

# SELENIUM ATTENUATION VIA REDUCTIVE PRECIPITATION IN DIVERSE SATURATED AND UNSATURATED SUBSURFACE CONDITIONS

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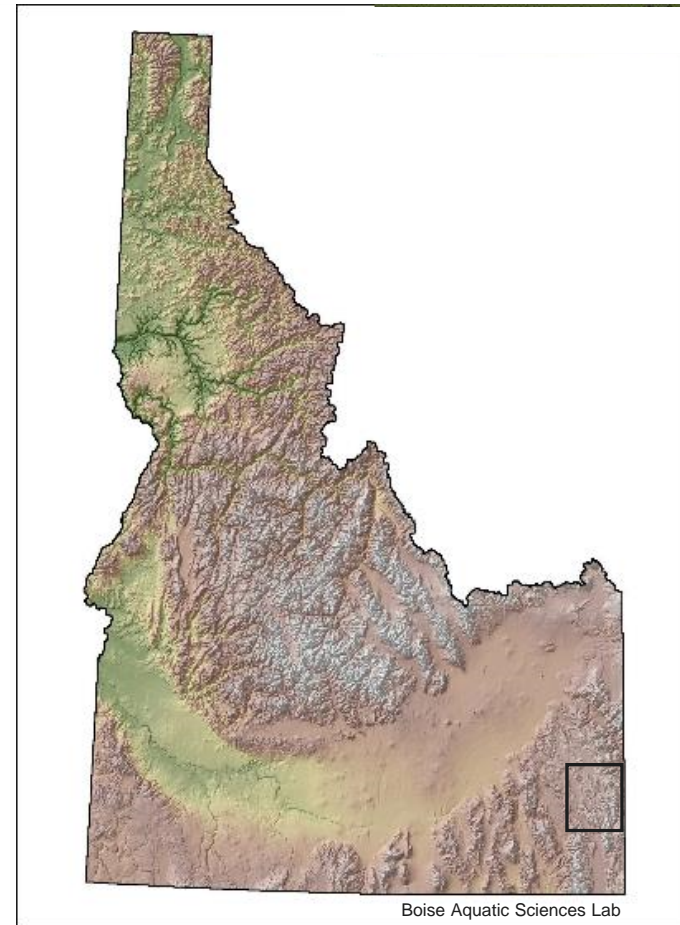
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## Outline

- Idaho phosphate mining and selenium (Se) impacts
- Se release and attenuation
- Conceptual site model
- Case studies
- Conclusions and implications

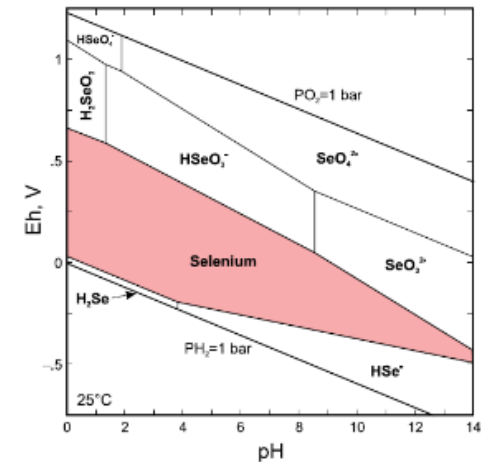
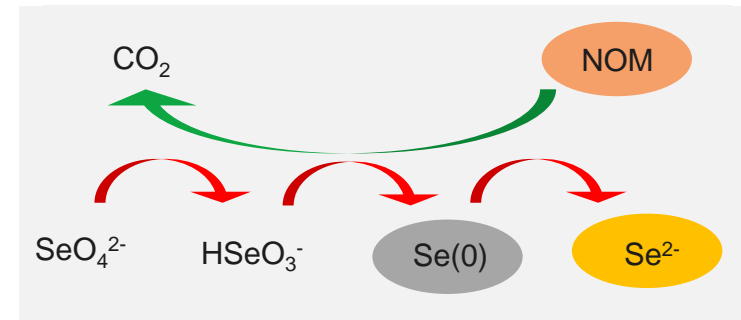
## Phosphate Mining in SE Idaho

- Western Phosphate Field
- Meade Peak Member of Phosphoria Formation source of phosphate ore
  - Se content up to 1,040 mg/kg (World Shale average ~ 1 mg/kg)
  - Enriched in other metals (e.g., As, Cd, Cr, V)
- Mining-related surface water / groundwater impacts
  - Local and regional
- Area-wide and site-specific investigations



# Se Release and Attenuation

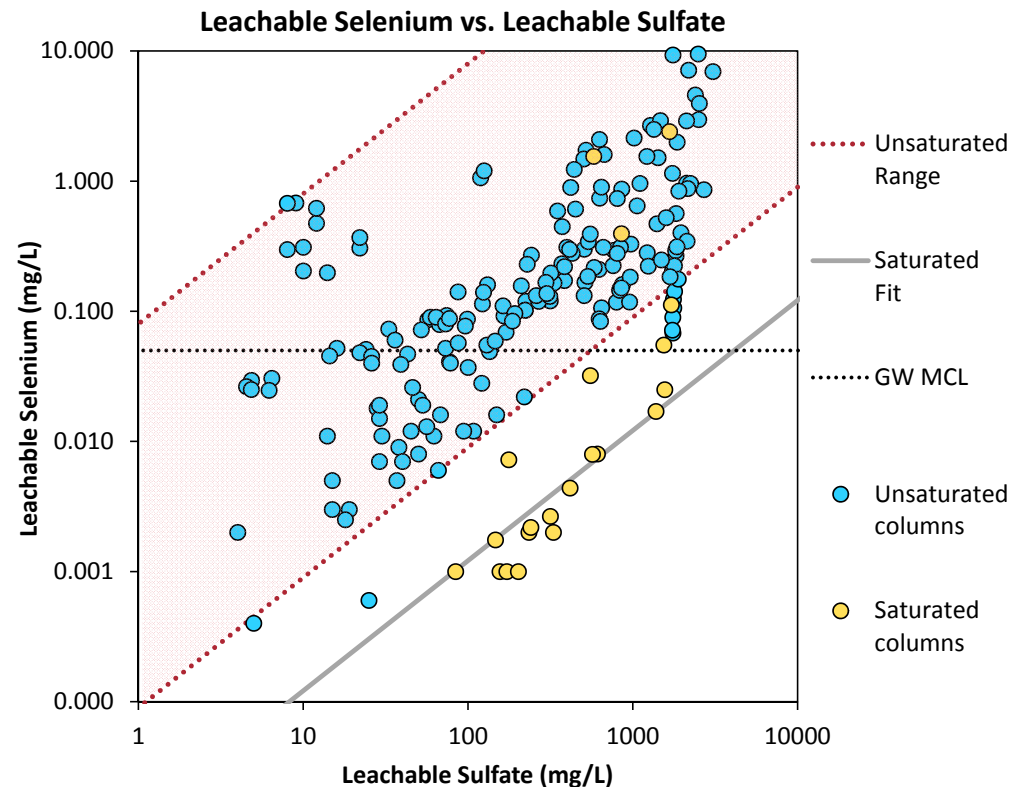
- Oxidative dissolution of Se
  - Sulfides/selenides, elemental Se, organic matter
  - Groundwater, seeps > 1 mg/L
- Sulfide oxidation → release of  $\text{SO}_4$ , divalent metals
  - Abundant buffering capacity, neutral pH
- Reduction to elemental Se, selenides
  - Biotic and abiotic (slow) processes
  - Requires actively reducing conditions
  - Immobilization of Se (re-oxidation slow)



Ford et al., 2007, EPA/600/R-07/140

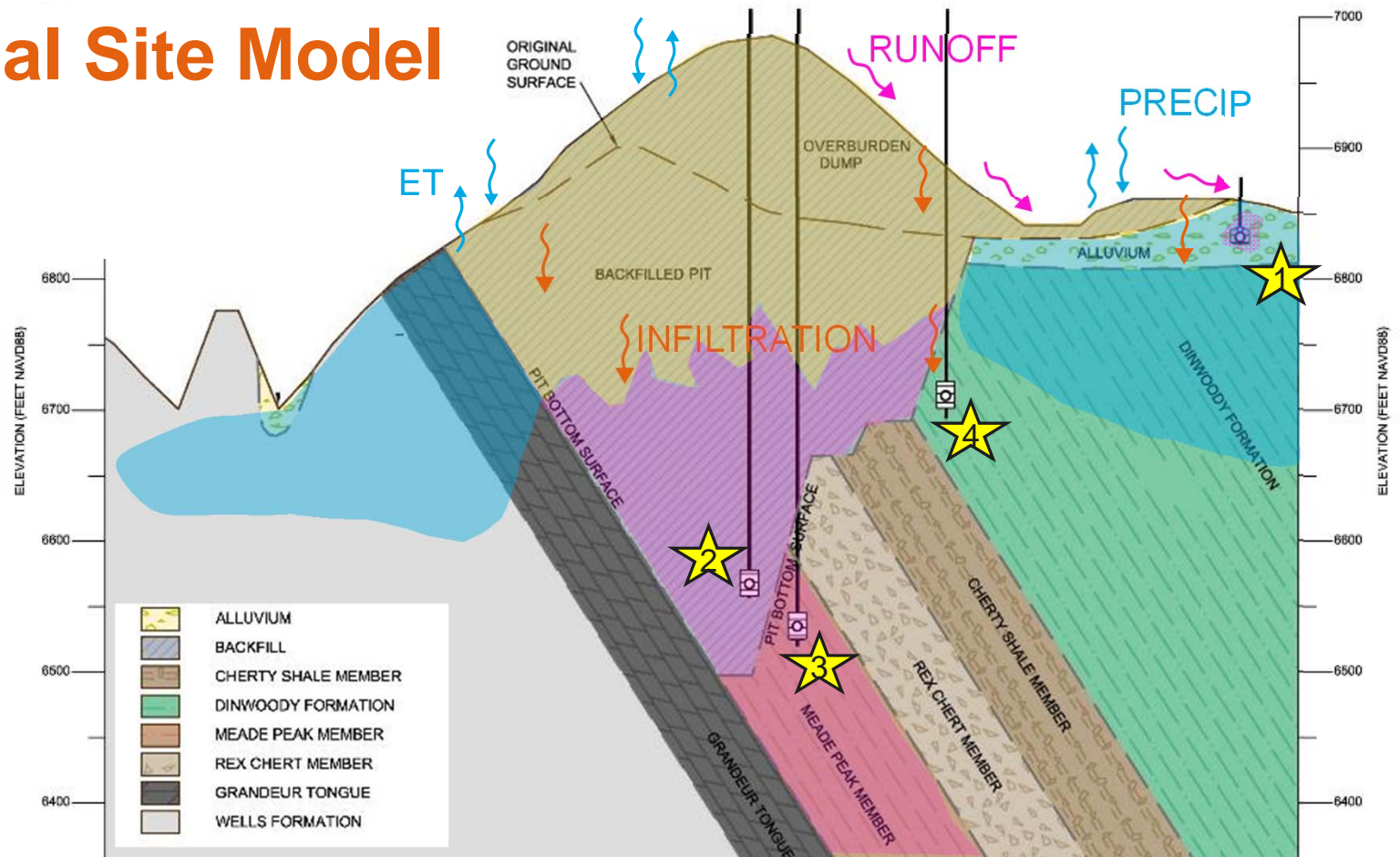
## Column Testing Data

- Saturated vs. unsaturated tests
- Correlation between leached Se and  $\text{SO}_4$
- Much lower  $\text{Se}:\text{SO}_4$  ratio for saturated columns
  - Less oxidative dissolution
  - Se reduction

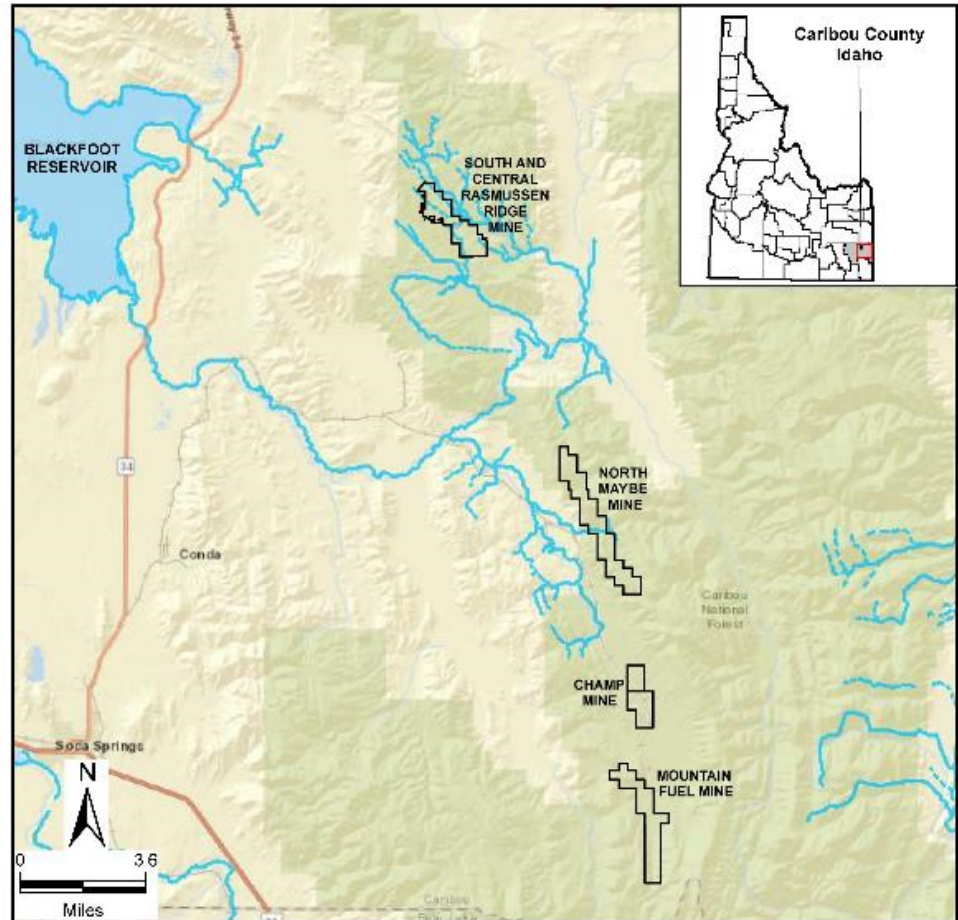


**$\text{Se}:\text{SO}_4$  ratios can be used to identify Se reductive precipitation**

# Conceptual Site Model

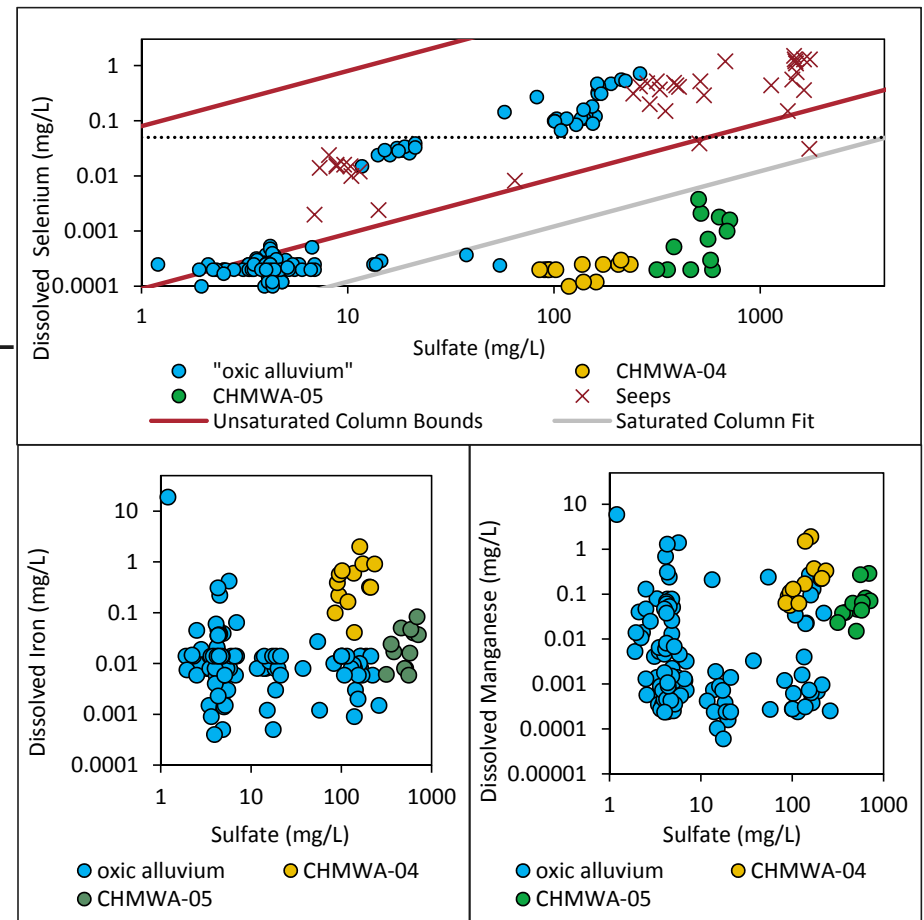


# Overview of Sites



## Se Reduction in Shallow Alluvium, Wetland Environment

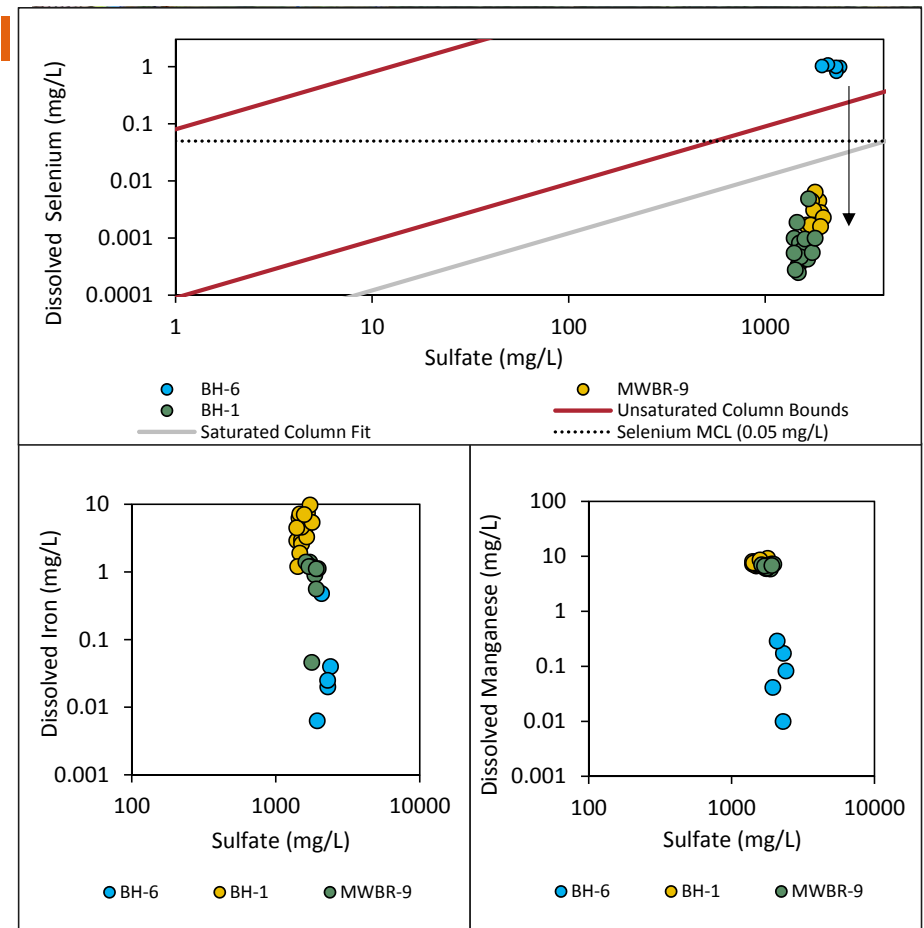
- Site impacts
  - Seeps: Se up to 1.46 mg/L
  - Oxidic alluvial groundwater: Se up to 0.7 mg/L
- Isolated natural reducing conditions
  - Wetlands along Goodheart Creek
  - DO, Fe, Mn, seasonally variable
  - Low Se, high  $\text{SO}_4$
- Se reduction in groundwater below wetlands





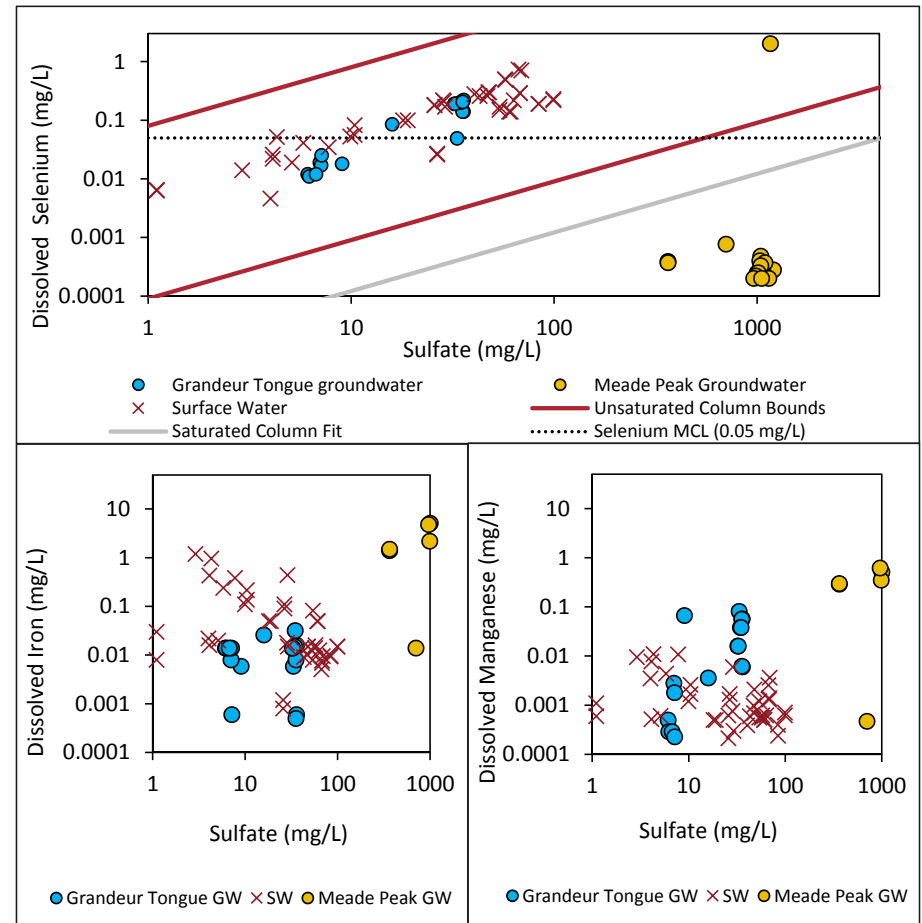
## Se Reduction in Mine Pit Backfill

- Saturated pit backfill vs external waste dump
- Se, SO<sub>4</sub> release in external waste groundwater
- Reducing conditions in pit backfill
  - Low DO, elevated Mn and Fe
  - Low Se, high SO<sub>4</sub>
  - Se reduction
- Waste rock configuration is key



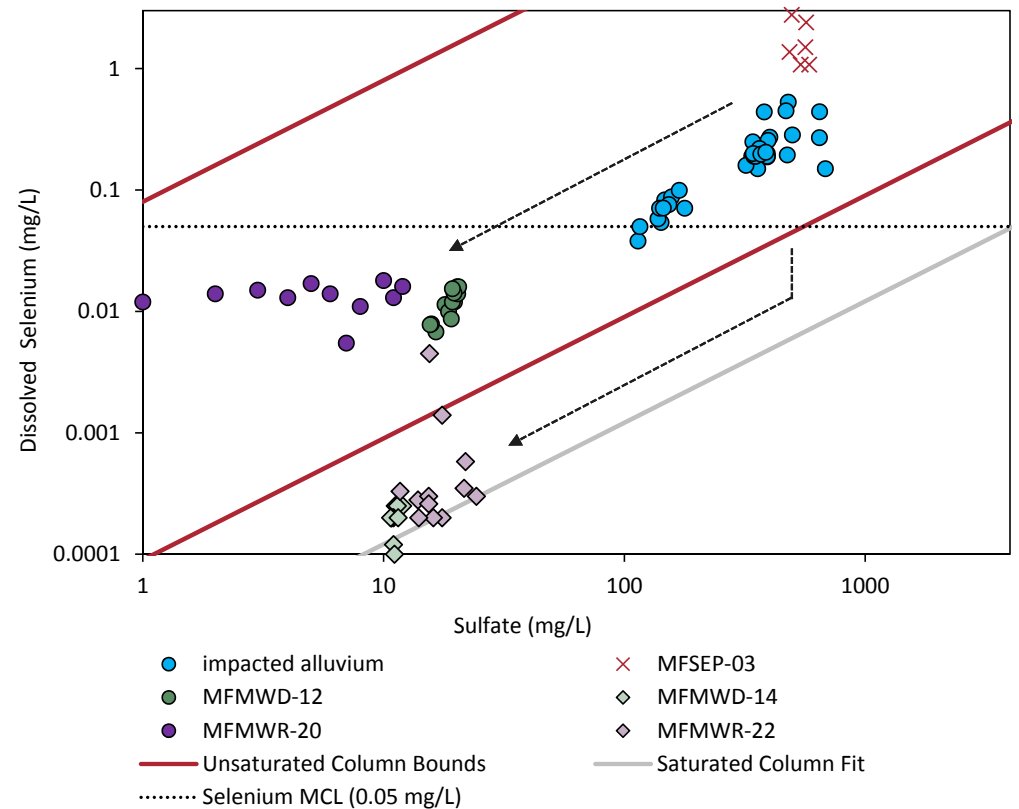
## Se Reduction in Shale Bedrock below Pit

- Impacted SW, infiltration
  - Se up to 0.74 mg/L
- Infiltration to Bedrock groundwater
  - Phosphatic shale member
  - Dolomite (Grandeur Tongue Member)
- Se reduction in shale member, where conditions suboxic



## Se Reduction in Unsaturated Waste Dump

- Impacted seeps, alluvial and bedrock GW on margins of dump
- Comparison between bedrock below, downgradient of dump
- Downgradient of dump, diluted impacts
- Below dump, diluted attenuated impacts



## Conclusions and Implications

- Se reduction to below levels of concern observed in diverse subsurface conditions in the Phosphate Patch
- Improves conceptual understanding of Se dynamics in environment
- Opportunities to harness natural process
  - Mine planning /reclamation
  - Mine remediation

# Questions

