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# McAlpine Lock Replacement Instrumentation

## Design, Construction, Monitoring, and Interpretation

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# McAlpine Lock Replacement
# Instrumentation

# INSTRUMENTATION DESIGN

# Instrumentation Design Philosophy

1. Every instrument has a purpose.
2. Envision placement and constructability.
3. Have adequate redundancy of instruments.
4. Use to verify critical or variable design parameters.

# Parameters Monitored

1. Concrete temperature
2. Concrete (monolith) strain
3. Monolith base pressures and distribution
4. Earth pressures and backfill sequence
5. Ambient temperature

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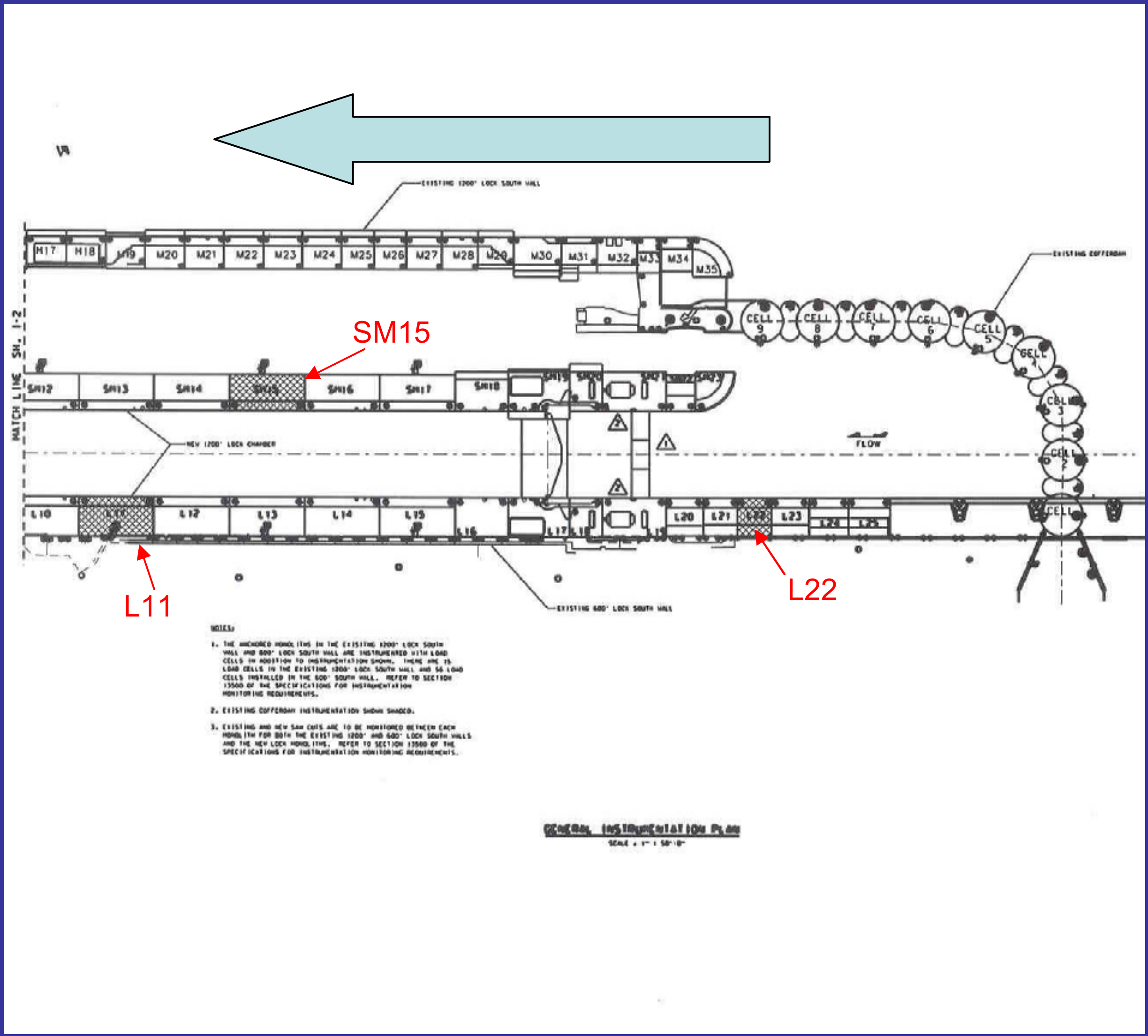
# McAlpine Lock Replacement
# Instrumentation




**Shaded Monoliths L11, L22 and SM15 have instrumentation**

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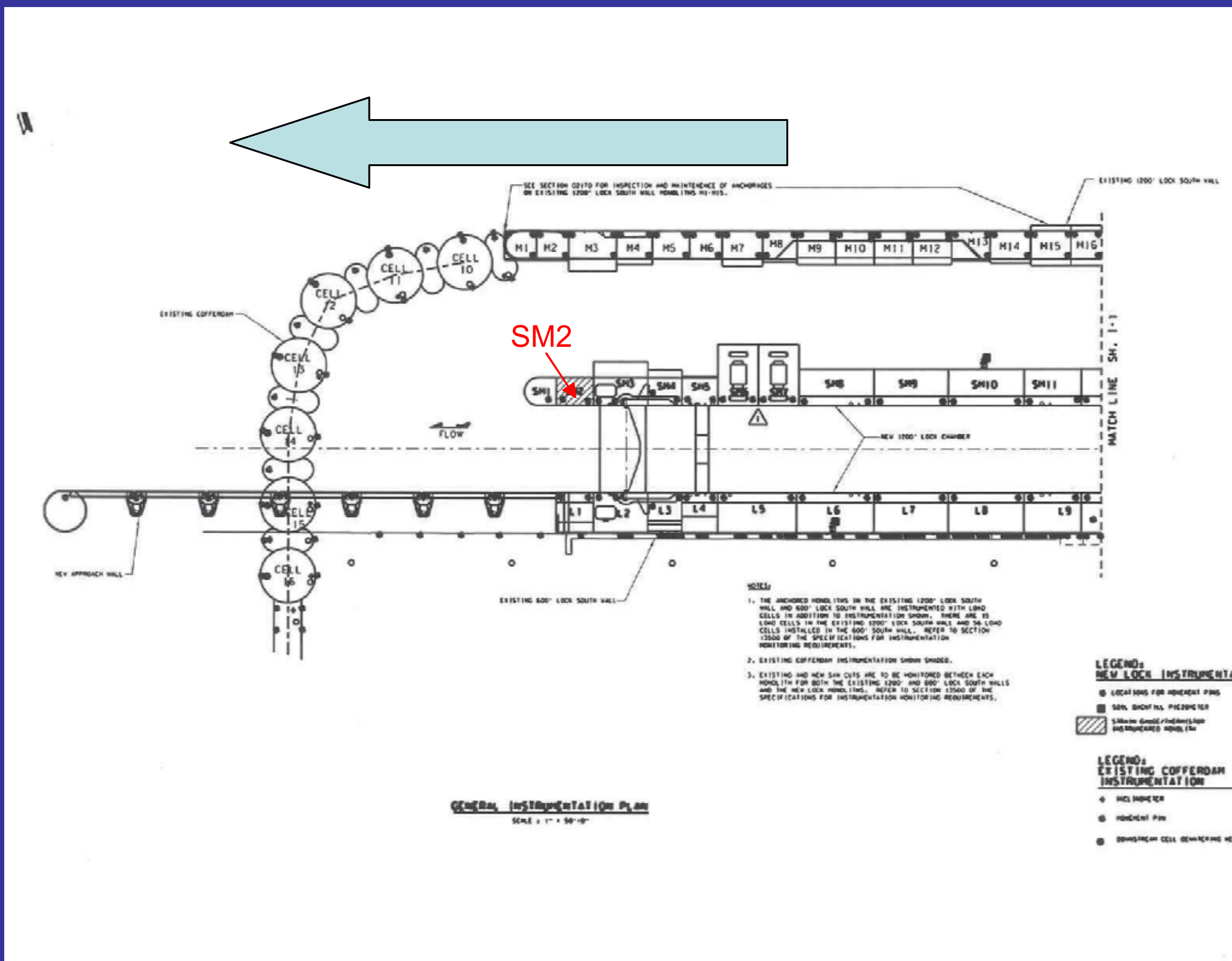
# McAlpine Lock Replacement Instrumentation




**Shaded Monolith SM2 has instrumentation**

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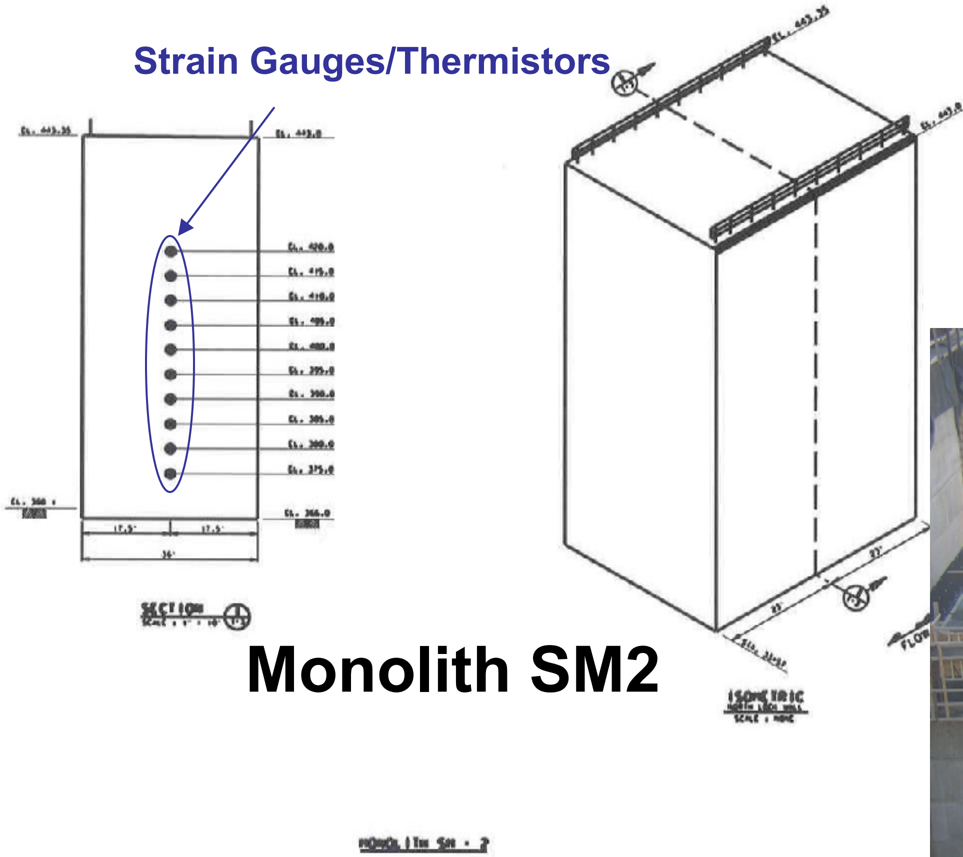
# McAlpine Lock Replacement
# Instrumentation




**Monolith SM2 with location of Strain Gauges**

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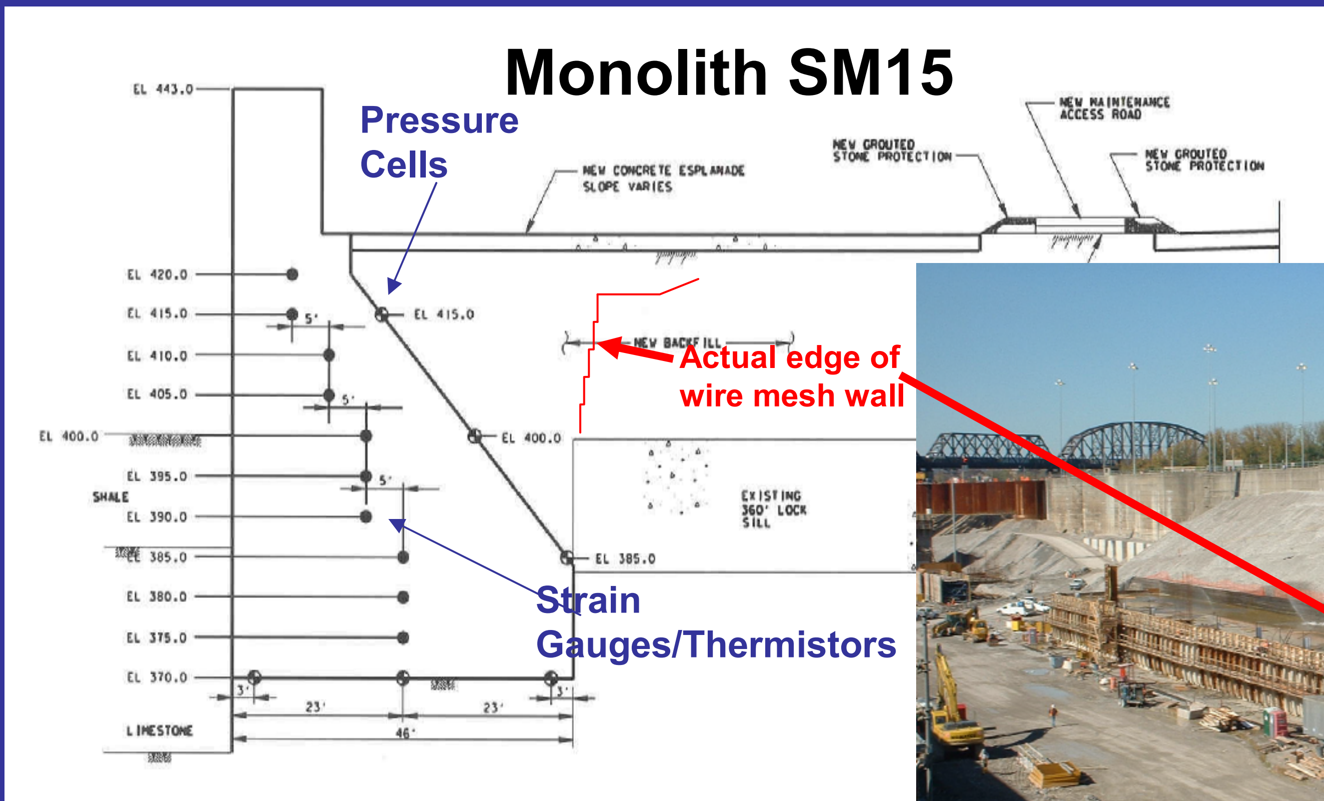


**SM15 showing locations of strain gauges (solid circles) and pressure cells (shaded circles).**

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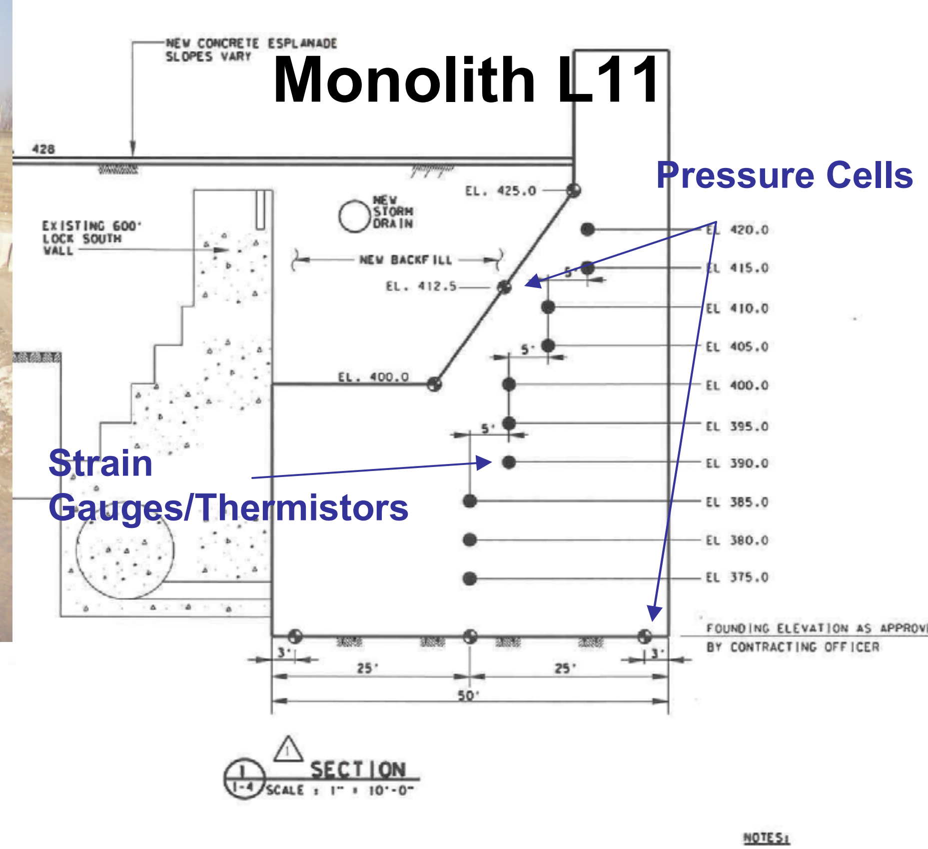


**L11 with locations of strain gauges (solid circles) and pressure cells (shaded circles).**

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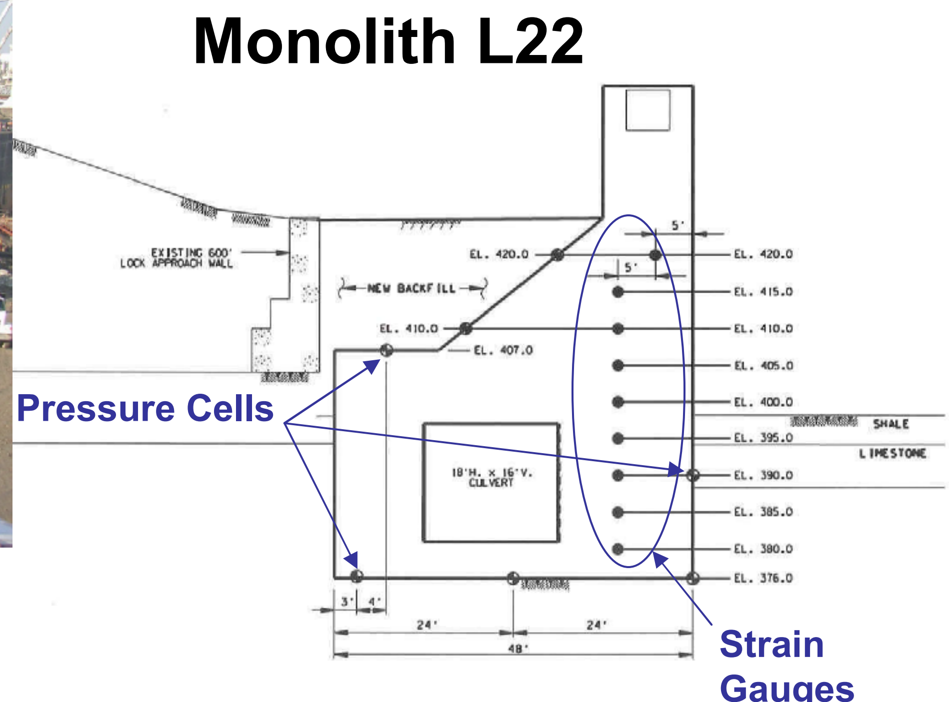


**L22 with locations of strain gauges (solid circles) and pressure cells (shaded circles).**

# INSTALLATION METHODS

# McAlpine Lock Replacement Instrumentation

Placement of Pressure Cell


Leveling Pressure Cell

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# McAlpine Lock Replacement Instrumentation


Placing Pressure Cell in L22

Completed Pressure Cell

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# McAlpine Lock Replacement Instrumentation

**Solar Powered Data Reading Station**

**Strain gauge mounted in L22**

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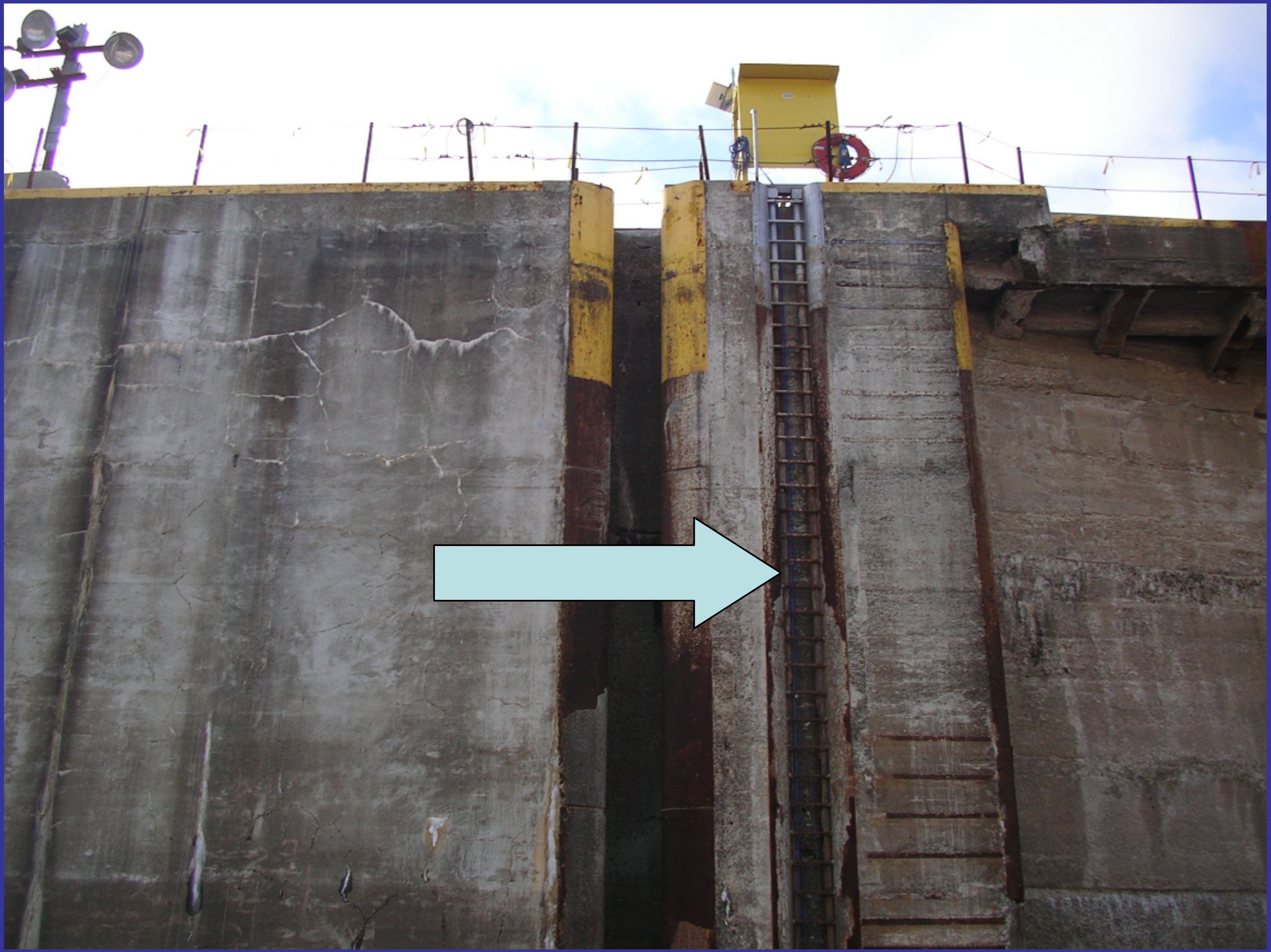
## Location of Wires for Instrumentation



# DATA INTERPRETATION

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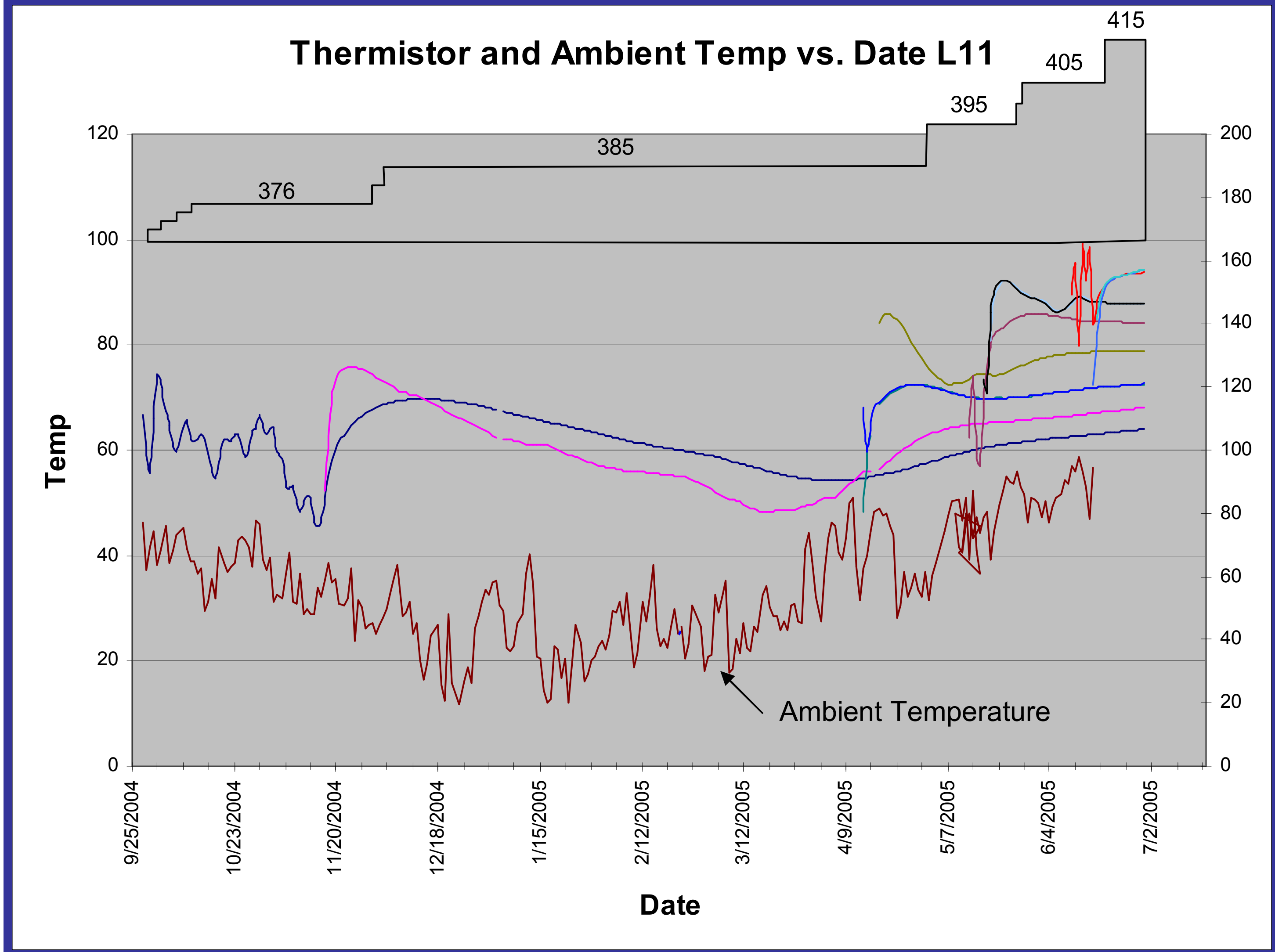
## Data Interpretation




L11 Thermistor

-Note: temperature increases during initial cure then decreases gradually

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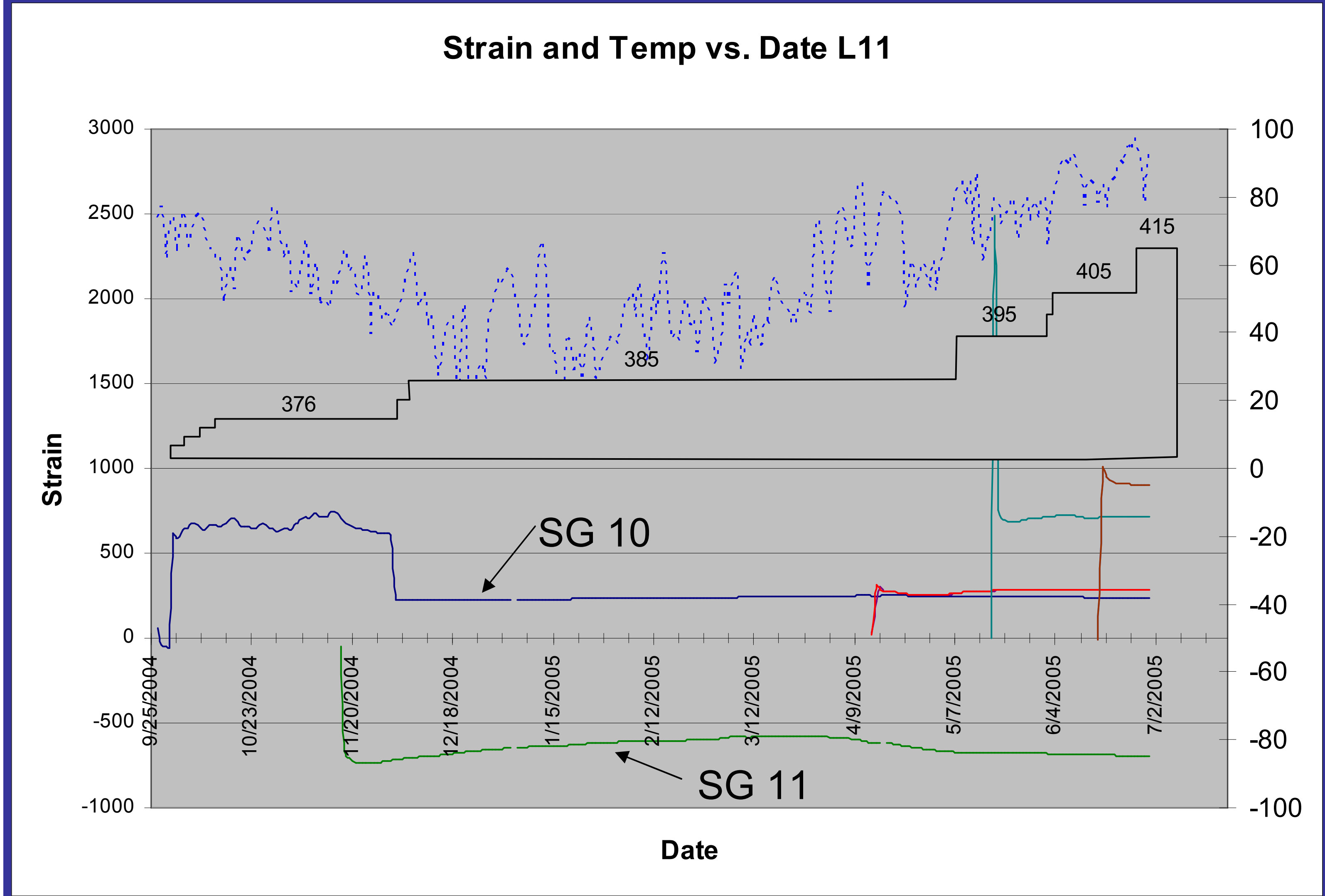
## Data Interpretation




## L11 Strain

-SG 10 is placed perpendicular to the lock centerline and is reading positive.

-SG 11 is placed parallel to the lock centerline and is reading negative.

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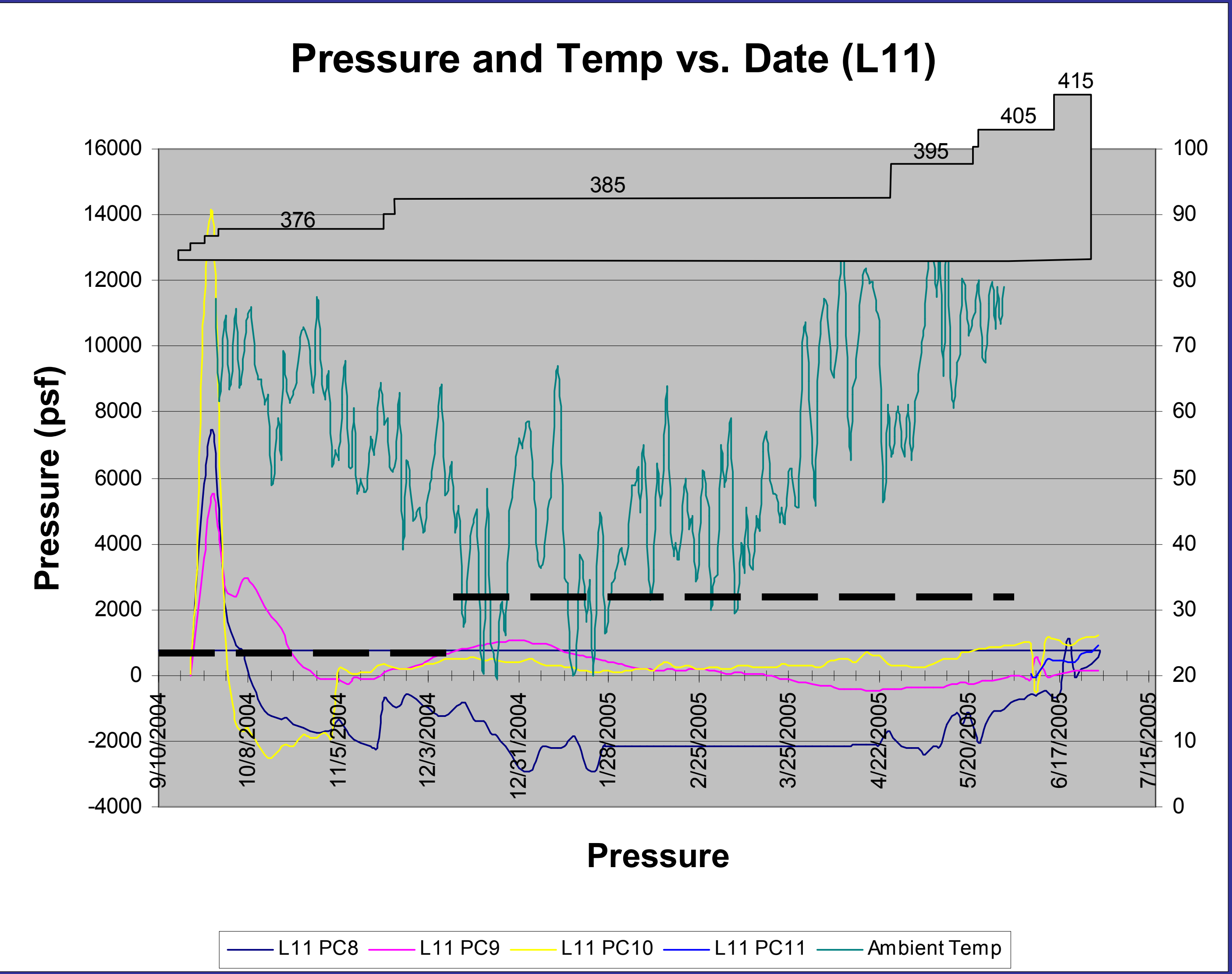
# McAlpine Lock Replacement Instrumentation

## Data Interpretation




## L11 Pressure Cells

-Note: Extreme spike as concrete is placed.

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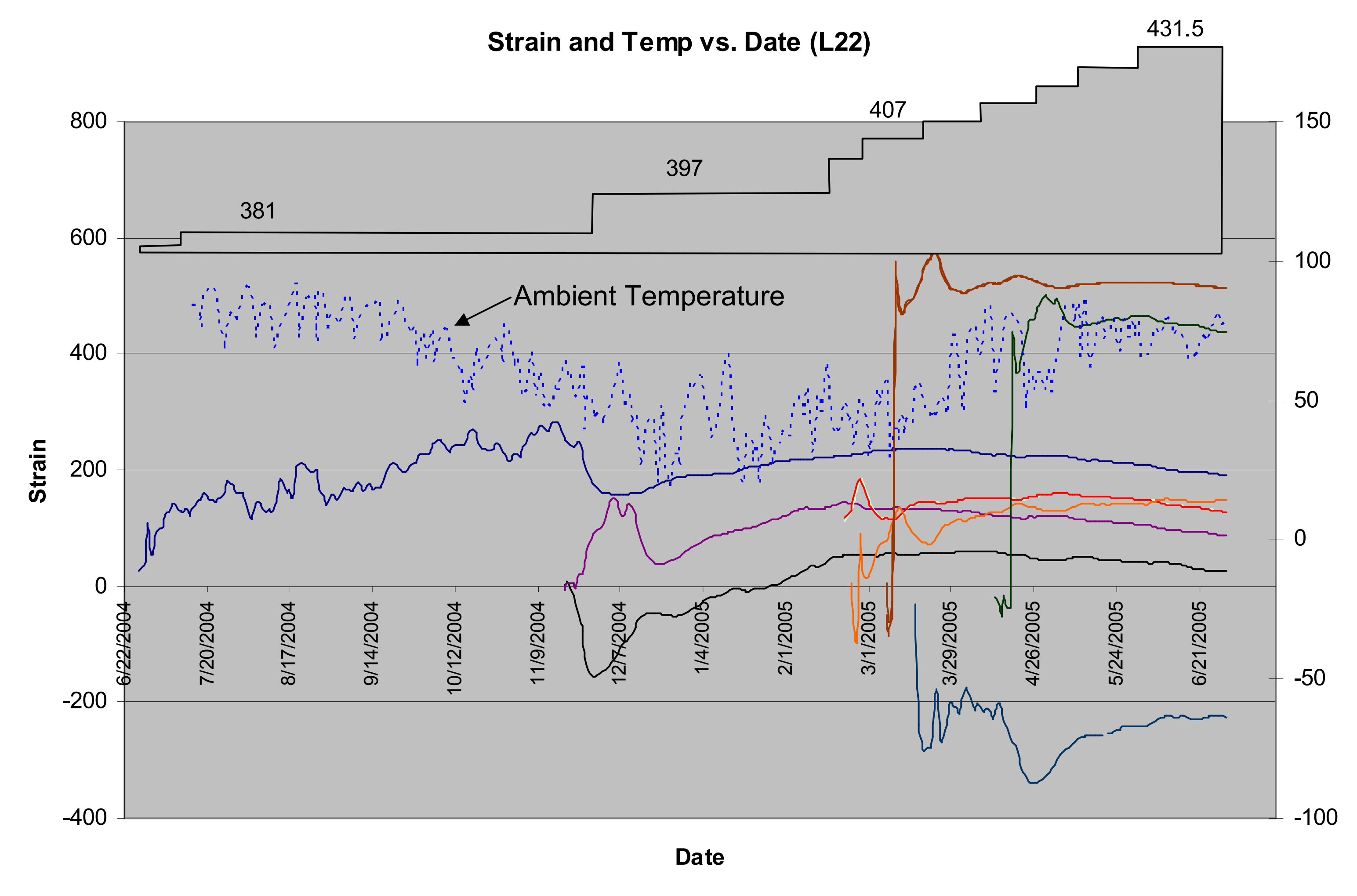
# McAlpine Lock Replacement Instrumentation

## Data Interpretation

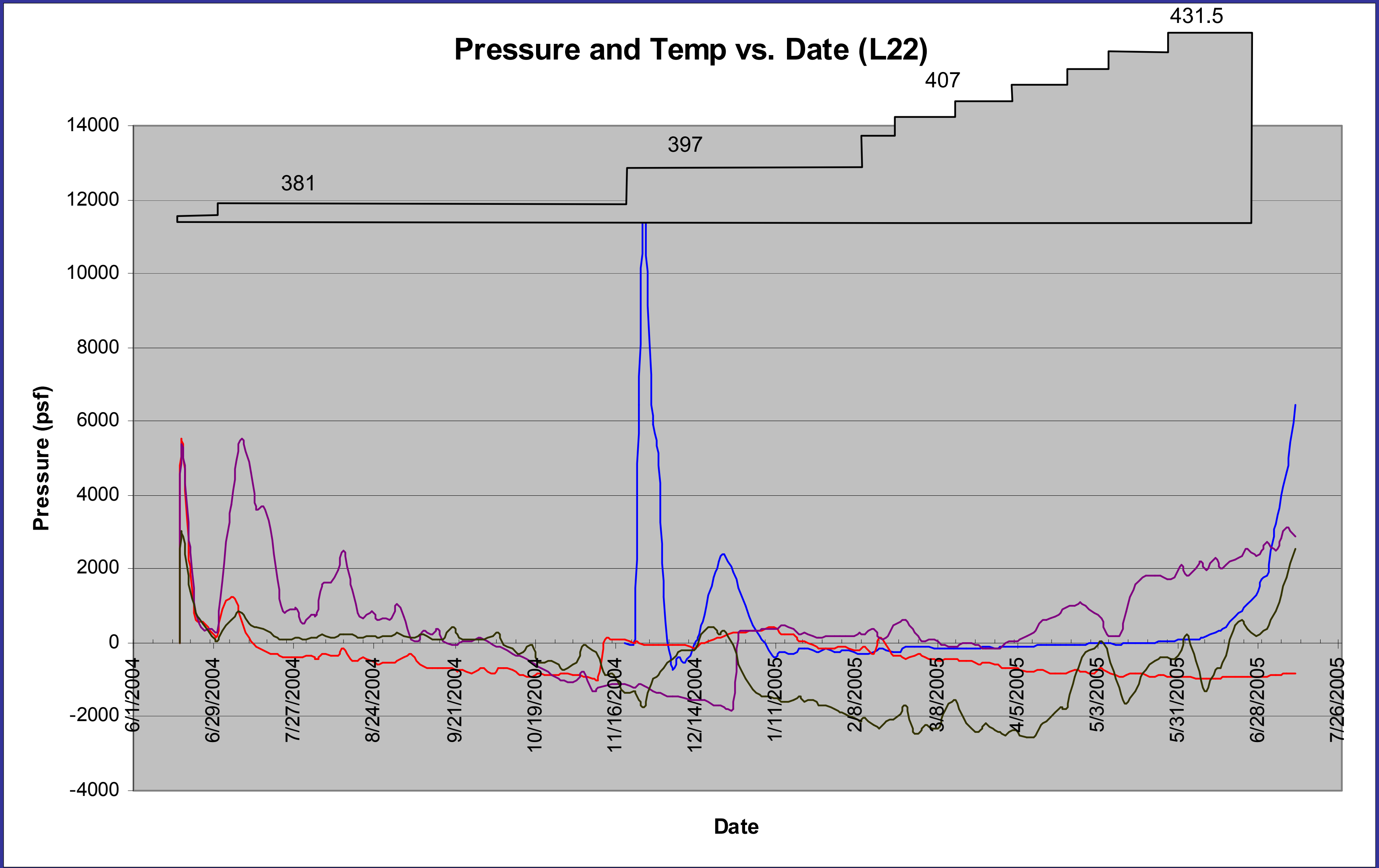



## L22 Strain

Note: Gages placed parallel to lock centerline, reading is negative.

# McAlpine Lock Replacement Instrumentation

## Data Interpretation




L22 Base Pressures

# Earth Pressures

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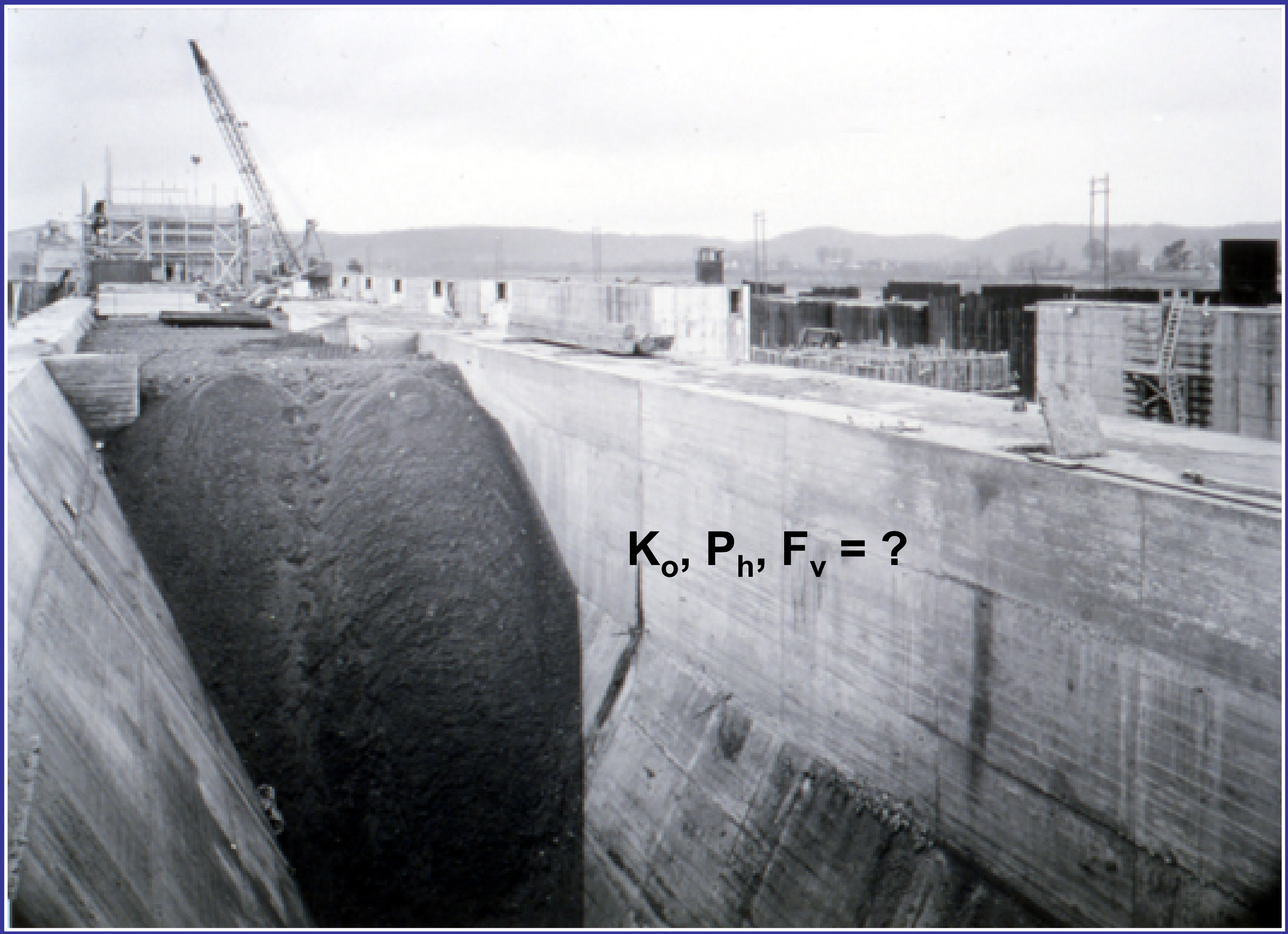
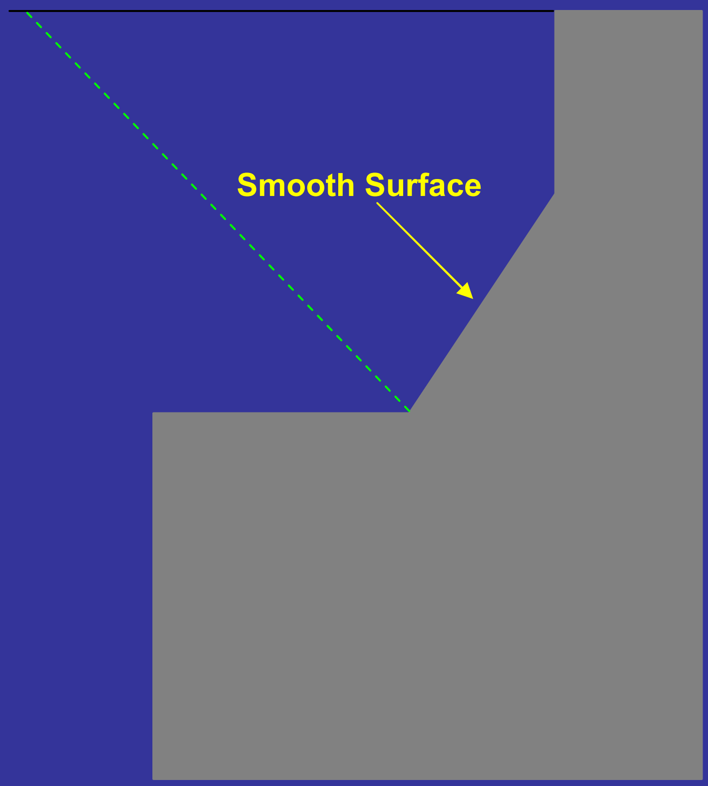


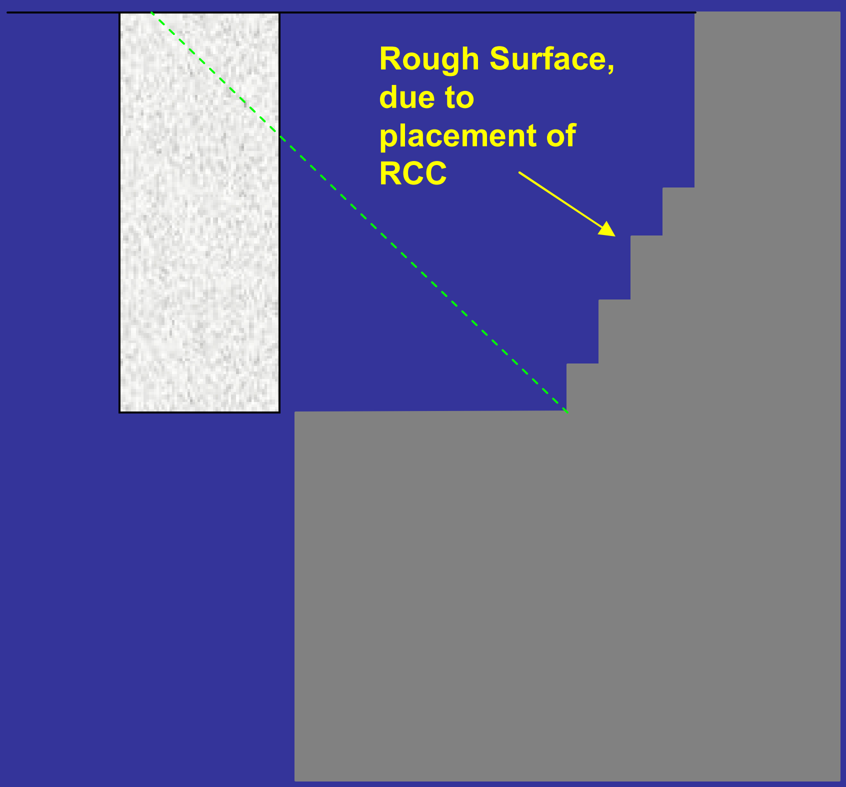
# McAlpine Lock Replacement Instrumentation

## Monolith Construction

### Design Shape




### Actual Shape

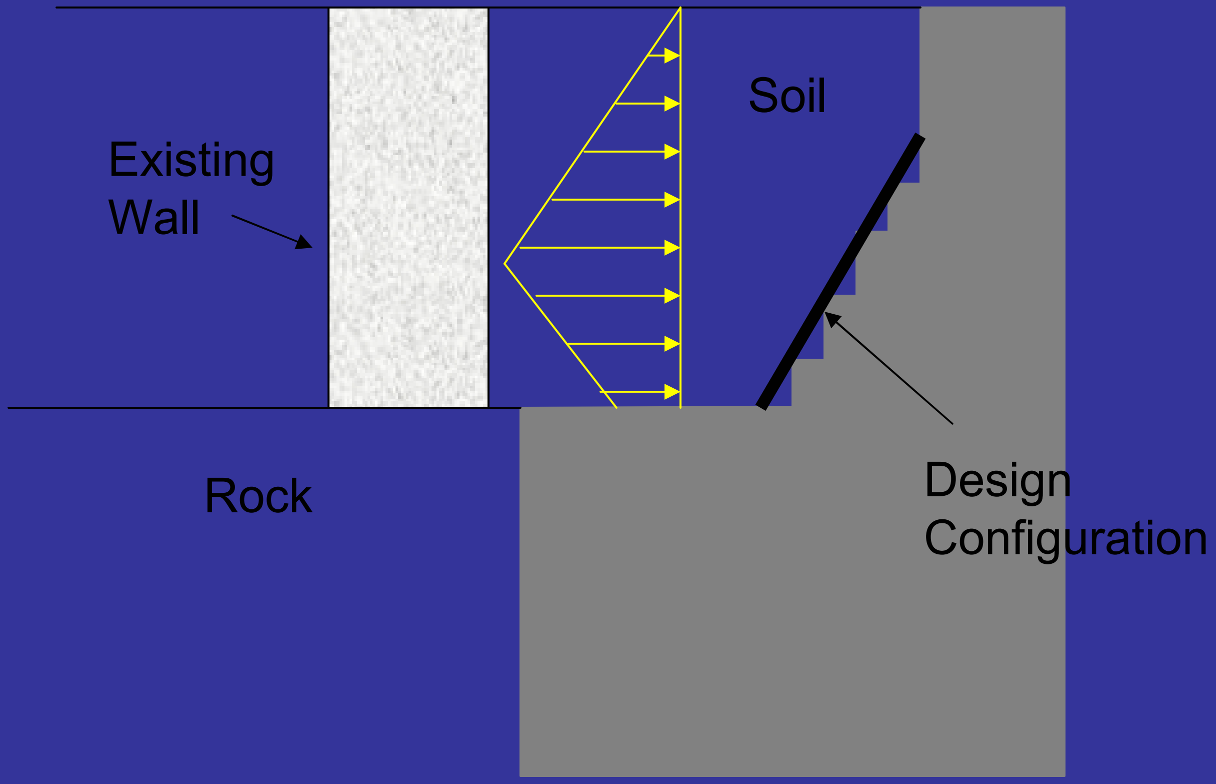


# General Design Methodology

$K_o$ Value used for lateral soil pressure calculations with reduction in lower area of monolith based on anticipated soil arching.

$K_o$ = 1- sinΦ

(Jaky's Equation)



# Design vs. Actual Construction Conditions

DESIGN

- Design attempted to account for arching on smooth sloping wall with Φ = 32.
- Actual design now calls for 3”minus gravel and a stair stepped wall. (Φ > 32).
- Instantaneous loading assumed.
- Arching action invokes increased vertical shear effects that were not included at time of analysis.

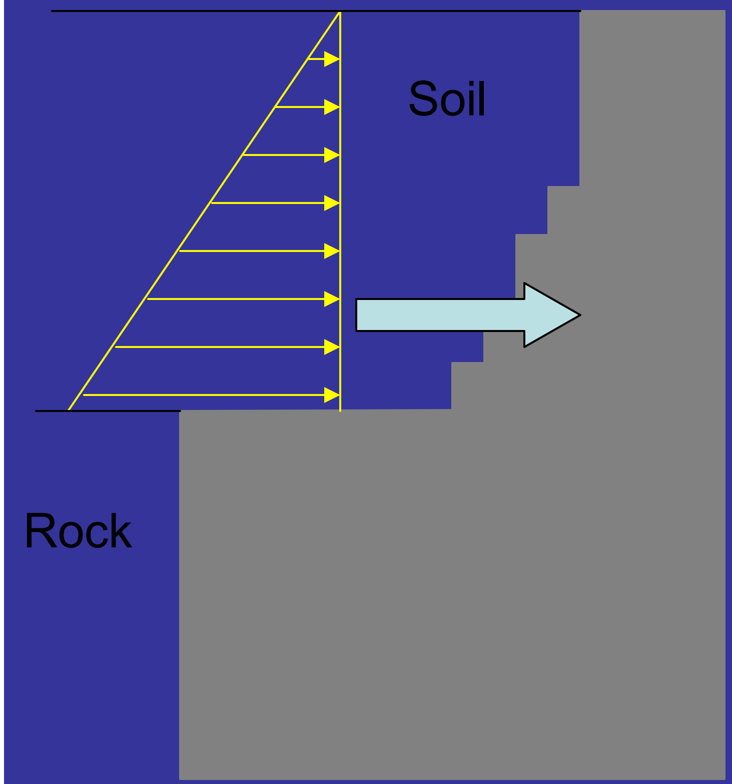
CONSTRUCTION CONDITIONS

- **Material change**
- **Stair-stepped back of monolith**
- **Confined backfill areas with unique configurations**
- **Staged Fill Placement**

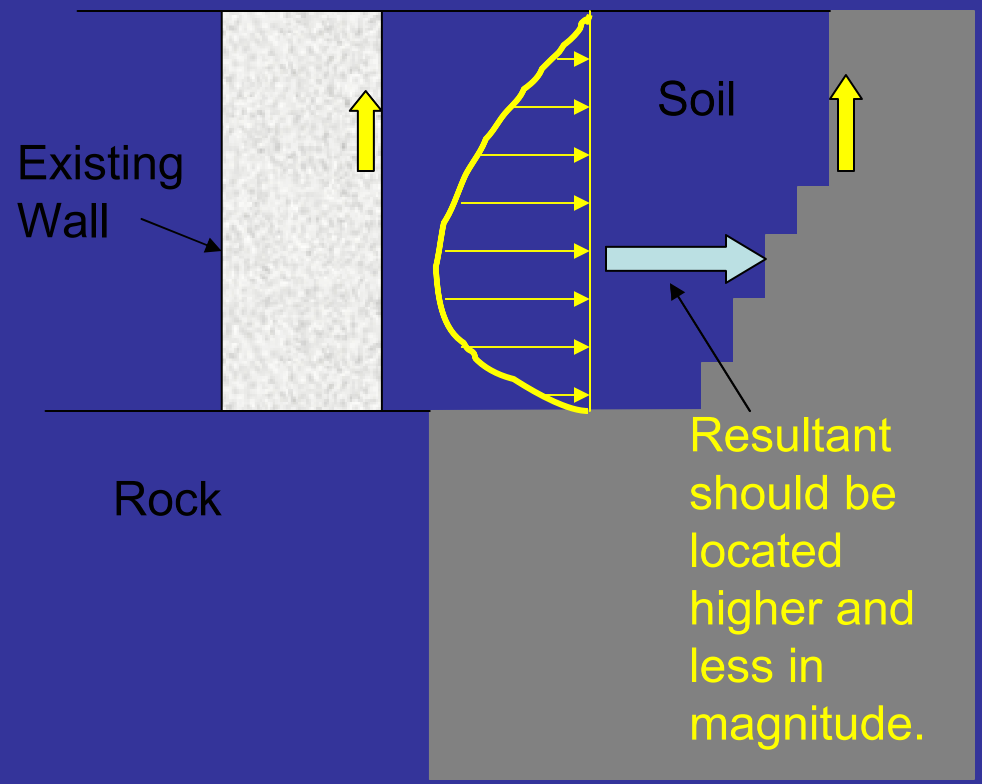
**CONCLUSION**

- **Changes from original design will likely increase arching effects, vertical shear, and nonlinearity of load distribution along the back of the monolith.**

## How Does Arching Effect Lateral earth Pressures on the Monolith?

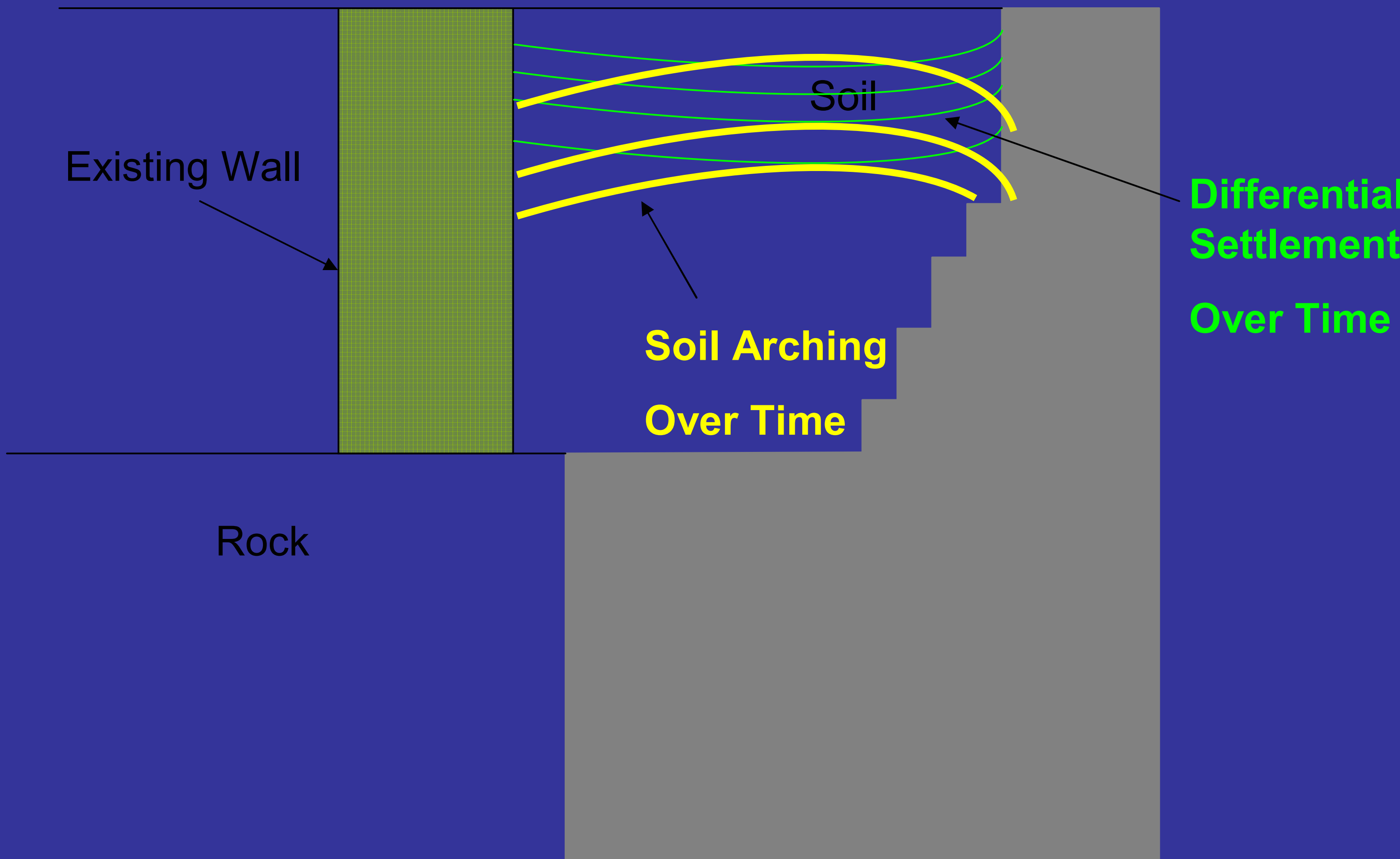



**Free Field Condition**

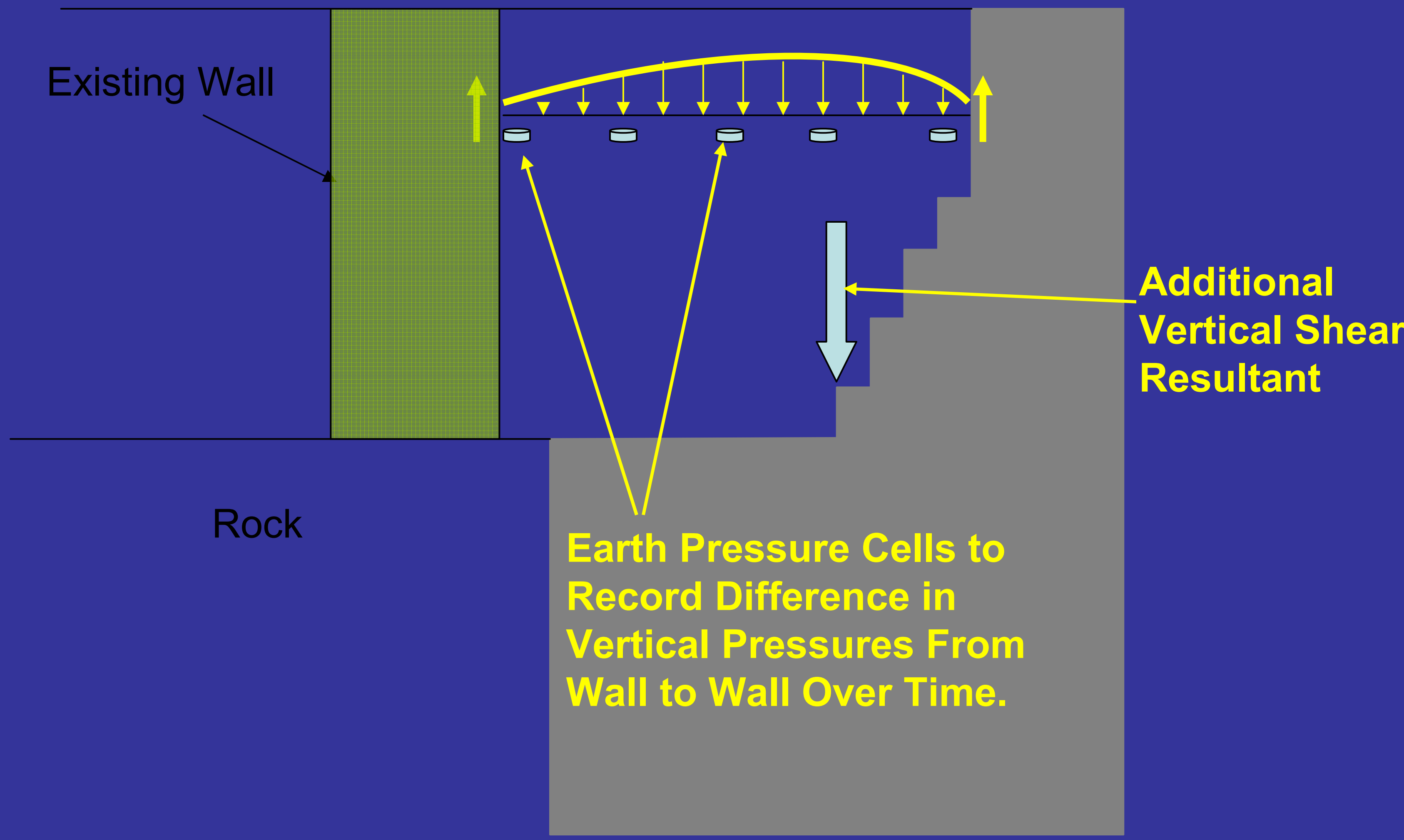



**Confined Field Condition**

# Soil Arching Mechanism



# Vertical Shear



# Why is Vertical Shear Important?

Publication Number: **EC 1110-2-6058**
Title: **Engineering and Design - Stability Analysis of Concrete Structures**
Proponent: **CECW-E**
Publication Date: **30 November 2003**

APPENDIX F

F-2

d. "Filz, Duncan, and Ebeling (1997) present an example calculation using vertical shear for a 30-ft high, step-tapered, rock founded, gravity wall retaining dense sand with surcharge. This example compares the result with a conventional design and **shows a 14 percent reduction in base width by including vertical shear, without compromising the design safety requirements."**

If applied to the McAlpine Lock Project (say at only 7 percent) it could yield:

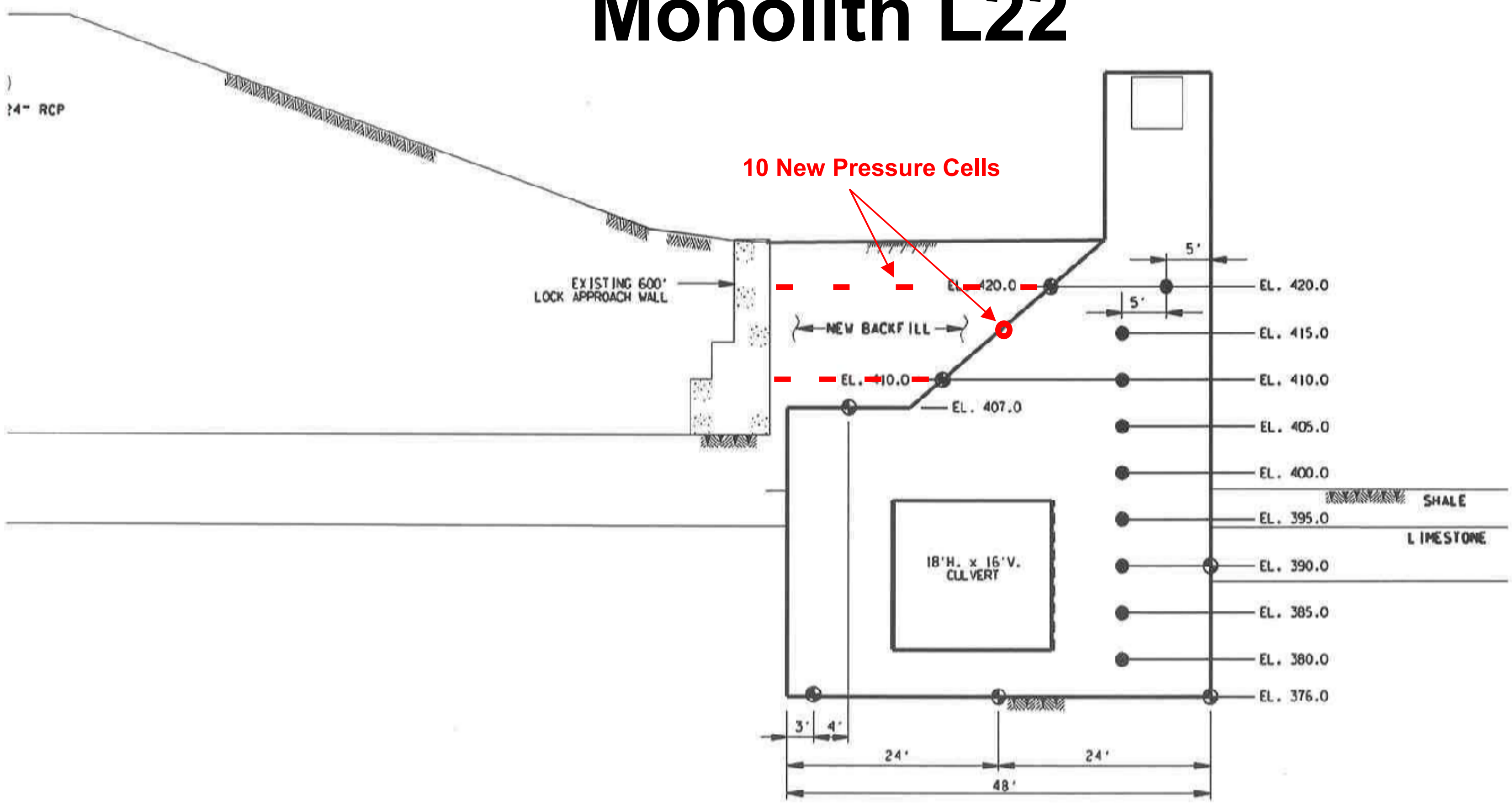
- (3.5 ft reduction in each monolith wide)X(2400 ft) = 23,000 CY
- (23,000 CY)X($150/CY) = $3.5M Savings

# SUPPLEMENTAL EARTH PRESSURE CELL WERE ADDED TO CONTRACT.

**Why?**

- **Verify design assumptions.**
- **Define earth pressure nonlinearity.**
- **Capture vertical shear loading over time.**

# Monolith L22



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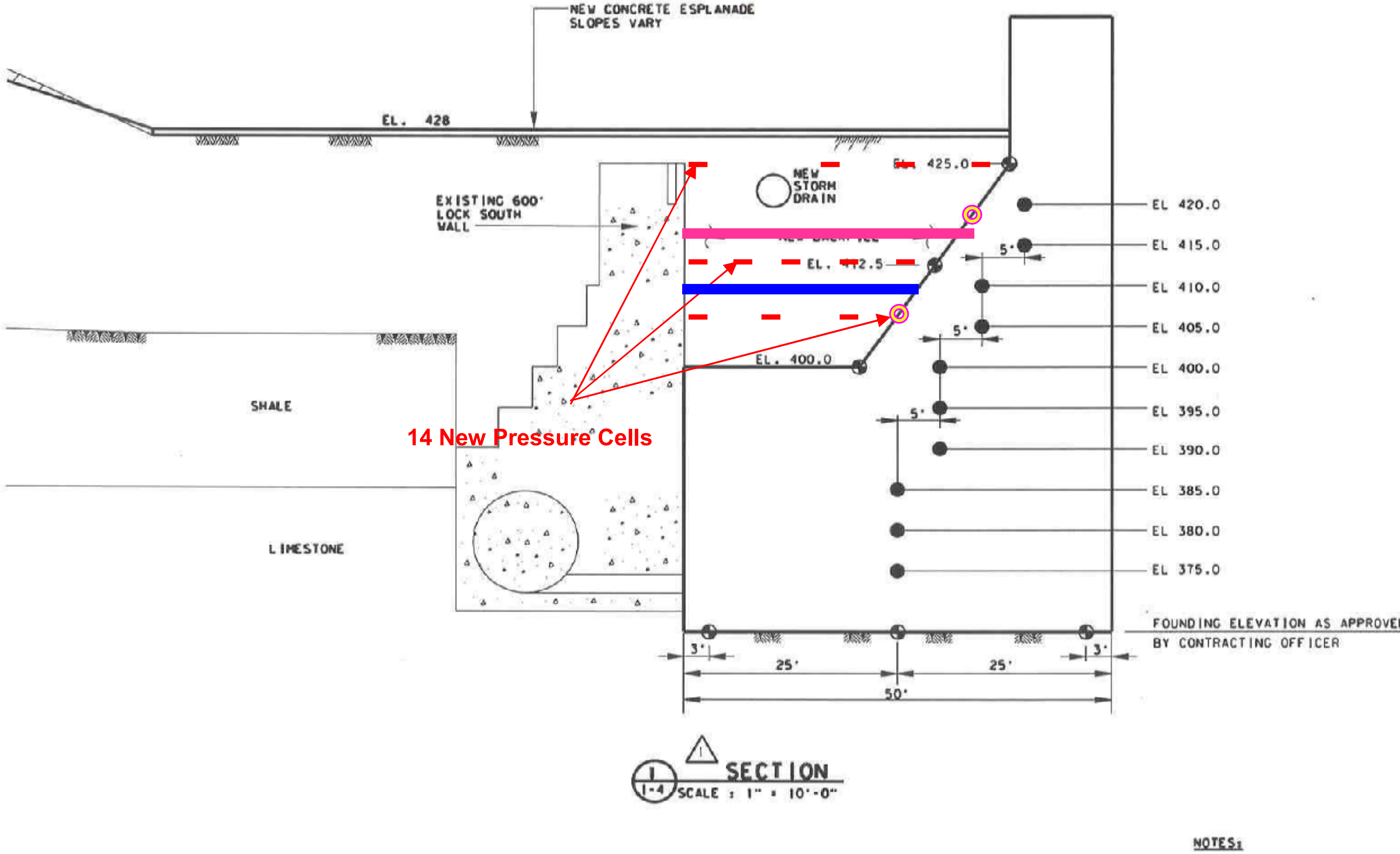
# Monolith L11



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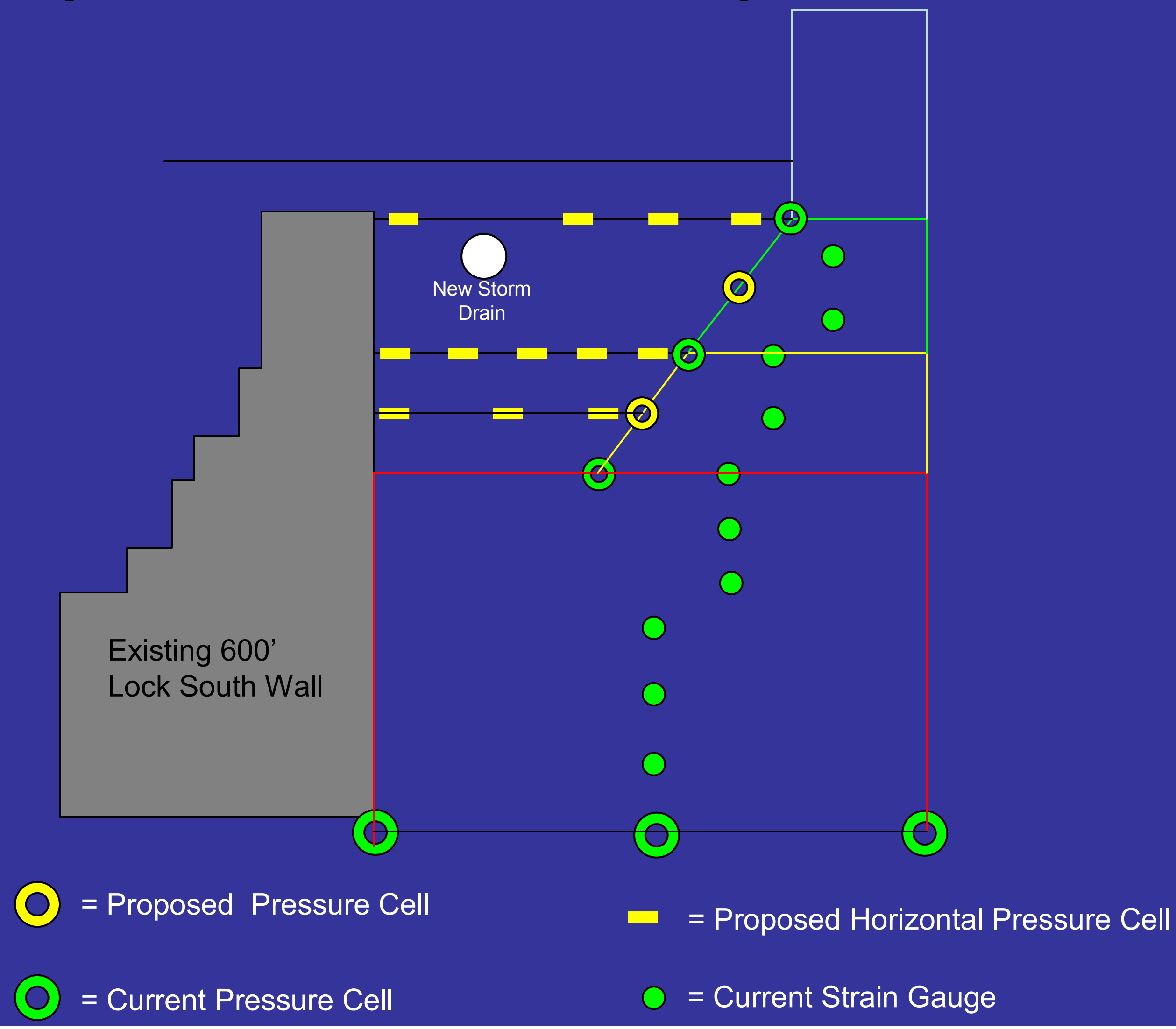
## Proposed Construction Sequence L11



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# EARTH PRESSURES DURING COMPACTION

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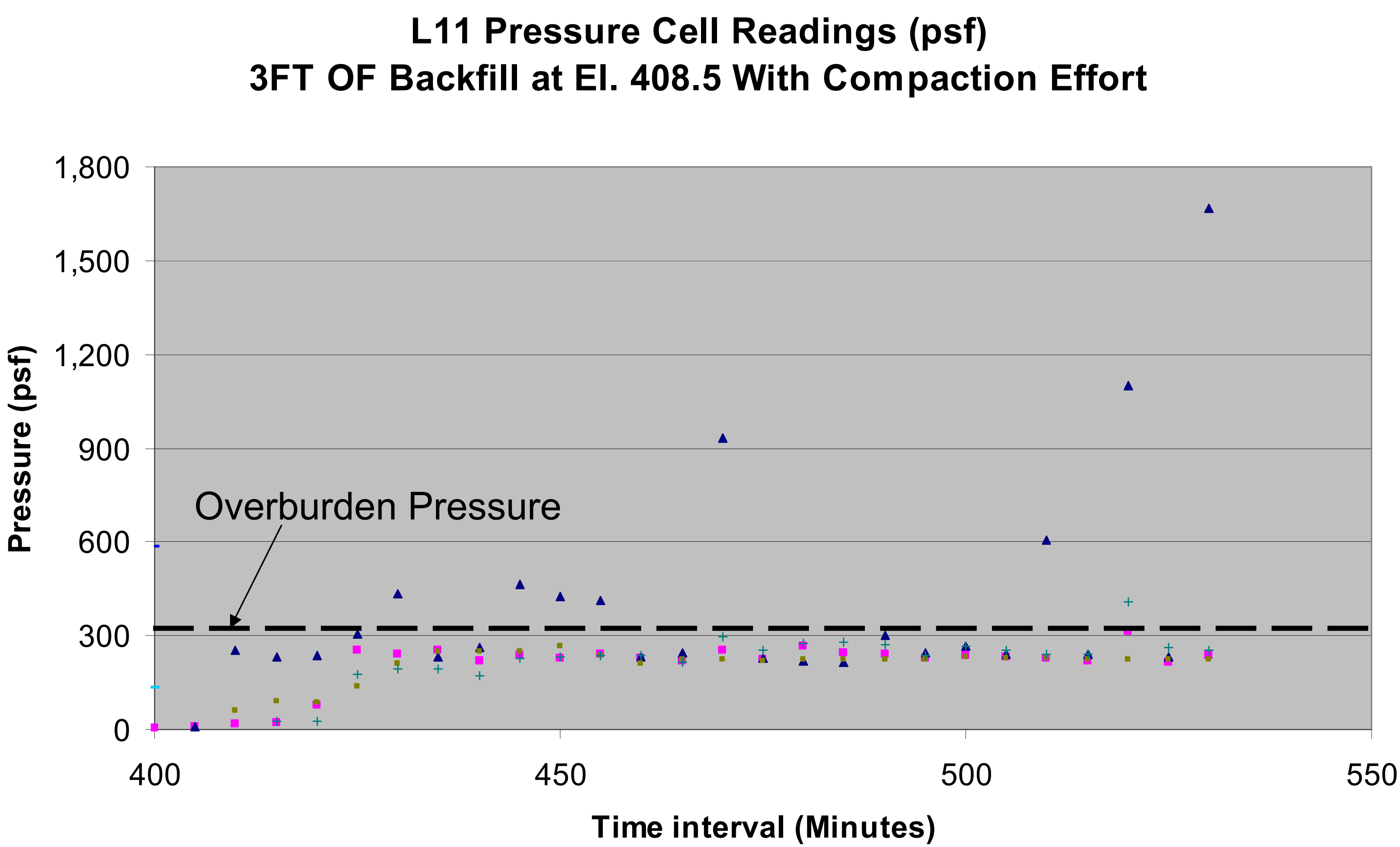

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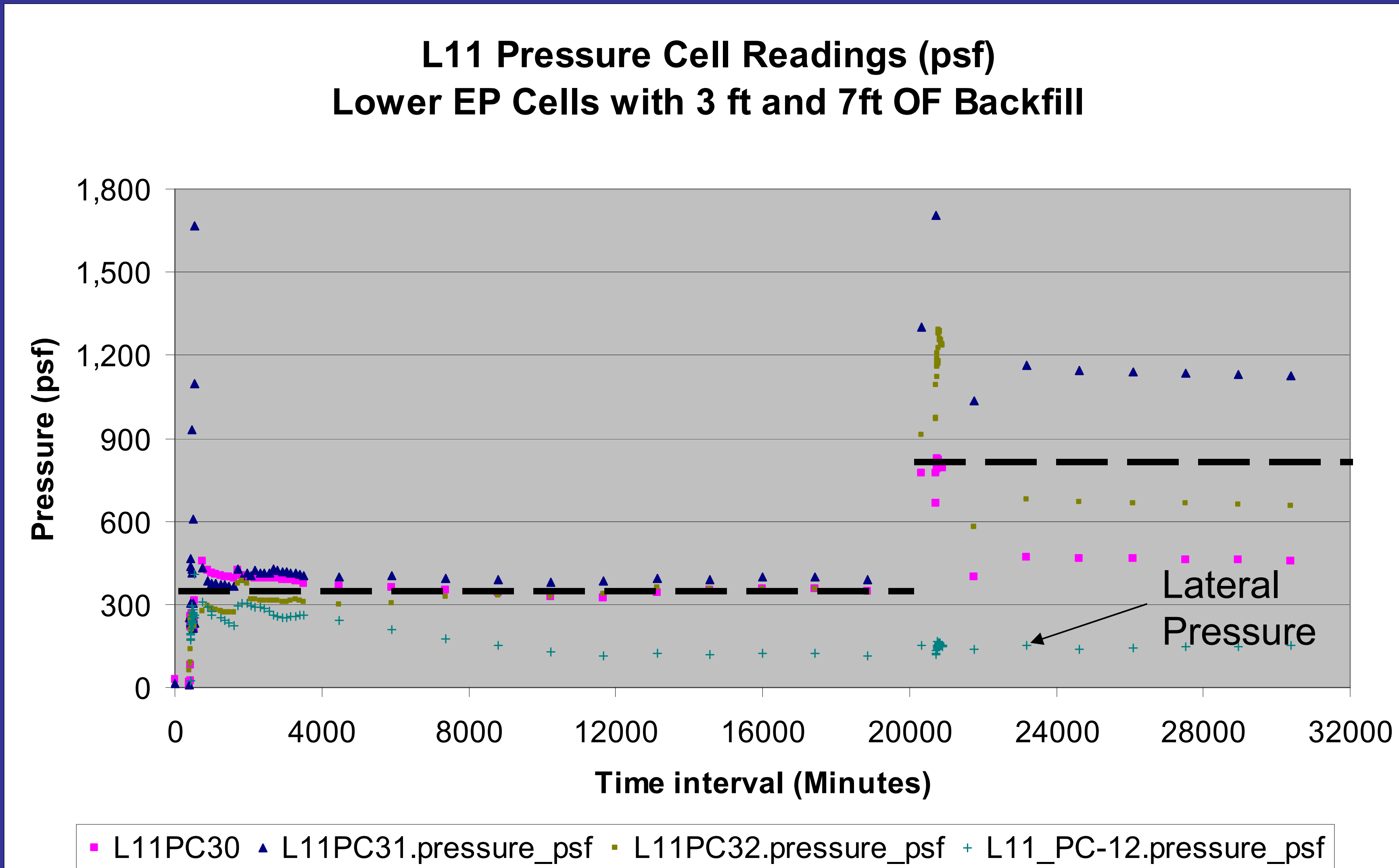

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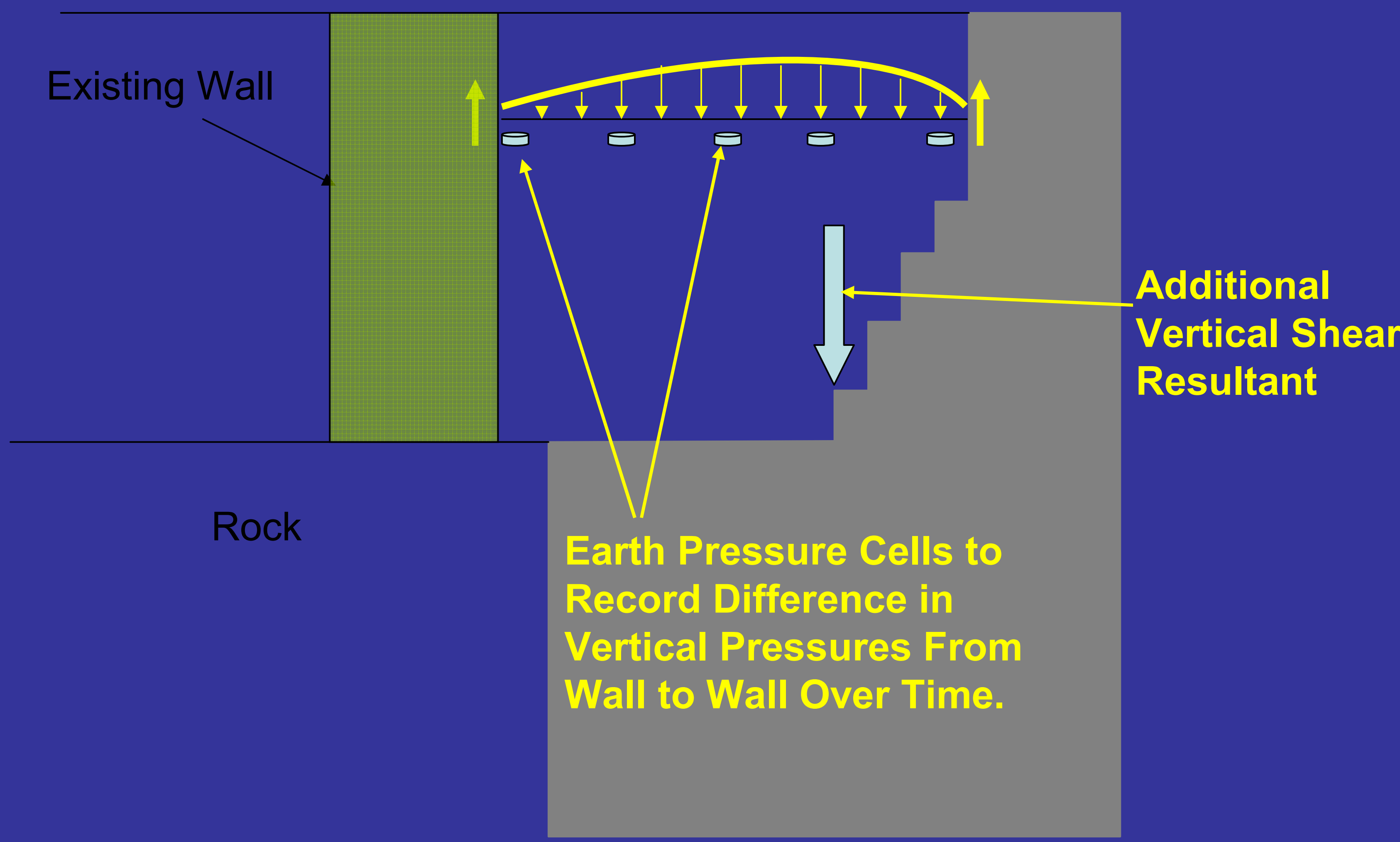
# Vertical Shear



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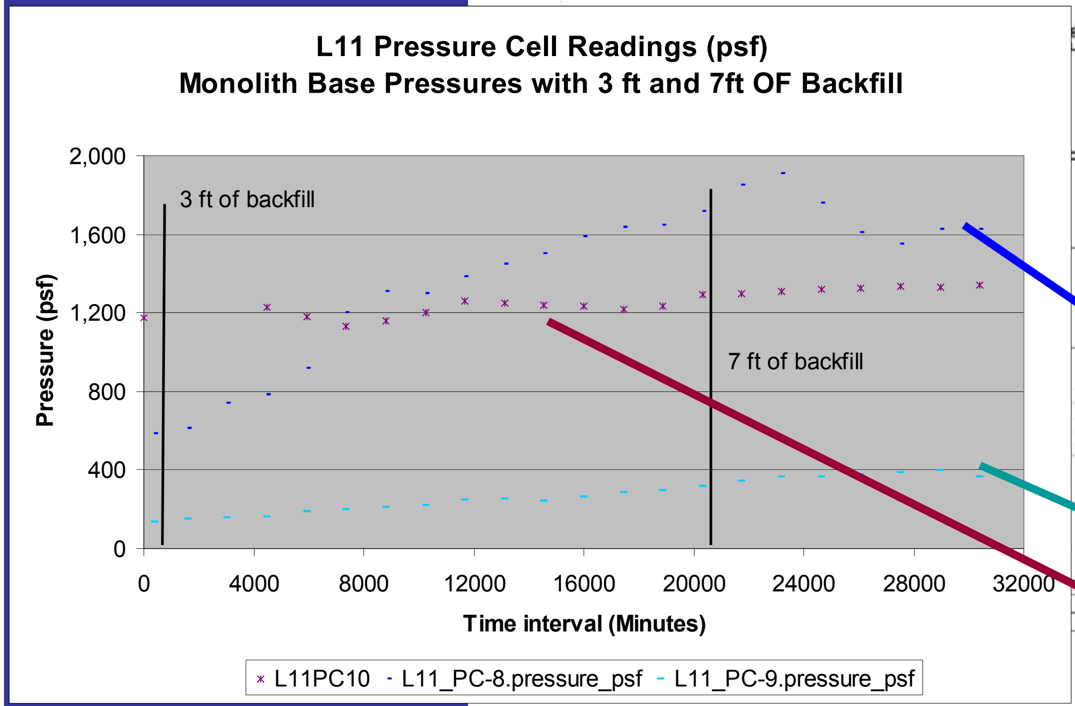


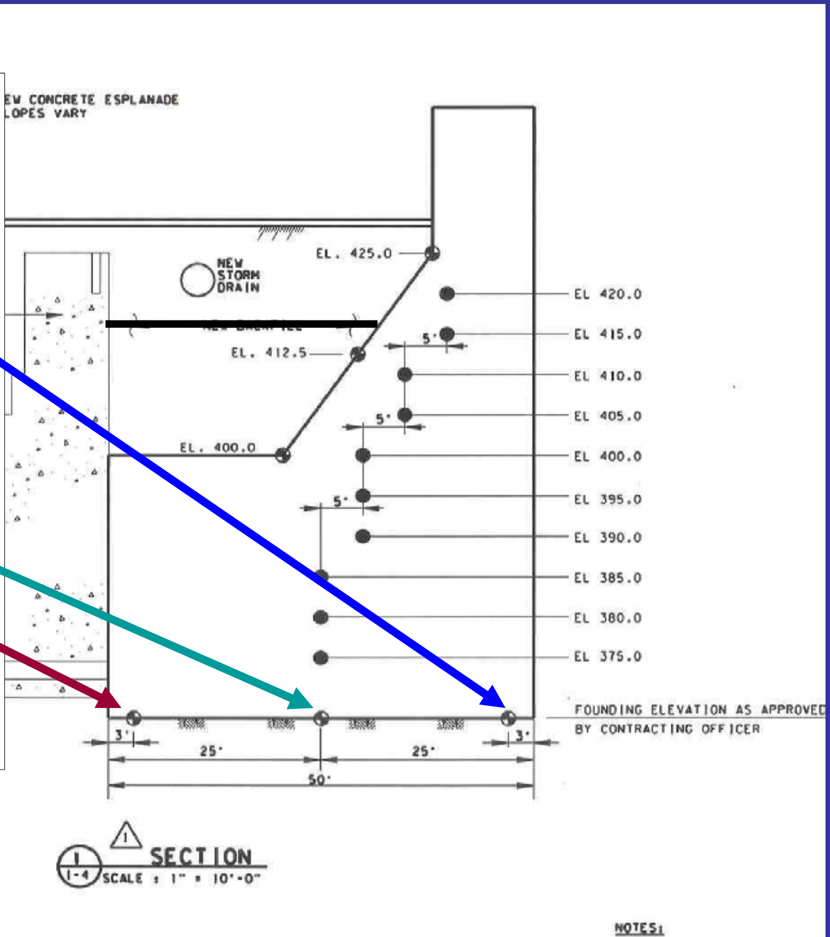


# BASE PRESSURES

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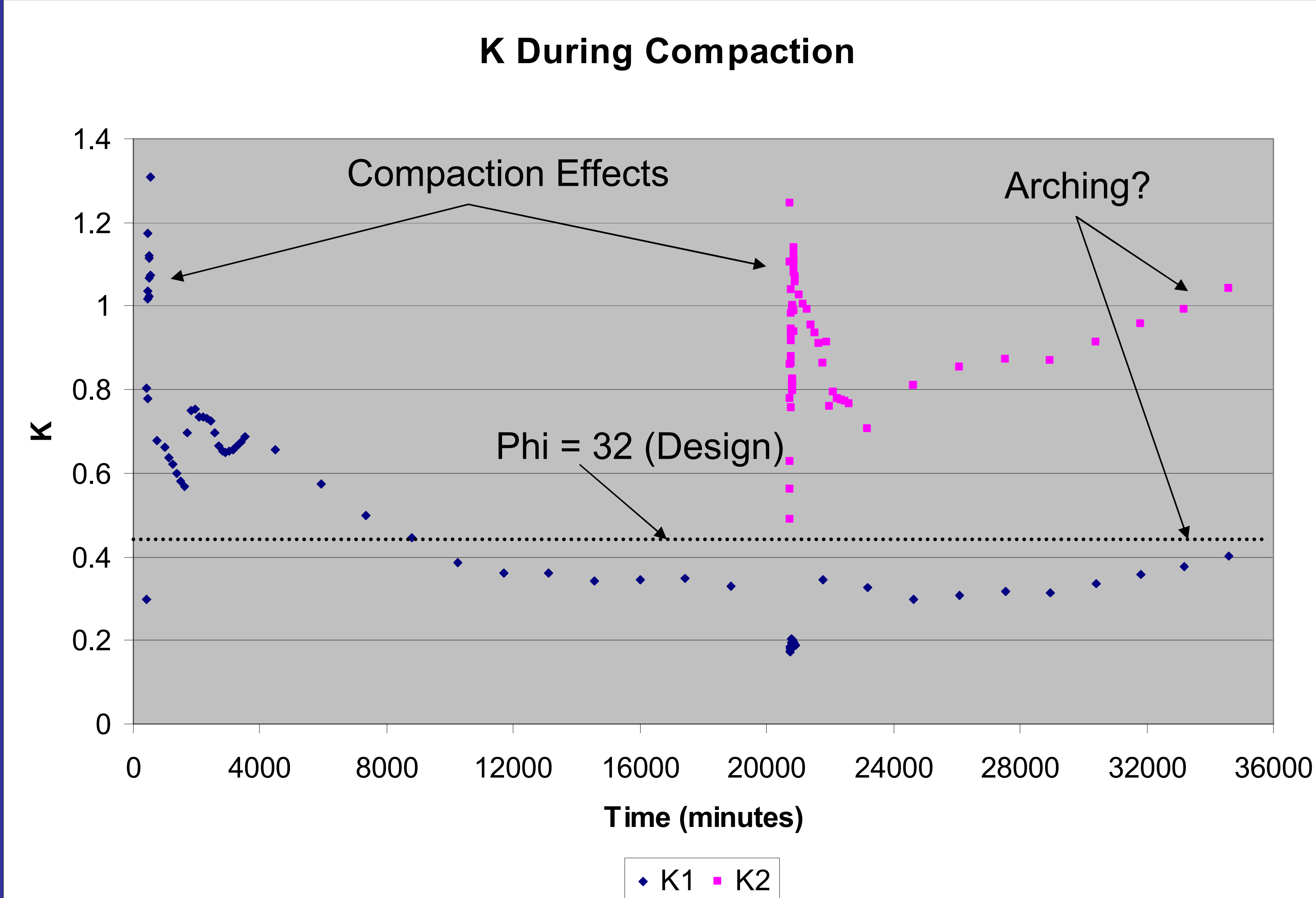
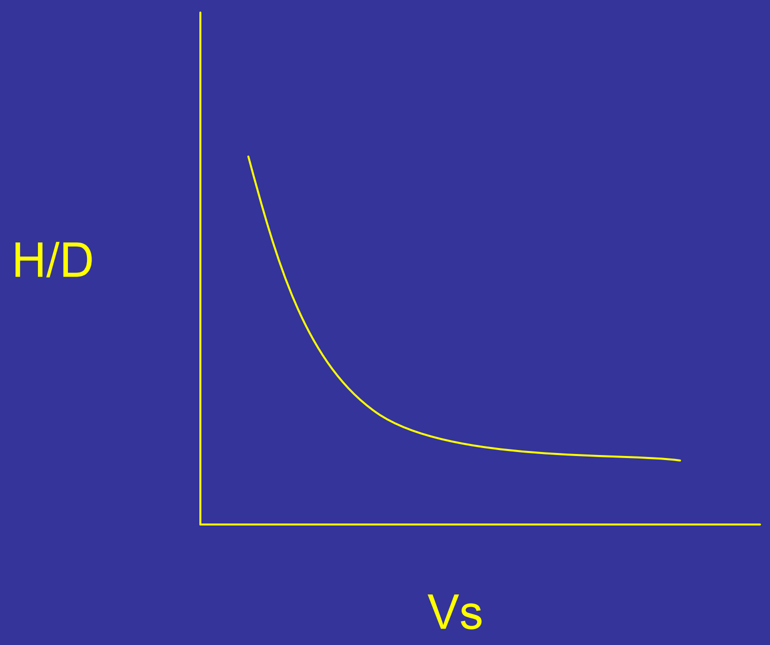


# Analysis Goals

1. Develop design charts and a simplified procedure for design future walls with similar conditions could be developed.



# Questions?