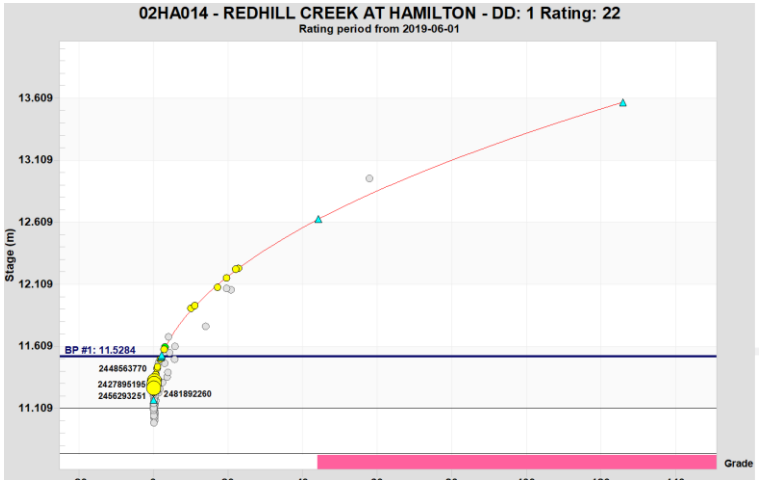
# HYDRAULIC MODELLING

- Redhill Creek at Hamilton (02HA014)

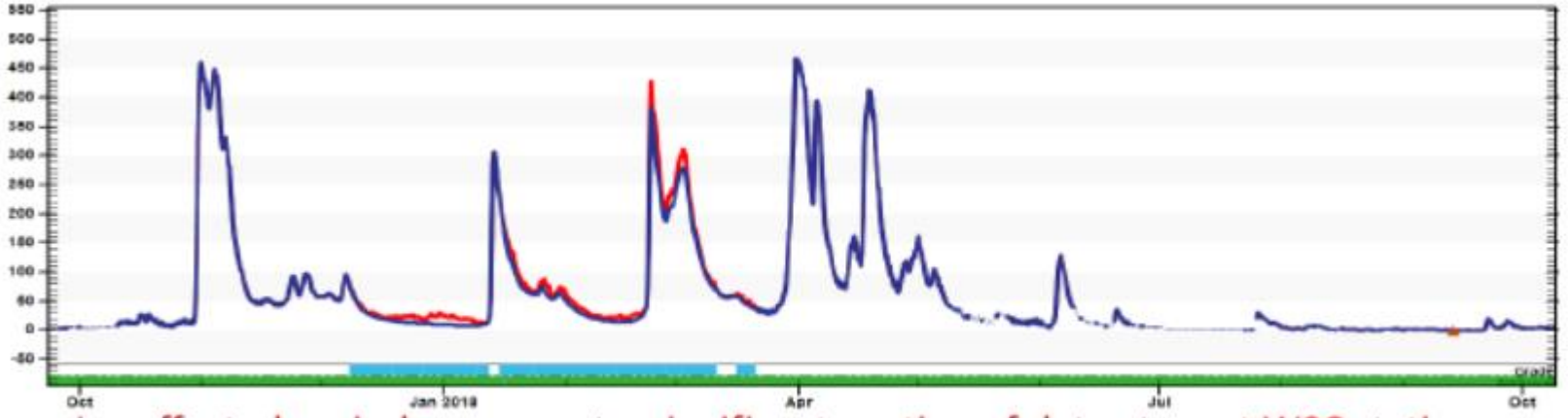
Figure: Location Red Hill Creek at Hamilton (02HA014) Hydrometric Station







# IMPROVING ICE AFFECTED FLOW DATA




Ice affected periods represent a significant portion of data at most WSC stations.

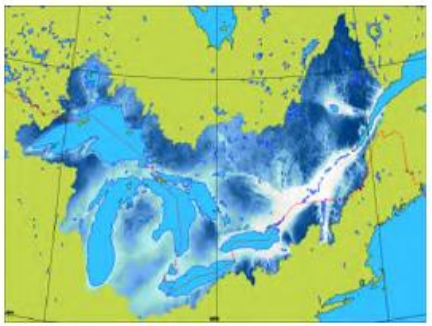
- Cameras (satellite and IP) and imagery
- Uplooking ADCPs
- Innovative measurement platforms
- Eastern test sites (year 2)
  - North Current River above Thunder Bay
  - Sackville River at Bedford
  - LSPIV equipment will also be installed at these sites

# THE DEVELOPMENT PROCESS (ISO)

- Identify promising technologies
- Develop test plan (sites, pilot system, etc.)
- Procurement
- Set up of test sites / pilot system
- Operate test sites / pilot system for full test period
- Analyze results
- Produce recommendations for operational implementation.
- Approval of recommendations (OMC, NAT).
- If approved, develop implementation plan (sites, timelines, training, SoPs, OSH, costs).
- Proceed with phased implementation.

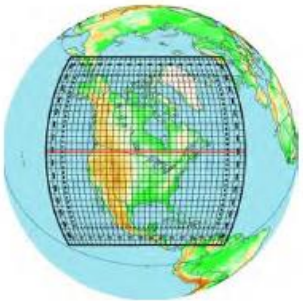
# ECCC's Current Earth System model

**Hydrology/Hydraulics/Stream Ecology**



**GEM LAM ( 2 - 10 km) atmospheric model**

**GEM RDPS (10 km) atmospheric model**

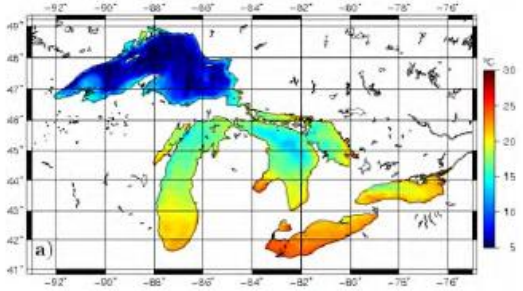


Runoff

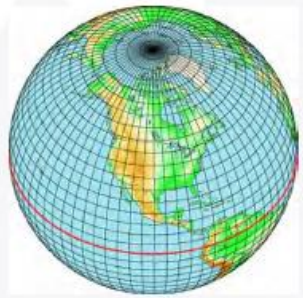
Streamflow

Turbulent fluxes

- 2 forecasts/day (00Z and 12Z)
- 48-h forecasts
- Assimilation cycle: direct insertion of RADARSAT ice cover and WSC streamflow



**NEMO+CICE (2 km) ocean-ice model**



**GEM GDPS (25 km) atmospheric model**

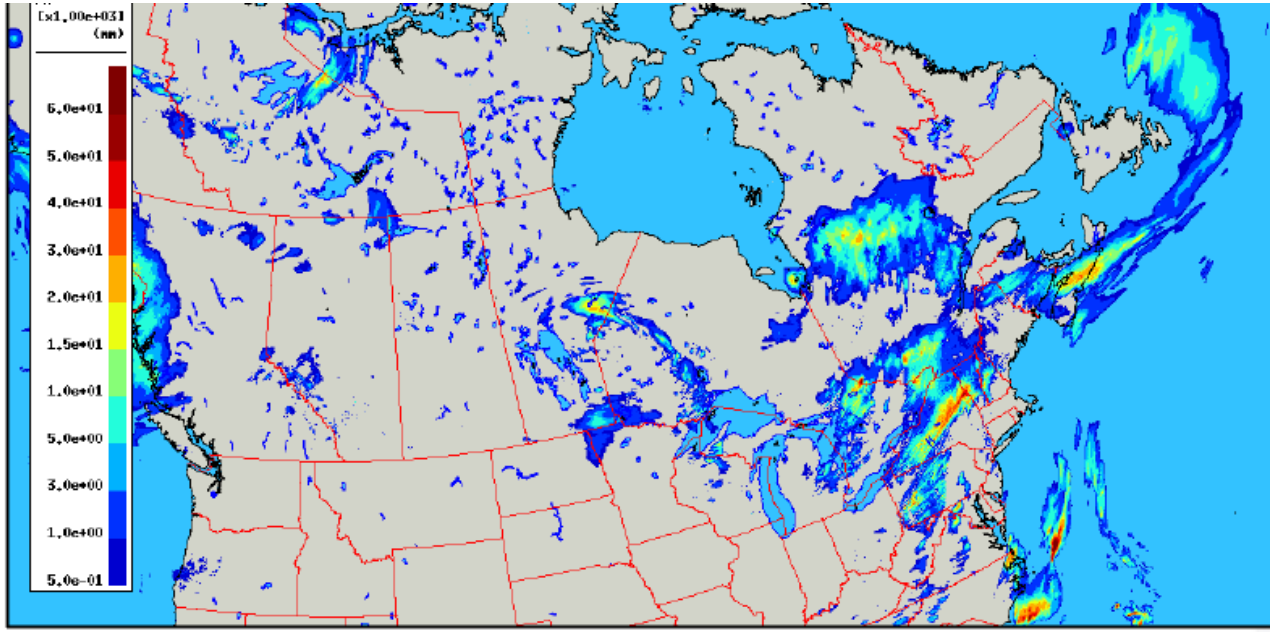
## Canadian Precipitation Analysis

- Real-time QPE for Canada since April 2011
- Combines in-situ data and radar with GEM short-term forecast
- 6-h and 24-h accumulations
- 10-km for North America
- 2.5-km for Canada

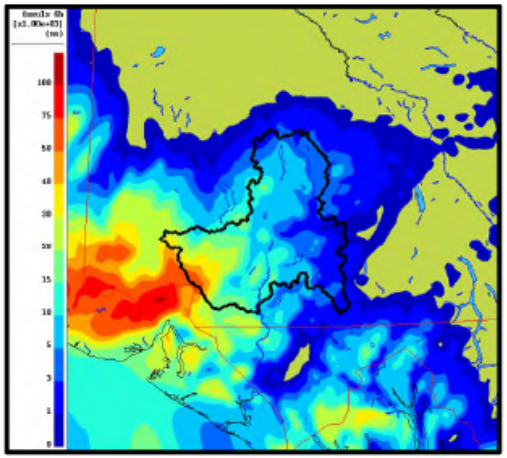
More details here:

http://weather.gc.ca/analysis

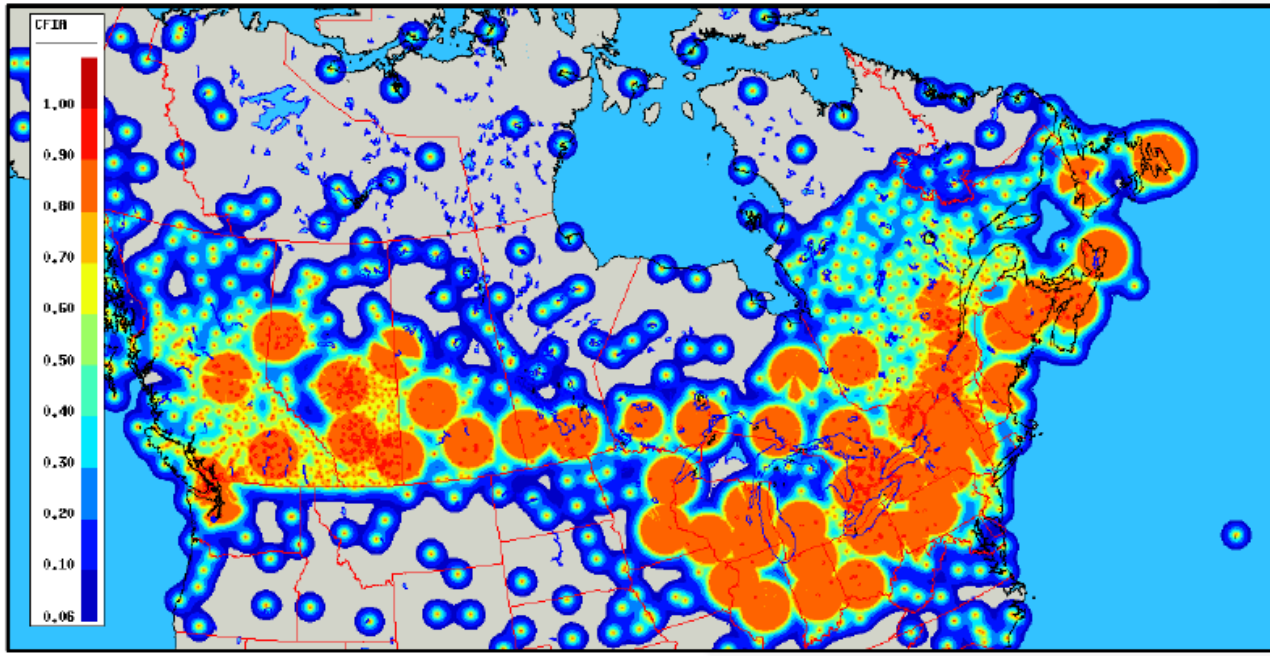
http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/submenus/capa_e.html




*6 hour total precipitation analysis at a resolution of 2.5 km valid at 18 UTC on July 1st , 2017*



*10.9 mm watershed average for basin 08AB001 valid at 06 UTC on February 14, 2017*

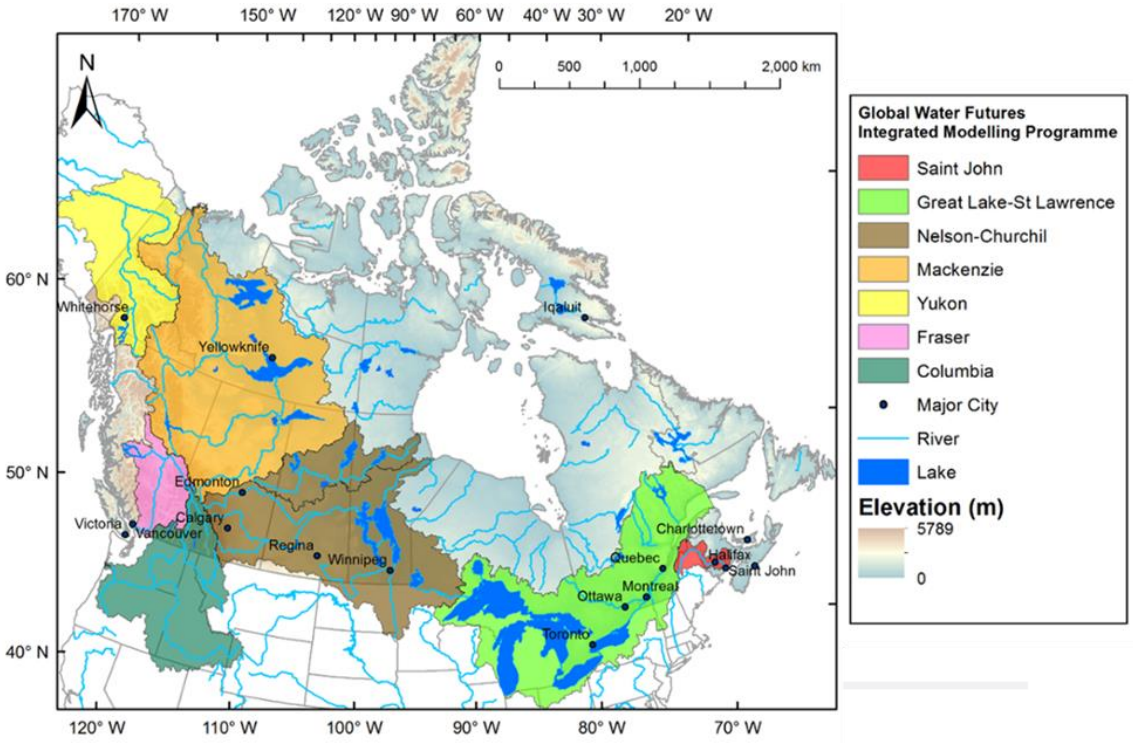



*Confidence Index of the Analysis (CFIA) valid at 18 UTC on July 1st , 2017*

# BUSINESS PRIORITIES AND IMPACT

Under the NHS Renewal's Forecasting Water Quantity component, the NHS is will be developing capability to predict water quantity in five of Canada's major water basins:

- Great Lakes-St. Lawrenc
- Saskatchewan-Nelson;
- Mackenzie;
- Columbia, and;
- Churchill.



# WORK PLANS

- Partner Engagement
  - Provinces and Territories
- Data Assimilation
  - Forecasting Integration with Aquarius for Water Survey Operations
- Technical Development
  - Short Range stream flow forecasting (2-6 days)
  - Long-range land-surface water availability forecasting (16-32 days)
  - Experimental automated coastal flood risk products for the East Coast
- Dissemination

# PROVINCIAL/TERRITORIAL (P/T) PARTNER ENGAGEMENT

- Determine knowledge and resource gaps that are hindering P/Ts from utilizing CMC forecast products.
  - Determine if and how NHS can assist in closing or occupying identified gaps.
- Determine how to make working level connections between MSC and the P/Ts to enhance the ESM products and services and their use.
  - This includes CaPA and other analysis or reanalysis information.
- Discuss and share the flow forecasting work being done in the PTs and by other organizations with a view to encouraging collaboration and efficiency (e.g. PPWB Committee on flood forecasting).
- Work with P/Ts to ensure CMC maintains and makes where possible open source models available for use by both NHS and P/T possible use.

# PROVINCIAL/TERRITORIAL (P/T) PARTNER ENGAGEMENT

- Establish a National Flow Forecasting Community of Practice
  - ensure that the flow forecasting and analysis products and services developed and offered by MSC provide relevant solutions for our P/T partners.
  - similar to and at the same level as the National Hydrometric Program Coordinators Committee (NHPCC)

- Develop a list (along with descriptions) of products currently available from CMC to P/Ts and plain language presentation materials.

- Documented understanding of the flow forecasting product and service needs for each province and territory.