Water resources modelling Manitoba (Nelson-Churchill)

Integrated Modelling Program for Canada

2nd Annual Meeting

Masoud Asadzadeh, Collaborator

SuJin Kim and Parya Beiraghdar

13 June 2019

University of Manitoba

Content

- HQPs
- Objective
- Funding
- State of the models
  - MODSIM
  - MODSIM ↔ WATFLOOD
- Plan for future work

HQPs

- Directly contributing to IWM modelling
  - Parya Beiraghdar, MSc, IWM modeling of the system
  - SuJin Kim, MSc, coupling IWM and watershed modeling (co-supervised by Dr. Stadnyk)

- Indirectly contributing to IWM modelling
  - Hervé Awoye, PDF, multi-modeling (co-supervised by Dr. Stadnyk)
  - Ajay Bajracharya, PhD, watershed modeling (co-supervised by Dr. Stadnyk)
  - Jack Kostick, UA, HYPE modelling under climate scenarios (co-supervised by Dr. Stadnyk)

Objectives

(copied form IMPC 2018)

- Develop Integrated Water Management model of system of reservoirs operated by MH
- Couple IWM with the hydrologic model of the study area
- Couple with AB-SK IWM model
- Analyze the models' response to future scenarios
- Adjust systems' operation to mitigate negative impacts of future conditions

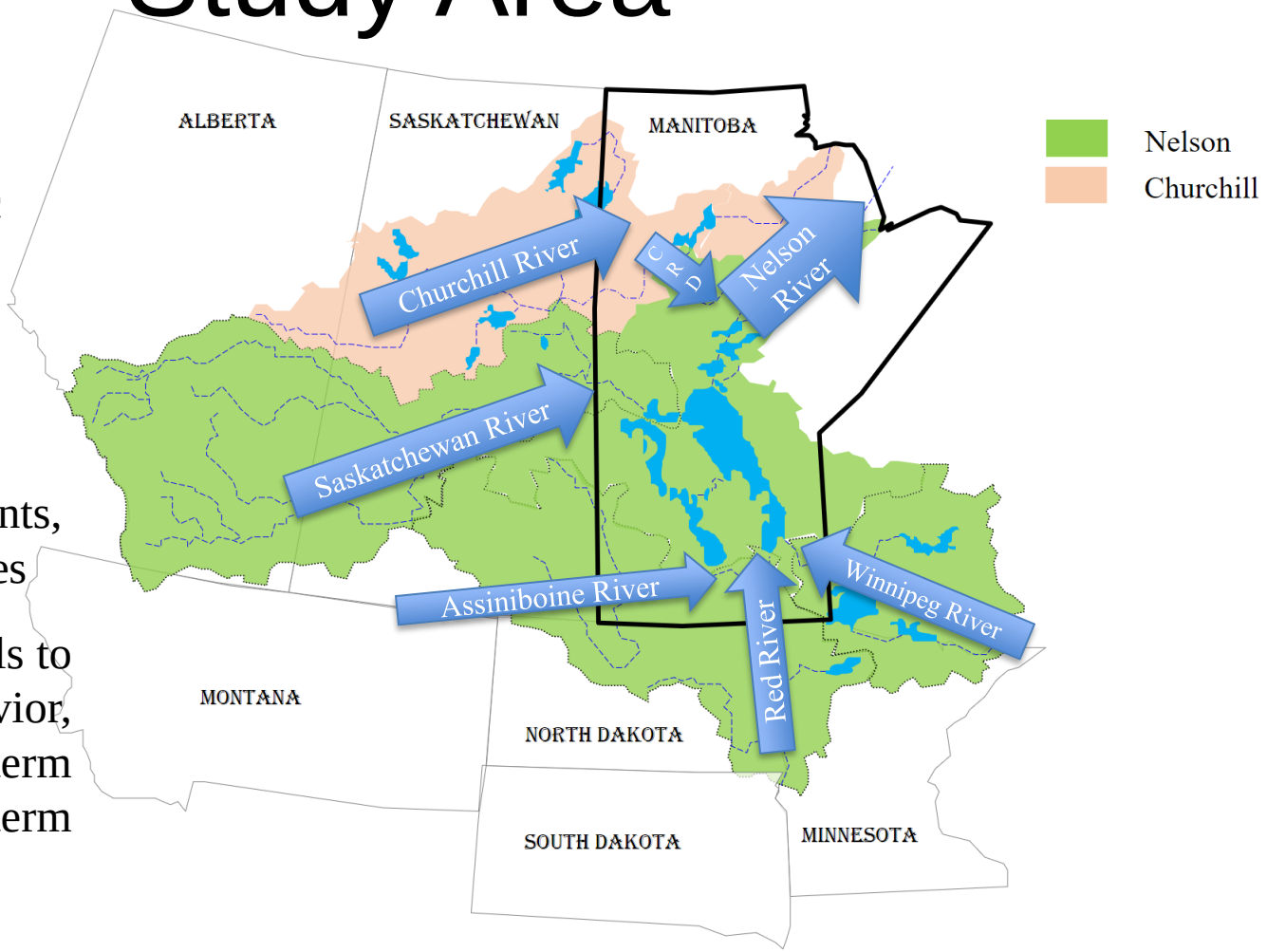
Funding

- As a collaborator, my research group is not directly funded by GWF
- NSERC CRD is re-submitted to match MH's contribution: $90k cash and $70k in-kind, co-PI: Dr. Tricia Stadnyk
- Partial HQP stipend is covered by Dr. Shawn Clark's IRC with MH in river-ice engineering at UofM

Study Area

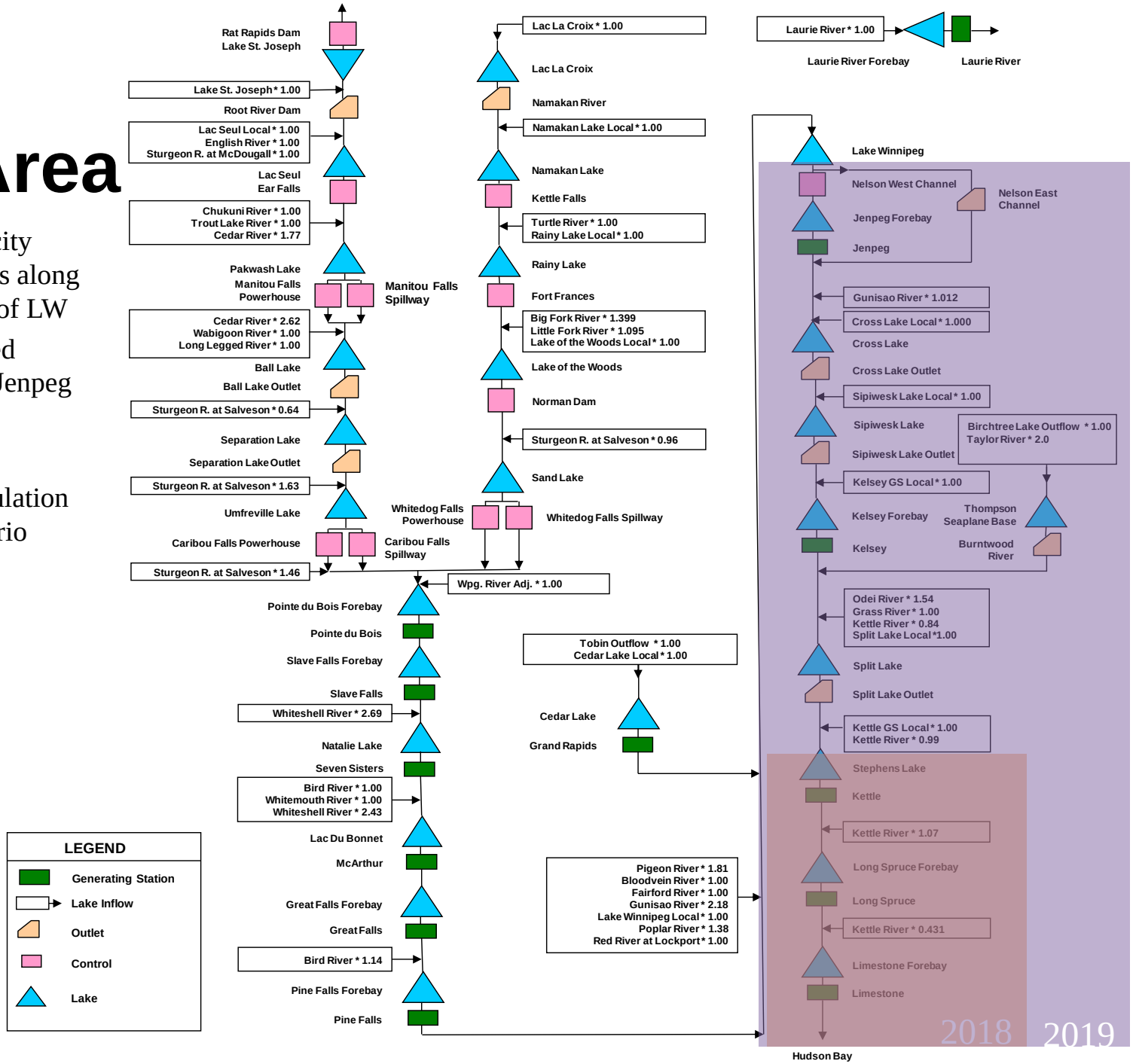
Highly controlled

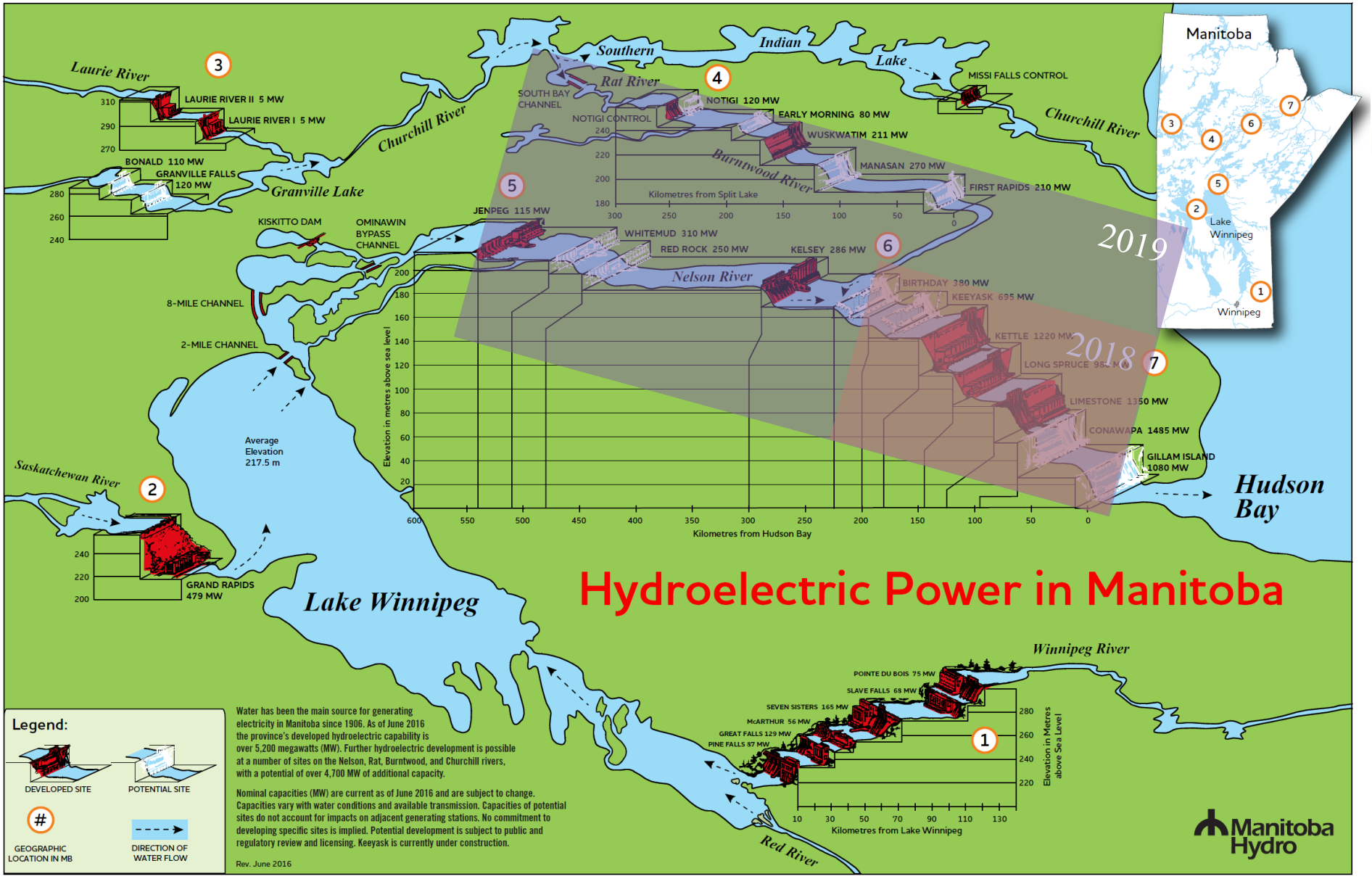
- 15 current hydroelectric generating stations
- 5200 Megawatts
- MB, SK, ON, ND, MN
- Other key hydraulic points, like Cross and Split lakes
- MH has in-house models to simulate system behavior, short-term (days), mid-term (months), and long-term (years)



Study Area

- 75% of hydroelectricity generation capacity is along Nelson downstream of LW
- MODSIM is extended upstream to include Jenpeg and Notigi
- Limited storage
- Straightforward simulation over historical scenario





Hydroelectric Power in Manitoba

Legend:

- DEVELOPED SITE
- POTENTIAL SITE
- # GEOGRAPHIC LOCATION IN MB
- DIRECTION OF WATER FLOW

Water has been the main source for generating electricity in Manitoba since 1906. As of June 2016 the province's developed hydroelectric capability is over 5,200 megawatts (MW). Further hydroelectric development is possible at a number of sites on the Nelson, Rat, Burntwood, and Churchill rivers, with a potential of over 4,700 MW of additional capacity.

Nominal capacities (MW) are current as of June 2016 and are subject to change. Capacities vary with water conditions and available transmission. Capacities of potential sites do not account for impacts on adjacent generating stations. No commitment to developing specific sites is implied. Potential development is subject to public and regulatory review and licensing. Keeyask is currently under construction.

Rev. June 2016

Manitoba Hydro

University of Manitoba

Mass Balance vs. Operational MODSIM

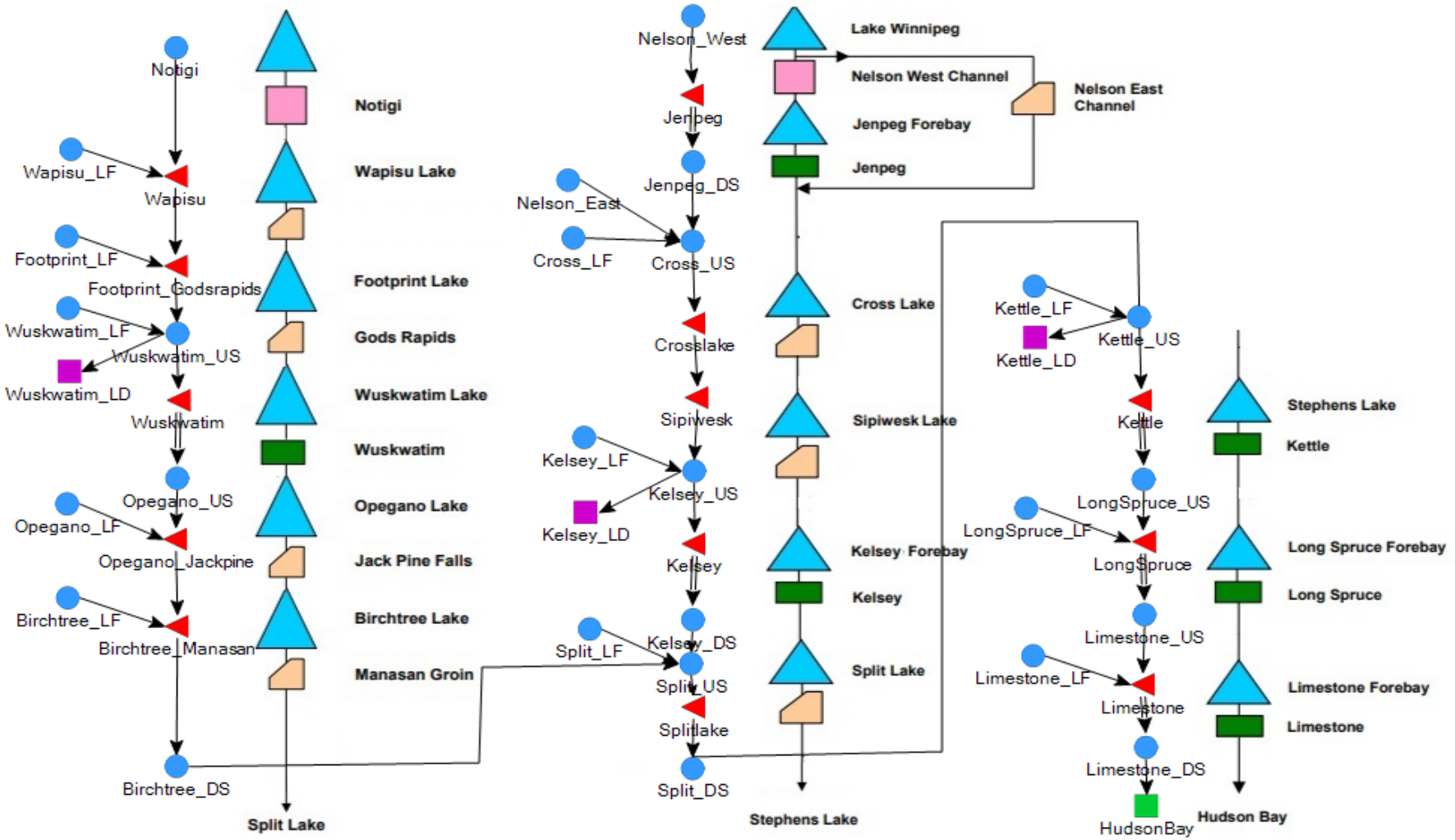
Mass-Balance

- Inputs
  - Channel
    - Daily streamflow
    - Daily local flow
  - Lake/Forebay
    - Daily Target storage
  - Power plant
    - Tailrace curve
    - Daily power demand
    - Efficiency table

Operational

- Inputs
  - Channel
    - Daily streamflow
    - Daily local flow
  - Lake/Forebay
    - Outflow function
  - Power plant
    - Tailrace curve
    - Daily power demand
    - Efficiency table

MODSIM Configuration



MODSIM NSE Scores (Mass-Balance)

Simulation period: 1/1/2013 – 1/1/2018

Reservoir	Flow	Forebay Level	Power
Jenpeg	0.99	1	1
Cross Lake	0.96	1	N/A
Sipiwesk	0.96	1	N/A
Kelsey	0.97	1	1
Wapisu	0.99	1	N/A
Footprint	0.99	1	N/A
Wuskwatim	0.93	0.65	0.99
Opegano	0.93	0.98	N/A
Birchtree	0.93	1	N/A
Split Lake	0.95	1	N/A
Kettle	0.96	1	0.97
Long Spruce	0.96	1	0.96
Limestone	N/A	1	1

MODSIM NSE Scores (Operational)

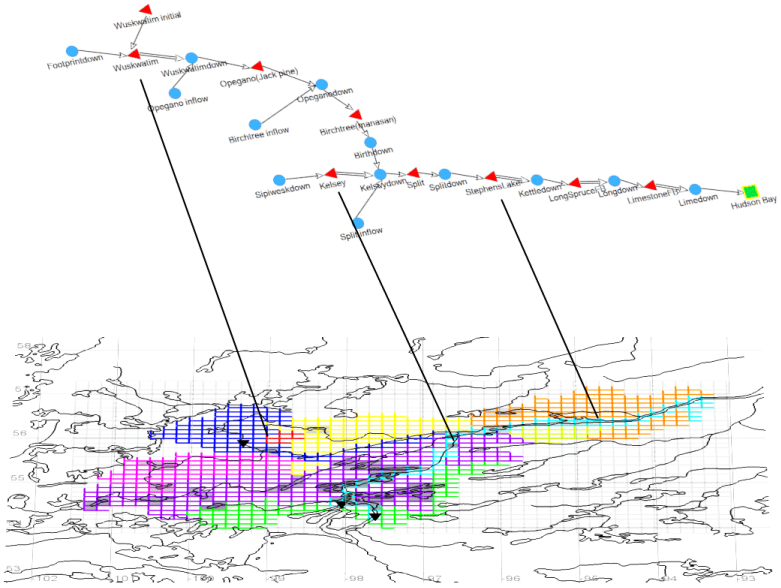
Simulation period: 1/1/2013 – 1/1/2018

Reservoir	Discharge	Forebay Level	Power
Jenpeg	0.96	0.99	1
Cross Lake	0.80	0.91	N/A
Sipiwesk	0.82	0.92	N/A
Kelsey	0.80	0.91	0.75
Wapisu	0.94	0.99	N/A
Footprint	0.80	0.91	N/A
Wuskwatim	0.80	0.93	0.91
Opegano	0.75	0.89	N/A
Birchtree	0.72	0.88	N/A
Split Lake	0.67	0.93	N/A
Kettle	0.69	0.87	0.73
Long Spruce	0.68	0.84	0.80
Limestone	N/A	0.89	0.79

Coupled hydrologic-operations modelling for the simulation of hydropower operations in the Lower Nelson River Basin

SuJin Kim

Poster Number: 27



Schematic of coupling location between WATFLOOD and MODSIM models of Lower Nelson River Basin

Objective:

Couple a physically-based hydrologic model (WATFLOOD / HEC-HMS) and a water management model (MODSIM-DSS) to assess impact of climate change on current hydropower operations in the Lower Nelson River Basin

Preliminary Findings

1. MODSIM is capable of simulating natural and regulated reservoirs with high accuracy
2. Model coupling improved flow simulation

University of Manitoba

Plans for the Last Year

- Extend the models further upstream to include Lake Winnipeg (end of summer)
- Improve operational MODSIM (end of summer)
  - Calibrate outflow functions
  - Incorporate MH's operation functions
- Coordinate with Razavi et al. to aggregate the upstream and downstream models (end of year)
- Run the coupled models over future climate scenarios and evaluate the system performance (end of year)
- Identify and simulate options to mitigate negative impacts of future climate (~March 2020)


TRAILBLAZER CHALLENGER
CHALLENGER DEFENDER VISIONARY
DEFENDER VISIONARY ADVENTURER TRAILBLAZER
VISIONARY ADVENTURER TRAILBLAZER CHALLENGER DEFENDER VISIONARY
ADVENTURER TRAILBLAZER CHALLENGER DEFENDER VISIONARY ADVENTURER TRAILBLAZER CHALLENGER
TRAILBLAZER CHALLENGER DEFENDER VISIONARY ADVENTURER TRAILBLAZER CHALLENGER DEFENDER VISIONARY ADVENTURER TRAILBLAZER
DEFENDER VISIONARY ADVENTURER TRAILBLAZER CHALLENGER DEFENDER
EST. 1877
UNIVERSITY
OF MANITOBA