

Groundwater-Surface Water Interaction

City of Calgary Nose Creek Landfill

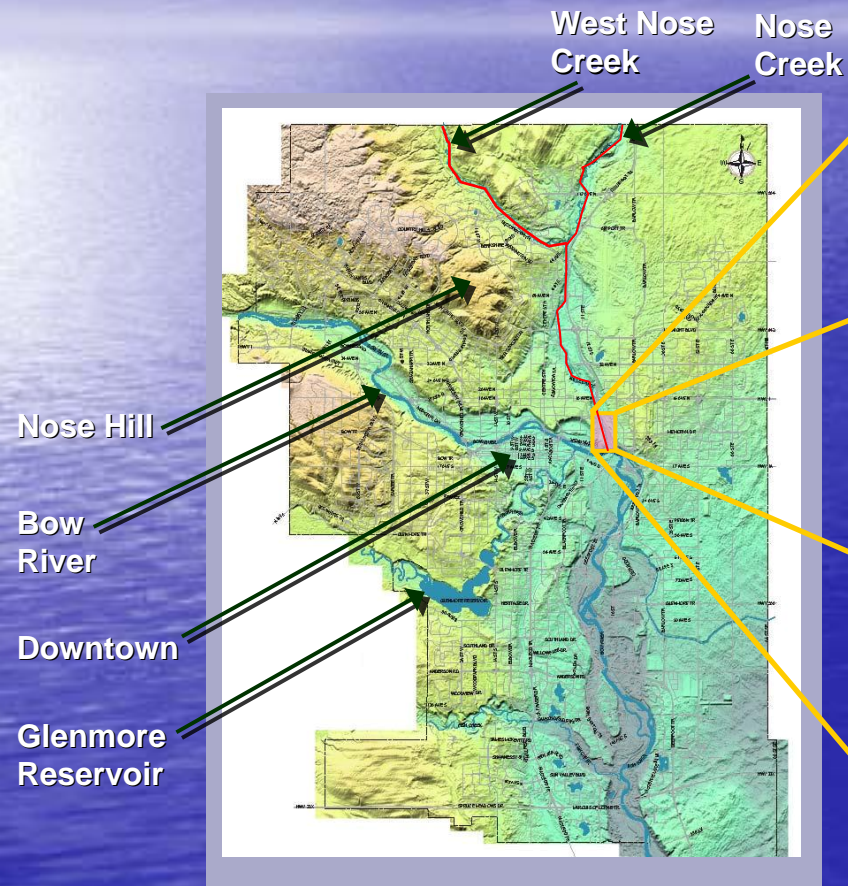
B. Marc Adams Sean Buckles Tom Dance
Corey Colbran

Presentation Outline

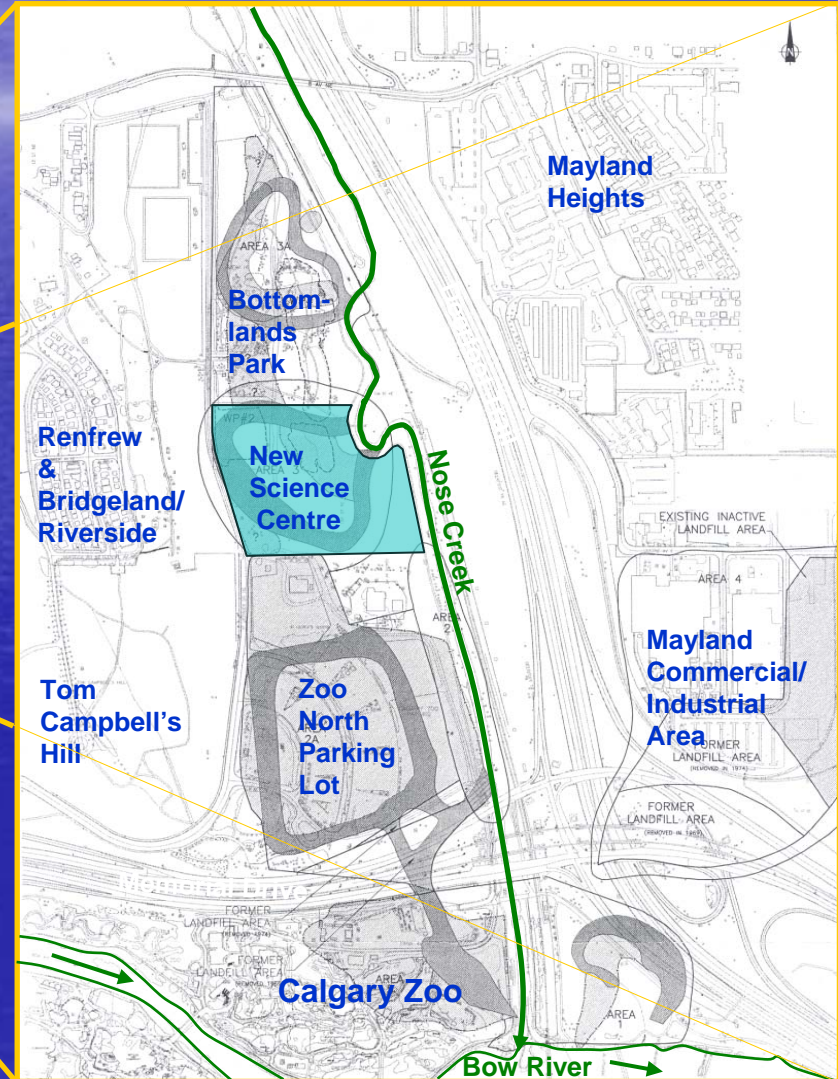
- Nose Creek & Nose Creek Landfill
- Site Conditions and Data Needs
- 2008 Investigation Program
- Conclusions

Nose Creek & Nose Creek Landfill

Site Location



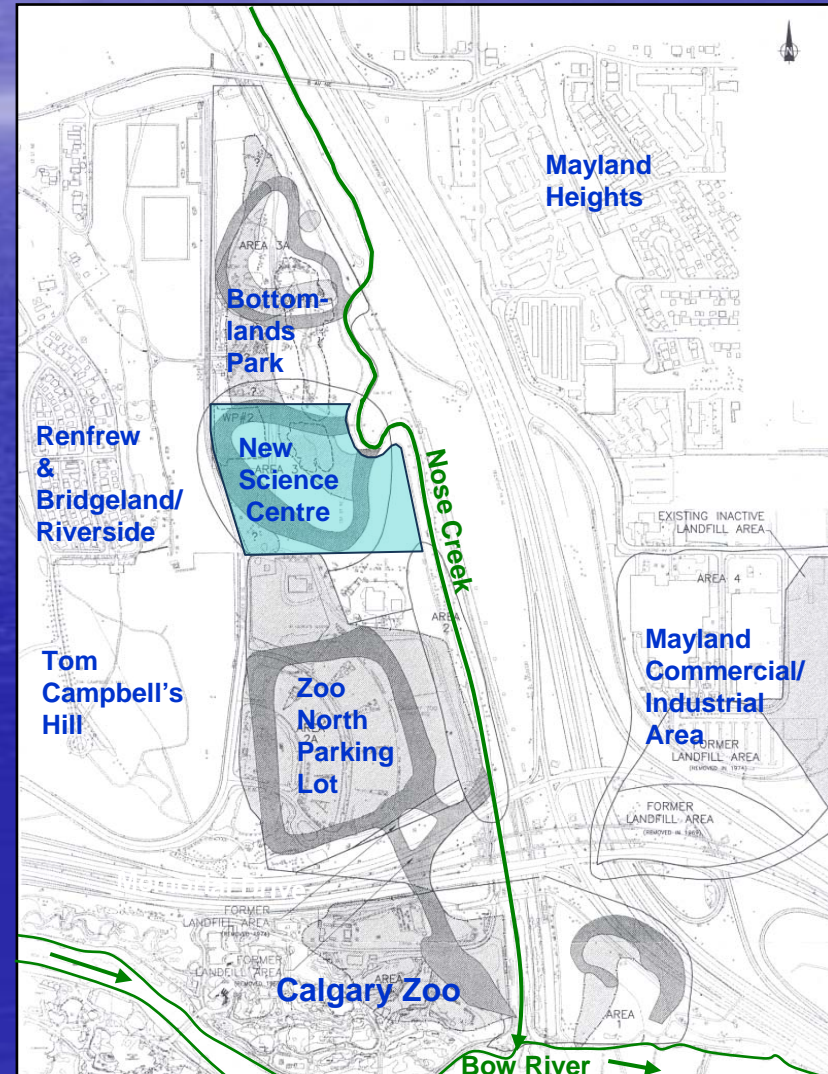
City of Calgary



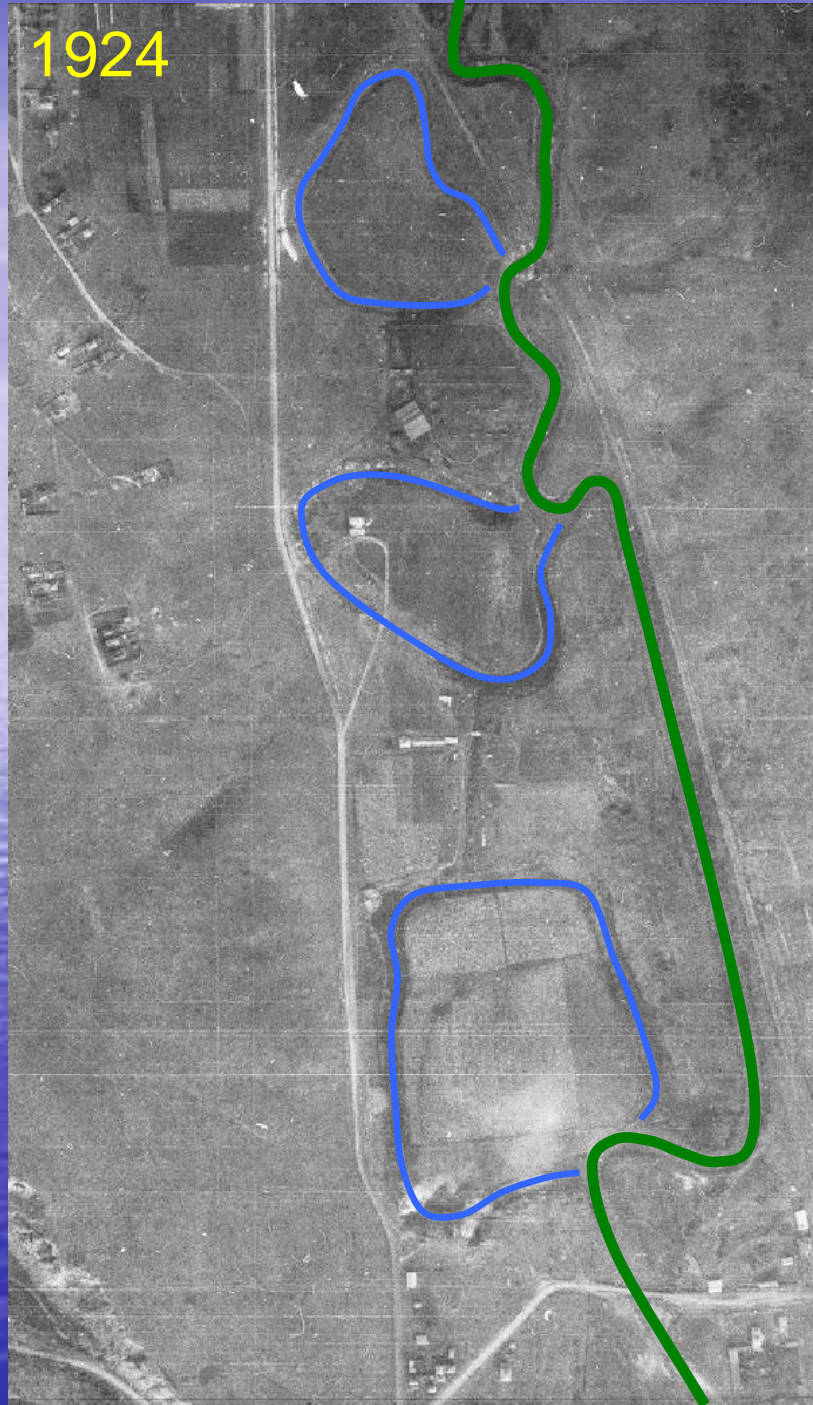
Nose Creek Landfill

Background

- Landfilling occurred from as early as 1914 to early 1980s
 - Official City facility ceased operation in 1967
 - Early activity and post-1967 period lacks documentation
- Oxbow lakes, stream channel, valley ravines, general low lying areas were filled
- Deposits of household and construction waste



1924



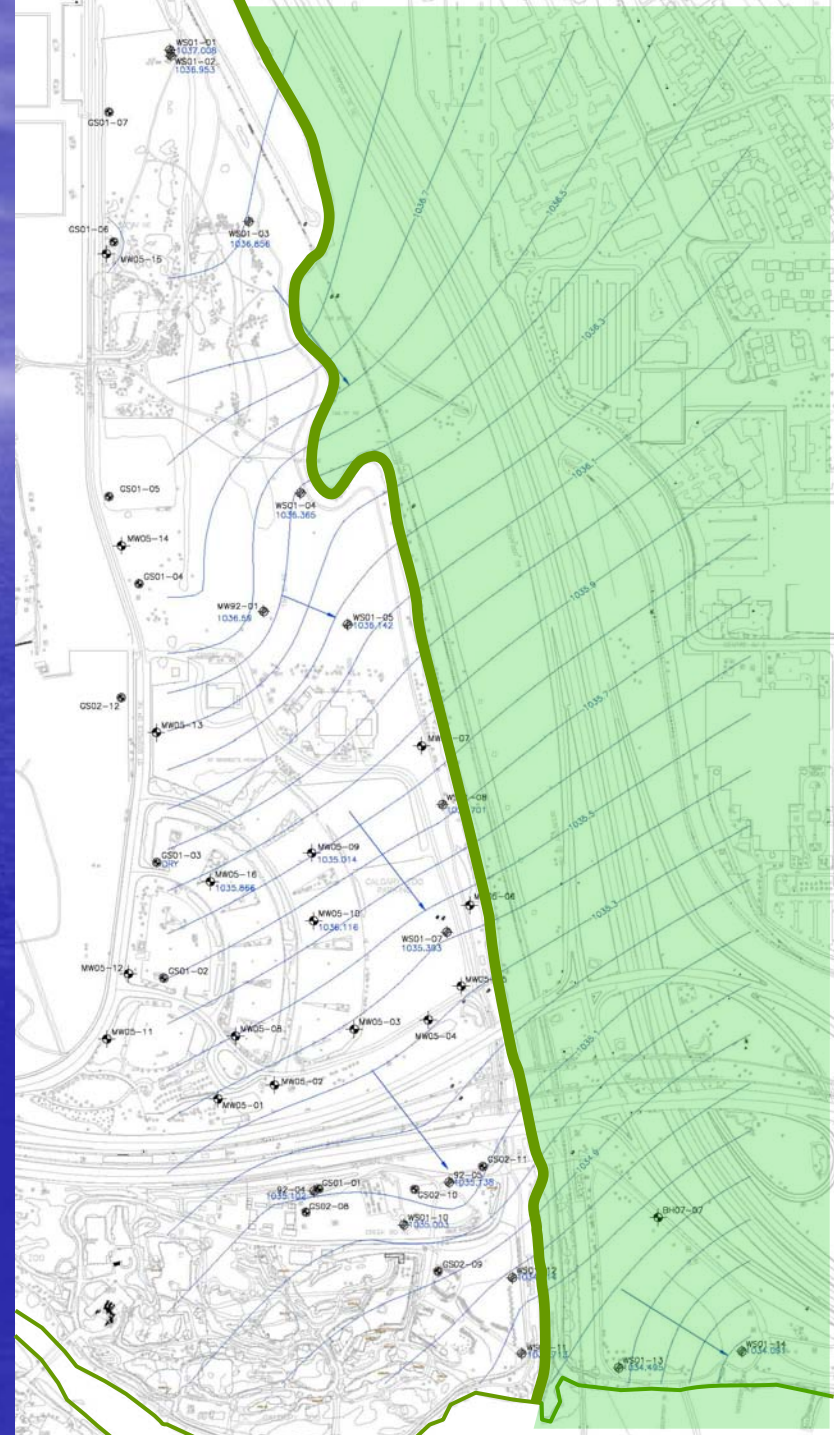
~2004



Site Conditions and Data Needs

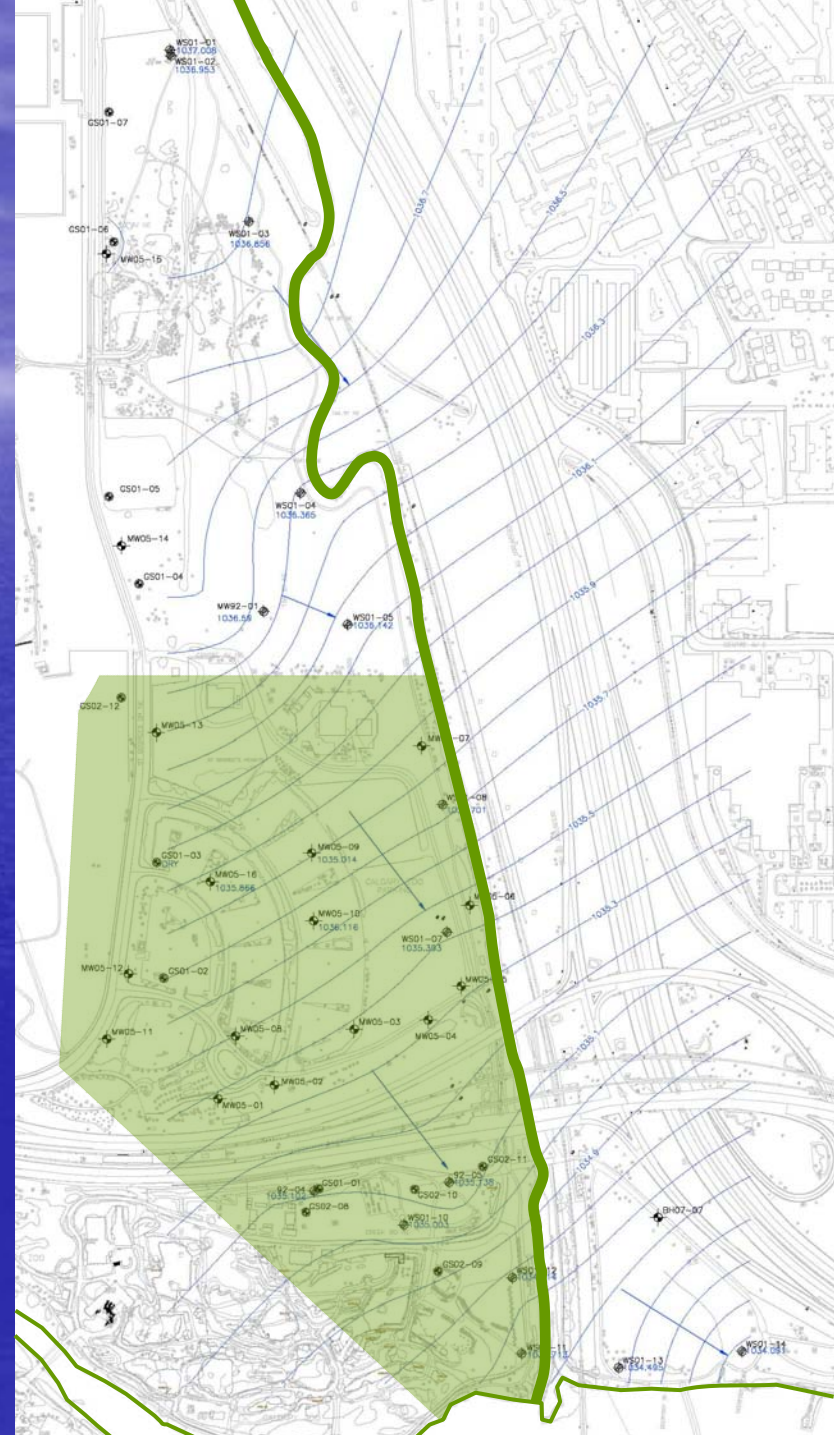
Groundwater Investigations

- From early-1990s to 2006
 - 41 monitoring wells west of Nose Creek
 - GW impacts identified
 - Inorganics (primarily Eco issue)
 - Organics (primarily HH issue)
- Uncertainty
 - Ultimate discharge area of landfill groundwater Nose Creek or Bow River?
 - Attenuation as GW moves to Bow River is significant



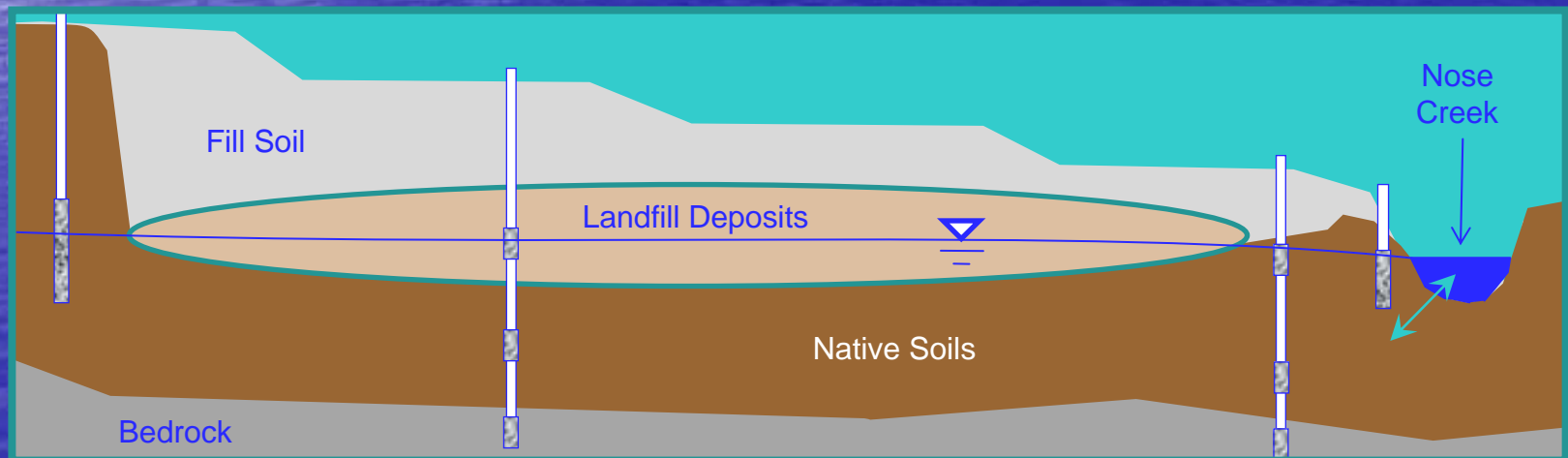
Risk Assessments

- Screening Level Ecological and Human Health Risk assessment in 2007
 - Screening level assessment indicates potential Eco impact to Nose Creek
 - Conservative assumptions need to be refined with further investigation
 - Supplemental risk assessment needed



2008/09 Objectives

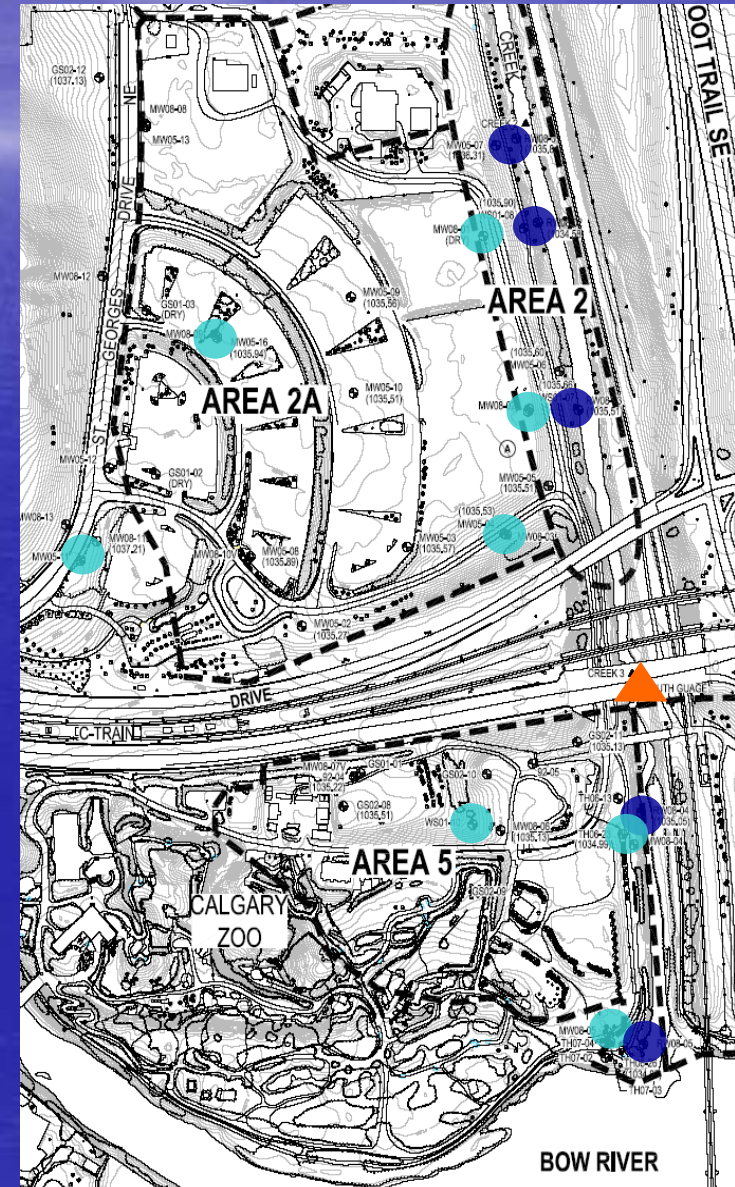
- Identify groundwater impacts reaching Nose Creek
 - Horizontal and vertical delineation of groundwater impacts
 - Define 3-D groundwater flow regime
 - Identify GW quality adjacent to creek
 - Identify GW-SW interaction



2008 Investigation Program

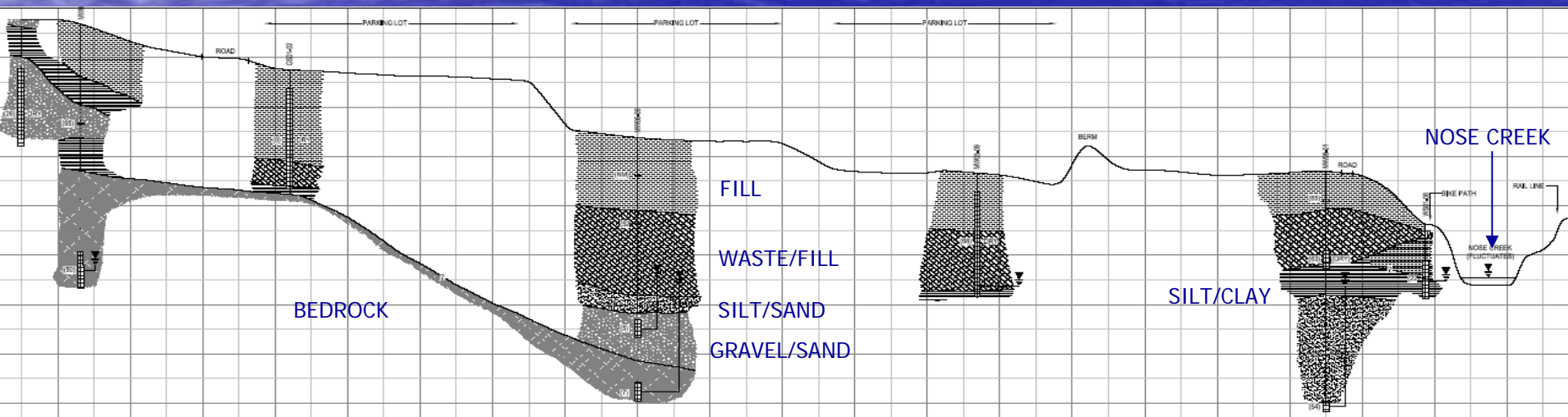
2008 Project Scope

- Seven (7) nested well locations ●
 - screened in all hydrostratigraphic units to shallow bedrock
- Five (5) creek-side drive-point wells ●
- Two (2) staff gauges located in creek ▲
- Comprehensive survey of all wells and gauges



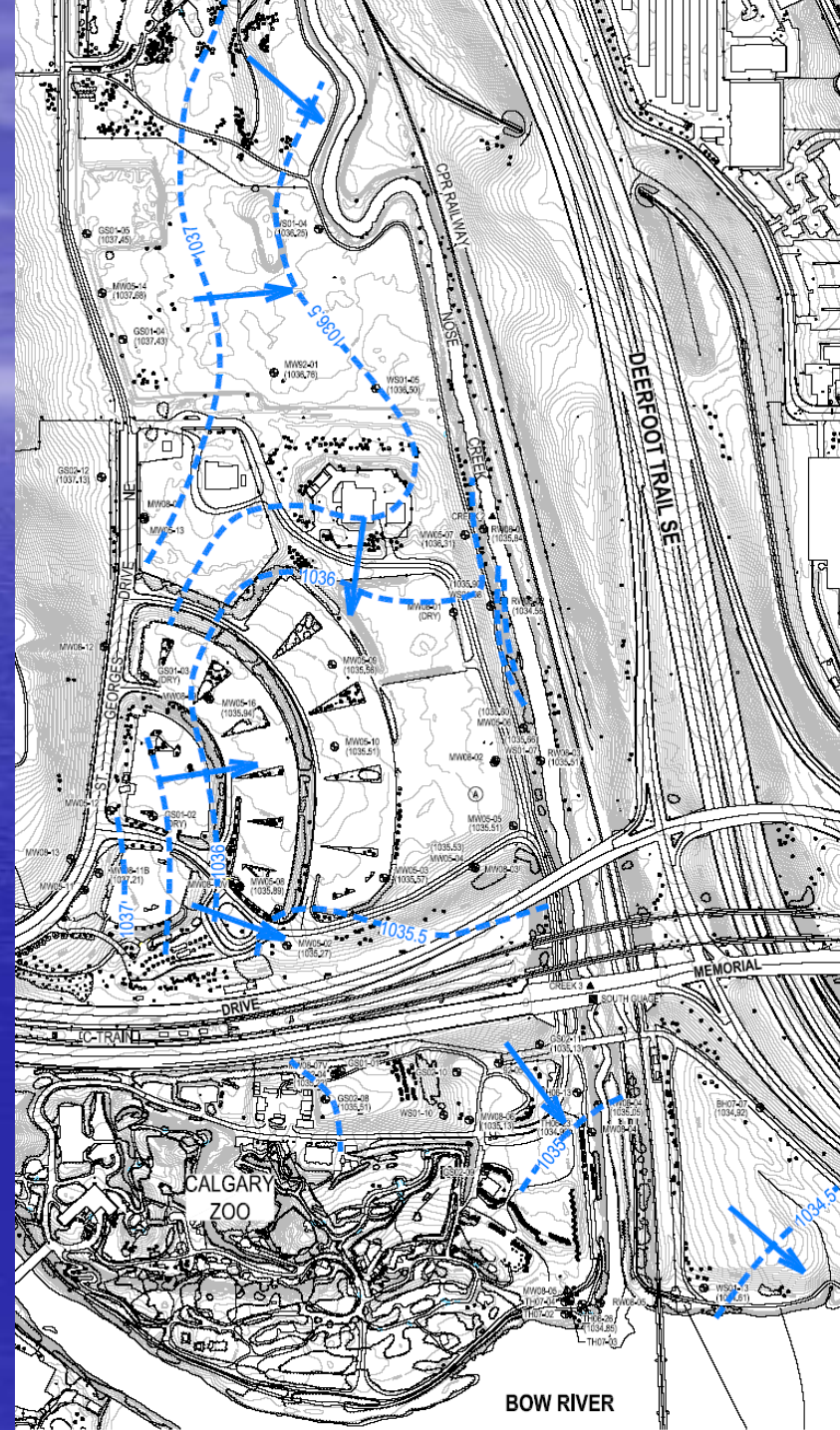
Site Stratigraphy

- Stratigraphy variable across site
 - Sand and silt (Fill) – ‘capping’ soils
 - Waste and soil (Fill) – up to 14.6 mbg
 - Interlayered soils (Native)
 - Silt/Clay ; Silt and Sand ; Gravel/Sand
 - Mudstone, claystone, siltstone (Bedrock) 12m to 20m depth



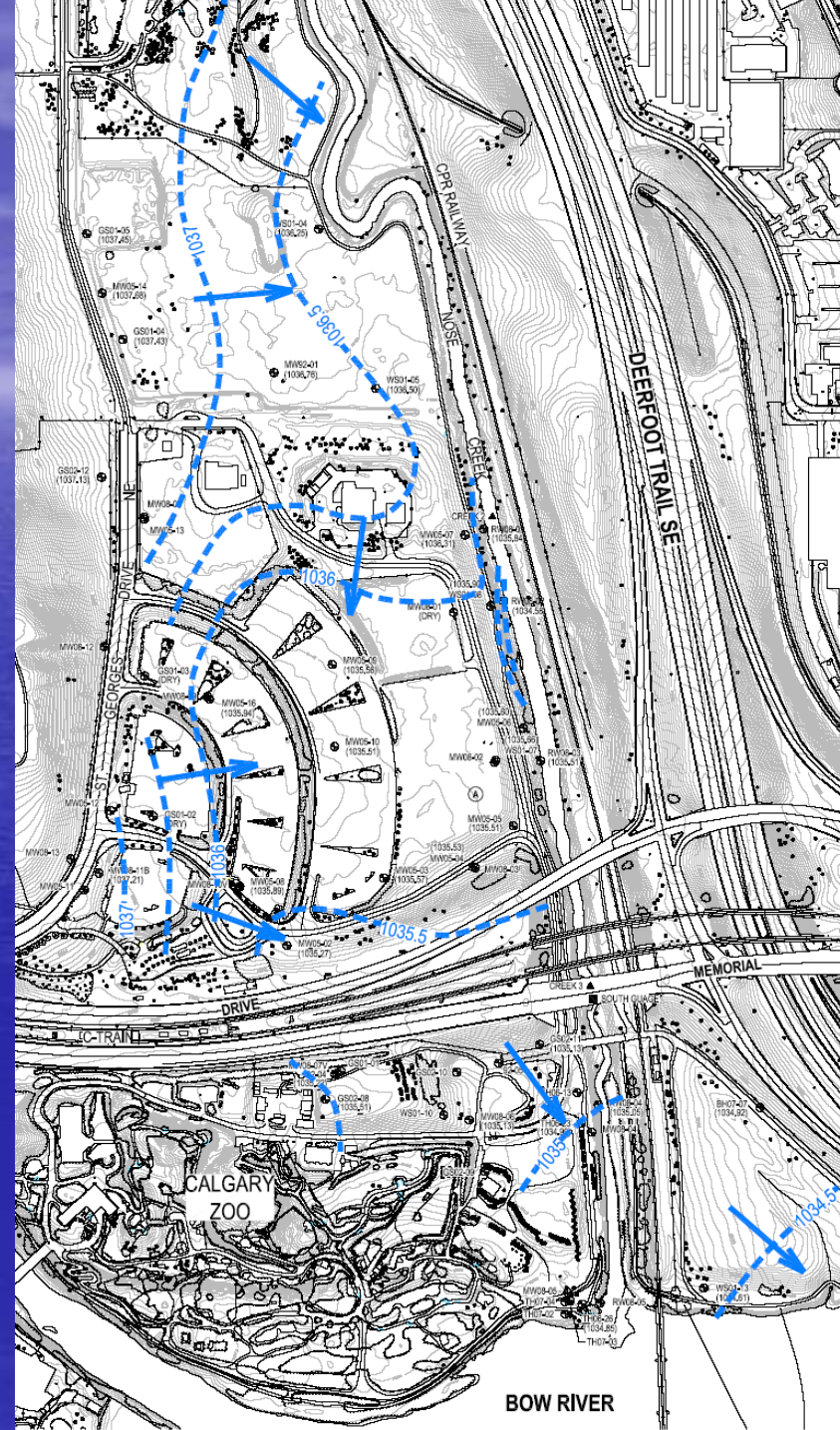
Groundwater Flow

- Groundwater depth
 - up to 19 m depth in west (shallower to east)
- Horizontal flow typically east and southeast
 - towards Nose Creek and Bow River
- Groundwater relatively flat beneath Area 2
 - variable seasonally
- Bedrock flow
 - generally to southeast



Groundwater Flow

- Horizontal gradients
 - 0.001 - 0.01
- Vertical Gradients
 - Typically downward
 - Upward at 2 locations
 - Bedrock to gravel (Area 5)
 - Gravel to waste (Area 2)
 - Expected seasonal variability
- Average K values
 - Surficial 10^{-6} m/s
 - Sand and Gravel 10^{-4} m/s
 - Bedrock 10^{-5} m/s



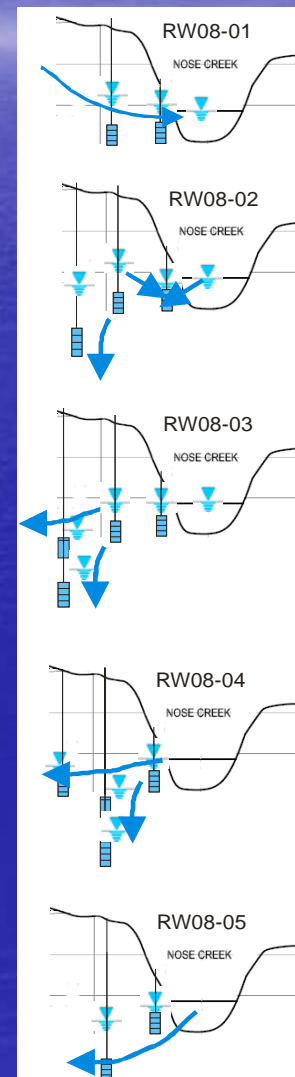
Groundwater Flow

- Complicating Factors to Flow
 - Bow River base flow (Area 5)
 - Nose Creek base flow (all areas)
 - Storm events – site runoff and river levels from upstream events
 - Historic creek channels (in-filled)
 - Complex stratigraphy and disturbance



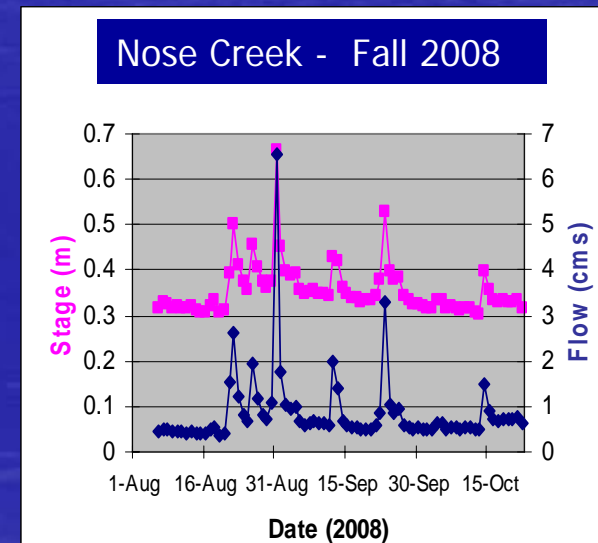
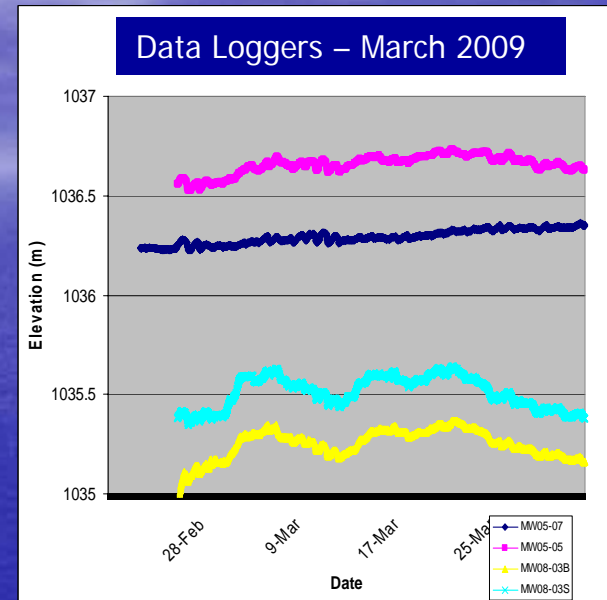
Groundwater Flow Interaction with Nose Creek

- Recharge-discharge
 - Expected to vary seasonally
 - Expected to vary by site Area
- Fall 2008
 - Site groundwater discharging to Creek at north end
 - Complex at RW08-02; also area of flat water table
 - Creek recharging groundwater from RW08-03 south (towards Bow River)



Groundwater Flow – Interaction with Nose Creek

- Groundwater Levels (March 2009)
 - Levels varied 0.3 m over period
- Creek fluctuation (fall 2008 data)
 - Level varied 0.56 m over period
 - Mean discharge - 0.9 m³/s (max 13.5 m³/s)
(Bow River avg. ~80 m³/s for period)
- Potential Site Discharge
 - Conservative max 0.006 m³/s (~0.6% of river flow)
 - Expect recharge/discharge to vary seasonally, and along reach of Creek



Groundwater Quality

- COPCs (groundwater)
 - Compounds typically associated with MSW
 - VOCs, PAHs, PHCs, dissolved metals, routine parameters...
 - Key indicator compounds
 - Chloride – to 2,200 mg/L
 - Ammonia – to 822 mg/L
 - Vinyl Chloride – to 75 ug/L

Groundwater Quality

- Site Interior
 - Area 2/2A typically greater concentrations
 - Concentrations typically attenuate with depth; greatest in waste layers
 - Concentrations variable with depth and area
 - Reducing, anoxic conditions beneath site
- Adjacent to Creek
 - Concentrations typically less in river probes
 - Reducing conditions noted (esp. Area 2/2A)



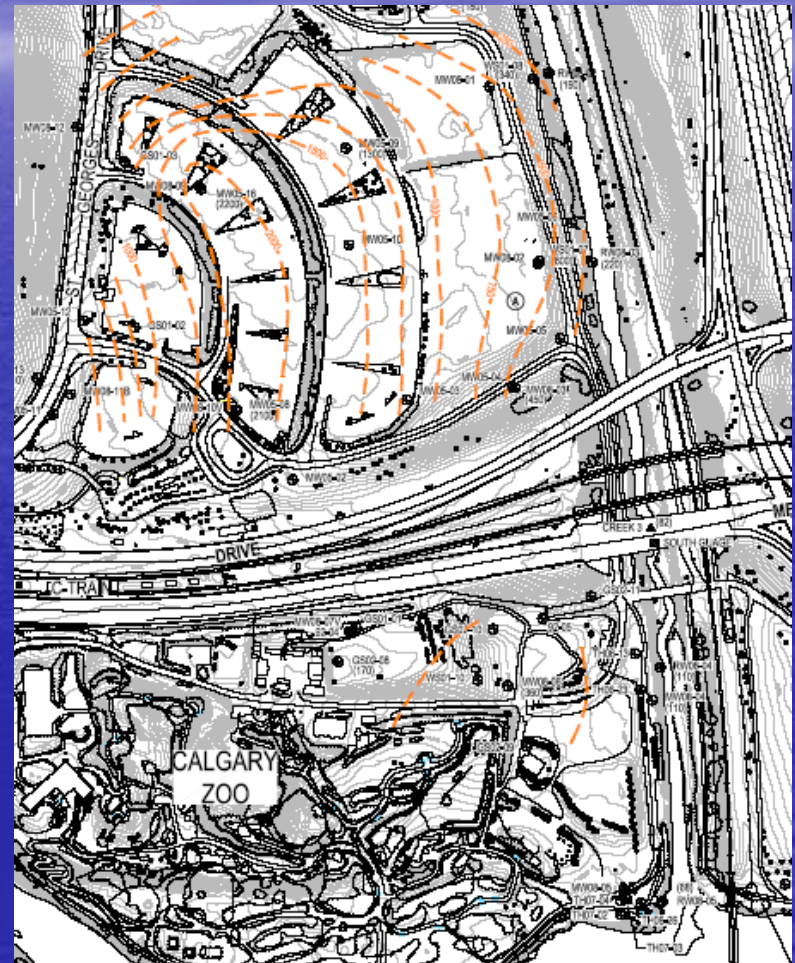
Surface Water Quality

- Creek Water
 - Nitrite, cadmium, selenium concentrations typically > site groundwater
 - PAHs adjacent to north end of site greater than detections in adjacent groundwater
 - No VOCs or PHCs detected
 - Sampled during normal flow
 - Expected to be highly variable during run-off events



Groundwater Quality

- Chloride as a tracer?
 - Chloride concentrations significantly reduced near Creek edge (order of magnitude, to max 220mg/L)
 - Creek Chloride at 80 mg/L
 - NH_4 correlates with Cl
 - Chloride and ammonia do not correlate with VOC, PHC, PAH occurrence



Conclusions and Ongoing Activities

Conclusions

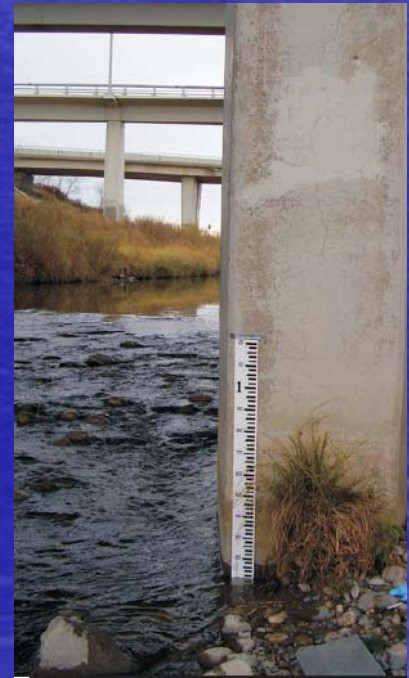
- Groundwater flow and discharge-recharge relationships with Creek appear to vary across the site
- Groundwater impacts generally diminish in proximity of Creek

Conclusions

- GW and SW respond differently to seasonal condition changes, likely leading to GW-SW interaction at Nose Creek that changes direction over the course of the year
 - Further data is needed to explore this conclusion
- Further instrumentation may be needed to focus more closely on the physical interaction between GW and SW at the site

Ongoing Activities

- Real time level monitoring
 - Data loggers in wells
 - AENV stream flow station
- Seasonal monitoring and quality assessment
- Supplemental risk assessment



Questions?