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Application of Piezocone Tests for Embankment Design During the Reconstruction of I-15 in Salt Lake City, Utah

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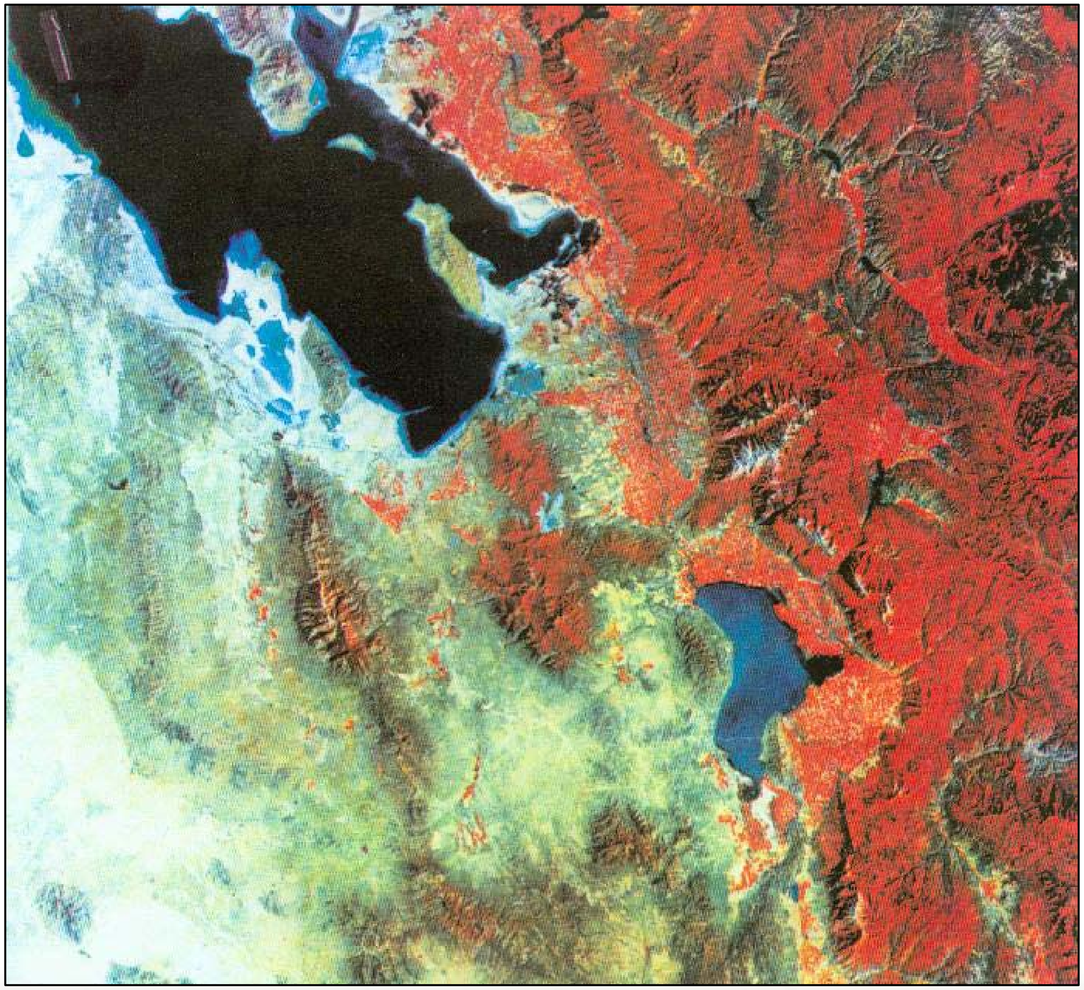
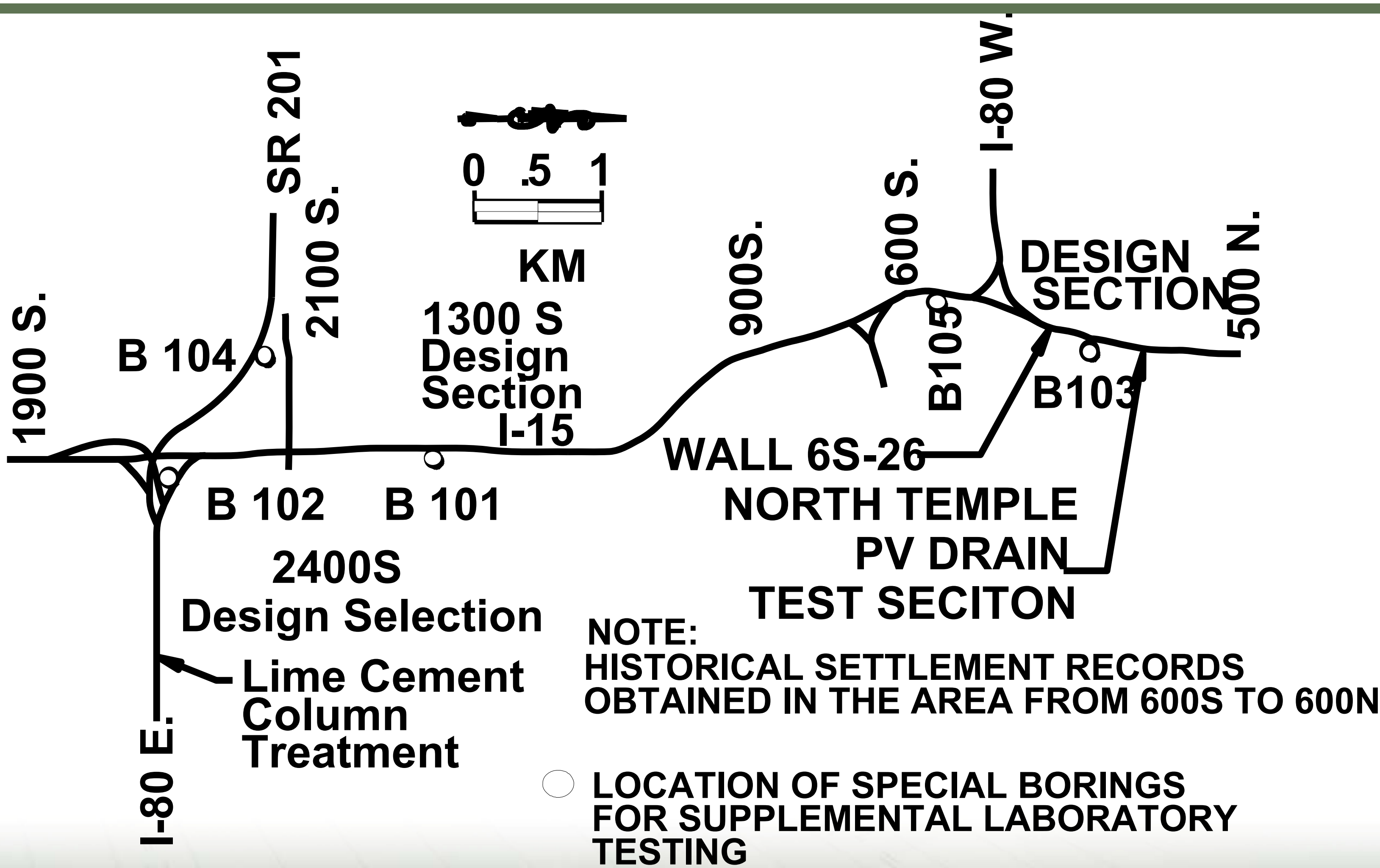
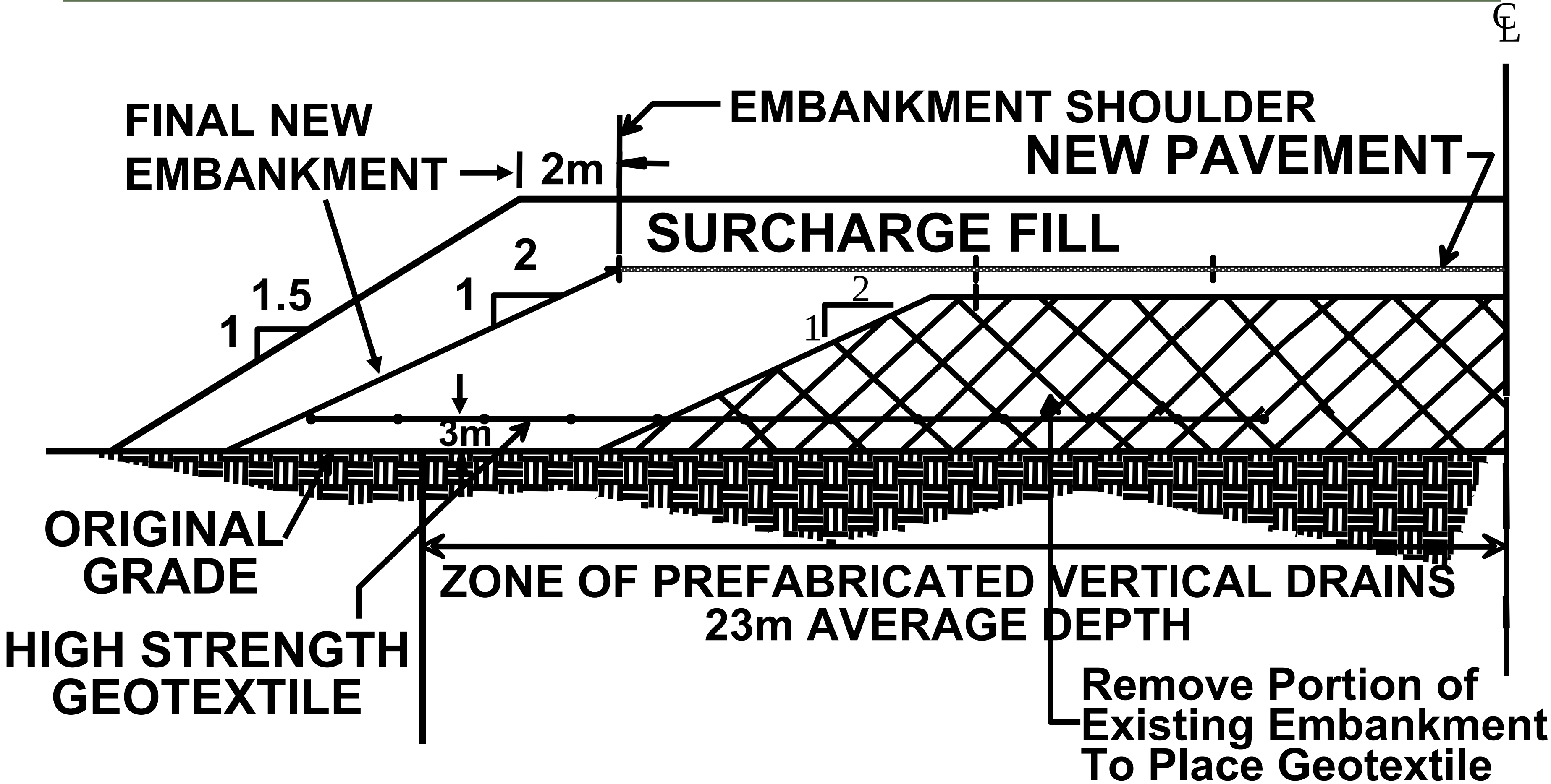
Glacial Lake Bonneville



I-15 Reconstruction and Location of Special Studies



Example of Foundation Stabilization Treatments – 1-15 Embankments



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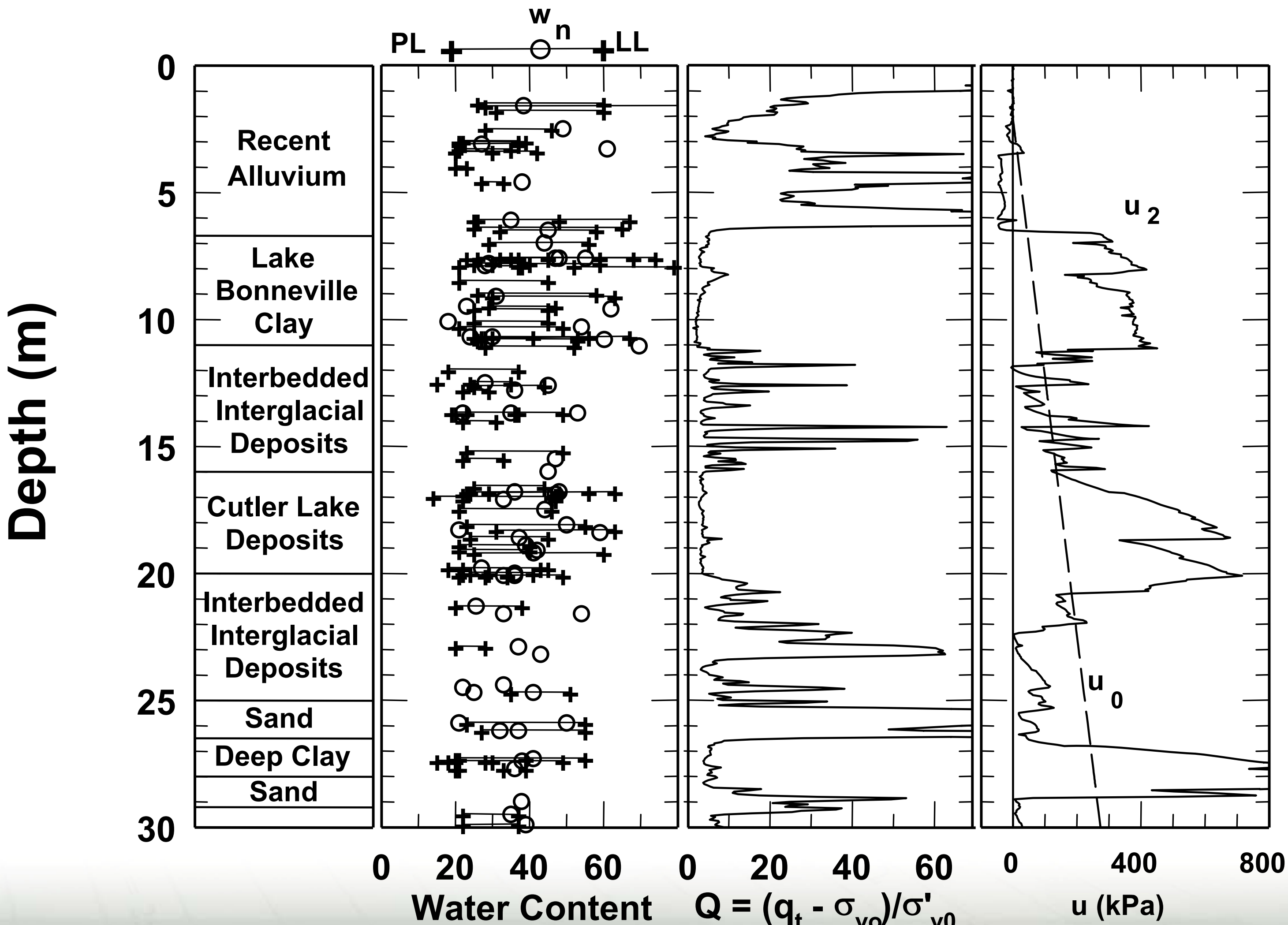
Settlements

- Selection of design criteria
- Primary consolidation settlements were 1 to 1.5 m
  - 100% primary needed at end of construction
  - Completion tied to the Winter Olympics
- Secondary compression
  - surcharge thickness design
- Surcharge needs controlled stability calculations

Piezocone Testing Data Was Used To:

- Provide nearly continuous data profiles
- Separate sand from clay
- Assess selected geotechnical properties
- Supplement and extend lab data

I-15 Subsurface Conditions



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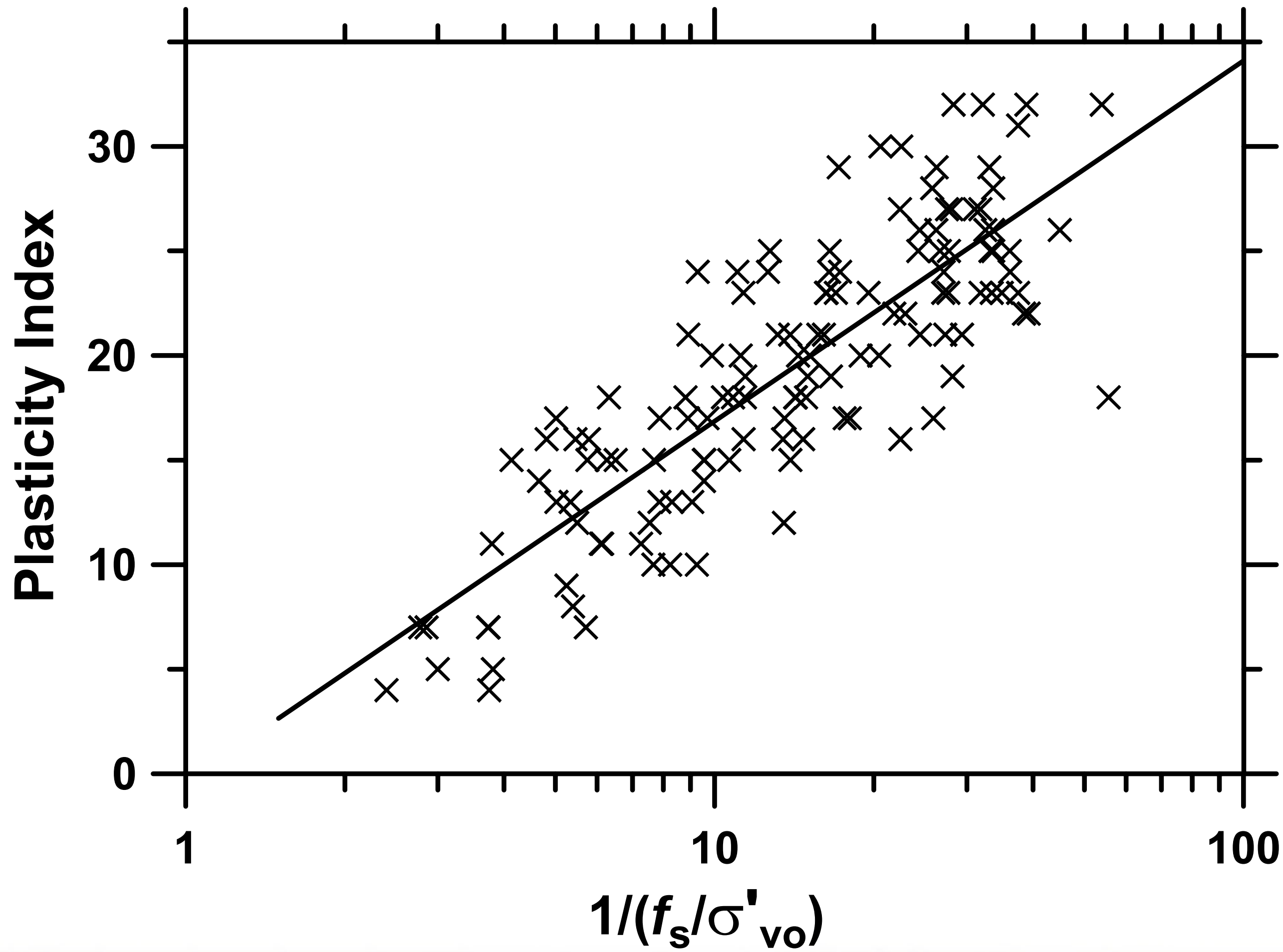
Assessment of the Soil Type Using Piezocone Sleeve Friction Data

- **Companion boring/sounding data relate soil index properties to the normalized sleeve friction, f_s/σ'_{vo}**

Plasticity Index Correlation – I-15



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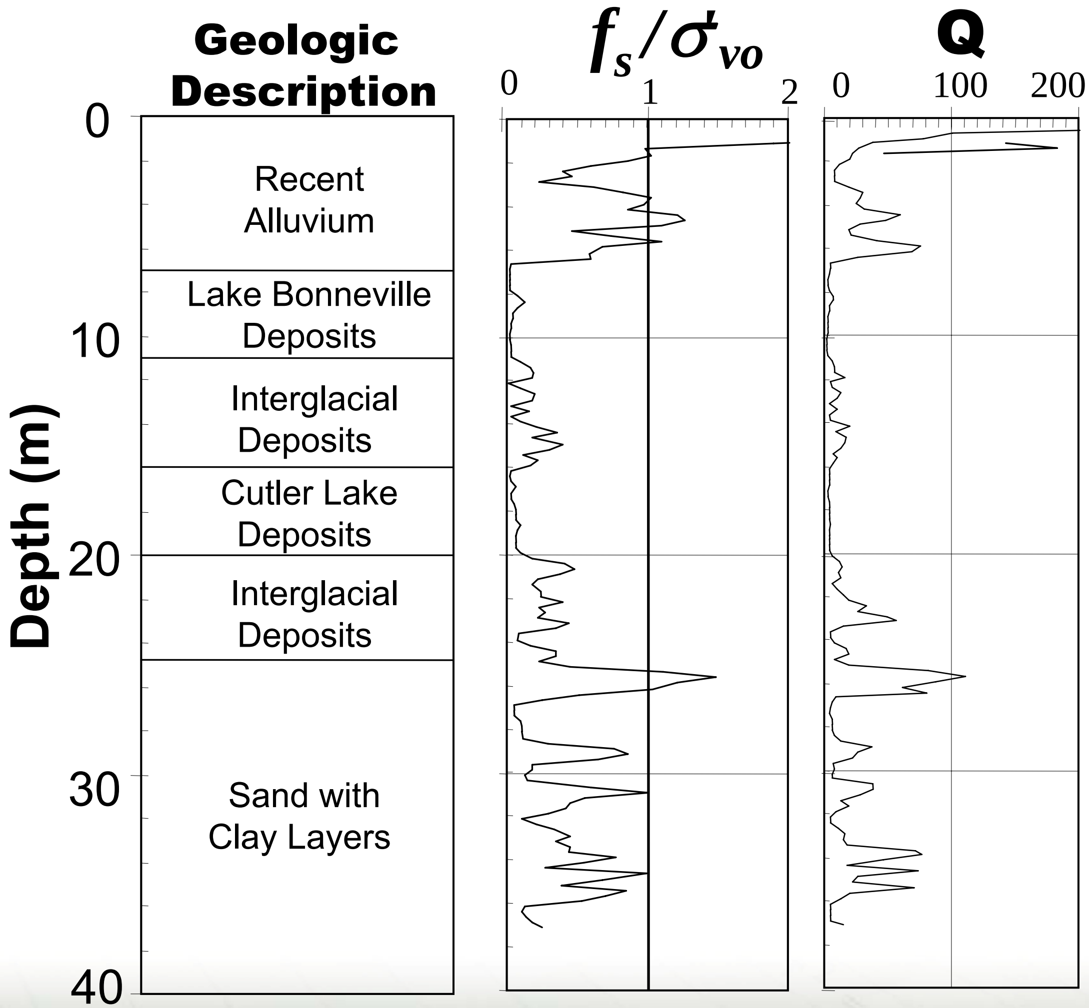
Identification of Lake Bonneville Clays



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OCR Assessment

- Most Important Factor in Settlement Calculations
- Normalized Net Tip Stress –

  $Q = (q_T - \sigma_{vo})/\sigma'_{vo}$
- Penetration Pore Water Pressure – u_2
- Normalized Sleeve Friction – f_s / σ'_{vo}

OCR Assessment

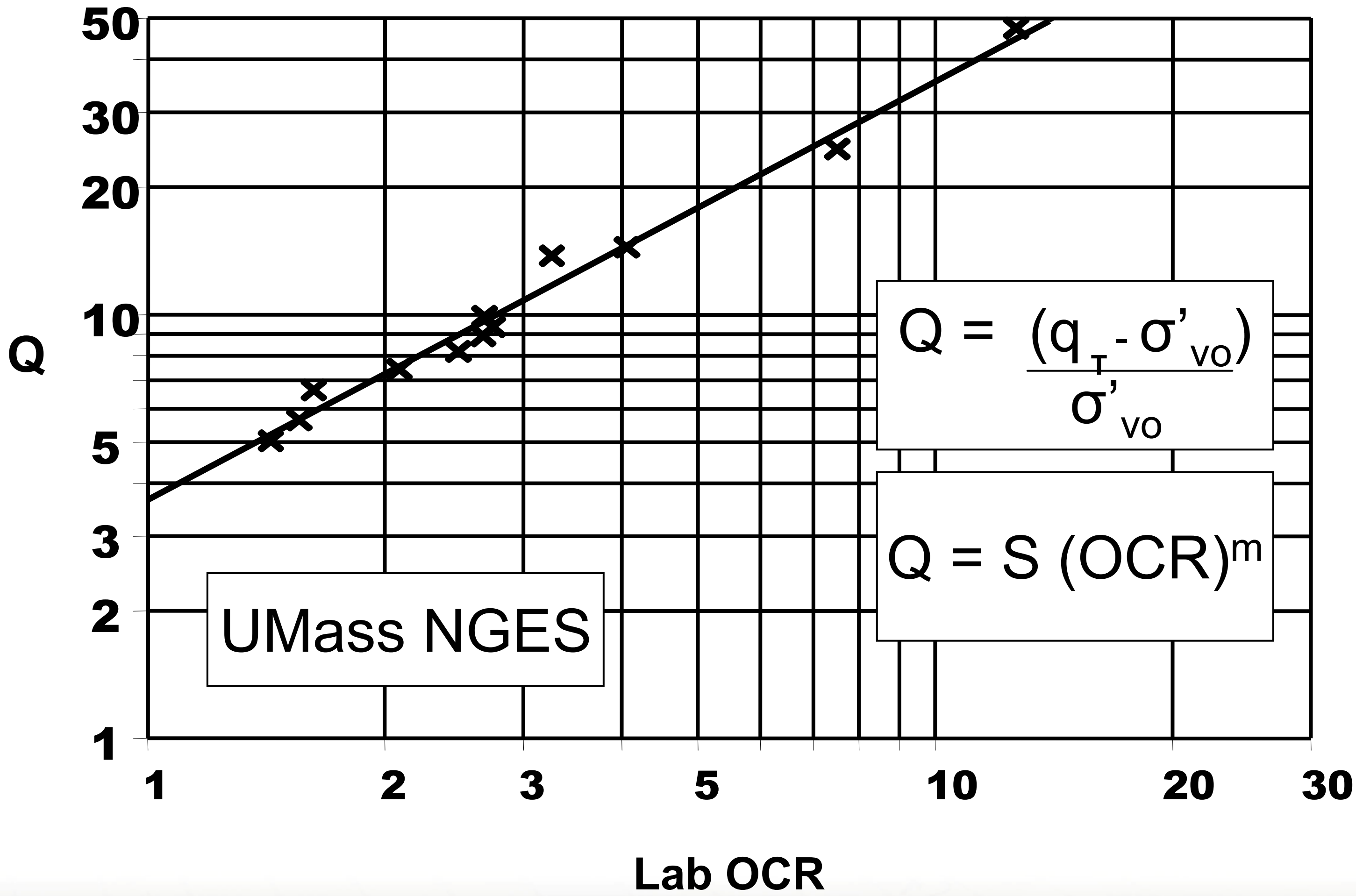
- Adaptation of the SHANSEP Equation

  $$s_u / \sigma'_{vo} = S\,(OCR)^m$$

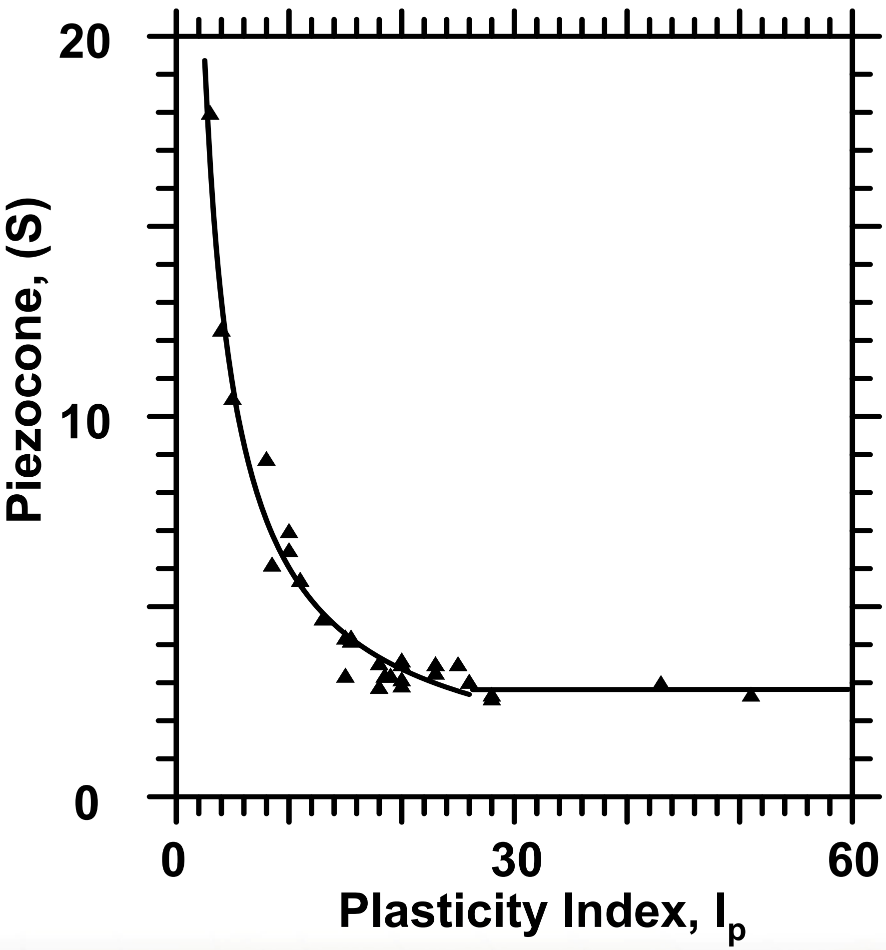
- (Ladd et al. 1998) to assess the OCR with piezocone data

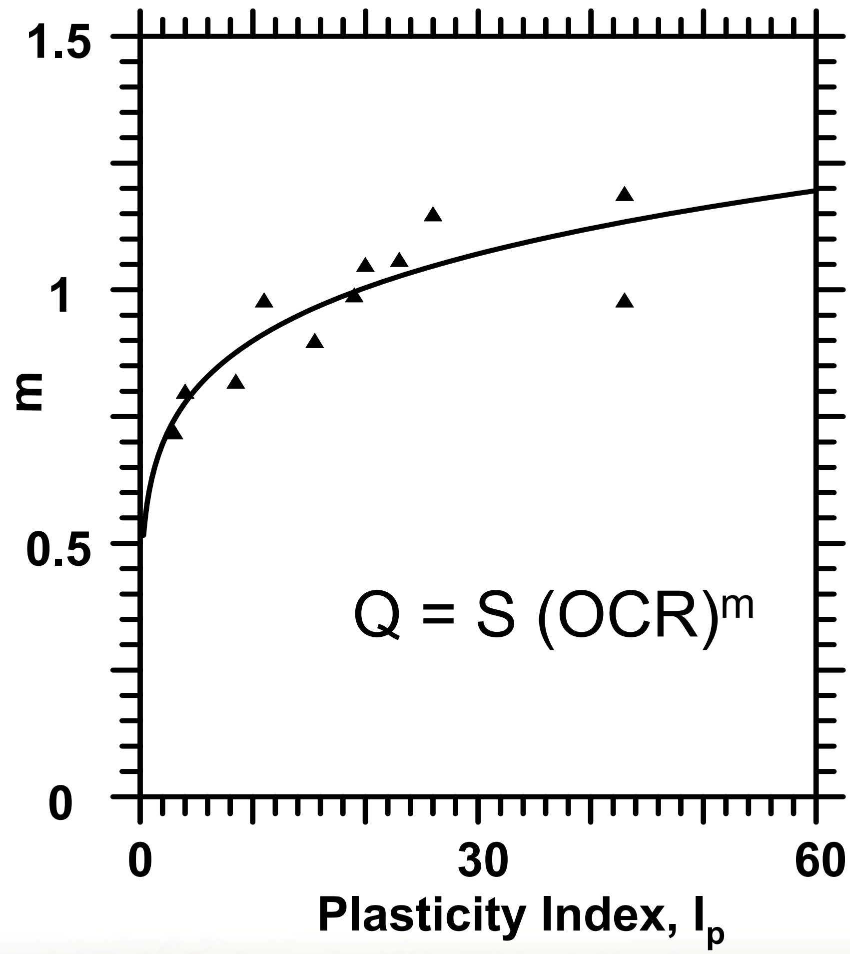
  $Q = S\,(OCR)^m$ Correlation Format

Correlation Format

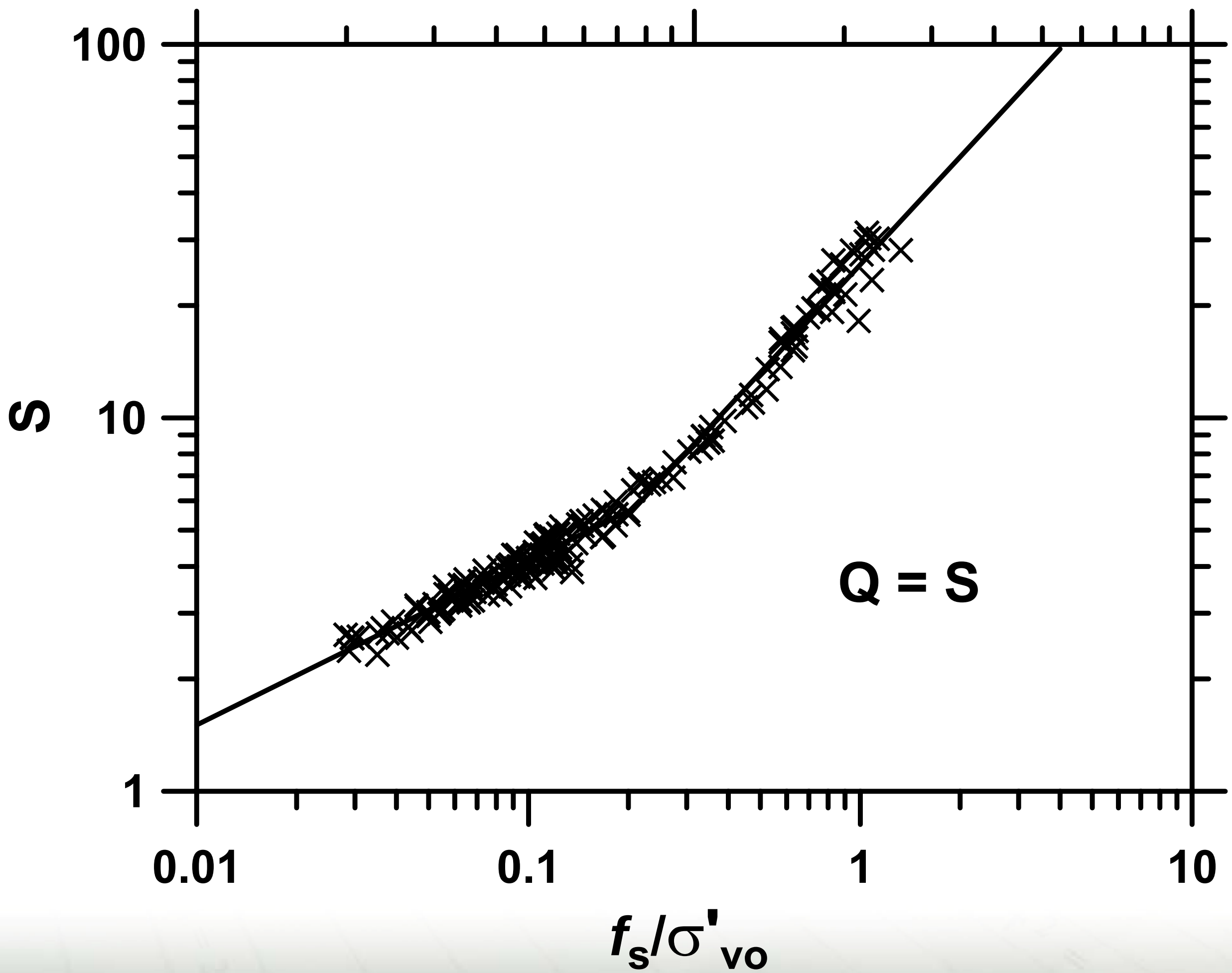


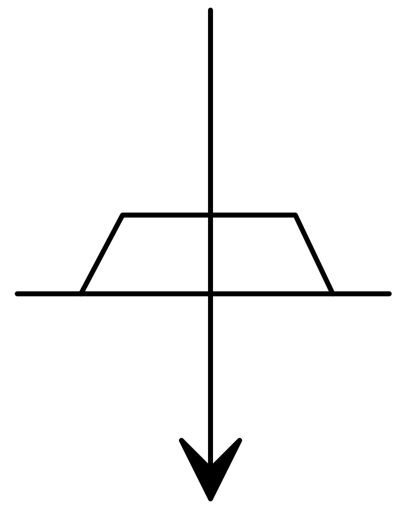
Variations in S and m with Plasticity Index – Piezocone Data





Piezocone Tests Through Existing Embankments - OCR = 1

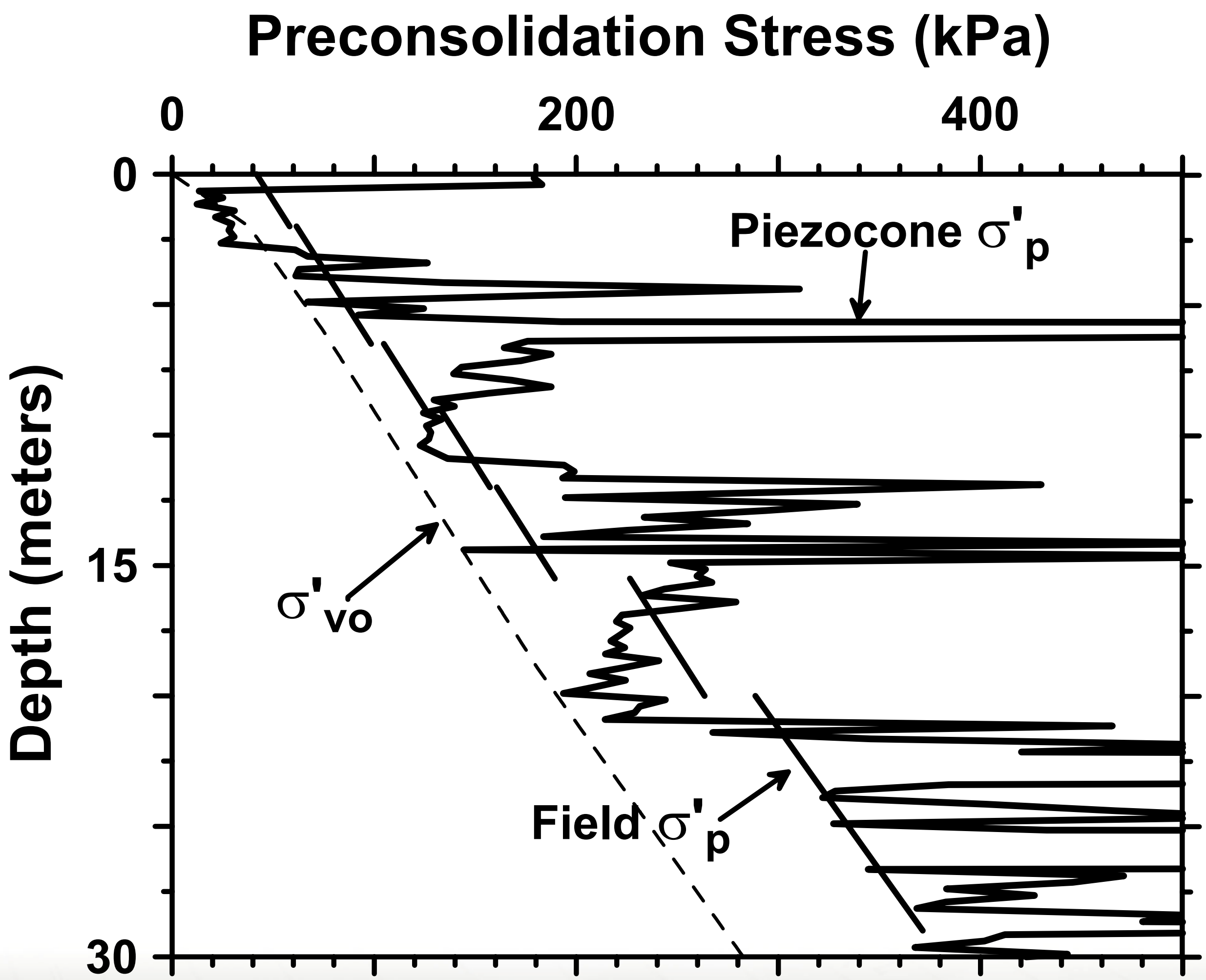




OCR Calculation in Lake Bonneville Deposits

- $OCR = (Q/S)^{1/m}$
- S related to (I_p) and (f_s / σ'_{vo})
- m related to (I_p) and (f_s / σ'_{vo})

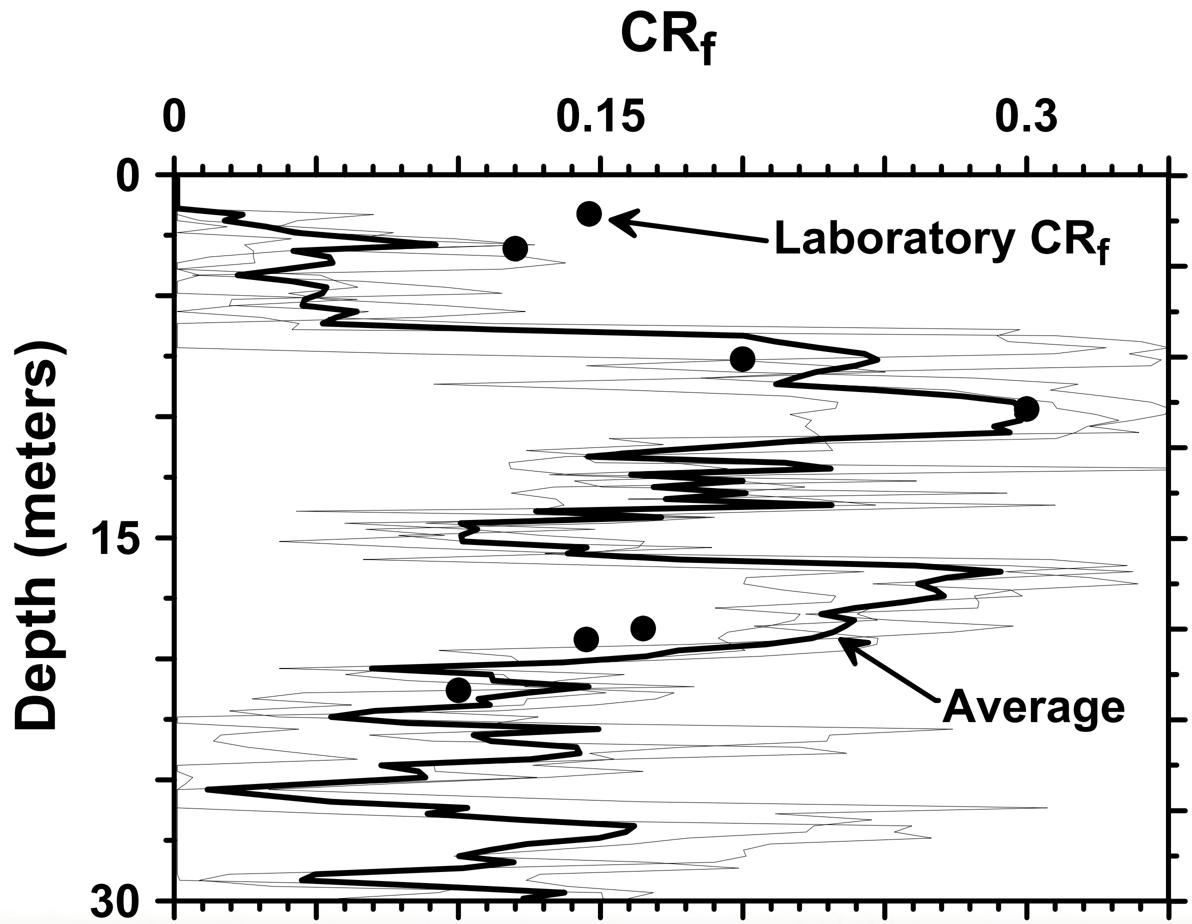
Stress History at North Temple



Undrained Strength Assessment

- SHANSEP approach (Ladd and Foott 1974) using design OCR profile
  - Testing at MIT to select coefficients
  - $S_{TC} = 0.3$ m = 0.8
  - $S_{DSS} = 0.24$ m = 0.8
  - $S_{TE} = 0.18$ m = 0.8

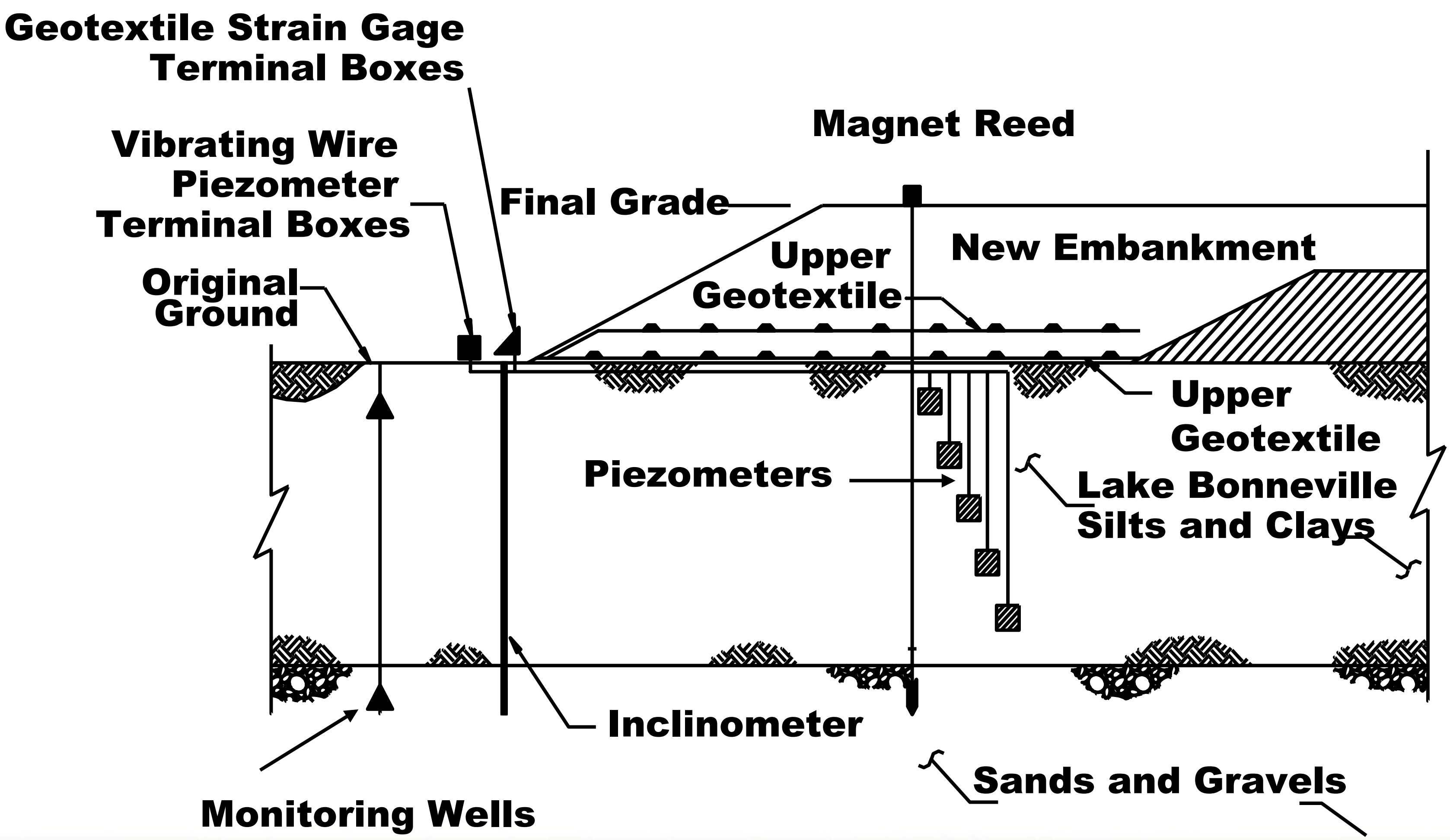
Assessment of Compression Ratio Profiles Using f_s / σ'_{vo}



Secondary Compression

- $C'_{\alpha} = 0.0425\ CR$
- Strain basis with original thickness

Instrumentation Section – New Construction



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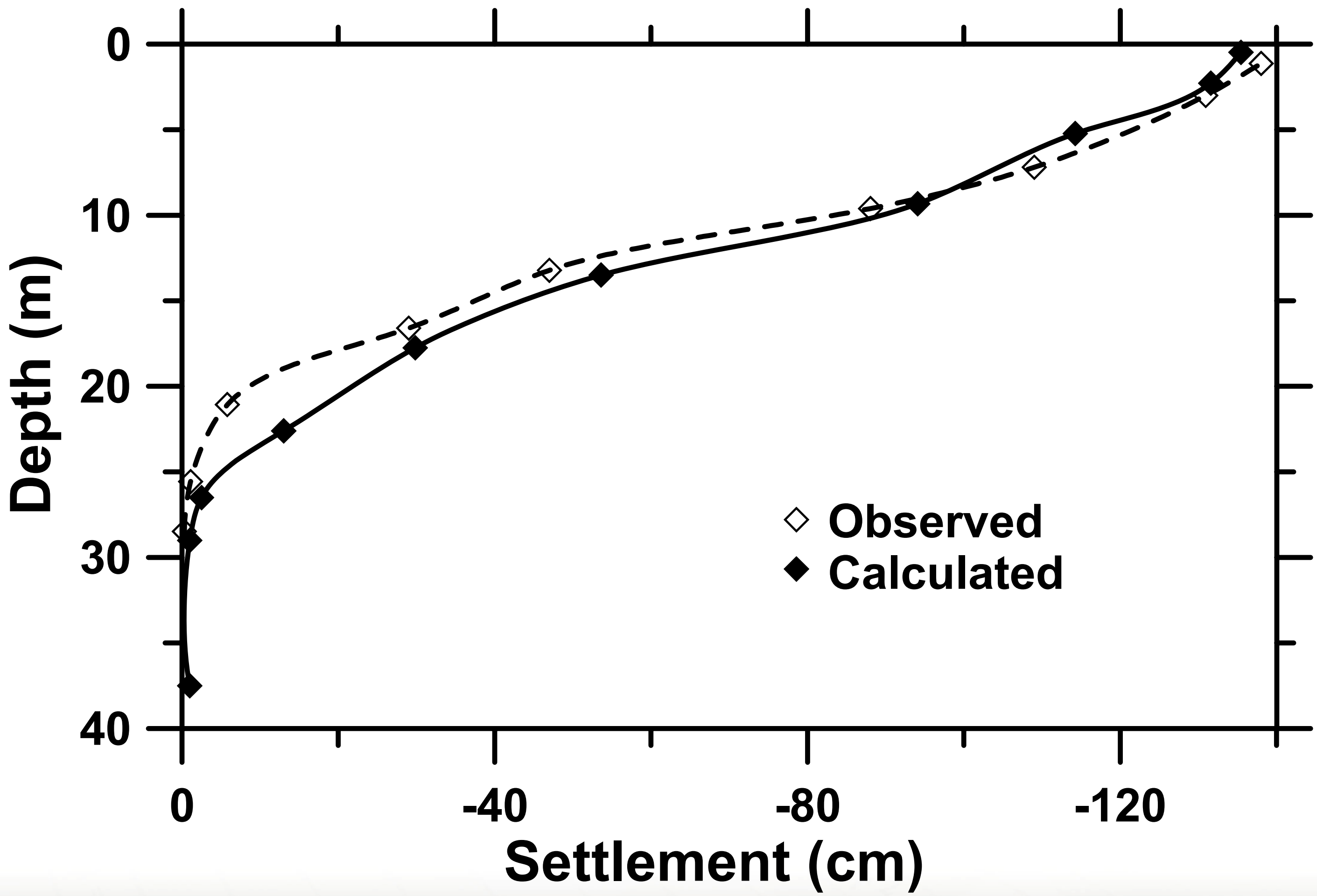
Settlement vs. Depth



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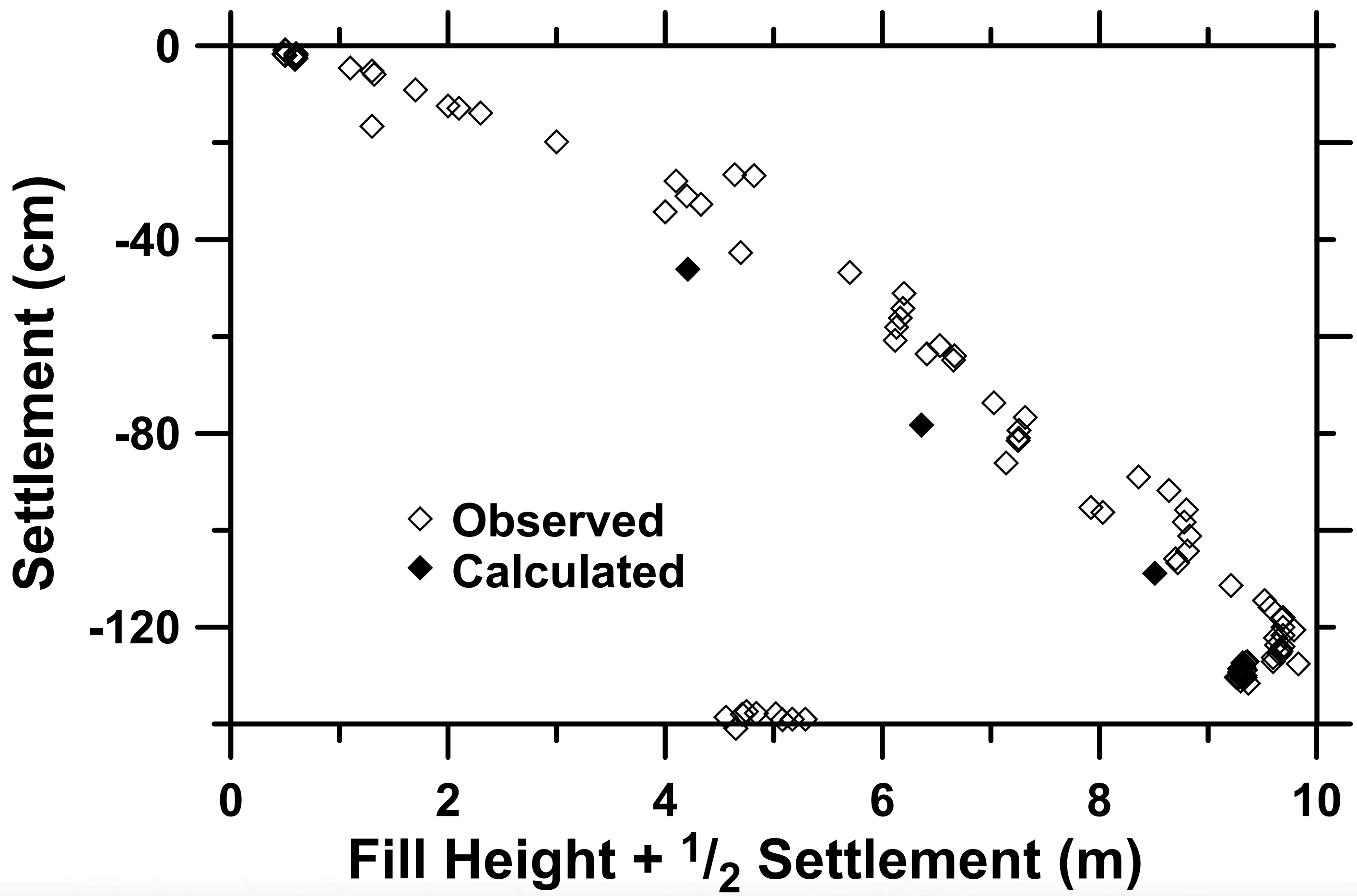
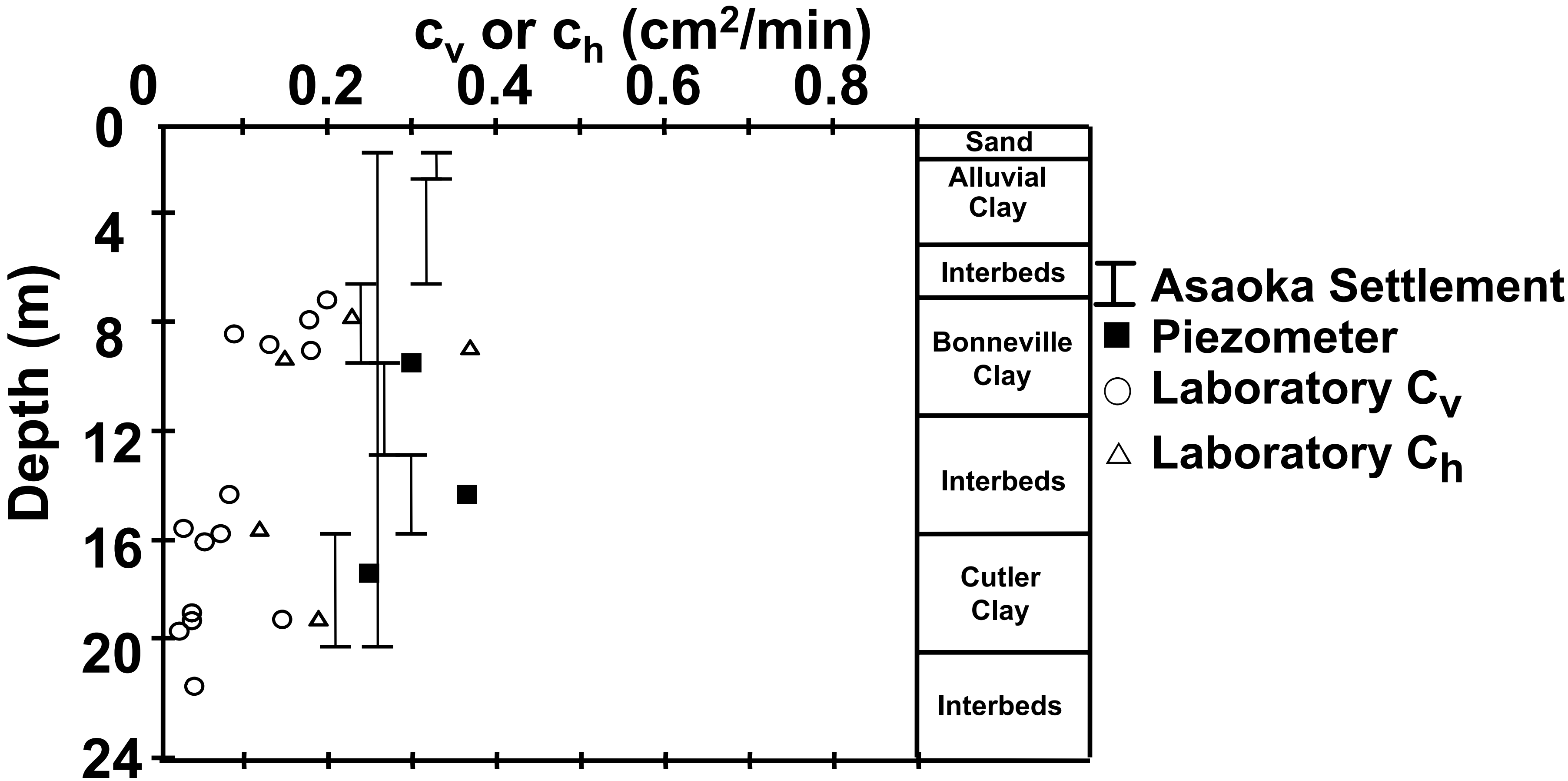
Settlement vs. Applied Stress



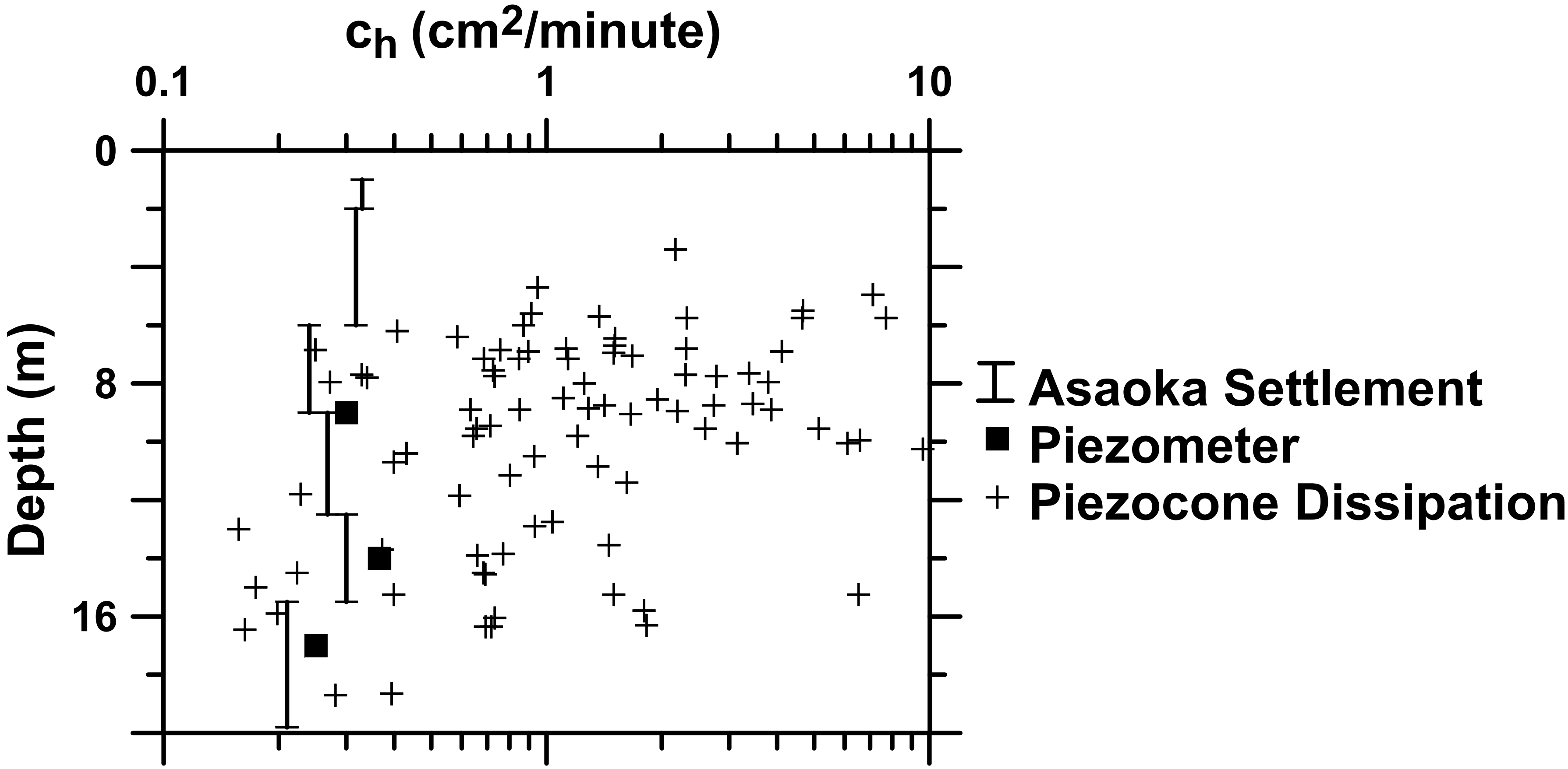
Rate of Consolidation

- Assessment of c_v and c_h
  - Historical Settlement Data – Pre-bid
  - Laboratory Study – Final Design
  - Field Study – Piezocone Dissipation Pre-bid Data Evaluation

Laboratory and Field Estimates of c_h and c_v



Assessment of c_h



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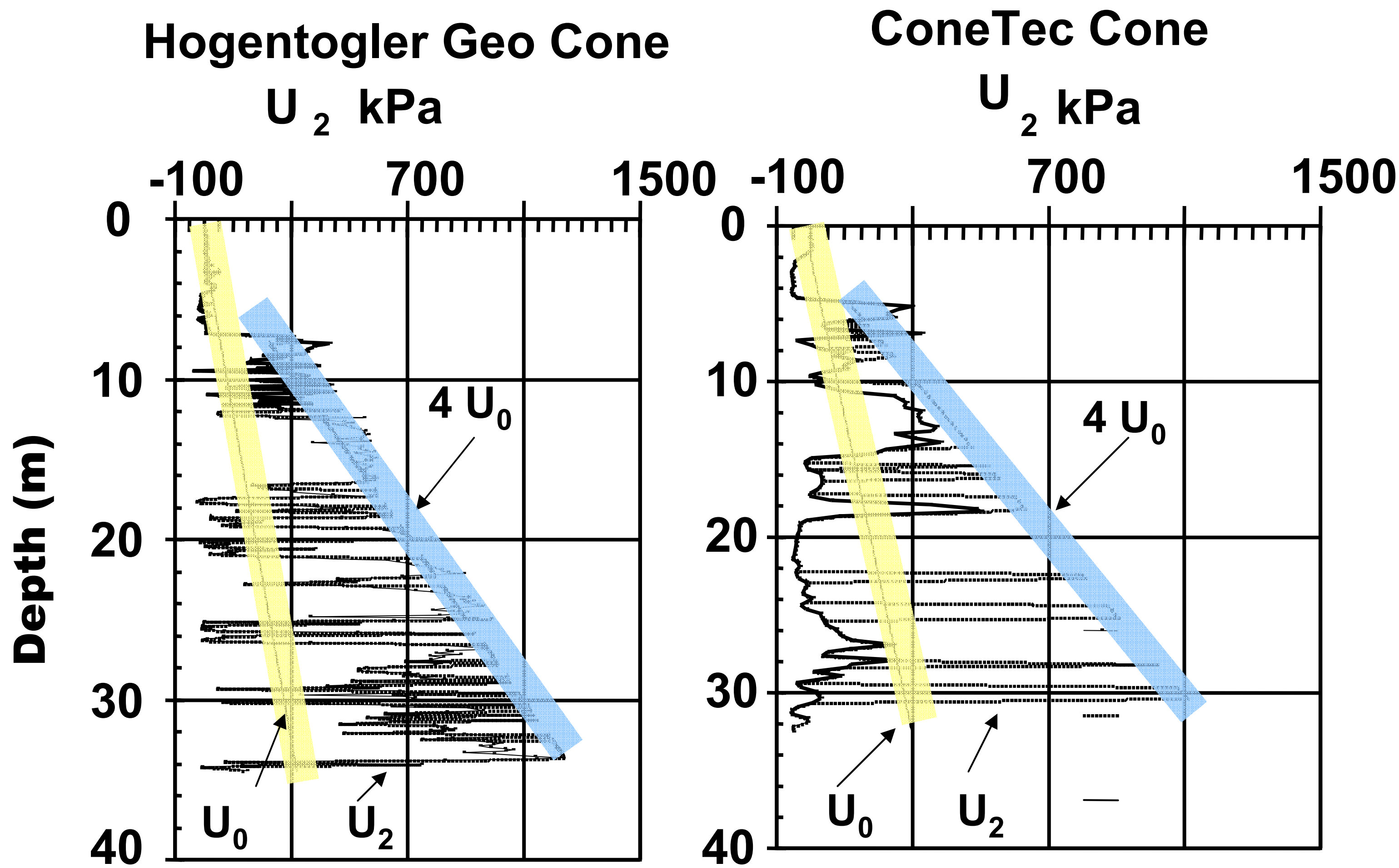
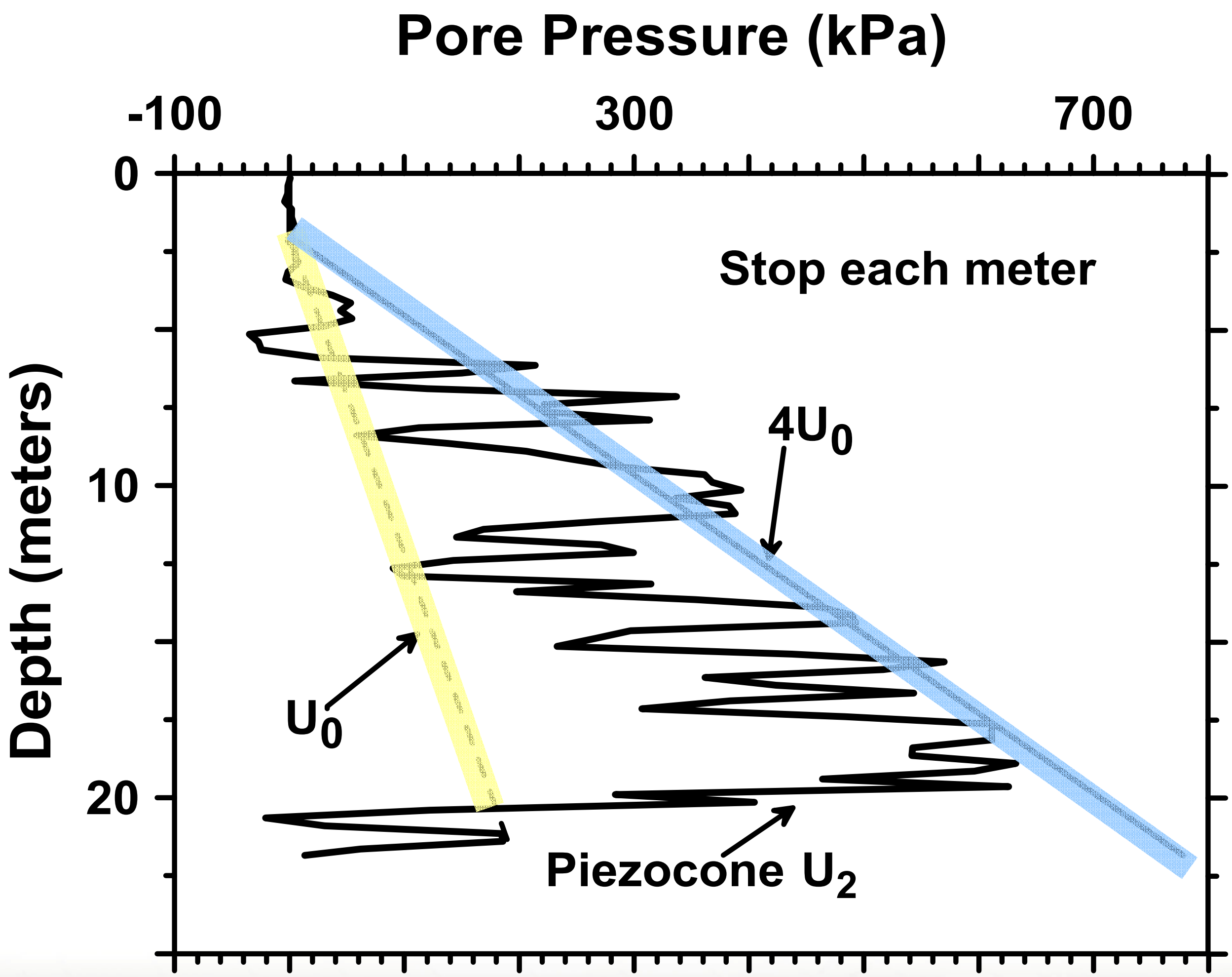
Penetration Pore Water Pressure Profiles with 4 u_0 Adjustment



Tip Re-saturation Technique



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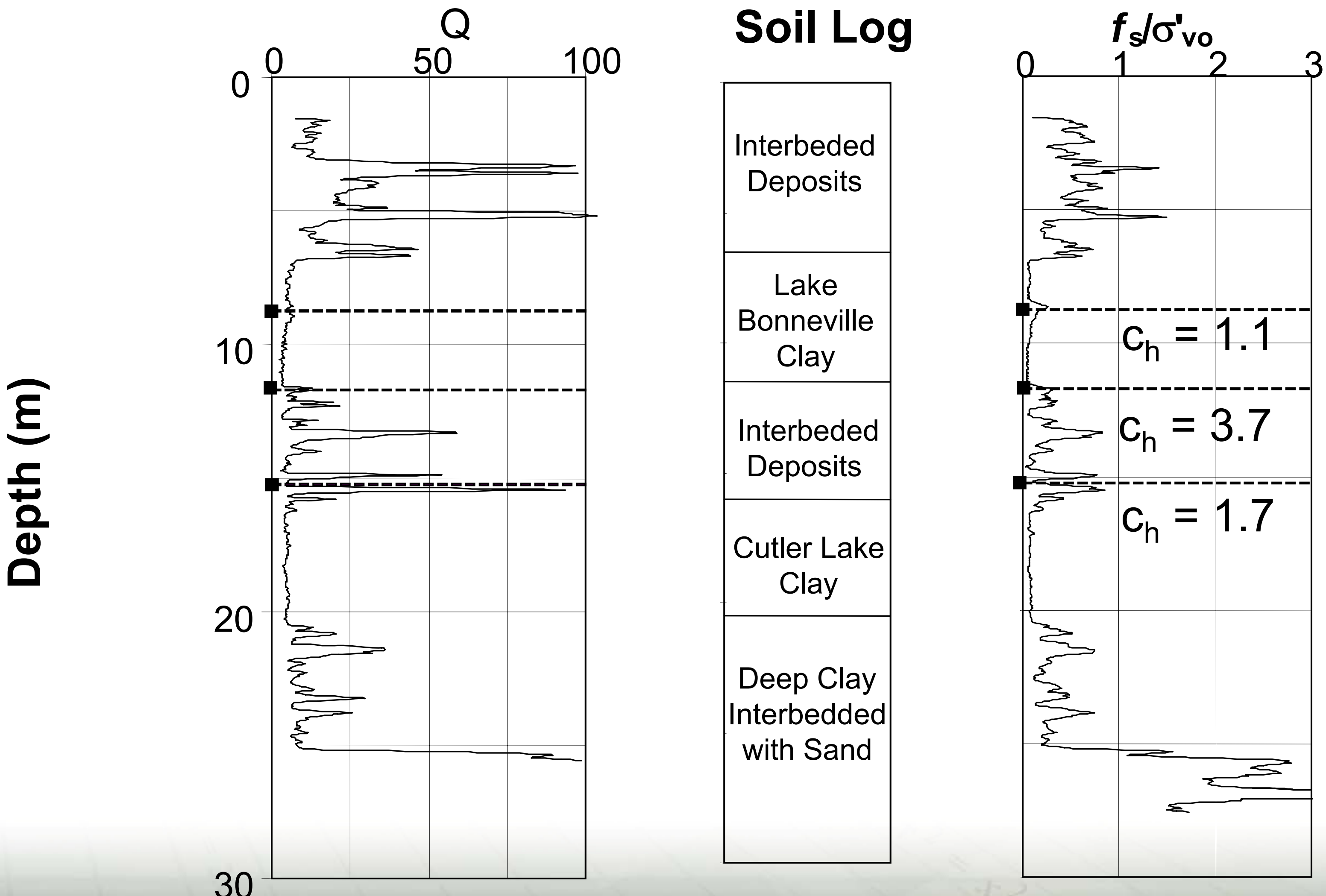
Dissipation Tests Near Drainage Layers



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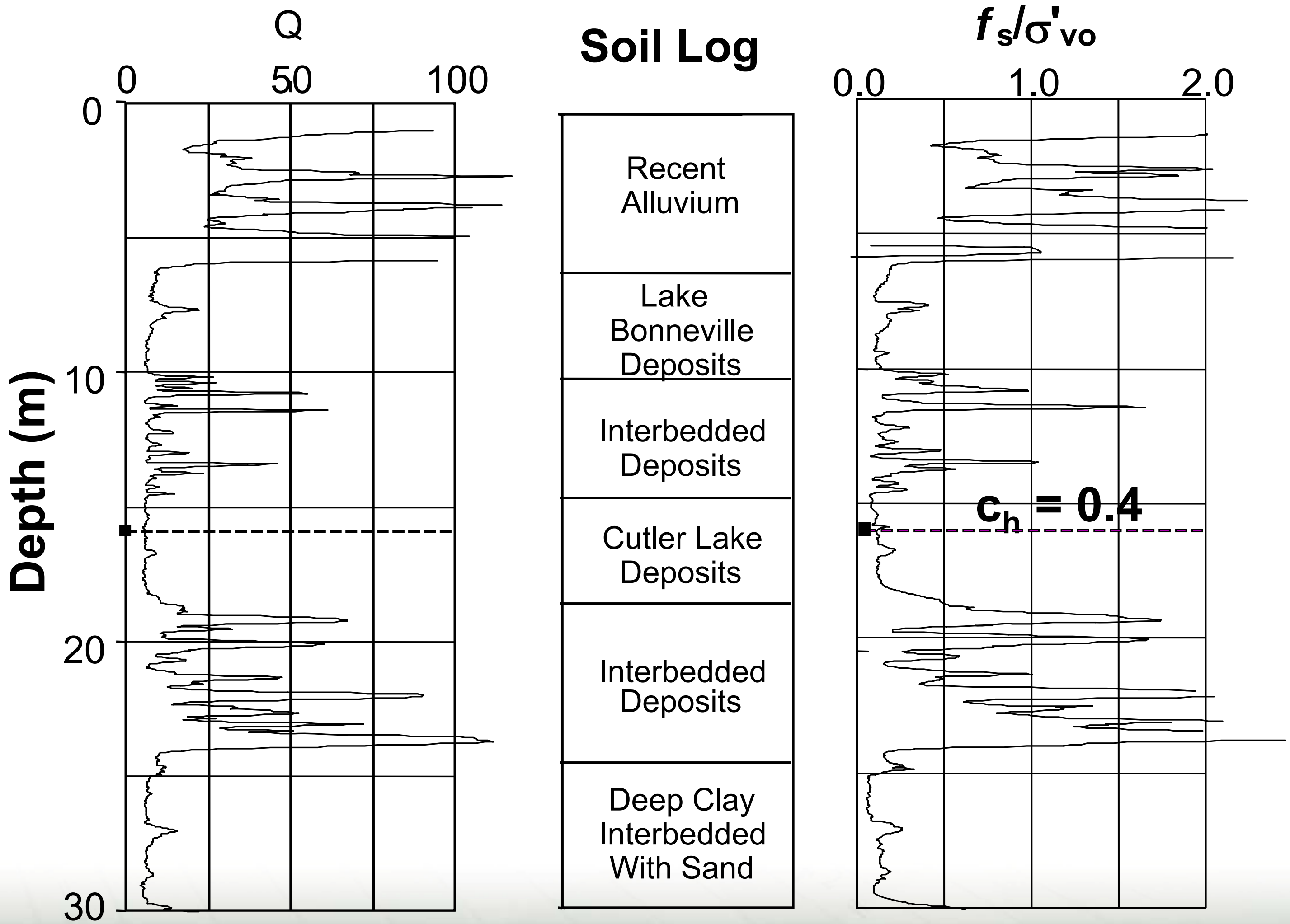
Dissipation Test Near Center of Clay Layer



Piezocone Dissipation Testing at I-15

- **Make dissipation tests in a second sounding selecting the test depths to target specific areas. Re-saturate the tip above the test depth.**

Conclusions

- Detailed assessments of the thickness and engineering properties of the sands and clays were obtained
- The adaptation of the SHANSEP method described by Ladd et al. (1998) works well in these soils

Conclusions

- The normalized sleeve friction, f_s /σ'_{vo}, was used successfully to assess soil type changes and to select empirical correlation coefficients to assess the OCR and compressibility of the Lake Bonneville Deposits

Conclusions

- **Tip de-saturation is a significant factor in the Lake Bonneville Deposits. Techniques were developed to accommodate the variable ground conditions.**