ECS Lunch and Learn

Supporting internal knowledge transfer within TRCA

June 29, 2022

Toronto and Region Conservation Authority

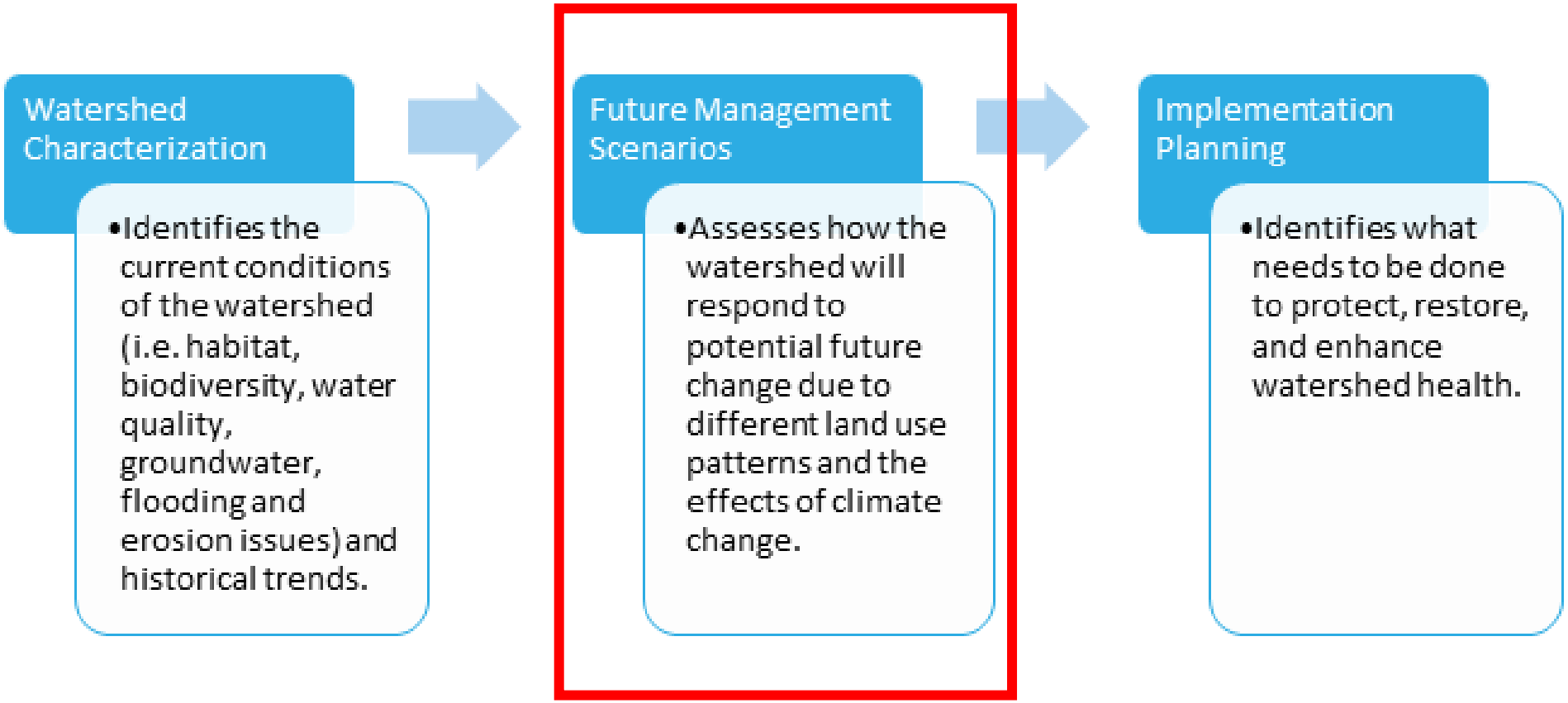
Water quality modelling for the Etobicoke Creek Watershed Plan

Presented by:
Bhaswati Mazumder, PhD Candidate, Toronto Metropolitan University
Lyndsay Cartwright, Senior Research Analyst, TRCA
Krista Chomicki, Research Scientist, TRCA

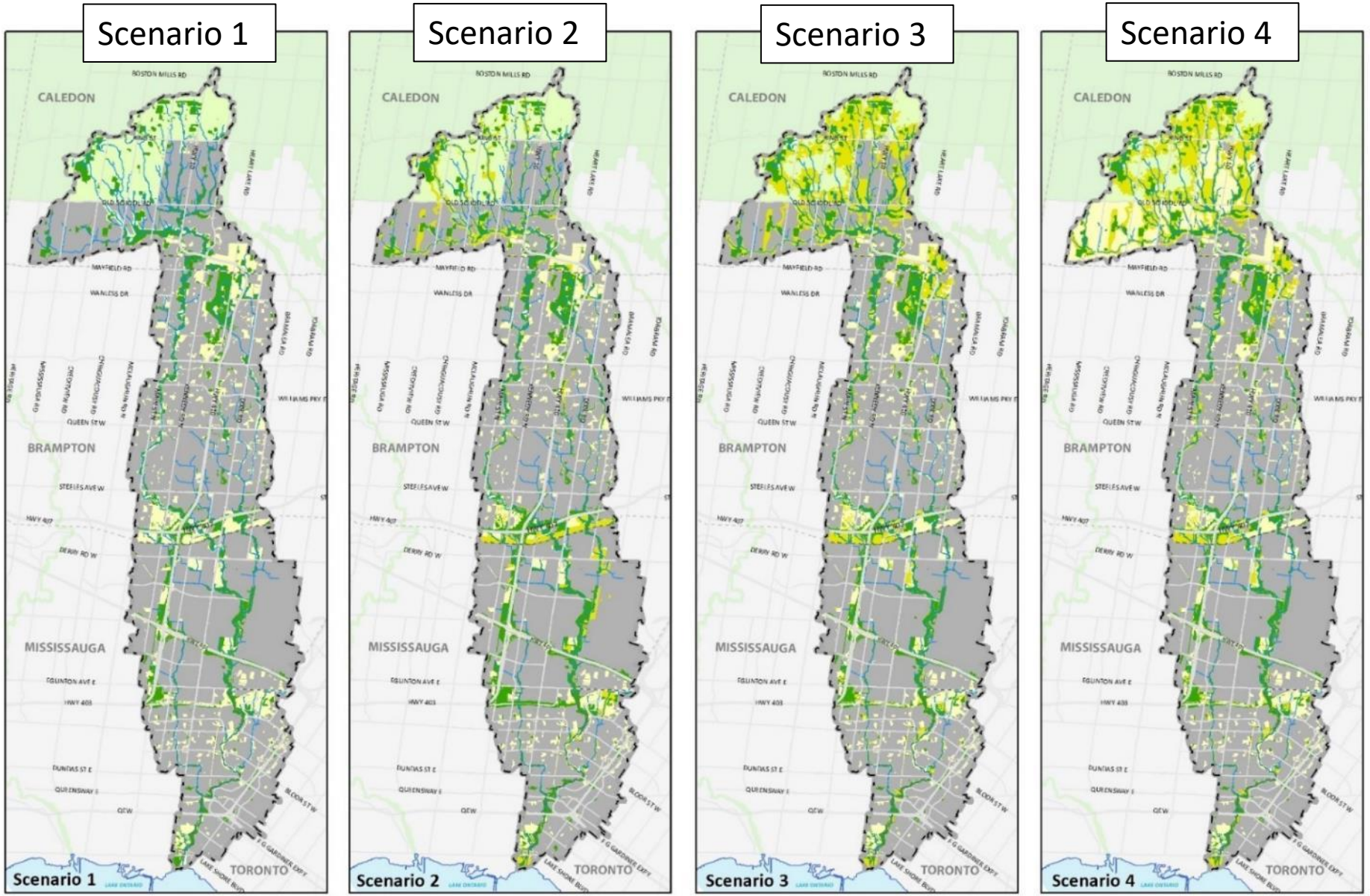
TRCA's Ecosystem and Climate Science Lunch and Learn
June 29, 2022

Toronto and Region Conservation Authority

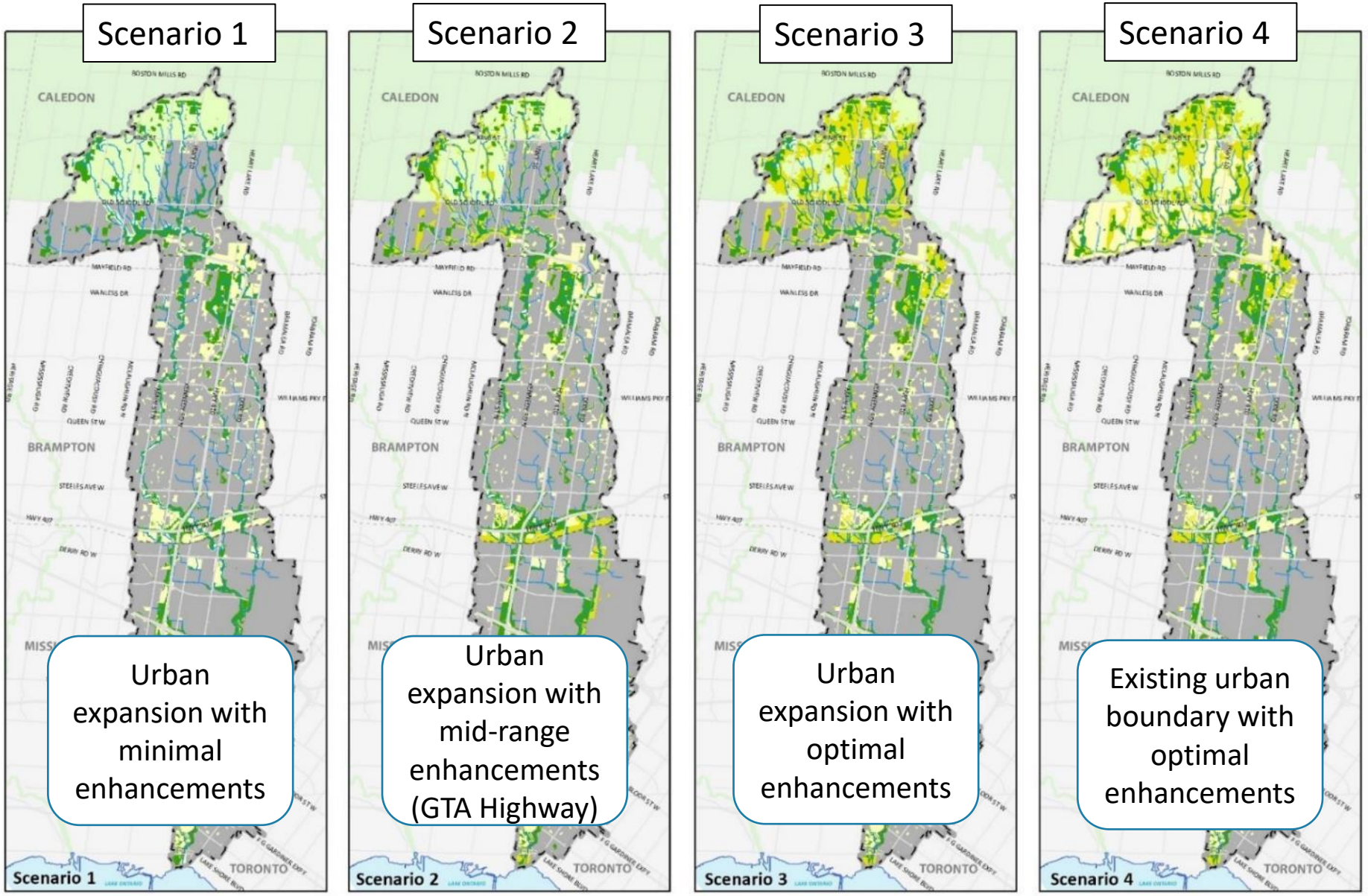
Etobicoke Creek Watershed Plan (ECWP)



Future Management Scenarios - ECWP

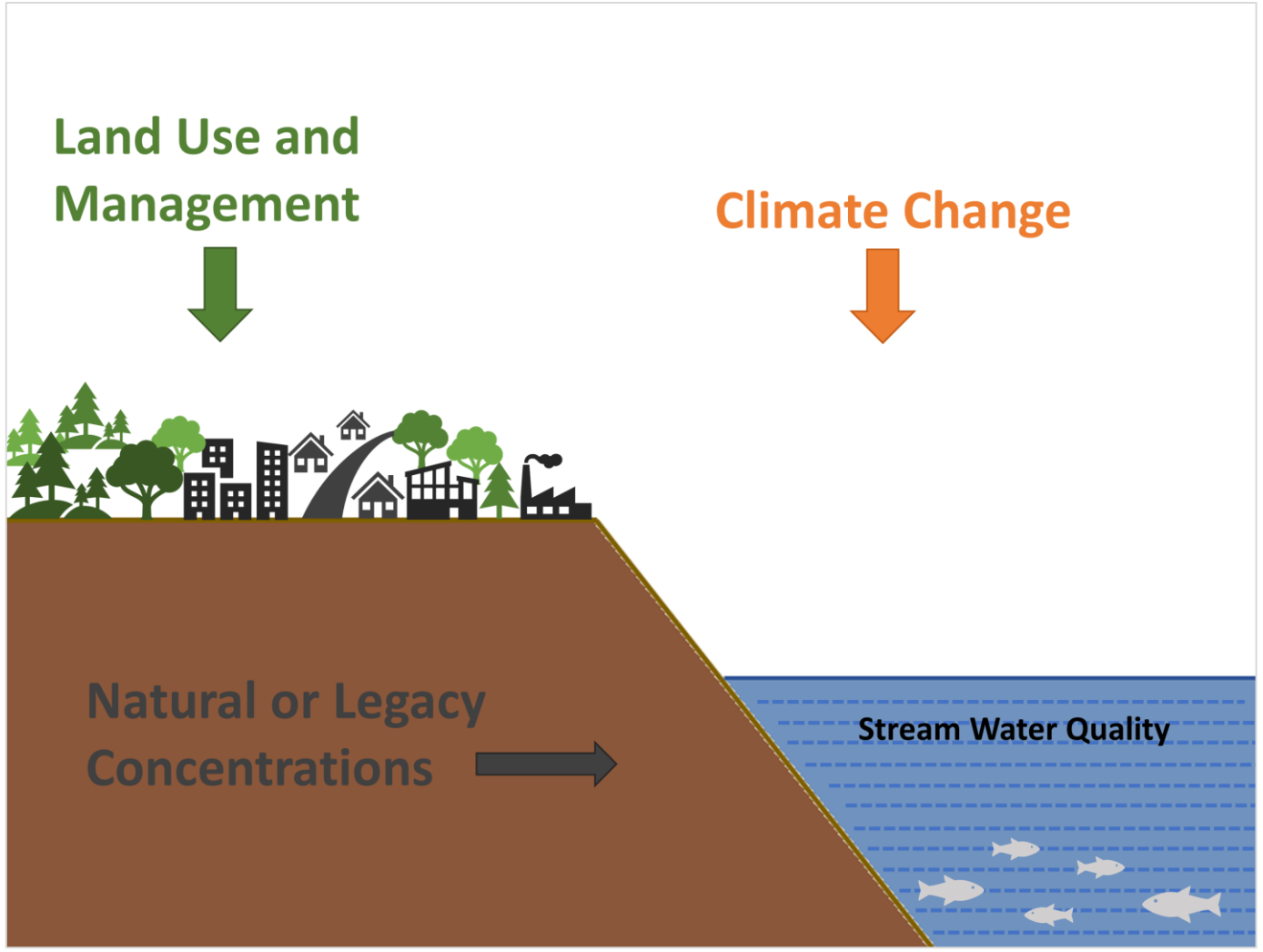


Future Management Scenarios - ECWP



Why Model Water Quality?

- Freshwater salinization and damage to ecosystems from year-long chloride ('Cl') peaks (Oswald et al., 2019)
- Impacts of urbanization and evidence of legacy effects on stream Cl (Mazumder et al., 2021)
- Metals and total phosphorus also identified as water quality concerns (represented by total suspended solids or 'TSS')



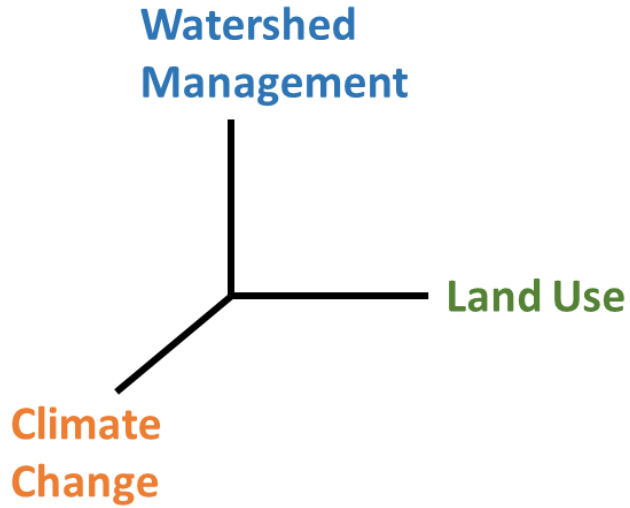
Gaps

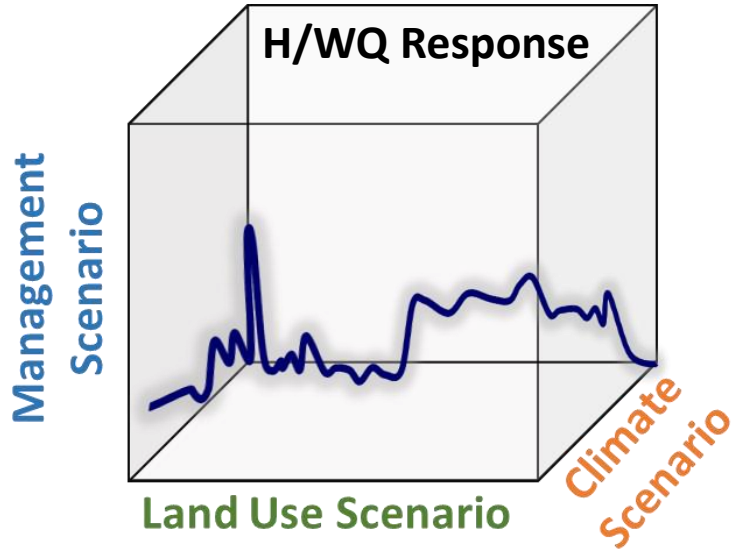
- Process-based models that integrate hydrology and water quality (H/WQ) response to different change scenarios are critical for decision support
  - Often fail to initiate due to lack of data, time and expertise

Goals

- Set up an integrated, continuous, process model for simulating H/WQ response to changes in climate, land use and management
- Address limitations in data, time and expertise in predicting long-term watershed-scale H/WQ response for planning and decision support

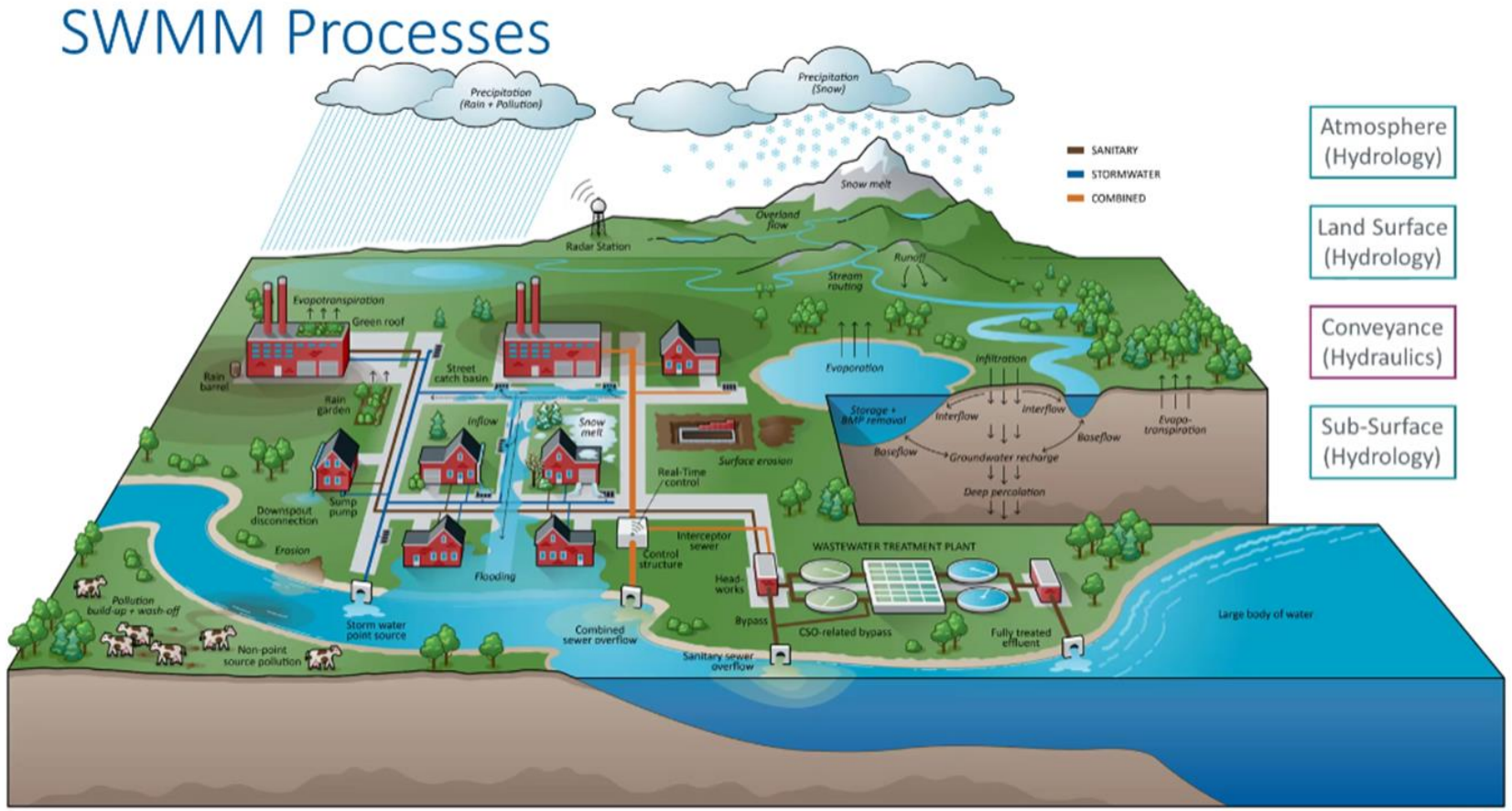
Dimensions of Change in a Watershed





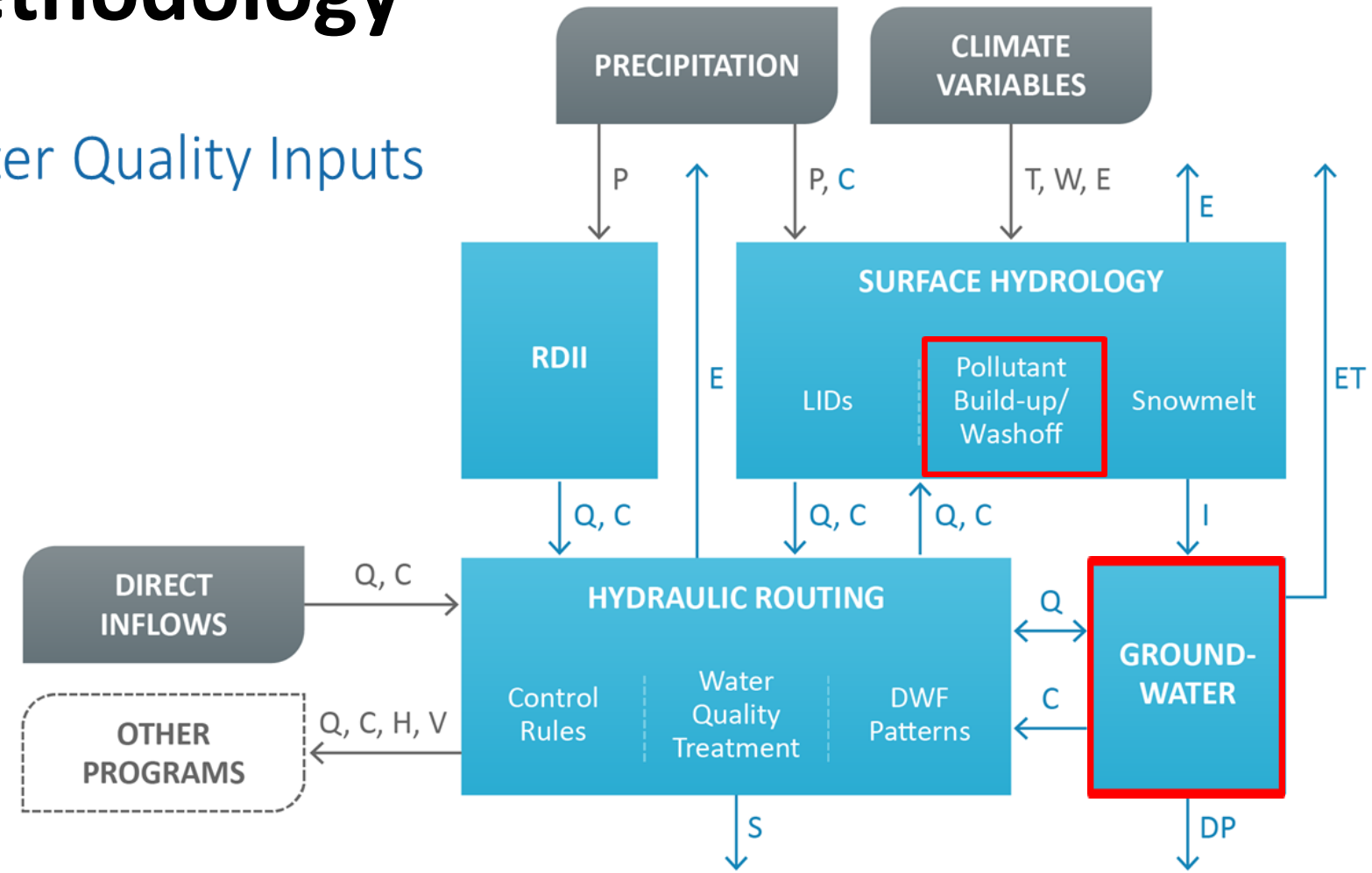
Methodology

- Stormwater Management Model (SWMM) by the US EPA
  - Free open-source engine (SWMM5)
  - User-friendly GUI available (PCSWMM)
  - Performs well with minimal parametrization and calibration with readily available data



Methodology

Water Quality Inputs



Input Function

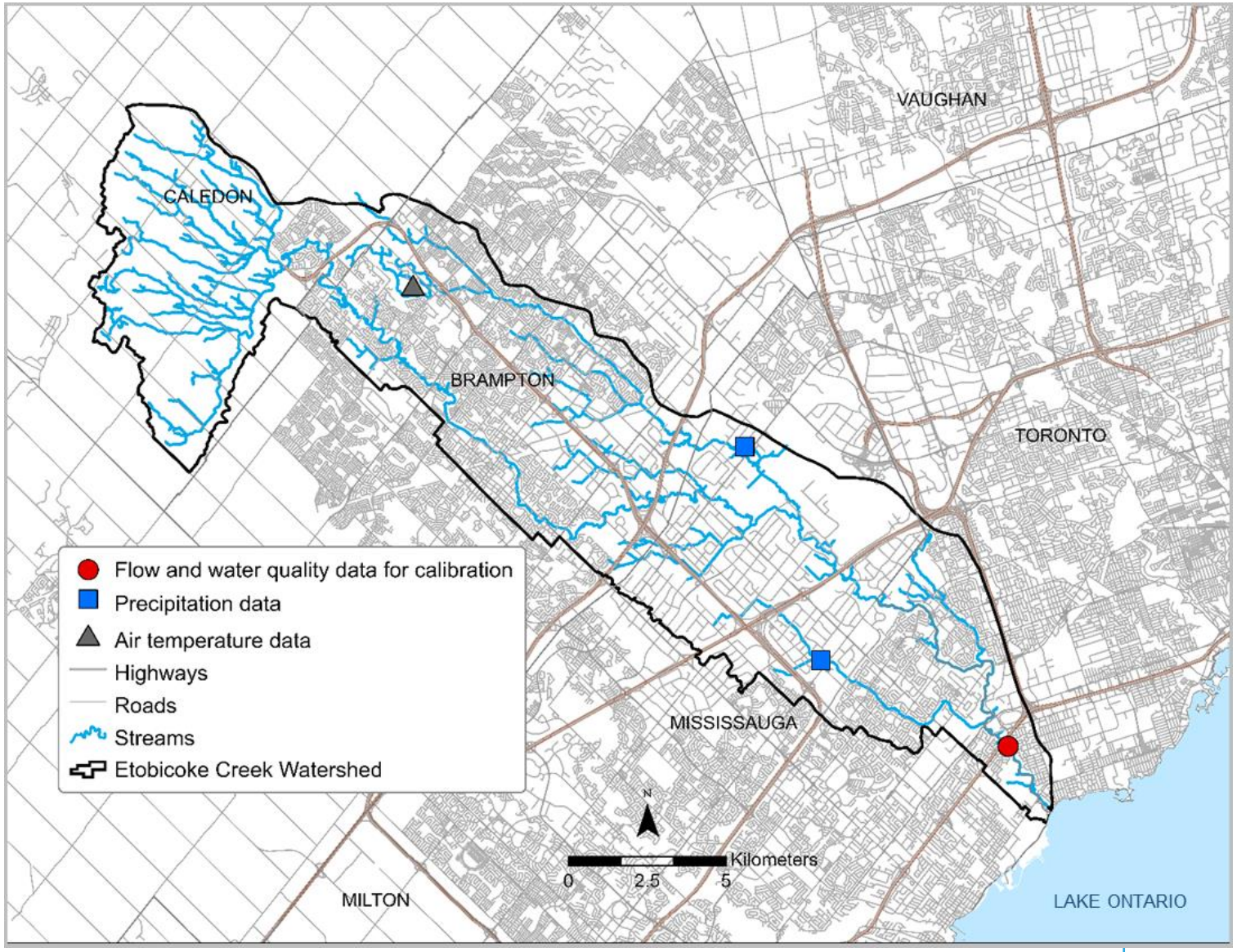
SWMM Process

C = Concentration
DP = Deep Percolation
E = Evaporation
ET = Evapotranspiration
H = Head/Depth
I = Infiltration
P = Precipitation
Q = Flow
RDII = Rainfall Dependent Infiltration & Inflow
S = Seepage
T = Temperature
V = Velocity
W = Wind Speed

- Cl: Build-up Wash-off Model
- TSS: Event Mean Concentration (EMC) Method

Time Series Inputs

- Precipitation
- Temperature
- Flow
- Water Quality
  - Calibrated with open data
  - Validated with high-frequency monitoring data

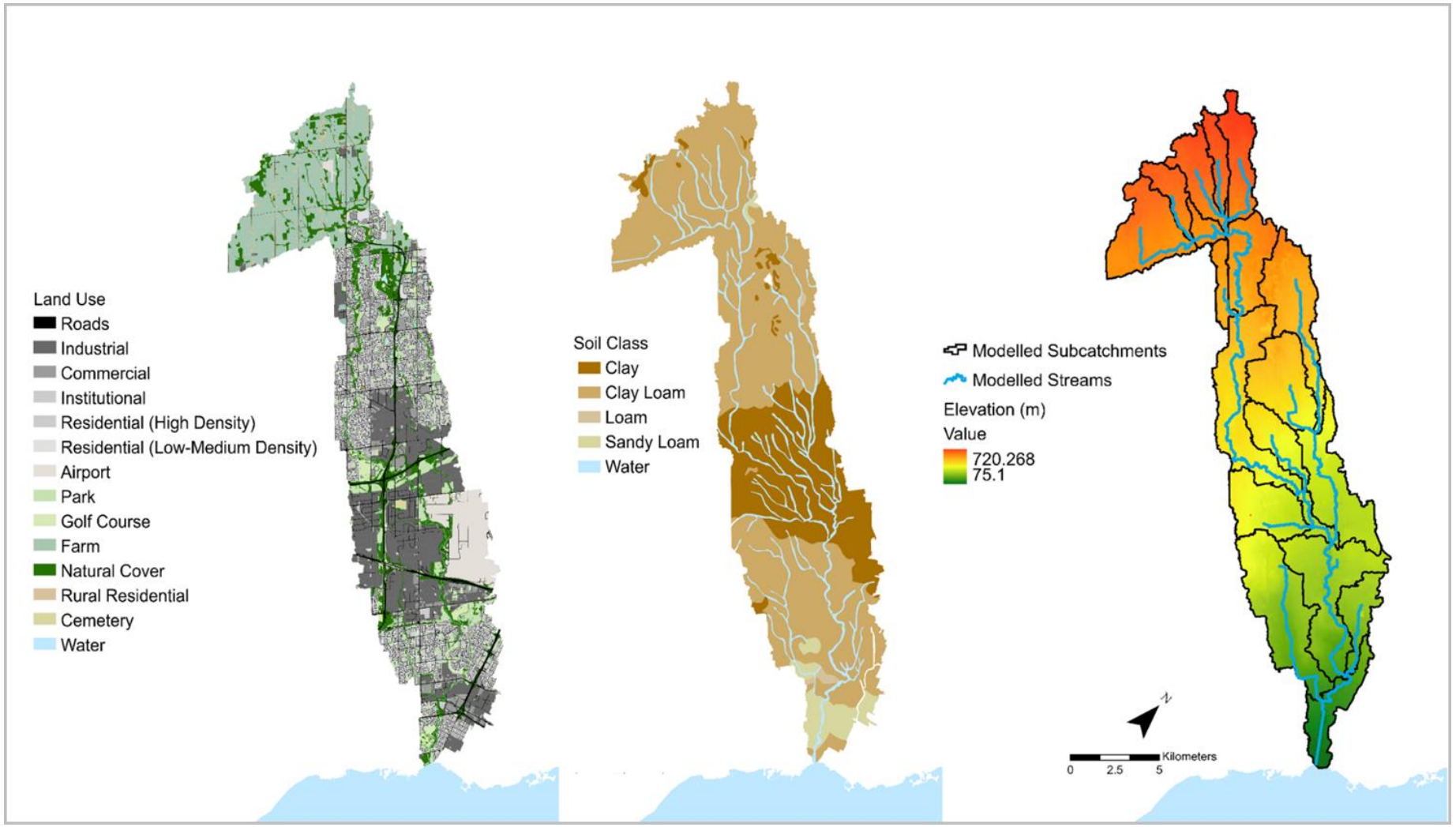


Spatial Inputs

- Land use
- Soil classes
- Elevation

- 129 stream segments

- 18 subcatchments for tributaries



Model Calibration

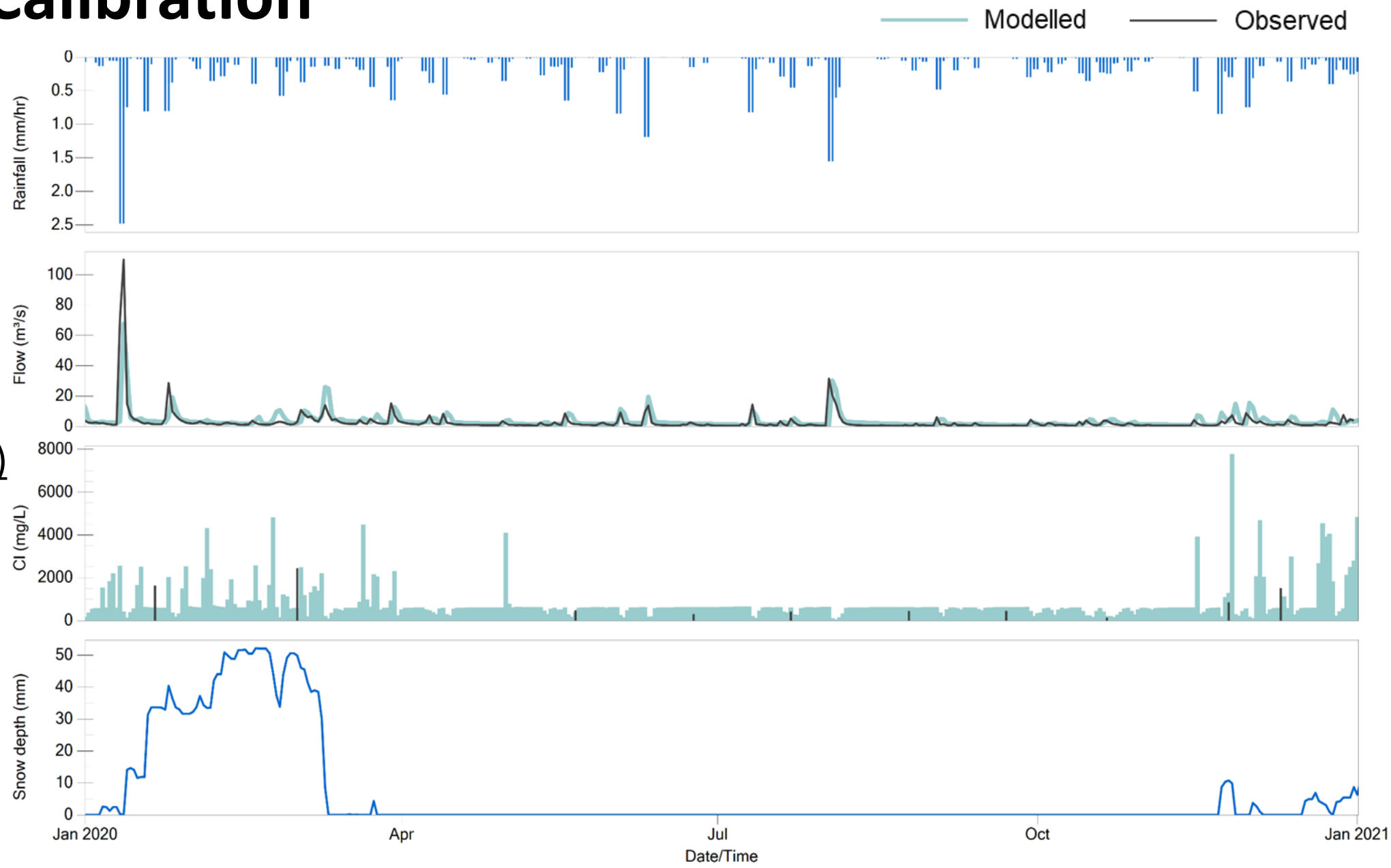
Flow (2020)

- NSE: 0.63
- R^2: 0.66
- Error Rating: *Good (based on ISE score)*

Chloride (2020)

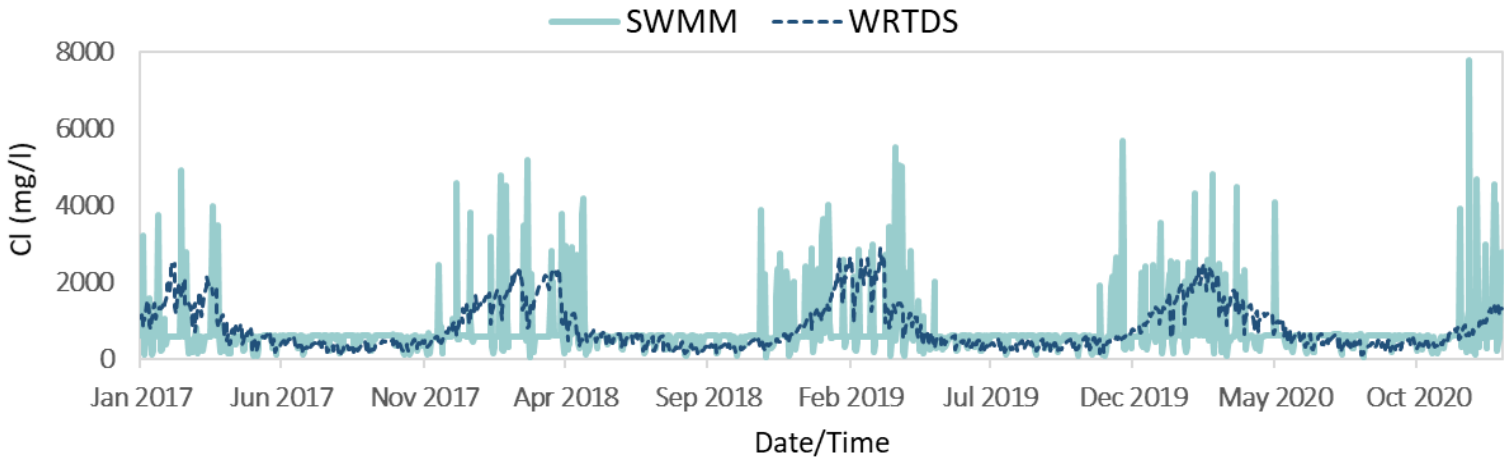
- NSE: 0.44
- R^2: 0.62
- Error Rating: *Fair*

Similar for TSS

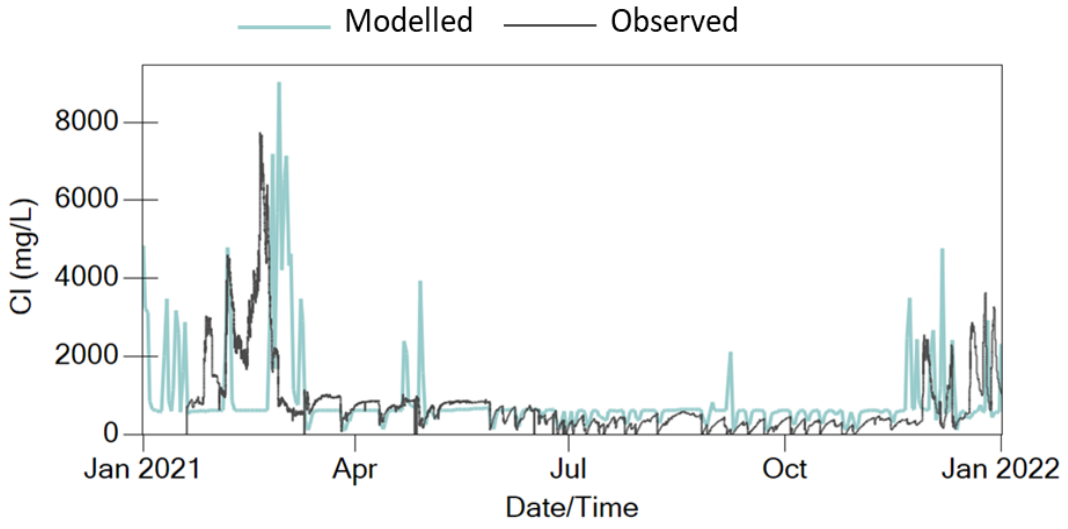


Model Validation

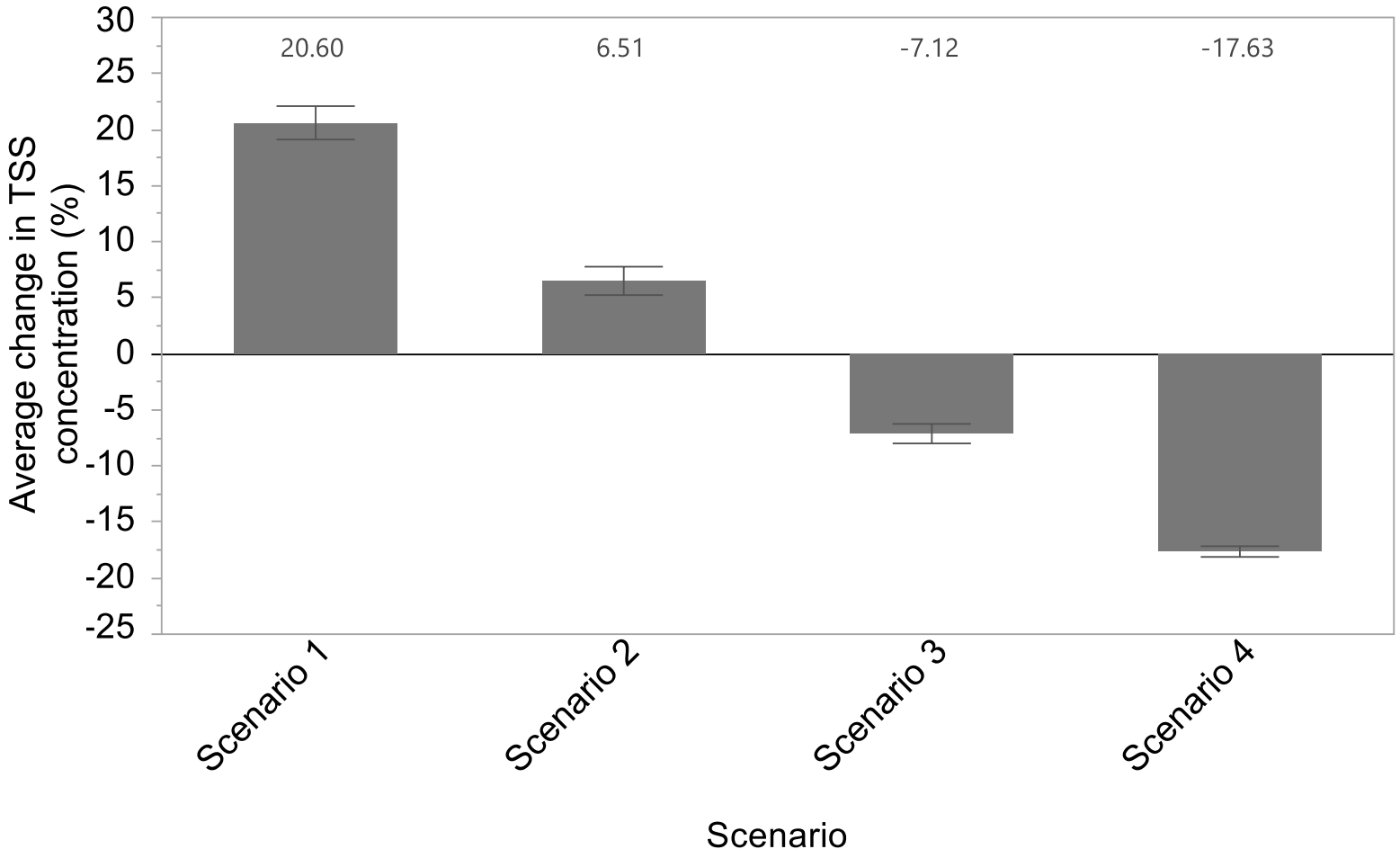
- Model diagnostics and hydrological signatures
- Statistical model
  - Daily Cl estimates from the Weighted Regressions on Time Season and Discharge (WRTDS) model



- High-frequency monitoring
  - Validation with 15-min conductivity in 2021
  - Poor NSE but *'Excellent'* ISE scores – most suitable for planning and design purposes (Shamsi & Koran, 2017)

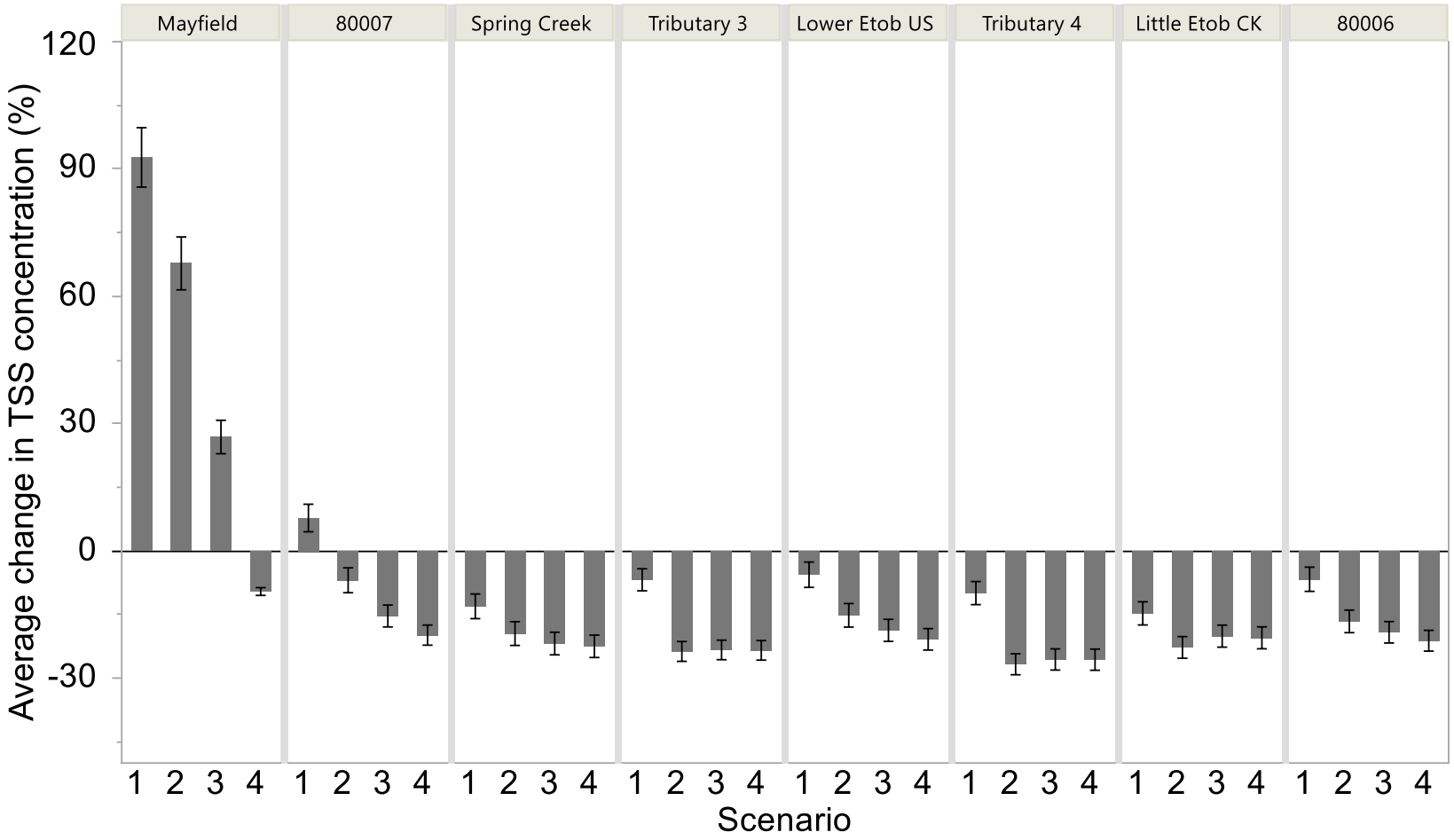


Results - TSS



Stormwater Tree Trench (STEP)

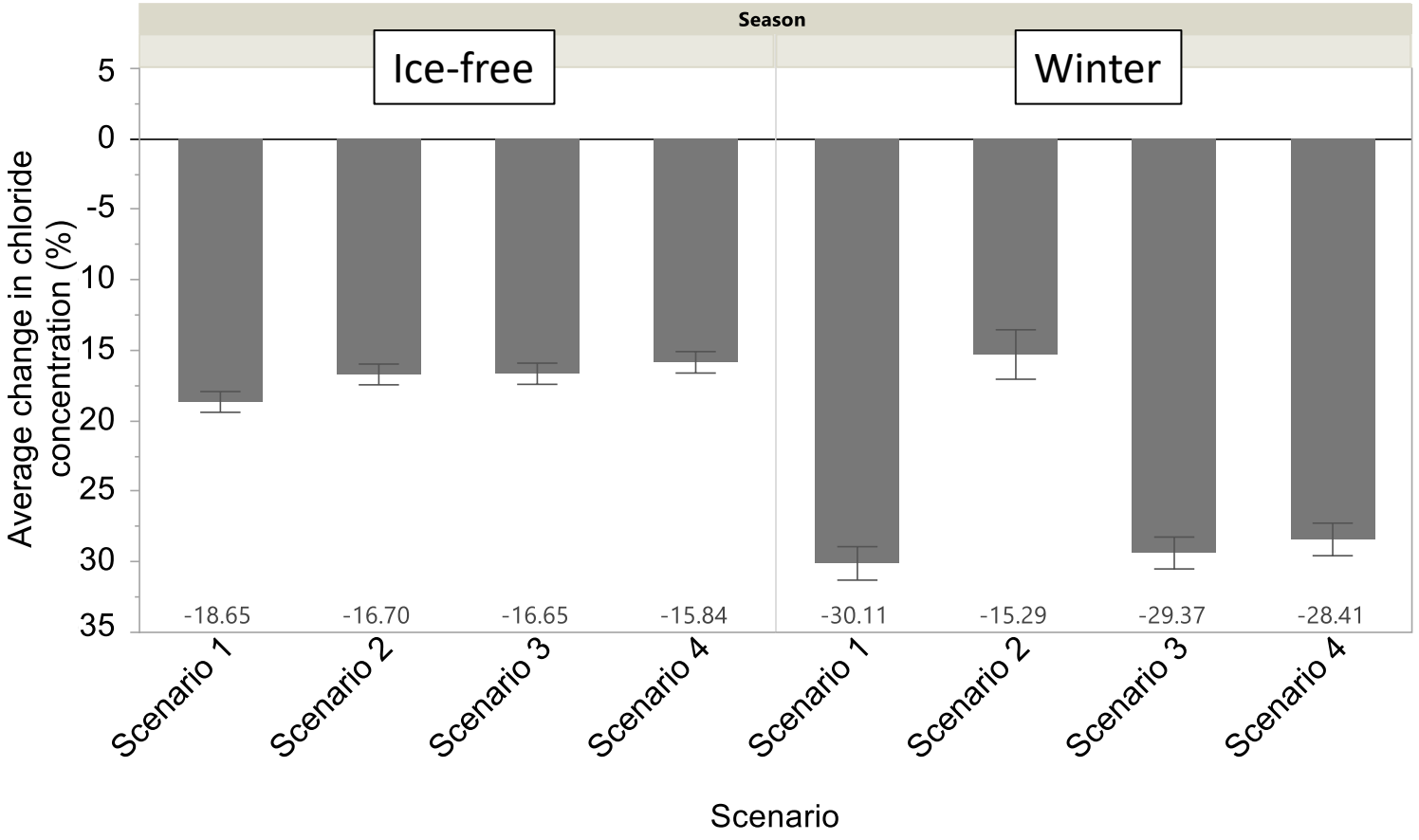
Results - TSS



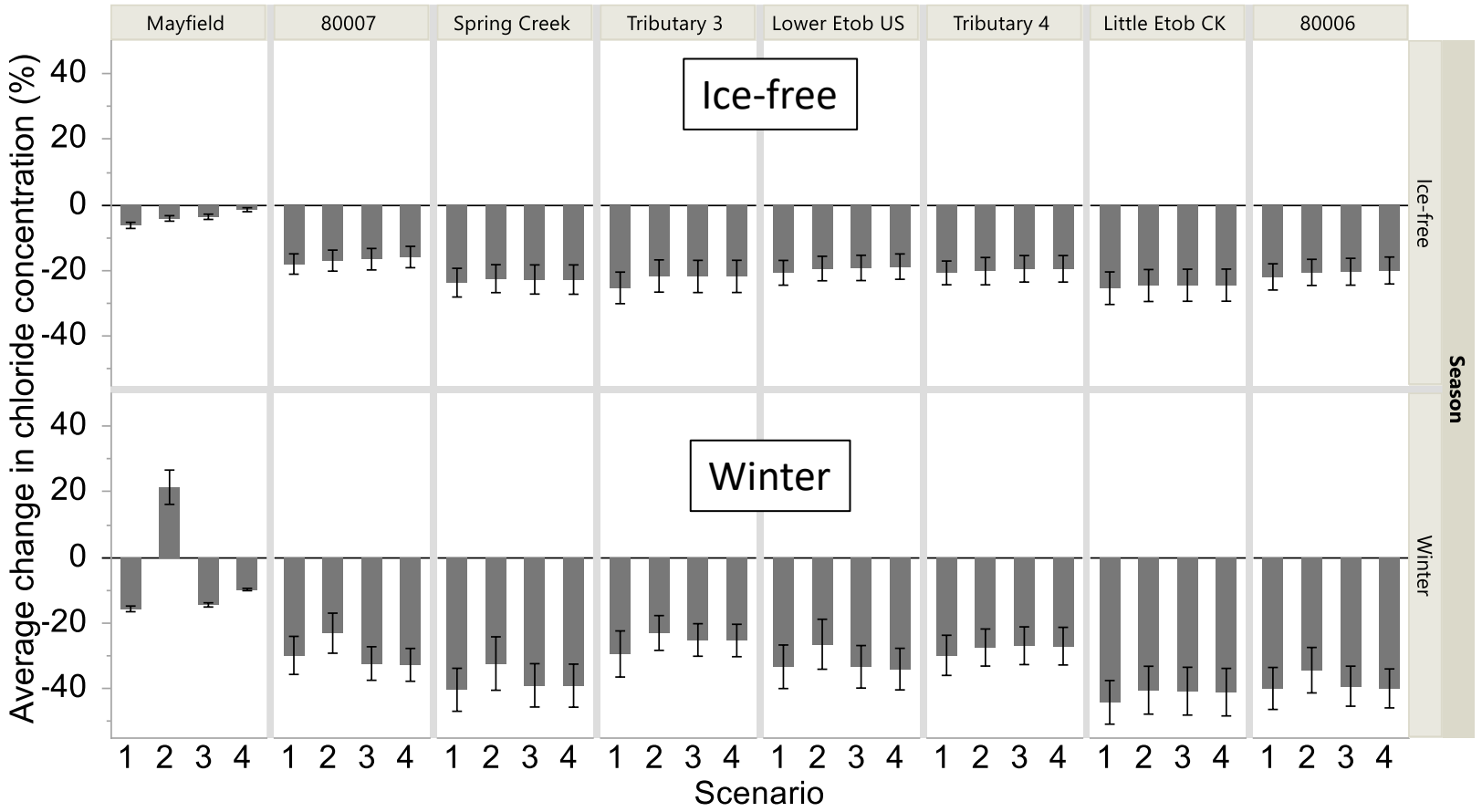
A stream with high TSS

Stormwater Pond (STEP)

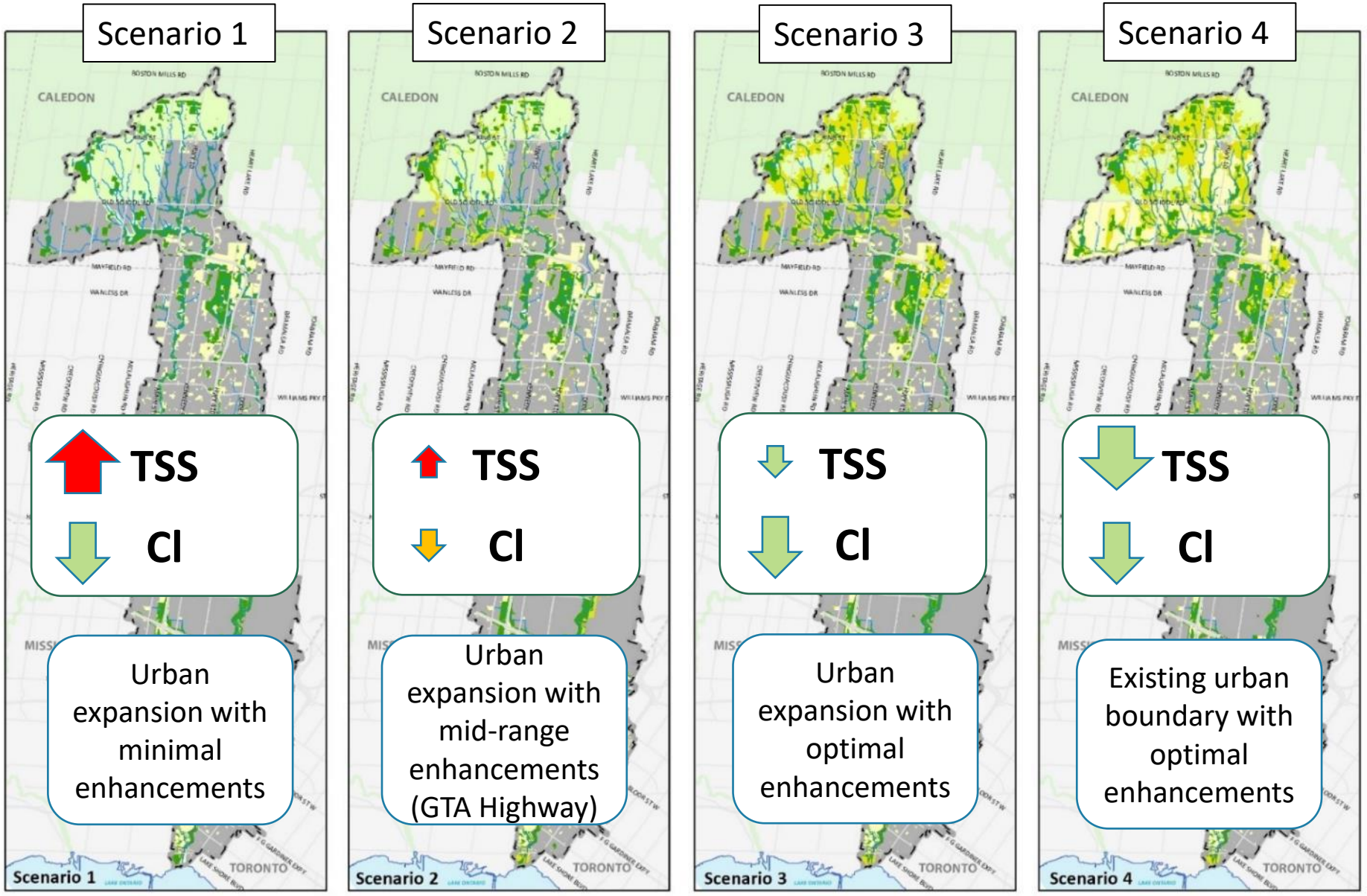
Results - Chloride



Results - Chloride



Results - Summary



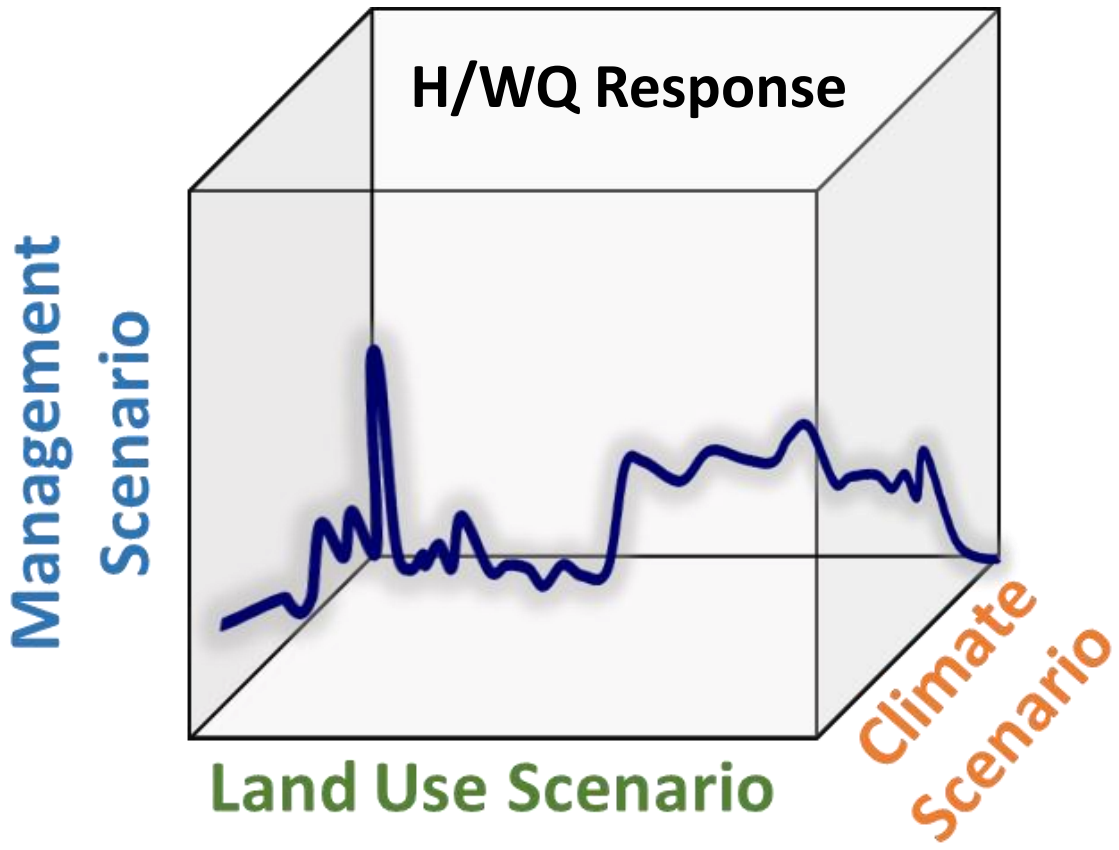
Next steps: Model Improvements

- Investigate each factor of change (climate, land use, management) individually as well as combined
- Validate the model capacity for simulating changes in watershed conditions
- Use continuous, high-frequency data for calibration
- Represent groundwater and legacy contribution to stream concentrations

Modelling Change

- Model validation using land use and climate from around 2015 showed:
  - Watershed conditions are being reasonably represented despite many uncertain variables

  - <u>2015 Flow</u>
    NSE: 0.26,
    R^2: 0.34,
    SWMM rating: *Excellent*



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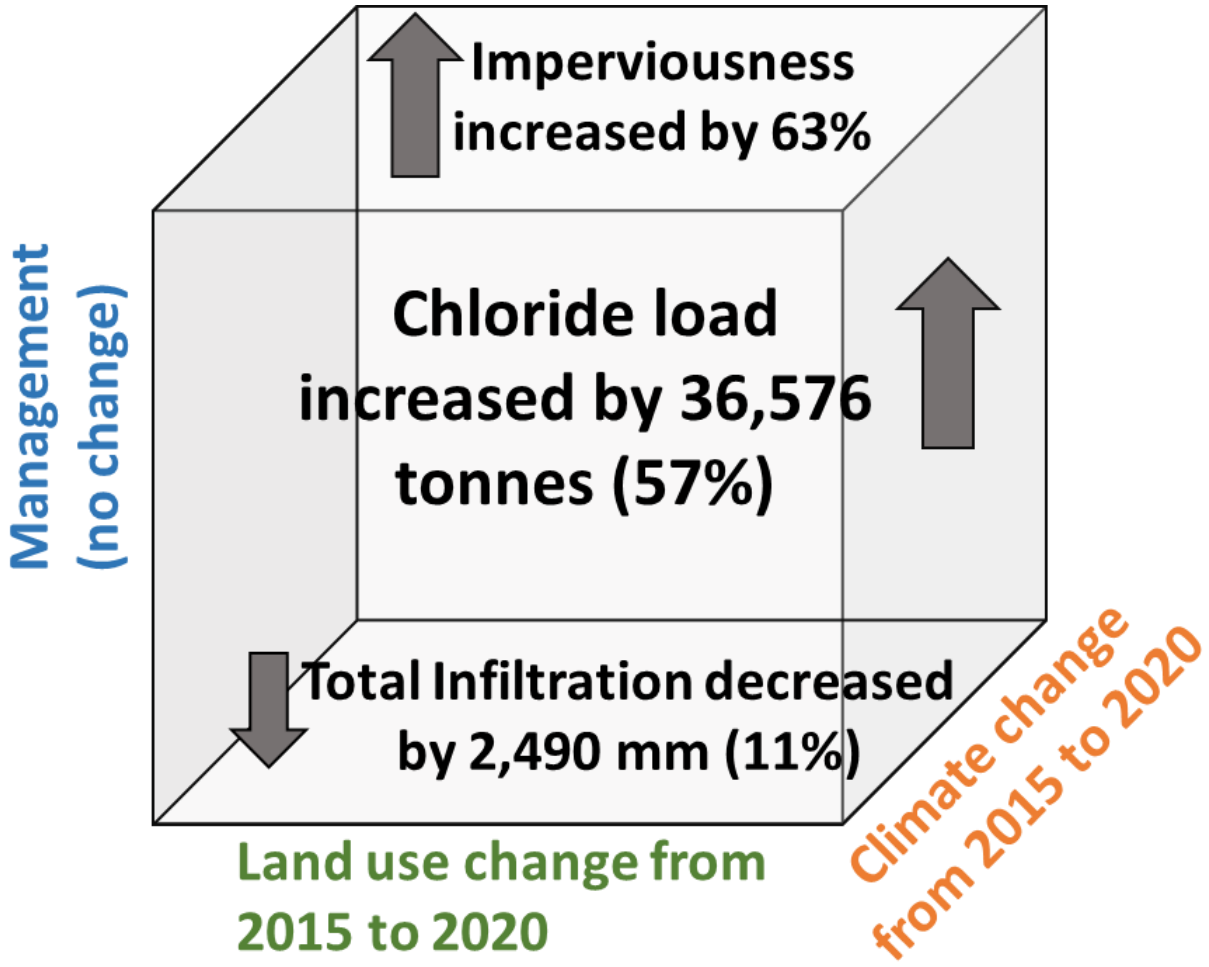
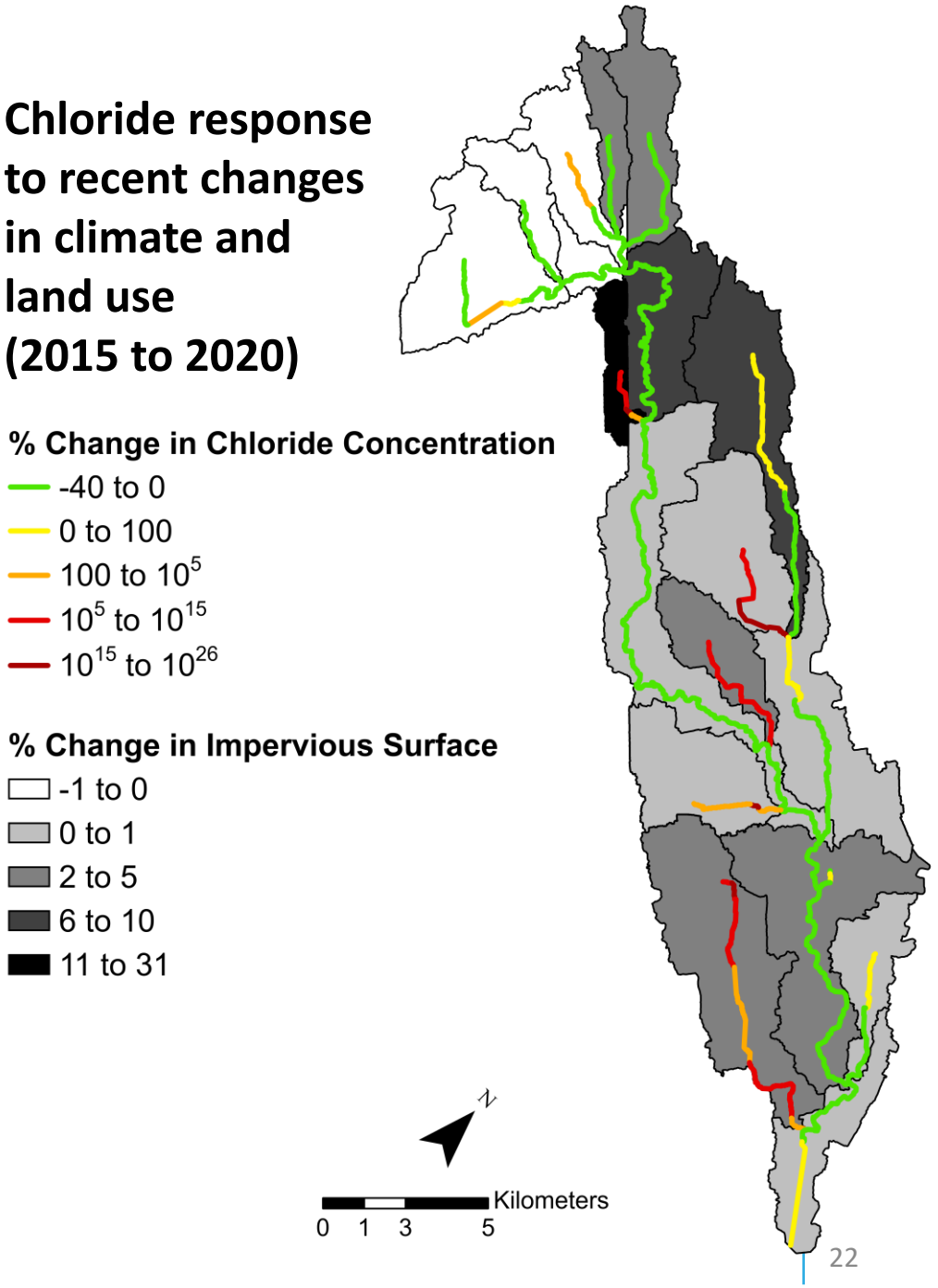
Chloride response to recent changes in climate and land use (2015 to 2020)

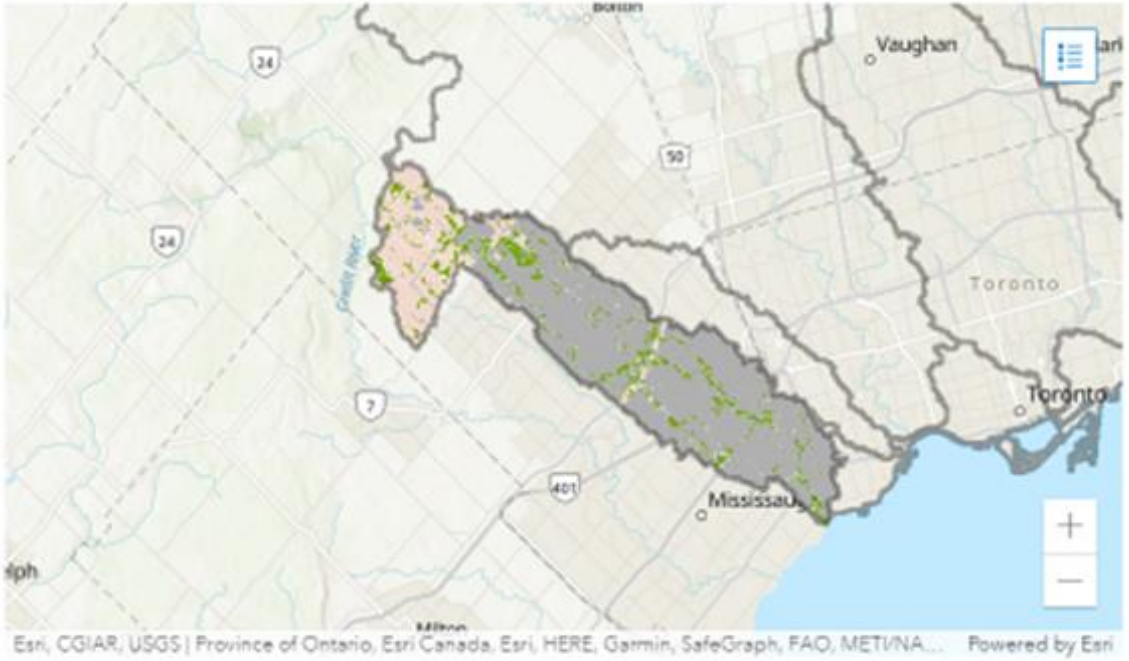


Interpreting Change

- Change in stream concentrations does not always concur with recent or immediate change in land use
  - Time lags
  - Spatial dynamics
- Need to investigate different periods and scenarios of change for informed decisions in watershed management



Etobicoke versus Humber



2017 Conditions

Total Area

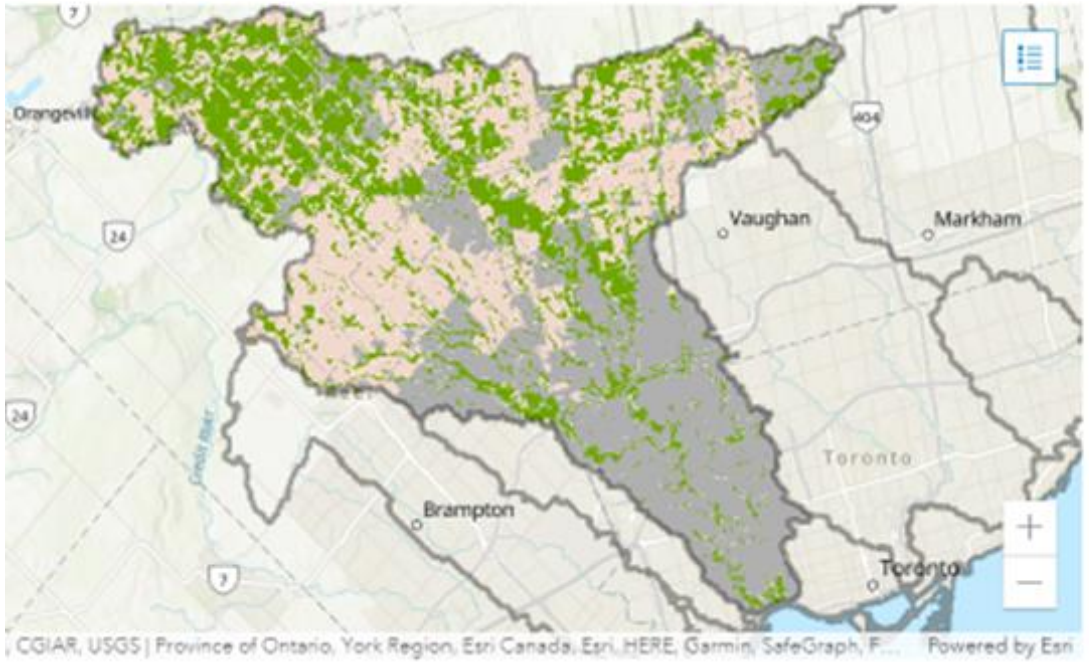
222 Km²

22,269 Ha

Urban Area	Natural Areas	Rural Area
151.6 Km²	27 Km²	43 Km²
15,155.1 Ha	2,744 Ha	4,350 Ha

Land Cover Breakdown

Hover mouse over the chart to view hectares



2017 Conditions

Total Area

910 Km²

91,024 Ha

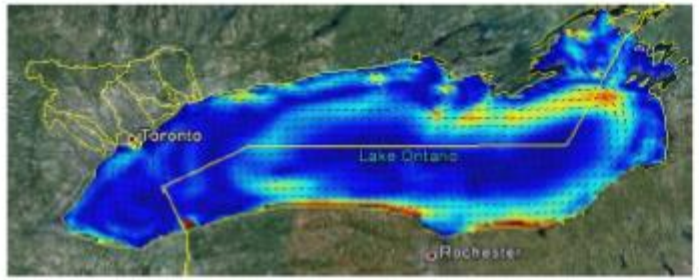
Urban Area	Natural Areas	Rural Area
311.8 Km²	295 Km²	303 Km²
31,183.1 Ha	29,545 Ha	30,295 Ha

Land Cover Breakdown

Hover mouse over the chart to view hectares

Humber River Watershed Plan

- Partnering with TMU and collaborating with ECCC
- What is the appropriate model?
  - 2 model approach?
    - ECCC: semi-calibrated SWAT model
    - TMU: urban model

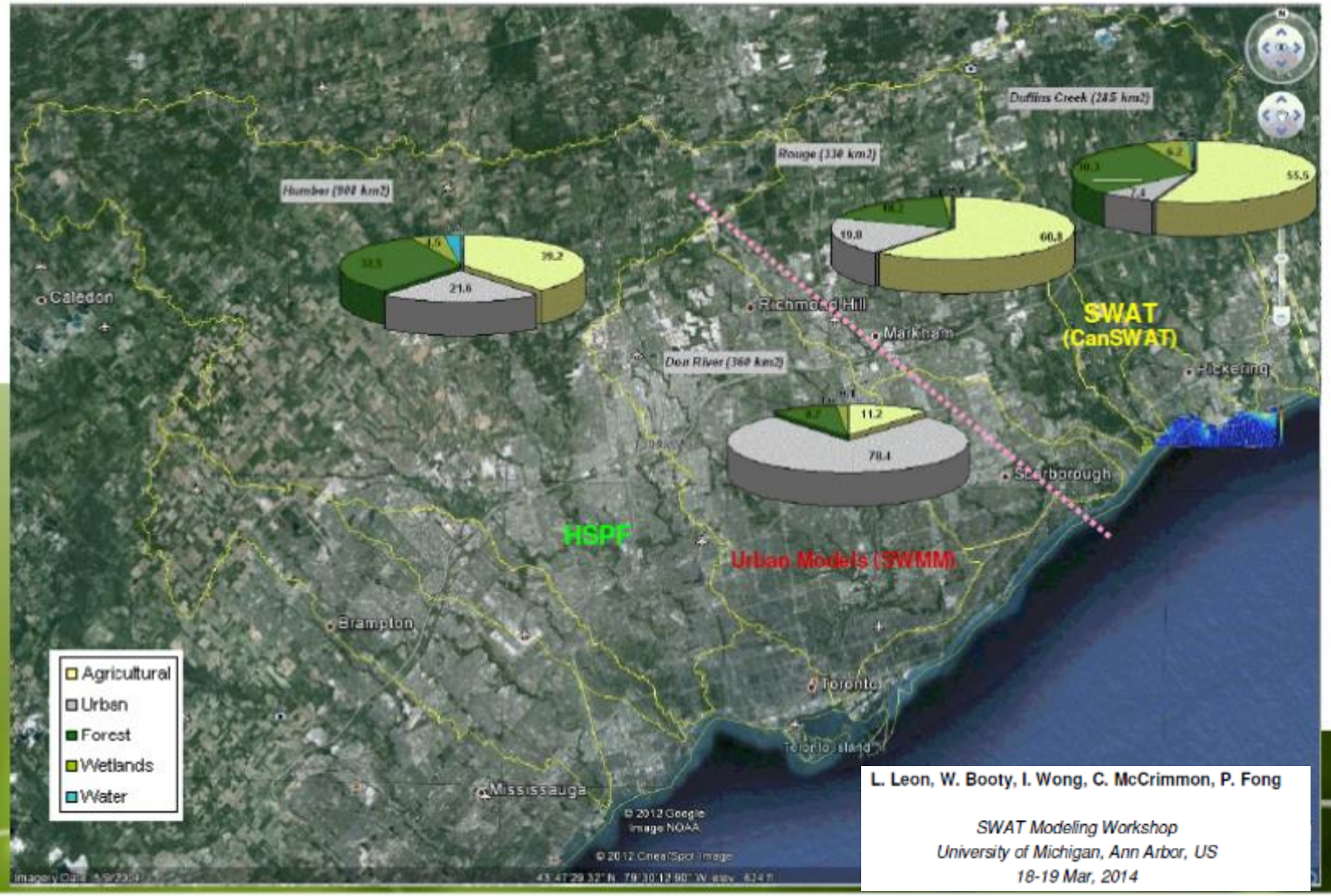


Integrated Watershed-Lake Modelling

Canada

Southern Ontario Watersheds [TRCA]

Urban growth MTA (W) ; Agriculture (E)



L. Leon, W. Booty, I. Wong, C. McCrimmon, P. Fong

SWAT Modeling Workshop
University of Michigan, Ann Arbor, US
18-19 Mar, 2014

Humber River Watershed Plan

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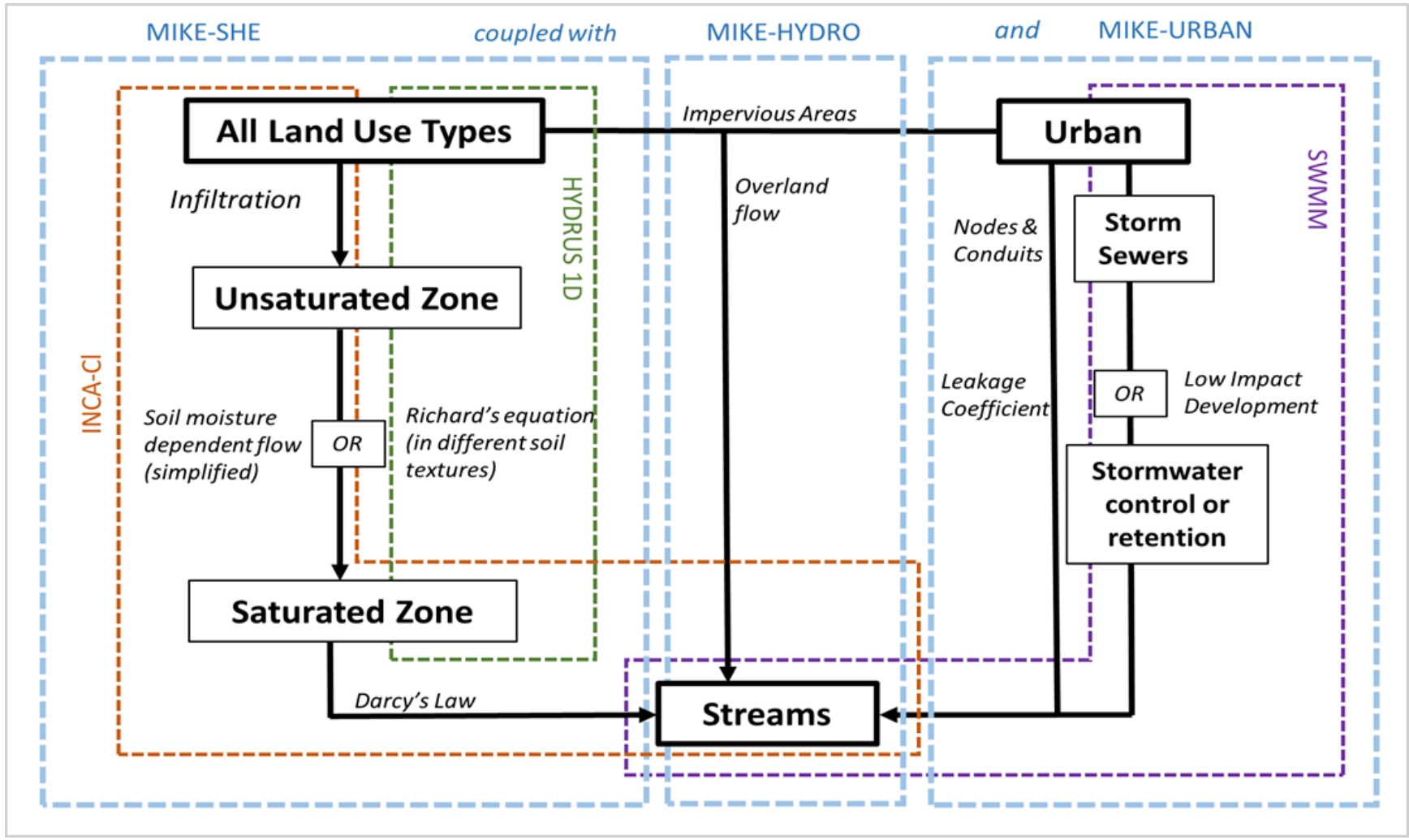

Objectives

- Water quality model
  - Chloride
  - Total Suspended Solids
  - Total Phosphorus
- future management scenarios (urban expansion and climate change)
- Cost-benefit strategy of management approaches (sub-watershed scale)
  - natural cover changes
  - urban forest increases
  - various levels of stormwater retrofits and LID implementation
  - Agricultural BMPs

Sustainable Technologies EVALUATION PROGRAM

Fostering Sustainability Through Innovation

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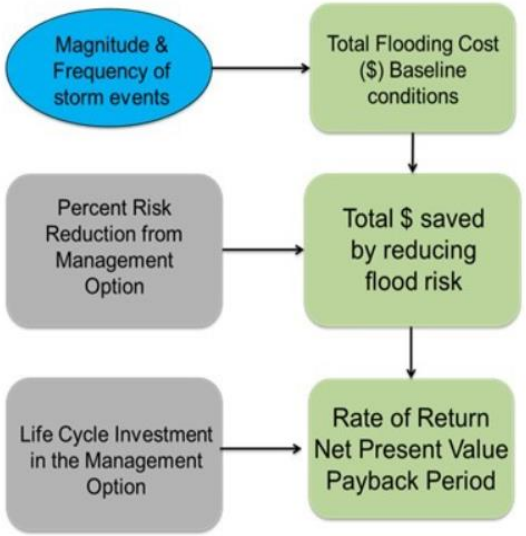
Risk and Return on Investment Tool (RROIT Version 1.0)

Trends in Canada and Ontario with respect to weather-related risk show increases in damages borne by property owners and municipal governments with respect to extreme rainfall and flooding events,[1] as well as increased frequency of legal action being taken against municipalities to recoup damages considered to have resulted from non-resilient infrastructure[2]. Predictive climate change modelling technology is becoming more advanced, and is being used on an increasing basis to estimate increased risk due to changes in climate patterns, such as more frequent extreme rainfall events; however, a gap remains in understanding the full financial implication of these events.

National Disaster Mitigation Program Stream 3, Disaster Mitigation Action Fund (DMAF) and Infrastructure Canada's Climate Change Lens require climate change risk assessments and return on investment analyses as prerequisites for infrastructure funding. With support through the National Disaster Mitigation Program, Credit Valley Conservation Authority and partners are developing a Risk and Return on Investment Tool for water infrastructure to assist municipalities and conservation authorities to make evidence-based, cost-effective decisions to reduce flood risk and meet funding requirements.



Contact:

Bhaswati Mazumder

Toronto Metropolitan University (formerly *Ryerson*)

Email: bmazumder@ryerson.ca

Current research:

- Mazumder, B., C.J. Oswald & C. Wellen (2022). **Salt to Stream: A process-based integrated watershed model for urban stream chloride using SWMM.** *CMOS-CGU-ESC 2022 Joint Congress 2022, Session 10050.* (Received the *DM Gray Award for Best Student Paper in Hydrology;* manuscript submission in progress for a special issue in *Hydrological Processes*).
- Mazumder, B., C. Wellen, G. Kaltenecker, R.J. Sorichetti, & C.J. Oswald (2021). **Trends and legacy of freshwater salinization: Untangling over 50 years of stream chloride monitoring.** *Environmental Research Letters*, 16(9), 095001.

Toronto Metropolitan University

Urban Water Research Centre

Upcoming ECS Lunch and Learns!

Tuesday, September 27
11:00am-12:00pm

TRCA Trail Strategy Implementation

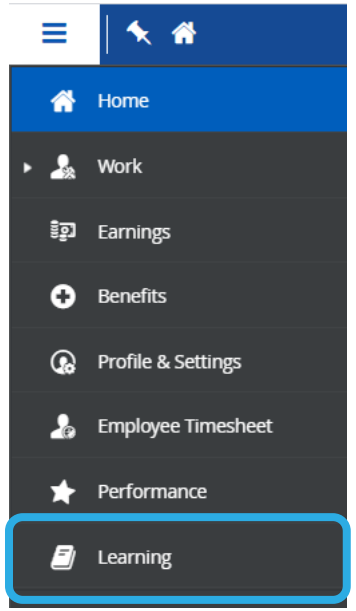
By Corey Wells and Caitlin Harrigan

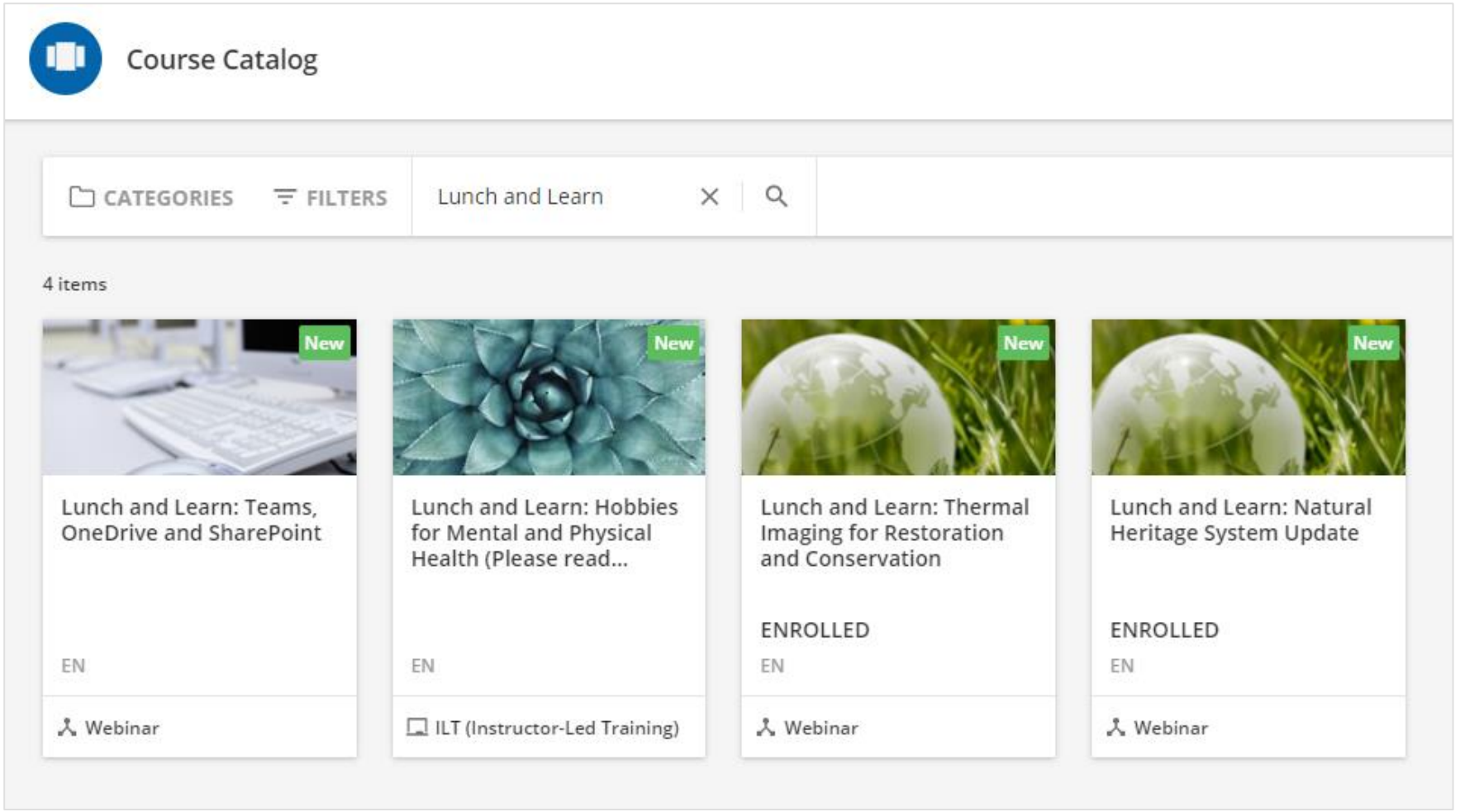
Tuesday, October 18
11:00am-12:00pm

Identifying and Prioritizing Agricultural Best Management Practices

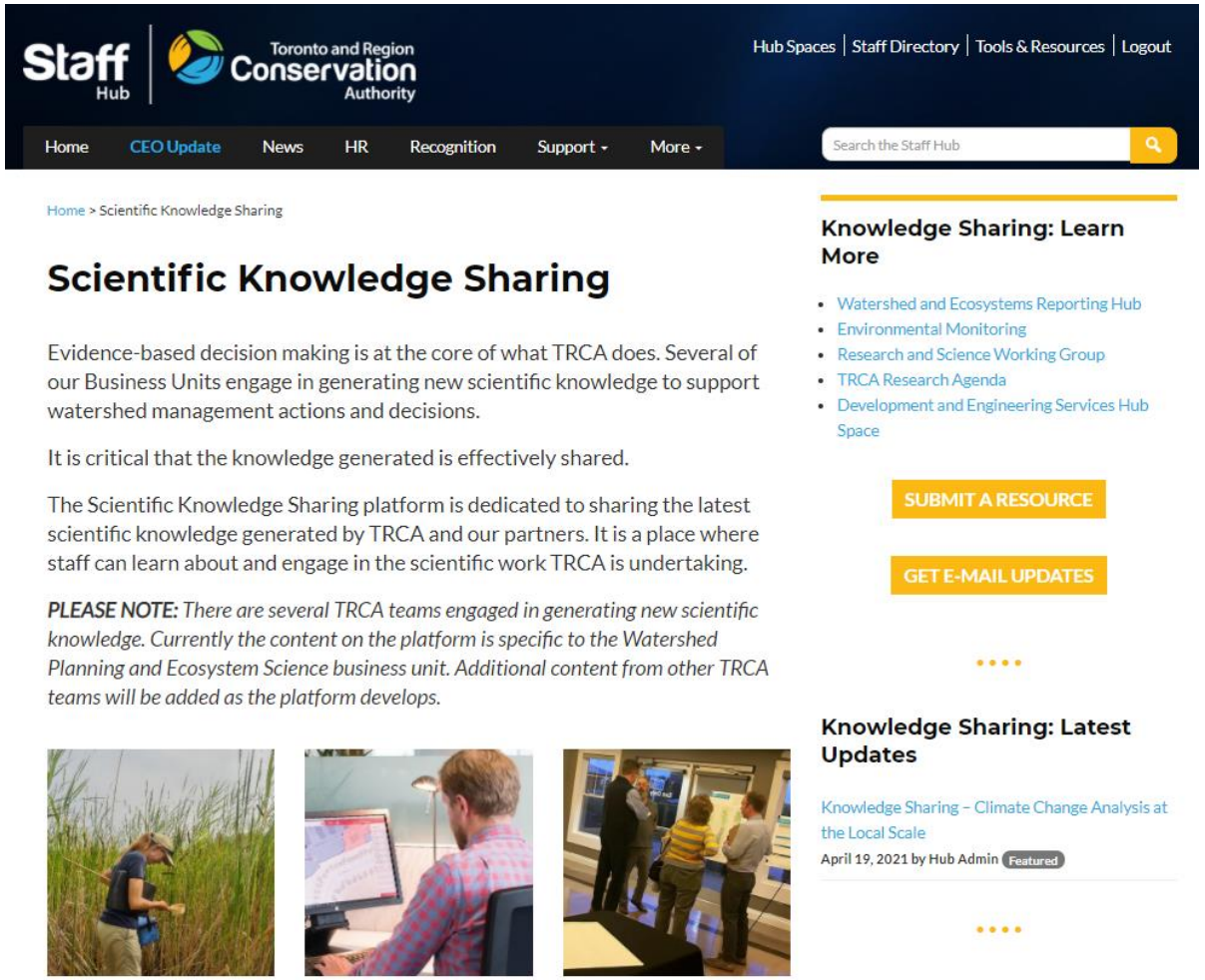
By Aidin Akbari

Learning Management System





Scientific Knowledge Sharing Hub



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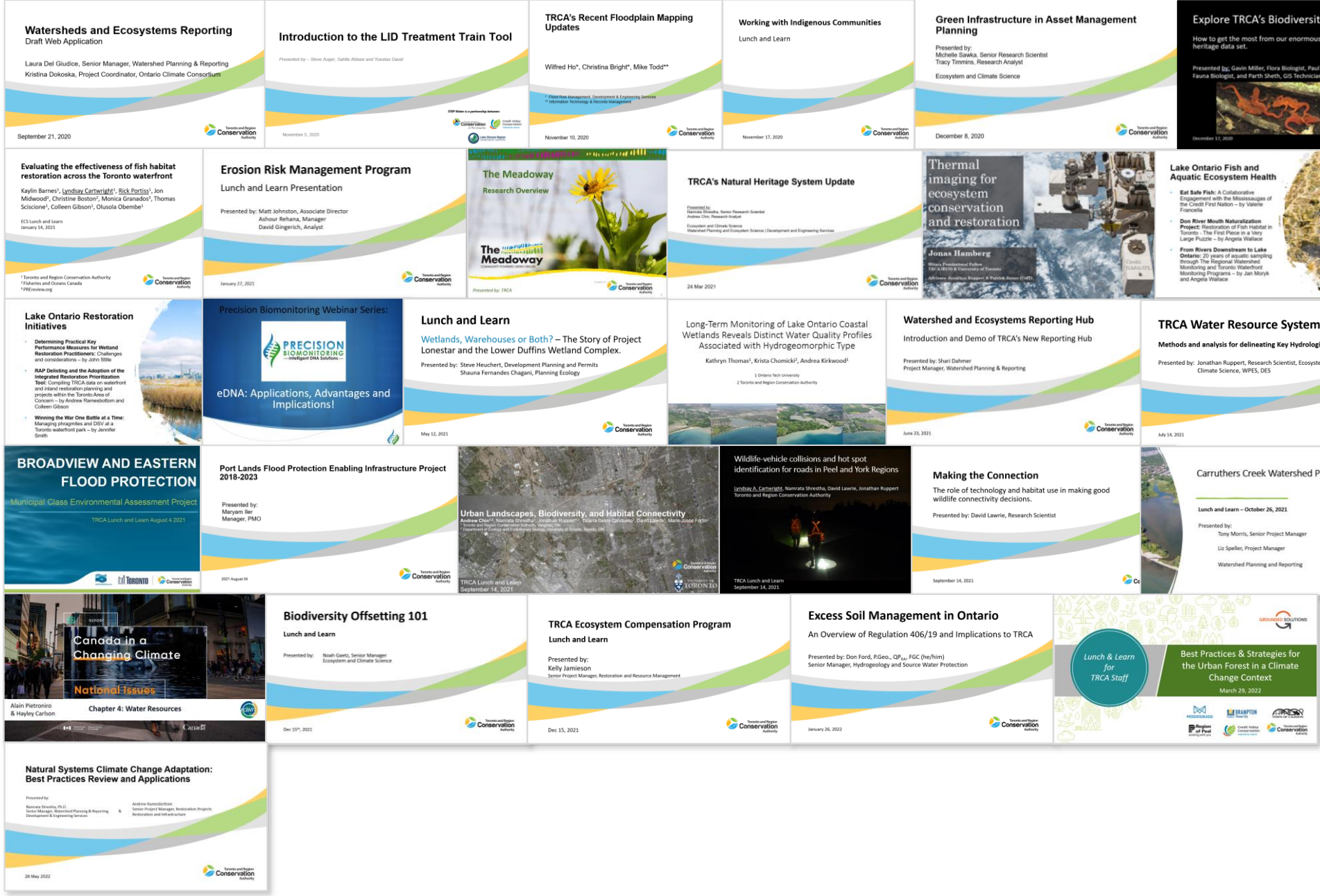
Past Recordings



Thank you

For questions about the ECS Lunch and Learn Series, please contact:

Sharon Lam
sharon.lam@trca.ca

Toronto and Region Conservation Authority