

Self-Calibrating Remote Control Monitoring Systems

Trent Armstrong
Candice Jackson
Gail Heath
Clark Scott
Casey Smith
Jesse Bennett

Mine Design, Operations & Closure Conference

May 1-5, 2011

www.inl.gov



Monitoring Philosophy

- Provide near real-time site performance information for management and project engineers
- Integrated multi-sensor design
- Automation of data collection, storage, and reporting
- Self-calibration of chemical sensor suite
- Remote control of data collection
- Secure web-based information accessibility
- Alarm capabilities

Quarterly Manual Monitoring Disadvantages

- Not cost effective for information gathered
- Monolithic - cannot be easily customized to fit a specific remediation system
- Does not provide a way to distribute information
- High cost per sample, it is not feasible to collect enough information to thoroughly understand the remediation system

Remote Monitoring Advantages

- Provides near real time decision making information for management and project engineers
- Economically establishes a baseline for EPA quarterly monitoring
- Multiple parameters such as temperature, chemistry, flow rate, hydrology and ion concentrations
- Reduces travel to remote sites through remote two way communications and remote calibration
- Can run on 12v DC generated by wind or solar
- Acquires information necessary to better understand the treated system
- Understand the dynamic system behavior to optimize current systems or enhance future remediation designs

May 3, 2011 12:51 pm

McCormick McCormick, SC 29835

McCormick

Plum Branch

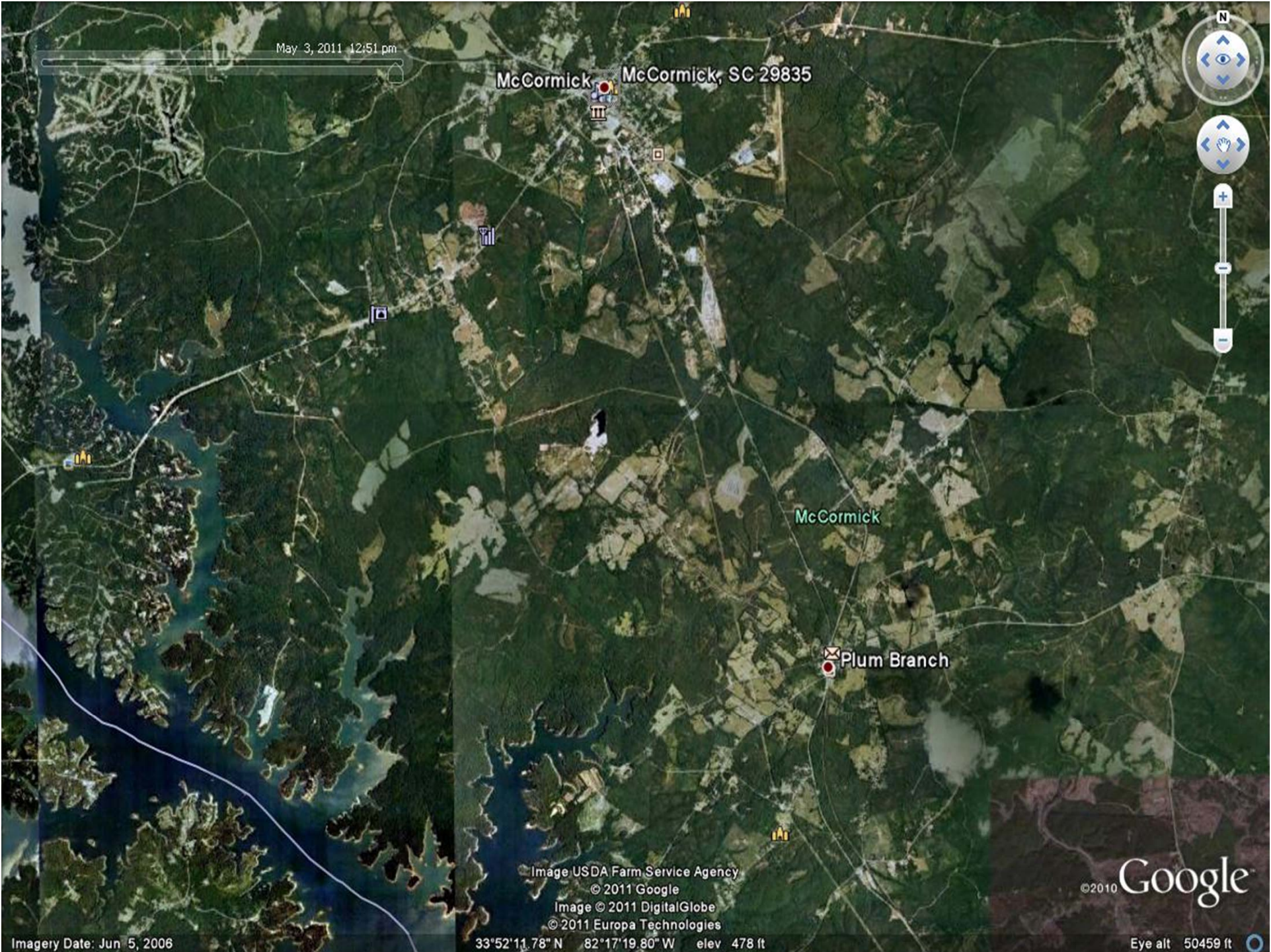
Image USDA Farm Service Agency
© 2011 Google
Image © 2011 DigitalGlobe
© 2011 Europa Technologies

©2010 Google

Imagery Date: Jun 5, 2006

33°52'11.78" N 82°17'19.80" W elev 478 ft

Eye alt 50459 ft



May 3, 2011 12:51 pm



Image USDA Farm Service Agency
© 2011 Google

©2010 Google

Imagery Date: Jun 5, 2006

33°52'32.49" N 82°17'34.83" W elev 478 ft

Eye alt 4088 ft



Barite Hill Mine

- Located near McCormick, South Carolina
- Operated by Nevada Goldfields, Inc.
- Mined from 1989-1994 (gold, silver)
- Open pit mining effort
- Impacts a tributary to the Savannah River
- Listed as a Superfund site on the National Priorities List (NPL) April 2009

Study Motivation

- Determine if the lake treatment will remediate the waste rock repository
- Understand the treatment system and how it interacts with the lake
- Find the location of largest influx of acid
- What are the conditions that produce the influxes

Monitoring Parameters for Barite Hill

- **Requirements**
 - Automated data collection and system access
 - User friendly interface to data
 - Automated data management
- **Pit lake Sampled at 5 foot intervals**
4 Wells Sampled at single location
 - pH
 - ORP
 - Dissolved Oxygen
 - Conductivity
 - Temperature
- **Lake Level Sensor**
 - Alarms at spillway
- **Subsurface Monitoring**
 - Resistivity
 - Temperature
 - Water levels
 - Water Chemistry
- **Ground Water**
 - Areal Extent
 - Flow Direction

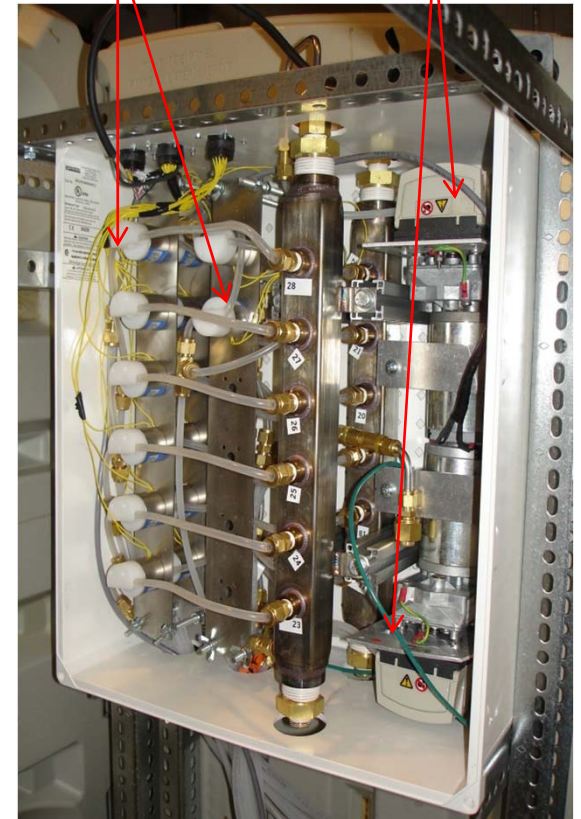
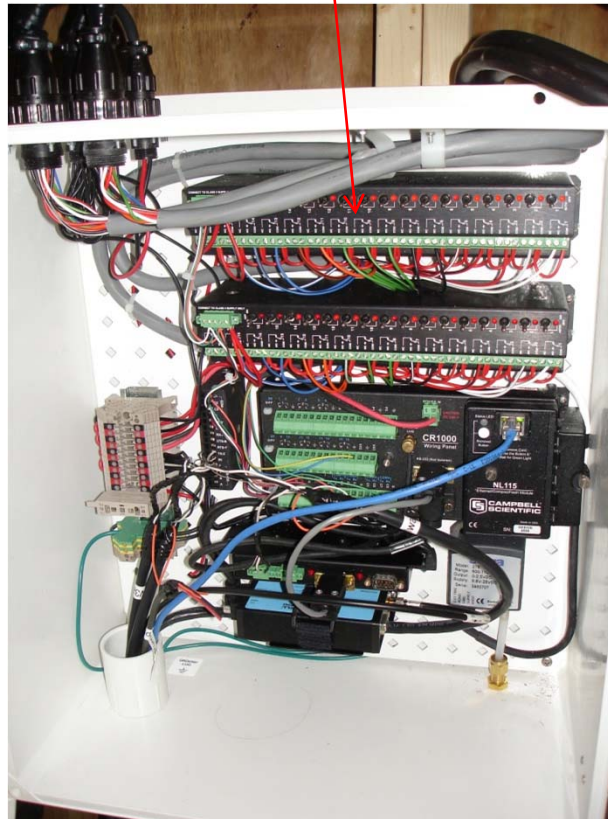
Instrumentation

Calibration Fluids

Controllers

Pinch Valves

Pumps

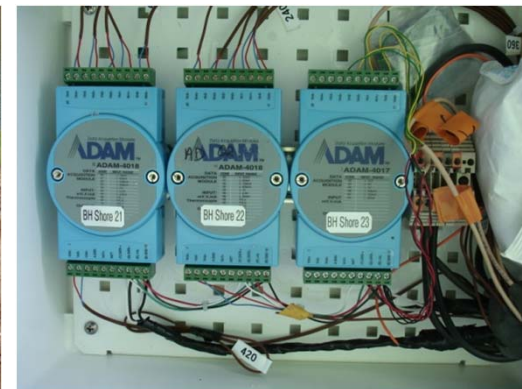


Camera and Lake level sensor



Wells

- Temperature
- Water level
- Automated water pumping
- Calibrated water chemistry



Lake Sampling

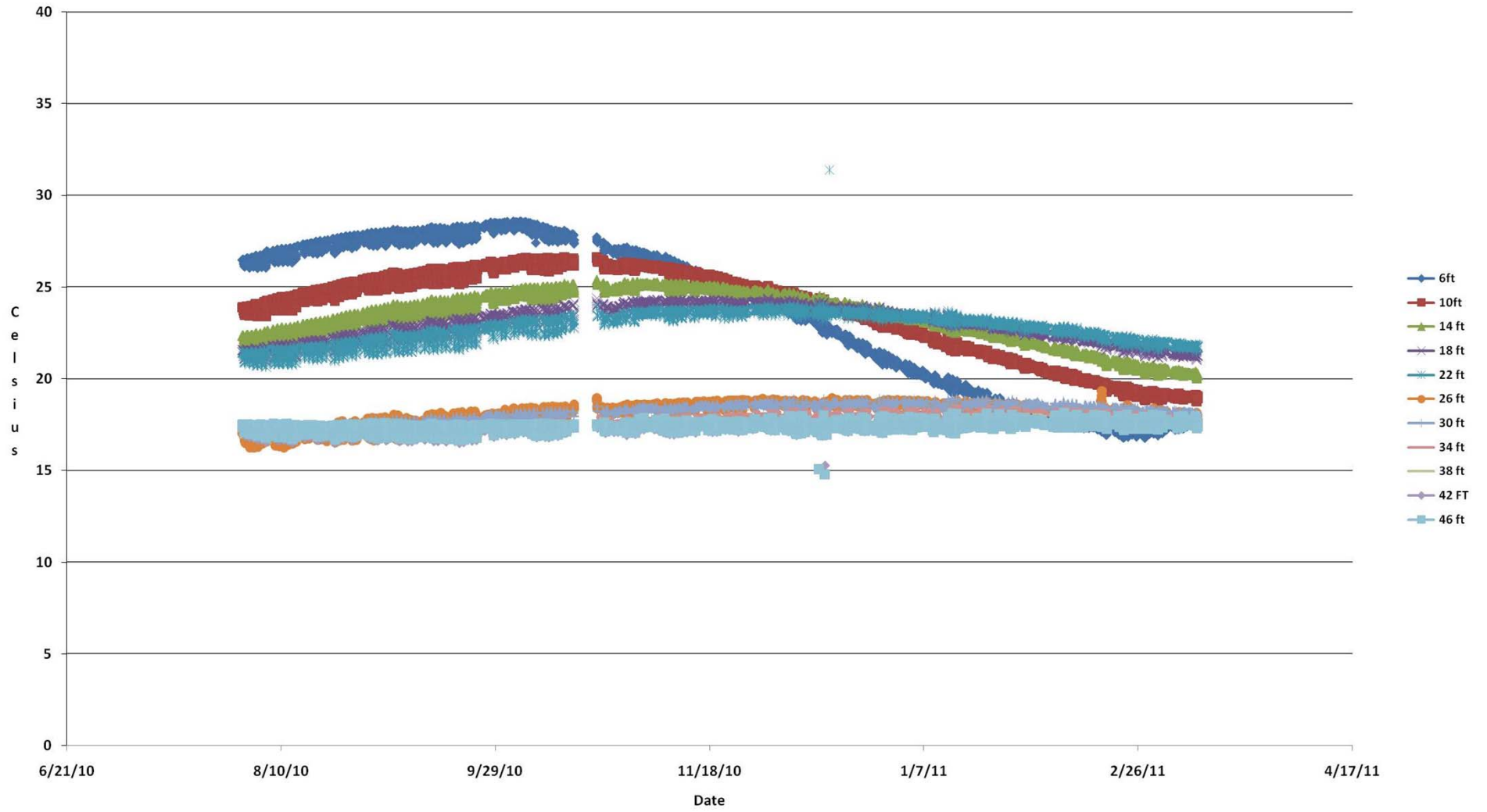
- Samples every 5 feet from surface to a depth of 55 feet
- Chemical analysis of samples completed everyday



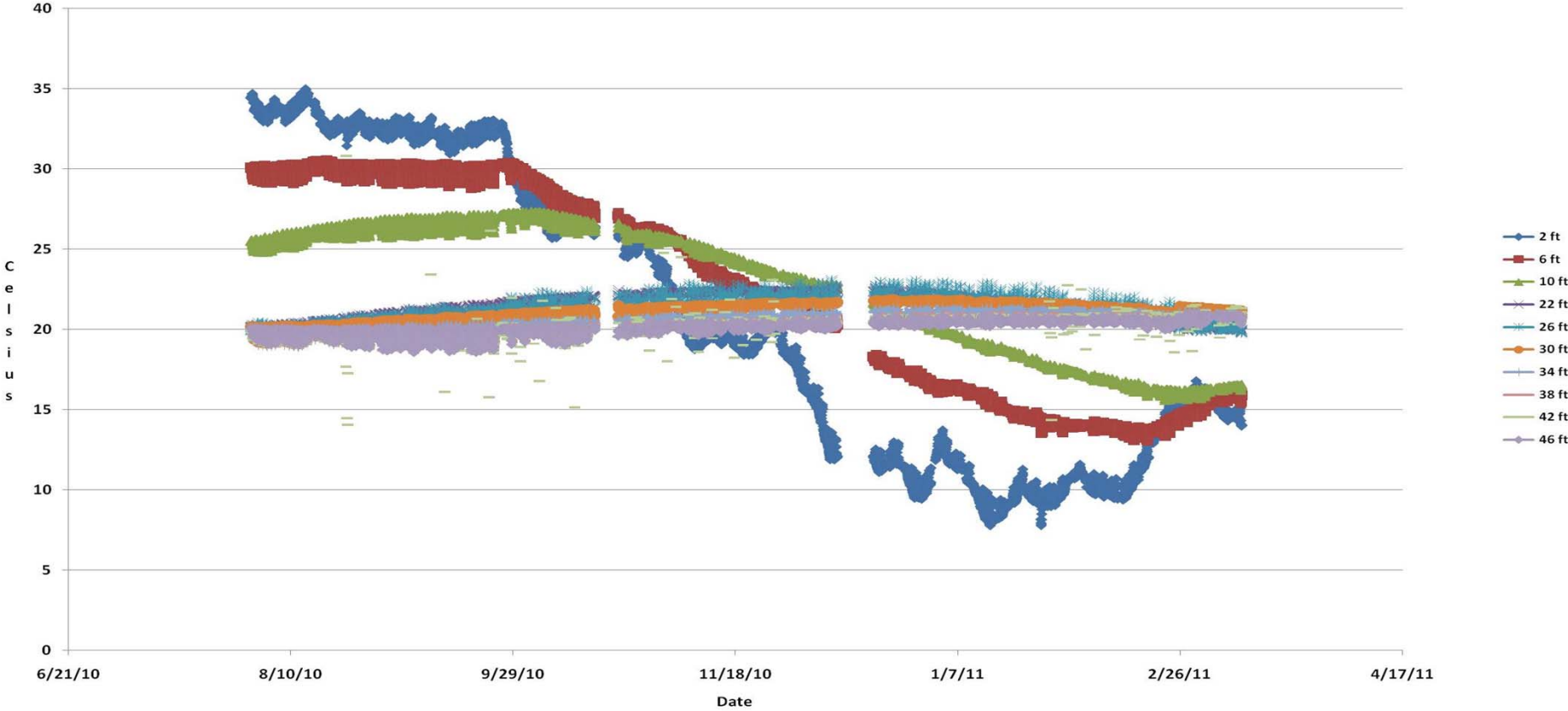
Barite Hill Results

- **Waste Rock Repository**
 - Temperature Variance is uniform in wells 26, 27 and 29
 - thermocline appears in Well 28
 - pH is 2.6 ± 0.3

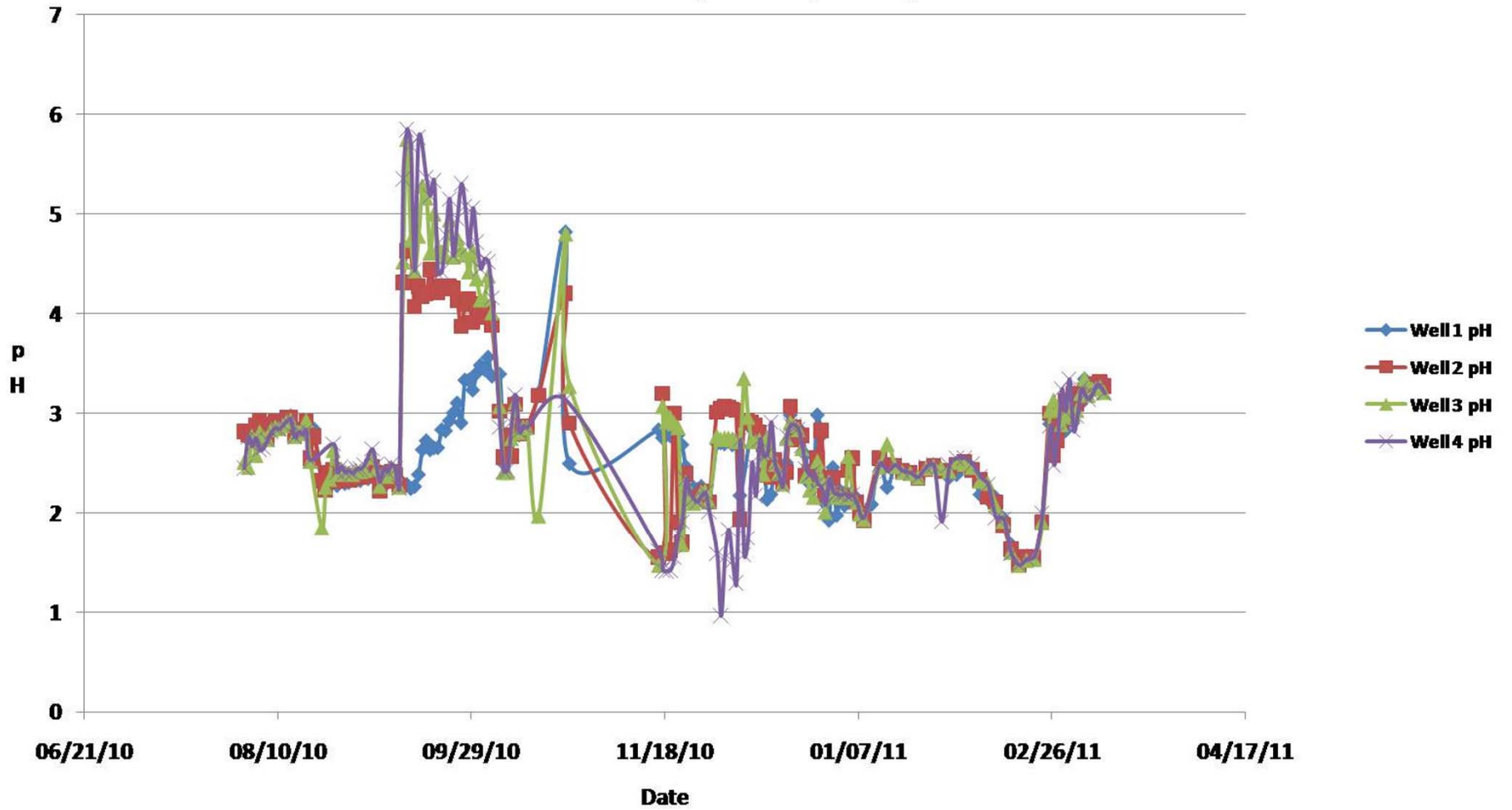
Well BH 28



Well BH 29



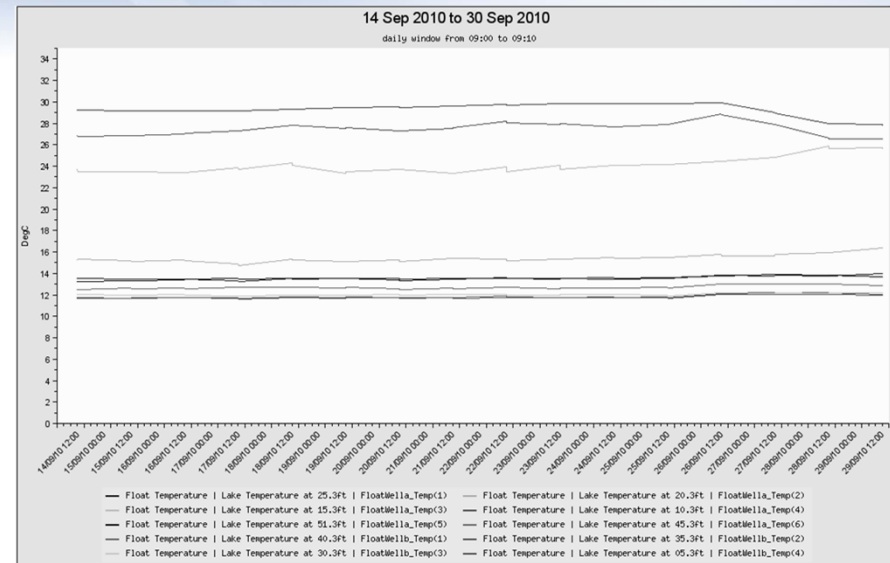
Waste Rock Repository Well pH



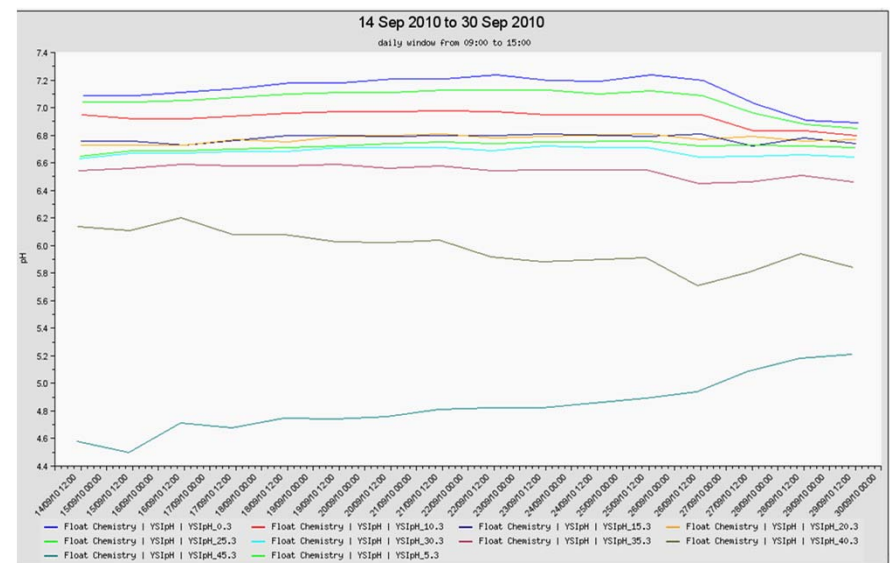
Barite Hill Results

- Pit Lake
 - Chemocline between 15 and 20ft
 - 45 ft to 50 ft is warmer than 30 to 35 ft
 - pH is consistent at top of lake
 - Bottom of lake is more acidic

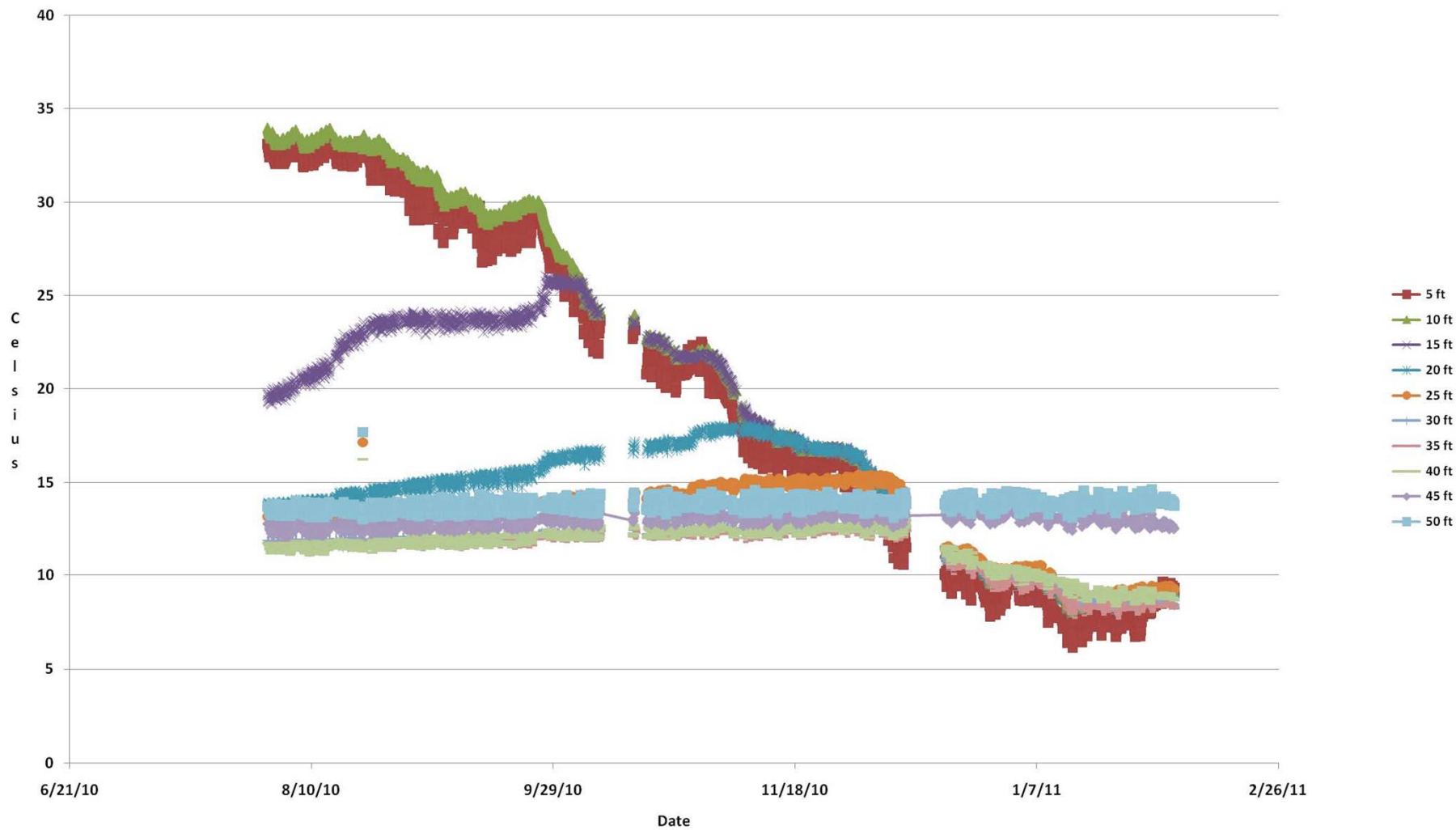
Float Temperature



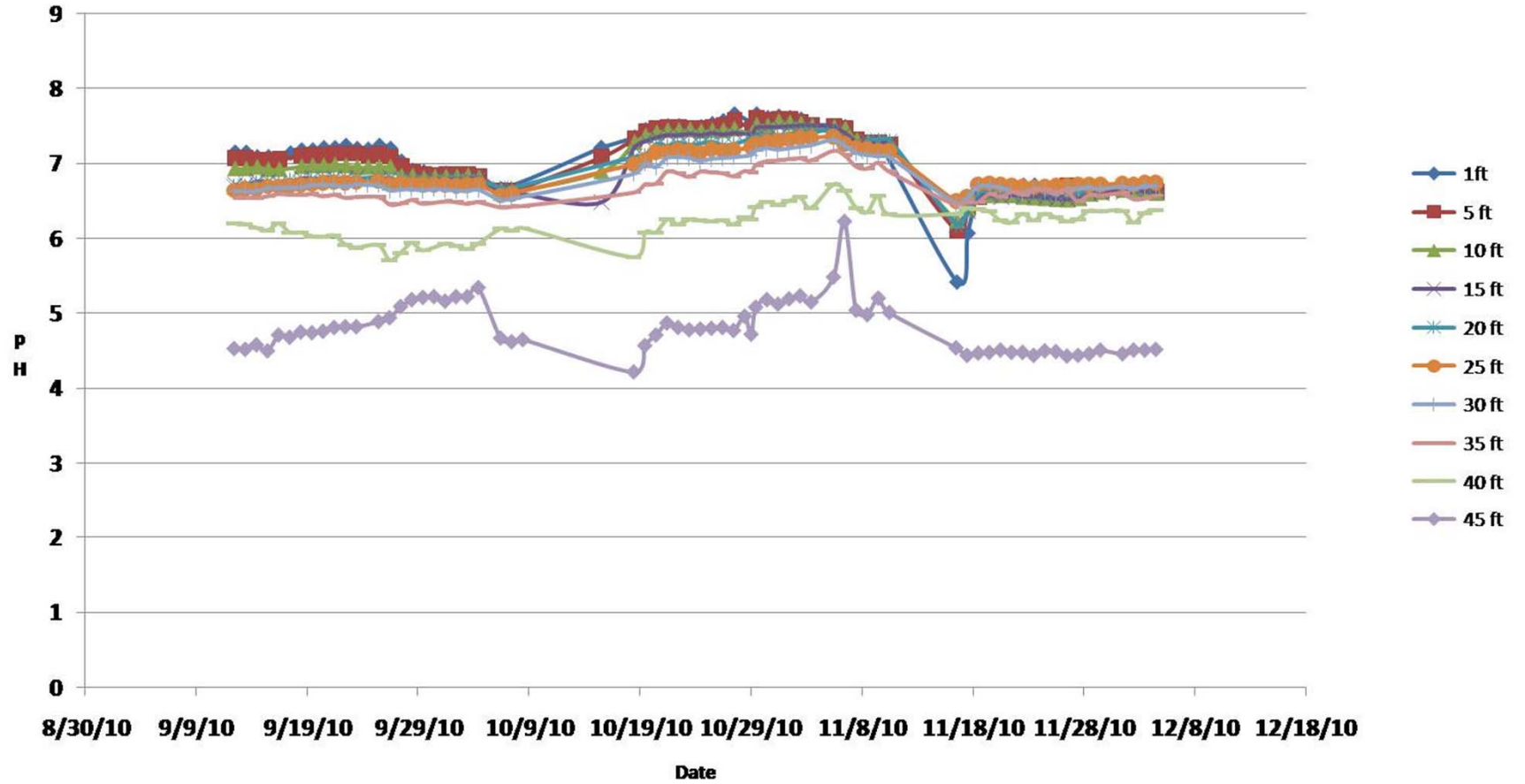
Float pH



Floating Raft BH 30

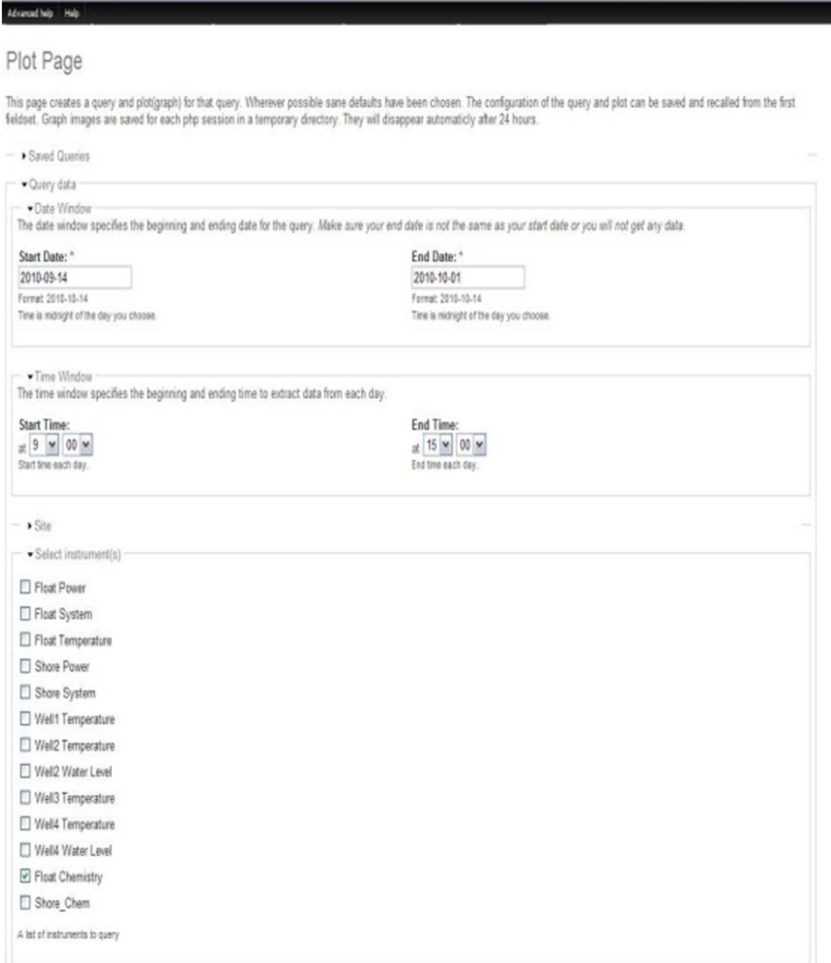


Lake pH



Web Site and Control Software

- Provides a database to store the data
- Allows password protected, graduated levels of access to the system
- Provides a simple plotting tool to view the data
- Allows for remote operation of the system
- Expandable to multiple types of monitoring sites



Advanced help Help

Plot Page

This page creates a query and plot(graph) for that query. Wherever possible sane defaults have been chosen. The configuration of the query and plot can be saved and recalled from the first fieldset. Graph images are saved for each php session in a temporary directory. They will disappear automatically after 24 hours.

→ Saved Queries

▼ Query data

▼ Date Window
The date window specifies the beginning and ending date for the query. Make sure your end date is not the same as your start date or you will not get any data.

Start Date: * End Date: *
Format: 2010-10-14 Format: 2010-10-14
Time is midnight of the day you choose. Time is midnight of the day you choose.

▼ Time Window
The time window specifies the beginning and ending time to extract data from each day.

Start Time: End Time:
Start time each day. End time each day.

→ Site

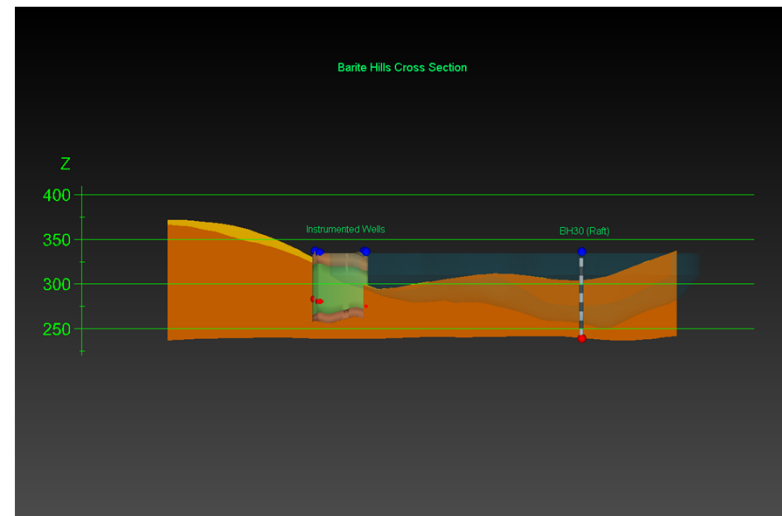
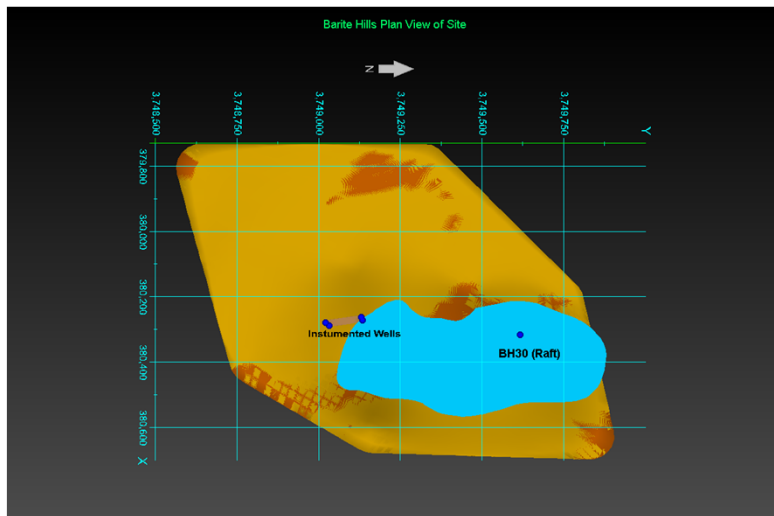
▼ Select instrument(s)

- Float Power
- Float System
- Float Temperature
- Shore Power
- Shore System
- Well1 Temperature
- Well2 Temperature
- Well2 Water Level
- Well3 Temperature
- Well4 Temperature
- Well4 Water Level
- Float Chemistry
- Shore_Chem

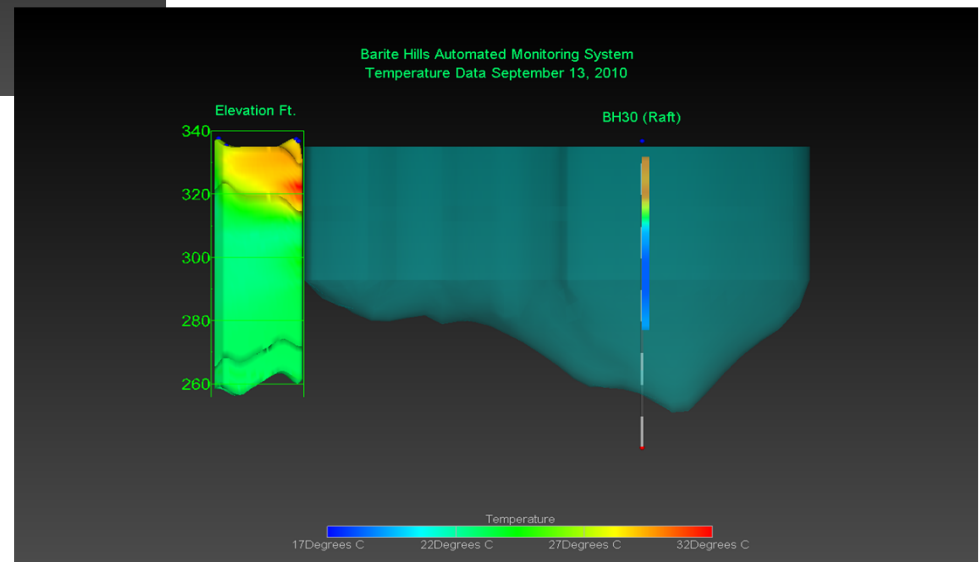
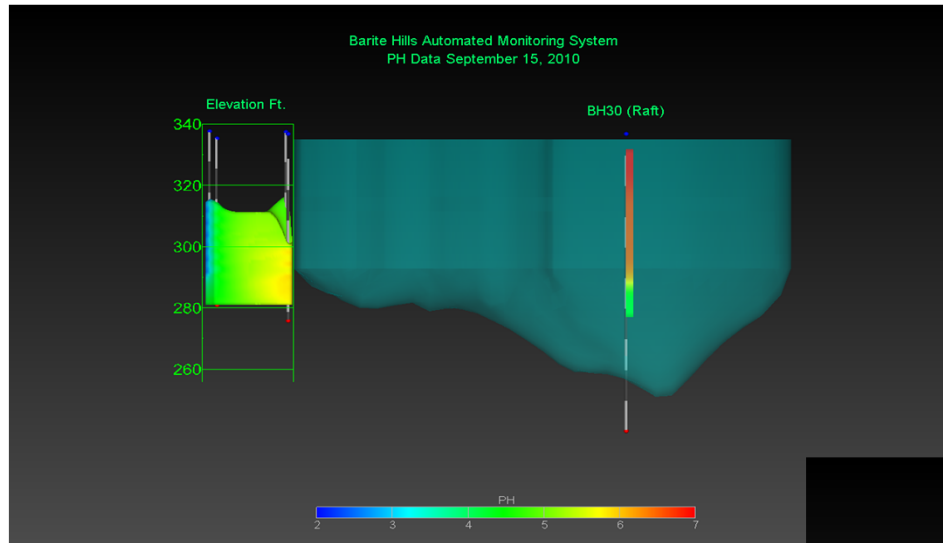
A list of instruments to query

Barite Hill Results 2010

- Will the pit lake remediation efforts effect the waste rock repository
- Due to the close proximity of the pit lake and the waste rock, analysis of the two sources of contamination are necessary
- The correlation of the two entities will allow a better understanding of the dynamics of the system.



Monitoring Results



Monitoring Results

- The ability to sample daily allows time series data evaluation, enabling an understanding of the system's dynamic behavior which allows for the optimization of the system.
- The most critical aspect to remote monitoring systems and their success is the ability to supply power, retrieving data, and calibrating the sensors.
 - The system is capable of being powered by 12V_DC generated by wind or solar power.
 - Two way communication is accomplished by either cell modem, satellite, or radio.
 - Calibrations are done weekly and data is storage securely online for easy interface.

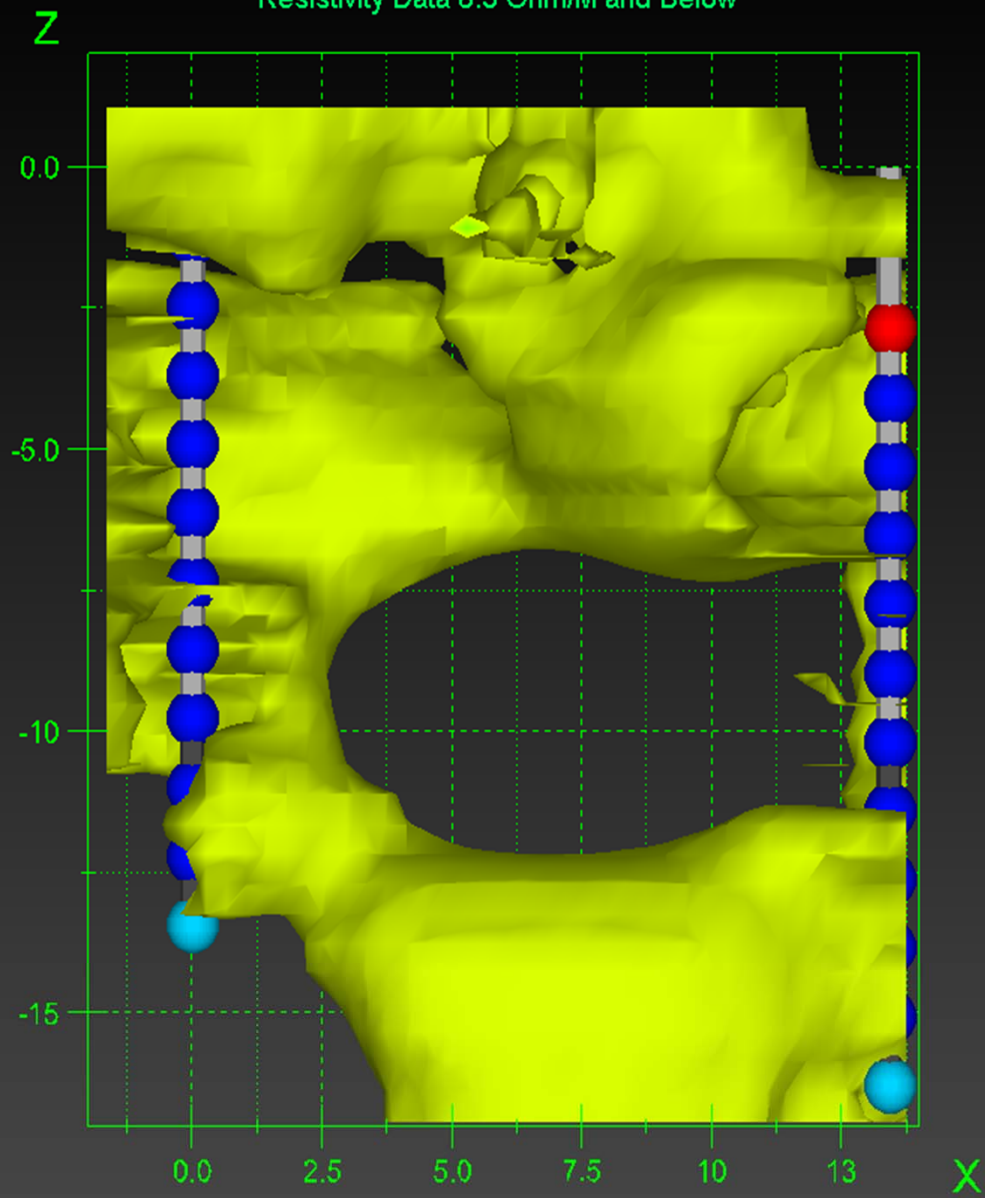
Resistivity Results

- Resistivity is a volumetric measurement system that detects
 - Water
 - Ion concentration
 - Ion exchange capacity
 - Temperature
 - Geology
- Conductive ground
- The south waste rock repository electrical response is consistent over the entire facility however it is more conductive than the north repository
- The north waste rock repository demonstrates a different behavior

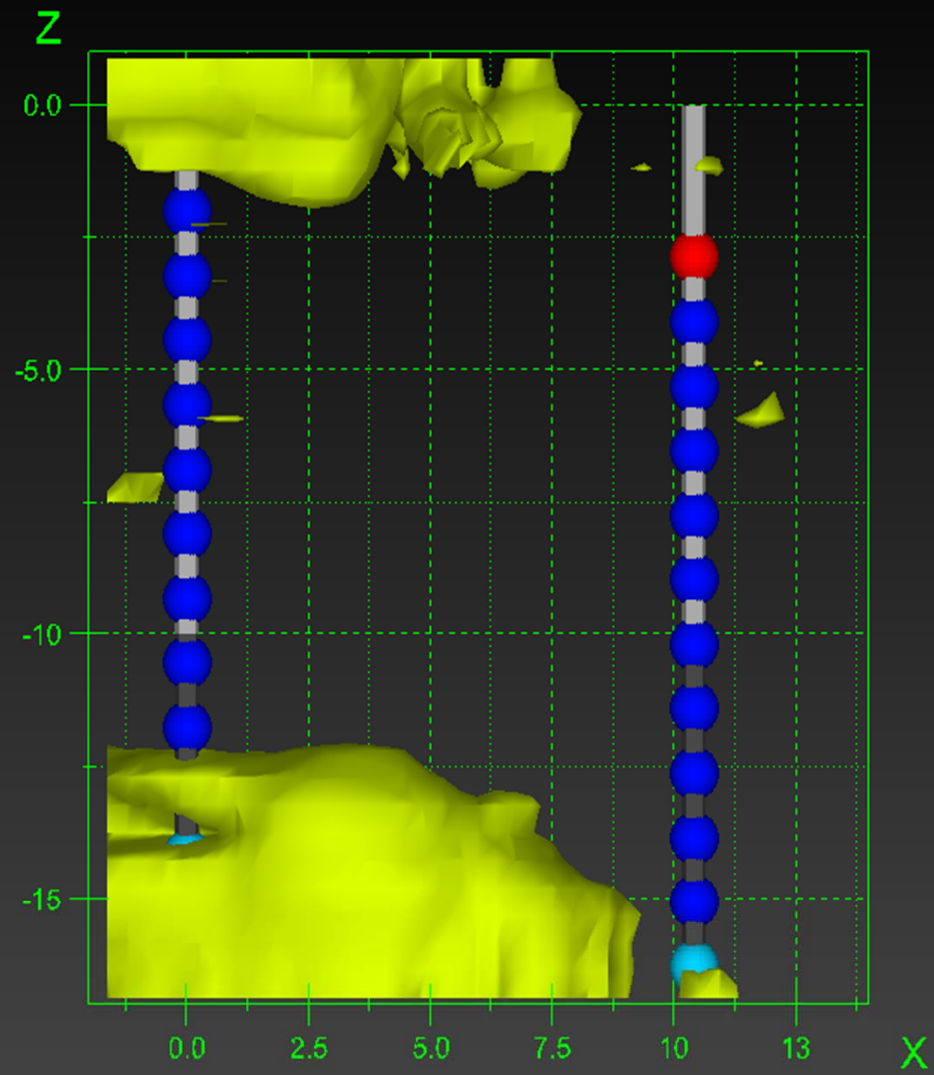
Resistivity Results

- Resistivity when teamed with point source measurements are the best technology for characterizing and monitoring chemistry, fluid flow, temperature, contaminant flow, and remediation behavior.
- Results show that wells BH 26, 27, and 29 show similar behavior
- Well BH 28 response are similar to the pit lake.
- Current study efforts are concentrated at wells BH 28 and 29 to understand the change in system behavior at this location.
- Well BH28 behavior could be produced by a several phenomena
 - Different lake connection rates, faster REDOX reactions, higher levels of bioactivity and or larger loads of Pyrite.

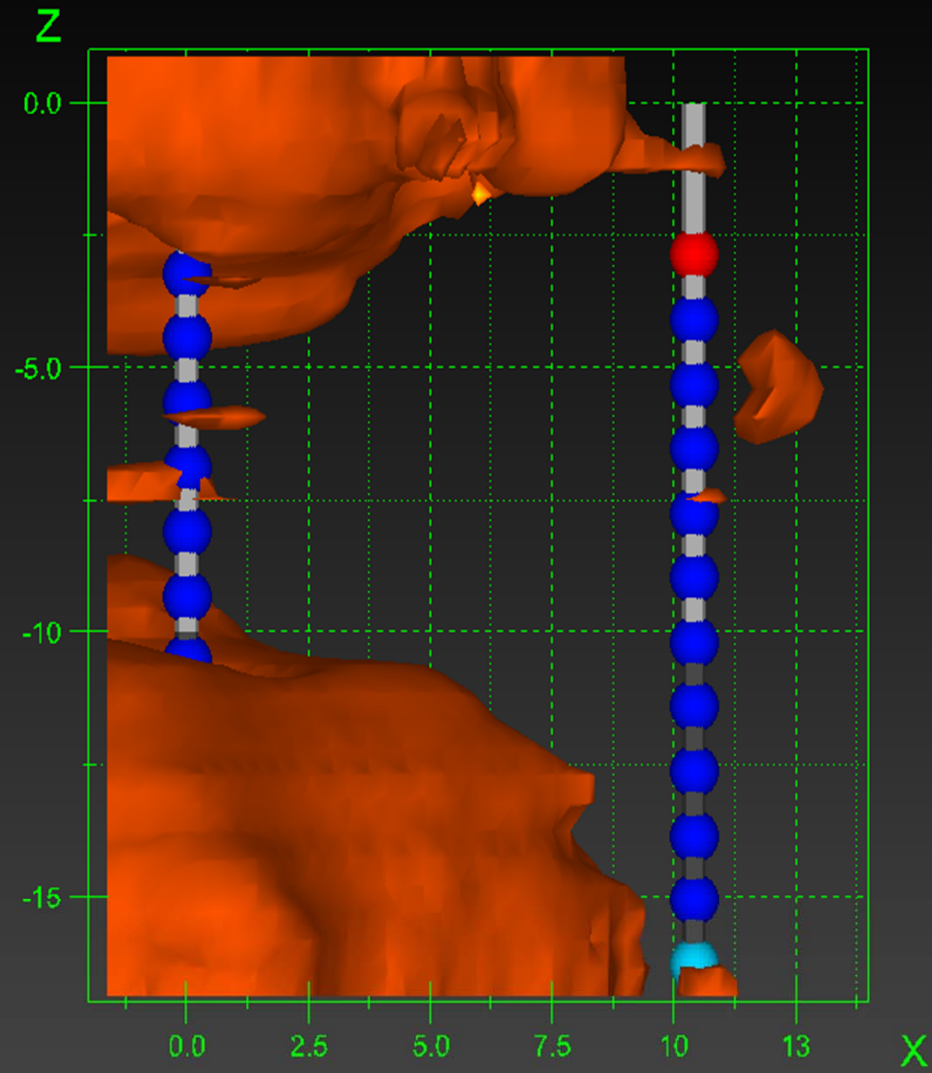
South Waste Rock Repository
Resistivity Data 8.5 Ohm/M and Below



North Waste Rock Repository
Resistivity Data 8.5 Ohm/M and Below



North Waste Rock Repository
Resistivity Data 11 Ohm/M and Below



Cold Weather and Remote Application

- The system can be implemented in areas without permafrost now
 - More work would have to be done to operate in that environment
- The system is designed to operate on 12 volt solar or wind
- Two way communication via cell modem, satellite, or radio
- Depending on sample and calibration frequency the system could easily run for four to six months

Summary

- Barite Hill Pit Lake is responding to treatments
- 3D resistivity shows that the North and South Waste Rock Repositories demonstrate different behavior
- The temperature, chemistry and resistivity results indicate that something is occurring around well BH28.
- The inoculation has dramatic effects on the lake only well BH28 was observed to have a difference which is the farthest from the lake.
- Pit lake has a thermo-cline that occurs near 30 feet
- Pit Lake has a weak Chemo-cline occurring near 35ft
- Well BH 28 mimics lake thermo-cline unlike the rest of the wells
- 4,275,000 temperature data points have been recorded
- 2,505 readings each of DO, Conductivity, ORP, pH
- 10,020 total chemical samples in 7 ½ months
- Total cost per sample: \$ 0.16

Future Work for Monitoring System

- In-situ Biological Monitoring
 - Species
 - Quantity
- Replace wet chemistry sensors with a more robust method

