Water Security Agency

SASKATCHEWAN

February 20, 2019

Flow Forecasting and Operations Planning in Saskatchewan

ECCC Forecasting Workshop

Curtis Hallborg, P,Eng.
Manager, Flow Forecasting & Operations Planning

Forecasting Group at Water Security Agency

2010



- Part of Hydrology Services
- No dedicated budget
- Antiquated tools

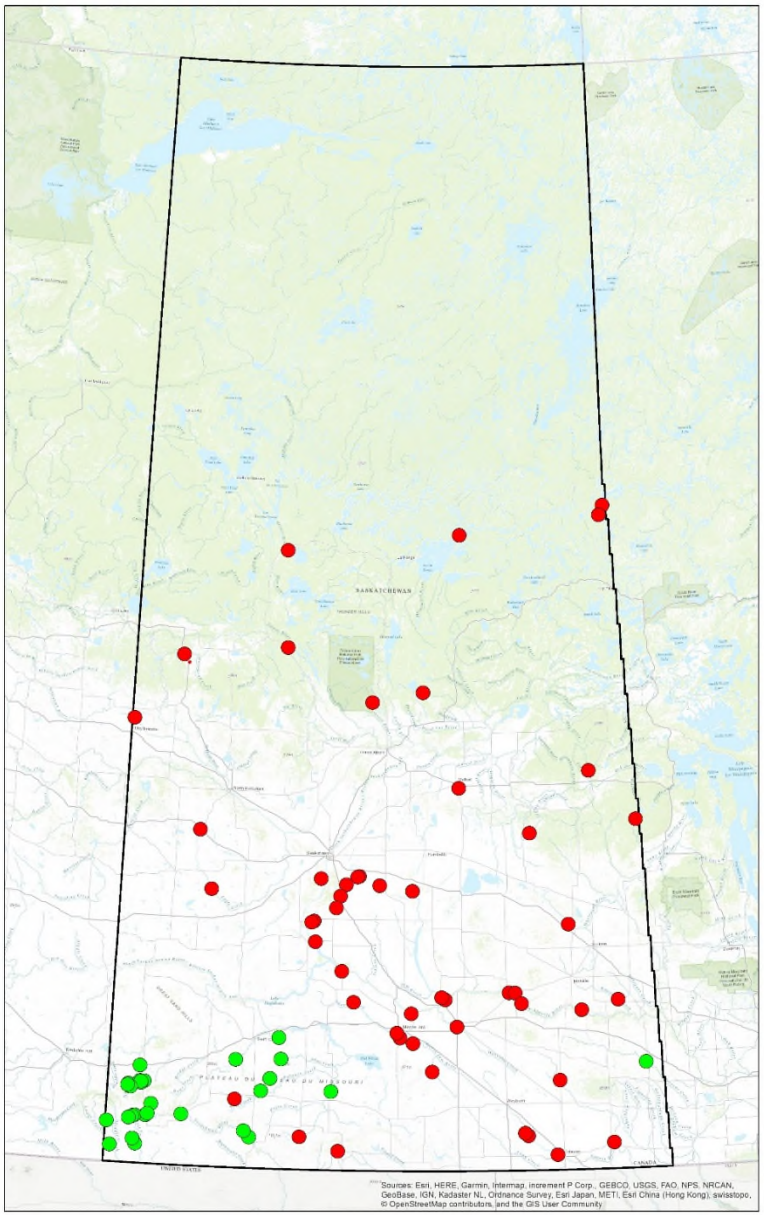
2019



- Distinct work unit
  - Flow Forecasting & Operations Planning
- Significant budget allocation
- Focus on tool modernization

Federal Dam Transfer

- On April 1, 2017, Agriculture & Agri-food Canada transferred 20 dams (and $350M) to the province.
- Primarily water supply reservoirs in the southwest
- Took WSA's inventory from 49 to 69 dams
- Some of these are "major" structures



Significant Flood Events



2010 – Maple Creek



2010 – Good Spirit Lake



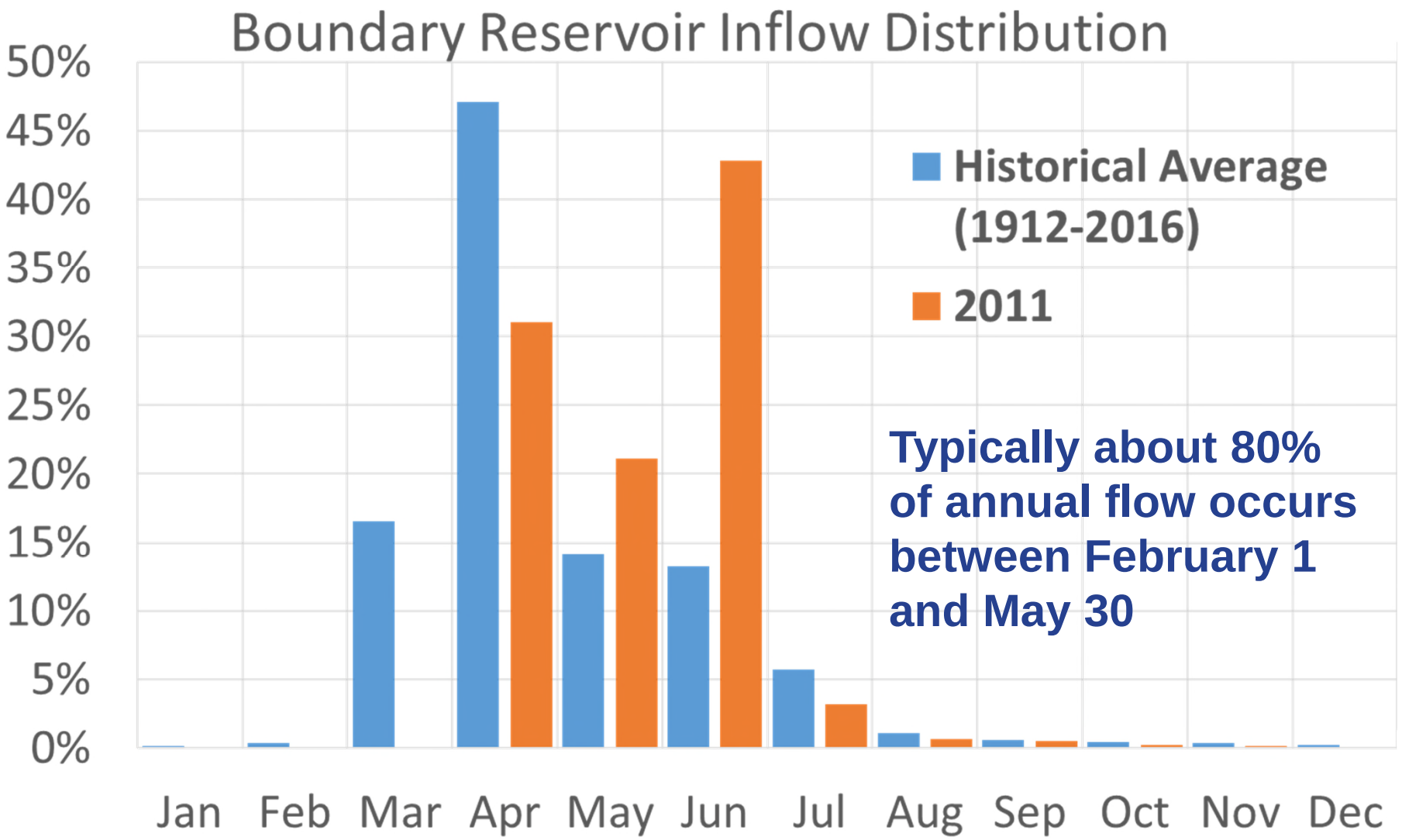
2011 – Souris



2014 – East Central Sask.

Common Denominator – GREEN → NO SNOW

Typical Distribution of Annual Flow



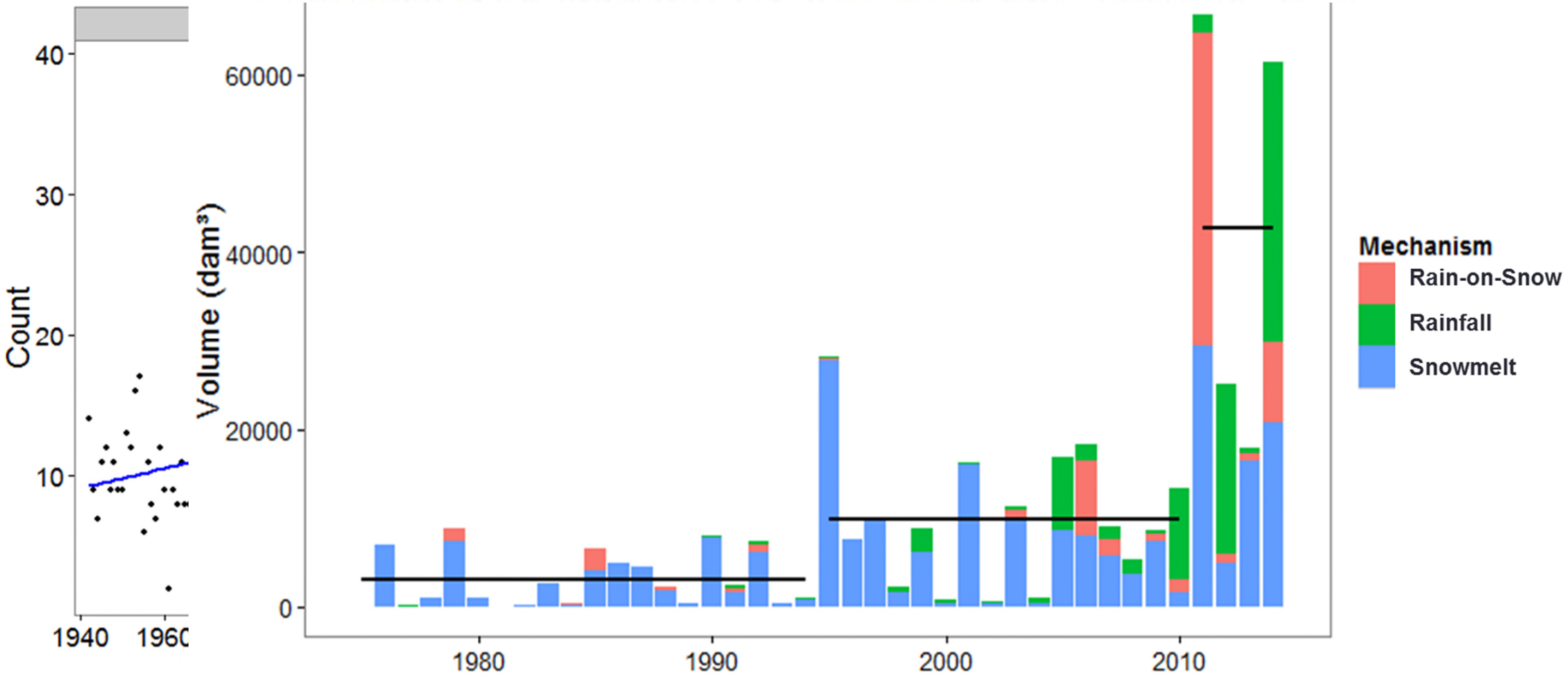
What's happening with our Precipitation in Sask?

- Increase in multi-day rainfall events and more rainfall runoff.

Hydrological regime changes in a Canadian Prairie basin

Stacey Dumanski, John W. Pomeroy* and Cherie J. Westbrook

Centre for Hydrology, University of Saskatchewan, 117 Science Place, Saskatoon, Saskatchewan, S7N 5C8, Canada

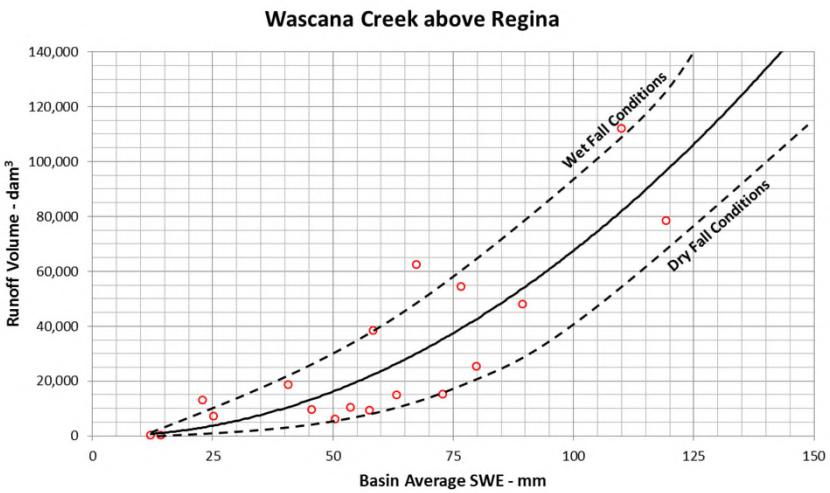


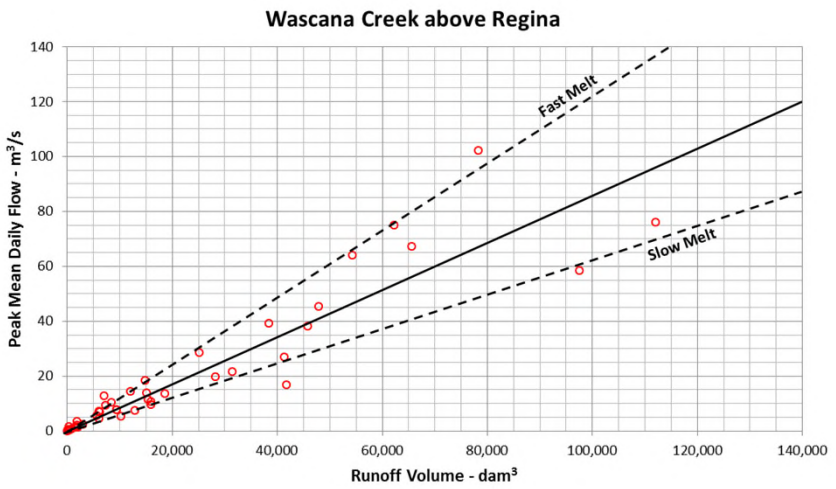
Current Tools Used by WSA

- Use simple empirical/regression relationships between snow water equivalent, antecedent conditions, and snowmelt runoff volume and peak flow.



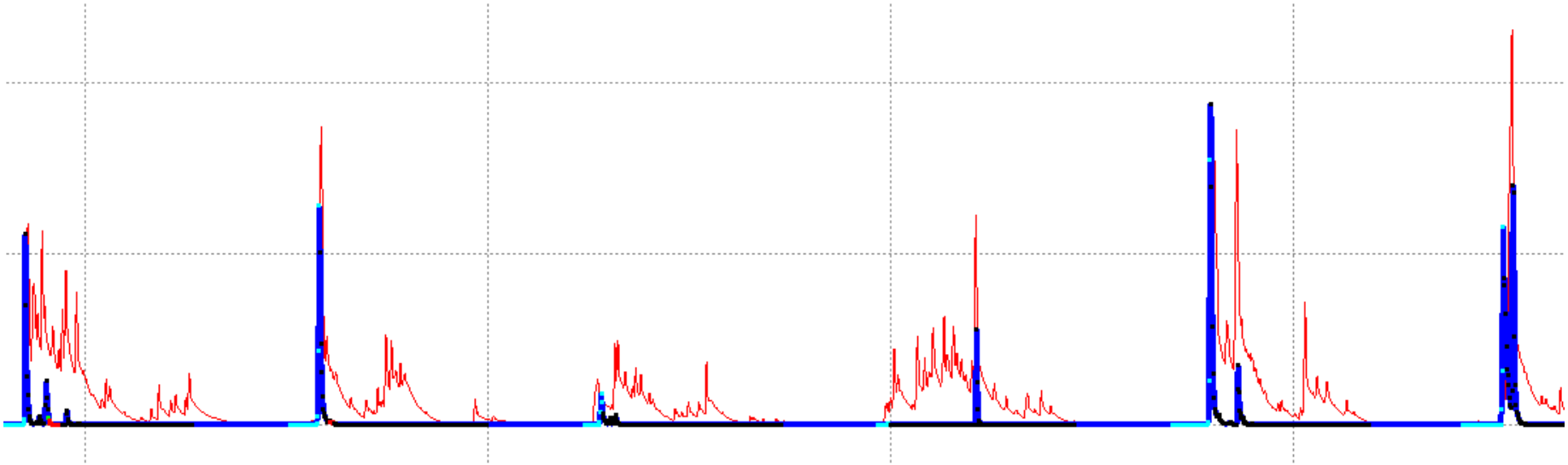
- No rainfall runoff modelling, just snowmelt





Why don’t we have hydrologic models?

It’s not easy to model the prairies

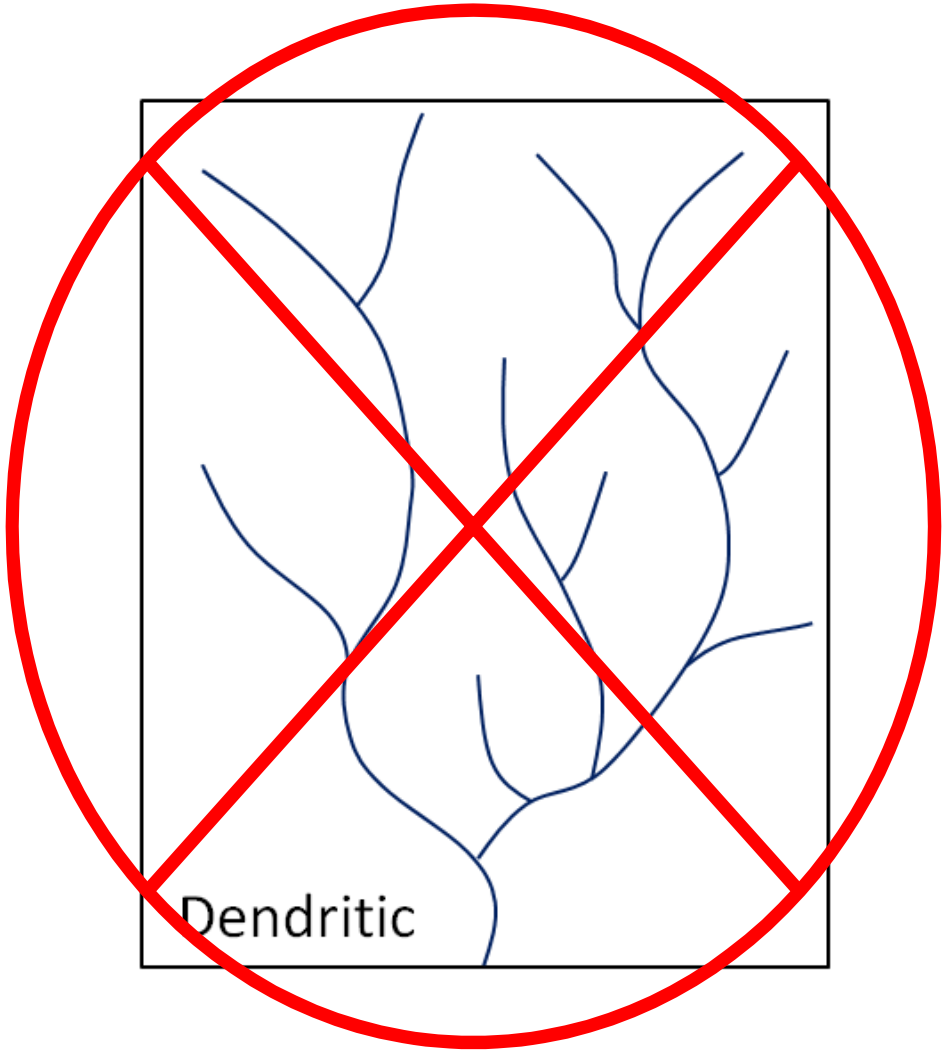


- Early attempts by WSA with “off the shelf” models that failed miserably:
  - The models wants to generate runoff from nearly every rainfall event.
  - Physical process are not included or are overly simplified.

Poorly Developed Drainage Networks

- Relatively **flat** (low energy), **dry** (semi-arid climate) and **young landscape** (recent glaciation).

- We have **Fill and Spill** systems with **dynamic contributing areas**.

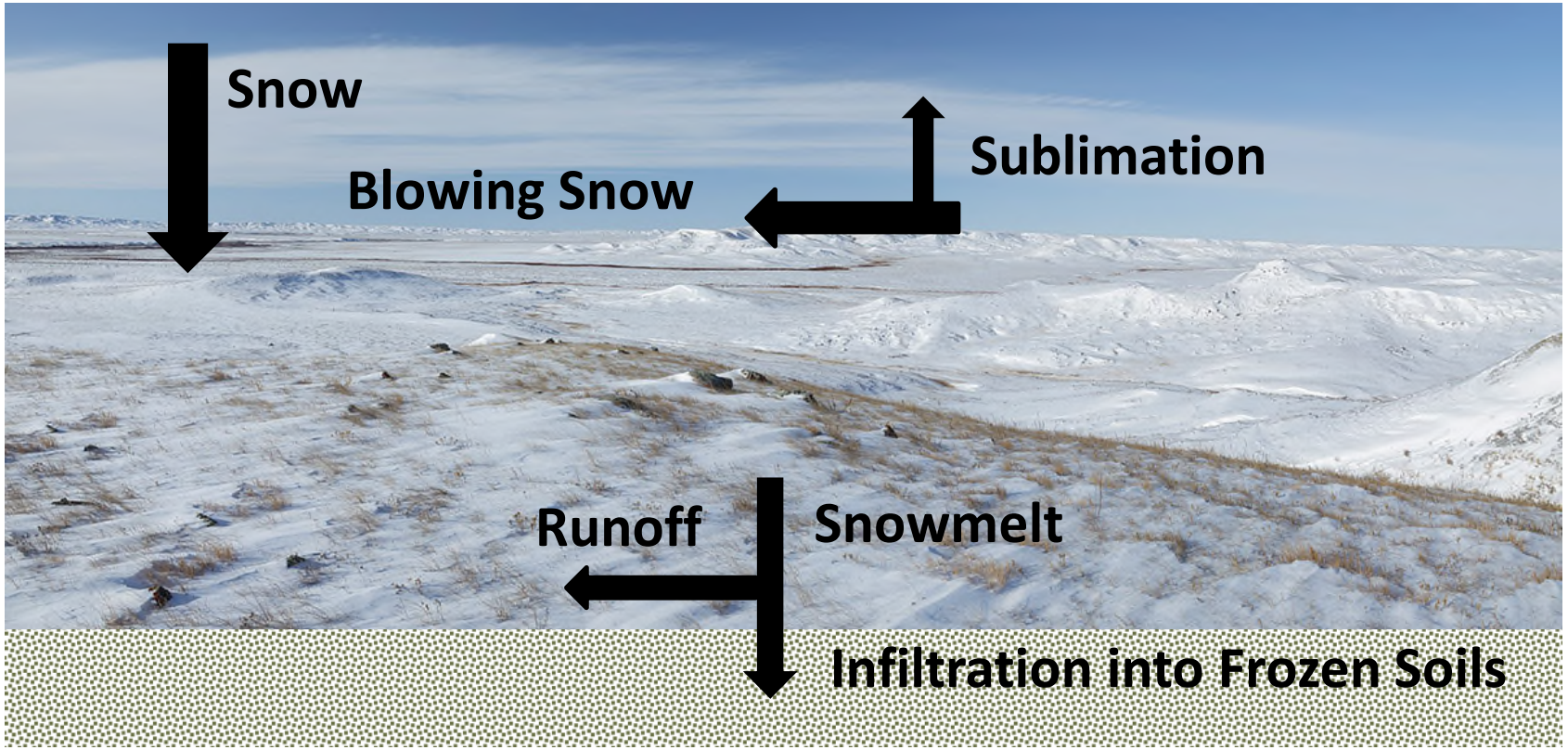


Example – St. Denis National Wildlife Area



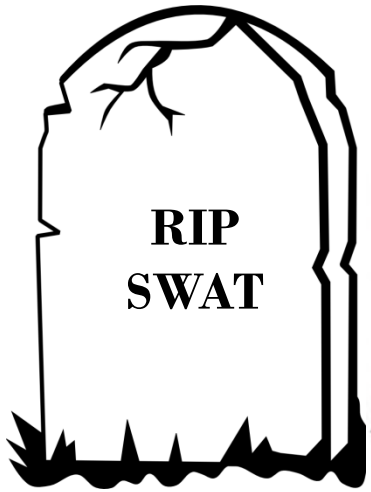
Environment Canada Photo

Challenges from Cold Region Hydrologic Processes



- **Most hydrological models omit cold region processes altogether or take an overly simplistic approach to handling them.**

“Prairies are the graveyard of hydrologic models”









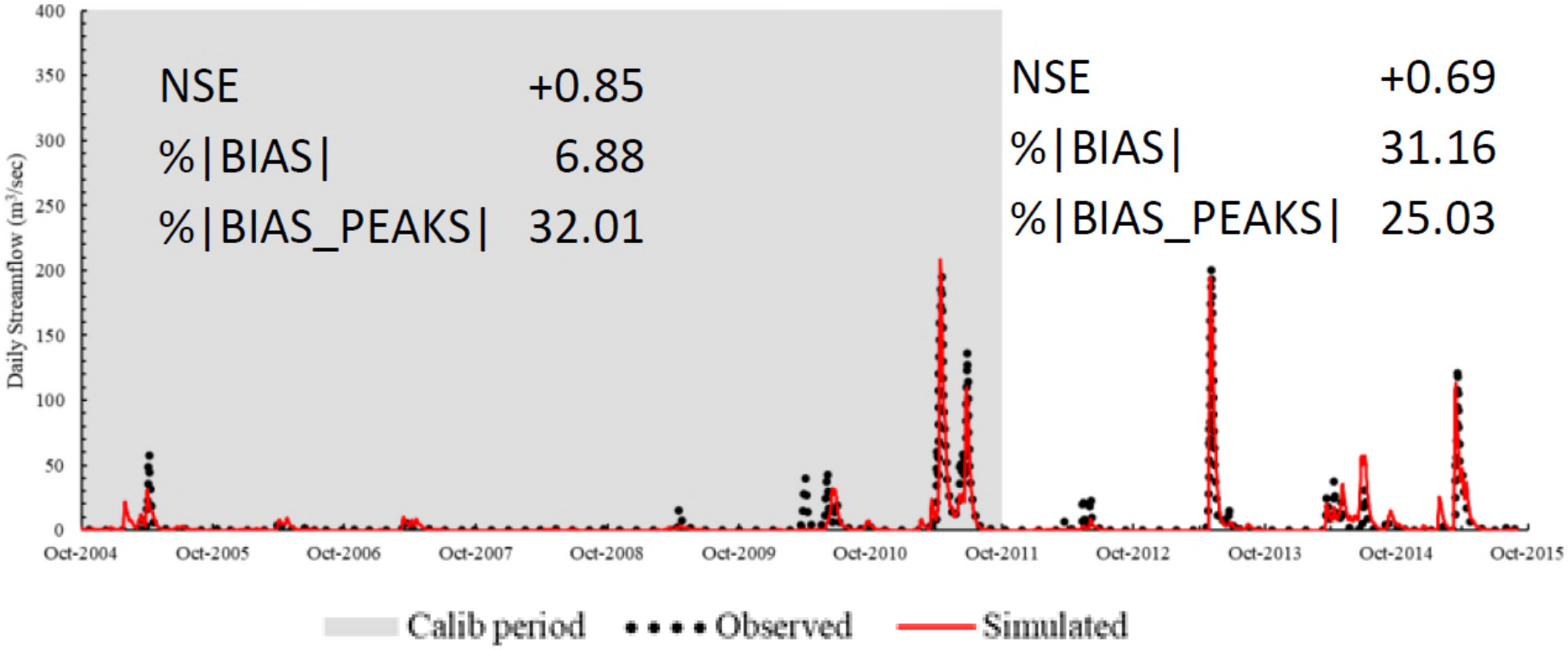
- There is hope through the development of modules to better handle prairie and cold region processes.





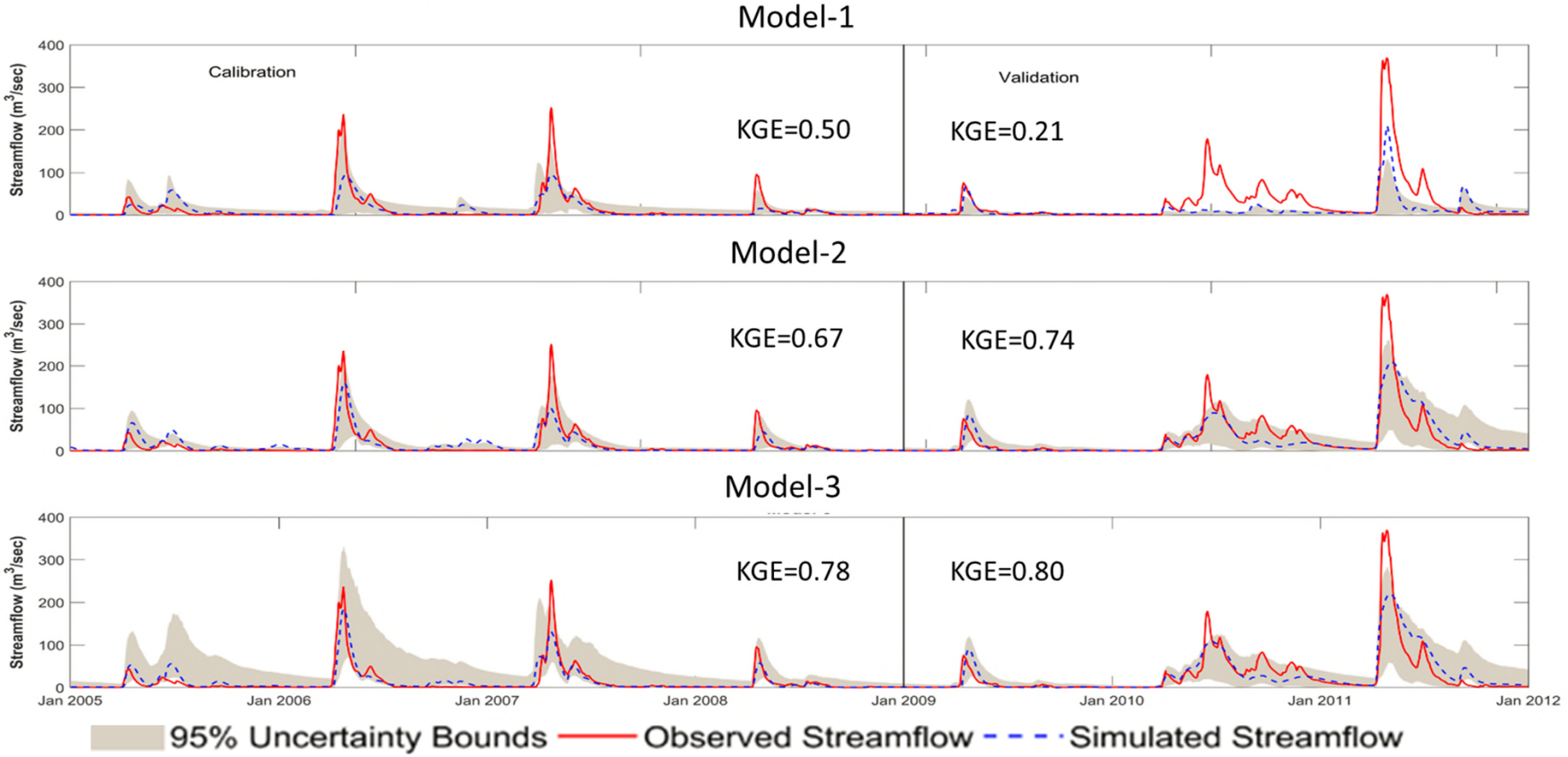
Successes in Prairie Modelling

- Unpublished results using **HBV-Prairie**
  - Created by Mohamed Ahmed, PhD candidate at the U of S completing research funded by FloodNet under the supervision of Drs. Amin Elshorbagy and Al Pietroniro
  - HBV + PDMROF



Successes in Prairie Modelling

- Ameer Muhammad work with SWAT using a (1) Lumped, (2) Semi-Discretized and (3) Discretized Pothole representations



Muhammad, A., Evenson, G.R., Stadnyk, T.A., Boluwade, A., Jha, S.K., Coulibaly, P., 2019. Impact of model structure on the accuracy of hydrological modeling of a Canadian Prairie watershed. J. Hydrol. Reg. Stud. 21, 40–56.

What is WSA Doing to Improve Tools/Model?

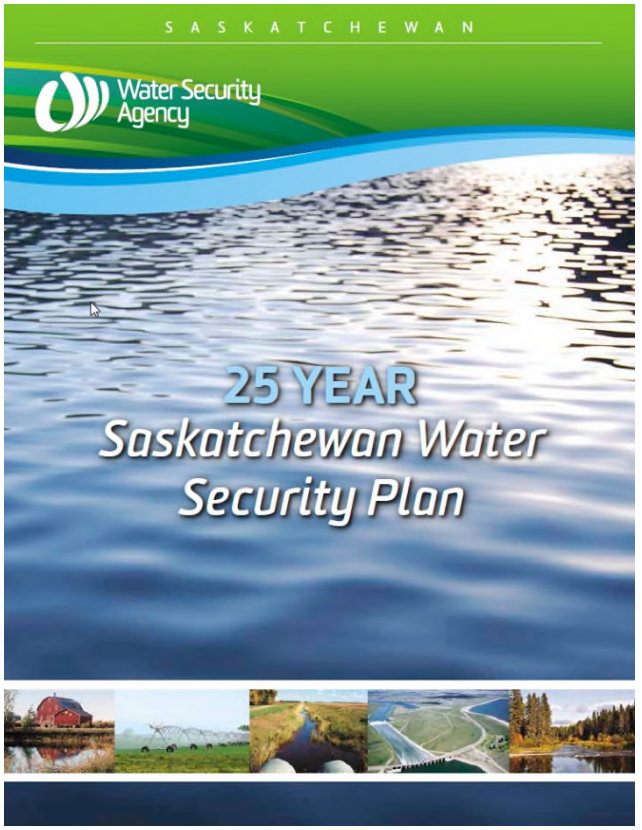
action area 5.1

flood damage prevention and emergency response in developed areas

actions

a. Develop improved flood forecasting tools *(2016)*

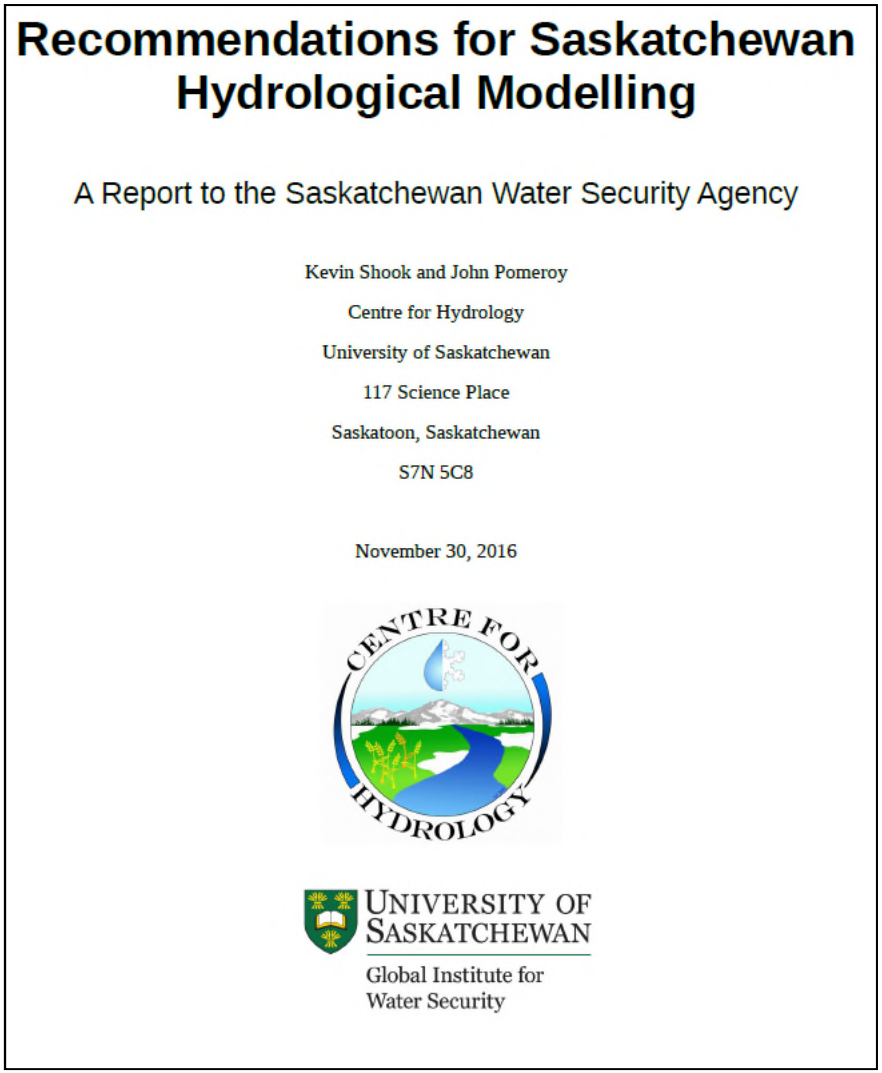
- New funding to flood forecasting in the 2014 and 2018 Provincial Budgets to improve flood forecasting functions, enabling the creation and growth of a dedicated flood forecasting unit



University of Saskatchewan Consultation

Key Points

- Most existing hydrological models do not include cold region processes.
- Even fewer models are able to simulate the fill and spill processes of the prairies.
- A physically based model is suggested rather than a statistically or conceptually based model.
    - Likely better equipped for a changing climate and for events outside of those included in the observed record.
- A separate reservoir simulation model is likely required.
- A data handling platform will likely be required.



Recommendations for Saskatchewan Hydrological Modelling

A Report to the Saskatchewan Water Security Agency

Kevin Shook and John Pomeroy

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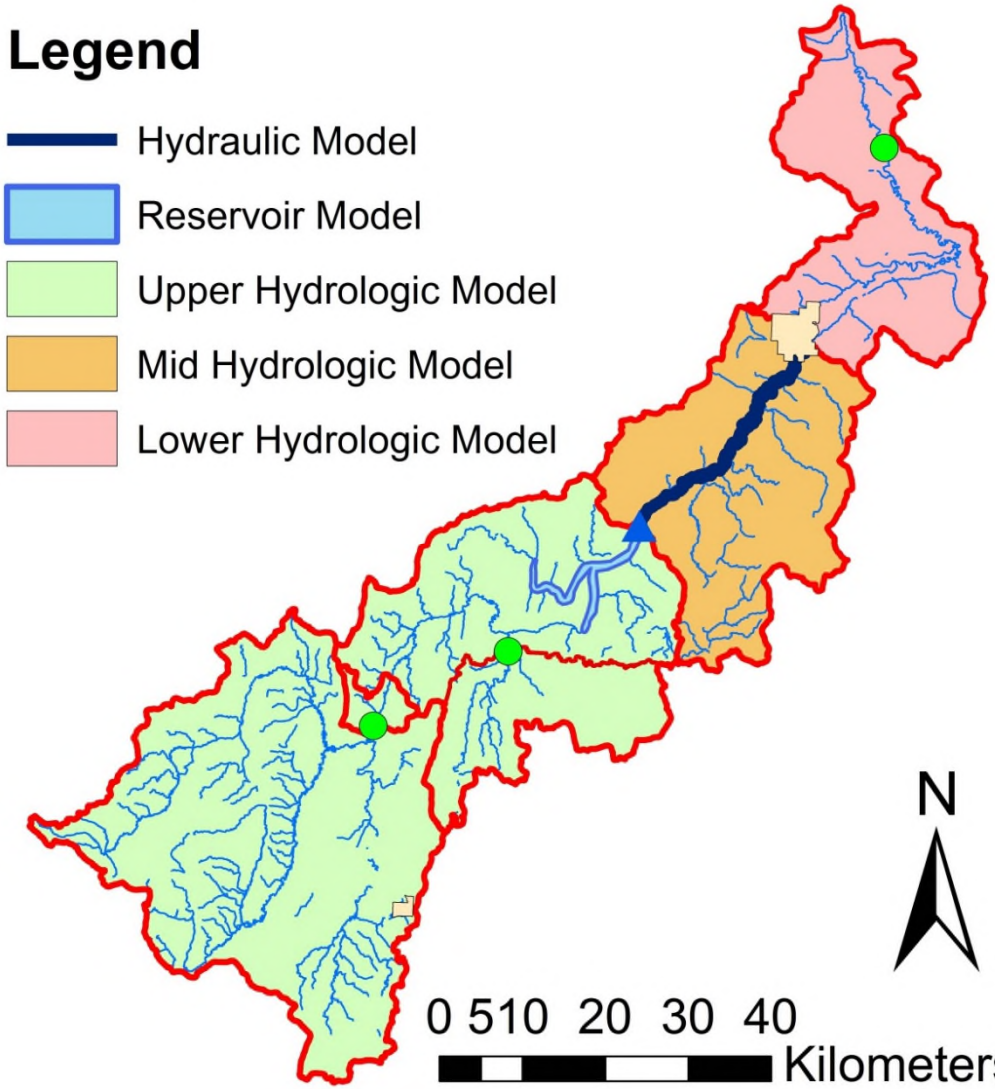
November 30, 2016

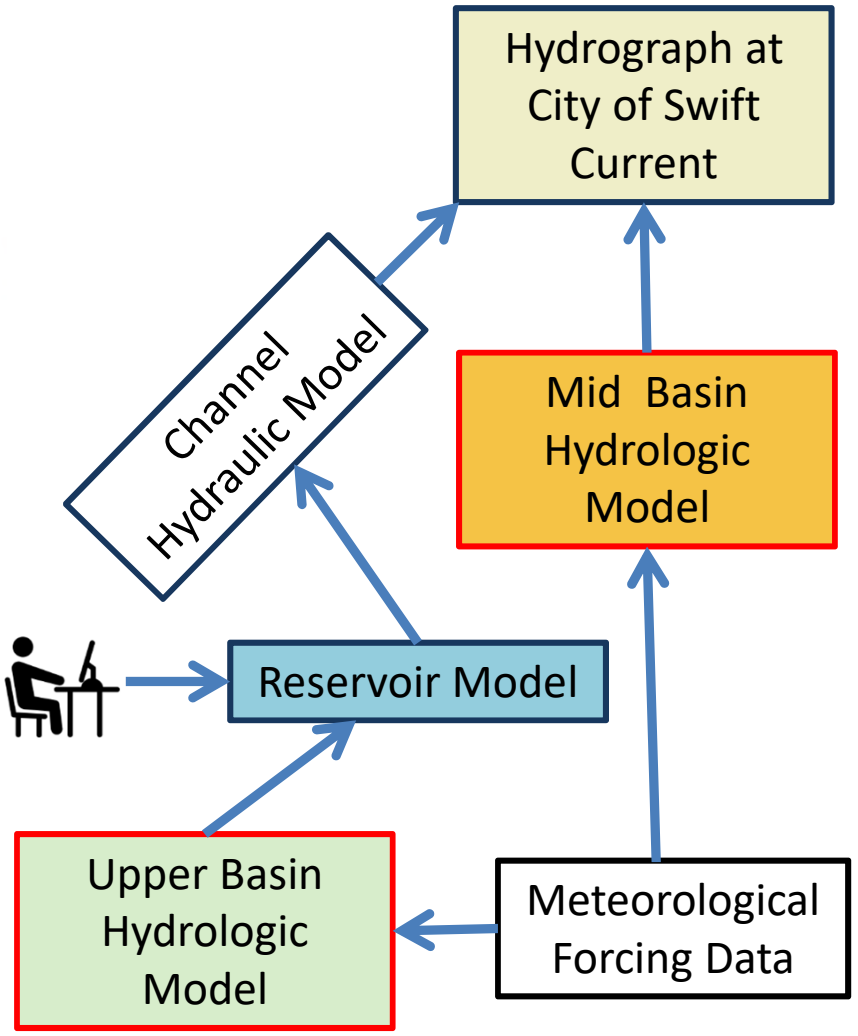
CENTRE FOR HYDROLOGY

UNIVERSITY OF SASKATCHEWAN

Global Institute for Water Security

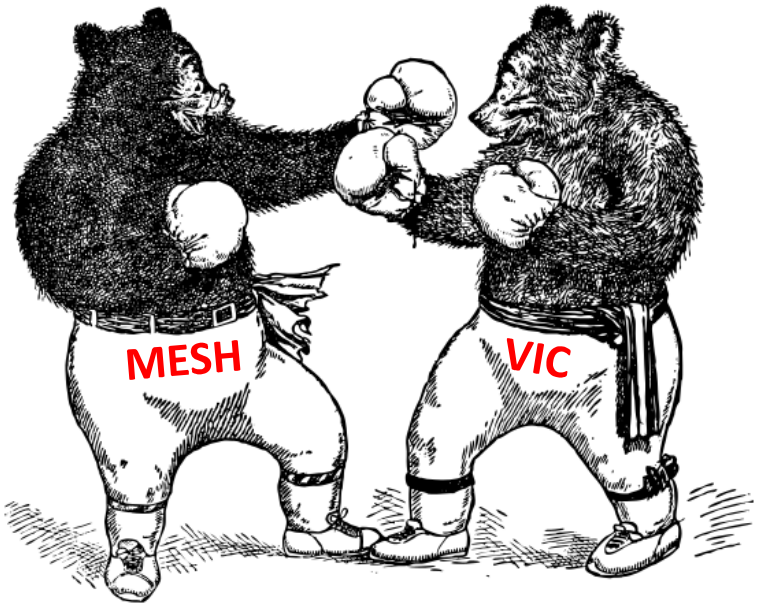
Potential Swift Current Creek Components



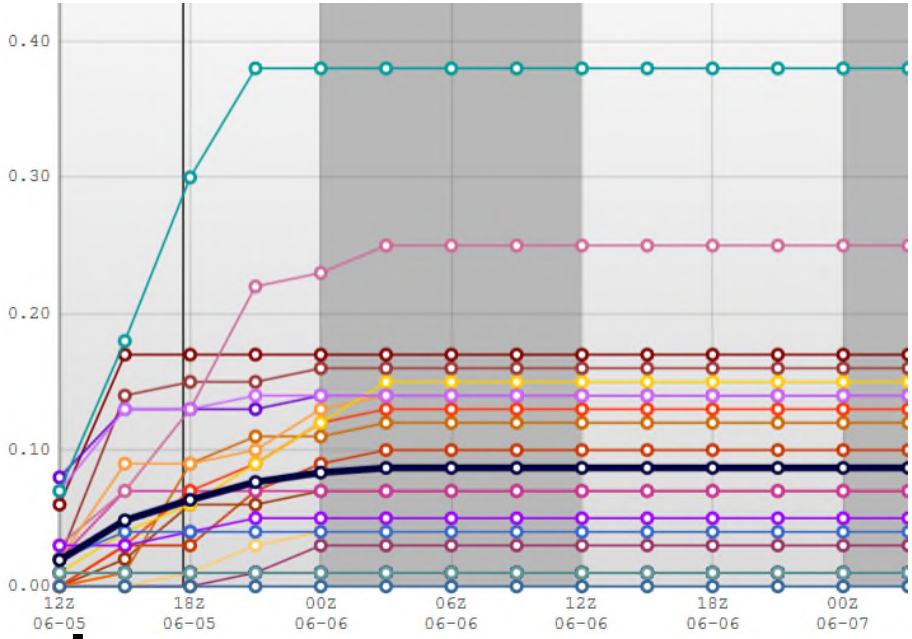


Model Inter-Comparison Project

- We are in the mid-stages of a model inter-comparison project
  - Two watersheds
    - Moose Jaw River
    - Swift Current Creek
  - Five hydrologic models for each watershed
    - VIC, MESH, SWAT-PDLD, HBV, & HBV-Prairie
  - Evaluate based on:
    - Data needs
    - Appropriateness for operational use
    - Predictive ability
- Expect to complete in mid-2019

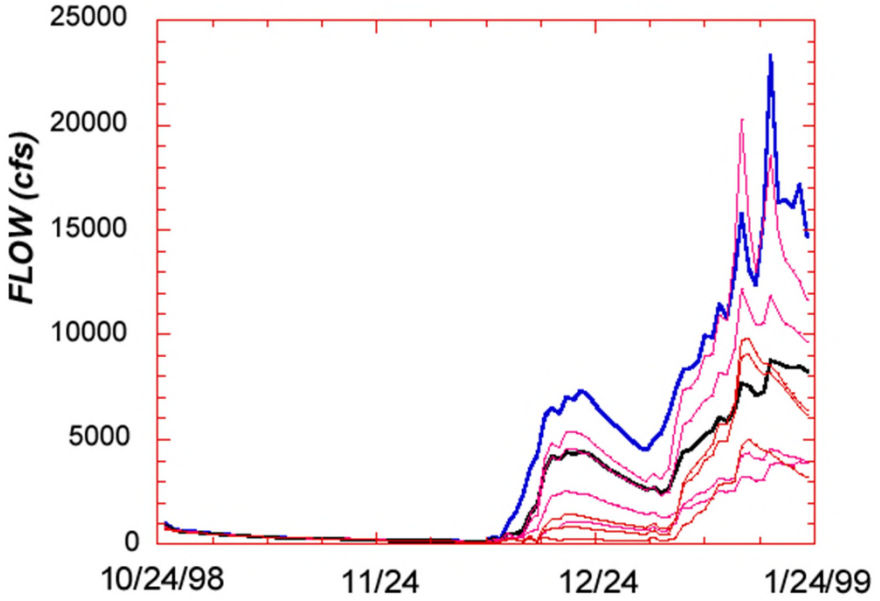


Deterministic Forecasting using Ensemble NWP Output



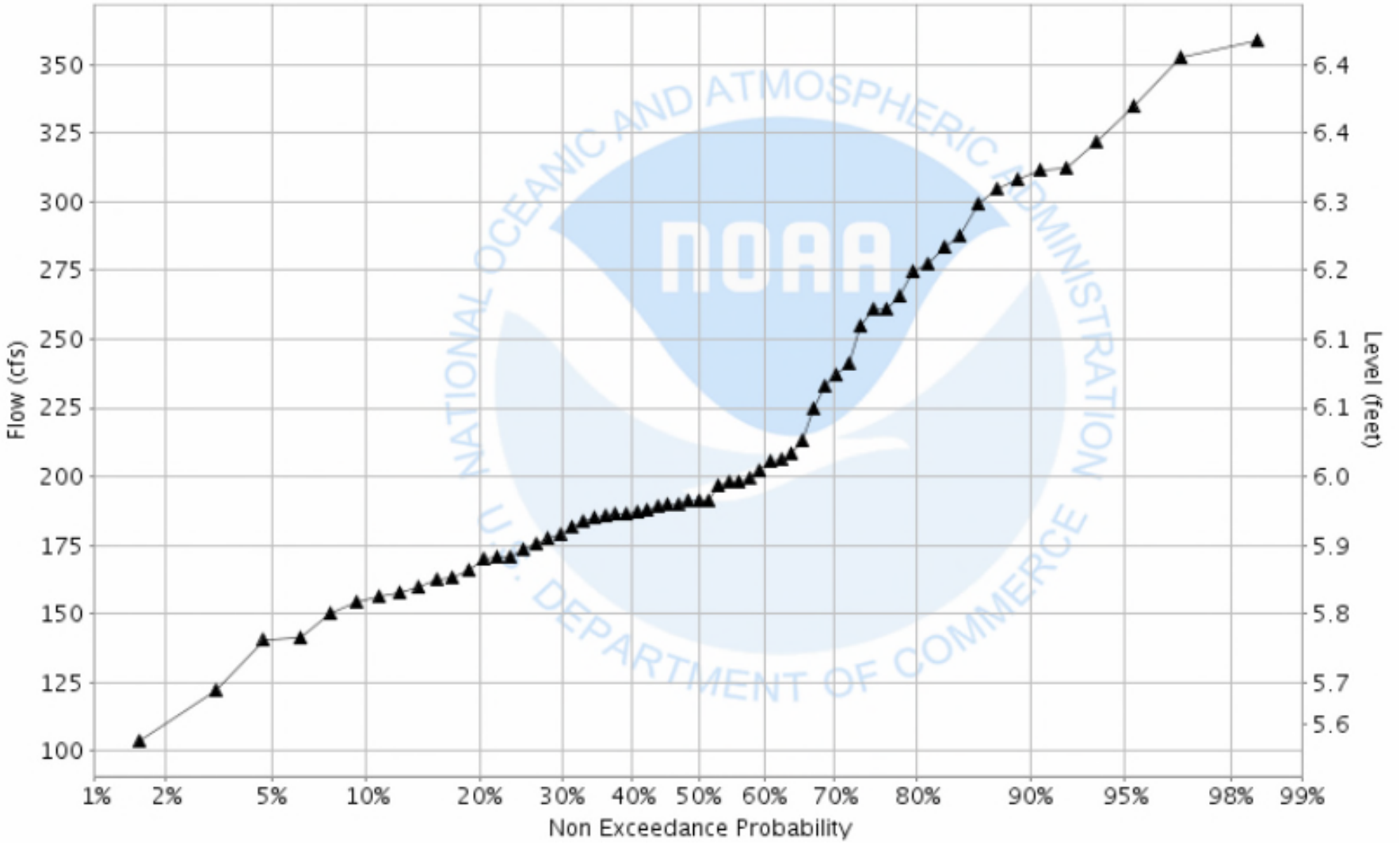
Ensemble Rainfall Forecast

Hydrological Model

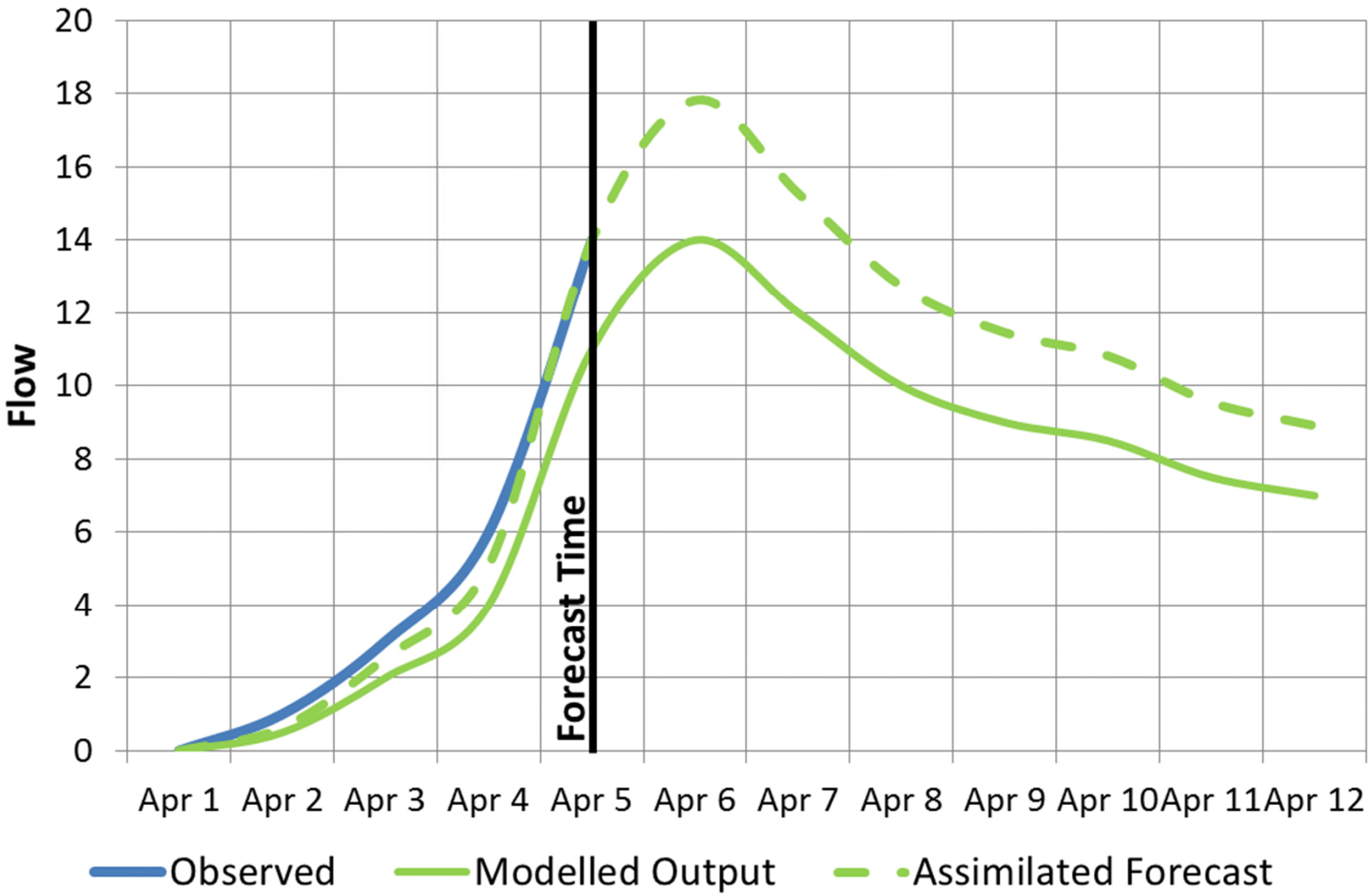


Ensemble Streamflow Forecast

Probabilistic Forecasting



Data Assimilation



How can ECCC's Proposed Products Help?

- Provide forecasts for basins we do not plan on modelling
  - Our work will be focused on locations where we have major dams or systems and/or significant flood hazards
- Provide a monitoring function
  - We will likely only operate most of our models in reaction to forecasted or ongoing events rather than on a continuous basis.
  - This product could alert us to potential events.
- Provide a member that could be included in a multi-model ensemble.
- Provide a backup forecast in the event of a catastrophic event that prevents us from running our system.

What would Saskatchewan like in the product?

1. Products available prior to 7:00 AM CST
2. Multiple runs per day (at least during events)
3. Available 7 days per week when conditions require
4. 7-10 day outlook (use RDPS and GDPS forecasts)
5. Sub-daily time steps for outputs (at least 3 hr, 1 hr preferred)
6. Outputs/hydrographs for the hydrometric gauging network, major reservoirs, and major urban areas.
7. Use ensemble NWP products to communicate uncertainty.
8. Access to model state variables in addition to flow outputs.
9. Assimilated models and/or forecaster intervention (not just a computer spitting out numbers – they need to make sense).
10. A commitment to continual improvement.
11. Free and open access to the outputs in an easy to ingest format.
12. Reliable/dependable if they are to be incorporated into operational systems.

What we don't want

1. ECCC issuing flood watches or warnings.
2. Products that are publicly available
    - When our forecasts disagree, we want to use our local knowledge and experience to make a judgement call on what forecast to use.

Miscellaneous Questions

1. Will any reservoir management be included in the models?
2. Will there be regular interaction between ECCC and the provinces and territories?
3. How will the hydrometric sites operated by the Province of Saskatchewan be integrated into the process?
4. When is the target date for the system to go live?