

*Idaho National Engineering and Environmental Laboratory*

# **Autonomous Monitoring System Results at the Gilt Edge Mine**



**Home of Science  
and Engineering Solutions**

11<sup>th</sup> Annual British Columbia ML/ARD Workshop

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*December 2004*

# Monitoring Philosophy

- Automation
- Remote control
- Web based data accessibility
- Complementary multi-sensor systems
- Alarm capabilities

*Gilt Edge Mine Superfund Site, South Dakota*  
*September 25, 2003*





7-ac. pre-mine drainage  
remains uncapped

Toe-buttress & covered  
ARD-vault in design

## Regrade and bed-layer



## 80-mil LLDPE membrane



## 18-in drain-rock layer



## 36" soil cover & reveg



# **Monitoring system goals... assessing cap performance functions**

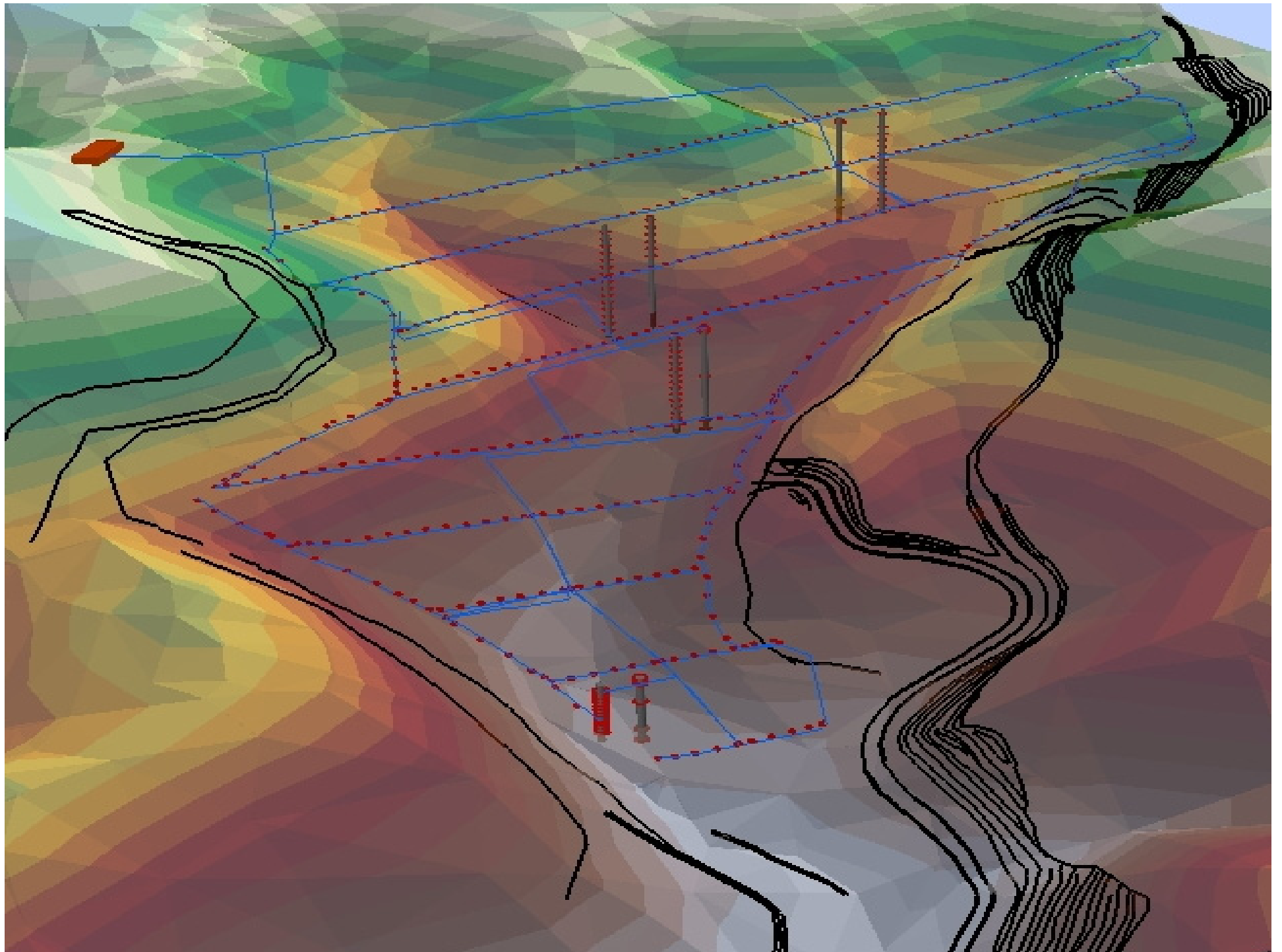
- Fluid flow
- Liner integrity
- Temperature
- Chemical processes
- Requirements
  - Automated data collection and system access
  - User friendly interface to data
  - Automated data management

# Monitoring system

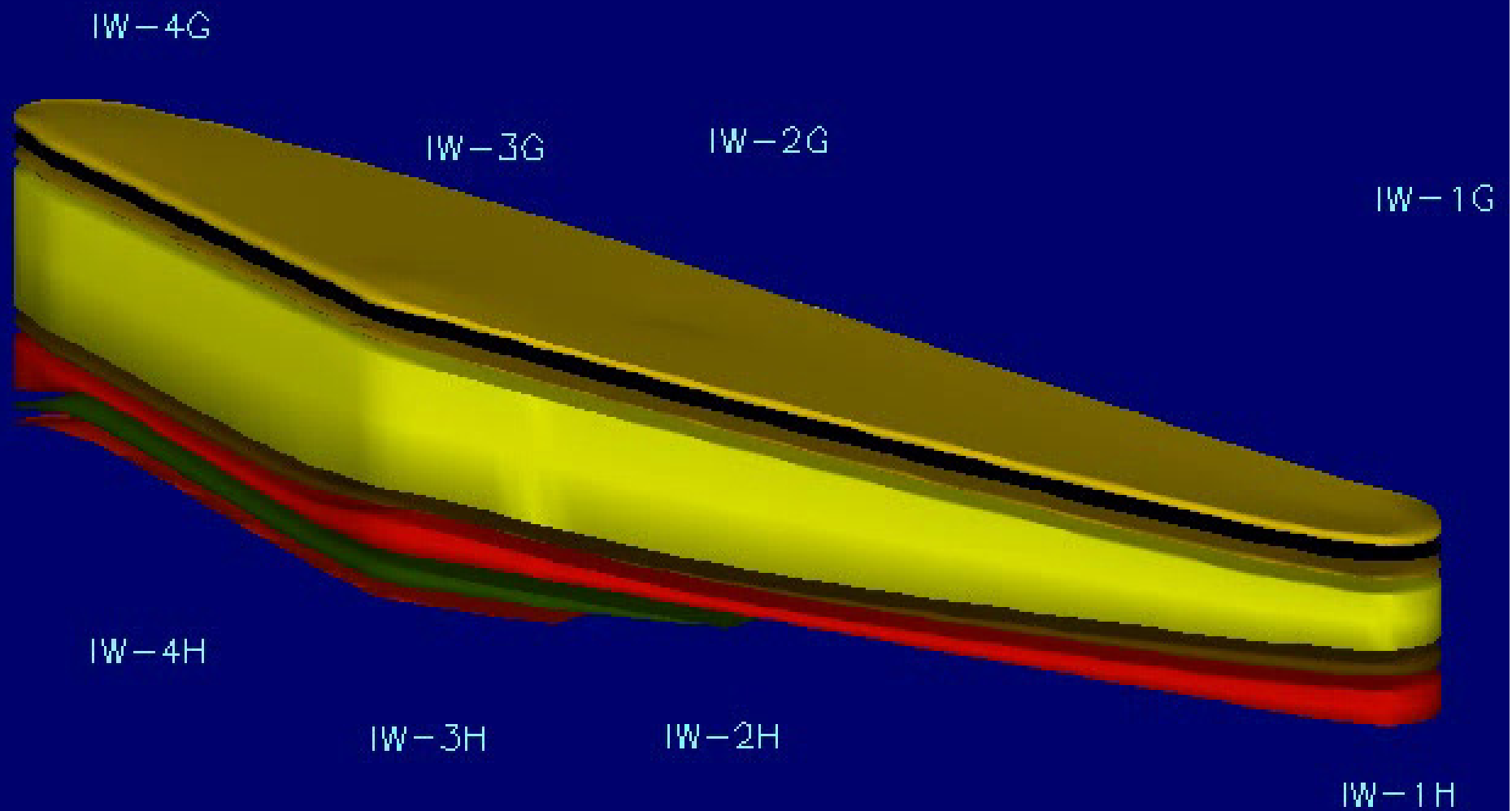
- Monitoring System Demands:
  - Automated
  - Autonomous
  - Remote controllable
- Data demands
  - Accessible to end users
  - Processed to yield useable information
  - Provide relevant information
- Automated monitoring systems
  - Adaptive data collection
  - Data transmission to a remote database
  - Data inversion and imaging
  - Notification of problems under the liner
- Remote interaction with system

# Monitoring System Components

- Tensiometers (pressure transducers)
- Suction lysimeters (water sampling)
- Gas ports ( air sampling)
- Thermocouples
- Resistivity system
- Outflow meter
- Weather station
- Moisture content sensors



# GILT EDGE GEOLOGIC LAYERS



# Internal fluid behavior

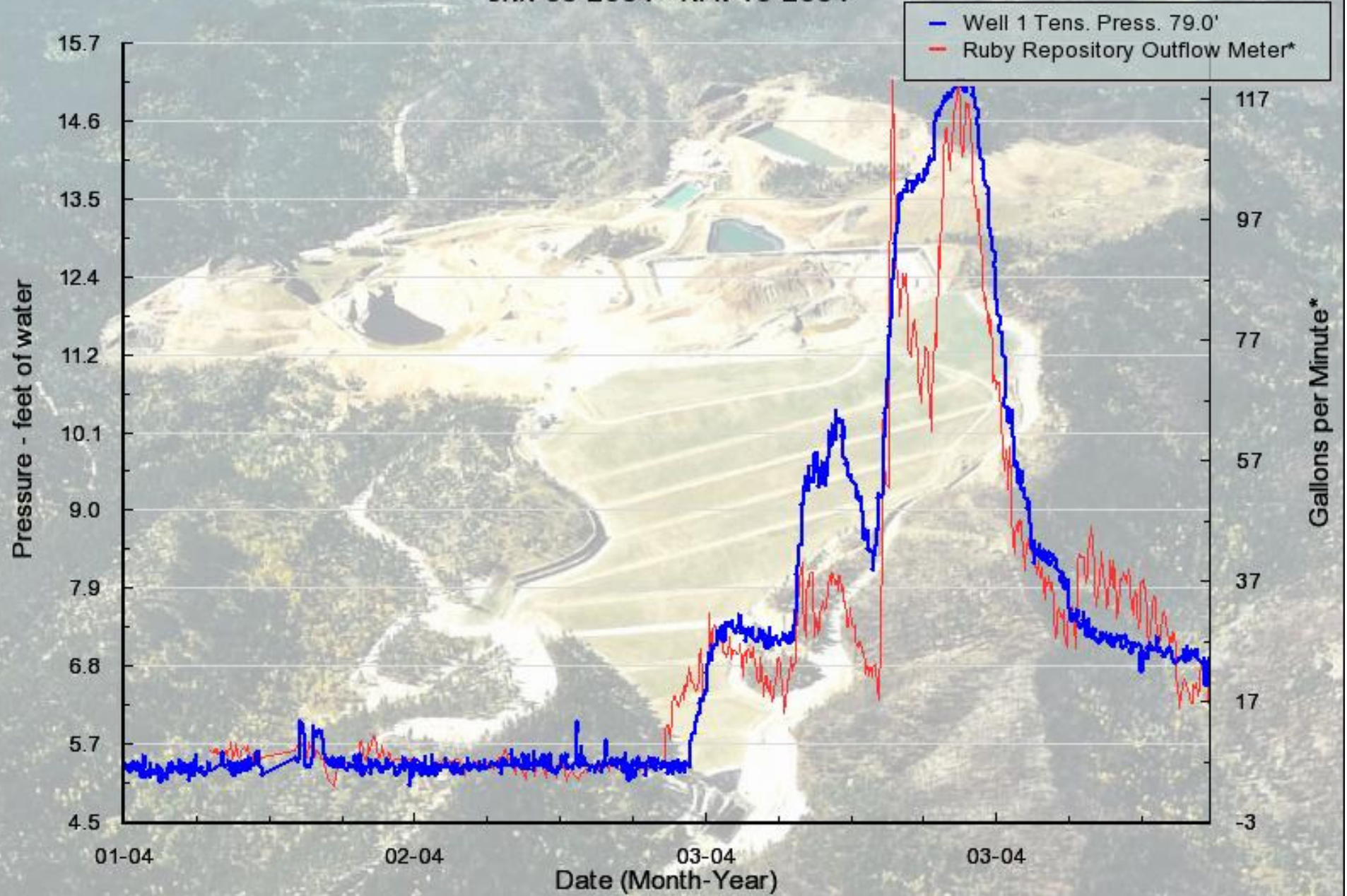
- Water introduction in the North tributary
- Water introduction in the South tributary
- Saturated and unsaturated locations within the Ruby Gulch Waste Rock Repository
- Why?

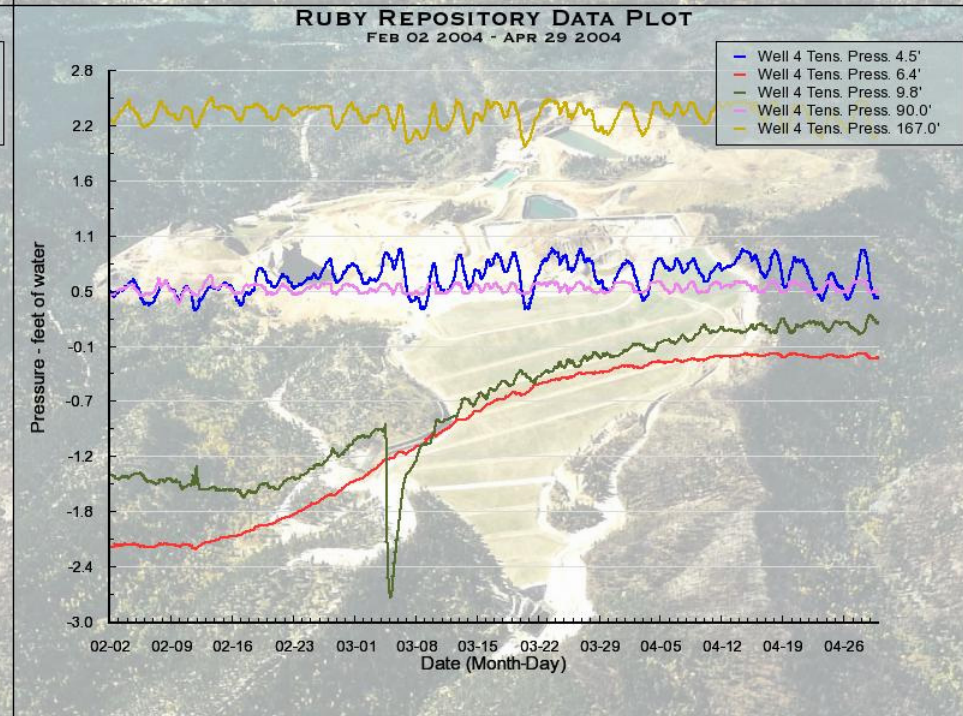
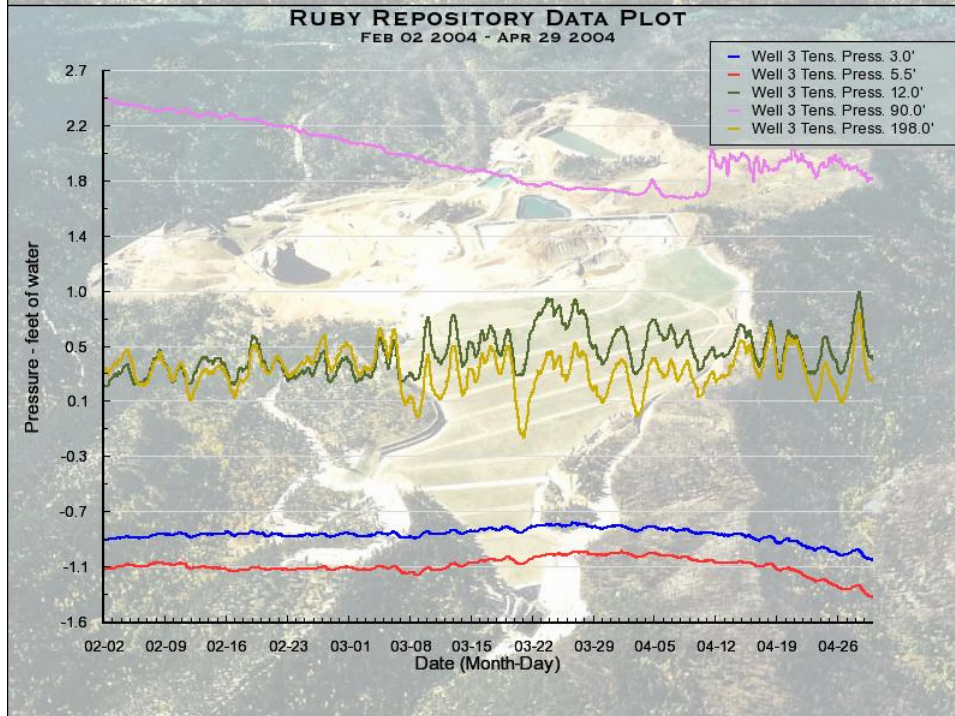
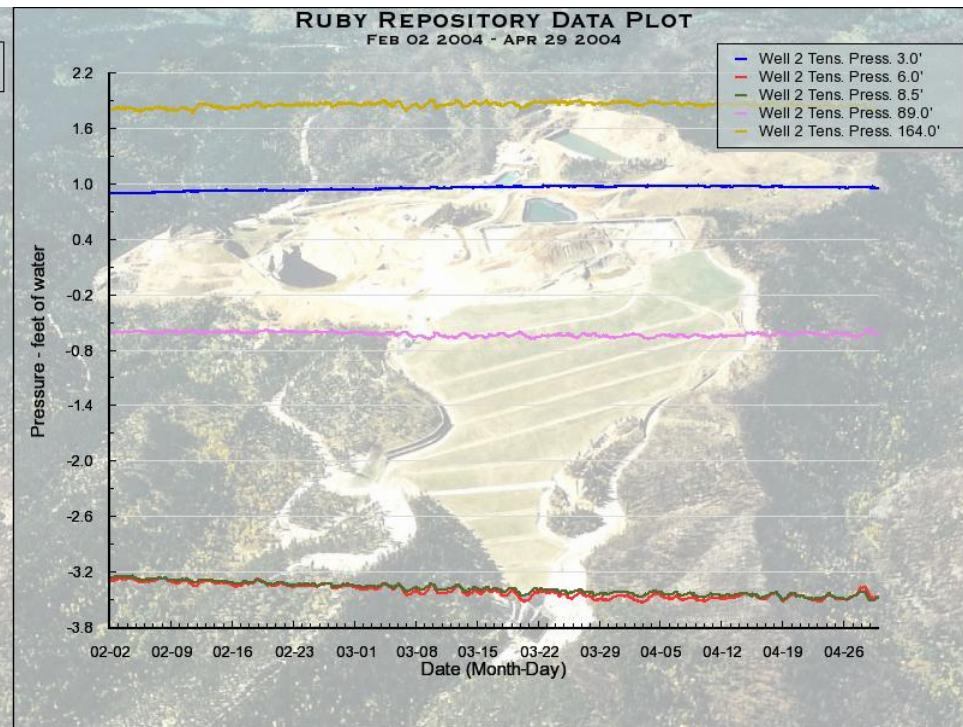
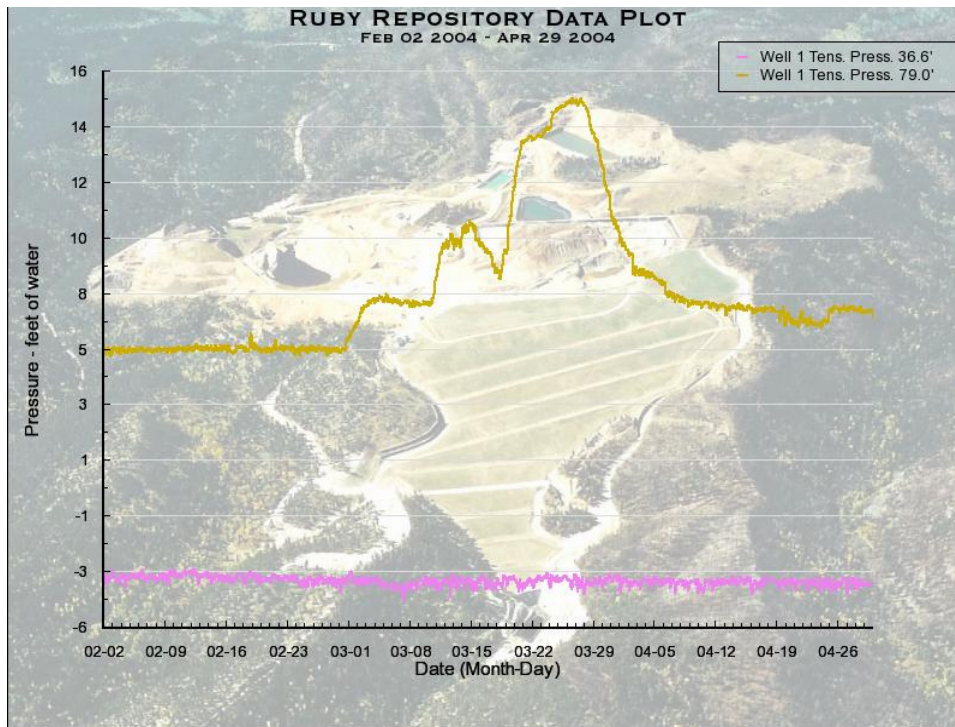
# Seasonal Effects

- Fluid outflow
- Temperature
- Pressure
- Resistivity
- Chemistry

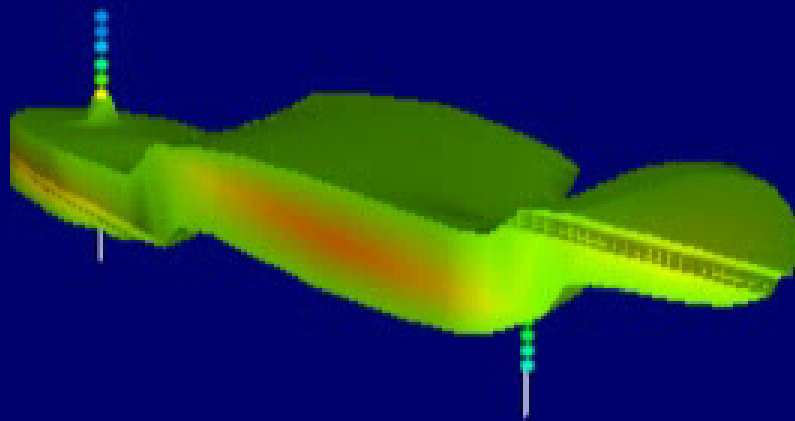
# RUBY REPOSITORY DATA PLOT

JAN 06 2004 - APR 19 2004

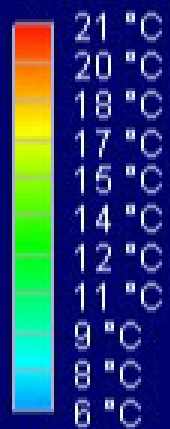




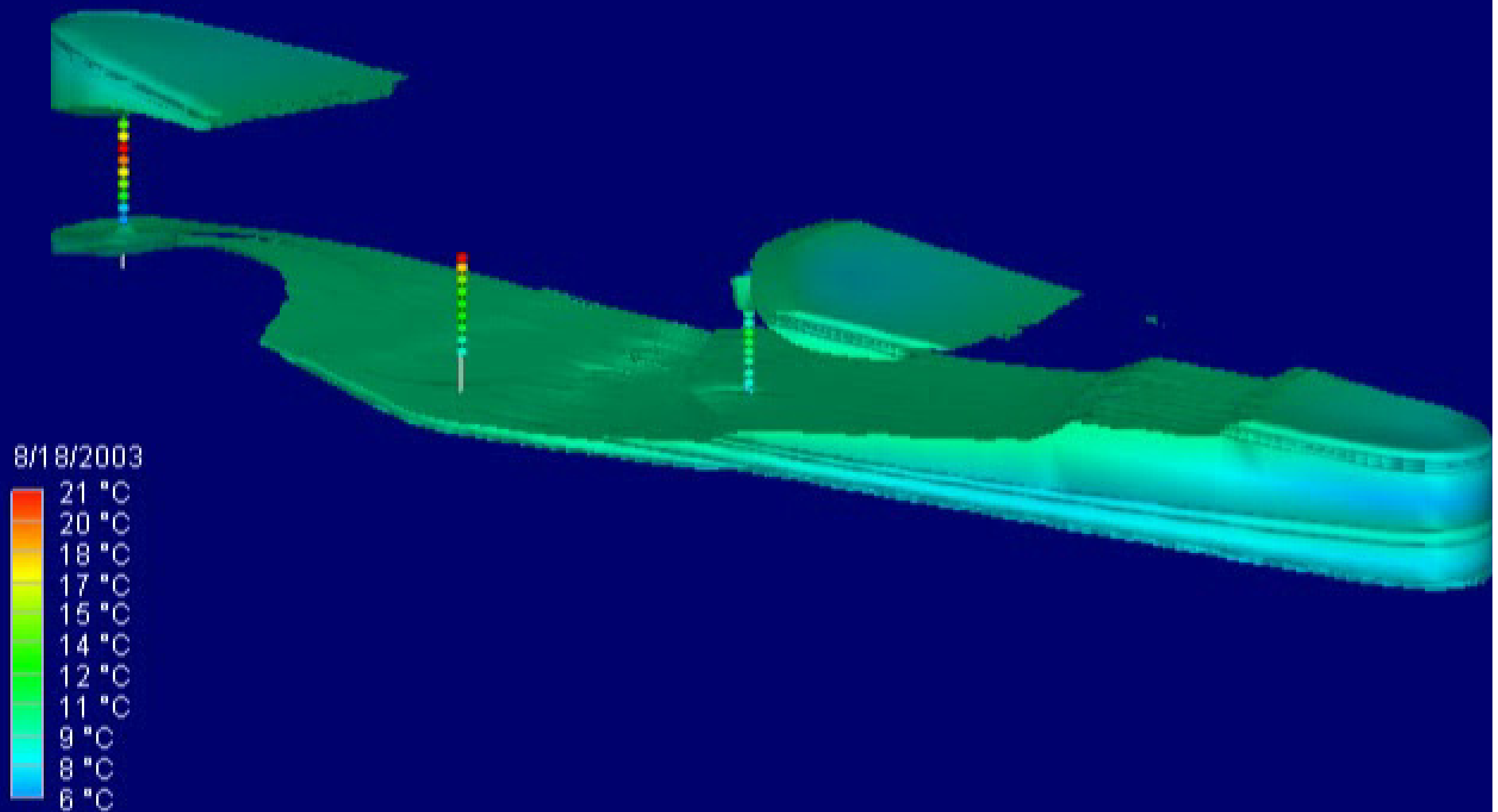
# TEMPERATURES 15 DEGREES C AND ABOVE



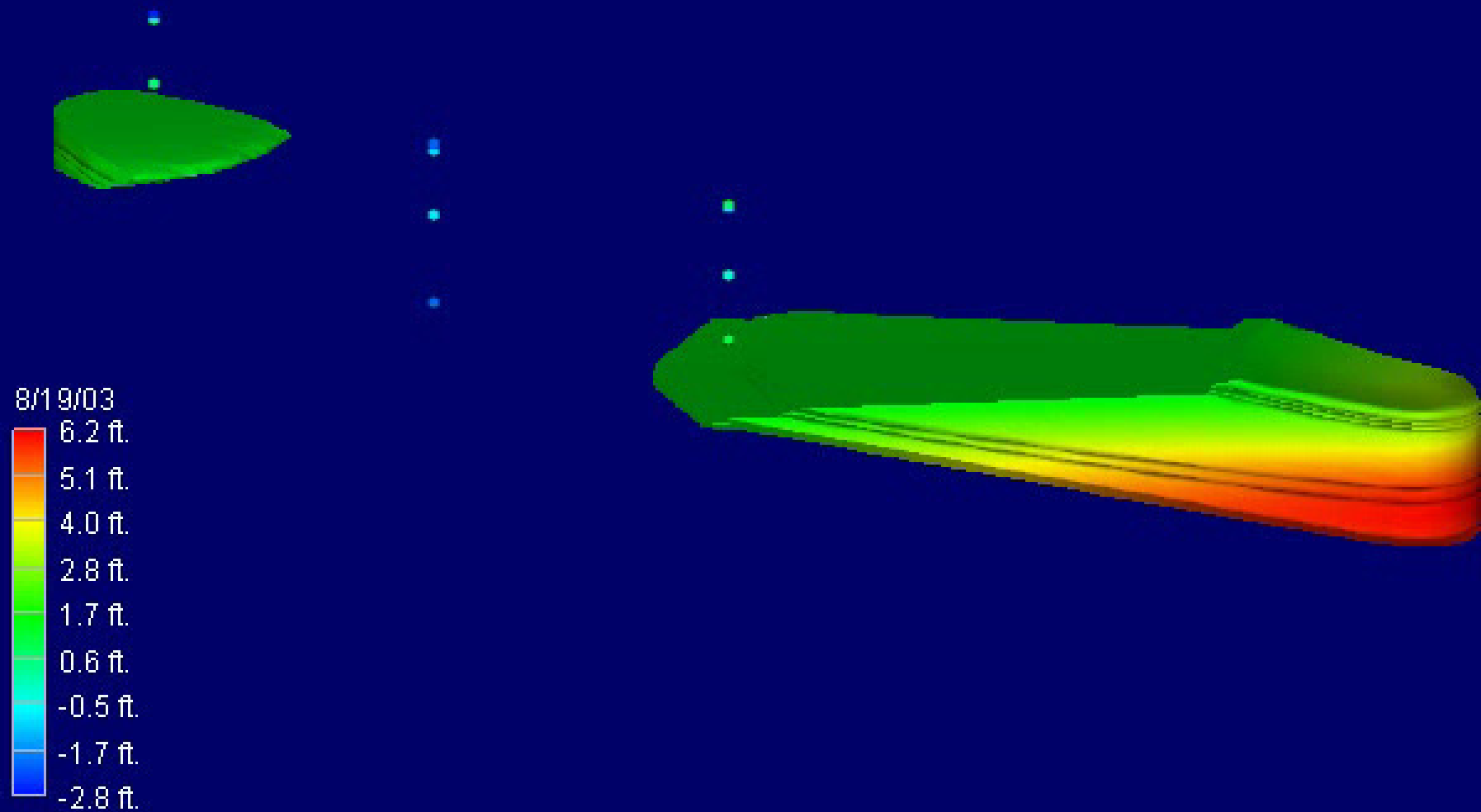
8/18/2003



# TEMPERATURES 10 DEGREES C AND BELOW

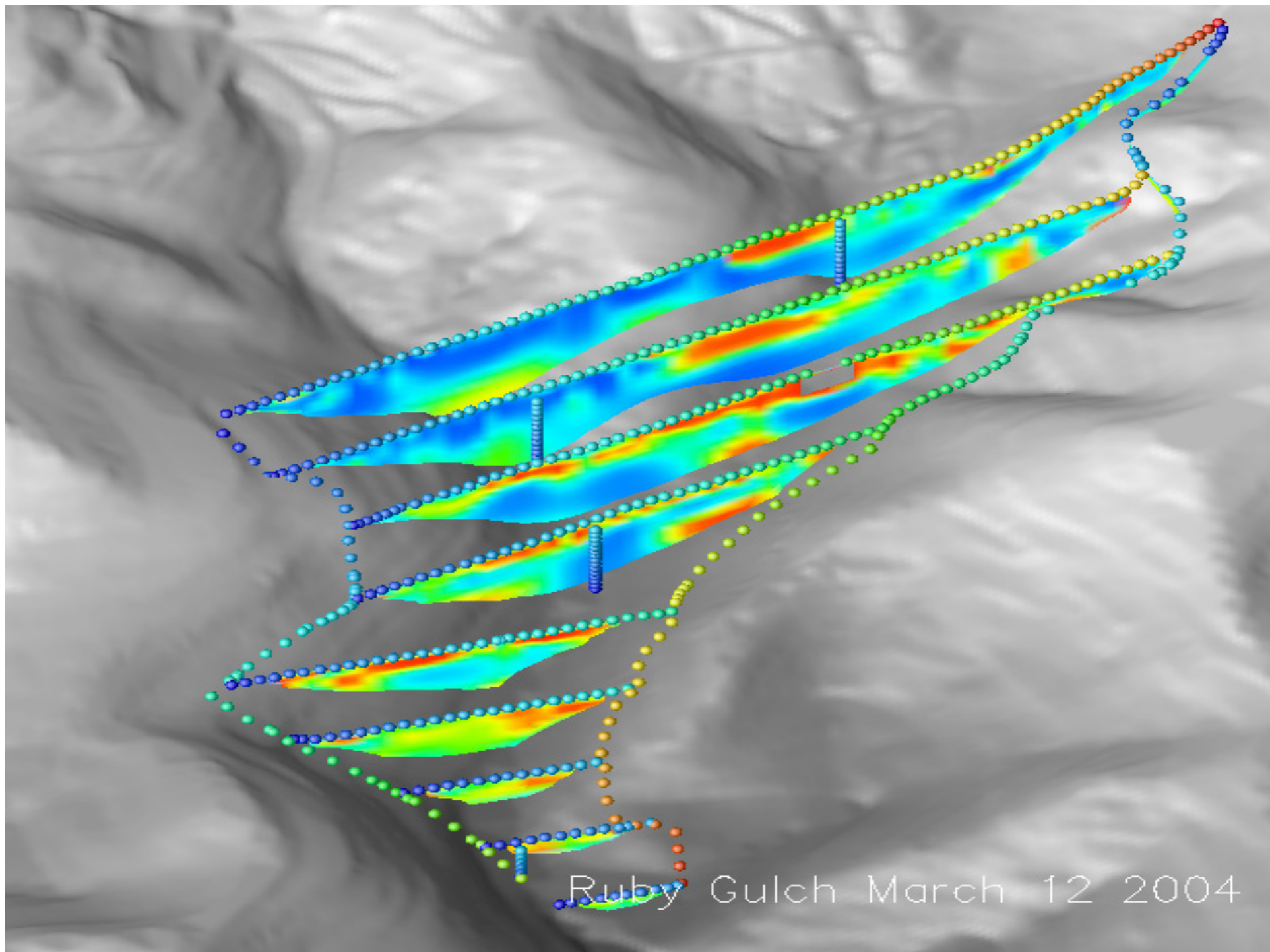


# PRESSURE ABOVE 1.5 FEET OF WATER



# Resistivity Observations

- Red = more resistive (dry / cold)
- Blue = more conductive (wet / warm)
- Little change in temperature – majority of changes due to change in moisture
- Flow down the center of old topography

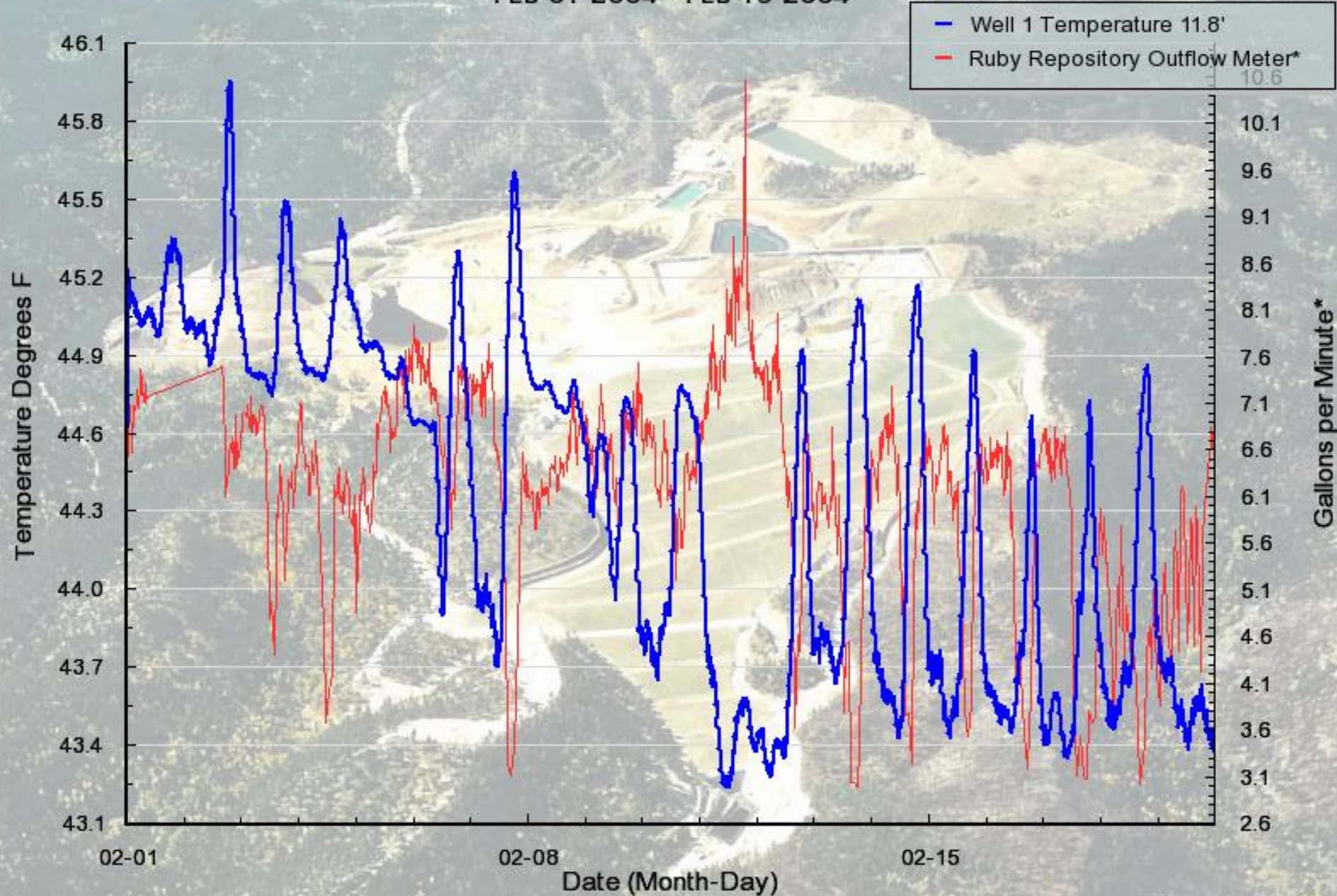


# Diurnal Effects

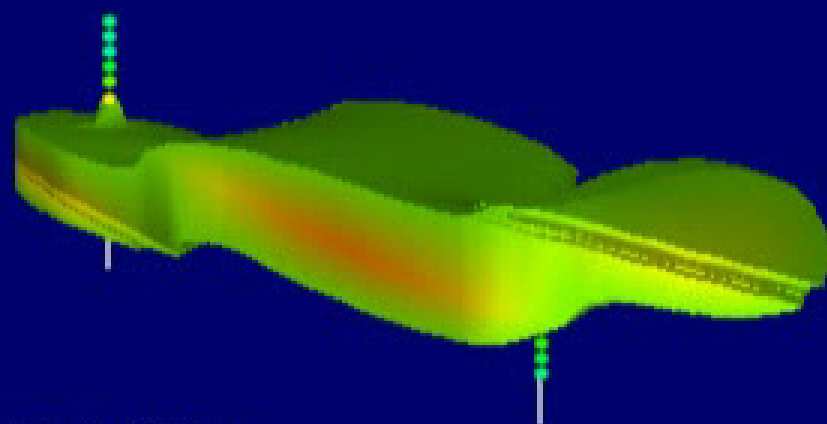
- Fluid outflow
- Temperature
- Pressure
- Resistivity

# RUBY REPOSITORY DATA PLOT

FEB 01 2004 - FEB 19 2004

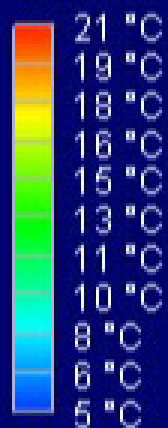


# TEMPERATURES 15 DEGREES C AND ABOVE

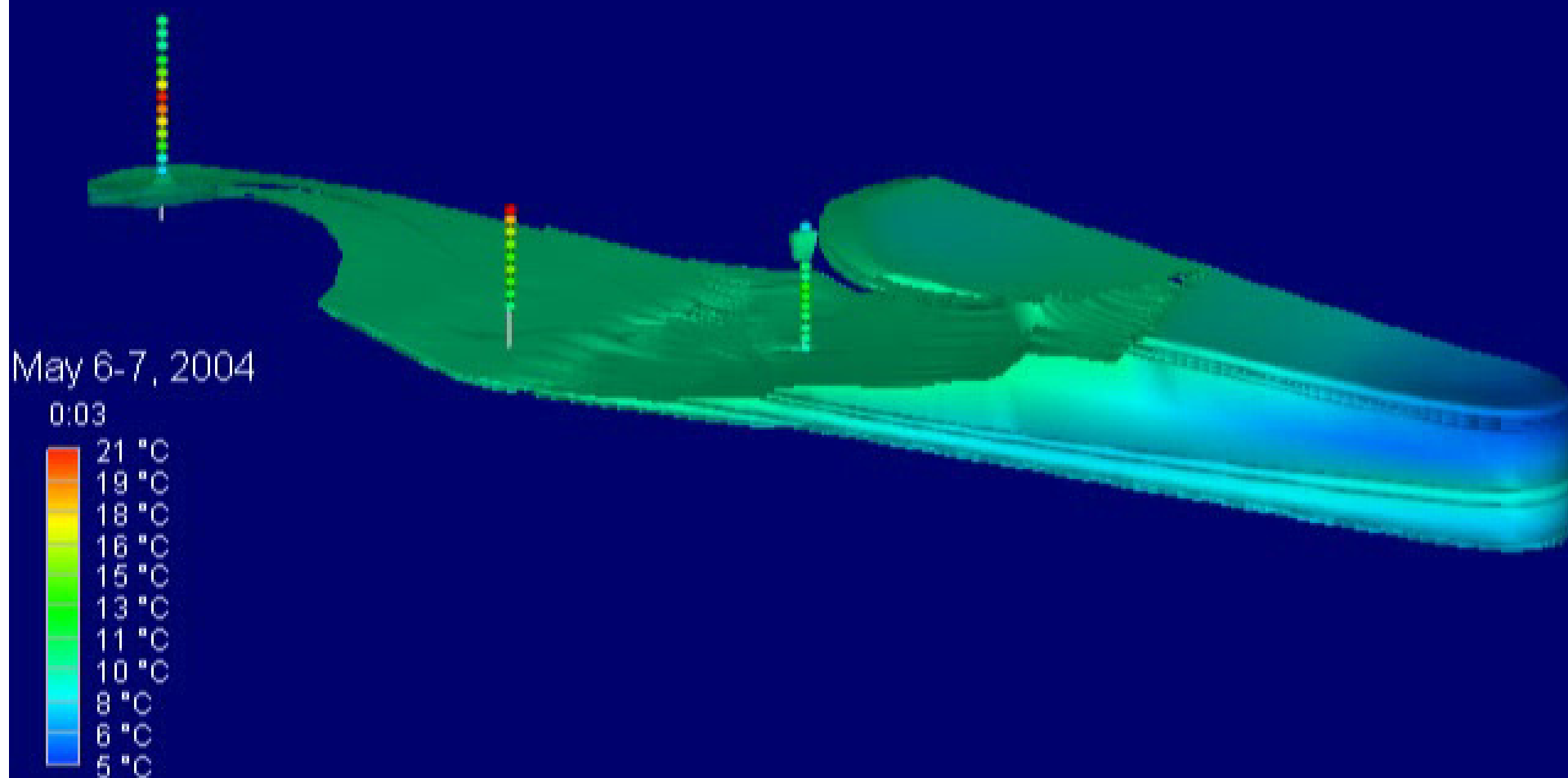


May 6-7, 2004

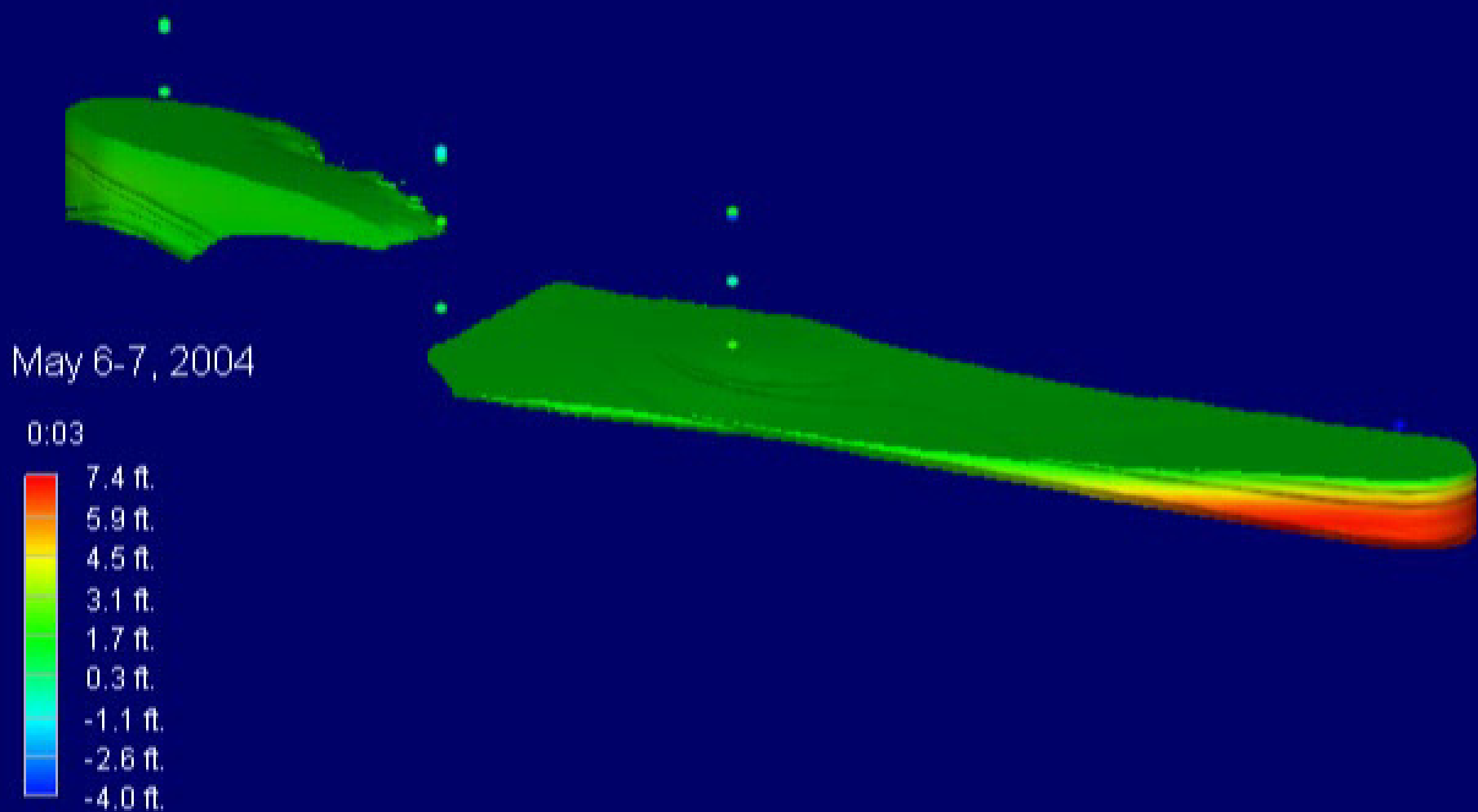
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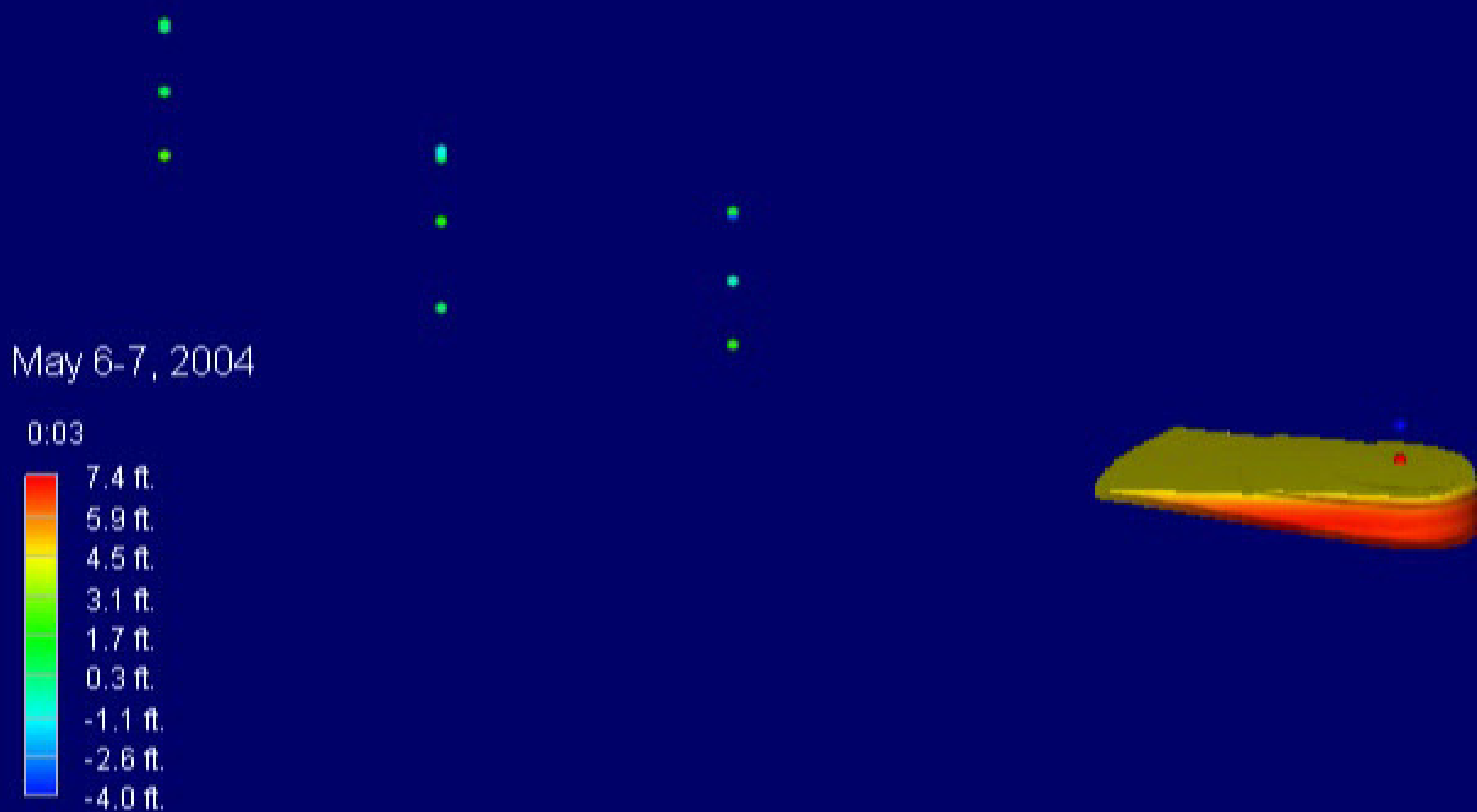
# TEMPERATURES 10 DEGREES C AND BELOW



# PRESSURE ABOVE 1.5 FEET OF WATER

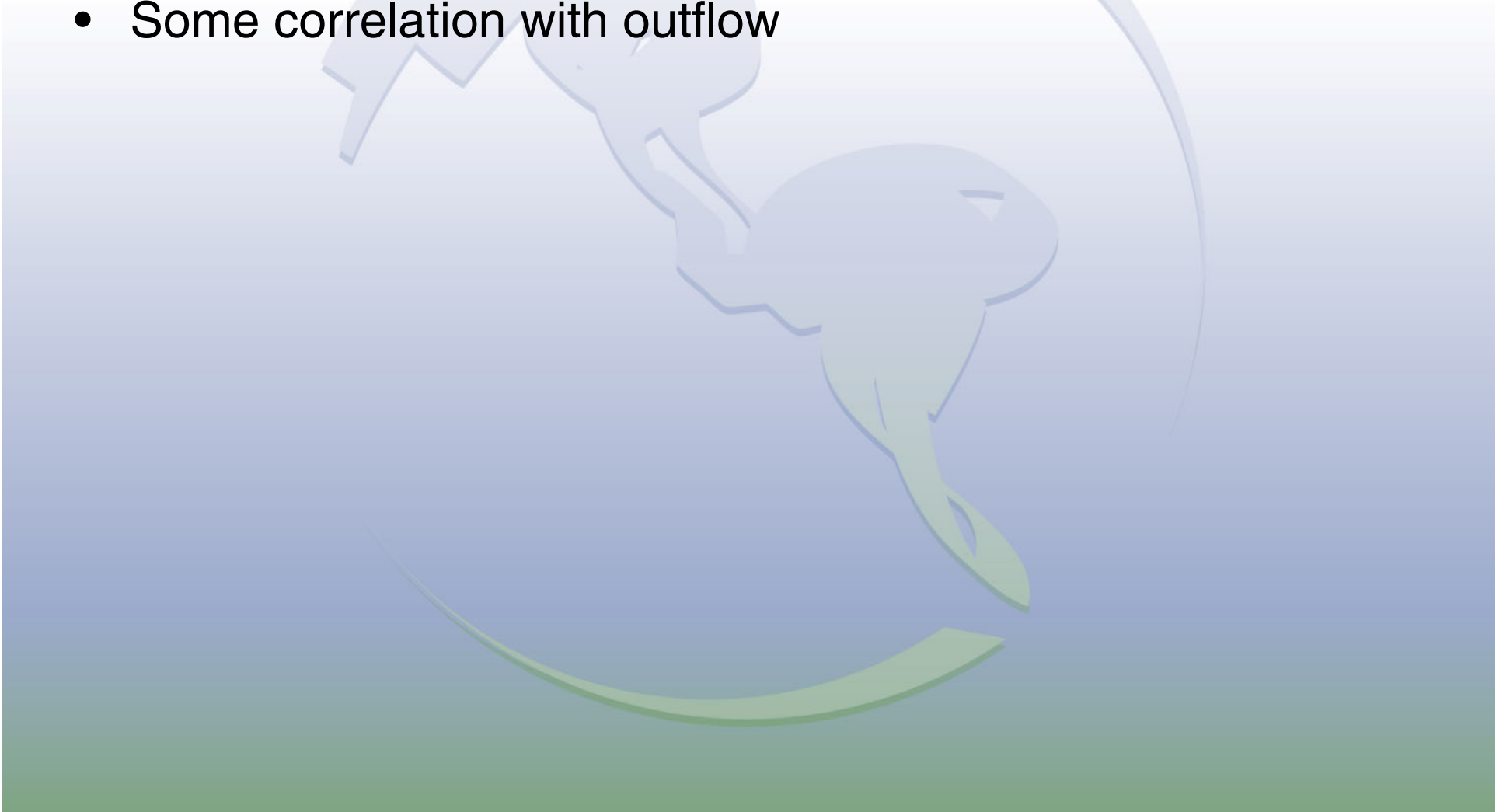


# PRESSURE ABOVE 4.5 FEET OF WATER



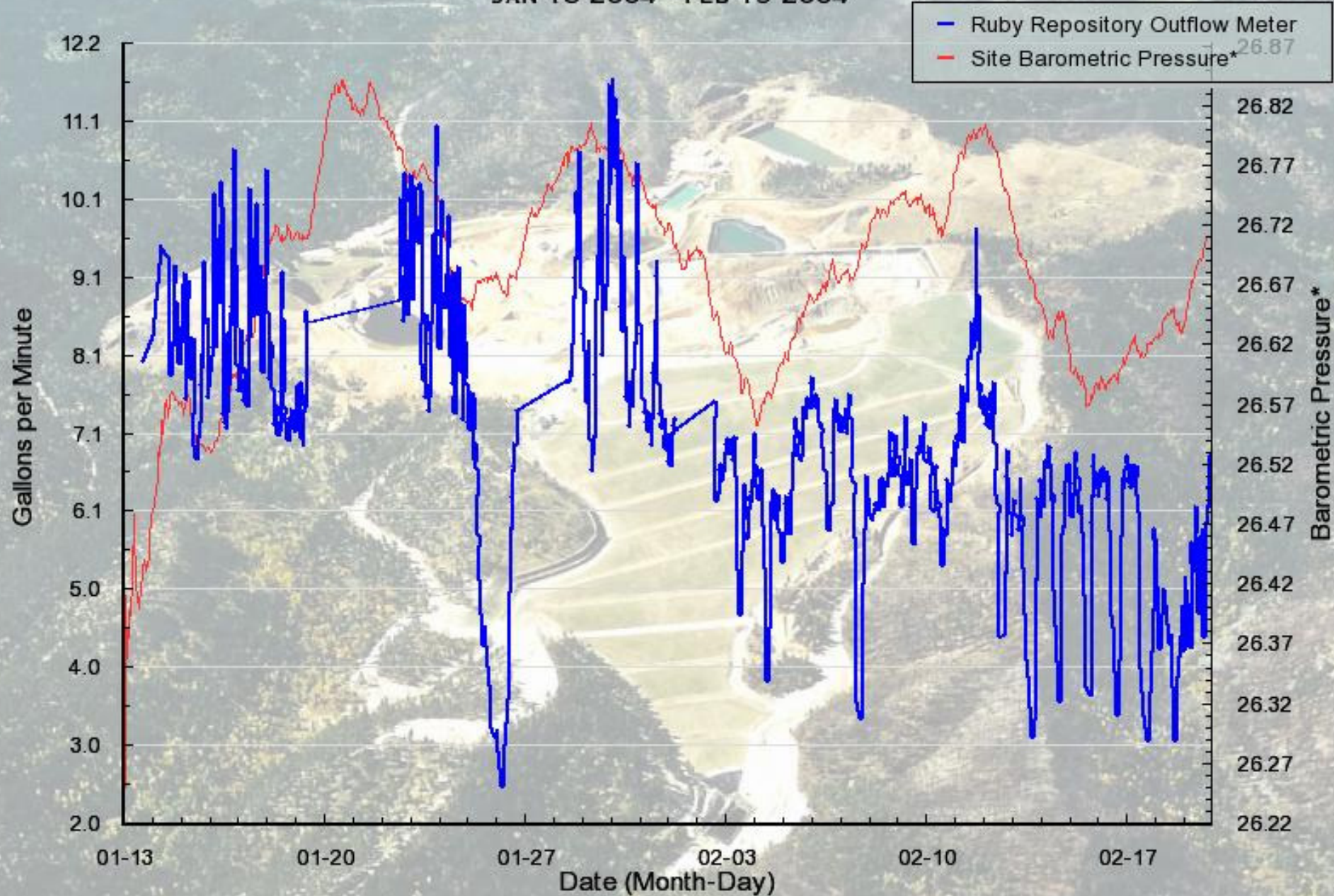
# Barometric Effects

- Some correlation with outflow



# RUBY REPOSITORY DATA PLOT

JAN 13 2004 - FEB 19 2004



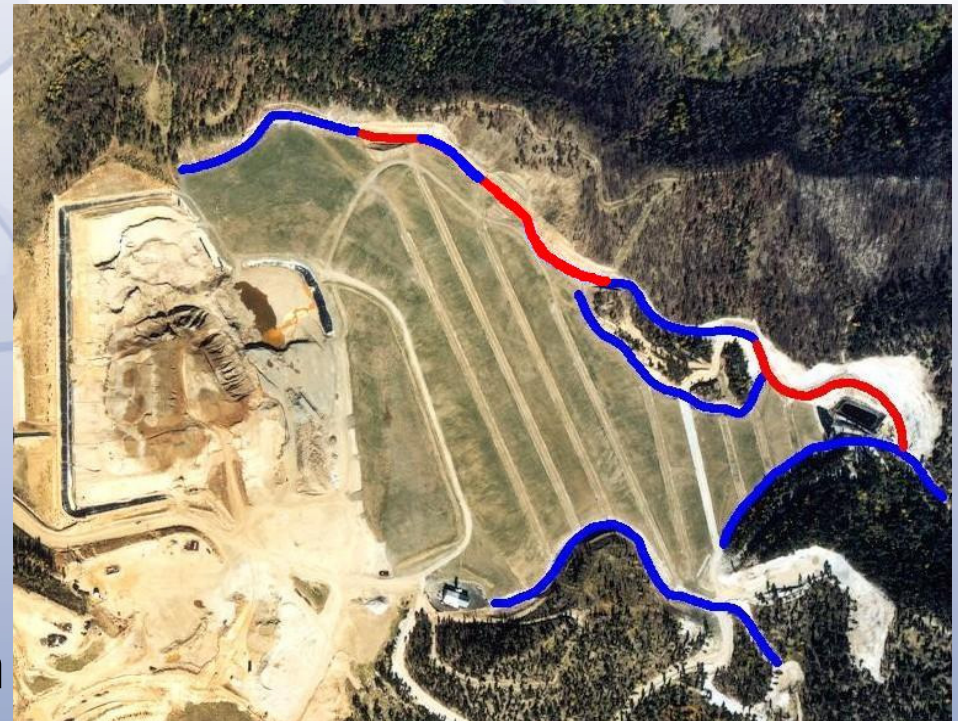
# Slug Test

- Resistivity



# Infiltration test: motivation

- During liner emplacement part of N diversion ditch remained unlined
- Concerns that this may provide pathway into repository
- Need to test diversion ditch performance in controlled environment
- Test in September 2004 from 9/15 to 9/18



Red unlined sections of  
diversion ditch

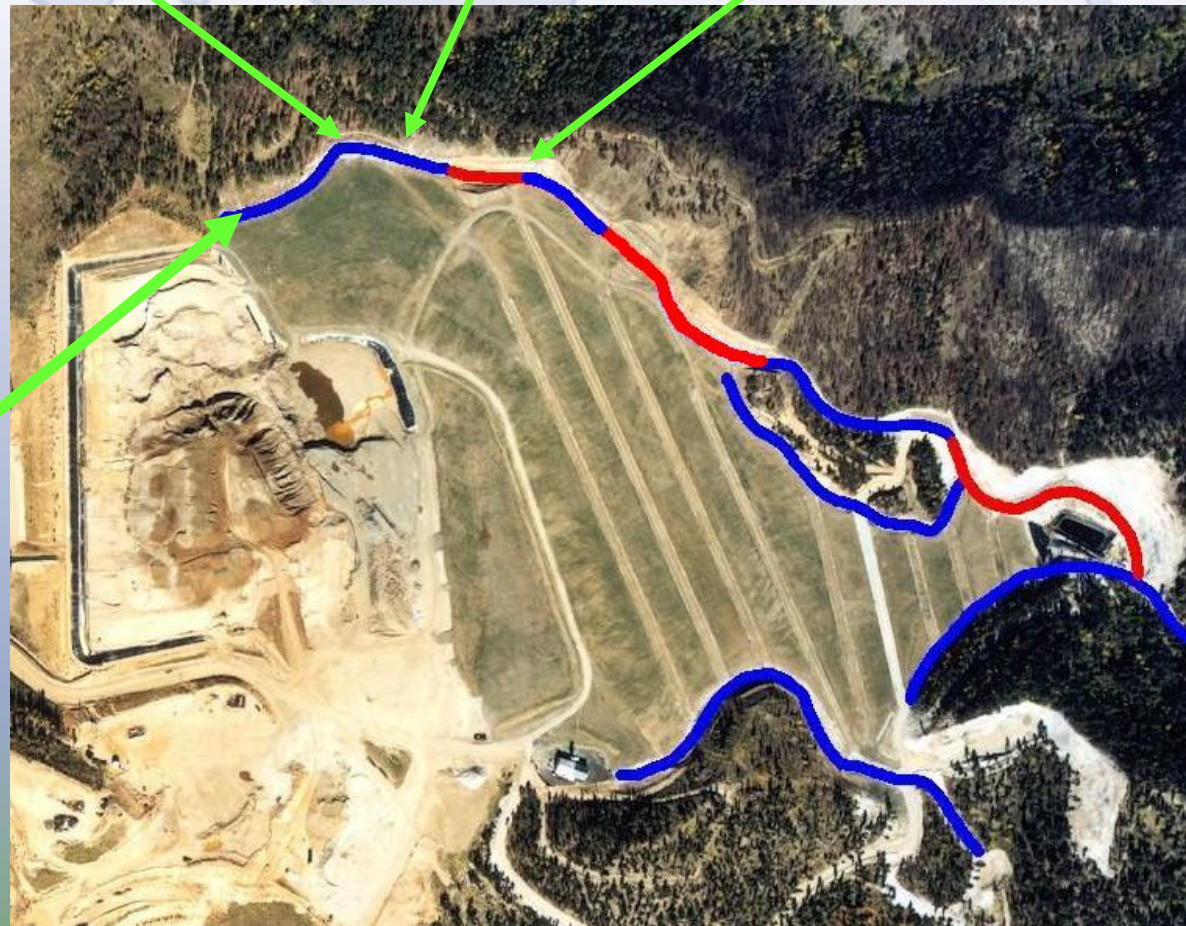
# Slug Test Schematic

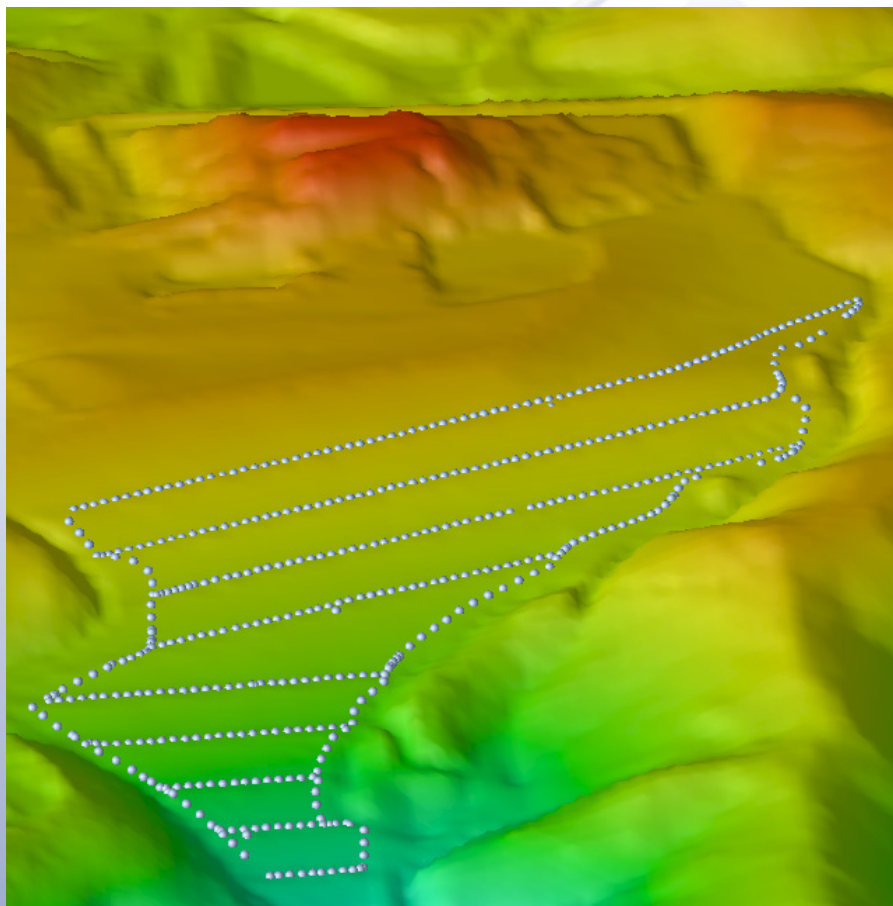
Water disappears approximately here  
from ditch during first days

First electrodes

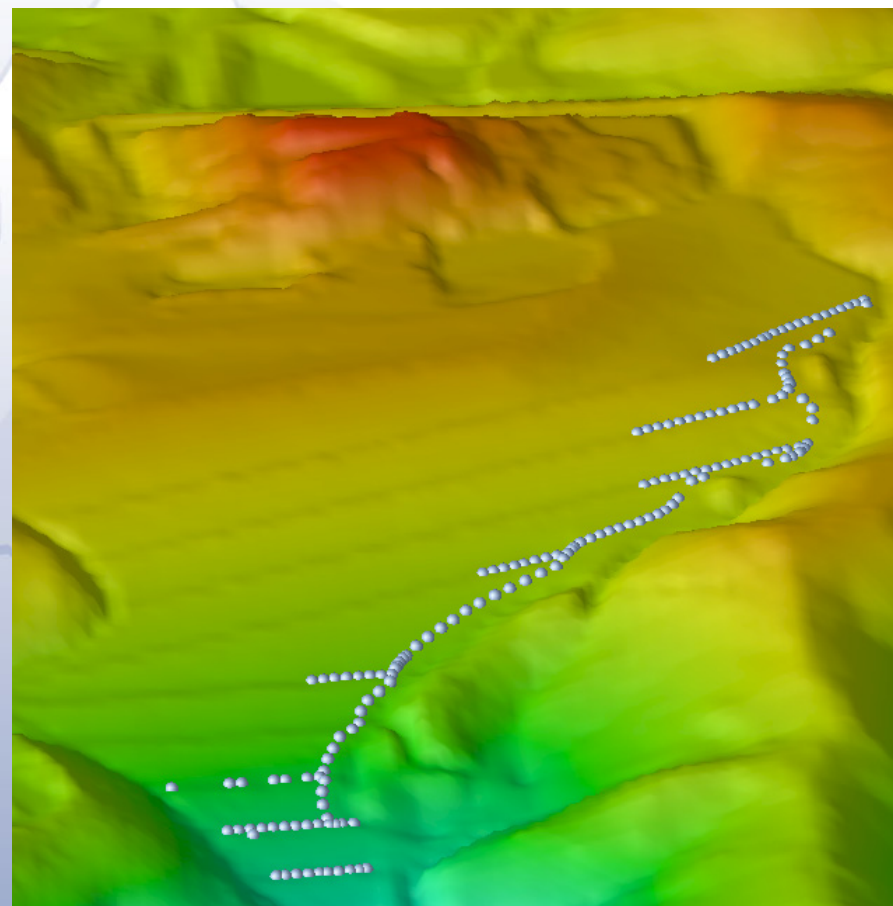
Lowest point on ditch where flowing  
Water was observed (~5 gpm on 9/17)

Discharge point  
From WTP

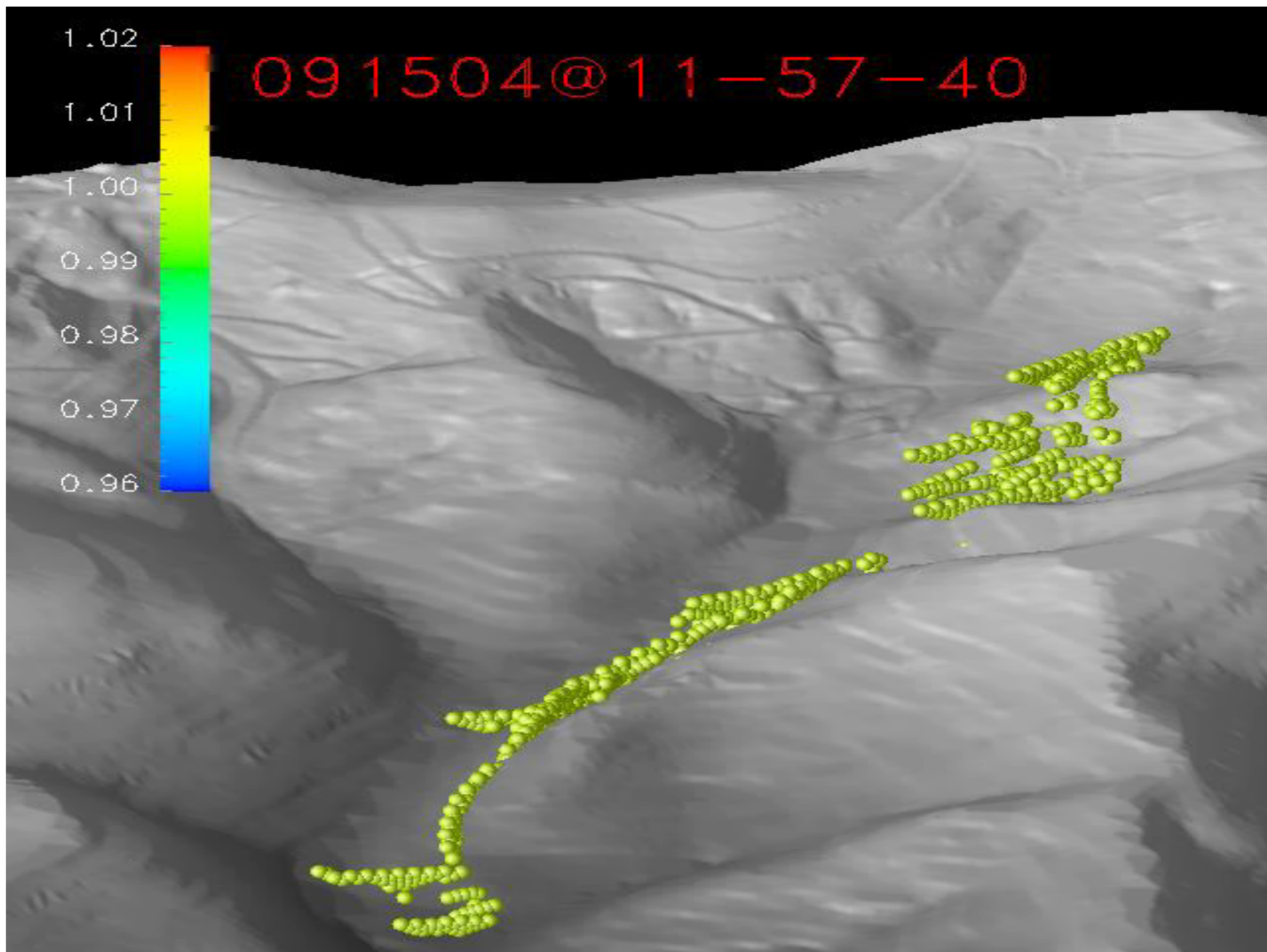


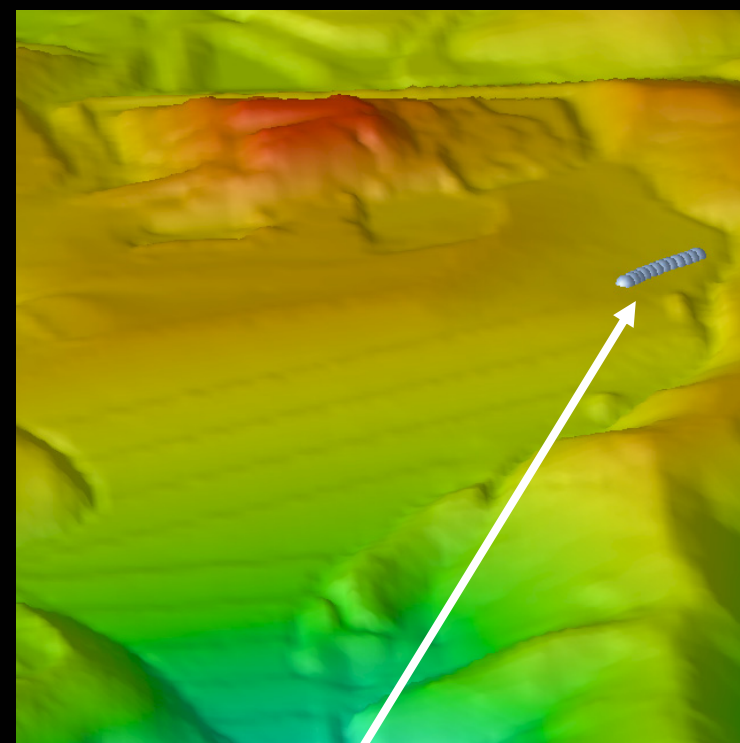
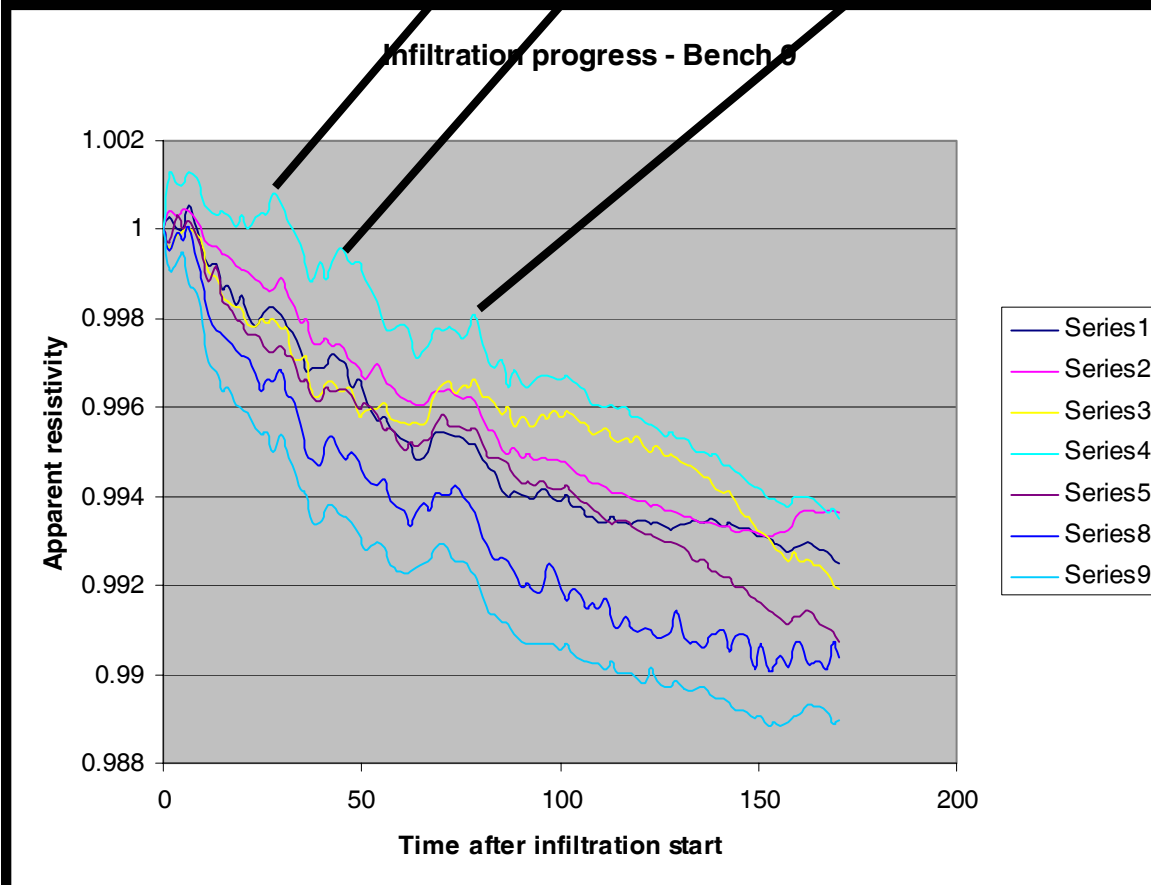
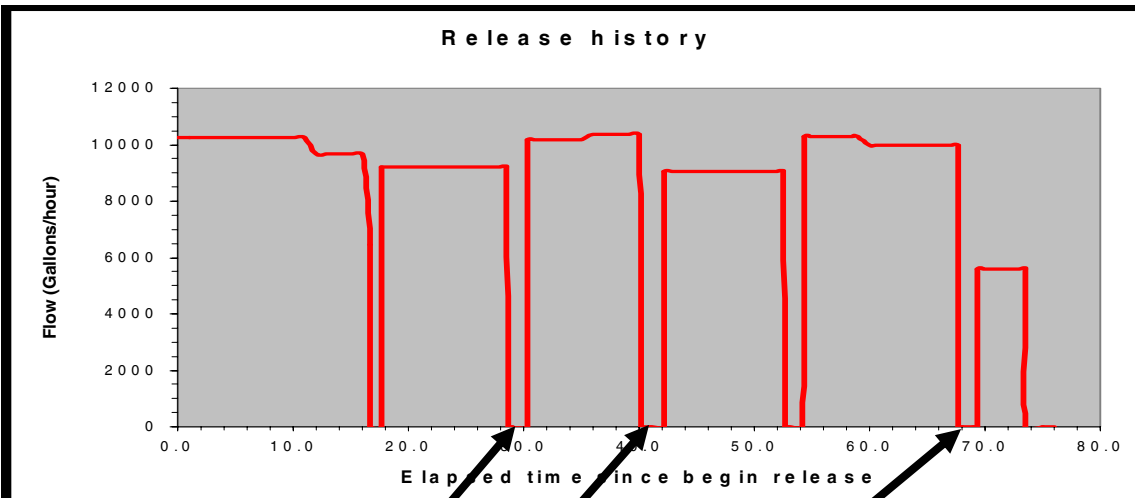


All electrodes



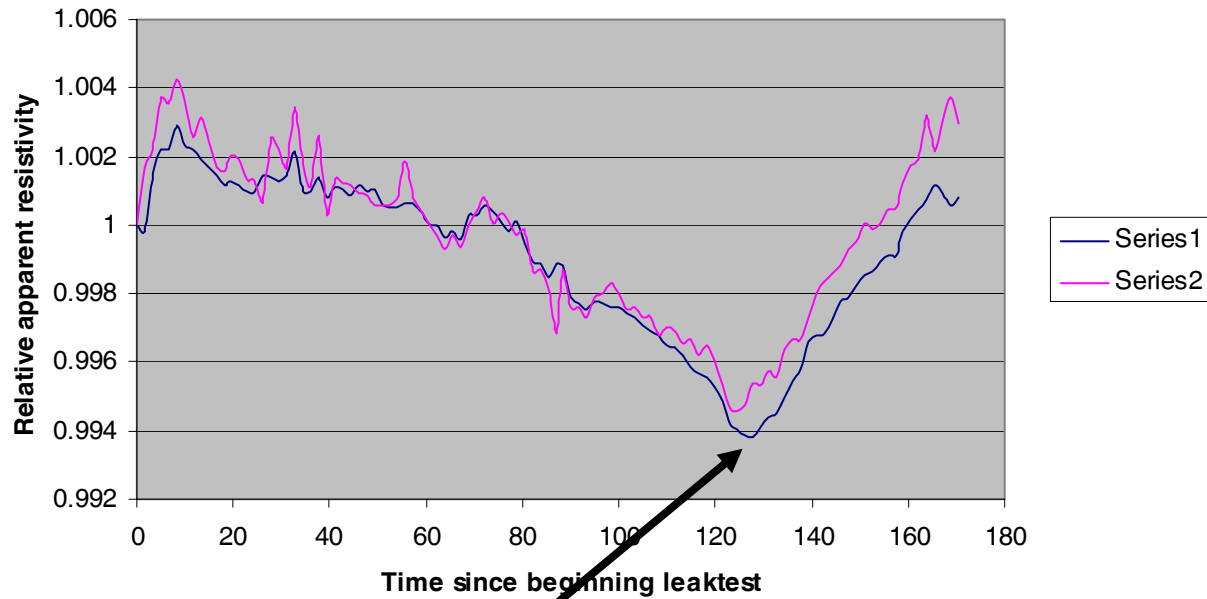
Electrodes used in infiltration test



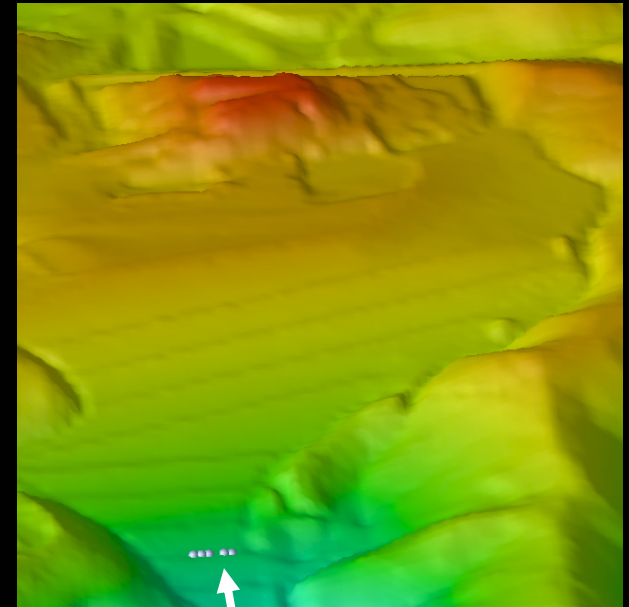
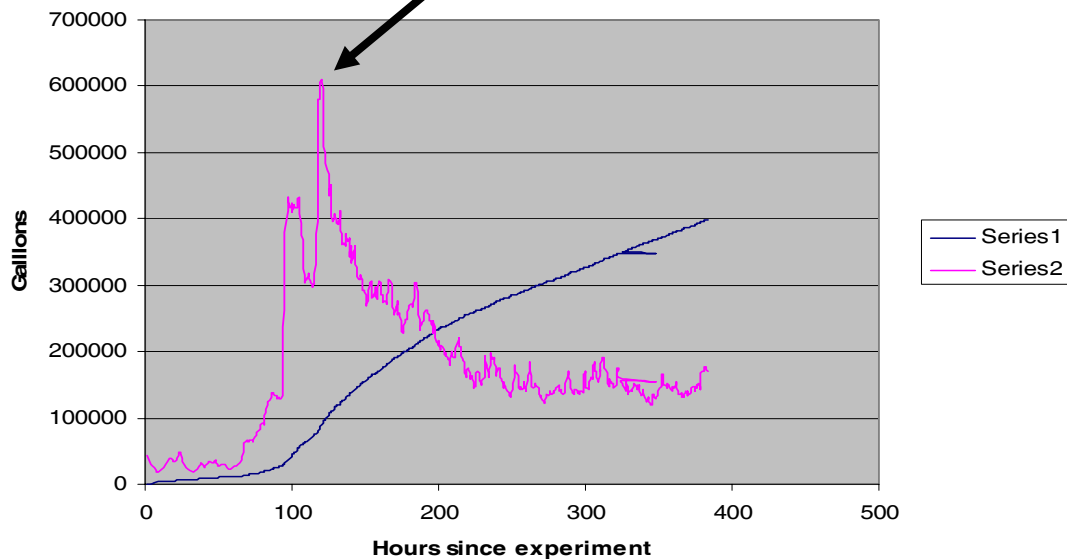


Electrodes  
Series 1 -9

**Apparent resistivity change - lower benches**



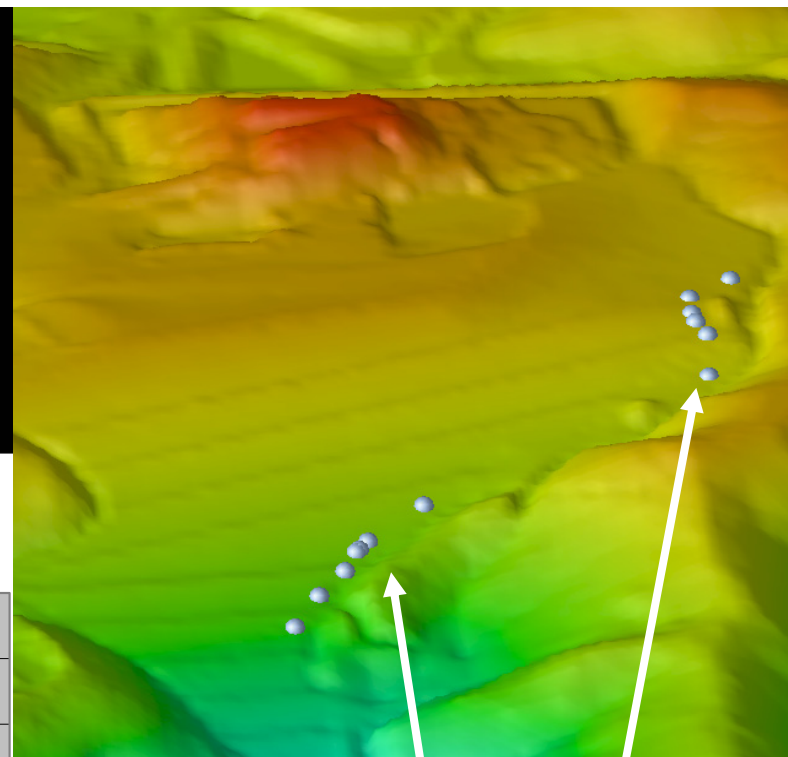
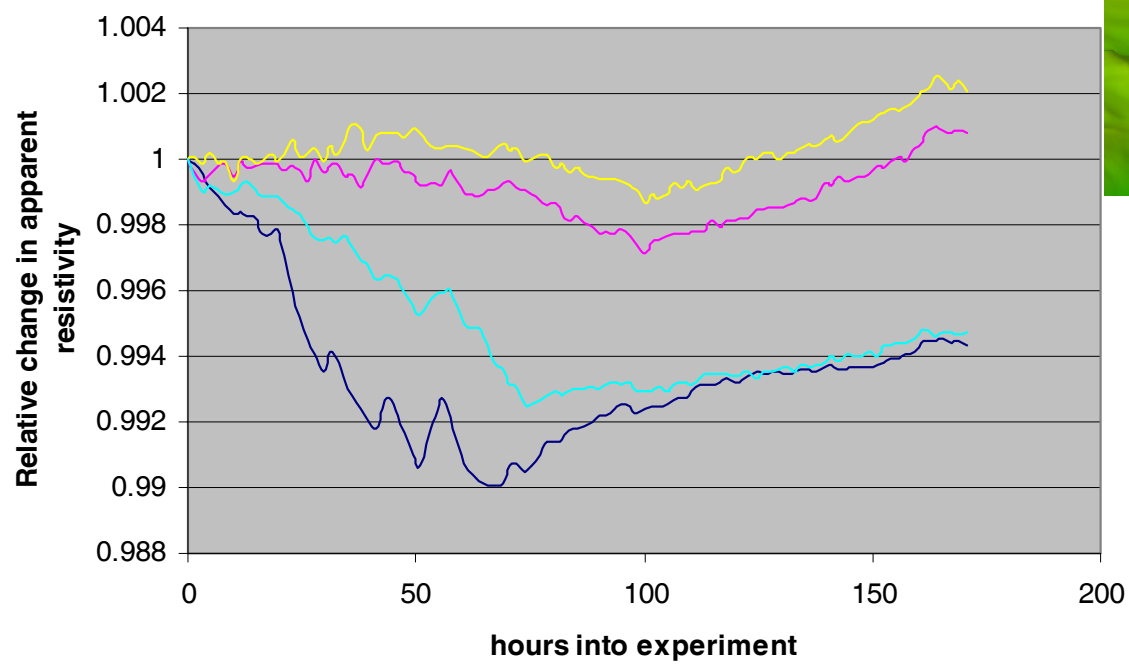
**Outflow (purple) and cumulative flow relative to leak start**



Electrodes  
Series 1 & 2

**Peak outflow and the apparent resistivity low are coincident in time**

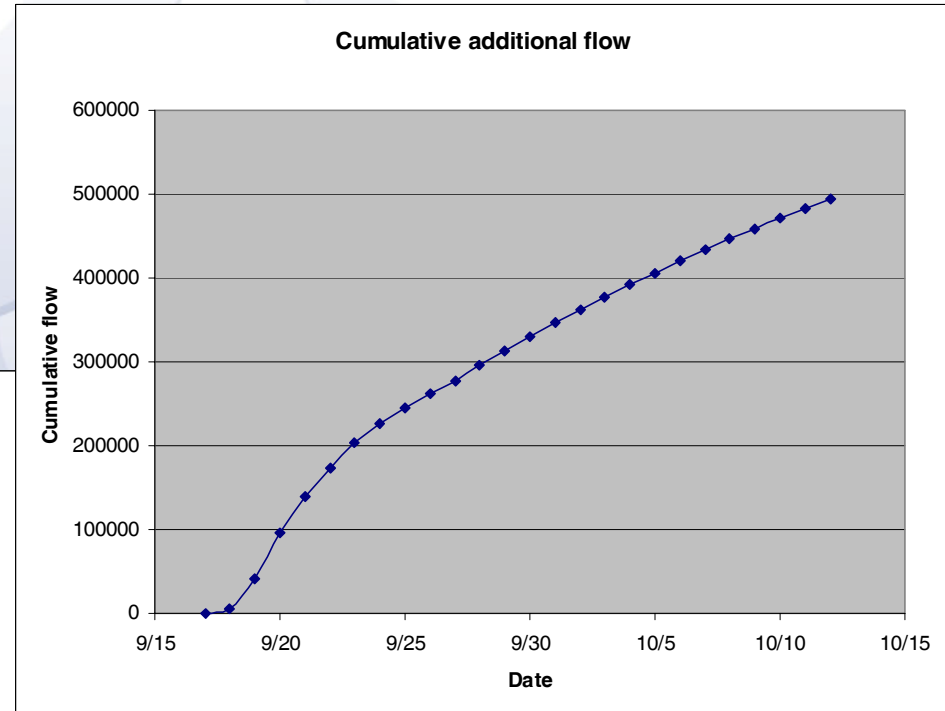
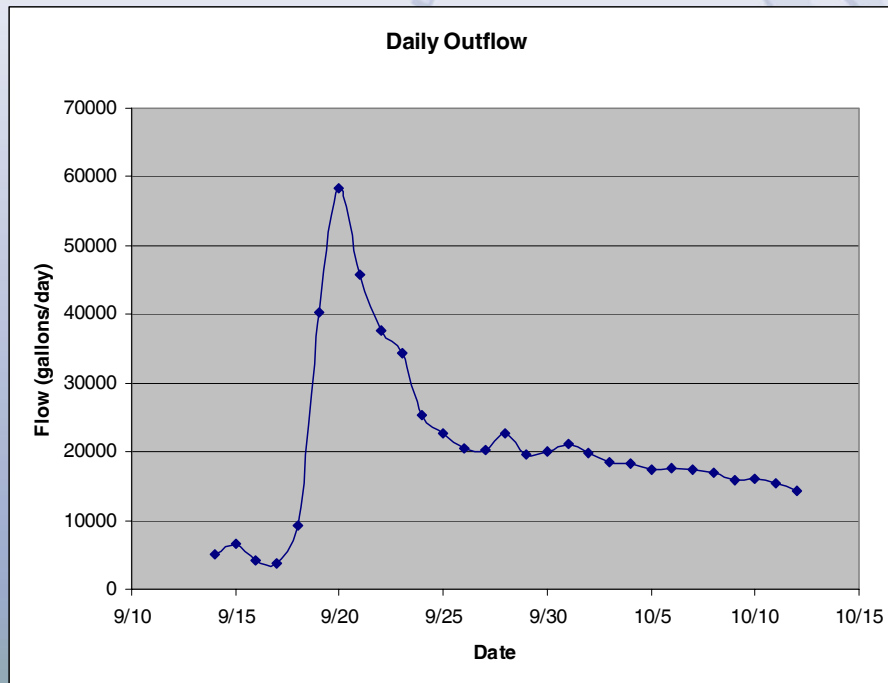
**Apparent resistivity change**



Electrodes  
Series 1 & 4

Electrodes  
Series 2 & 3

# Daily total flows during slug test



Cumulative total flow based on  
3600 gallon/day base flow

# Infiltration test

- Water escapes the North Diversion Ditch in the upper section, and enters the repository centered through the area just West of bench 9
- Resistivity shows arrival of water in lower end of dump – similar in time to outflow peak
- Unexpected result was discovering the high resolution and sensitivity of the resistivity system

# System Outflow Responses

- Correlation between outflow and internal rock mass temperature
- Diurnal effects
- Seasonal Effects
- Chemistry help drive system
- Barometric pressure on outflow