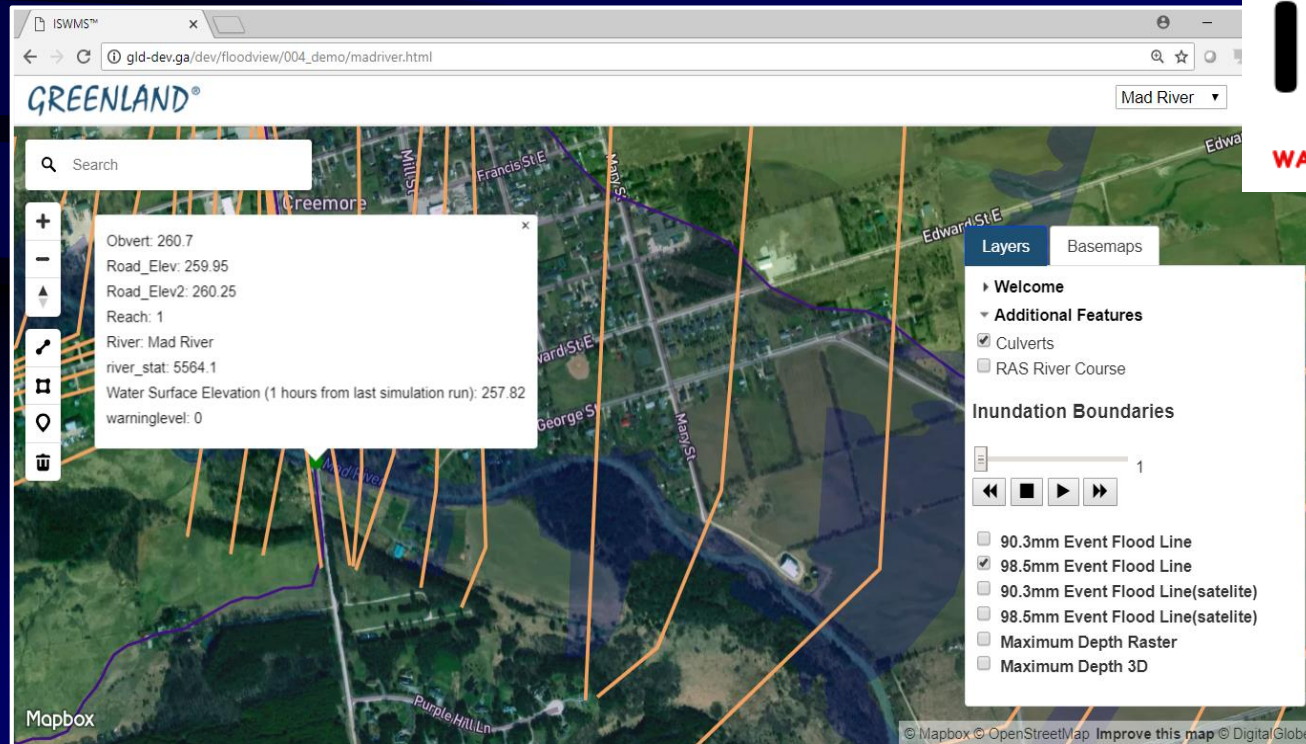


Forecasting Flood Inundation - Real-Time Transfer of Forecast Flows from HEC-HMS into HEC-RAS ISWMS - An International Decision Support Joint Venture for Floodplain Mapping & Flood Forecasting

Presented by Nicholas Keast, P.Eng.
In Collaboration with
George Yang, P.Eng.

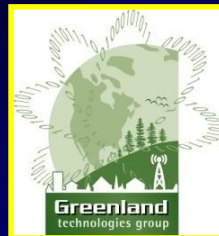


Evolution of the ISWMS™ - Partners

The **GREENLAND® Group**, in partnership with Simcoe County, GSCA, and MRCA, and with the support of the NVCA and the NDMP, developed a tool to assist with planning around forecasted floods.



Greenland developed a stand-alone, or Internet based tool, to provide decision makers with **Forecasted Water Levels**. The tool automatically grabs Environment Canada open forecast data and feeds into **calibrated HEC-HMS models** to determine forecasted flows, and feeds forecast flows into **calibrated HEC-RAS models** to forecast water levels and inundation.



For more information visit,
www.grnland.com

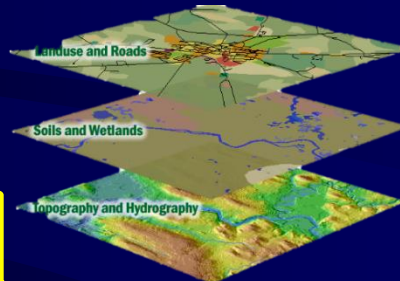
Internet Decision Support System Platforms (with International Partners)



1980-90's
*'Tandy, IBM-XT &
AST Computers and
Dot Matrix Age'*



**Integrated GIS and
Geo-processing that
incorporates best-
available science**



Since 2000
*'Information
Technology' Age*

Since 2013
*'Intelligence
Information' Age*



Cloud
Computing
& Storage



Web-based
GIS and
Predictive
Tools & Data

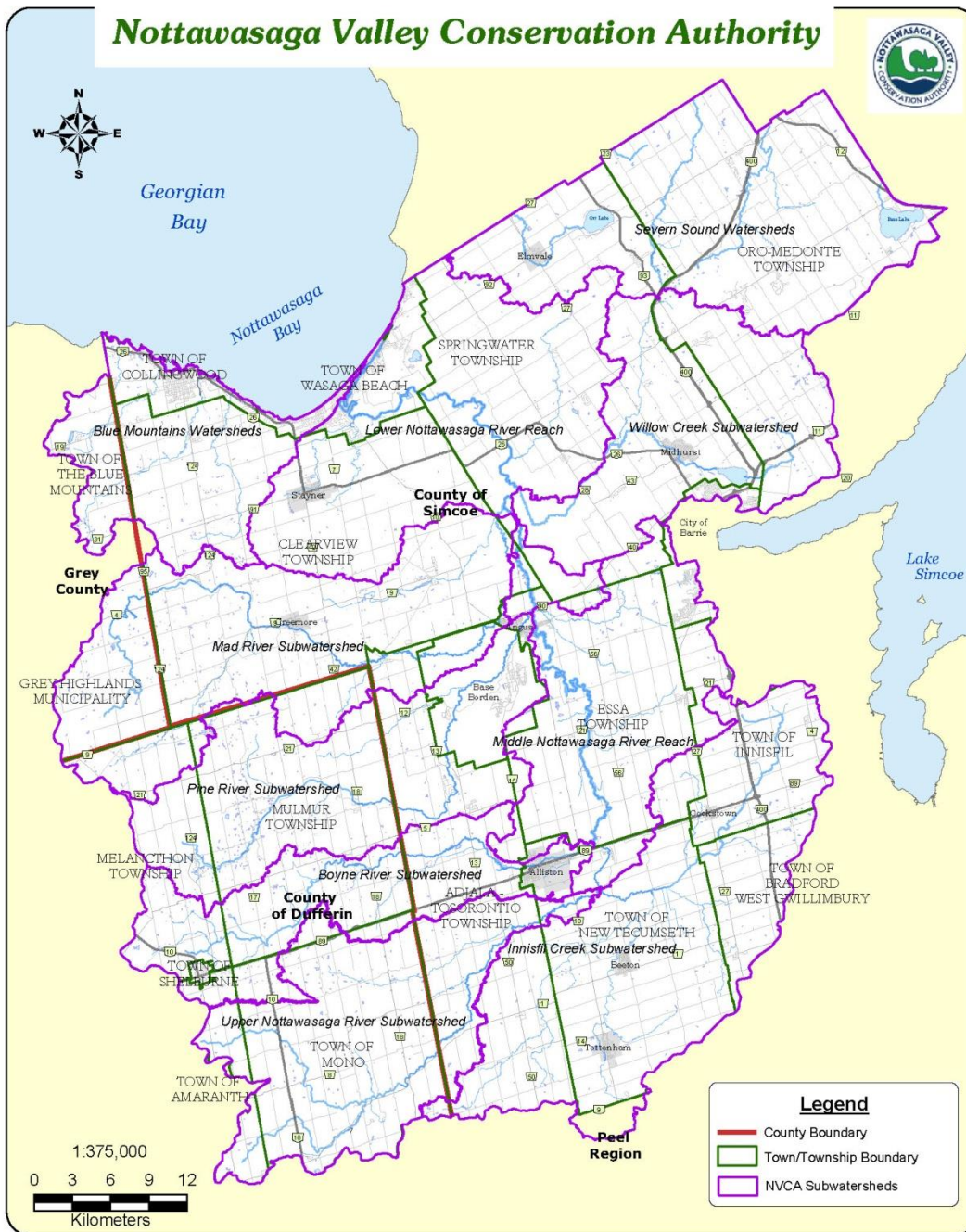


Mobile Devices
and Sharing

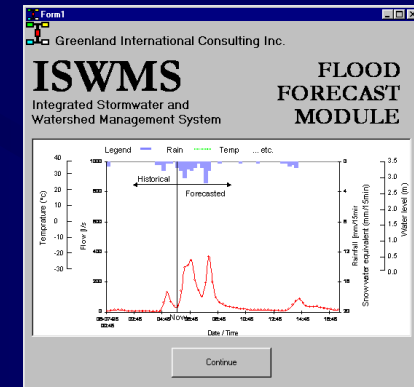


COMMUNITECH





Evolution of the ISWMS™ Decision Support System by GREENLAND® (Since 1999)





MONITORING

Watershed Management

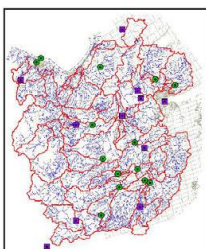
Nottawasaga Valley Watershed Flood Forecasting System

Client: Nottawasaga Valley Conservation Authority

Location: County of Simcoe, Ontario

The Nottawasaga Valley Conservation Authority (NVCA) is a member of the *Greater Toronto Conservation Authorities Flood Forecasting and Warning Committee*. This group has developed a set of standards for flood forecasting and warning which sets out the rationale and recommended minimum standards for Flood Forecasting and Warning. At the end of 2003, the NVCA adopted these minimum standards as part of its Business Plan process.

The Integrated Stormwater and Watershed Management System (ISWMS™) is a tool designed to help watershed and drainage system managers cope with multiple, linked and often competing water resources objectives at different geographical scales. The software was developed for the NVCA by **GREENLAND**. In 2003, we prepared a flood forecasting model of the 3,500 km² Nottawasaga Valley Watershed after calibration/verification with data collected from a many climate and streamflow monitoring stations, located throughout the basin (see image below).



GREENLAND was also responsible for the installation and data processing of many monitoring stations. The stations included state-of-the-art remote sensing and data acquisition equipment (see images to the right). The ISWMS™ flood forecast model is now functional and being used by the NVCA to determine critical flows during flood events at major flood damage centres.



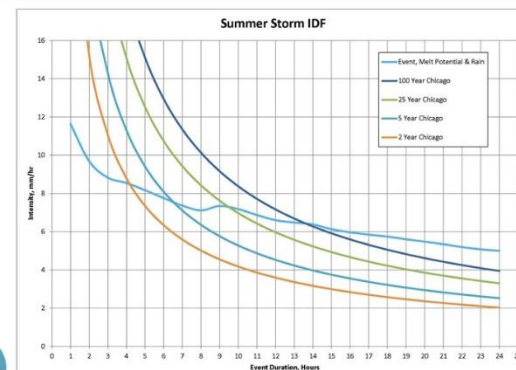
Local Watershed Partnership Projects & Related Research (1999 – Present)

Rainfall / Snowmelt Research: South Georgian Bay

- Late April, 2013 – a small rainfall event caused unproportionally large floods in Ontario.
- Snowmelt-IDF curves were developed for this region based on large climate data-sets.
- Late April 2013 potential snowmelt was calculated – plotted against summer-storm IDF.



Rainfall / Snowmelt Research: South Georgian Bay



R. Mark Palmer, P. Eng., President and CEO
Greenland Group of Companies
c/o Greenland International Consulting Ltd.
Head Office: 120 Hume Street
Collingwood, Ontario
L9Y 1V5

February 19, 2015

RE: Acknowledgment of Information Technology Development Partnerships and Collaborations

Dear Mr. Palmer:

The Greenland Group (Greenland) was introduced to Communitech in 2013 along with business partners affiliated with the University of Waterloo and Centre for Community Mapping (COMAP). This letter is to acknowledge the importance of this proactive joint venture and to indicate our strong interest in future project partnerships with Greenland and other network members.

Founded by a group of entrepreneurs in 1997, Communitech is an industry-led innovation center in Waterloo Region, supporting a tech cluster of nearly 1,000 companies employing 30,000 people. Communitech supports tech companies at all stages of their growth and development – from startups to rapidly growing mid-sized companies and large global players. Communitech supports companies in commercializing innovation and technology, with the goal of creating a greater number of successful global businesses. This support includes Greenland, which has been a Canadian leader for over 20 years in the development of water resources decision support systems and other engineering software.

Communitech worked with Greenland and project partners from the University of Waterloo and COMAP to build "CANWET-5" – a web-based platform for simulation of watershed processes. The new platform will be pivotal in enabling Canadian watershed management through engagement of stakeholder groups and agencies using a common system. This achievement represents the first piece in a much larger and integrated decision support system to address cumulative stresses and regional impacts from climate change factors. CANWET-5 will be important to identify open/transparent and sustainable solutions too.

Greenland is now supporting other joint initiatives with Communitech. These leading-edge information technology projects will include other private sector members with the Communitech network, as well as Ontario government agencies and First Nation communities. These projects are intended to develop commercialized products and services involving the Greenland Group and other Communitech partners and to enable new Canada-wide related collaborations.

Communitech 151 Charles Street West, Suite 100, Kitchener Ontario Canada N2G 1H6
T: 519-888-9944 F: 519-888-7007 info@communitech.ca www.communitech.ca



National Research Council Canada Conseil national de recherches Canada



Global Affairs Canada

Affaires mondiales Canada

ISWMS (v.2) Internet Platform JV

NEWS LOCAL

Local firms going to Paris for global conference



By JT McVeigh, The Enterprise-Bulletin
Monday, September 14, 2015 10:45:59 EDT AM



Eric Palmer, left, along with his parents Jane and Mark and brother Andrew are all of Greenland Consulting Engineers. The firm, long-recognized for their innovation will be heading to Paris, France, one of two Collingwood firms representing the National Research Council.

Mark, if any of your prospective clients or contacts have questions regarding our collaborative efforts to date, ongoing discussions and project leveraging capabilities, the Communitech team would be more than happy to help.

Inquiries can be directed to Geoff Bellew, who is our senior strategic advisor and resident expert in supporting collaborative projects amongst industry and academic partners. Please contact Geoff directly at 519.888.9944 ext. 1063.

We look forward to our continued strong collaboration with Greenland.

Sincerely,

Iain Klugman
CEO

Mrs Jing Li
Lund University Paradisgatan 2
SE-221 00 Lund
Sweden

24th February 2016
Brussels,

Dear Mrs Jing Li,

We are pleased to confirm the labelling of the project FLOODVIEW under our Open Call 7. This label is awarded subject to the satisfaction of national funding authority's requirements and obtaining funding.

ACQUEAU is the first EUREKA Cluster dedicated to environmental and water related technologies. It aims to promote innovation and market driven solutions to develop new technologies in the water sector. The ultimate aim of a EUREKA Cluster is to facilitate the generation of market-driven, pan-European collaborative water research and technological development R&D projects for the benefit of the European industry.

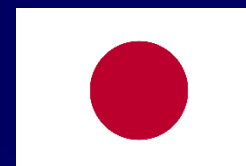
The ACQUEAU label is awarded to project proposals with the potential of developing breakthrough innovations. It allows successful consortium companies to apply for national funding in support of the labeled project; the label is an assessment of quality, economic interest and viability of the projects.

In order to receive the label, please, proceed to make the payment for the administration fee (see invoice attached). This is set at the 0.15% of the proposal budget which covers the cost of administering the call process.

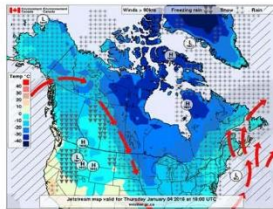
Our warmest congratulations - we look forward to working with Project Assignments, and your partner on this innovative project and keep at your disposal for any additional information or request you might have.

Yours sincerely,

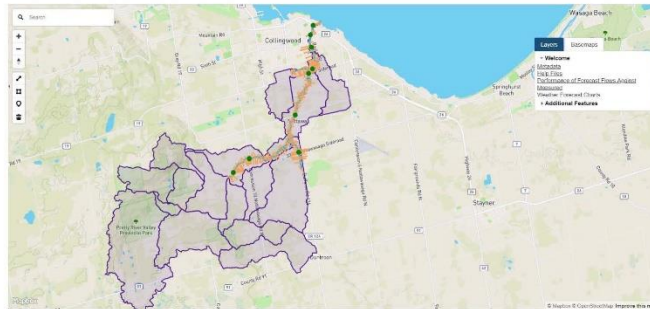
Daniel VILLESSOT
Chairman of the Board

A handwritten signature in black ink, appearing to read "D. Villesot", with a long horizontal stroke extending to the right.

NDMP Intake 3 – Proof of Concept & Pilot Projects for Public Safety



ENHANCED FLOOD
RISK EMERGENCY
PREPAREDNESS
PLAN
NATIONAL DISASTER
MITIGATION PROGRAM
County of Simcoe
September 26, 2018



PREPARED FOR:

County of Simcoe



PREPARED BY:

Greenland
International
Consulting Ltd.



Integrated Science and Watershed Management System (ISWMS™)

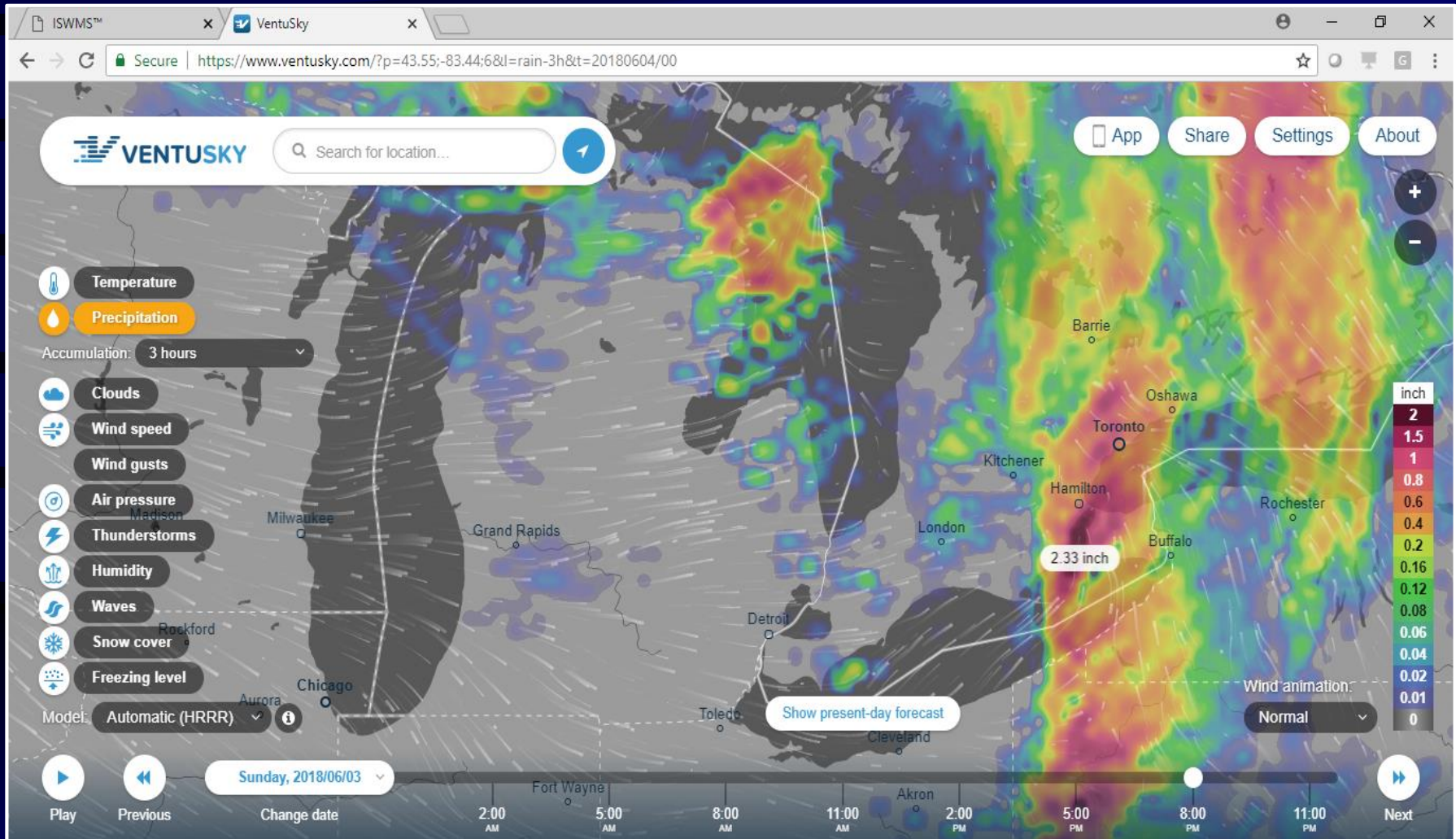


The Integrated Science and Watershed Management System (**ISWMS**) was originally developed by the GREENLAND® Group as a windows-based & desktop Decision Support System (DSS) for stormwater management; hydrological modelling; floodplain mapping and flood forecasting. Version '1' was completed in 2003.

At the time, the long-term DSS 'vision' (but depending upon the availability of certified open data and timely evolution of cost-effective operational platforms) included other science-based tools + integrated GIS / Internet tool sets.

The **ISWMS (v.2)** goal includes multi-functional stormwater management; hydrologic; water quality; nutrient trading; hydraulic and contaminant transport; flood forecasting; climate change impact; instream (biological) health assessment; and, Best Management Practice capabilities for watershed management programs. Other Internet-based platform tools by the GREENLAND® Group are also being used for concurrent water infrastructure & flood control planning / design initiatives.

ISWMS (v.2) Flood Forecasting and Floodplain Mapping Internet Platform for Ontario River Basins

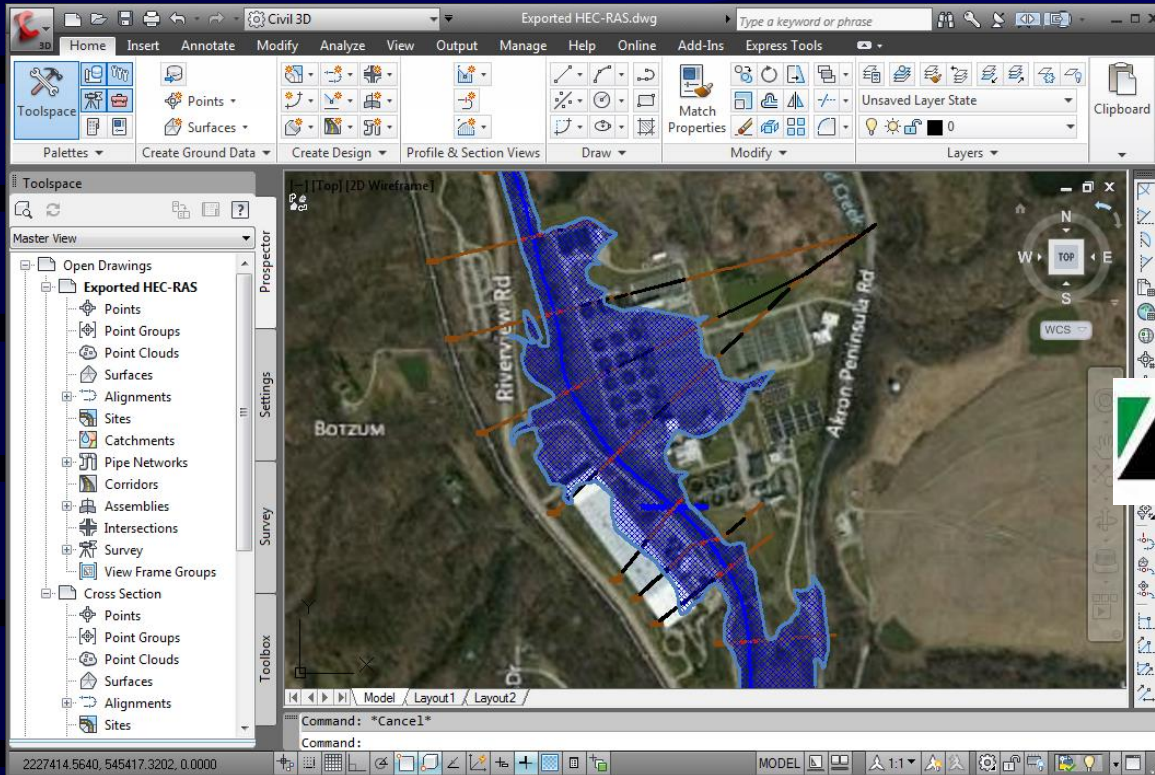


ISWMS (v.2) Internet Platform: 48-Hour and Weekly Precipitation + Rainfall Intensity Predictions Using Real-time ECCC and NWS Climate Station Data for North America



Background

- **Desired characteristics of a hydrologic model**
 - Similar capabilities as the GAWSER model
 - Ability to support flood flow estimates, continuous simulation, real-time forecasting, sediment and water quality wash off.
 - physically based
 - affordable
 - well documented
 - supported
 - broad user base particularly in the consulting community
 - good institutional arrangements
 - continued support and development
 - training
 - viability of the model into the future.
- **HEC-HMS has the above characteristics.**



ISWMS (v.2) 'Big Data' Platform (AWS) Analytics



CivilGEO, Inc.
8383 Greenway Blvd, 6th Floor
Middleton, WI 53562
Tel: 608-709-7101
www.civilgeo.com

Greenland International Consulting Ltd.
120 Hume Street
Collingwood, ON L9Y 1V5
Canada

2016 December 08

Attn: R. Mark Palmer, President and CEO

Dear Mr. Palmer:

CivilGEO is pleased to provide support for the current FLOODVIEW flood prediction and forecasting tool initiative with European and Canadian partners. We understand that the project will also the development of a web-based decision support system to address management and planning pressures in light of increasing severity and frequency of flooding events in many parts of the world.

CivilGEO is a software development firm specialized in developing and modeling tools to address engineering and planning needs related to water resources. We see an excellent opportunity for software including our 3D HEC-RAS to contribute to the functionality of the proposed web-based platform. We therefore welcome the opportunity to support Greenland as a member of the development consortium and will endeavor to reach mutually agreeable terms for collaboration.

Thank you for inviting CivilGEO to be a part of this important initiative and we look forward to further discussions.

Regards,

Chris Haeder, M.S., P.E., CEM
Engineering Director

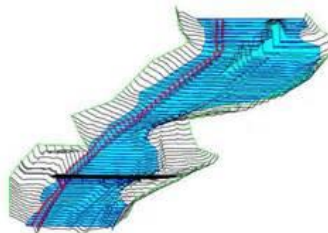
HEC-HMS

*The Hydrologic Engineering Center's
Hydrologic Modeling System (HMS)*



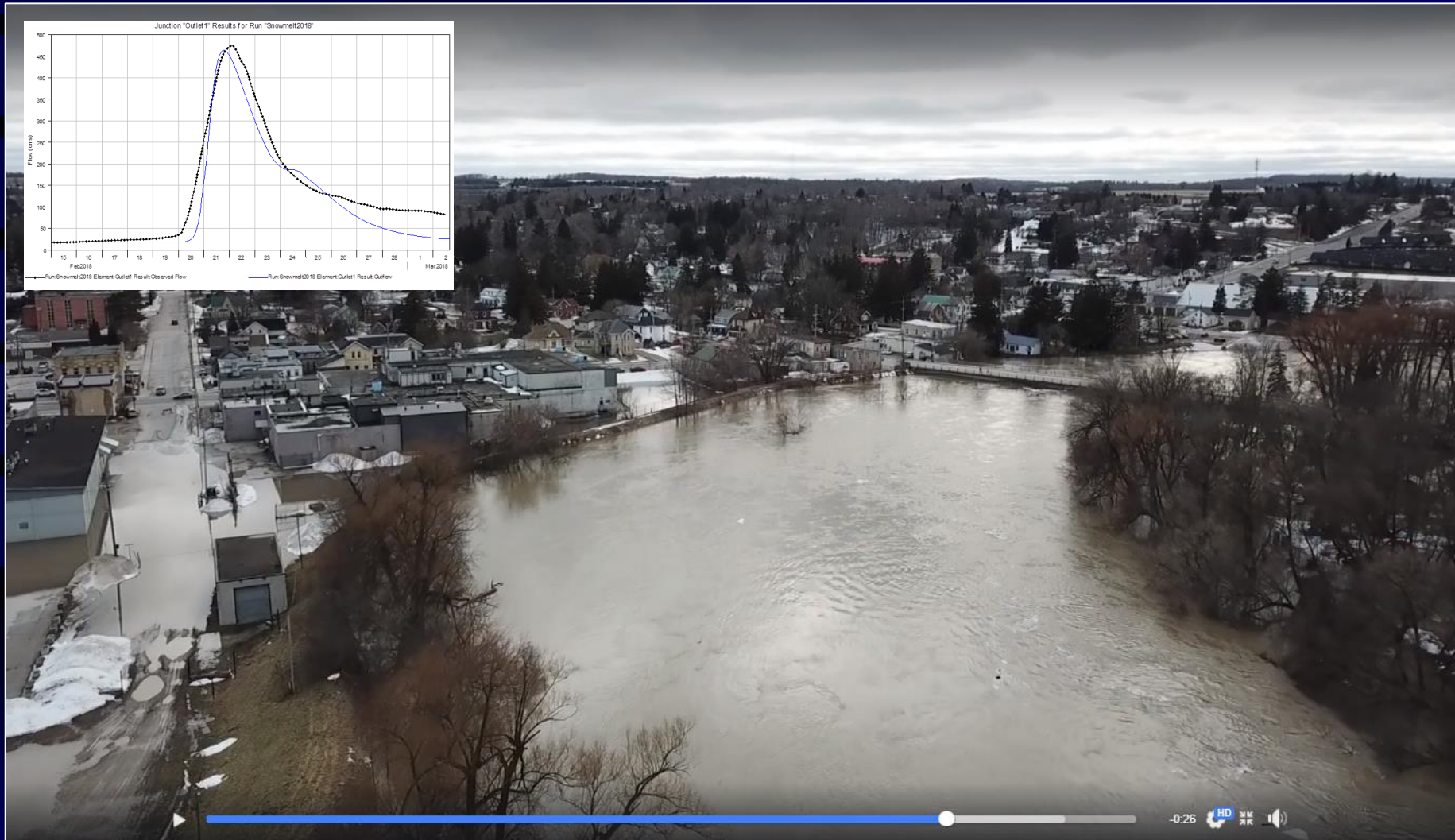
**US Army Corps
of Engineers**
Hydrologic Engineering Center

HEC-RAS River Analysis System

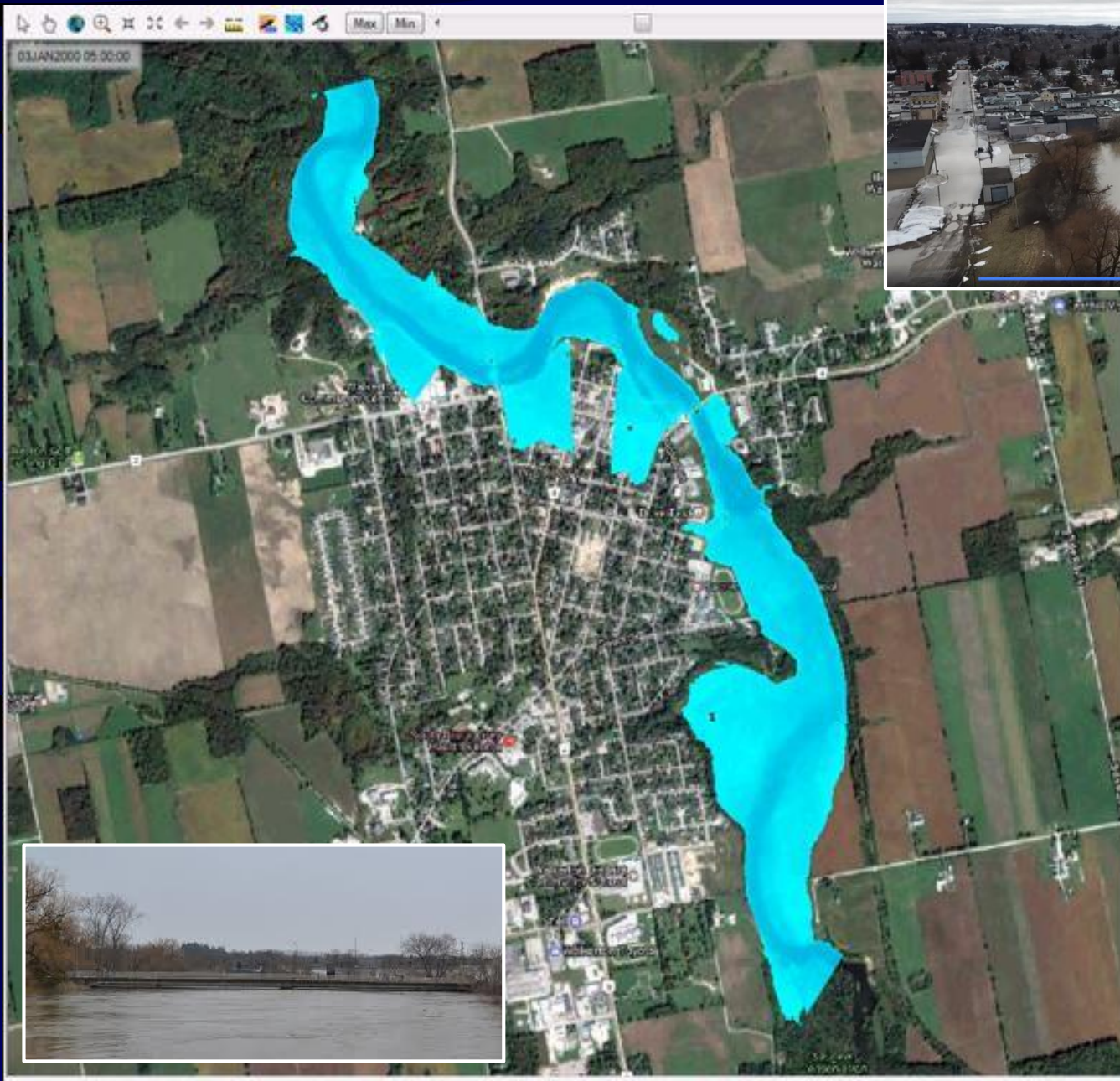


ISWMS (v.2) Flood Forecasting and Floodplain Mapping

Verification of the Saugeen River Watershed (Ontario)



Independent Drone Video Verification of the Peak River Discharge
from the February 20 – 24, 2018 Rainfall + Snowmelt Flood Event



**ISWMS (v.2)
Forecasted vs.
Actual Saugeen
River Water Levels
from the
Feb. 20 – 24, 2018
Rainfall + Snowmelt
Flood Event**

**(Predicted Days
in Advance and
Within Inches!)**



ISWMS (v.2) – Simcoe County Pilot Area



County of Simcoe
Office of the Chief
Administrative Officer
1110 Highway 26,
Midhurst, Ontario L0L 1X0

Main Line (705) 726-9300
Toll Free 1-866-893-9300
Fax (705) 725-1285
simcoe.ca



October 19, 2015

Mr. R. Mark Palmer, President / CEO
Greenland International Consulting Ltd.
120 Hume Street
Collingwood, ON L9Y 1V5

Dear Mr. Palmer:

Re: Canada-Europe Partnership to Develop a Cloud-based Flood Reduction & Forecasting Platform

The County of Simcoe is the upper tier government and planning authority for most of the South Georgian Bay – Lake Simcoe Source Water Protection Region. The County, in partnership with its member municipalities, other levels of government, floodplain management agencies and two (2) conservation authorities, also provides leadership through policy, and actively in the restoration and protection of the environmental health and quality of these watersheds. As you know, in order to comply with, and be environmentally proactive with respect to the Province of Ontario's "Places to Grow" legislation, the County of Simcoe utilized innovative decision support tools such as Greenland's CANWET™ model. In 2012, CANWET™ was also used by the County to prepare a "Water and Wastewater Infrastructure Visioning Strategy". To this day, the information in the Strategy's final report is used by local municipalities, development interests and other stakeholders as a background reference to help identify sustainable development solutions.

As part of Greenland's growing international opportunities and commercialization of other in-house tools and decision support systems, we believe the subject Canada – Europe partnership will enable Greenland and its Ontario-based partners to further develop the "Integrated Science and Watershed Management System (ISWMS™)" not only for use across Canada but also overseas for the benefit of many. The ISWMS™ platform includes the CANWET™ system, other proven tools and new ones being developed for an integrated stormwater management; low impact development; climate adaptation; and floodplain management focus.

This letter confirms the County of Simcoe's commitment of support which includes initially facilitating the introduction of this landmark international collaboration with all 16 local municipalities, other governments (small and large) and other agencies that partner now with the County of Simcoe on land use planning; infrastructure renewal; and flooding risk/damage reduction initiatives. Further considerations could also be contemplated through County Council once the project is approved and underway in the spring 2016.

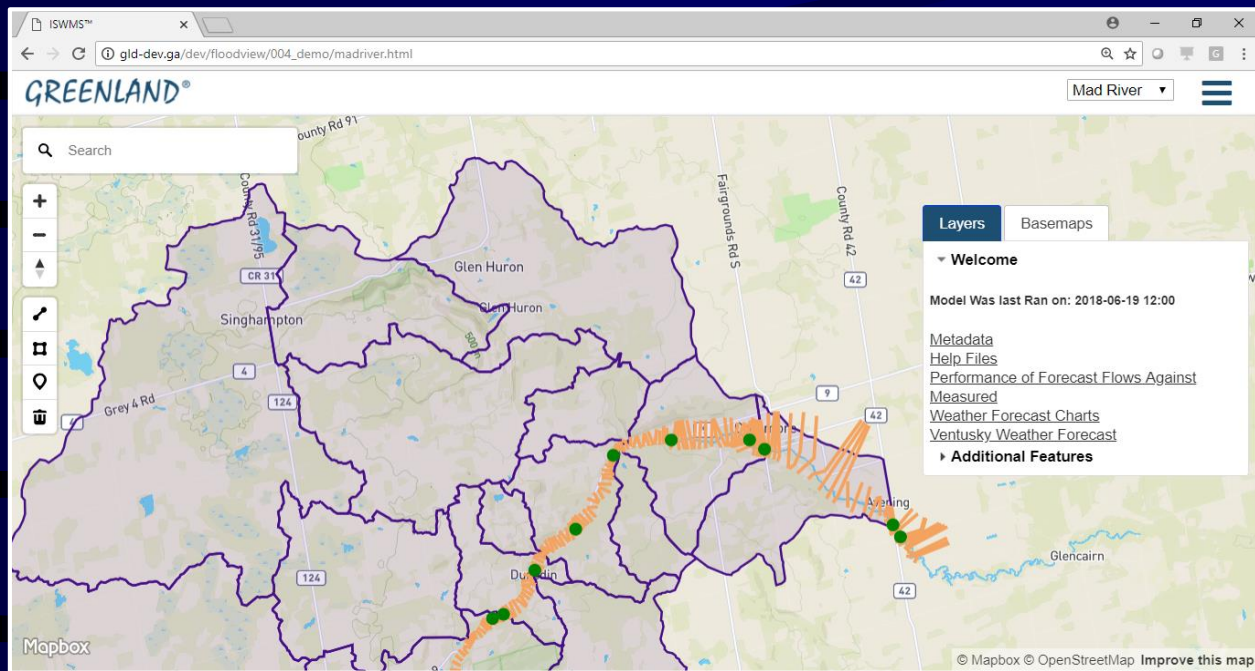
As always, I look forward to our continued working relationship with you and your colleagues and the significant benefits these efforts will have for our residents and environment. The County of Simcoe appreciates your efforts towards developing information based decision making tools and we are confident that this project will prove beneficial in our collaborative goal to improve watershed health for all County residents.

If you require any further information, please do not hesitate to contact me.

Sincerely,

Mark Aitken
Chief Administrative Officer
The Corporation of the County of Simcoe

CAO-003-C01



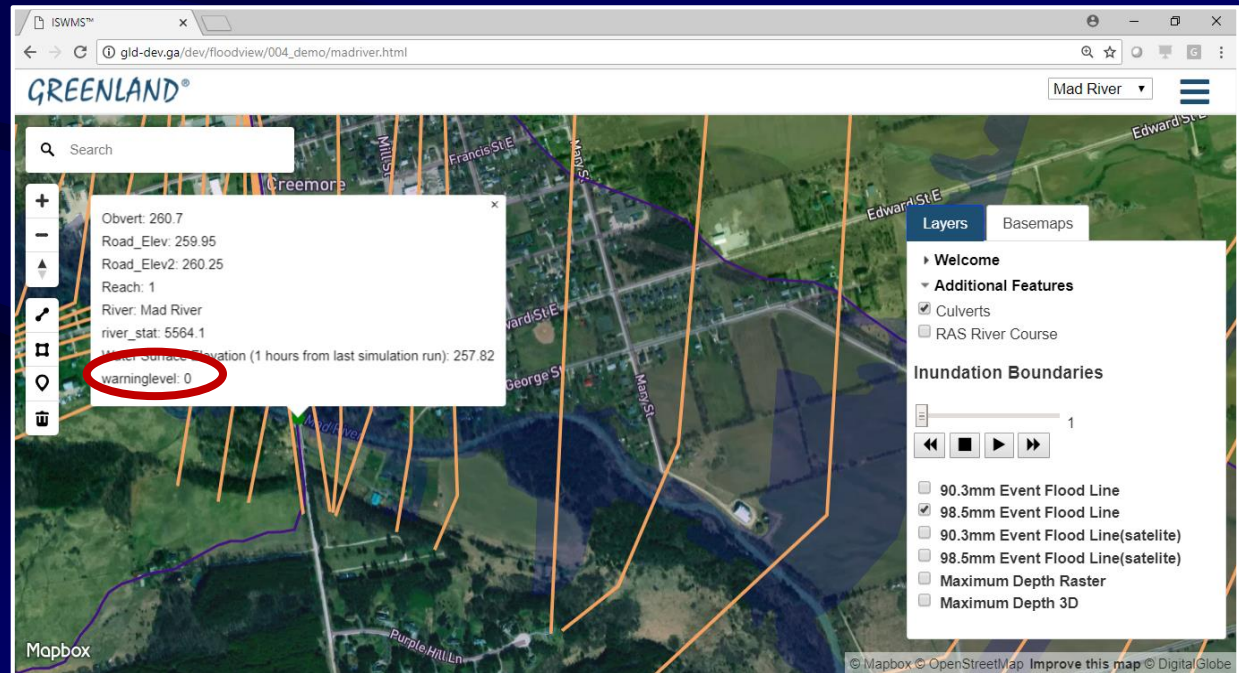
ISWMS (v.2) Use with Emergency Management and Flood Forecasting Operations

County of Simcoe (Completed: 2018)

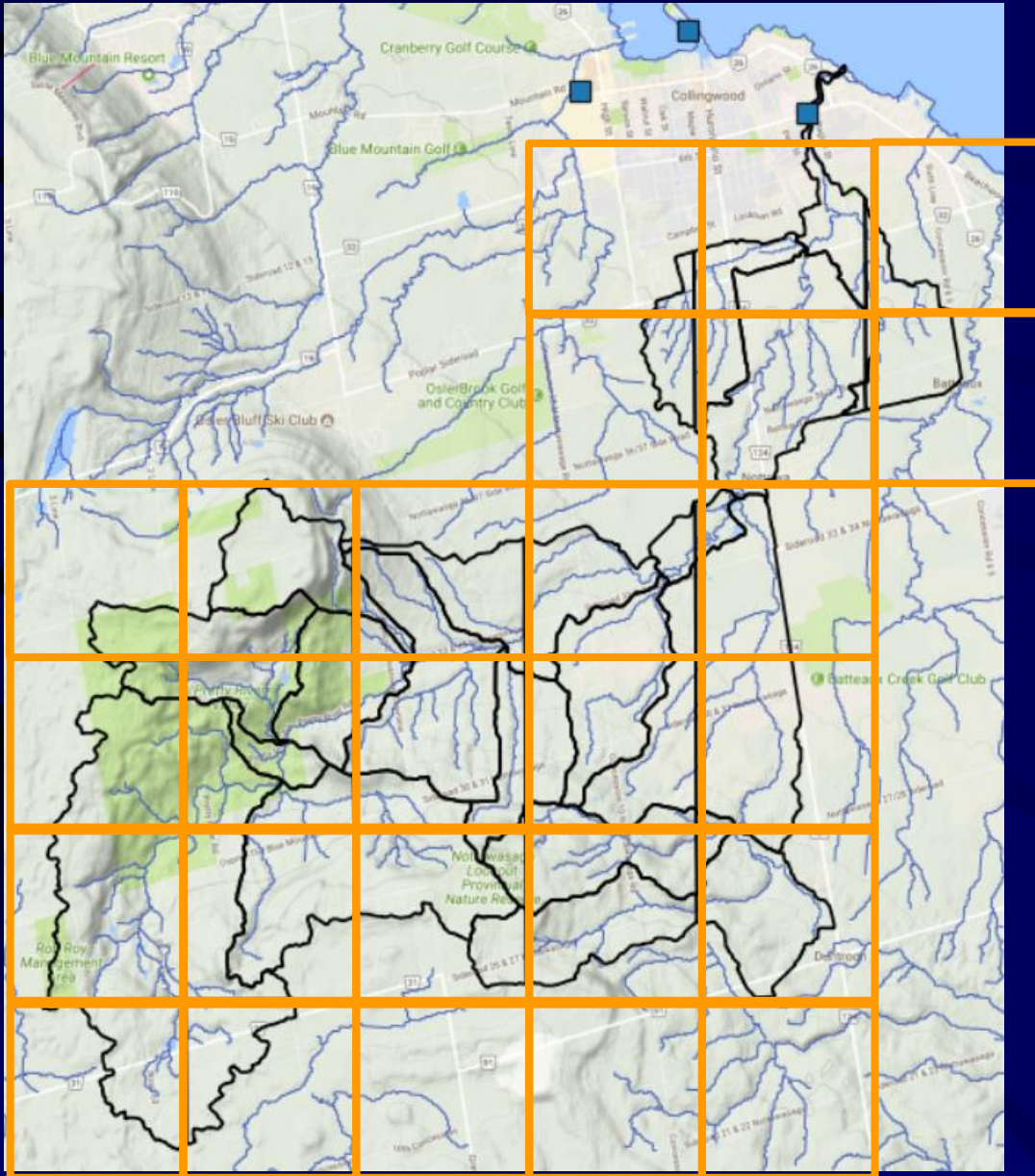
ENHANCED FLOOD RISK EMERGENCY PREPAREDNESS PLAN
NATIONAL DISASTER MITIGATION PROGRAM
County of Simcoe
September 26, 2018

PREPARED FOR:
County of Simcoe

PREPARED BY:
Greenland International Consulting Ltd.



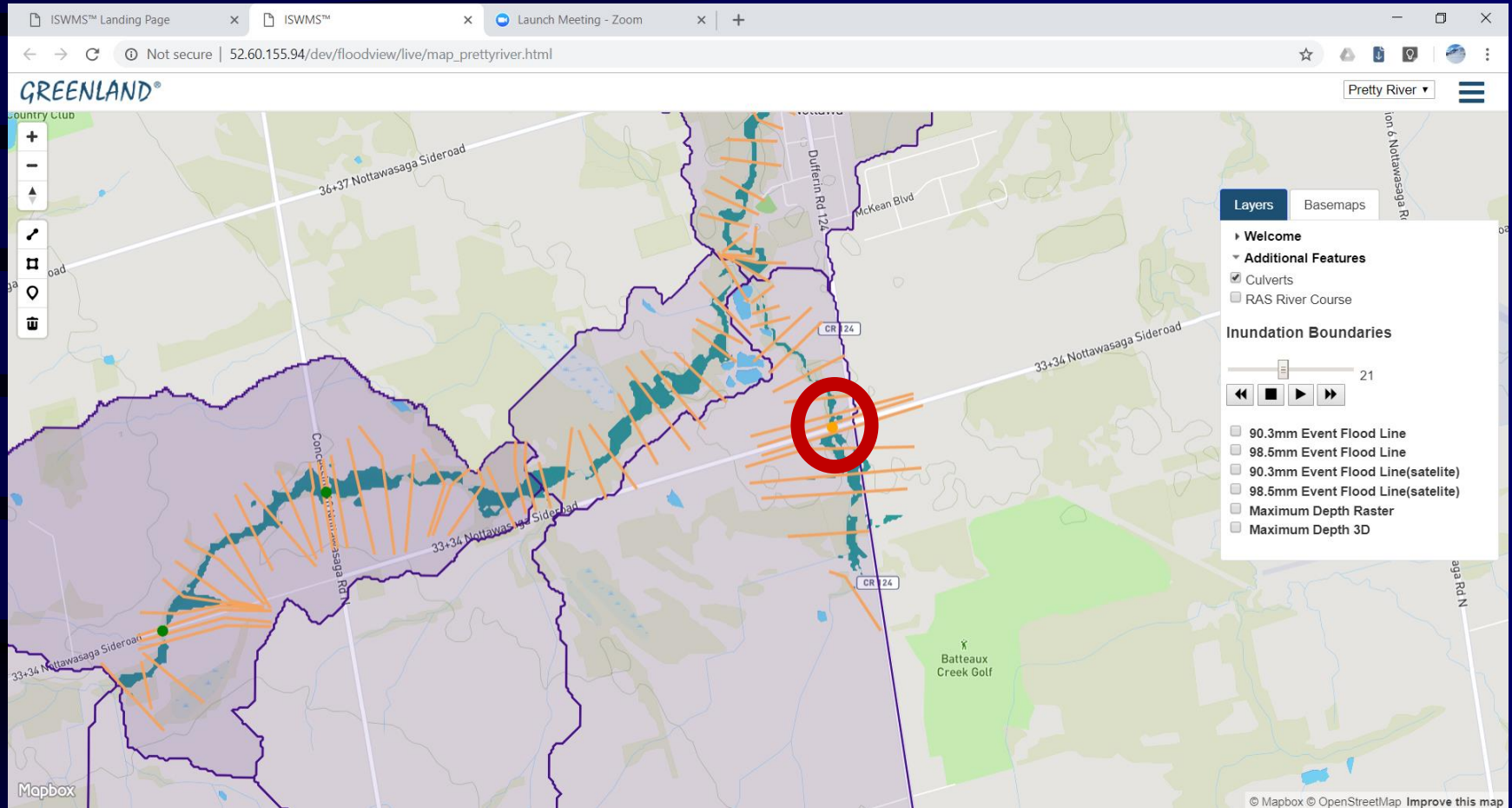
ISWMS (v.2) – Gridded Climate Forecast



**ISWMS (v.2) Use
Environment Canada
Open Forecast Data**

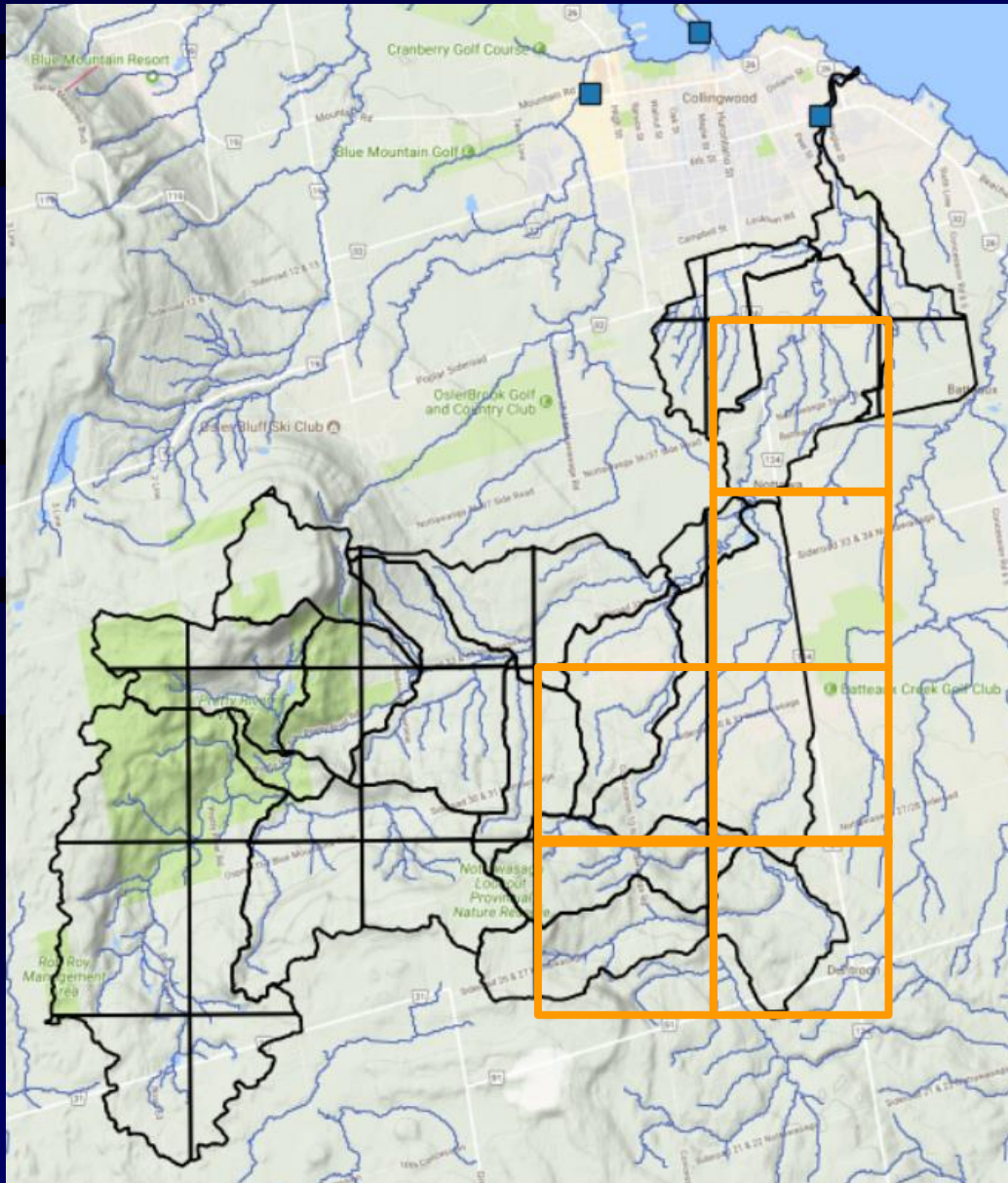
- **Precipitation**
- **Temperature**
- **Dew Point**
- **Snow pack**
- **Soil Moisture**

Case Study – February 2-5, 2019



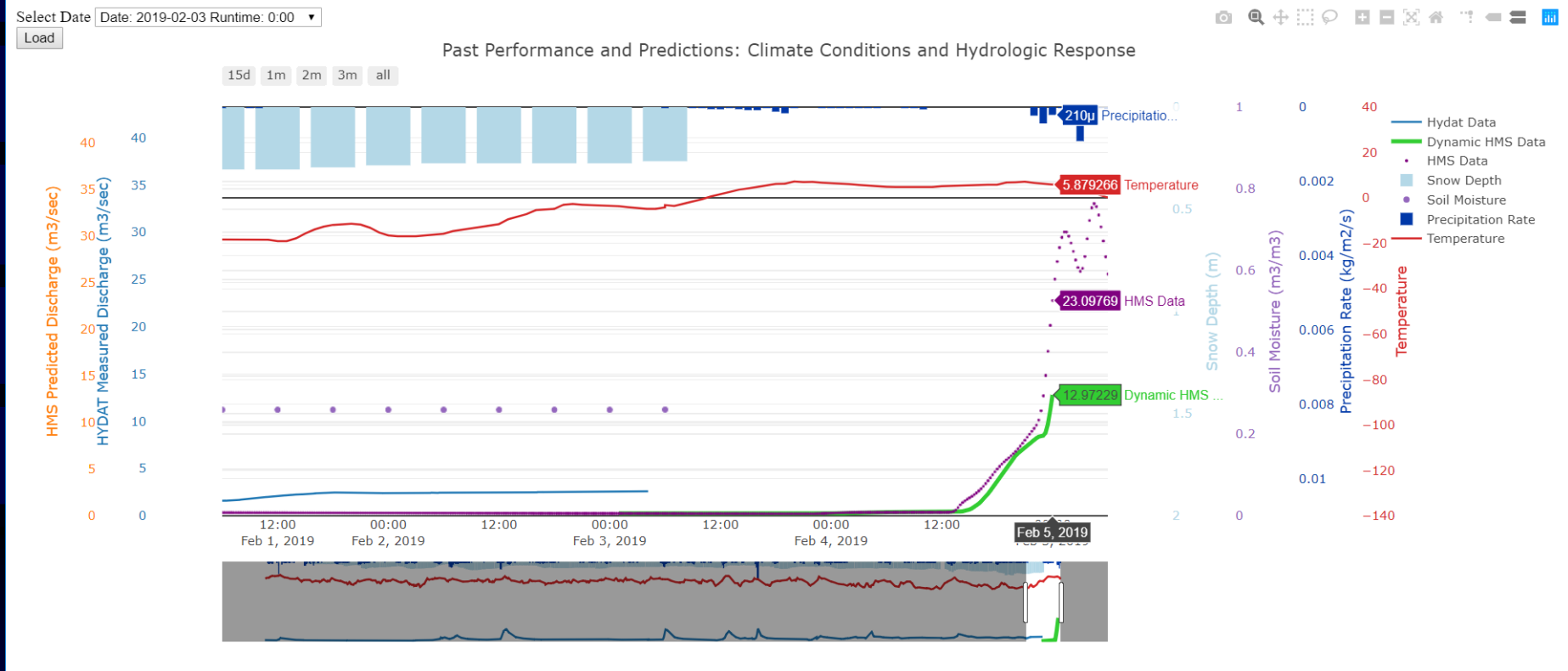
Pretty River Flow Prediction on February 4, 2019 at 06:00 – Peak Flows triggering warning Levels at 21 hrs from forecast

Spatial Variability Across Watershed



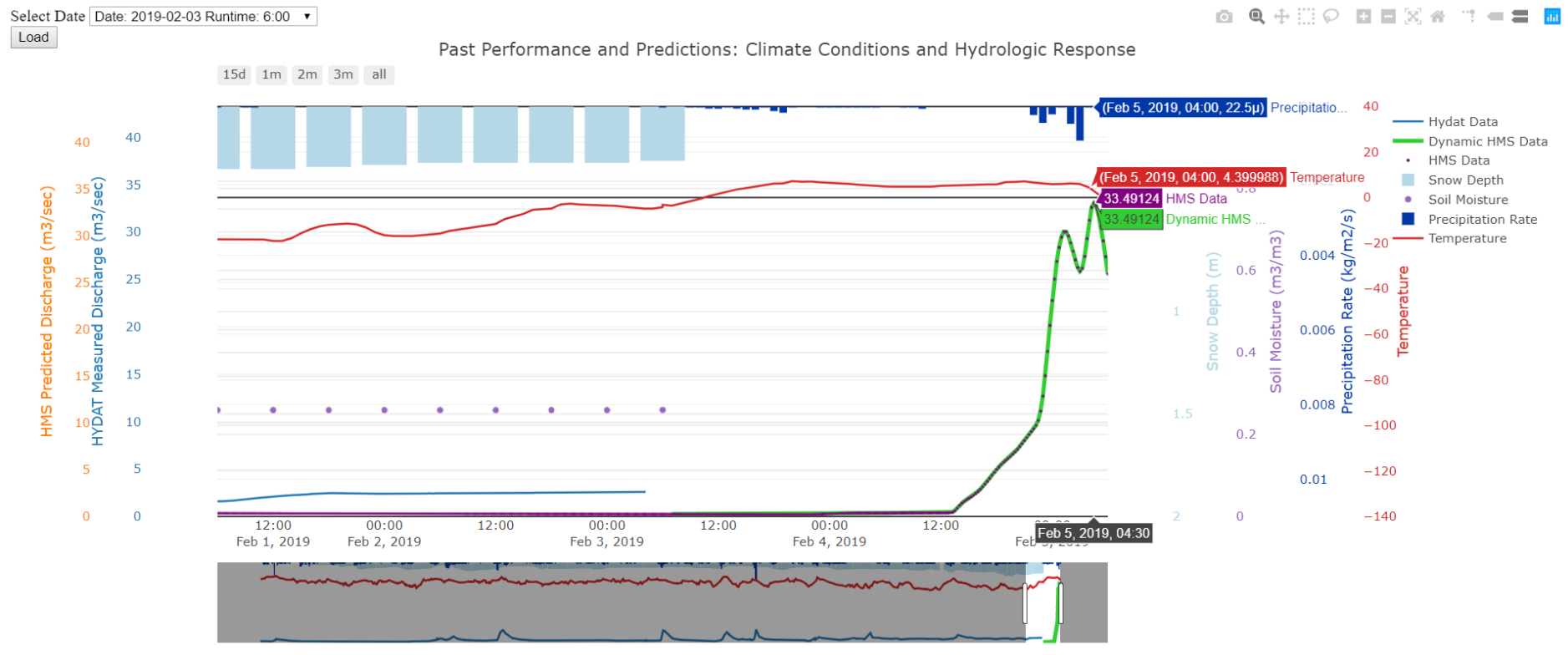
**Forecast Grids on
Smaller Branch seeing
Flood Trigger**

Development of Flood Flow



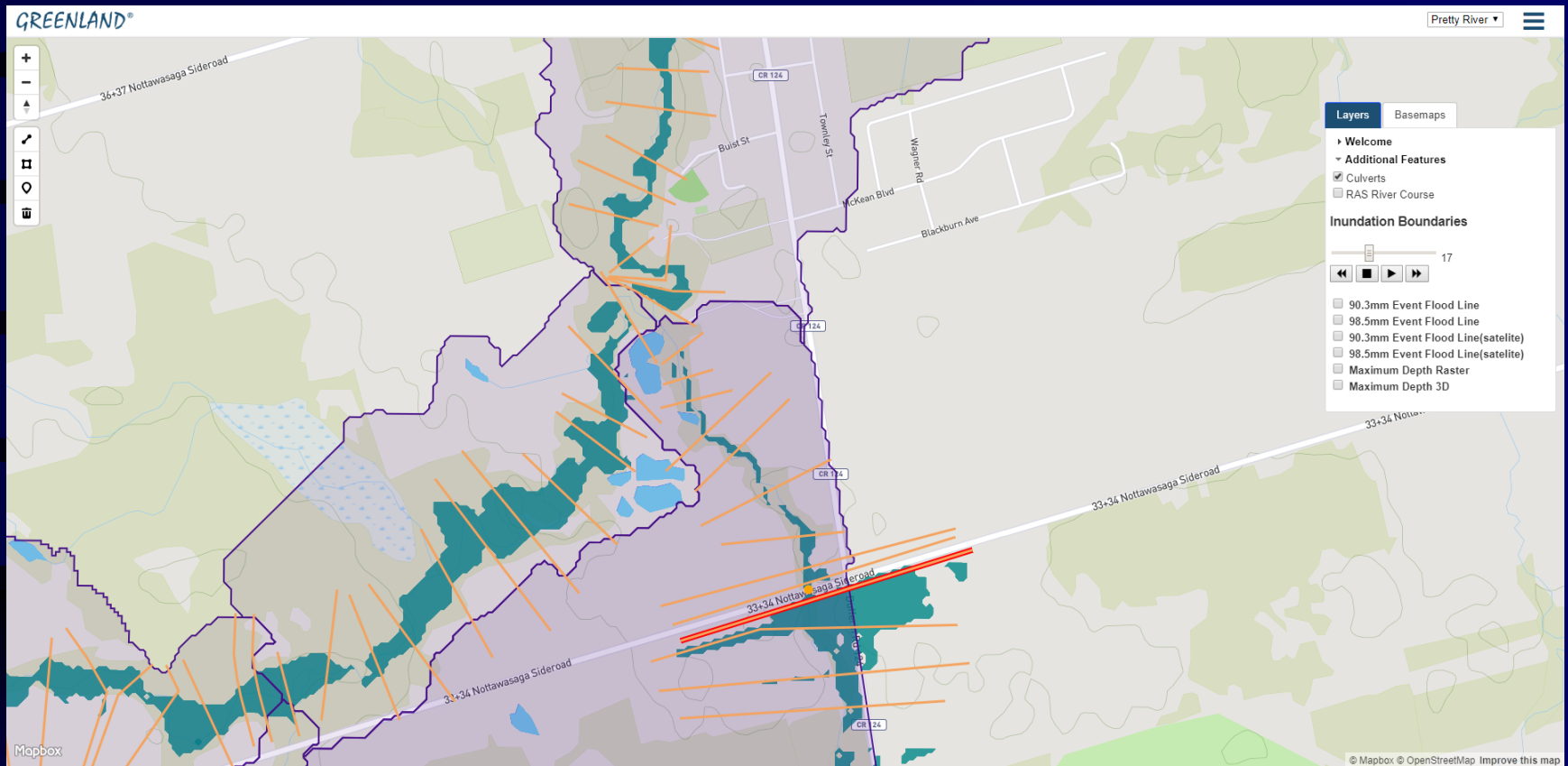
Flow Progressing through Each Forecast

Development of Flood Flow



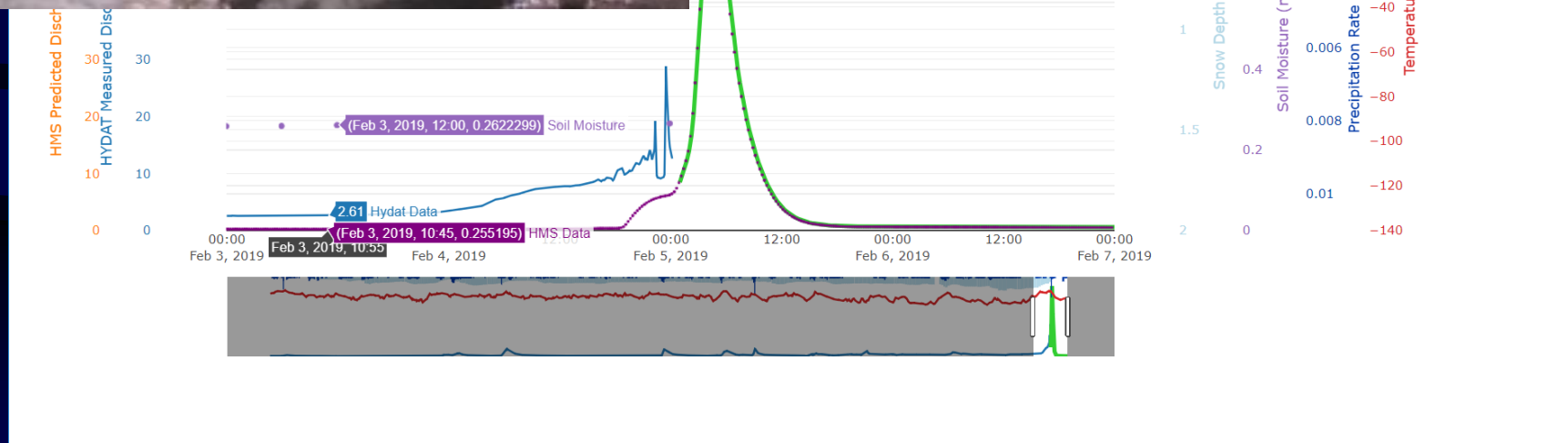
Flow Progressing through Each Forecast

Development of Flood Flow



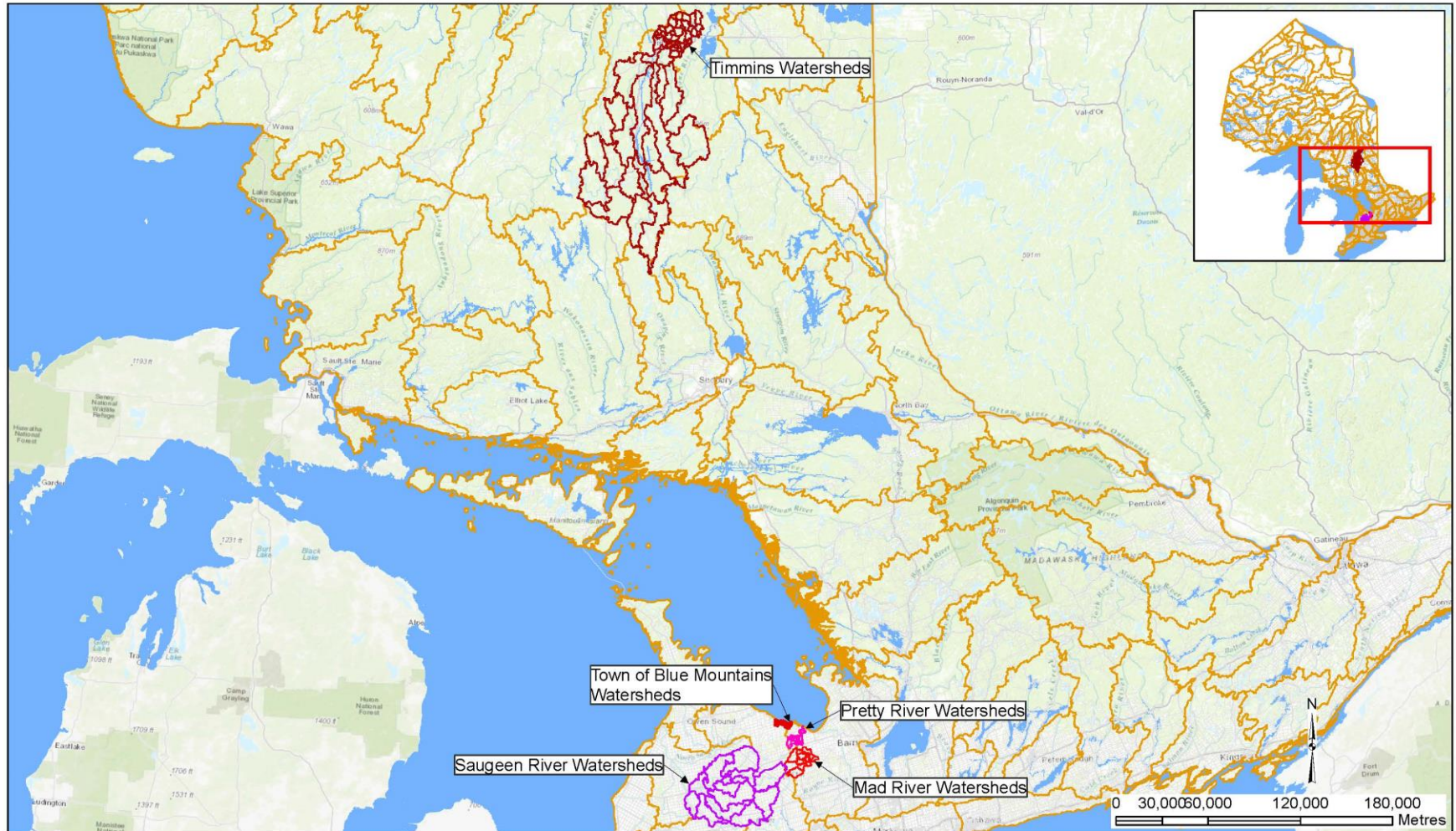
Flow Progressing through Each Forecast

Field Observations & Feedback



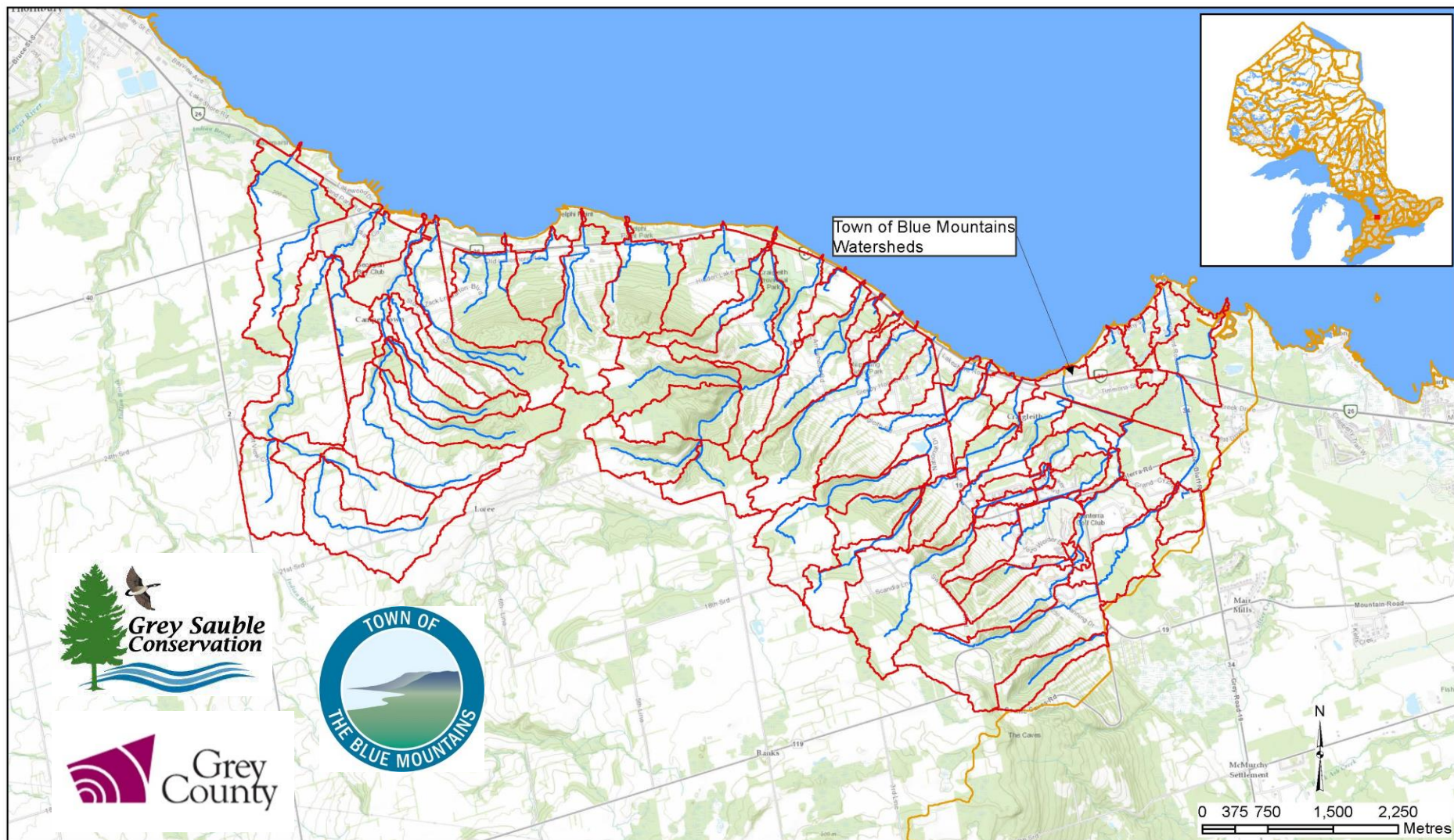
ICE JAMS & MELT FREEZE CYCLES

ISWMS (v.2) Expansion Supported by NDMP Intake 4



GENERAL NOTES 1. DO NOT SCALE DIMENSIONS. 2. ALL DIMENSIONS ARE TO FACE UNLESS OTHERWISE SPECIFIED. 3. ALL DIMENSIONS ARE TO FACE UNLESS OTHERWISE SPECIFIED. 4. ALL DIMENSIONS ARE TO FACE UNLESS OTHERWISE SPECIFIED. 5. ALL DIMENSIONS ARE TO FACE UNLESS OTHERWISE SPECIFIED.	BENCH MARKS 1. 1000 2. 1000 3. 1000 4. 1000 5. 1000	NO REVISIONS 1. 1000 2. 1000 3. 1000 4. 1000 5. 1000	DATE APPROVED 1. 1000 2. 1000 3. 1000 4. 1000 5. 1000	Legend Watershed_Timmins Watershed_Grey Watershed_Mad River Watershed_Saugeen River Watershed_Pretty River WATERSHED_TERTIARY	ISWMS STUDY WATERSHED	 GREENLAND Consulting Engineers 120 Bloor Street Collingwood, Ontario, L9Y 1Y5 Tel: (705) 444-8805 Fax: (705) 444-8802 E-mail: greenland@greenland.com Website: www.greenland.com	ONTARIO SCALE HOR: 1:250,000 VERT: 1:12,500 DESIGN: G. VAN G. DRAWN: G. VAN G. REVIEWED: D. MOSS DATE: Oct 2017 SHEET NO: 3770
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NDMP Intake 4 – Snowmelt Assessment for the Grey Sauble Conservation Watershed



<div>GENERAL NOTES</div> <div>1. DO NOT SCALE DRAWINGS.</div> <div>2. WORKS BY CONTRACTOR OR OTHER PERSONS OR ORGANIZATIONS TO THE PROJECT OR DESIGN ORDER BY JAN 1 1987.</div> <div>3. WITHIN A LIMITED SERVICE DRAWING, AS THEY SAY, ARE NOT BEING SUBMITTED FOR CONSTRUCTION.</div> <div>4. THE ENGINEER AND THE PROJECT OF LOCAL WATERSHEDS (WATERSHED) IS A SUB-PROJECT OF THE PROJECT, AND SHALL BE PROVIDED.</div>	<div>BENCH MARKS</div> <table><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table>											<table><tr><th>NO</th><th>REVISIONS</th><th>DATE</th><th>APPROVED</th></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr></table>	NO	REVISIONS	DATE	APPROVED																	<div>Legend</div> <div><div></div> Watershed_Grey</div> <div><div></div> WATERSHED_TERTIARY</div>	<div>ISWMS</div> <div>STUDY WATERSHED</div>	<div></div> <div><div>GREENLAND Consulting Engineers</div><div>120 Blaine Street</div><div>Collingwood, Ontario, L9T 1V5</div><div>Tel: (705) 444-8805</div><div>Fax: (705) 444-5482</div><div>E-mail: greenland@greenland.com</div><div>Website: www.greenland.com</div></div>	<div>TOWN OF BLUE MOUNTAINS</div> <table><tr><td colspan="2">SCALE HOR: 140,000</td><td>VERT</td><td>FIGURE NO</td></tr><tr><td>DESIGN: G. YANG</td><td>DRAWN: G. YANG</td><td></td><td></td></tr><tr><td>REVIEWED: D. MOSS</td><td>DATE: Oct 2017</td><td></td><td>SHEET NO</td></tr><tr><td colspan="3"></td><td>3770</td></tr></table>	SCALE HOR: 140,000		VERT	FIGURE NO	DESIGN: G. YANG	DRAWN: G. YANG			REVIEWED: D. MOSS	DATE: Oct 2017		SHEET NO				3770
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Future Evolution of ISWMS™

Project – HEC-HMS to
ISWMS

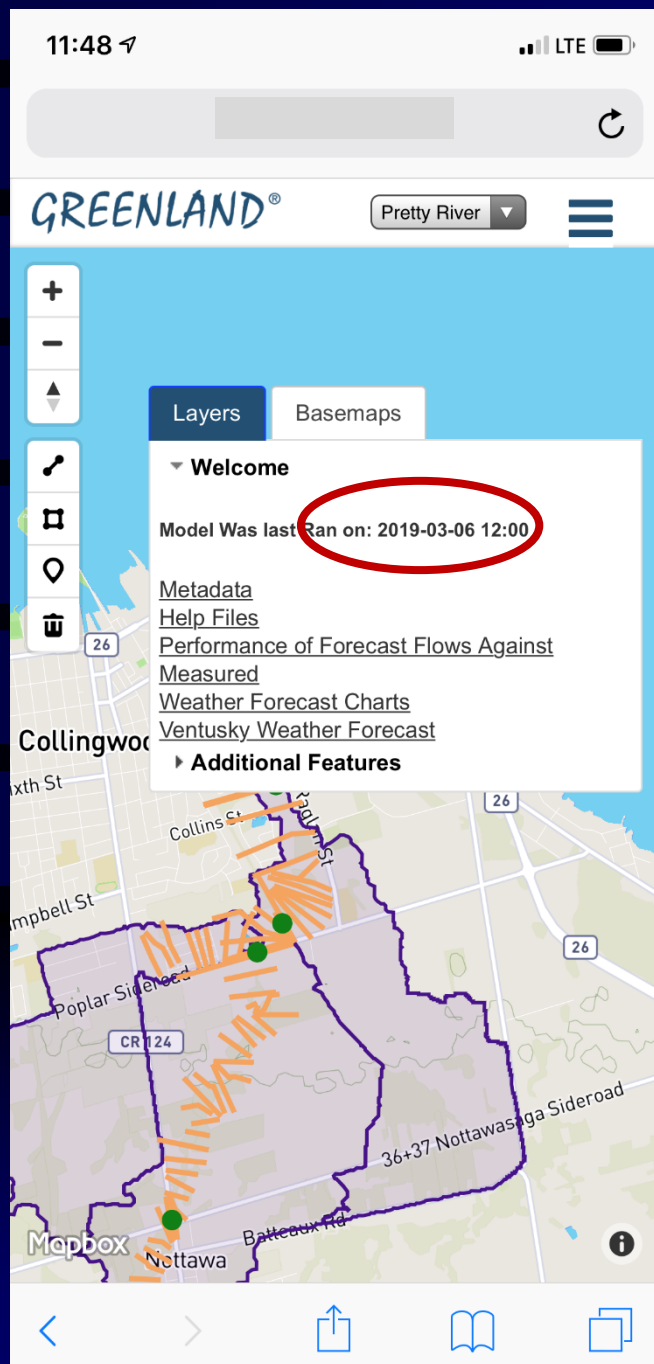
Project – Adjusting Base
HEC-RAS

Project – Field Sensor
Feedback Loop



NDMP Intake 5





THANK-YOU !
(www.grnland.com)

