GEO-INSTRUMENTATION in 2010

Specifying Performance

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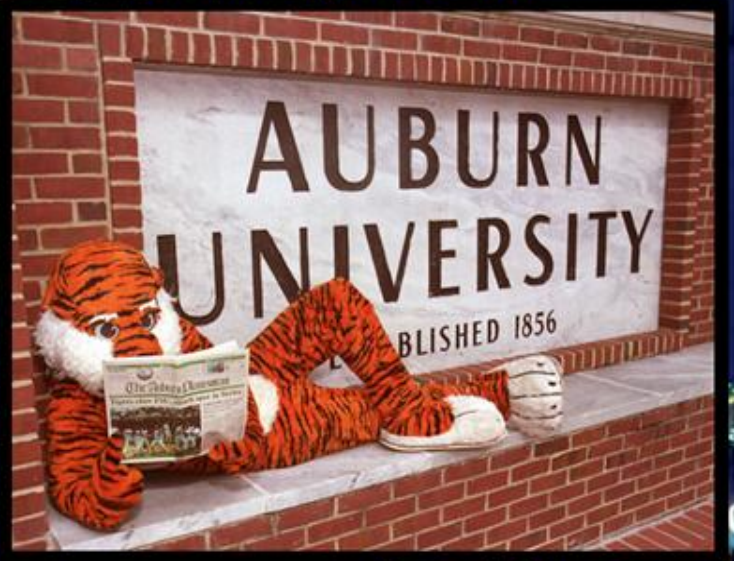
HAIL FROM

EDUCATION



Indianapolis
Kentucky
Virginia
North Carolina
South Carolina
Alabama
Louisiana
Houston

Project Resume

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General Reasons for Utilizing Geo-Instrumentation

- Verification of Design Parameters
- Monitoring of Performance – Construction and Long Term
- Improved Designs – Lower Project Cost
- Risk Management
- Many More!!!!!!

The Attention Getters

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What Structures Benefit from Instrumentation Monitoring?

- Dams, Levees, Canals
- Embankments
- Bridges
- Slopes and Retaining Walls
- Buildings
- Tunnels, Mines
- Etc…….

According to the Lawyers

"If you undertake any complex undertaking, you need a plan of action, you need execution and you need monitoring to see if you are achieving your goals"

- McKenna Long & Aldridge, LLP
TVA Kingston Spill

The Effect

Many owners and engineers have realized the benefits of instrumentation systems for short term and long term monitoring of performance in civil projects.

The Problem

Design engineers often utilize older specifications and plan details or do not fully understand the instrumentation system components. Specifications often mix NEW technologies with OLD execution methodologies.

Beware of Cut & paste specs

What's the Harm?

- Less than Desired Performance
- Improper Installation
- Increased Project Cost
- Change Orders

Let’s Look Some Examples

- Piezometers
- Inclinometers
- Drilling Methods
- Surface Completions
- Data Acquisition Systems

Piezometers

	Standpipe	Pneumatic	Vibrating Wire
Response	Slow	Fast	Fast
Accuracy	High	Medium	High
Repeatable Readings	Need Technique	Need Patience	Easy
Obtain Readings Remotely	No	Yes	Yes
Connect to Data Logger	No	No	Yes
Potential for Lighting Damage	No	No	Yes
Main Expense	Drilling Borehole	Drilling Borehole	Drilling Borehole

VERY Different Installation Methods

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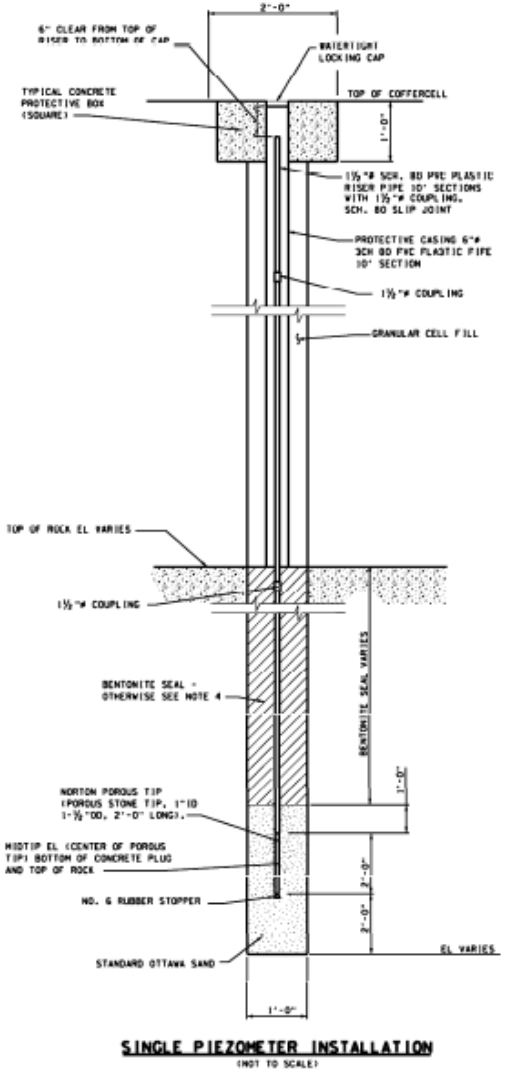
Piezometer Response Times

Forgotten Mathematics!
All about Volumes!

Standpipe - Generally requires significant change in volume to indicate changes in pressure

Vibrating Wire - Requires very, very, very small change in volume to indicate change in pressure.

Standpipe Piezometers



Hvorslev - Sizable Intake Zone and Small Riser to Reduce Lag Time.

Required Volume Change per 1' head Pressure Change

2" Riser = 617 cm^3

1" Riser = 154 cm^3

¾" Riser = 87 cm^3

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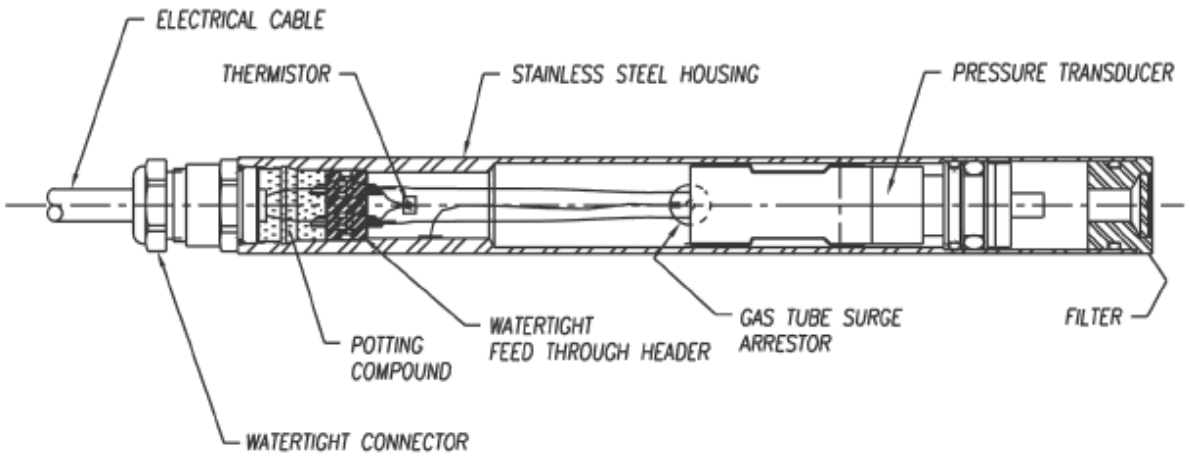
Vibrating Wire Piezometers

Typical Required Volume Change per 1' head Pressure Change

VW = .01 to .001 cm^3



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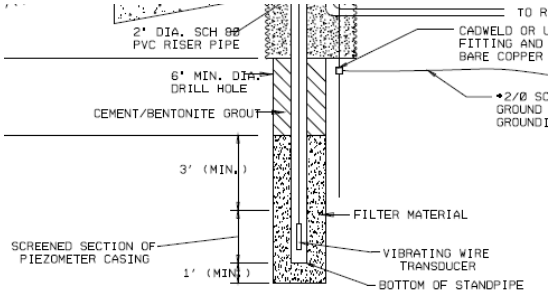
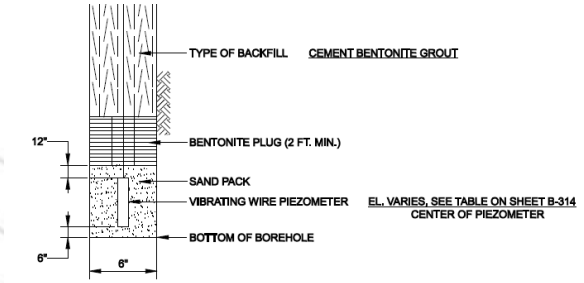
VW Install Methods

- Inside Open Standpipe
  - Increases Response Times
  - Increases Installation Cost – Larger Boreholes
  - Difficult to Nest
  - Barometric Correction
  - Can be Easily Replaced



- Sand Intake Zone
  - Increases Response Times
  - Increases Installation Cost – Larger Boreholes
  - NO Advantage



VIBRATING WIRE PIEZOMETER DETAIL (P-X)
NTS

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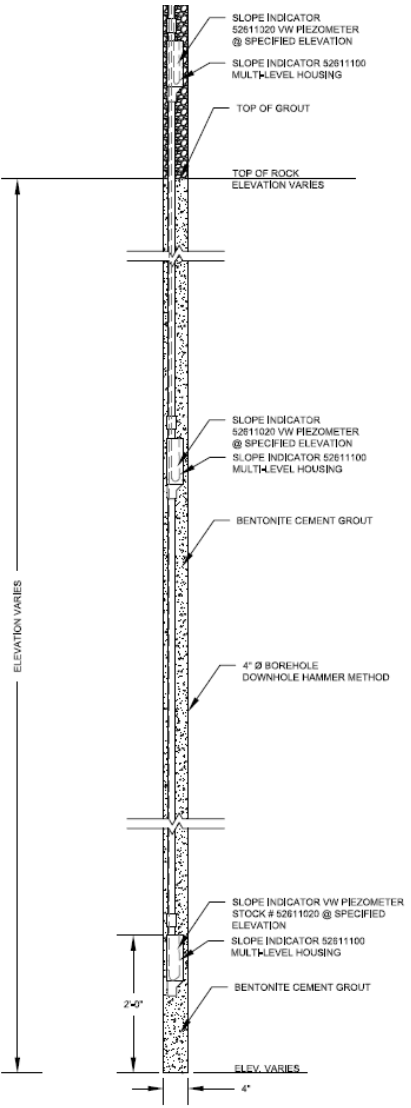
VW Install Methods – Cont.



- Fully Grouted
  - Decreases Response Times
  - Decreases Installation Cost – Smaller Boreholes Rapid Installation
  - Easily Nested
  - Multi-Sensor Boreholes – Reduces Cost
  - Well Documented
  - Can Not be Easily Replaced

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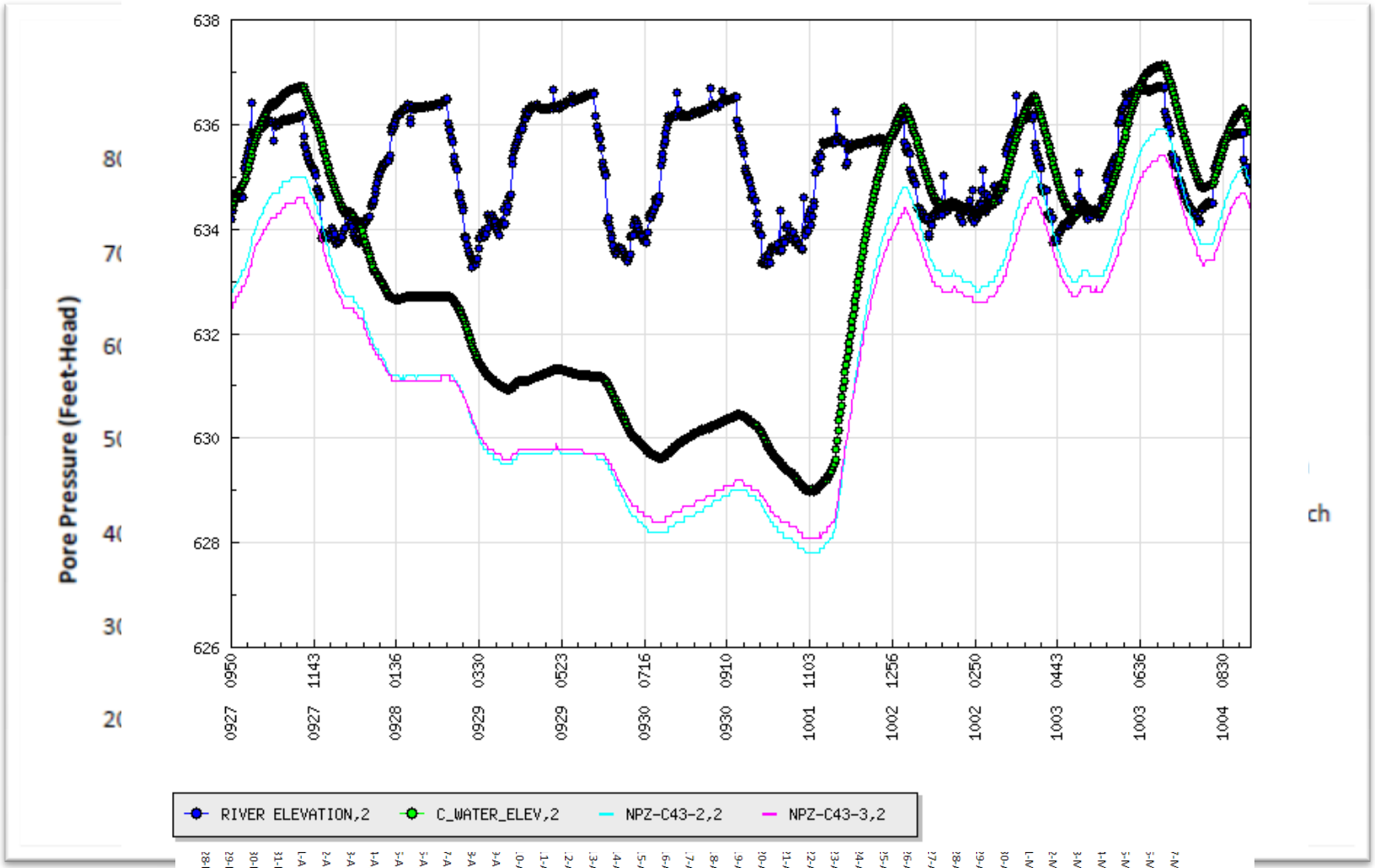
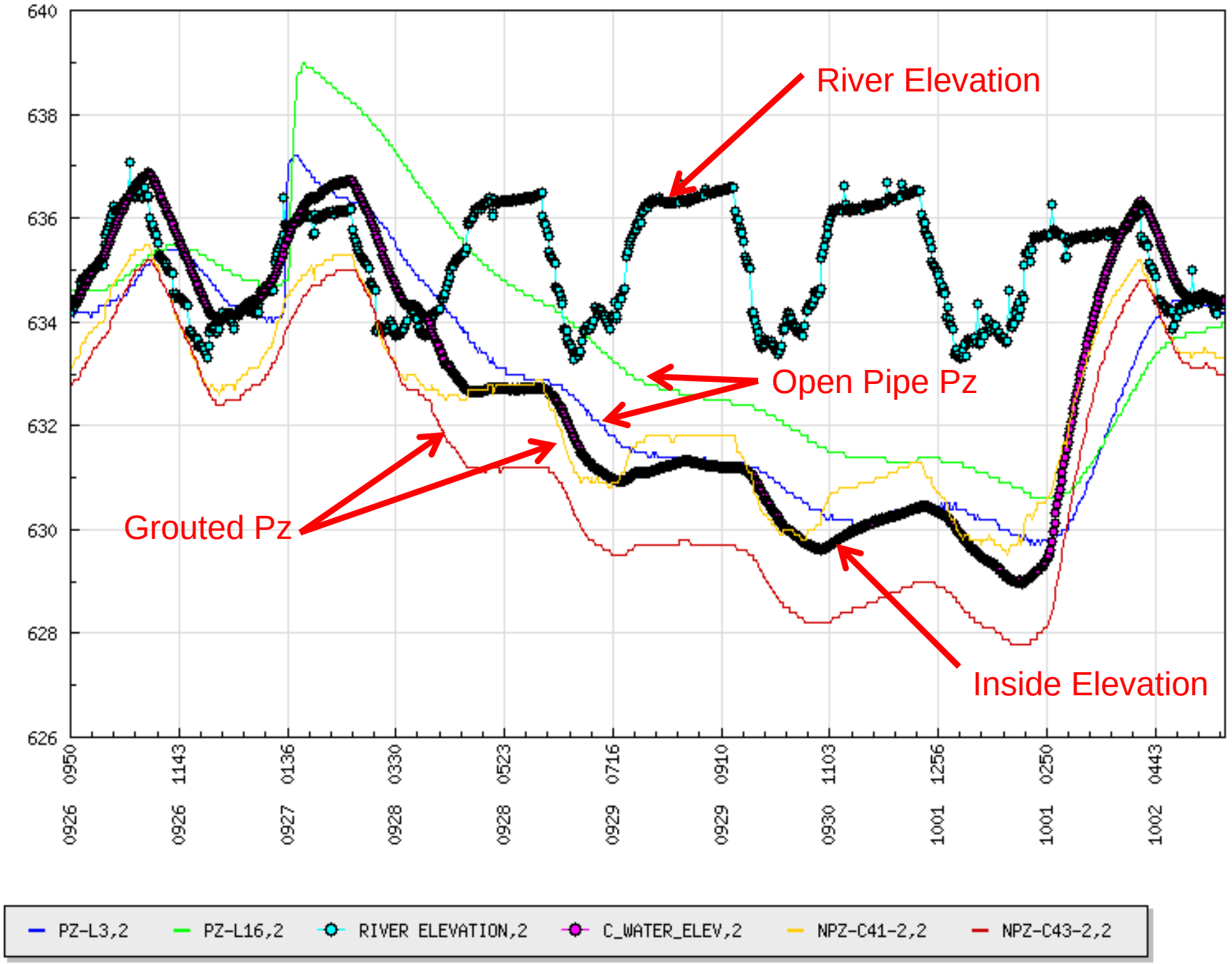
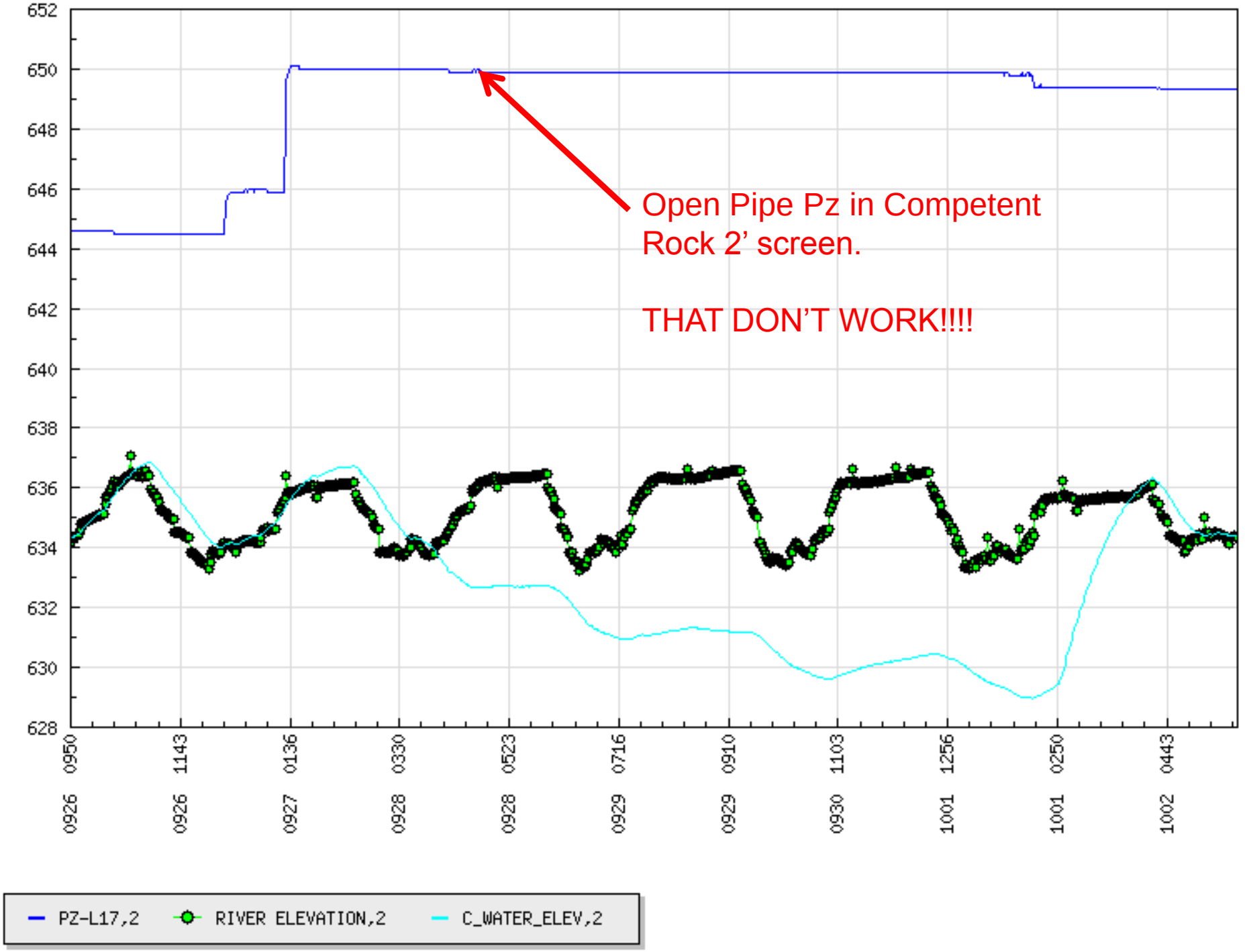
The Proof of Fully Grouted Rocks




River Elevation
Open Pipe Pz
Grouted Pz
Inside Elevation
640
638
636
634
632
630
628
626
0950
1143
0136
0330
0523
0716
0910
1103
1256
0250
0443
0926
0926
0927
0928
0928
0929
0929
0930
1001
1001
1002
PZ-L3,2
PZ-L16,2
RIVER ELEVATION,2
C_WATER_ELEV,2
NPZ-C41-2,2
NPZ-C43-2,2


652
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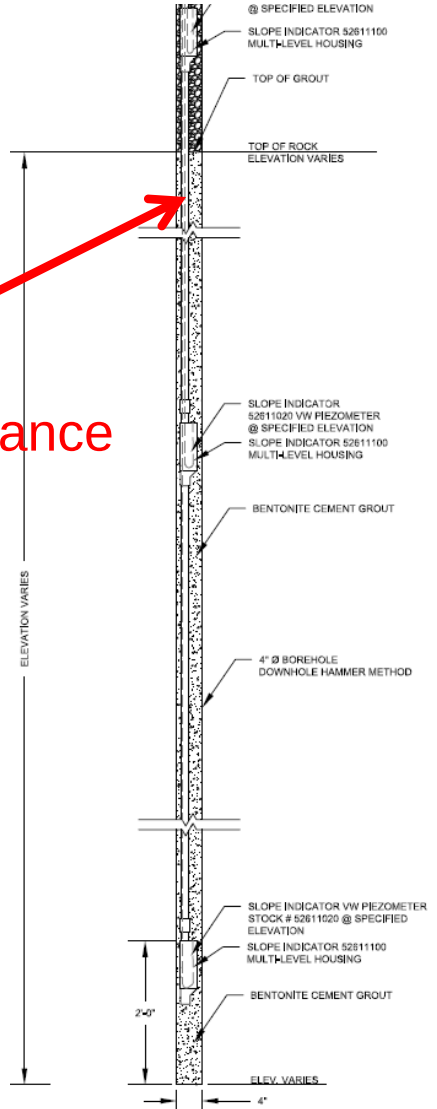
0929
0930
1001
1001
1002
Open Pipe Pz in Competent Rock 2' screen.
THAT DON'T WORK!!!!
PZ-L17,2
RIVER ELEVATION,2
C_WATER_ELEV,2

Project Specific Cost Savings

12 Nested Piezometers in Aggregate and Bedrock

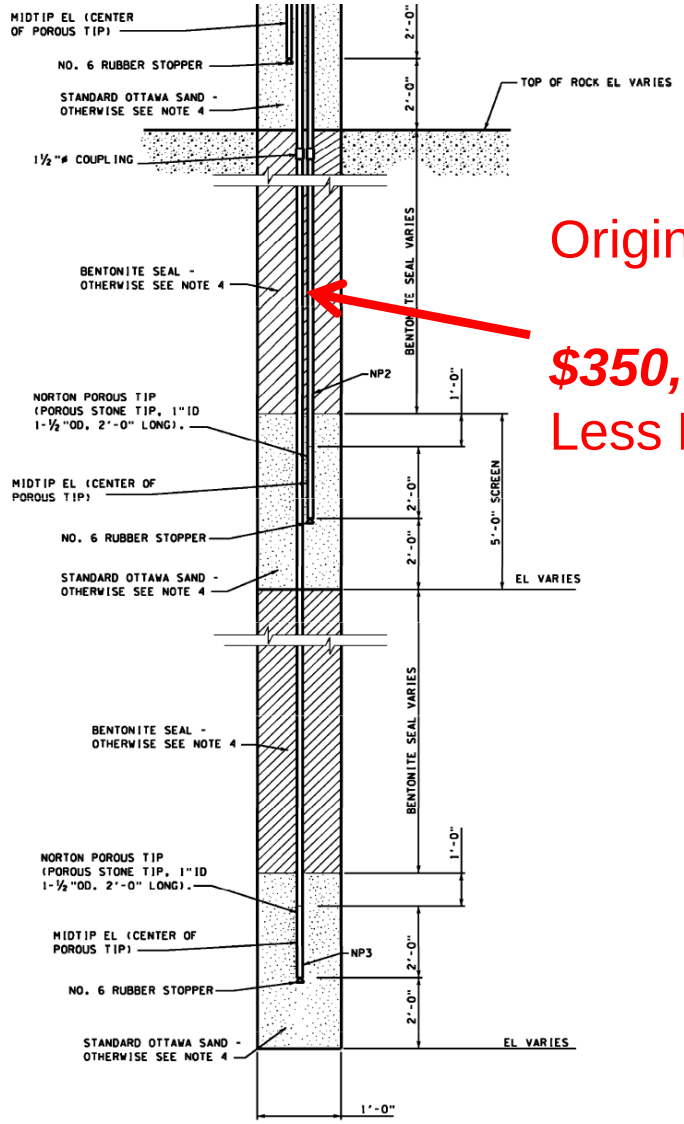
Modified Design

$350,000 Less
Greater Performance



Original Design

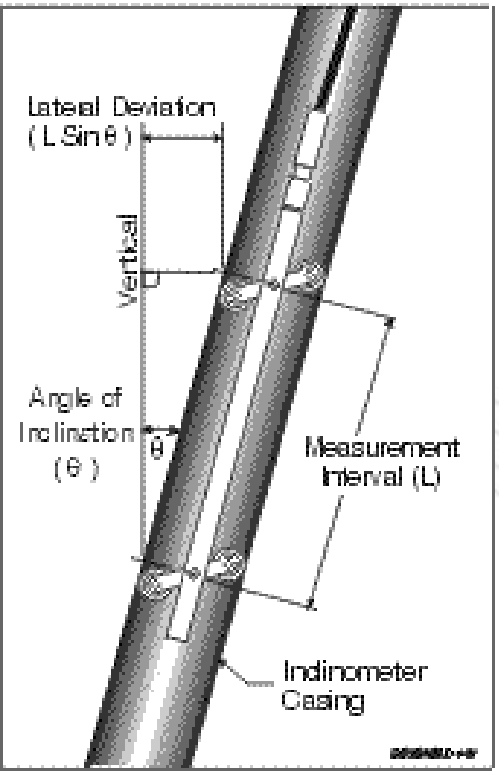
$350,000 Higher
Less Performance



Common Costly Msitakes for VW Piezometers

- Sand Intake Zones - Don't Need Them
- Not Utilizing Multi-Sensor Boreholes
- Over-sizing boreholes
- Open standpipe construction
  - Use only when necessary for recovery

Inclinometer Considerations



- Casing Size and Type
- Installation Techniques
- Settlements
- Error Detection
- Transversing or In-place
- Multi-Sensor Installation

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Casing Size and Types

- Select a reputable vendor
- Follow manufacturer recommendations for casing types and connection types
- Casing Sizes Depend on Project Requirements
  - 1.90 inch ONLY for Structures
  - 2.75 inch Structures and Short Term
  - 3.34 inch Landslides and Long Term Monitoring - IPIs

Specified Most Often

Should be 3.34" More Often

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Installation Technique Specs

- Borehole
  - Diameter enough for Tremie Pipe = 1” > Casing. Don’t Oversize adds cost.
  - Appropriate methods = Mud drilling specs don’t work in rock.
  - Relatively straight +/- 3 degrees
  - Spiral Surveys – Generally not needed, except for very deep installations
- Counter Buoyancy
  - NEVER hold casing down from the top
  - Use internal weight - Drill Rod, Anchor, or SAND?
  - Stage Grouting

Settlement and Error Detection

- Utilize settlement detection systems in Compressible Soils
  - Spider Magnets
- At least 10 feet into stable ground
- Transversing Probes are not interchangable
  - 2 probes Specified on Same Project?
  - Calibration Casing Needed

Multi-Sensor Installation

- Don’t Get Over Technical
- Tremendous Cost Savings
- Piezometer & Inclinometer
- Piezometer, Inclinometer, & Magnetic Extensometer

HOW TO SAVE $125,000!!

Data Acquisition

- Manual Readings
  - Non-continuous and can miss important details
  - Requires knowledgeable labor to read
- Data Acquisition Systems
  - Automated Readings
  - Fully Automated Reporting or Manual Download

Automated Data Acquisition Systems (ADAS)

- Mini Loggers
  - Self Contained
  - Manual or Automated Reporting (Wireless)
  - Typical Single Type Sensor Input
    - 1 to 16 Sensors
- Full Size Loggers
  - Larger Systems – Mixed Sensor Types
  - Fully Programmable
  - Automated FTP upload or Web Based Monitoring

Some ADAS Product Examples

I don’t promote any brand and there are more out there.

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Data Acquisition Considerations

- ADAS – Typically provides better data and cheaper monitoring cost for remote locations
- Web based or scheduled upload
  - Time Critical Data
  - User access
  - Alert Systems
  - What do you do with the data?
- Power Requirements
  - Solar or AC
- System Types
  - Many Systems and Components

Record for Worst Cut and Paste Specification

"Pour Clean Motor OIL in Annulus of Settlement Gauge" - Detail drawing note on public project.

$6,000.00 Spent to Qualify a "Clean Fill Soil" for RR Fill Placement

Added $2,000.00 to Consulting Fees for Project Change Request

Lots of Sensors and Systems

- Pressure Cells
- Strain Gauges
- Settlement Systems
- Time Domain
- Fiber Optics
- Automated Total Stations

Technology Advancing Rapidly

- More efficient, more reliable
- Networking
- New Sensors
  - Fiber Optics
  - Shape Arrays
  - Automated Stations
- Turnkey Systems
  - Many companies with Pre-Package Solutions

Common Themes Observed in Current Specifications

- ✓ Old Specs – Behind the Times
- ✓ Mixed and Matched Specs
- ✓ Incorrectly Specifying Methods
- ✓ Incomplete Understanding
- ✓ Over Specifying Materials

How to Avoid the “Bear”

- Limit use of Materials Specifications
  - Consult with Manufacturers and Consultants on the latest products and techniques
- Performance Specifications
  - Tell us “What you want the system to provide”
  - More likely to get pricing advantage
  - Can design/build
  - Prequalify engineers, installers, and consultants
  - Joint effort in preparing instrumentation plans.

Joint Instrumentation Monitoring Plan

&

Contractor TBD

June 2010

Nashville District Dam Safety Officer Date

Resident Engineer Date

Manger Date

Contractor Data Manager Date

Note: This document is included in the specifications in draft format. Some names, web addresses, etc. have been generalized or intentionally left blank until the contract is awarded.

A Good Example

What makes it Good?

- Precisely describes system purpose and function
- Specifies data flow and personnel
- Specifies thresholds and safety chains
- Specifies performance of each instrument types and reading intervals
- Limits precise material specifications
    - Submittals utilized for approval of materials

Final Tips

- Instrument with a GOAL !
  - A goal determines the appropriate instruments and data acquisition methods
  - Acquiring data for the sake of getting data is a bad practice.
- Ask
  - If you are not sure of WHAT you can accomplish ask!

Thank You !
Questions?

If you would like a copy of this presentation please email or call me.

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