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Characterizing Groundwater - Surface Water Interactions Cowichan Watershed, British Columbia, Canada

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GSA 2014 - Vancouver
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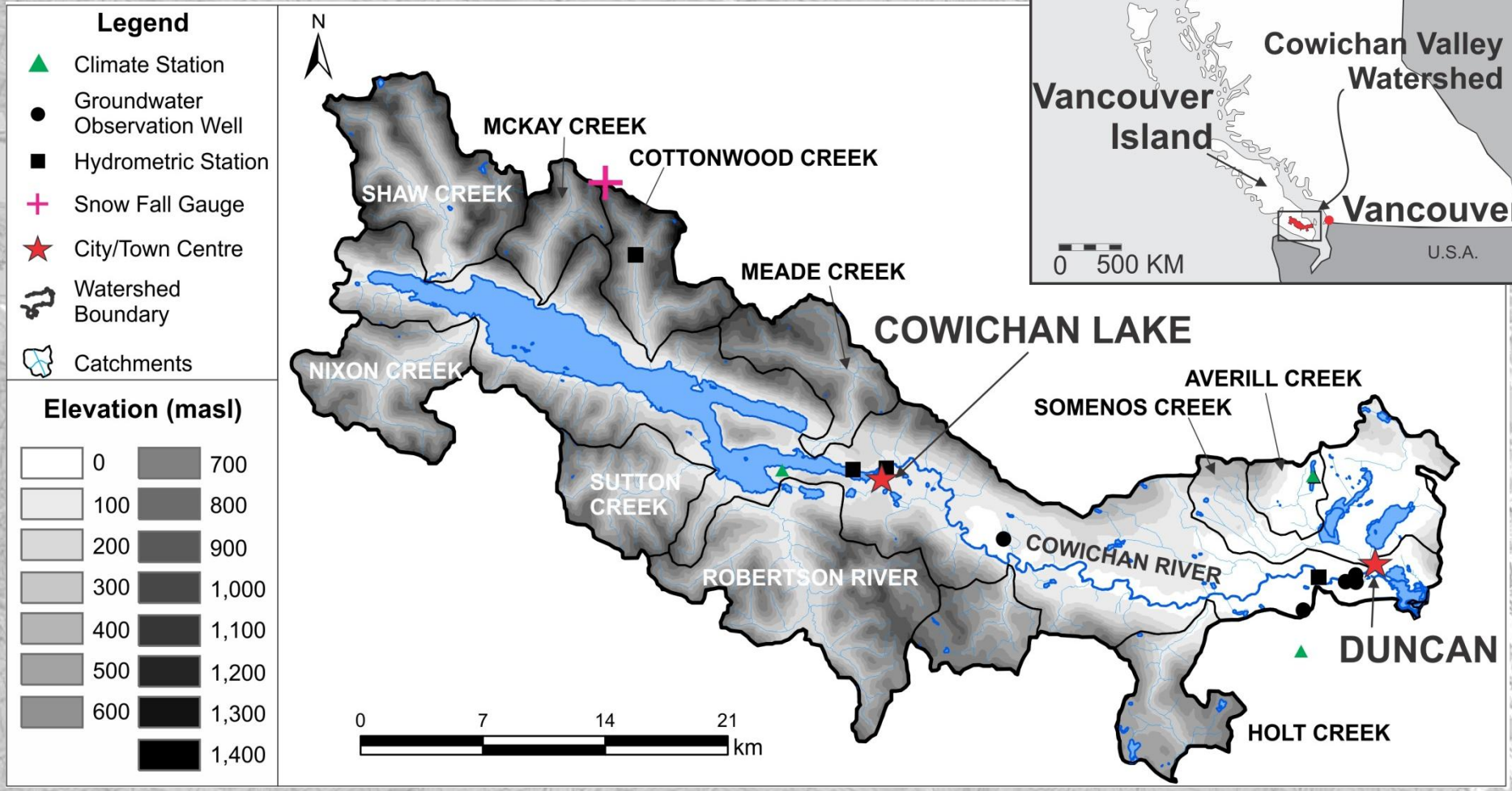
GW-SW Interactions Watershed Scale

“Surface water commonly is hydraulically connected to groundwater, but the interactions are difficult to observe and measure.”
Winter et al. (1998)

“Identification of stream reaches that interact intensively with groundwater would lead to better protection strategies of such systems.”
Sophocleous (2002)

The Cowichan Valley Watershed

- Located on southeast Vancouver Island, BC, Canada
- 930 km^2 watershed, several lakes, notably Lake Cowichan (62 km^2)
- The Cowichan River (lake to coast) – 50 km long



The Cowichan Valley Watershed

- Large variability in seasonal weather patterns
- Balance of in-stream flows, water demands of industry, agriculture, and residential users

Flood forces Vancouver Island evacuations

Hundreds of people have had to leave their homes

Last Updated: Friday, November 20, 2009 | 1:38 PM PT The Canadian Press

Dozens of homes have water "up to the doorknobs" and others are under evacuation alert after heavy rain combined with high tides to flood low-lying parts of Duncan, B.C., an hour's drive north of Victoria.

An aerial view of the flooding in Vancouver Island's Cowichan Valley, where more drenching rains are predicted. (CBC)

B.C.'s Cowichan River in danger of drying up

Record-breaking drought threatens salmon runs

The Canadian Press Posted: Oct 7, 2012 11:01 AM PT | Last Updated: Oct 7, 2012 12:12 PM PT 126

Water flows in Cowichan River at crisis low levels

Angry chief demands changes on river control

Cowichan River Drying: River Could Dry Up By End Of October, Threaten Salmon Runs

CP | By Sarah Simpson, The Canadian Press

Posted: 10/07/2012 7:00 am Updated: 10/07/2012 1:13 pm

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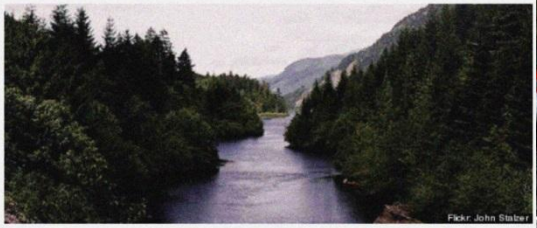


Flickr: John Stalber

he Cowichan River to battle a small brush fire earlier this month.

Cowichan River too dry for salmon run - volunteers truck fish up river

Share Print

October 05, 2012 06:29 from

The sunny, dry autumn weather is threatening the Chinook salmon run on the Cowichan River. Water levels are so low fish aren't able to make it to their spawning grounds above Skutz Falls.

But a group of citizen volunteers is trying to save the day by giving the Chinook a ride.

The counting fence installed by Cowichan T

Cowichan News Leader Pictorial - News

TEXT

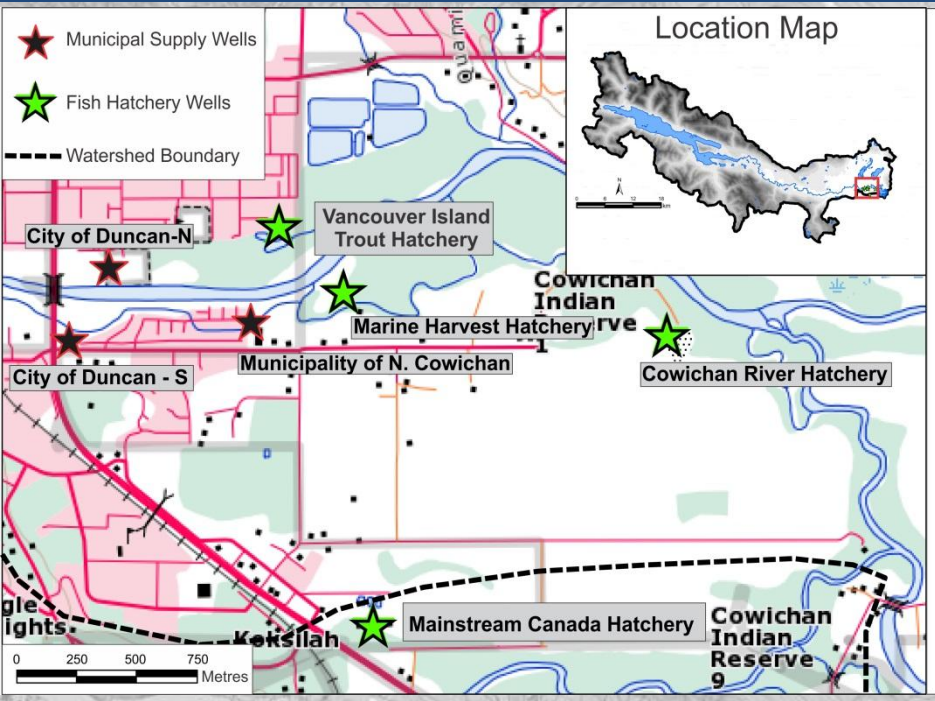
0 COMMENTS EMAIL LETTER PRINT FOLLOW SHARE

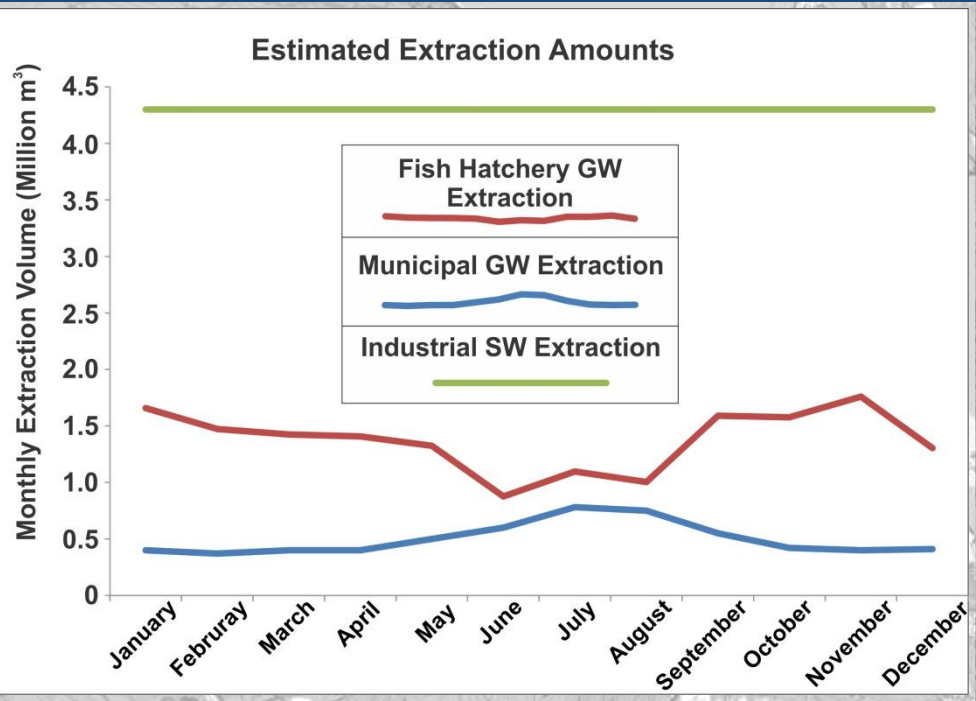
Fishing stopped on Cowichan River as chinook-salmon rescue starts

Chinook salmon trucked to Sandy Pools for spawning on the Cowichan River Friday. That chomp wound is from seals eating salmon prevented by drought from swimming upstream.

Courtesy: Parker Jefferson

Major Users of Water





Water Usage – Groundwater

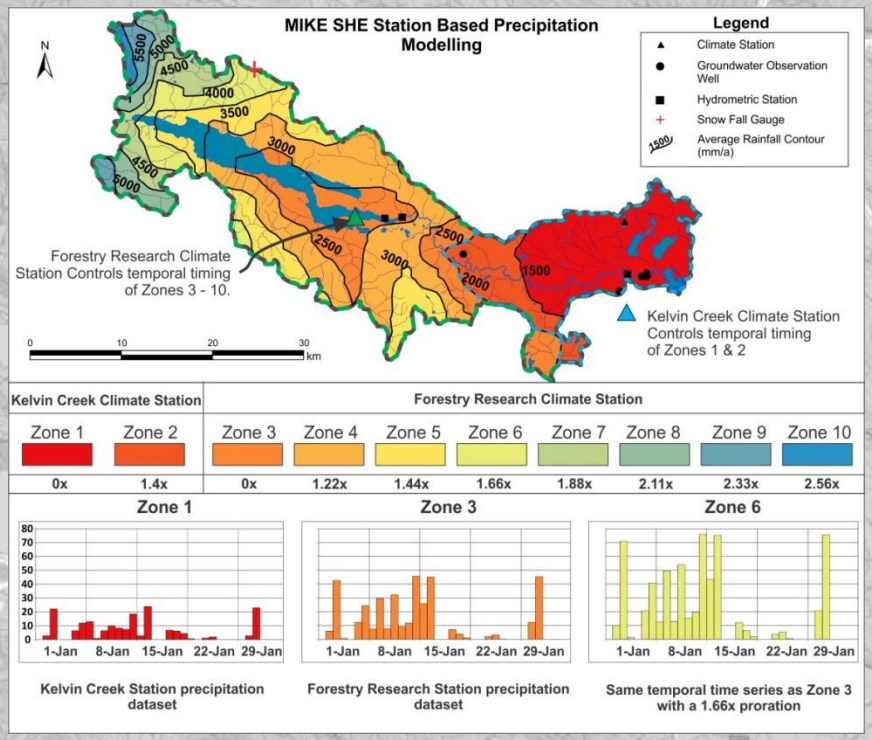
- Major groundwater extraction users consist of industry (hatcheries), agriculture, and municipalities

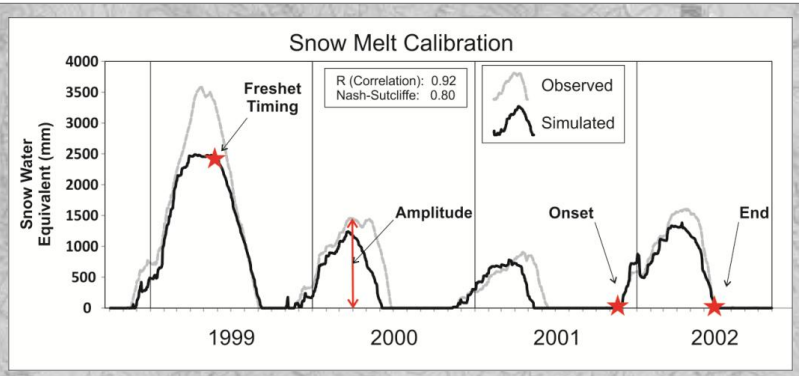
Water Usage –Surface Water

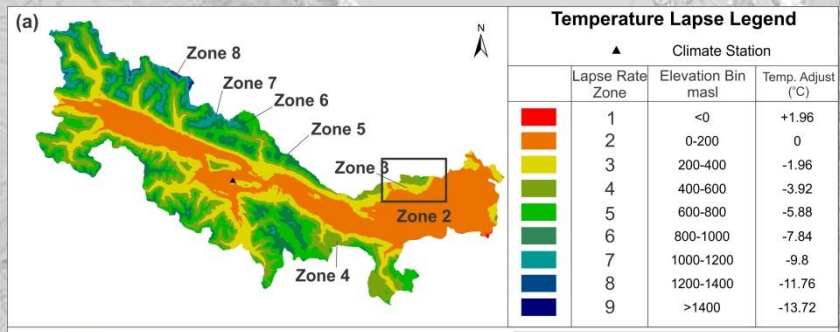
- Major surface water users consist of industry (paper mill), agriculture, and municipalities

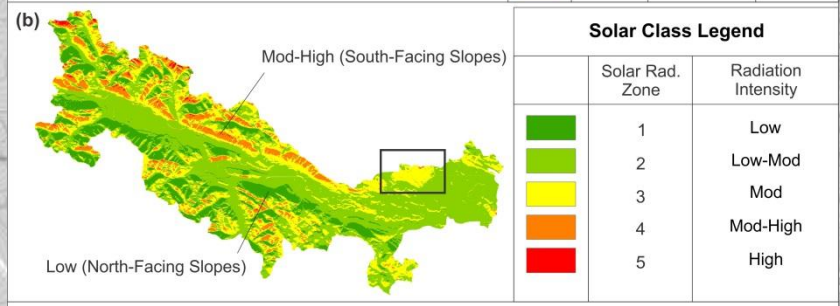
MIKE SHE – Coupled Groundwater - Surface Water Model
Modelled Climate

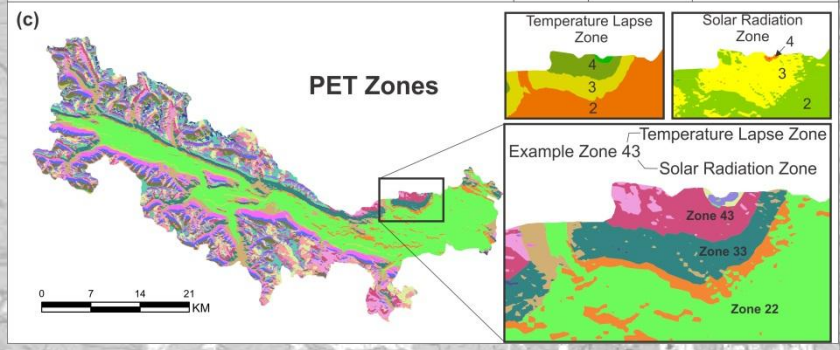
- Spatially distributed: precipitation, PET, solar radiation, and temperature (lapse rate)

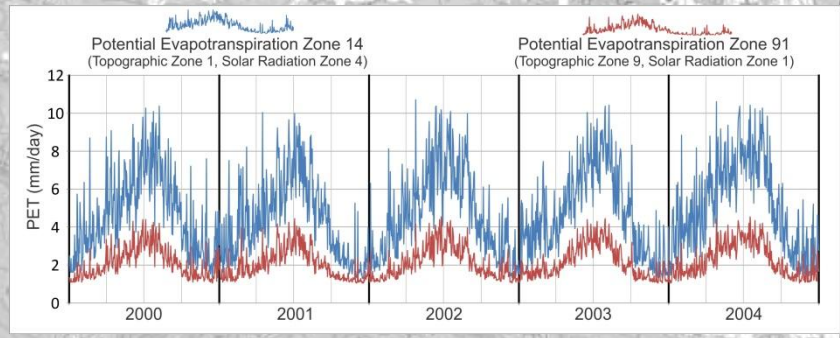






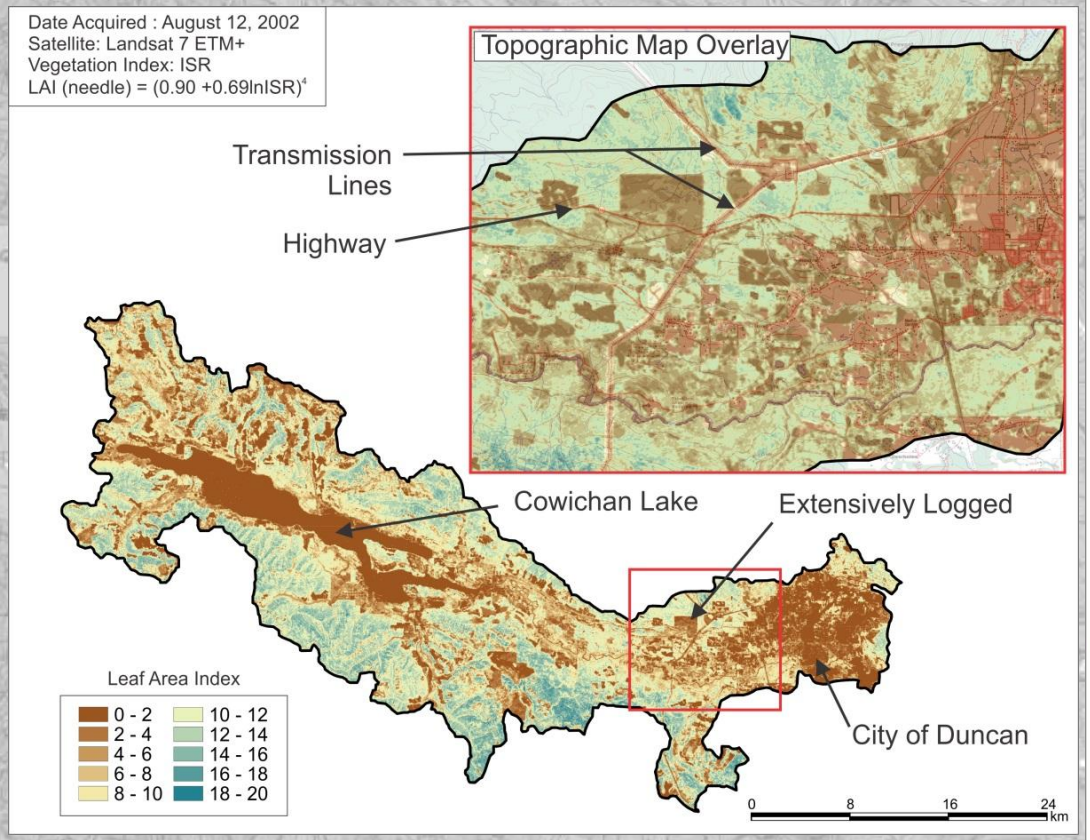


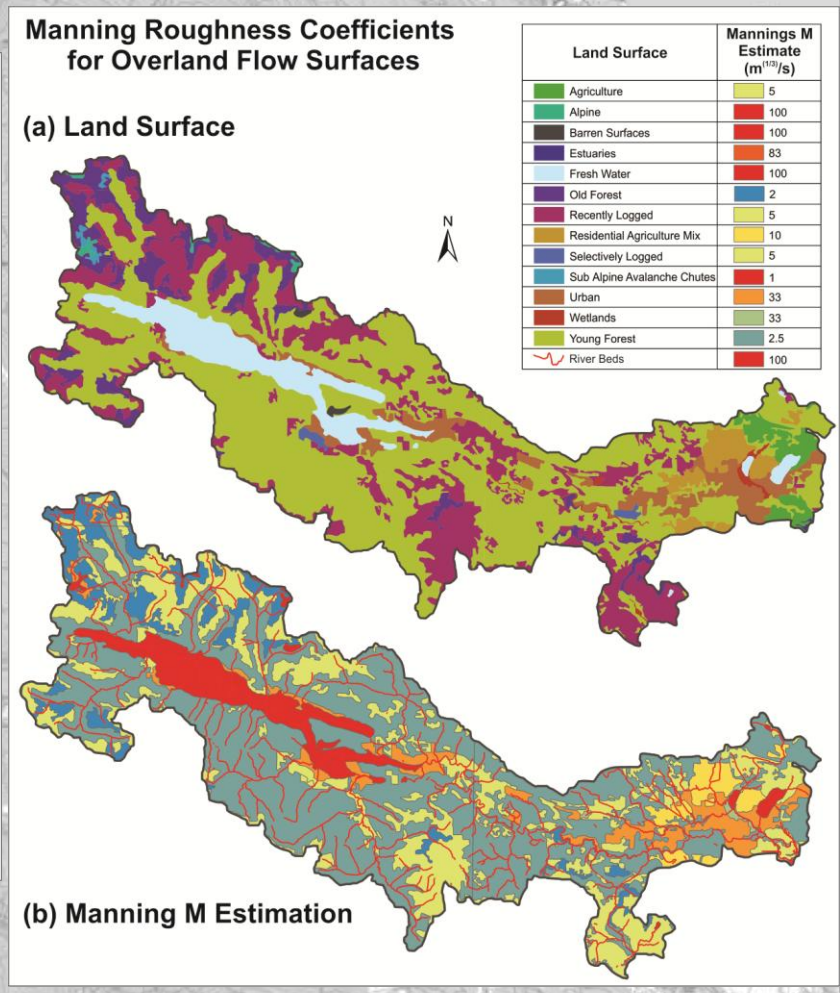




MIKE SHE – Coupled Groundwater - Surface Water Model
Modelled Land Surface

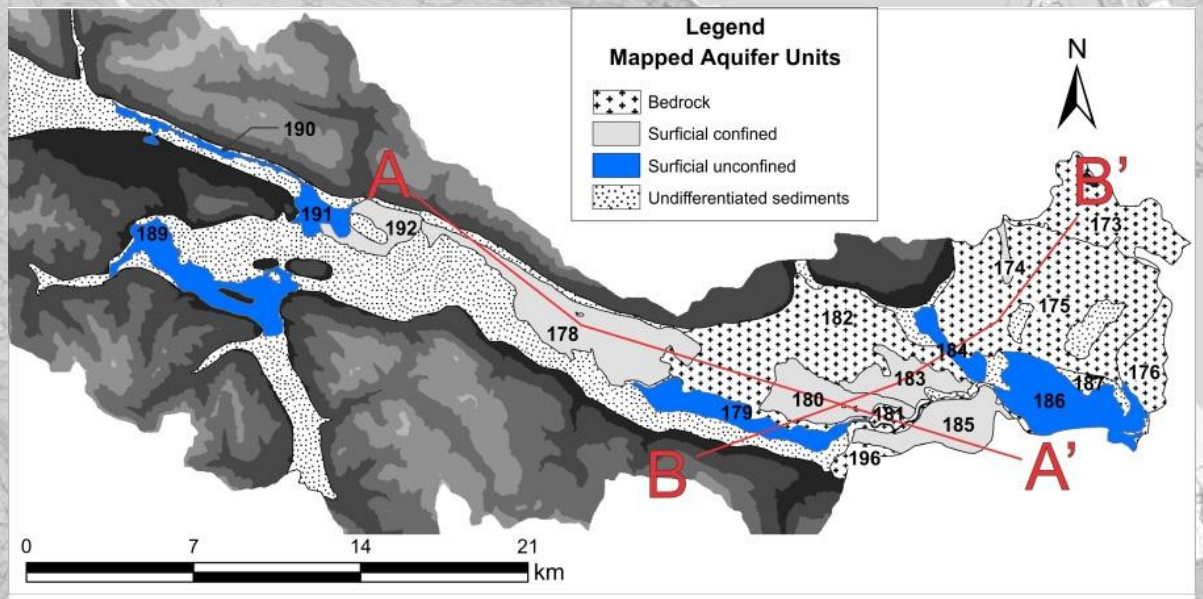
- Land surface processes (canopy interception, depression storage, ET, overland flow) were modeled using 1) remote sensing data, 2) land use classifications.

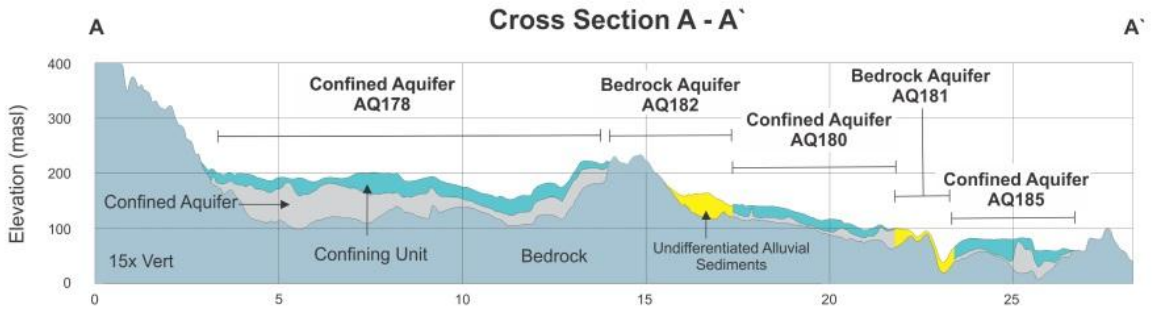


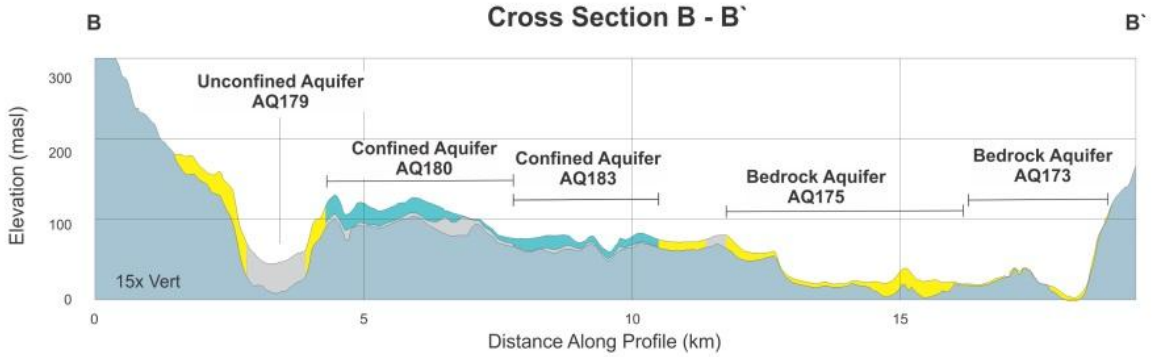


MIKE SHE – Coupled Groundwater - Surface Water Model
Geological Modelling

- Geology is complex within an alluvial valley
- Limited data
- Used geophysics, borehole logs, geology maps, etc.
- Model discretized vertically into two units – alluvium and bedrock, and further discretized into HSUs





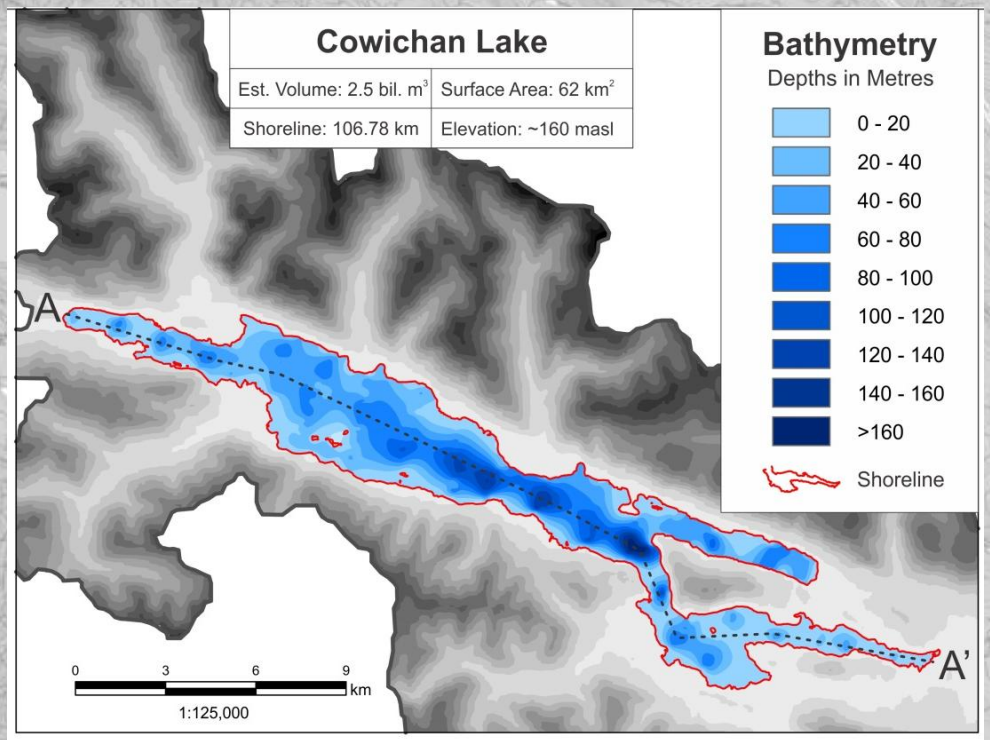


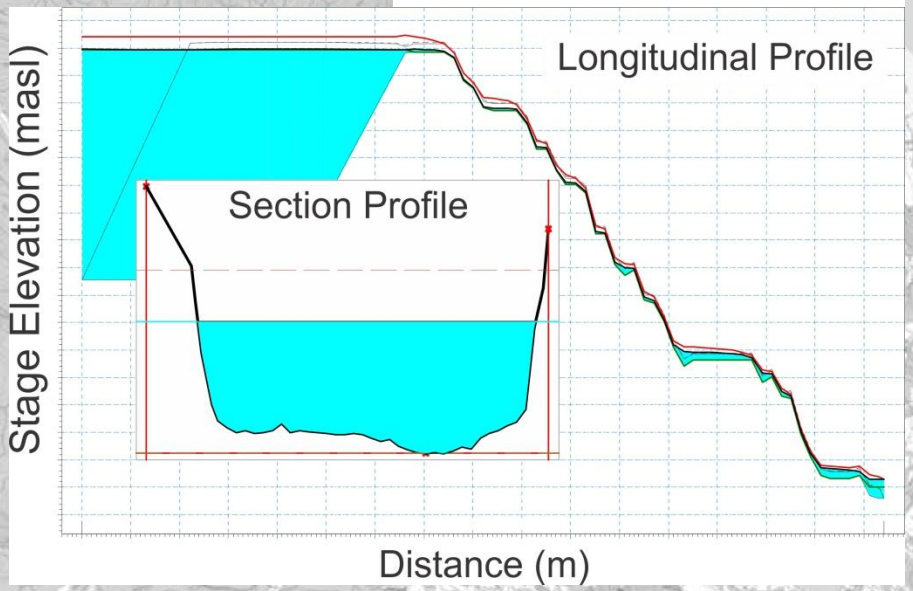
MIKE 11 – River Module

Linked Groundwater - Surface Water System

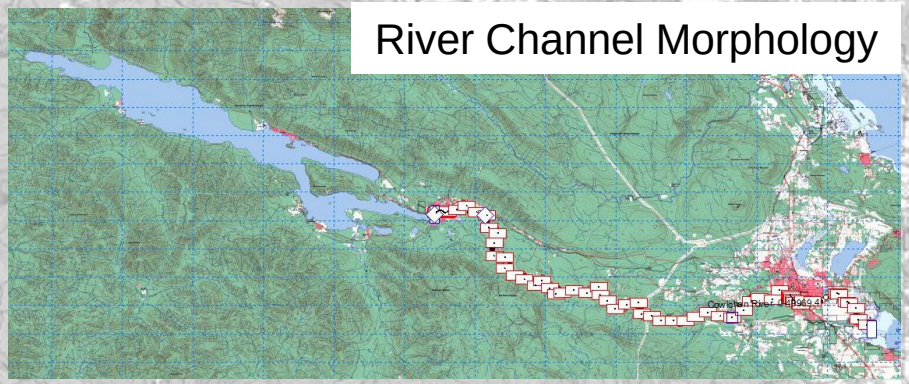
- Lake and river morphology added to the model
- Morphology is found to be important for model calibration

Riverbed Cross-Sections
Q-H Relationship





River Channel Morphology



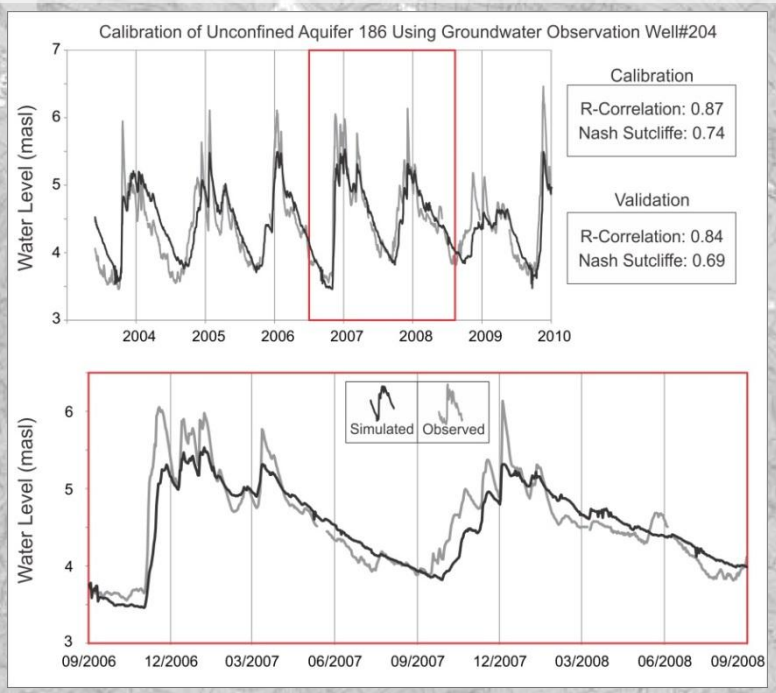
MIKE SHE – Model Calibration

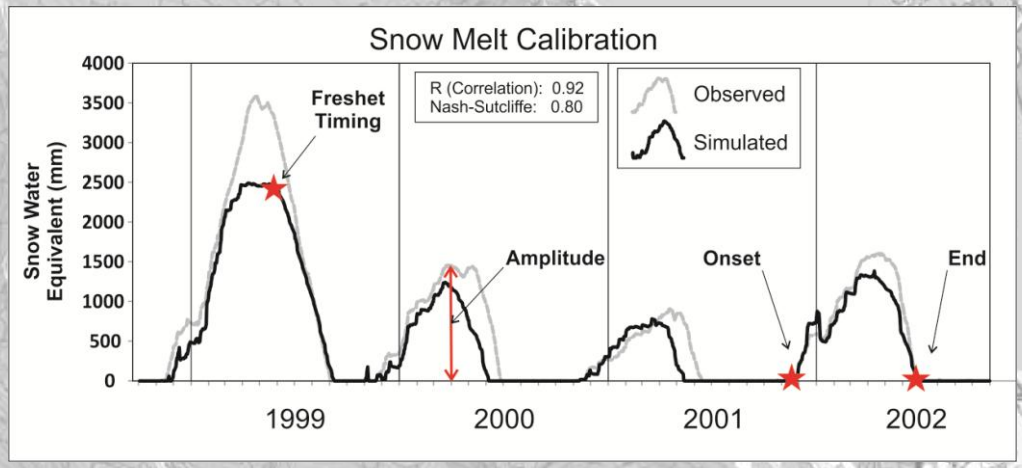
Surface Water Calibration

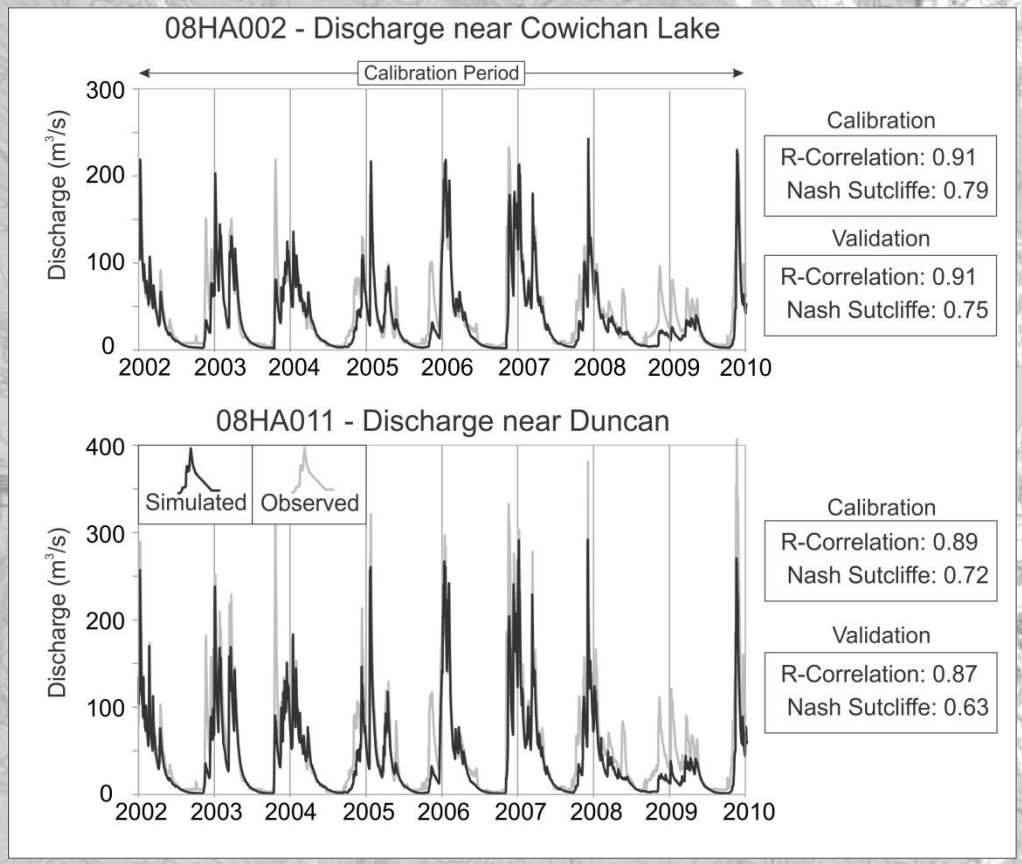
- Jump Creek Snow Pillow
- Cowichan Lake Stage 08HA009
- River Discharge
  - 08HA002 – Lake Cowichan
  - 08HA011 – Duncan

Groundwater Level Calibration

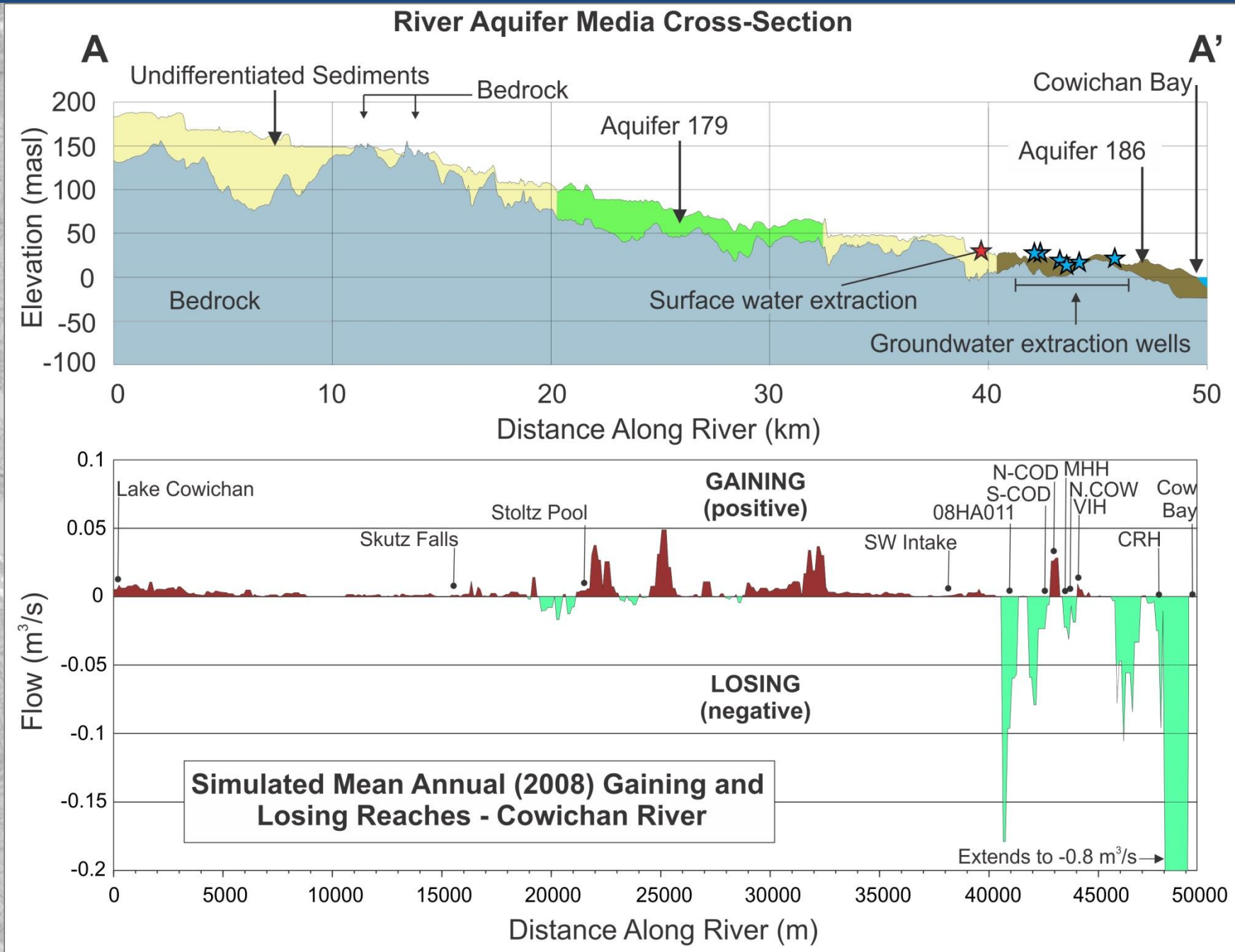
- Adjusted the K, Ss and Sy values in attempt to model gw fluctuations





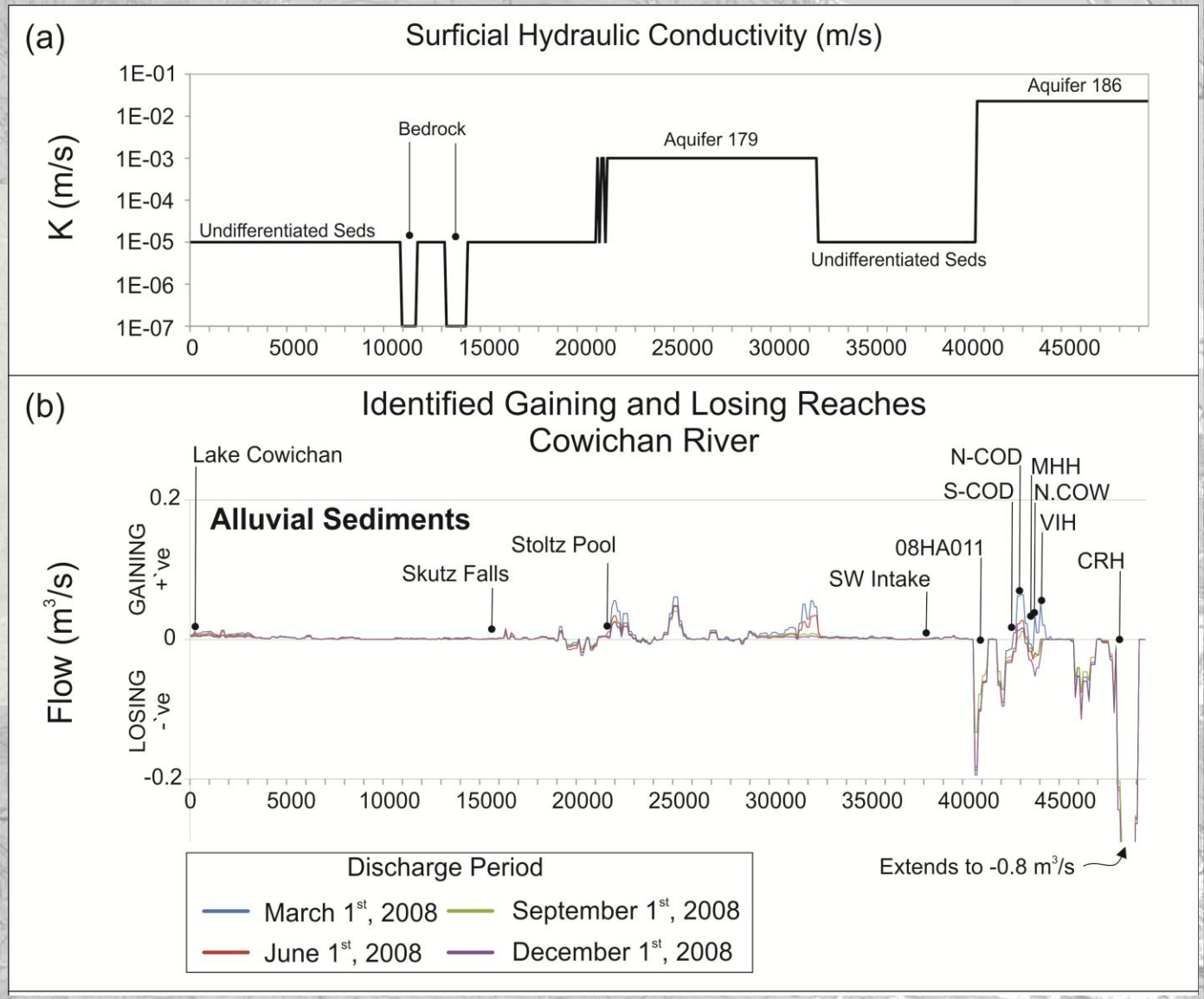


MIKE SHE – GW/SW Interactions



MIKE SHE – GW/SW Interactions

- Exchange results related strongly to K
- Alluvium and bedrock both add to the river
- Exchange results reflect groundwater recharge conditions



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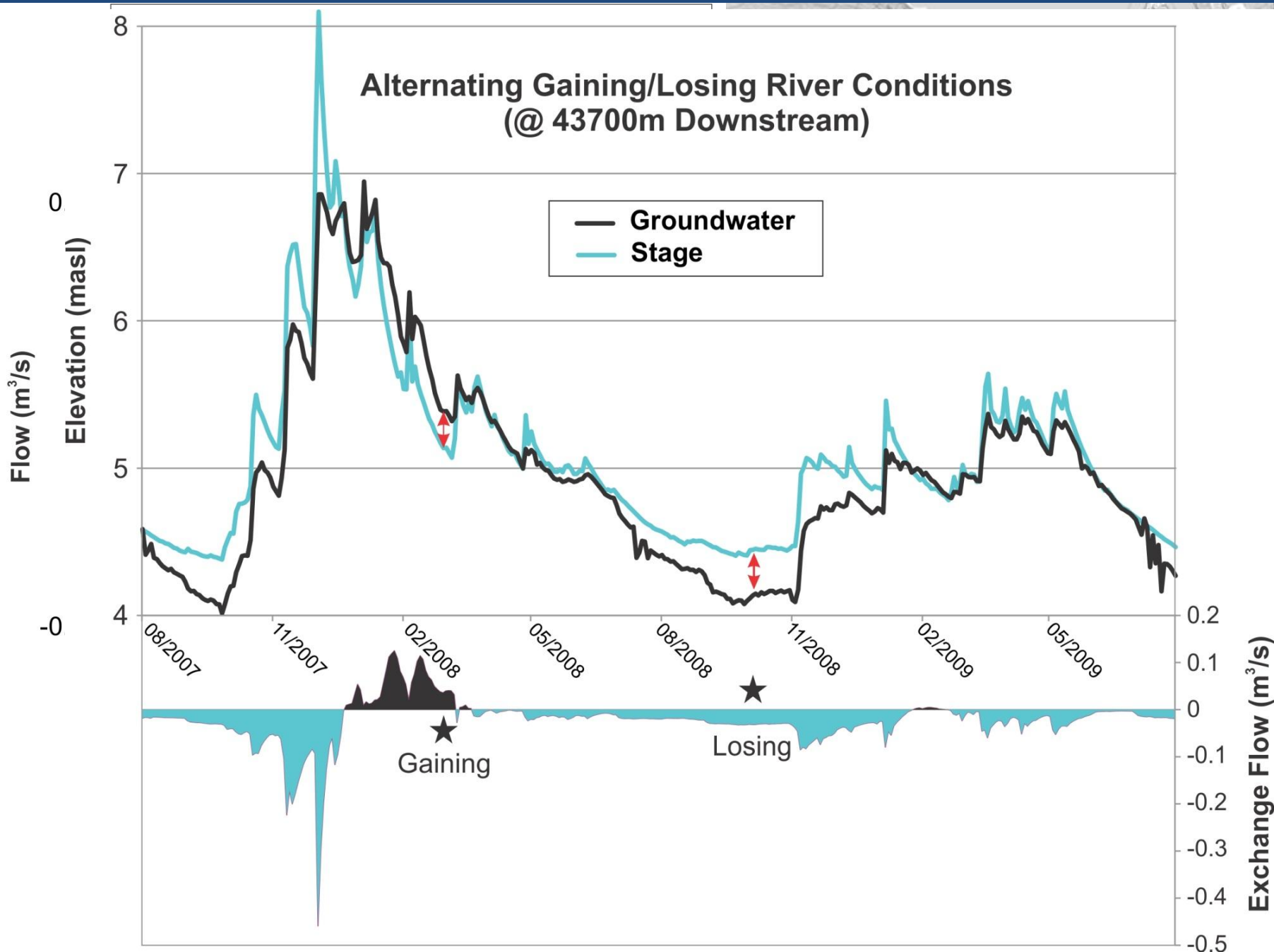
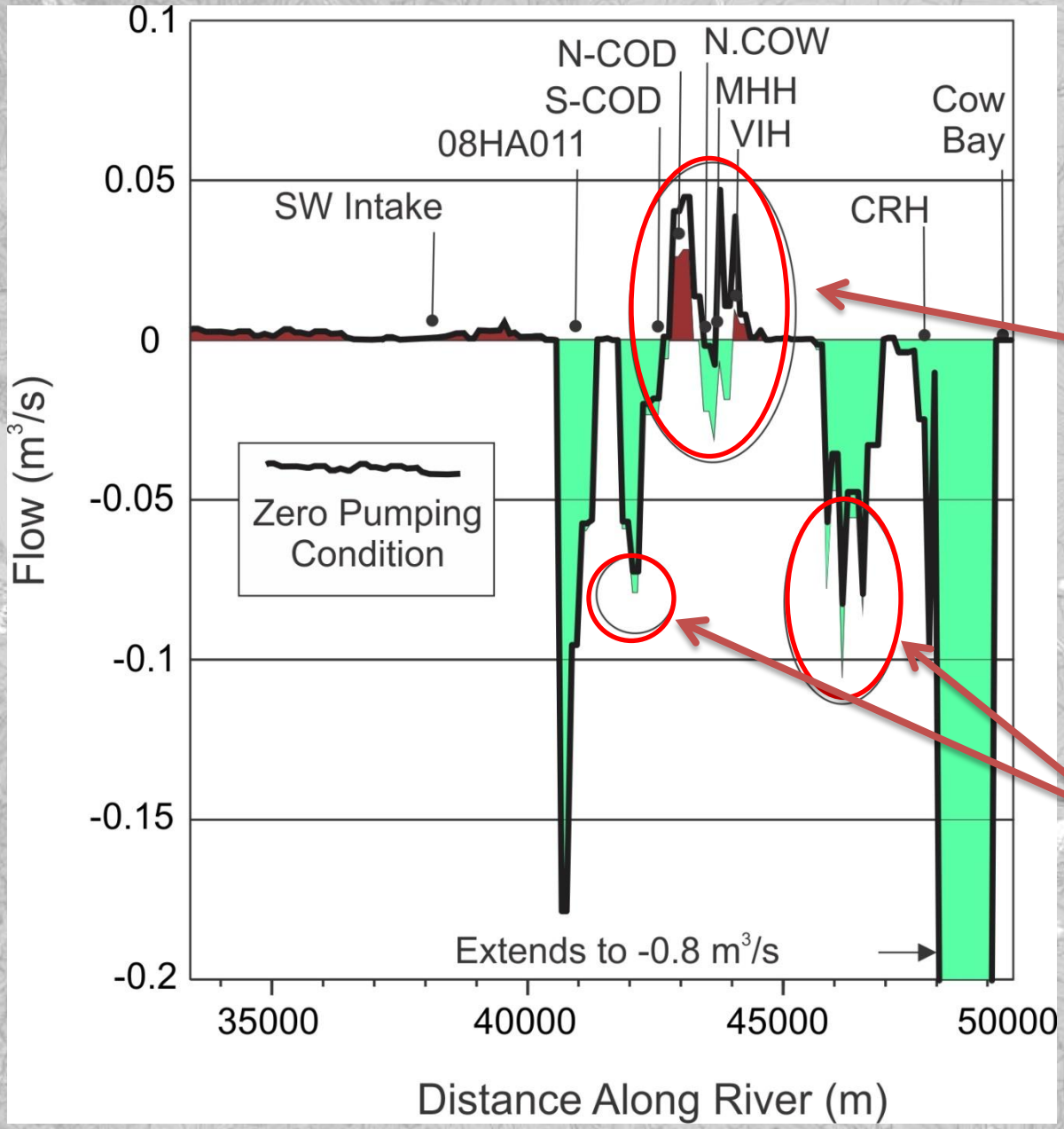


MIKE SHE – GW/SW Interactions – Influence of Pumping



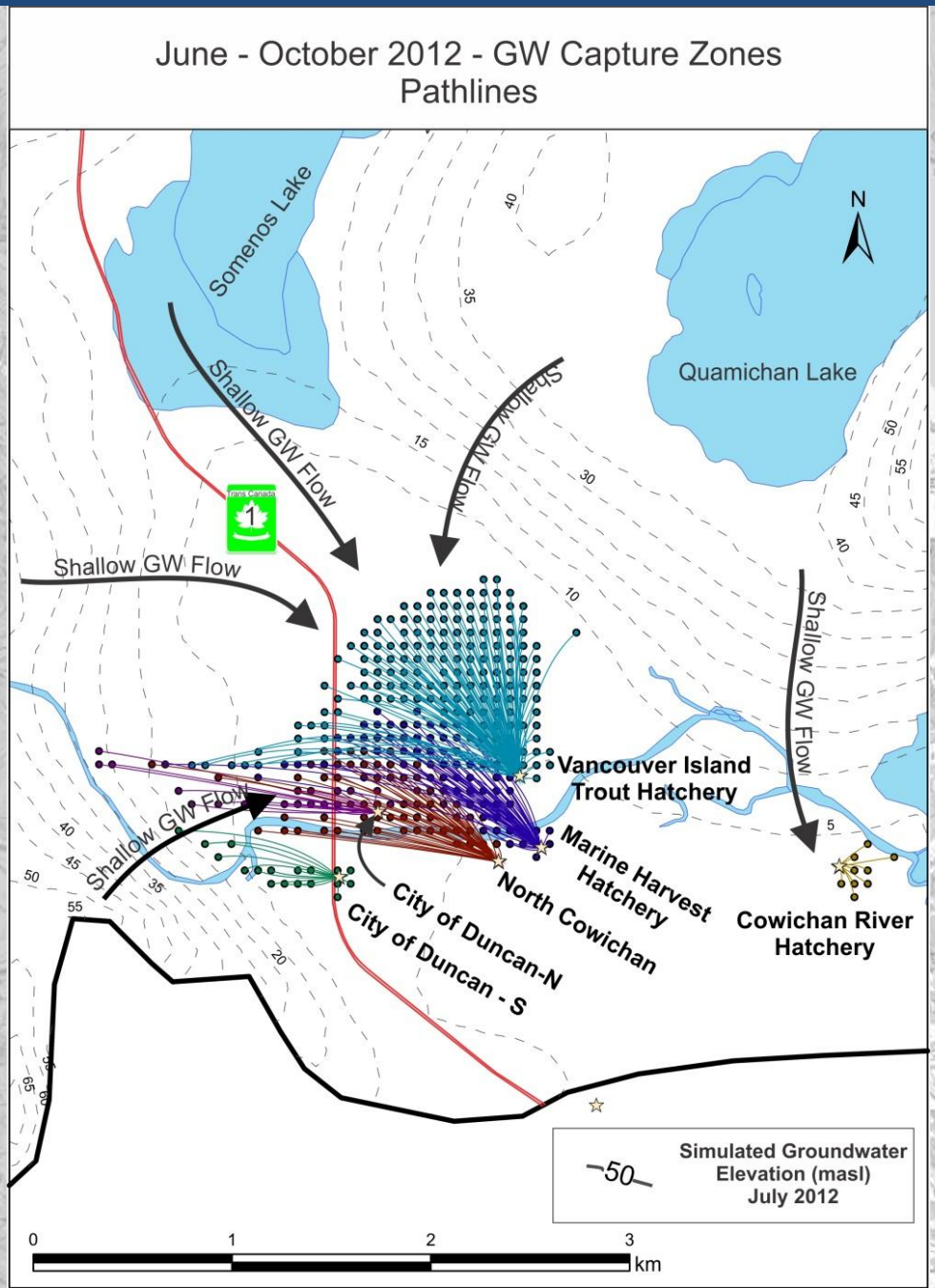
Model simulation with extraction wells set to zero

Mostly a gaining stream reach under "zero pumping condition"

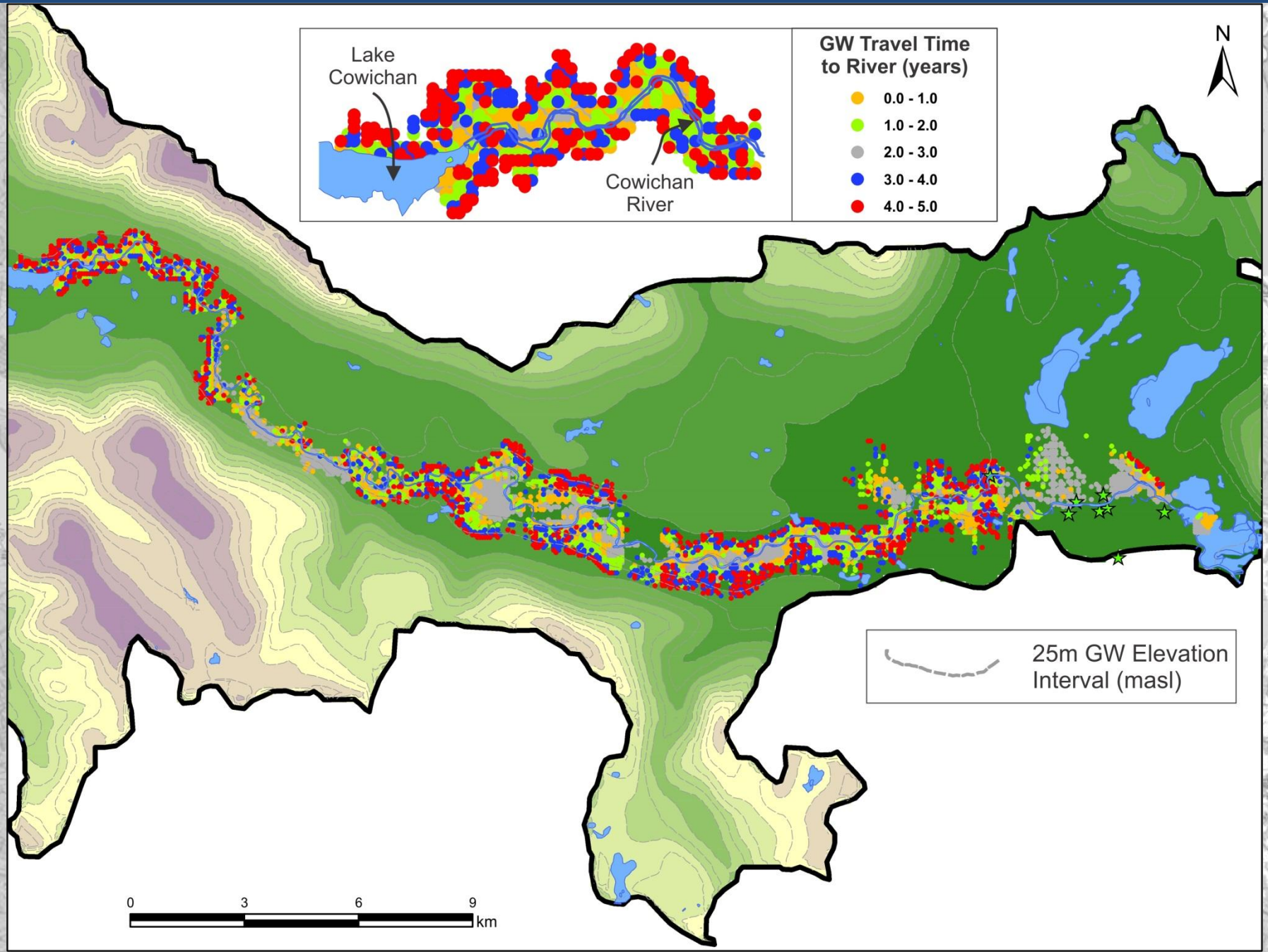
Losing conditions shown to be slightly less

MIKE SHE – GW Pumping Capture Zones

- Registration of particles by sink location – GW pumping wells
- Transient capture zone analysis during the low flow season
- The extent and shape of the capture zones lend evidence to suggest influence with the Cowichan River



MIKE SHE – Groundwater to River Catchment – 5 Year

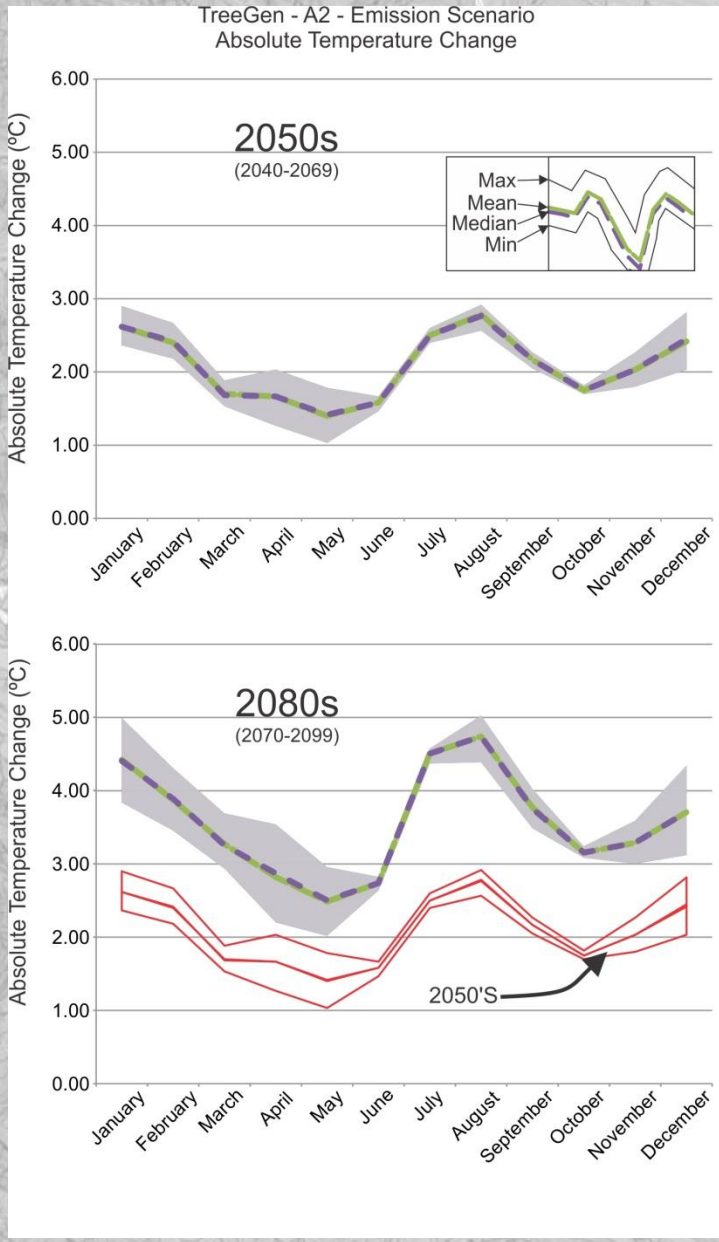


MIKE SHE – Climate Scenarios – A2 Emissions Scenario

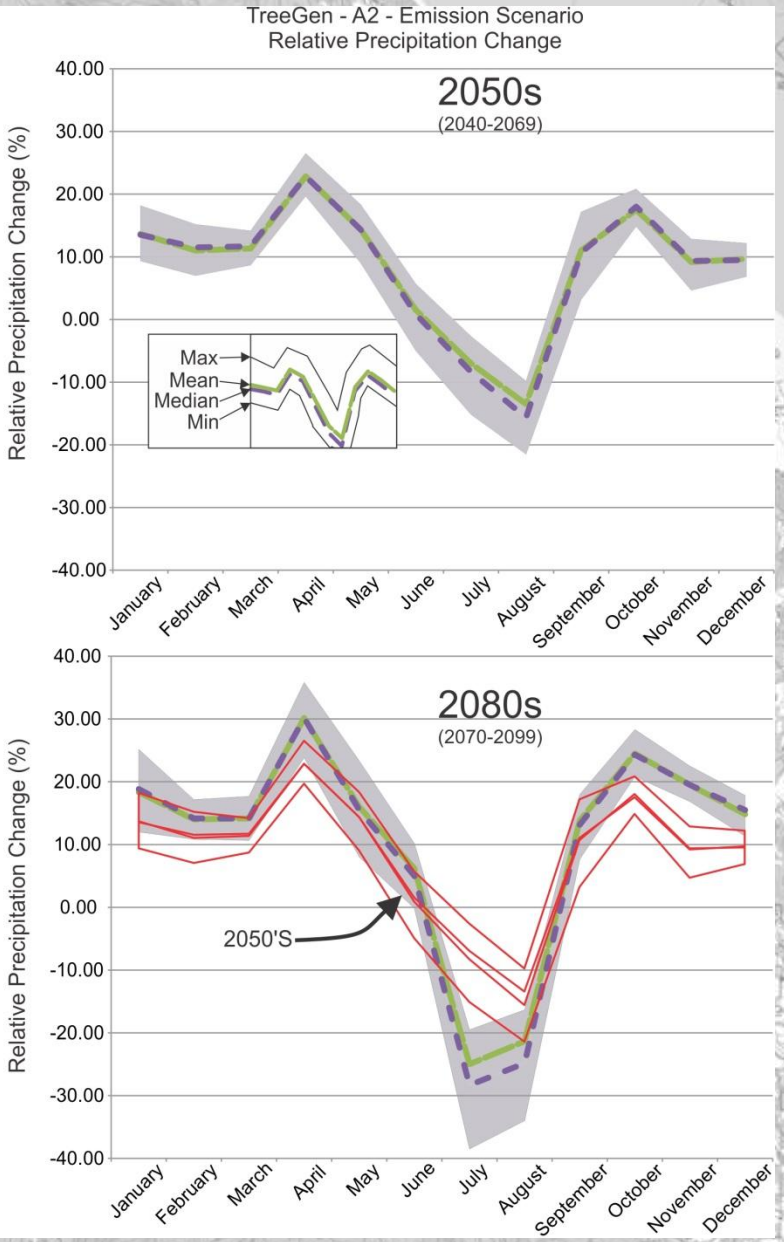
PACIFIC CLIMATE IMPACTS CONSORTIUM

- 2040 – 2069
  Δ +1-2.5 °C
- 2040 – 2069
  -15% to +22%
  Change in
  Precipitation
- 2070 – 2099
  Δ +2.5-4.5 °C
- 2070 – 2099
  -25% to +30%
  Change in
  Precipitation

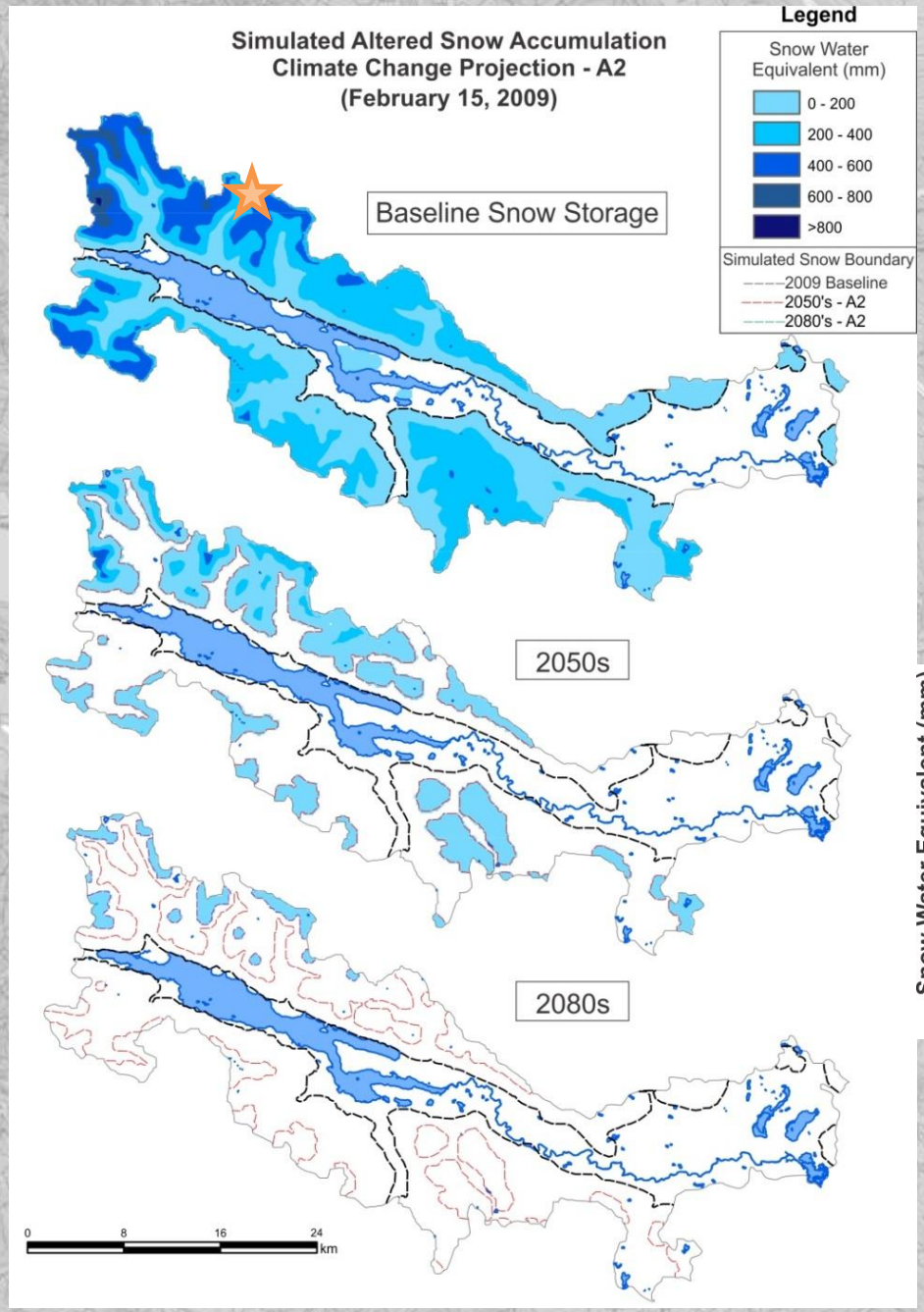
Absolute Temperature Change



Relative Precipitation Change

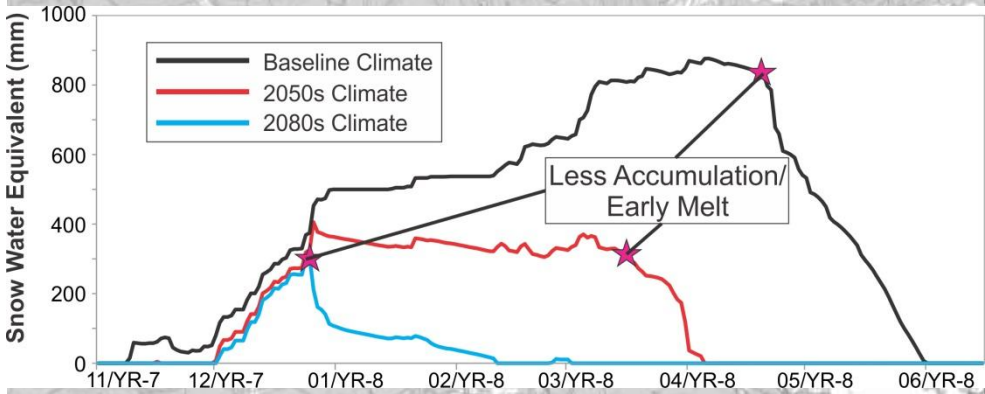


MIKE SHE – Climate Change - Snow Pack

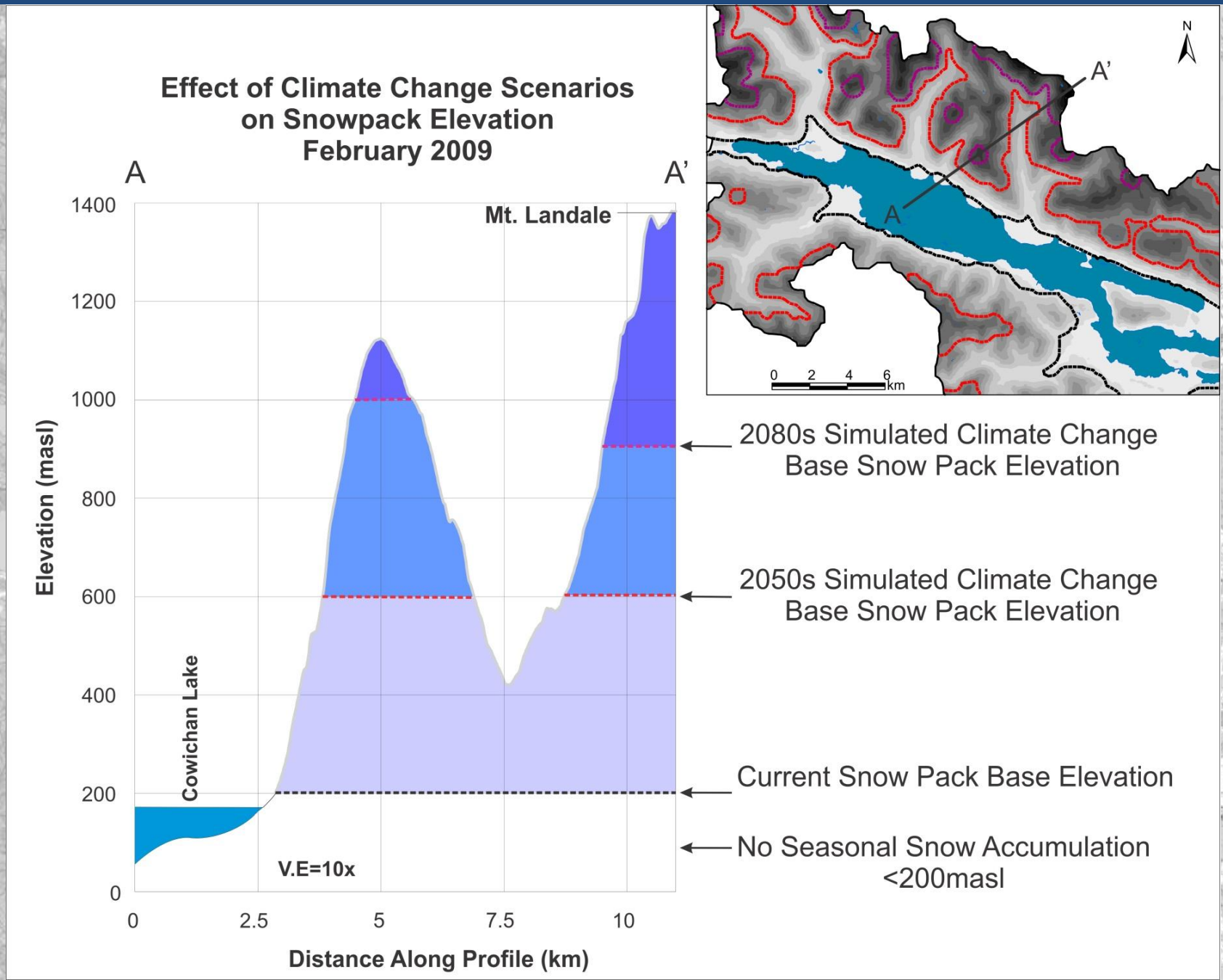


Main Results

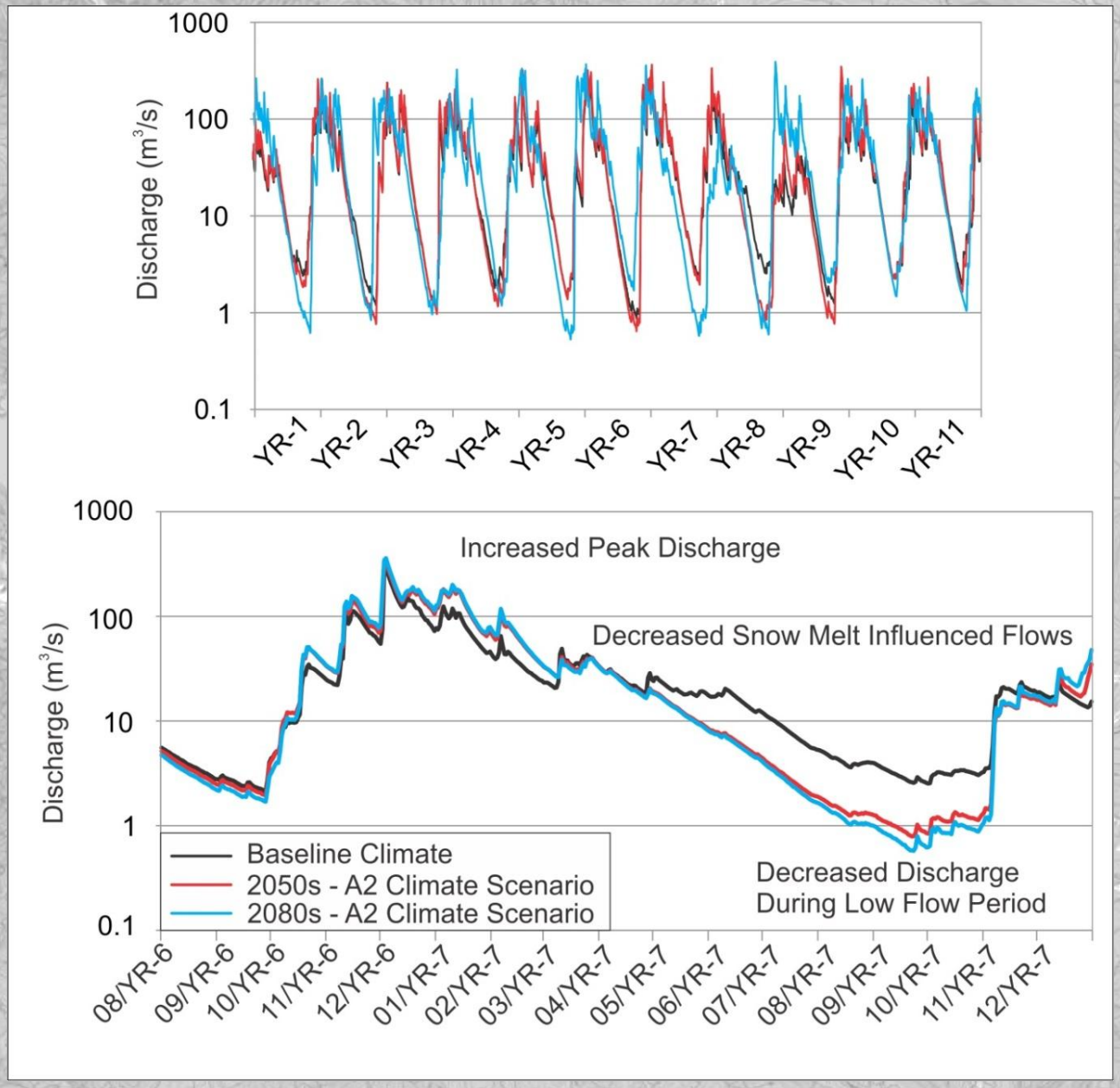
- Snow pack greatly reduced under climate change scenarios
- 2050s and 2080s climate change results in little to no snow accumulation



MIKE SHE – Climate Change - Snow Pack



MIKE SHE – Climate Change – Discharge in the Cowichan River



Main Findings

- Significant reduction in low-flow river discharge
- Little to no evidence of the freshet flows in the late spring
- Increased peak flows within the winter season (increased flooding)

Thank you
Questions?

Acknowledgments:

P. Lapcevic and S. Barroso
BC FLNRO
Funding: Cowichan Valley Regional District