Estimating Source Water Contributions in a Small Precambrian Shield Catchment Within Nipissing First Nation, Northeastern ON

MacKenzie, William J.[1], April L. James[1], Colin P.R. McCarter[1], and Curtis Avery[2]

[1]Department of Biology, Chemistry, and Geography, Nipissing University, North Bay, ON P1B 8L7 [2]Department of Environment, Nipissing First Nation, Garden Village, ON P2B 3K2

Introduction

- Understanding the complex interactions between surface waters and groundwater is critical to properly secure our shared water resources.
- This study will provide an estimate of groundwater and lake water contributions to streamflow as well as how road salt and other automotive contaminants are impacting our shared water resources.

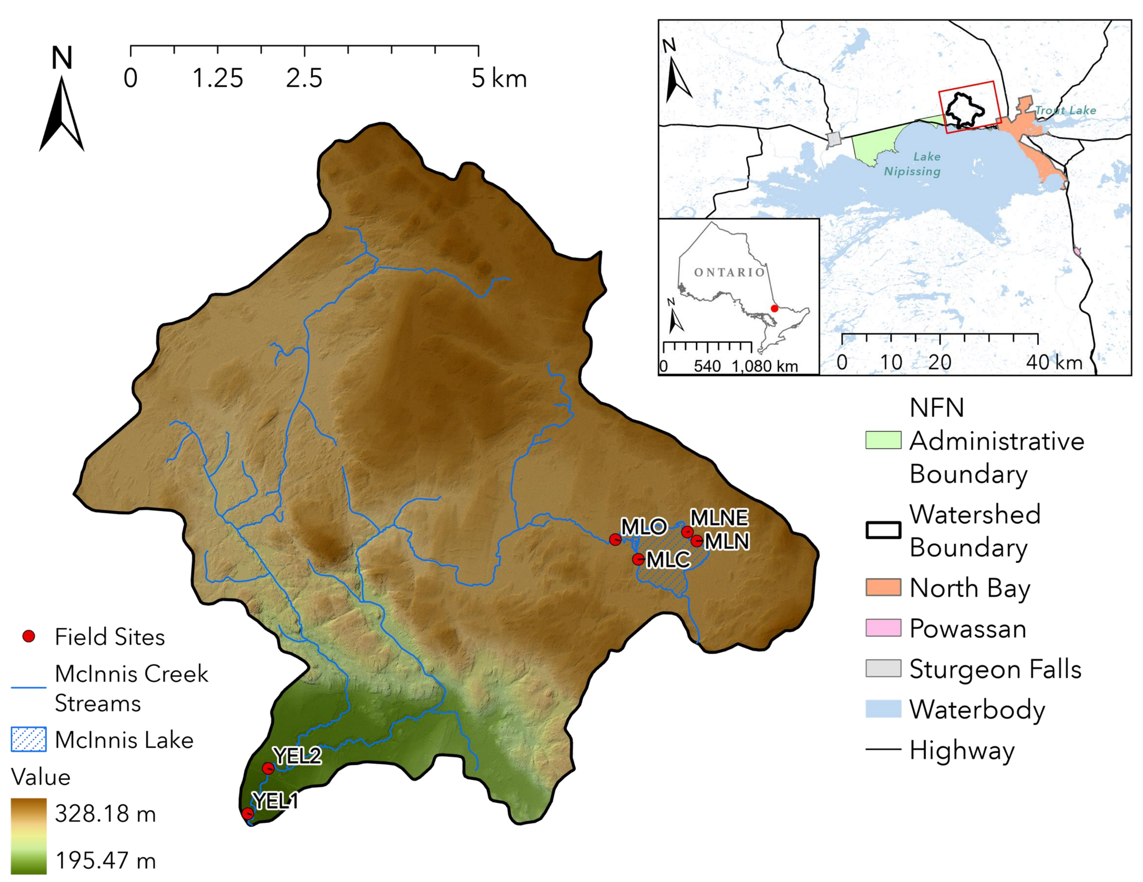


Figure 1. Lidar-derived digital terrain model (DTM) for McInnis Creek (0.5 m resolution). Field site locations have been illustrated within the catchment and an inset map outlines the catchment location within North Bay, NFN, and the Province of Ontario.[1,3,4,6,8,9]

Research Questions

1. What are the source water contributions to streamflow?
2. Can high frequency electrical conductivity (EC) measurements be used as a proxy to model chloride in low conductivity environments where chloride exists as a point source pollutant?
3. How does water quality evolve through the catchment?

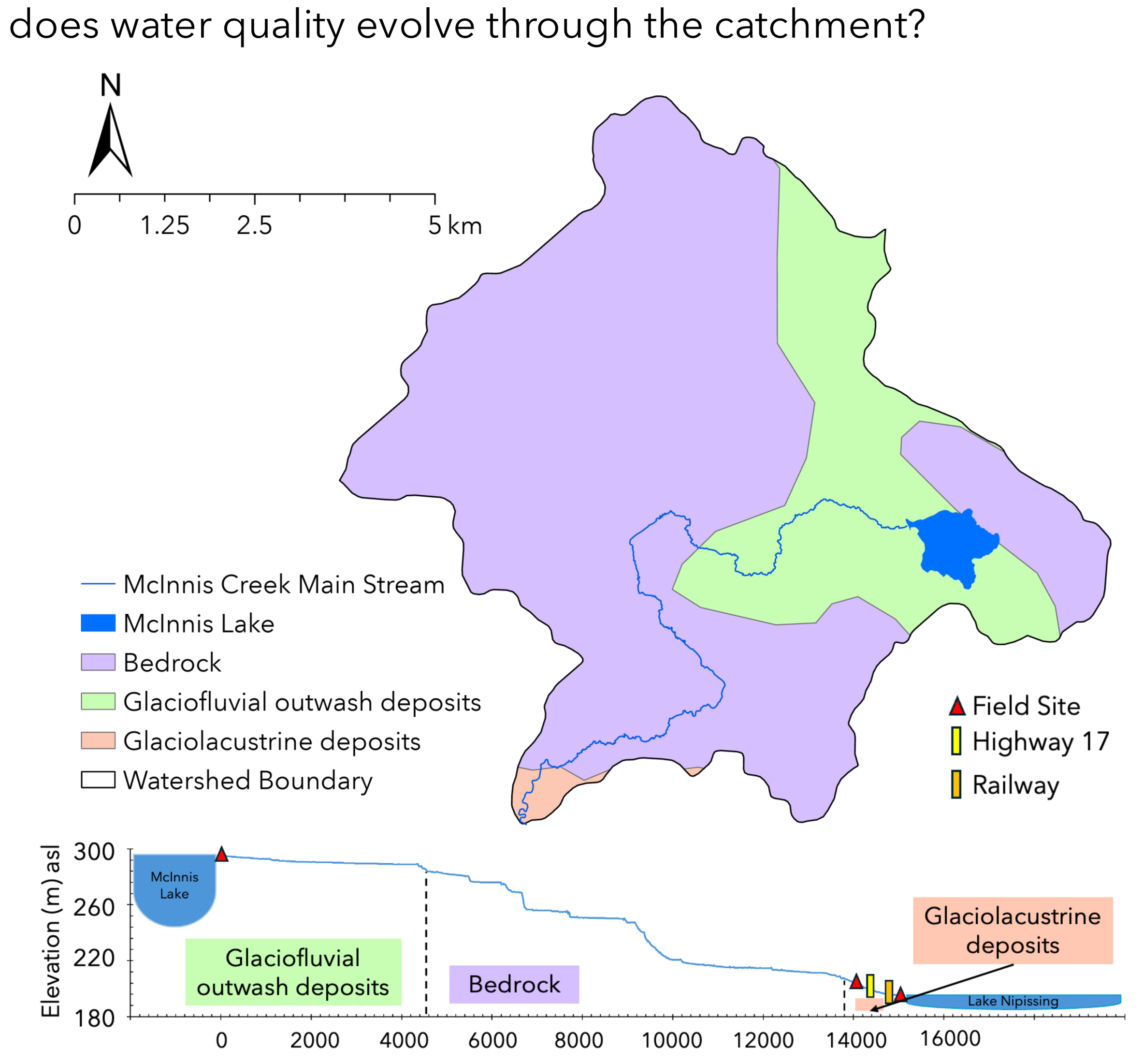
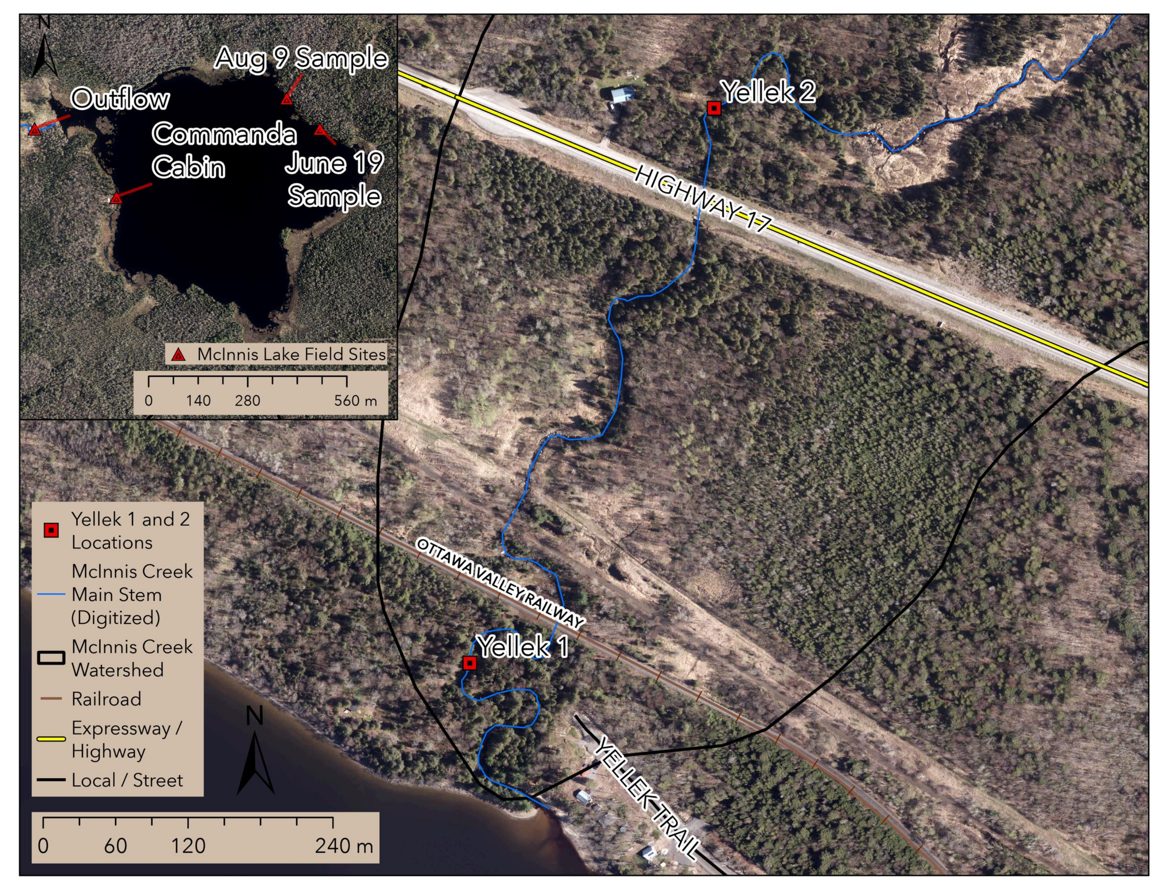


Figure 2. Quaternary geology for the McInnis Creek watershed (top) with a conceptual diagram of the elevation profile (bottom).[2,4,5,6,9]

Reference

(OMECP) Ontario Ministry of Environment Conservation and Parks. (2014). *Map: Provincial Groundwater Monitoring Network | ontario.ca*. https://www.ontario.ca/page/map-provincial-groundwater-monitoring-network

Methods and Field Locations



- McInnis Creek is a small north shore tributary of Lake Nipissing situated on the traditional lands of Nipissing First Nation (NFN).
- It is one of 26 previously studied Precambrian Shield catchments located within the Sturgeon-Lake Nipissing watershed and is an ungauged basin connected to a small headwater lake.
- Three monitoring locations were developed, a headwater lake, and two stream sites above and below the Trans Canada Highway (17) that bisects the catchment.

Figure 3. Satellite imagery (top left) of the field site locations above and below Highway 17 and at McInnis Lake (inset map). Photographs of main field site locations (below) showcase where weekly samples and instream monitoring equipment was installed.[2,4,7-9]

- Synoptic samples of stream water, lake water, and precipitation were collected (Mar-Dec 2024).
- Water samples will be used for the analysis of stable water isotopes, major ions, trace metals, and dissolved organic carbon.
- Continuous instream measurements of EC and water stage were taken at both stream monitoring sites along with weekly discharge measurements to derive rating curves to estimate stream water discharge.

Preliminary Results

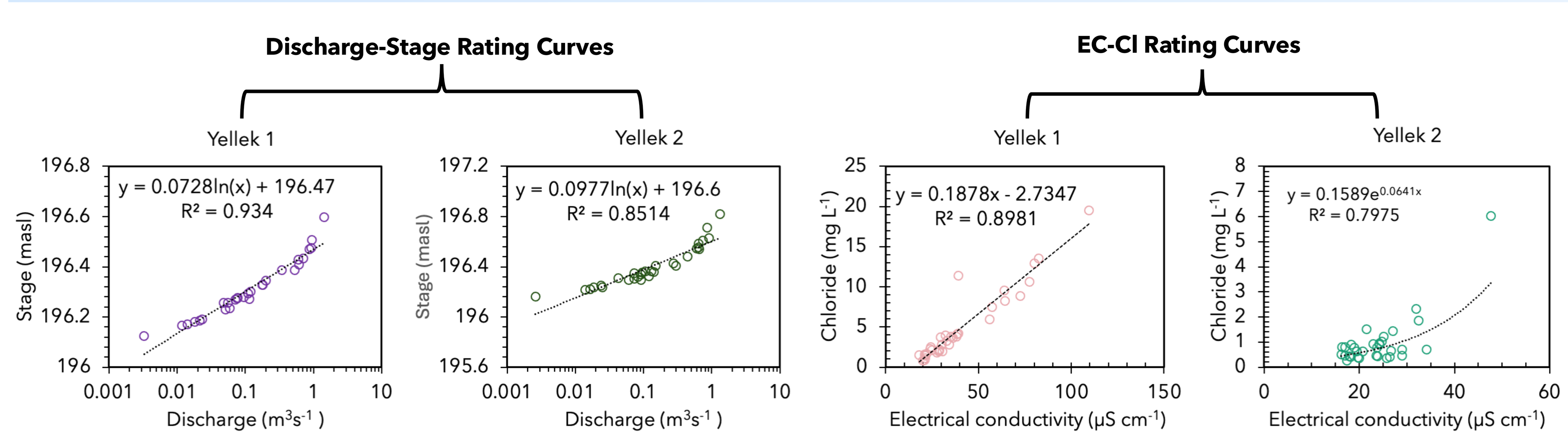


Figure 4. Discharge-stage relationship (left) and EC-Cl relationship (right) were calculated through the use of weekly discharge and conductivity measurements. Chloride data was obtained from weekly grab samples that were analyzed using ion chromatography.

- Increased scatter at low and high flows for both sites highlights the need for two equations to account for the range of flow conditions.
- Yellek 1 provides a better relationship for both discharge-stage and EC-Cl than Yellek 2.

Data Sources: (**1**) 2021 Census Boundary Files: provided by Statistics Canada.*; (**2**)Central Ontario Orthophotography Project (COOP) 2021: provided by Land Information Ontario. Contains information licensed under the Open Government License – Ontario; (**3**) Lakes and Rivers in Canada – Canvec – Hydro Features: provided by Natural Resources Canada; Earth Sciences Sector.*; (**4**) Ontario Digital Terrain Model (Lidar-Derived). 2024: provided by the OMNRF through Ontario GeoHub.**; (**5**) Ontario Geological Survey 2011. 1:250 000 scale bedrock geology of Ontario; OGS, Miscellaneous Release – Data 126 – Revision 1. Copyright is held by the King's Printer for Ontario.; (**6**) Ontario Integrated Hydrology (OIH) Data: provided by the OMNRF through Ontario GeoHub.**; (**7**) Ontario Railway Network (ORWN): provided by the OMNRF through Ontario GeoHub.**; (**8**) Ontario Road Network (ORN) Composite: provided by the OMNRF through Ontario GeoHub**; (**9**)Ontario Watershed Boundaries (OWB): provided by the OMNRF through Ontario GeoHub.** * Contains information licensed under the Open Government License – Ontario. ** Contains information licensed under the Open Government License – Canada.

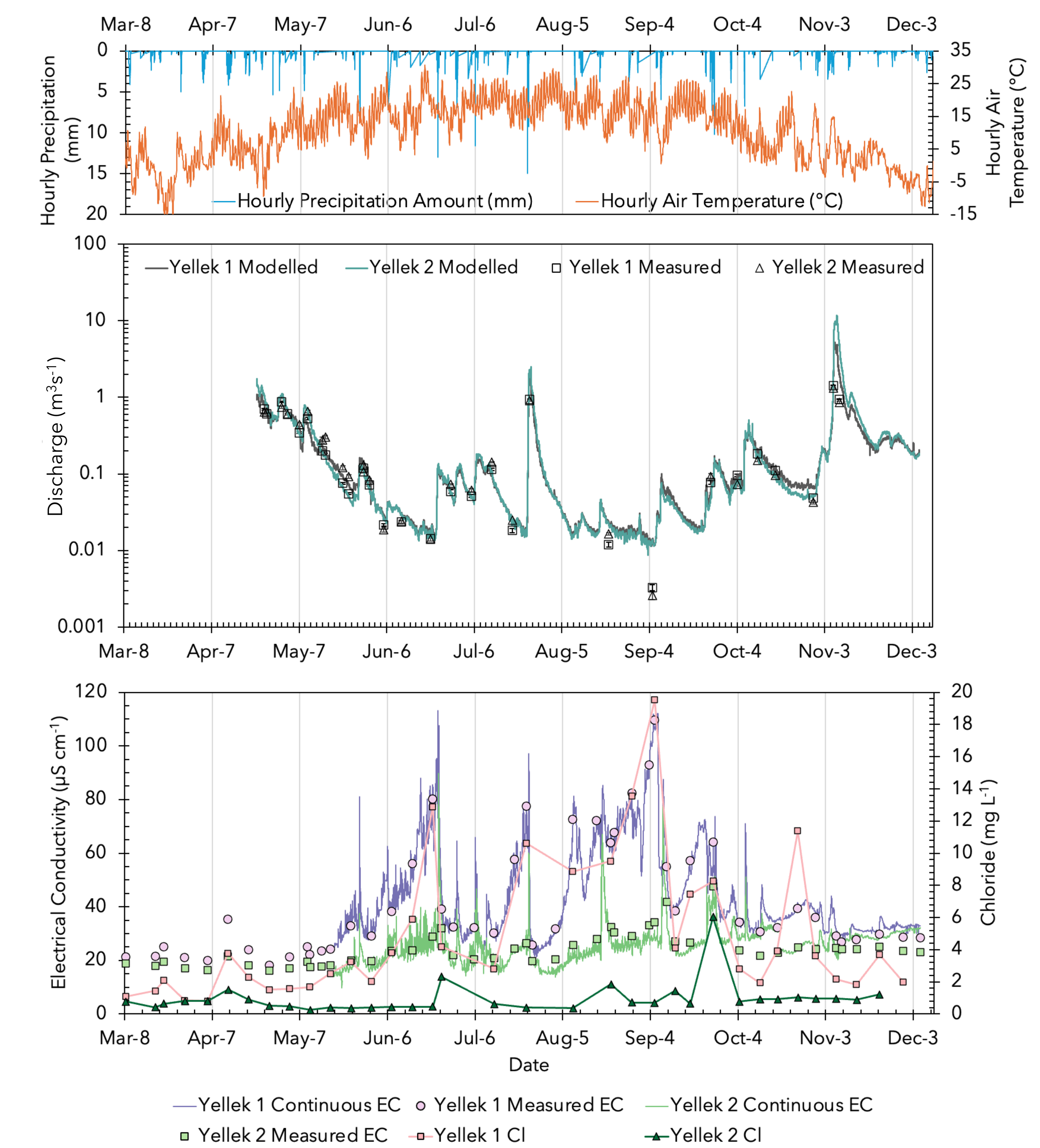


Figure 5. Hourly air temperature and precipitation (top) and modelled discharge (middle) at 15-minute intervals for both sites using a non-linear power equation as shown in Figure 4. Continuous specific conductivity (bottom) is represented for both sites on a 5-minute interval along with weekly chloride concentrations.

$$f_{lake} = \frac{EC_{Y1/Y2} - EC_{GW}}{EC_{lake} - EC_{GW}} \qquad f_{GW} = 1 - f_{lake}$$

Where f_{lake} = fraction of lake water and f_{GW} = fraction of groundwater

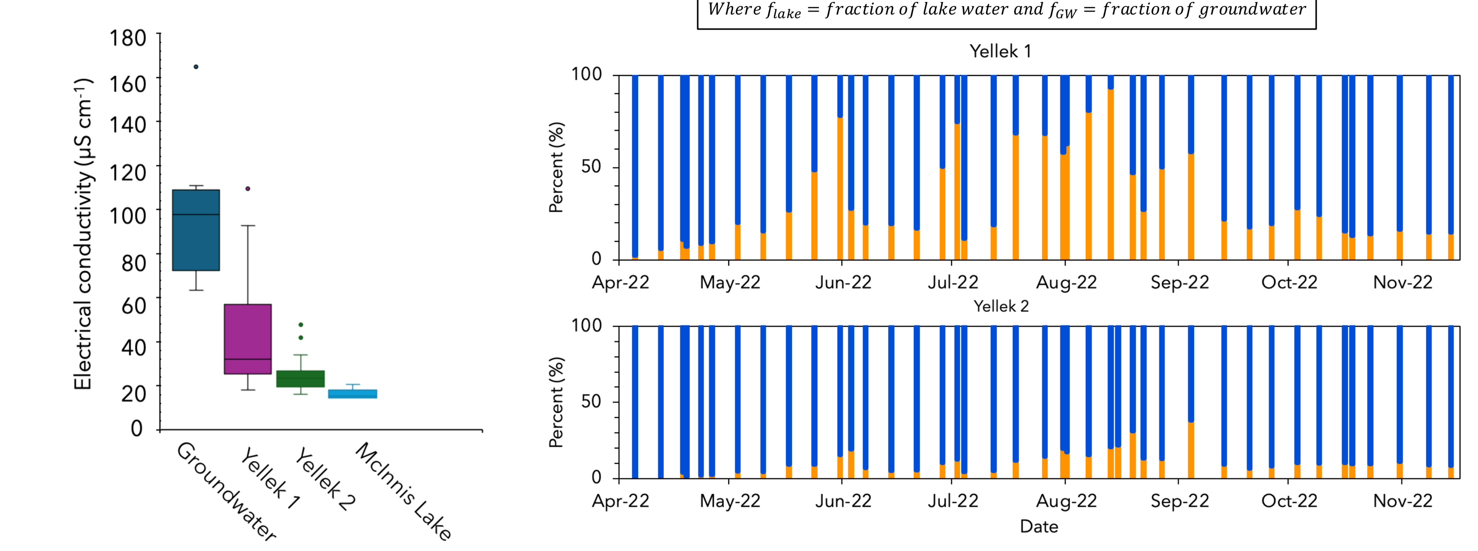


Figure 6. Variation in electrical conductivity (left) includes the end-members used for the calculation of source water contributions (right) using a 2-component mixing model equation (middle).

Interim Findings

- Downstream Yellek 1 exhibits a much higher EC and Cl⁻ concentration than upstream Yellek 2 inferring a major influence from Hwy 17.
- Yellek 1 displays a greater percent groundwater contribution over the field season than Yellek 2.
- Utilization of isotope data will allow a 3-component mixing model and additional water quality data will provide evidence of potential pollution inputs.