Flow and Load Accretion Study Improved Understanding of Hyporheic Exchange plus Contaminant Plume Sources and Transport

Isaac Guld, P.Eng.

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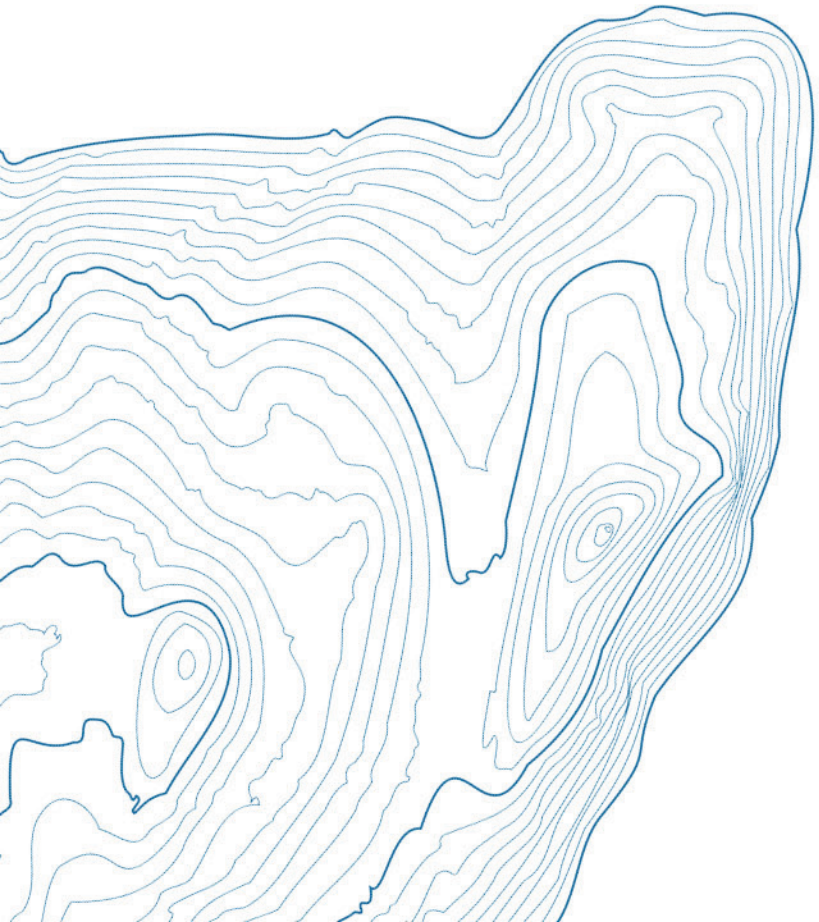
WVTF IMWA 2024

BGC ENGINEERING

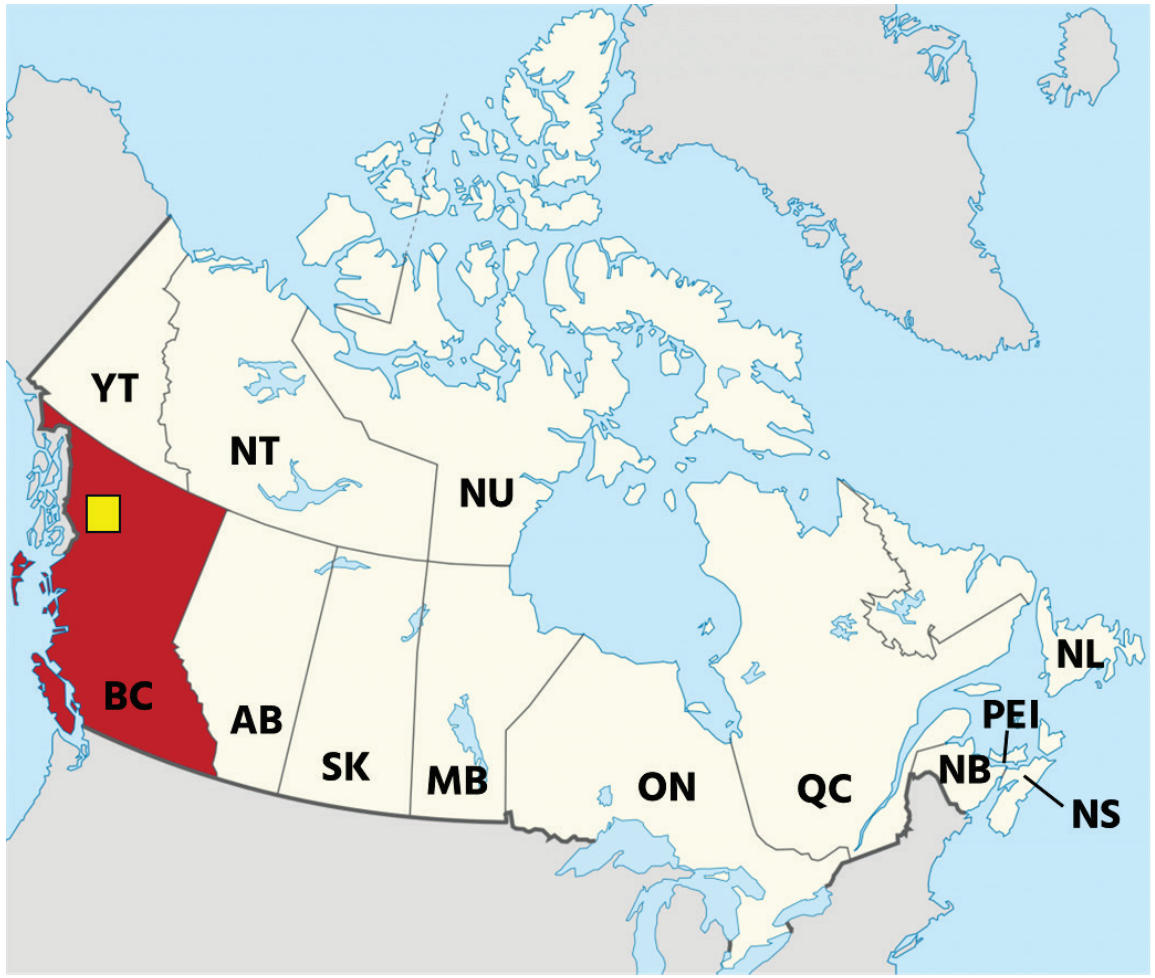


Background, Purpose, and Objectives

Background

Location

- Open pit mine in northwestern British Columbia (BC), Canada
- In operations for almost a decade
- An extensive groundwater monitoring network; routinely sampled for water level and water quality
- A Trigger Response Plan (TRP) developed for the Mine, with specified trigger levels for identified constituents of potential concern (COPCs) – includes sulfate and selenium



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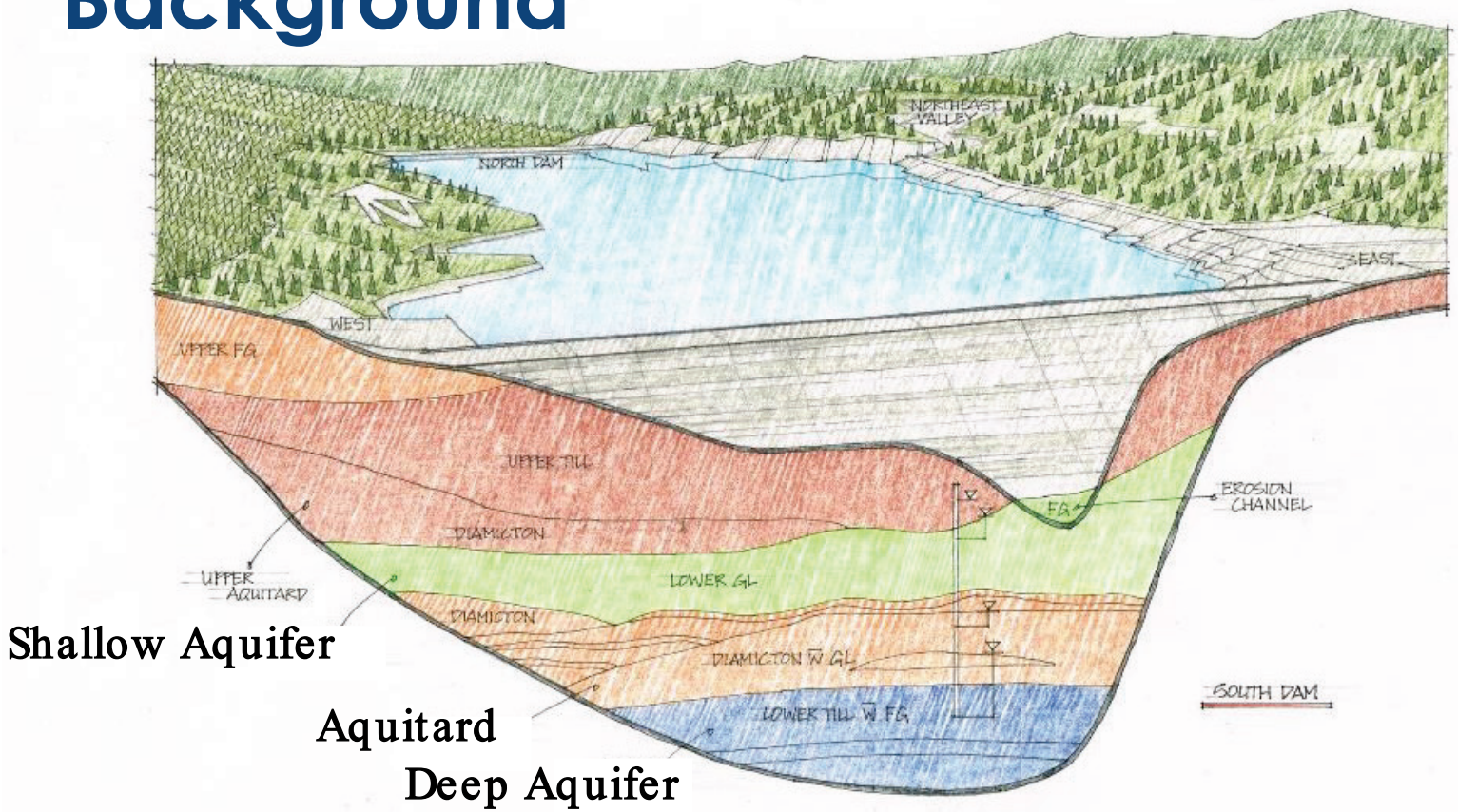

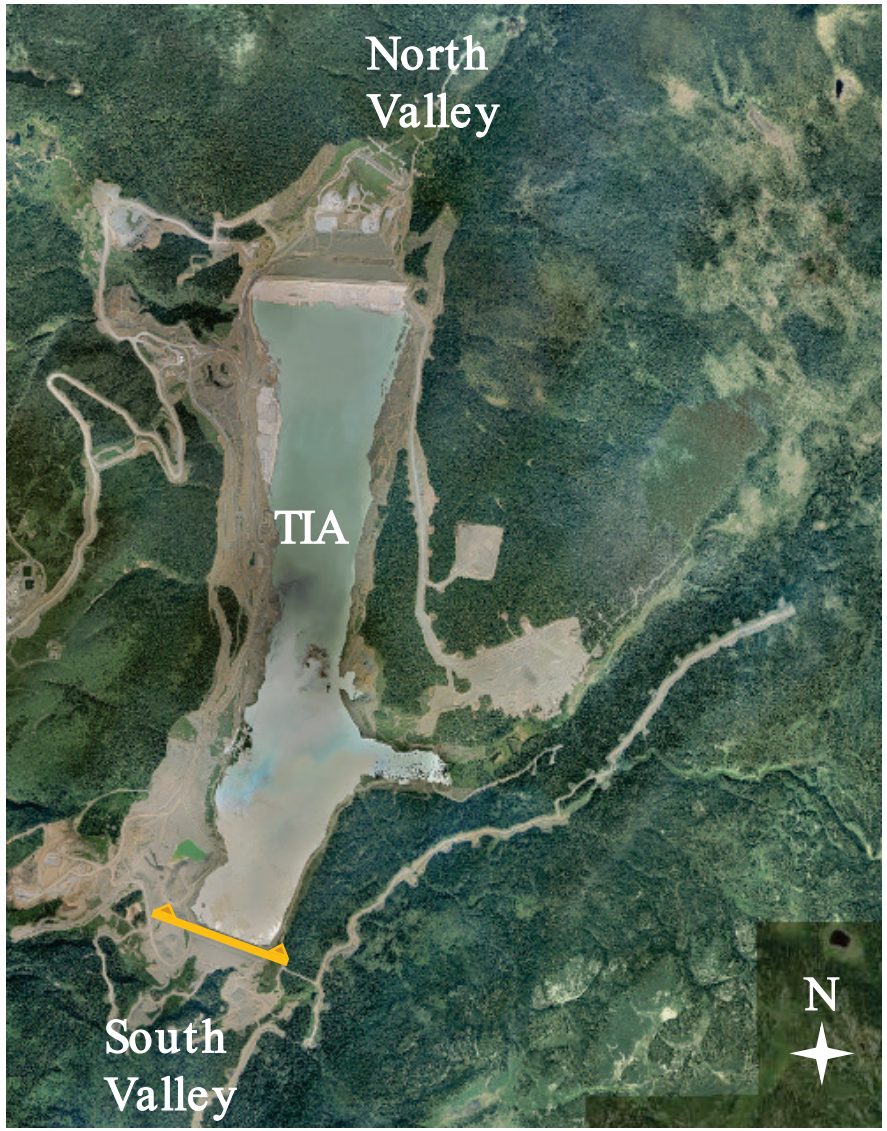

- Surficial geology in the TIA valley consists of glacial sediments over 125 m thick in the valley bottom.
- The hydrostratigraphy in the South Valley is conceptualized to largely consist of a shallow aquifer, and a deep aquifer (largely confined).

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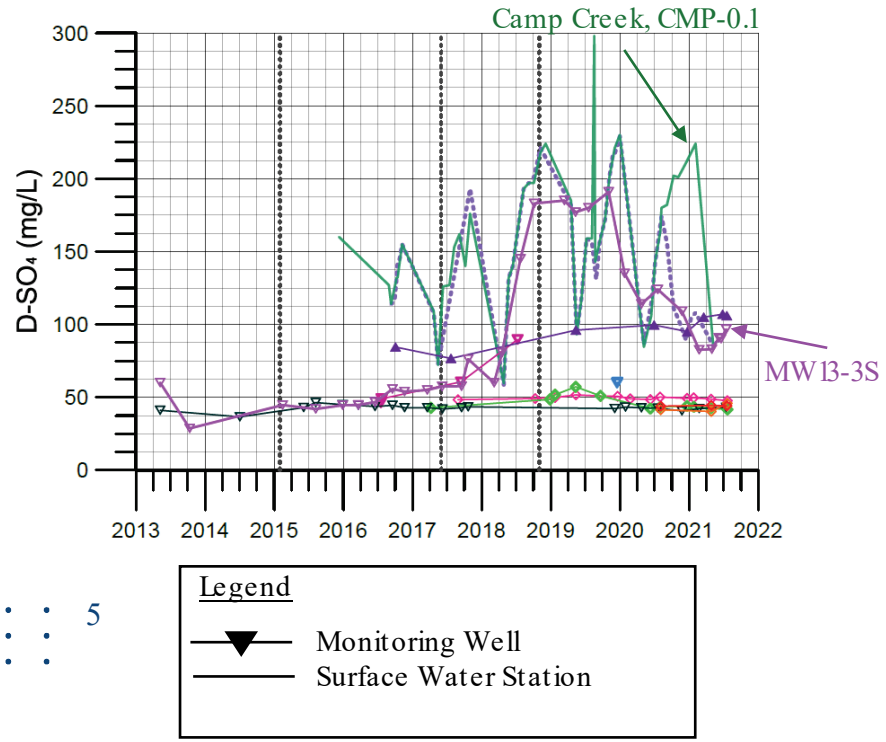
Background

Sulfate Anomalies

Elevated SO_4 noted in South Valley deep aquifer downgradient of a seepage recovery dam, possible connection to Camp Creek

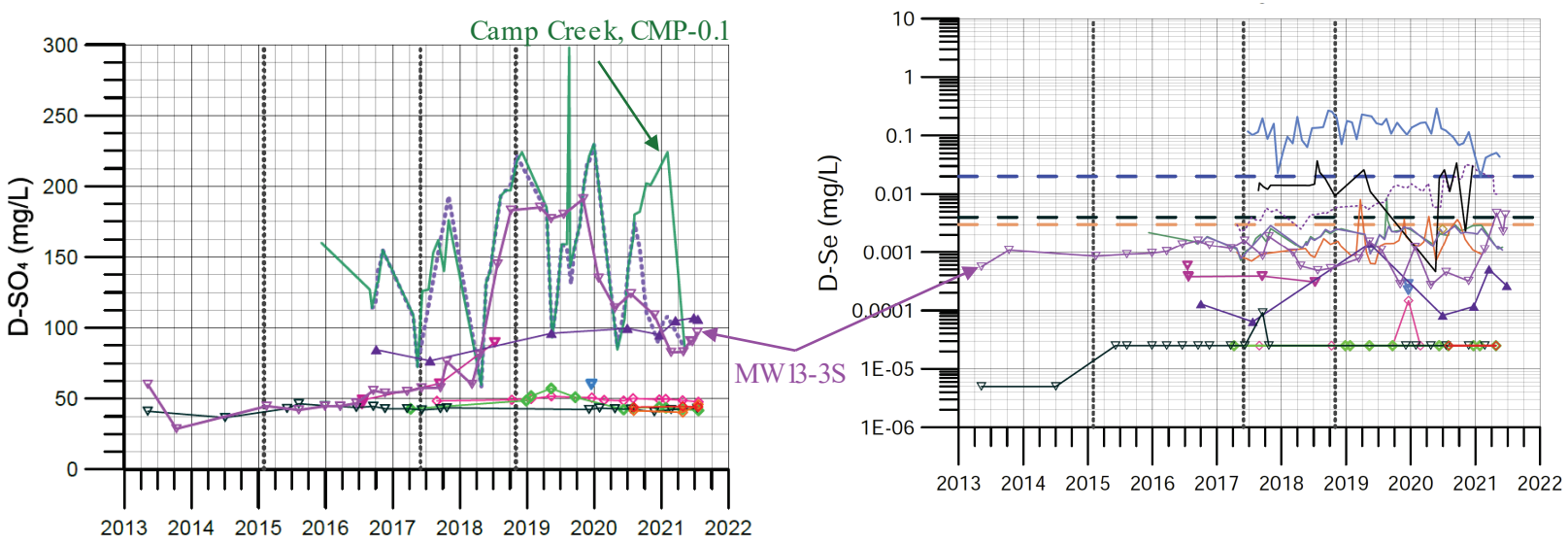


Background

Selenium Anomalies

Confirmed Trigger Level Exceedance of dissolved selenium (D-Se) in the South Valley deep aquifer

Elevated SO_4 noted in South Valley deep aquifer downgradient of a seepage recovery dam, possible connection to Camp Creek



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Sulfate Plume

Confirmed Trigger Level Exceedance of dissolved selenium (D-Se) in the South Valley deep aquifer

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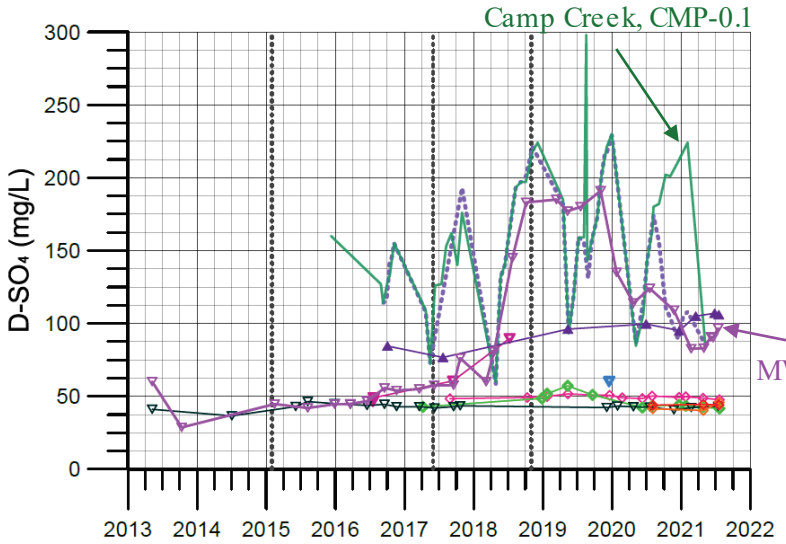
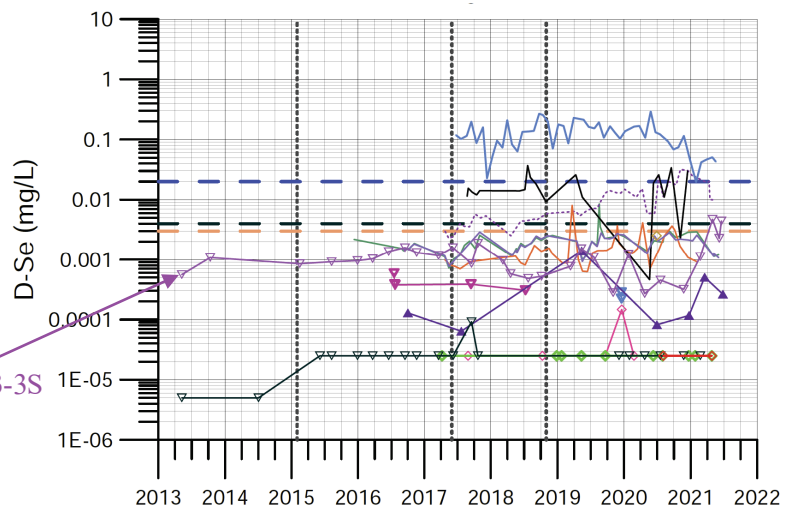
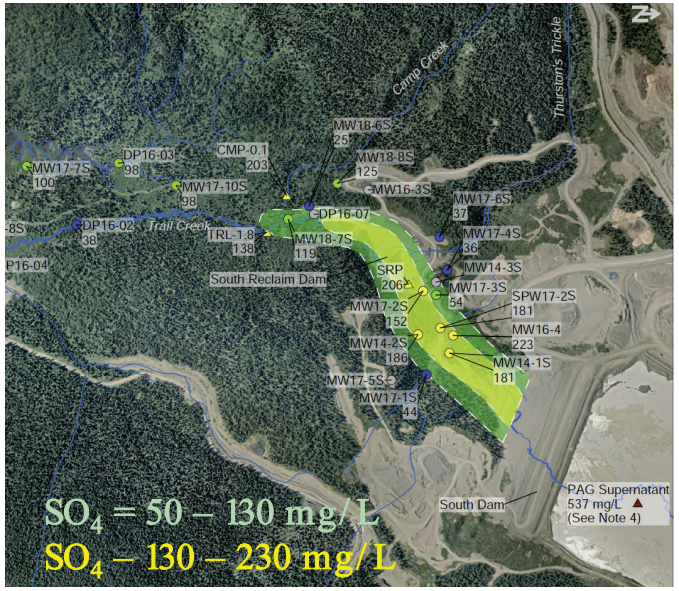
Challenges in estimating the leading edge of interpreted SO_4 plume in the shallow aquifer







Legend

- Monitoring Well
- Surface Water Station
- Trigger levels

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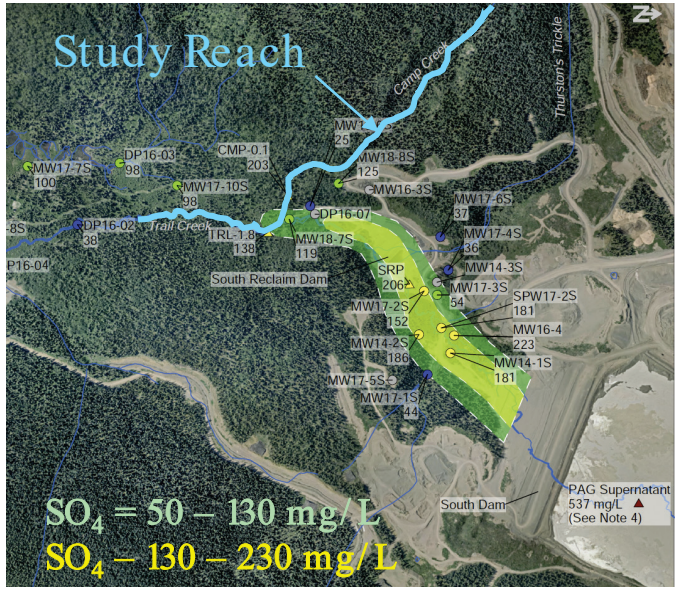
Purpose

Flow and Load Accretion Study

- **Study Purpose**
  - Investigate whether Camp Creek and/or Trail Creek is recharging the South Valley shallow aquifer, and possibly the deep aquifer, and acting as a loading source to MW13-3S.

Challenges in estimating the leading edge of interpreted SO_4 plume in the shallow aquifer

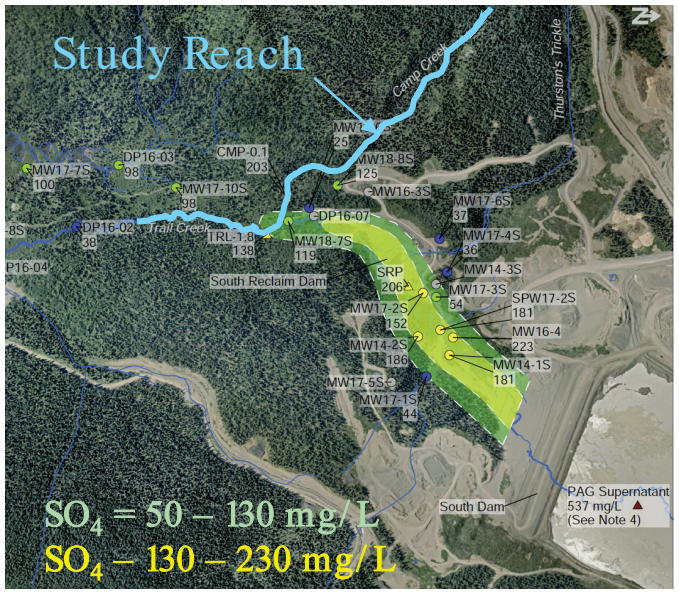


Purpose

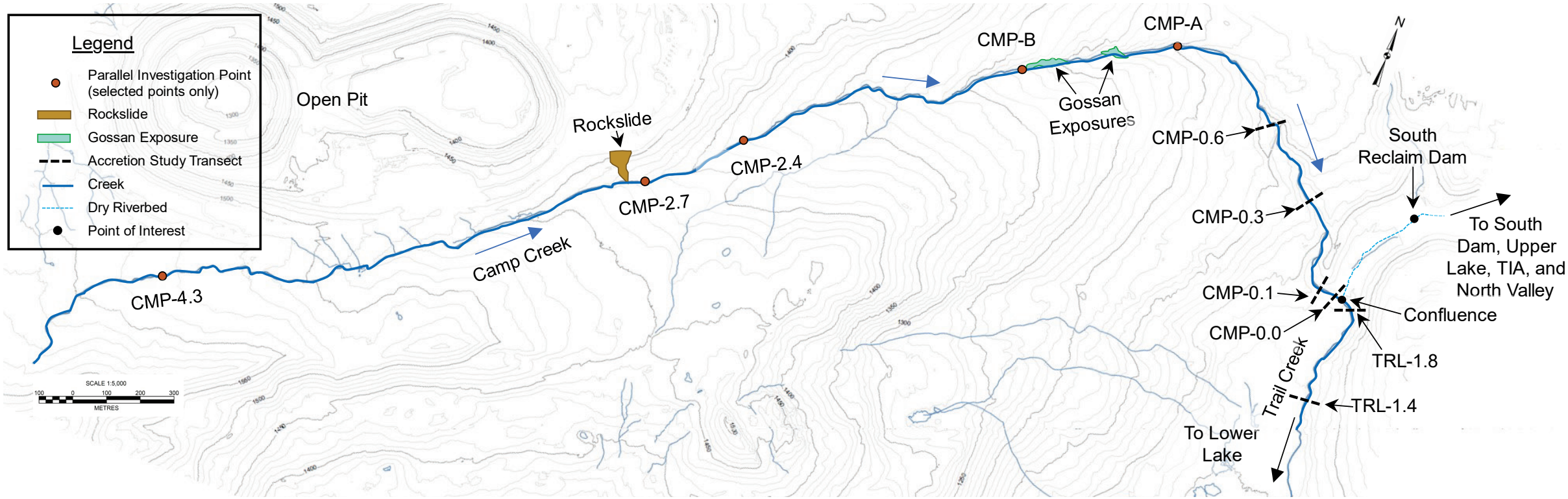
Objectives

- **Study Purpose**
  - Investigate whether Camp Creek and/or Trail Creek is recharging the South Valley shallow aquifer, and possibly the deep aquifer, and acting as a loading source
- **Study Objectives**
  - Identify losing and gaining reaches along Camp Creek and Trail Creek
  - Assess seasonal variations in discharge and load
  - Assess the potential for hydraulic communication between surface watercourses and the South Valley groundwater flow system
  - Assess the source of the elevated SO_4 in the watercourse *

Challenges in estimating the leading edge of interpreted SO_4 plume in the shallow aquifer



Study Area Overview



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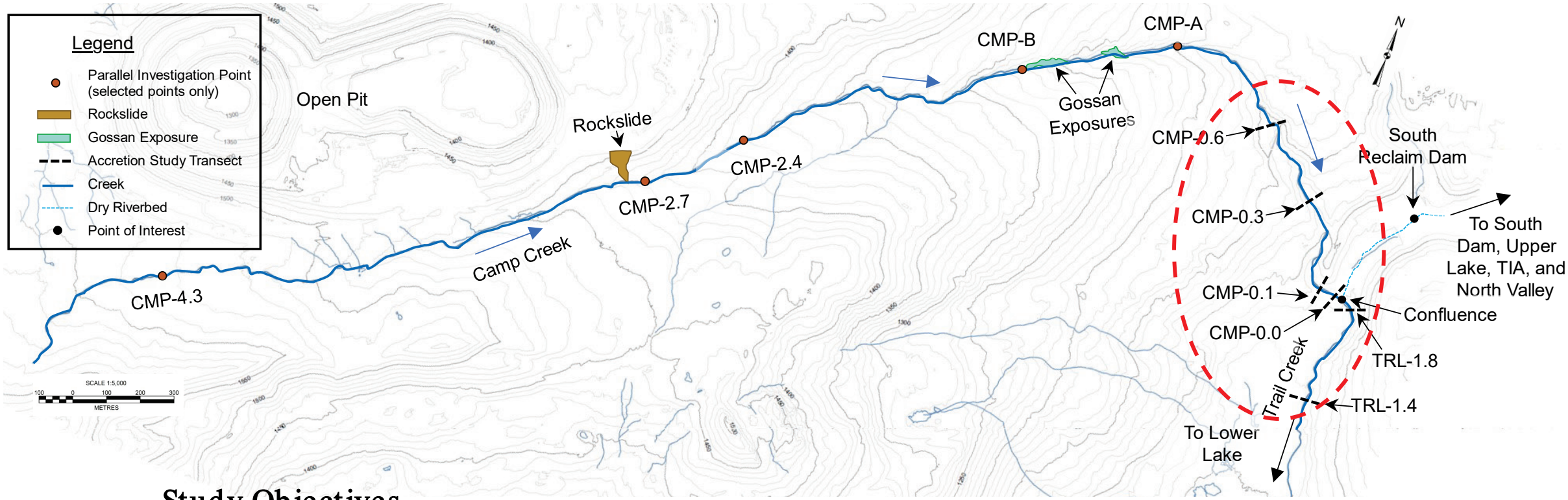

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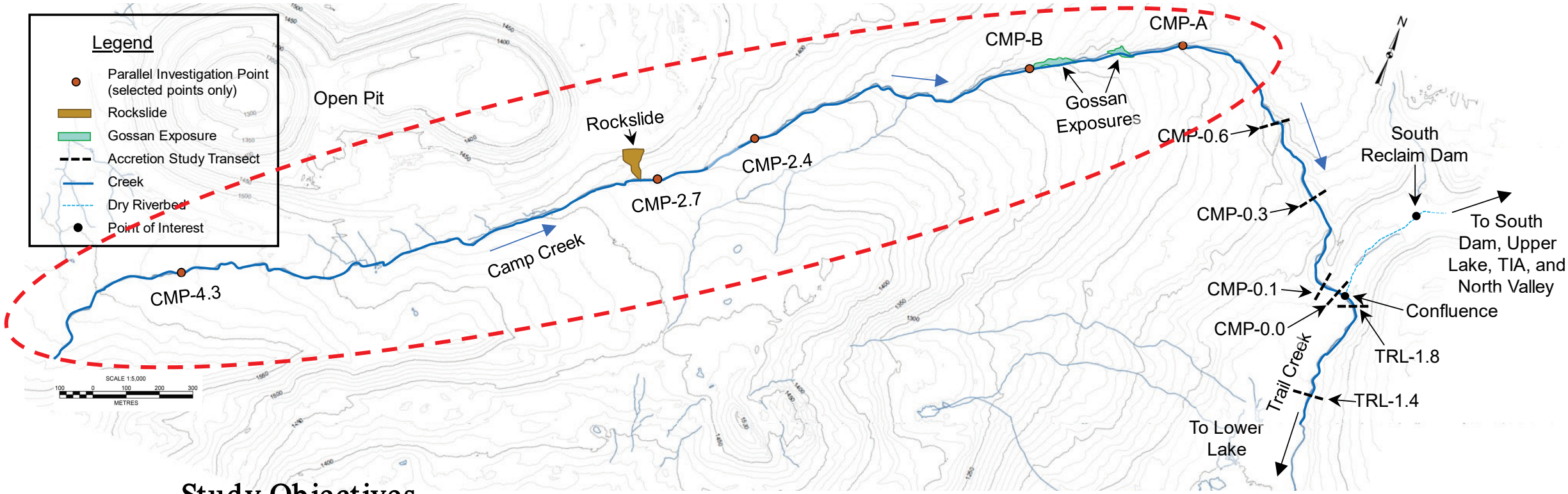

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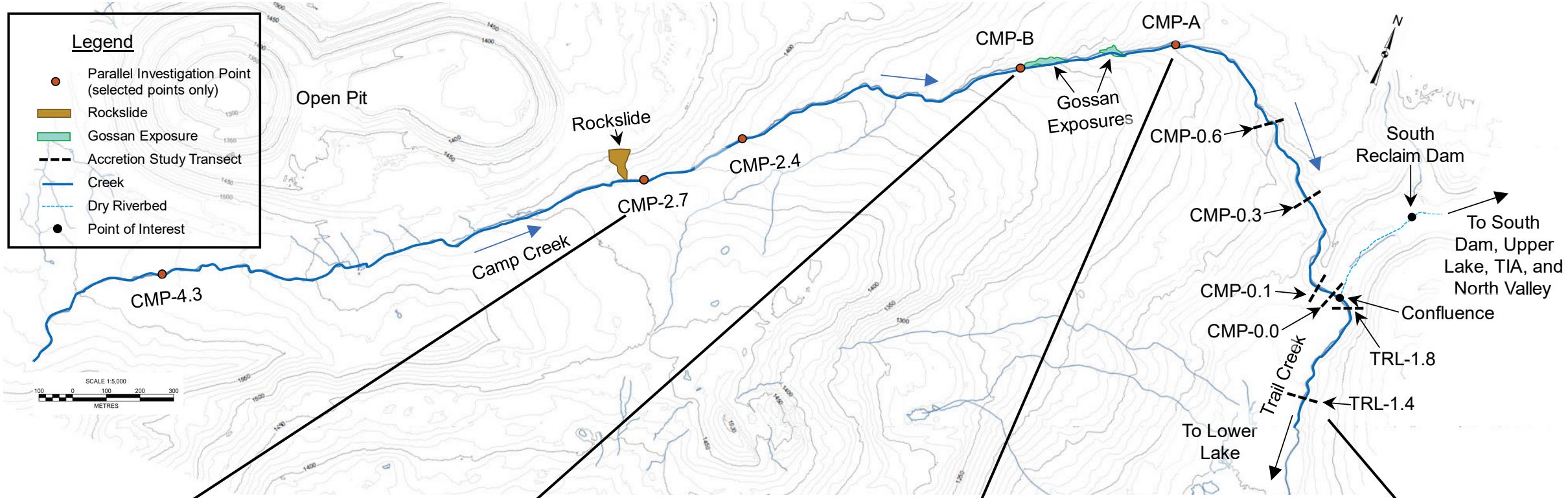
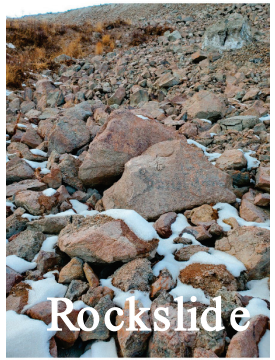
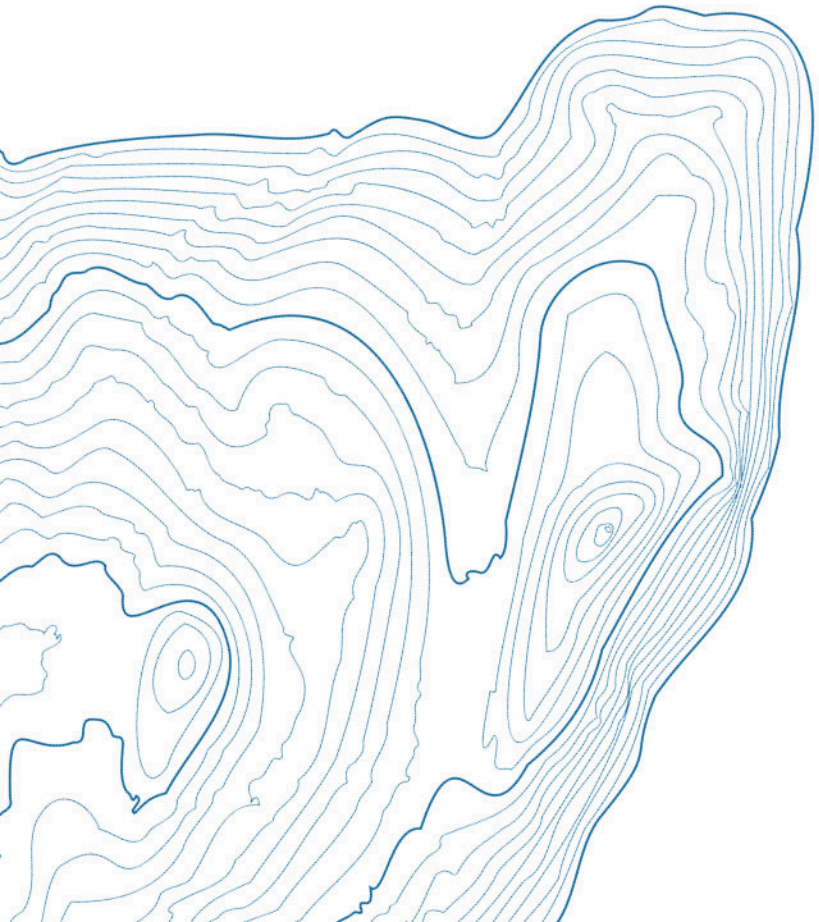


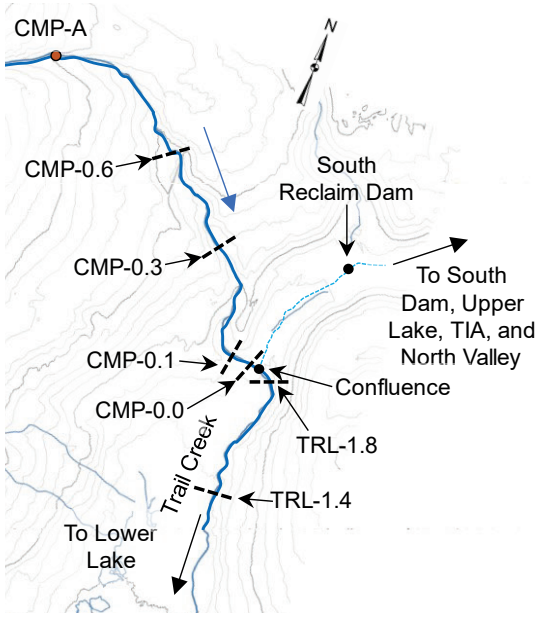


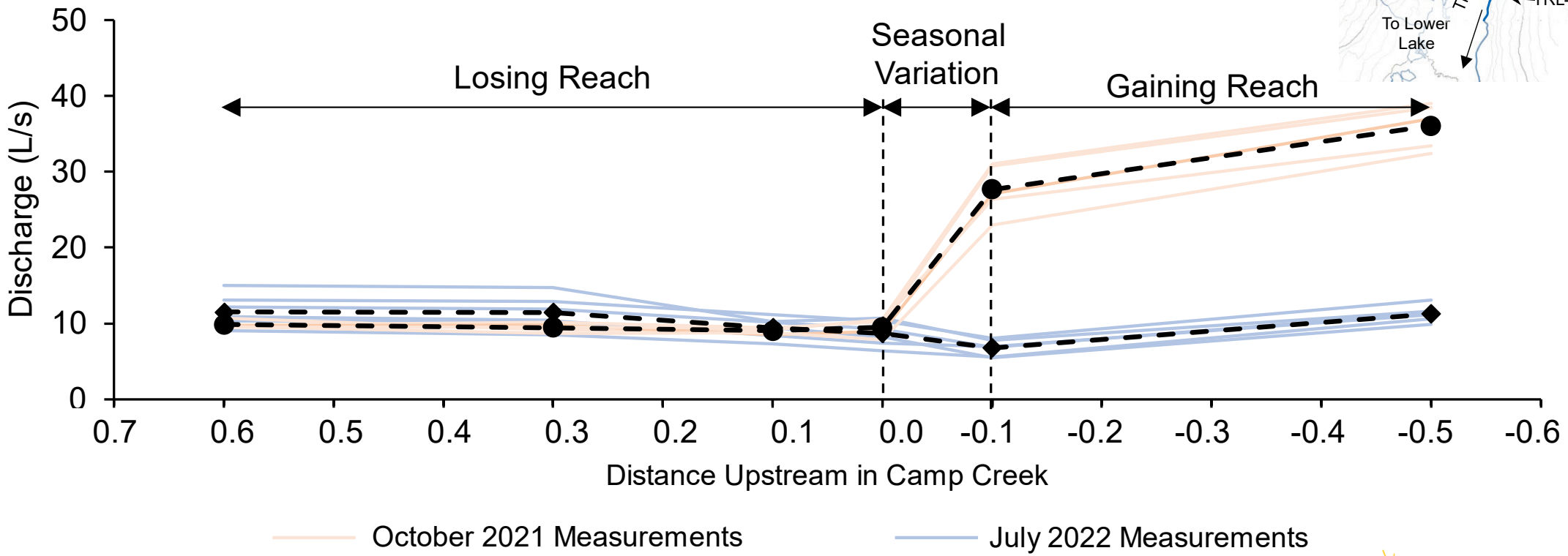


Results

Results

Accretion Study – Flow





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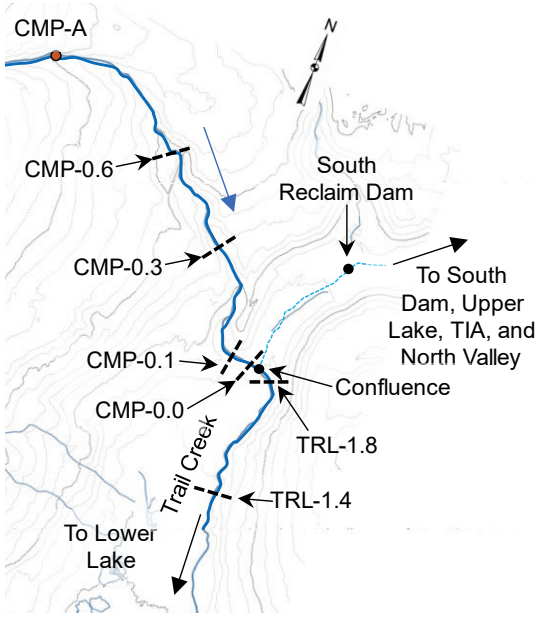

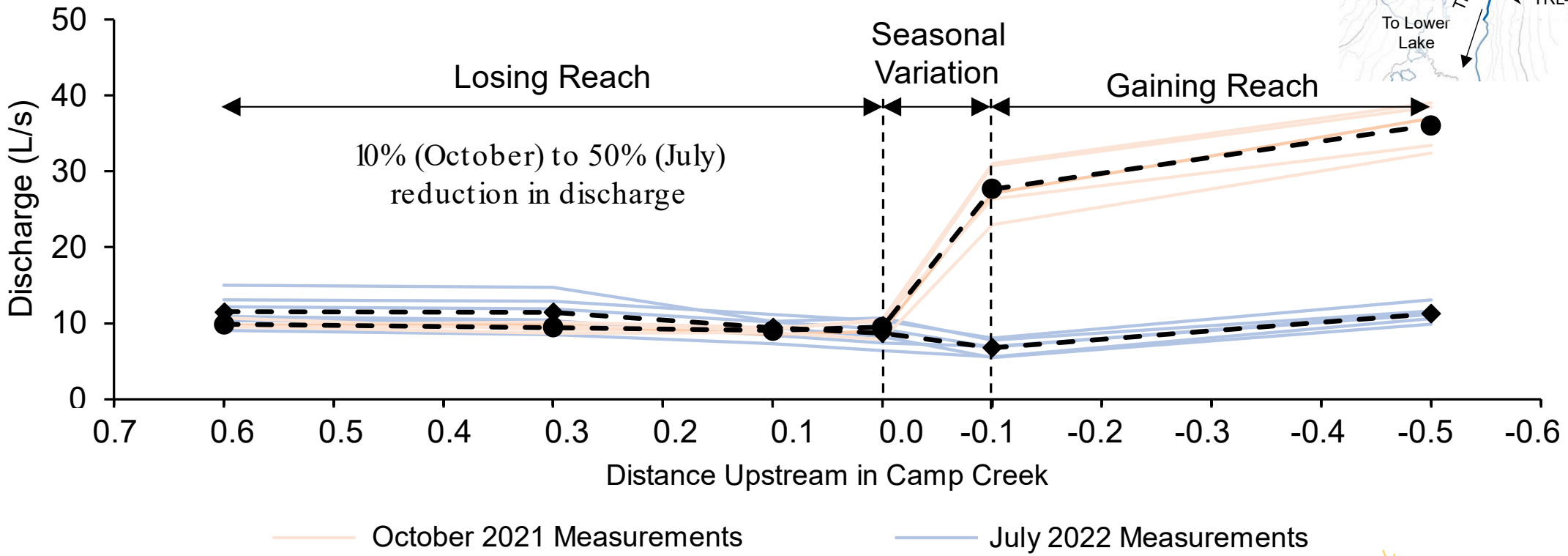

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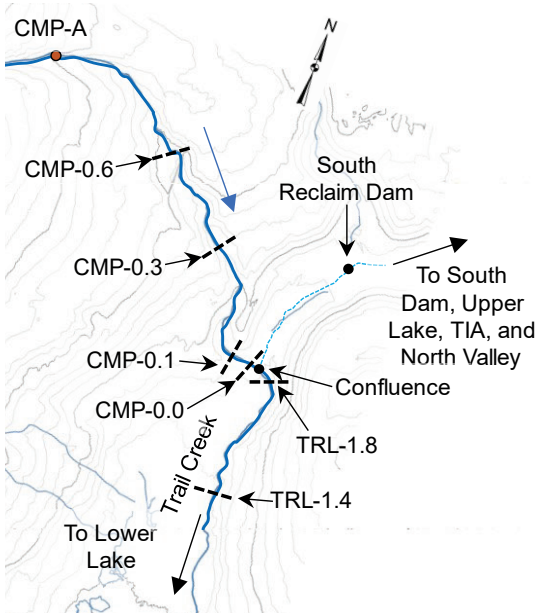
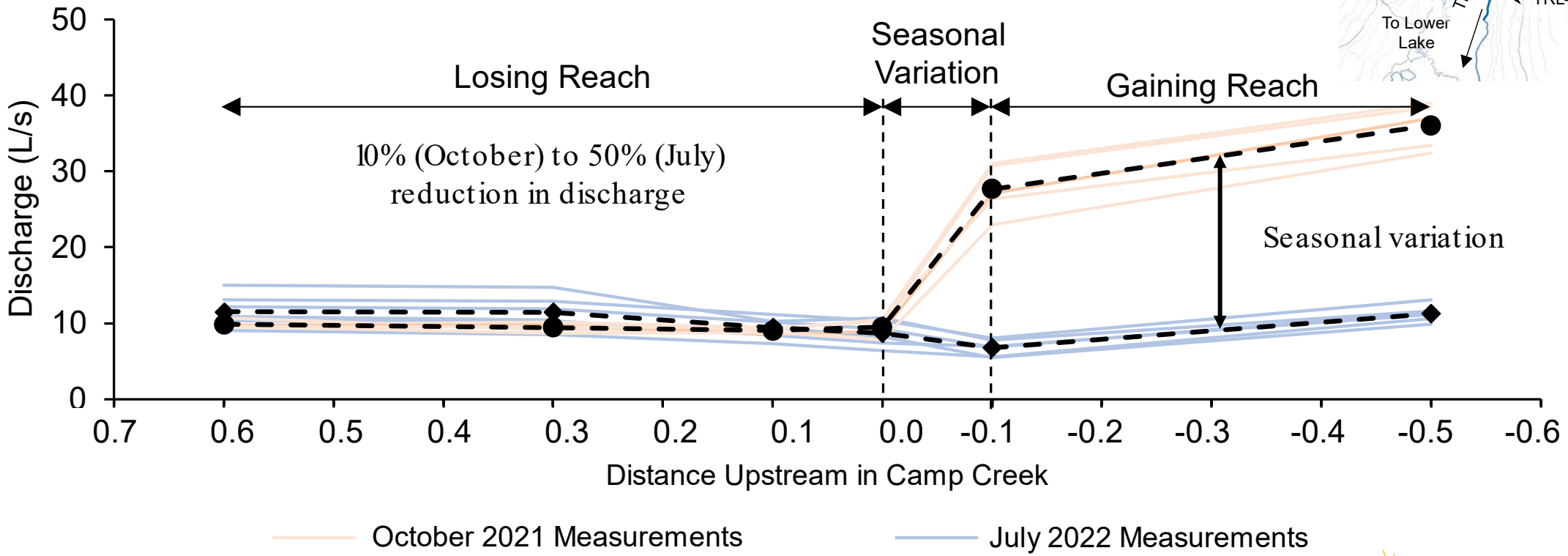
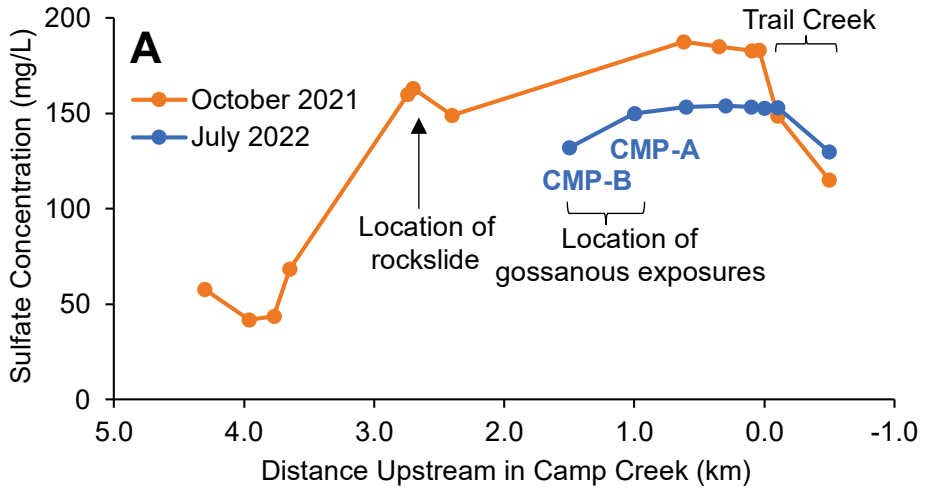


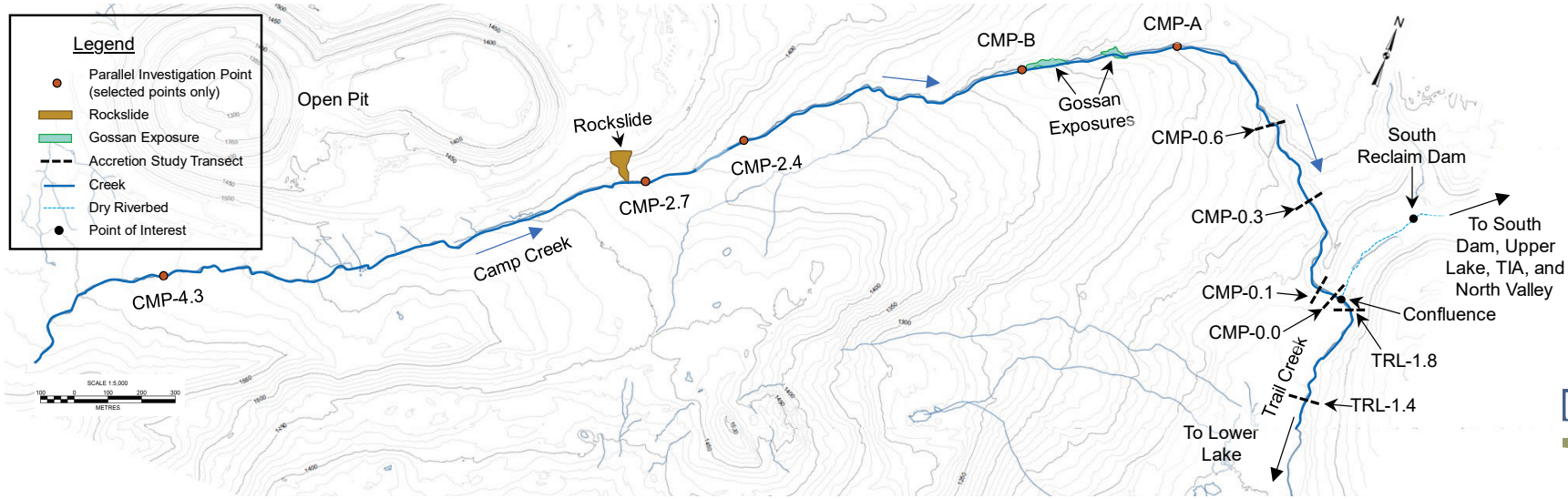


Results

Accretion Study – Sulfate



- SO_4 concentrations noted to increase near the rockslide, and downstream of the gossan exposures
- Concentrations remain steady along Camp Creek
- Concentrations begin to decrease at confluence with Trail Creek , and decrease by approximately one-third at TRL-1.4 (relative to CMP-0.0)



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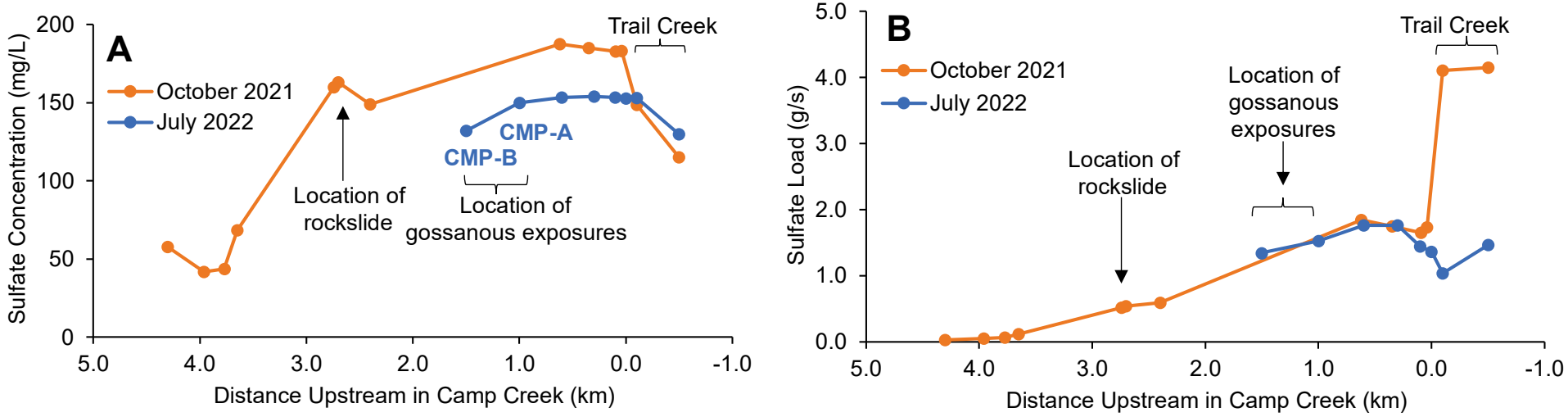
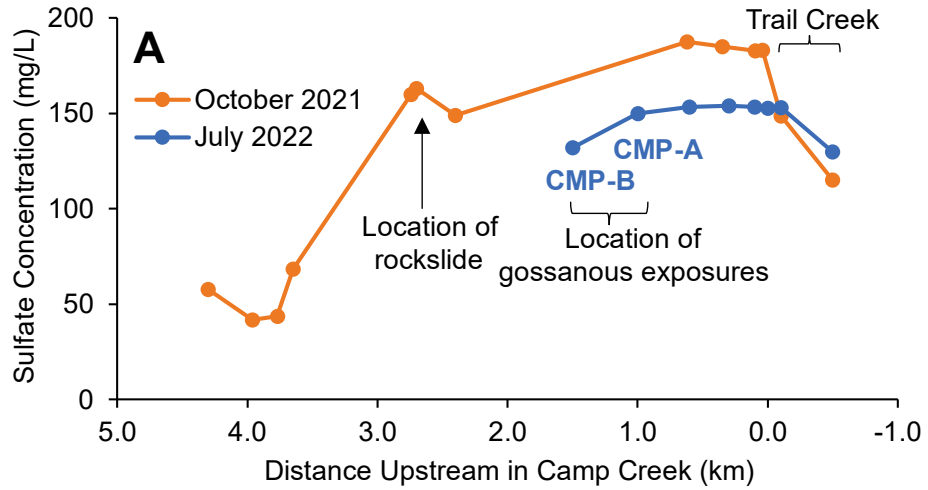
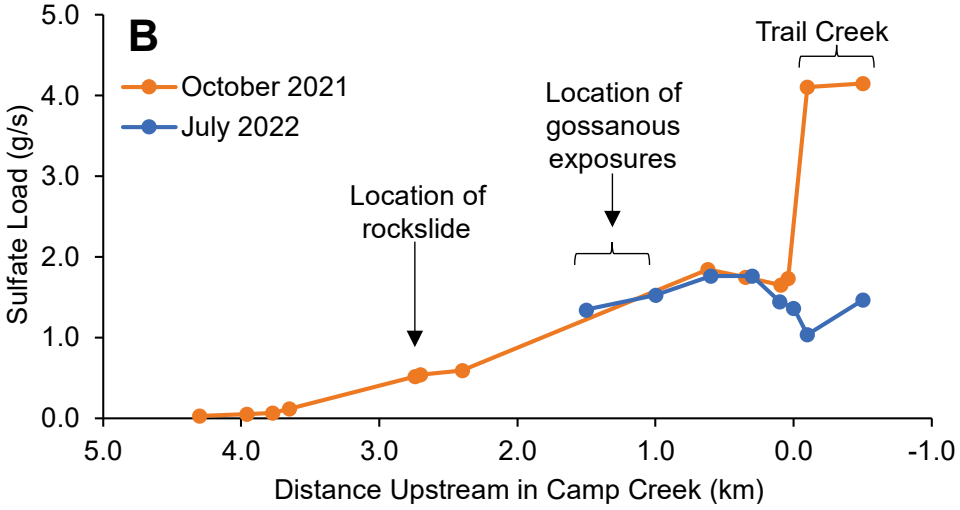


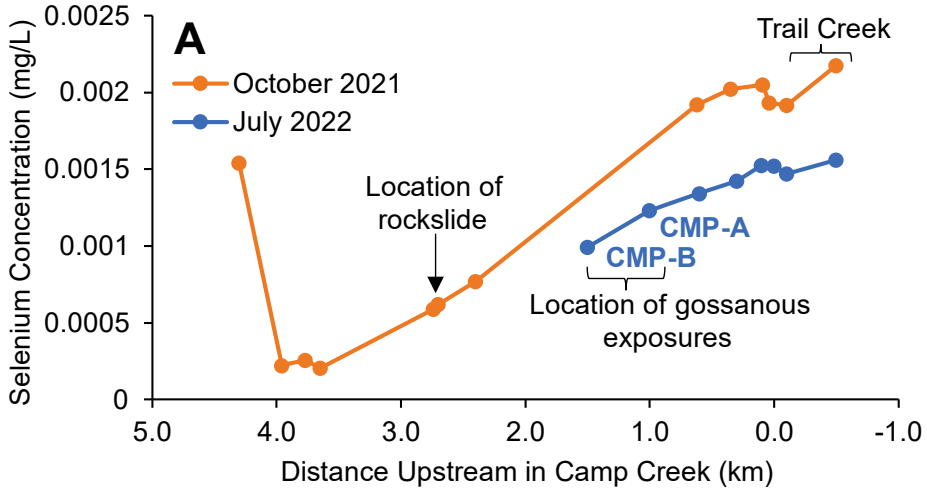
- Along Camp Creek
  - Sulfate loadings increase from upstream to downstream and indicate, in addition to the rockslide and gossan exposures, another source zone may be present between these areas
  - Sulfate loadings show slight decrease to no change along lower reaches
- At the confluence of Trail Creek
  - Sulfate loadings increase materially (i.e., 2 – 2.5x higher at TRL-1.8 than CMP-0.0), indicating decrease in concentrations is not attributed to dilution from fresh (or non-impacted) sources
  - Mixing calculations showed the sulfate concentration of groundwater contribution to Trail Creek was ~ 100 mg/L, similar to concentrations associated with plume's leading edge

Results

Accretion Study – Sulfate & Selenium







- Selenium showed similar trends as sulfate, with generally increasing concentrations along Camp Creek and notable increases near the rockslide and gossan exposures.
- Notable difference between sulfate and selenium is the increase in selenium concentration along Trail Creek

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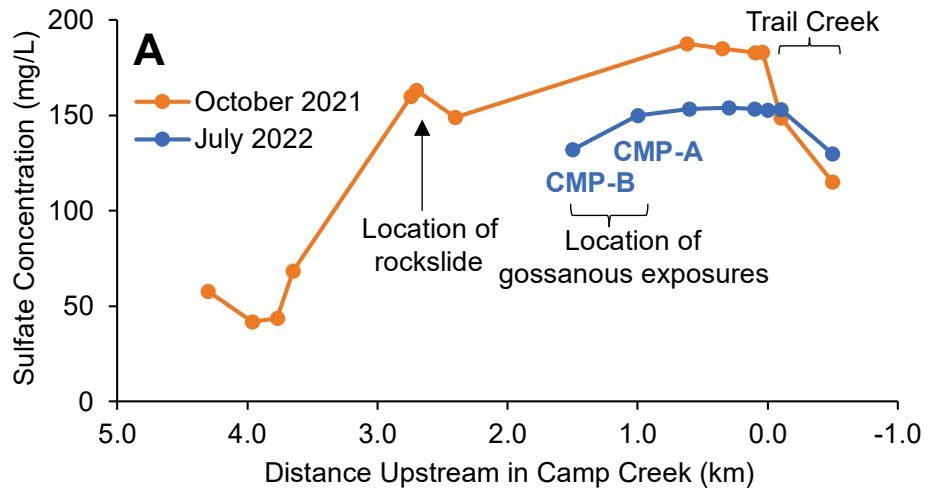
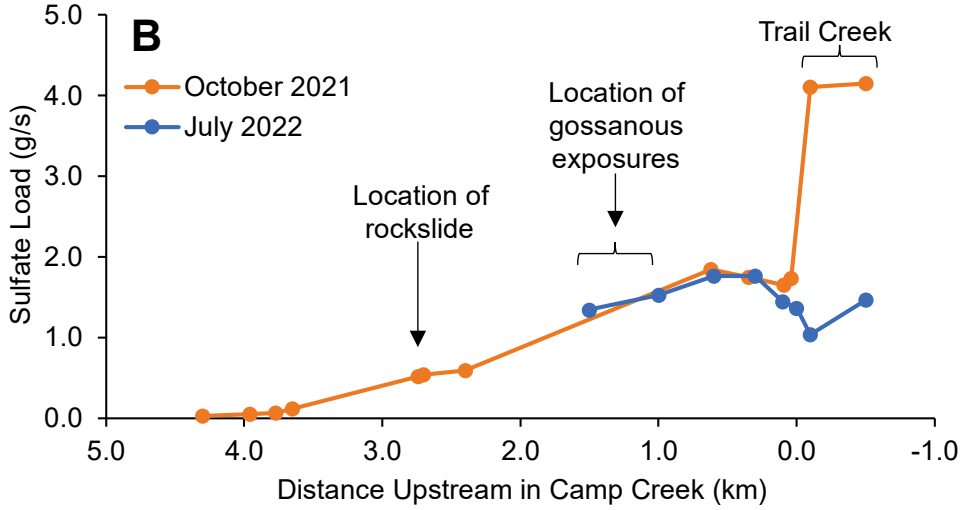
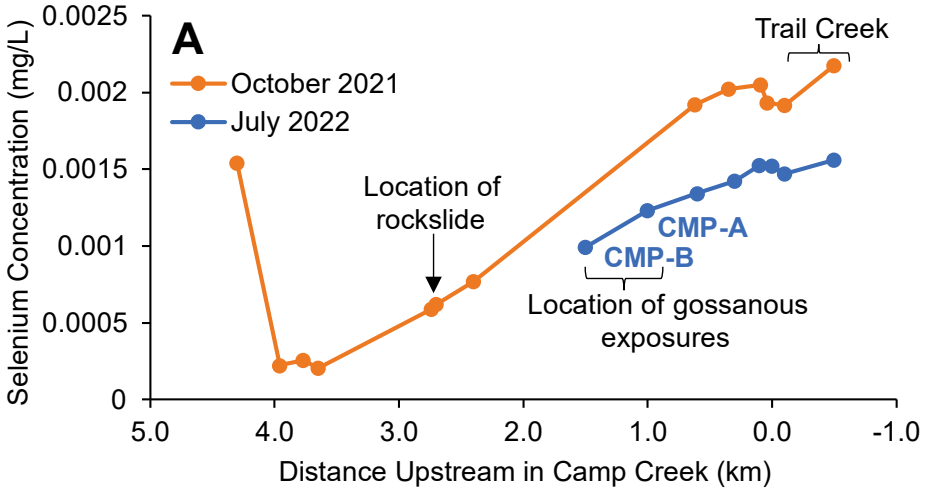
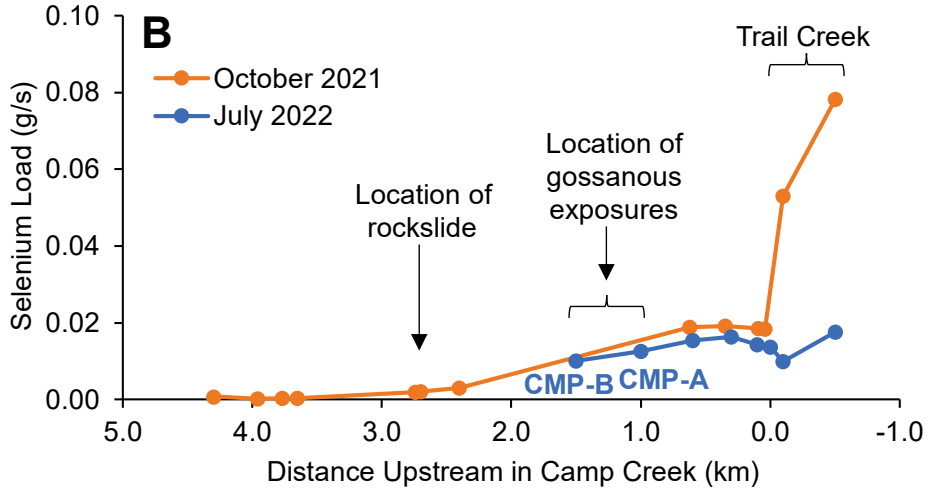
Results

Accretion Study – Sulfate & Selenium

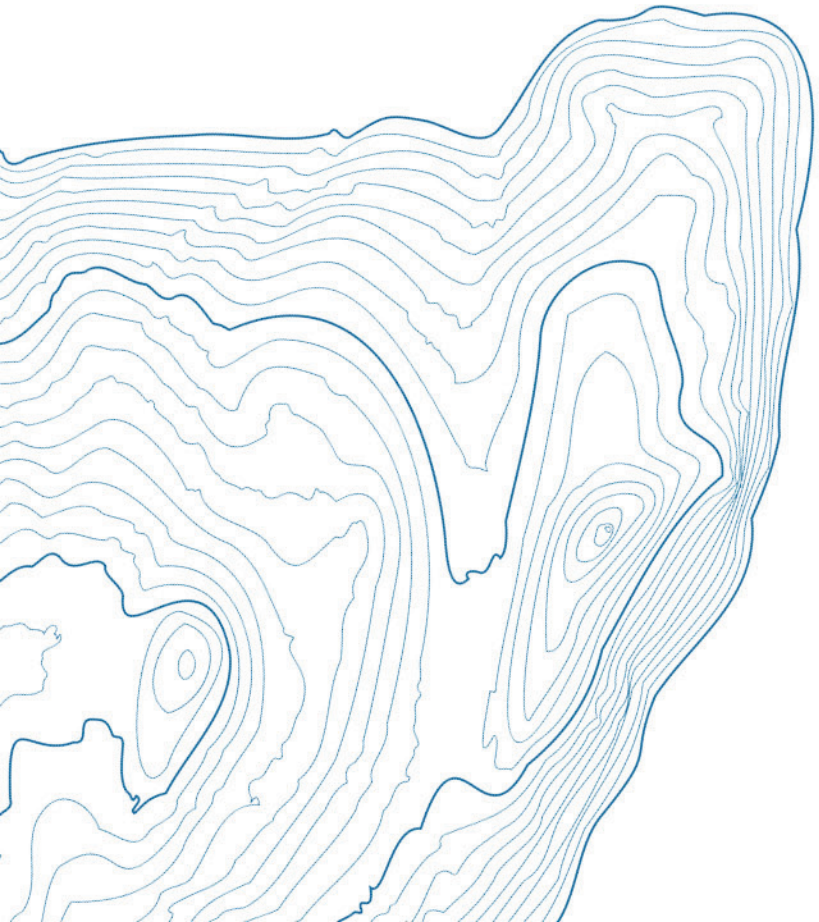








- Similar loading observations between sulfate and selenium; increasing from upstream to downstream
- Along Trail Creek, selenium loadings increase over a larger reach (Oct event), which is suggestive of a discharge zone to Trail Creek from the variably impacted shallow and/or deep aquifer



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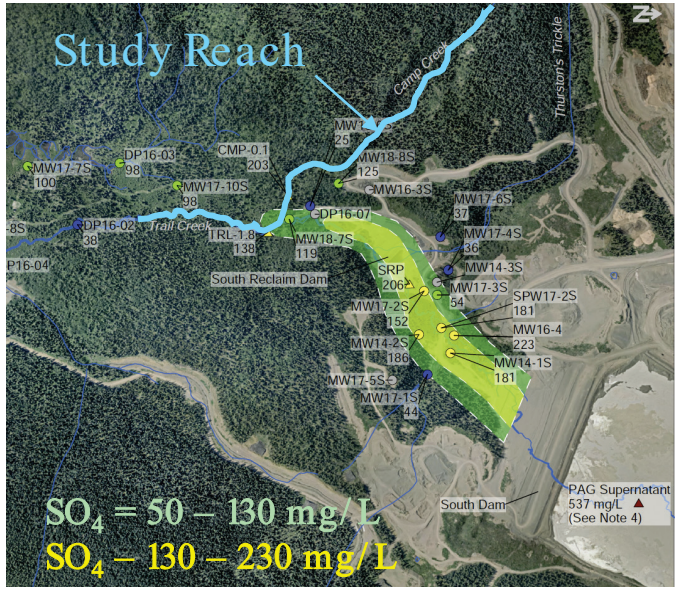

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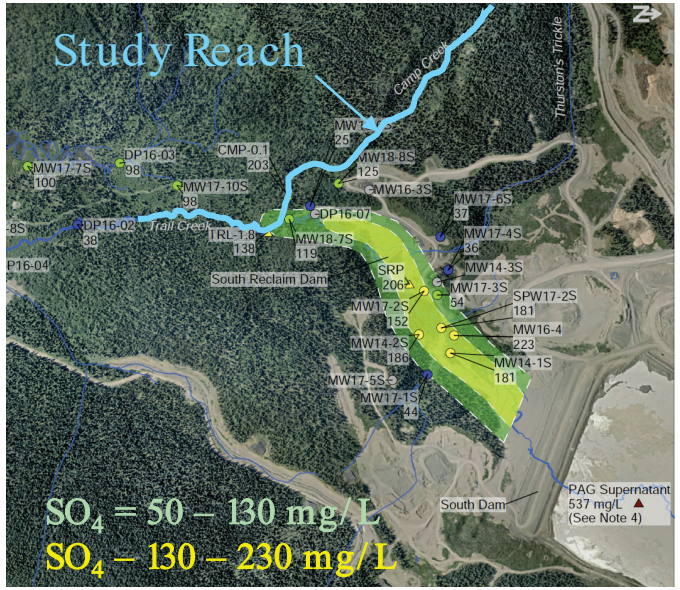
Findings

Site Specific

- **Study Findings**
  - Camp Creek is interpreted to be a losing creek along its lower reaches, while upper reaches of Trail Creek are generally gaining, with seasonal variation.
  - There is potential for hydraulic communication between surface watercourses and the South Valley shallow aquifer and potentially the deep aquifer, therein supporting the likelihood for higher background sulfate values in areas of the South Valley near Camp Creek (i.e., downstream of the seepage reclaim dam).
  - The leading edge of an interpreted sulfate plume in the South Valley shallow aquifer was better constrained by results from the flow and load accretion study. That is, the leading edge is interpreted to be downgradient of the seepage reclaim dam, and contributes to baseflow and loadings reporting to Trail Creek.



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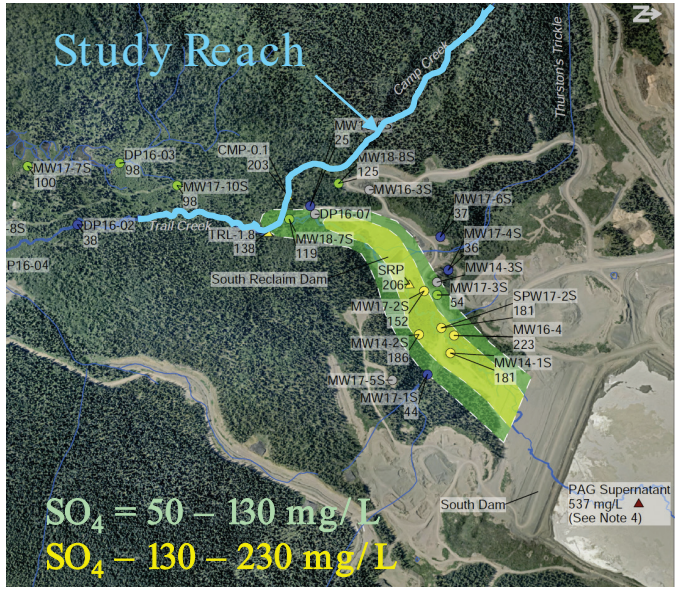
Findings

Site Specific

- **Study Findings**
  - The upper reaches of Camp Creek were identified as contributing substantial loadings to the creek, which included a rockslide near CMP-2.7 and a 1.4 km reach (downstream of the rockslide) that includes a 500 m (long) gossanous exposure.
  - Given these observations, this study suggests the naturally mineralized nature of surface or near surface exposures along Camp Creek embankments likely influence the creek's chemistry, which is conveyed farther downstream and toward the South Valley.



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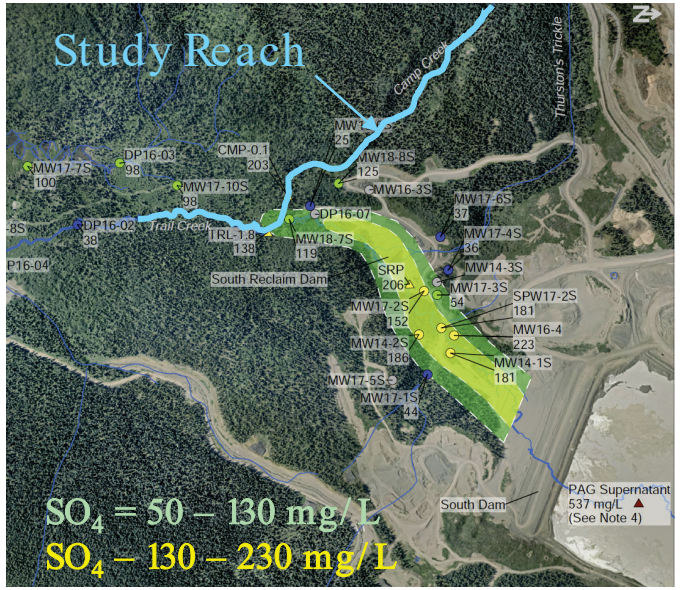
Findings

Generalized

- **Study Findings**
  - The flow and load accretion study demonstrates the interconnected state of this watershed, which is not uncommon in other watersheds.
  - Hyporheic exchange should not be discounted when investigating contaminant sources and transport, and the confounding effects of multiple contaminant sources should not be viewed as insurmountable.
  - Investigative methods such as flow and load accretion studies are effective tools for the dissociation of sources, as noted by this study in better constraining a plume's leading edge, despite being masked by elevated background conditions.



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Contact us

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BGC Locations

CANADA	EDMONTON	FREDERICTON	DOMINICAN REPUBLIC
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CALGARY	HALIFAX	SANTIAGO	