

# Soil Mixing Design Methods and Construction Techniques for Use in High Organic Soils



*GRIP 2013*

*Presented by: Danny Winters, P.E.*

# Problem Statement

- ◆ Organic soils are problematic for roadway construction; typically, the material is replaced, modified, or bridged.
- ◆ Insitu soil mixing is one method that can be used to stabilize the material but the low pH necessitates high binder content and promotes unwanted variability in the resulting strength.

# Project Overview

- ◆ Existing Soil Mixing Methods
- ◆ Case Histories with Long-Term Performance
- ◆ Various Binder Materials
- ◆ Techniques for New and Existing Roadways
- ◆ Lab / Field Tests to Evaluate Long Term Performance
- ◆ Cost Evaluation
- ◆ Guidelines for Soil Mixing

# Research Approach

- ◆ Task 1 Literature Review
- ◆ Task 2 Laboratory Testing
- ◆ Task 3 Field Testing and Exploration
- ◆ Task 4 Cost Evaluation / Guidelines and Recommendations
- ◆ Task 5 Reporting

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# FDOT Soils and Foundations Handbook

## Section 8.4.1.3

1. Reduce fill height
2. Provide waiting period to allow for majority of consolidation to occur
3. Increase surcharge height
4. Use a lightweight fill
5. Install wick drains within the compressible material to be surcharged
6. Excavate soft compressible material and backfill with granular soil
7. Ground modification such as stone columns, dynamic compaction, etc.
8. Deep soil mixing
9. Combinations of some of the above



# Wet Soil Mixing



# Dry Soil Mixing





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# Organic Laboratory Samples



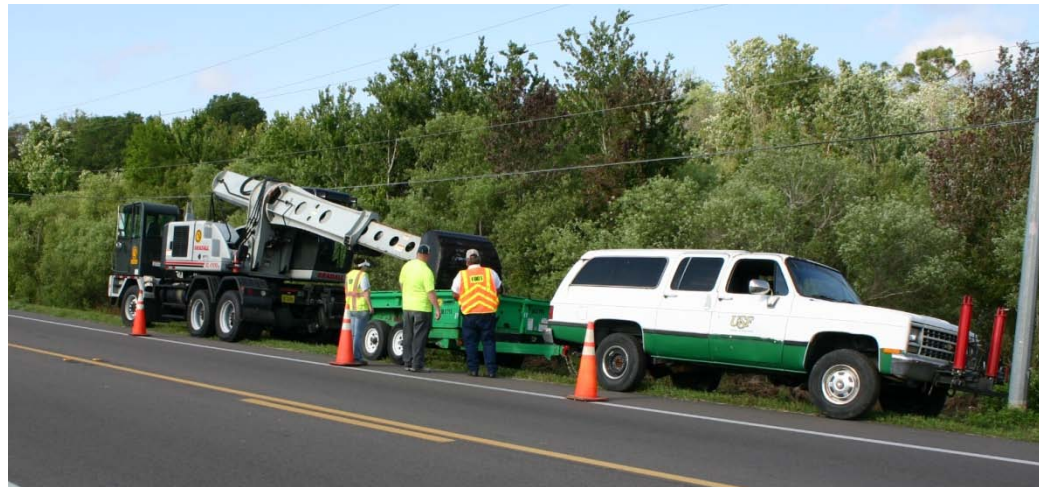


# Organic Laboratory Samples



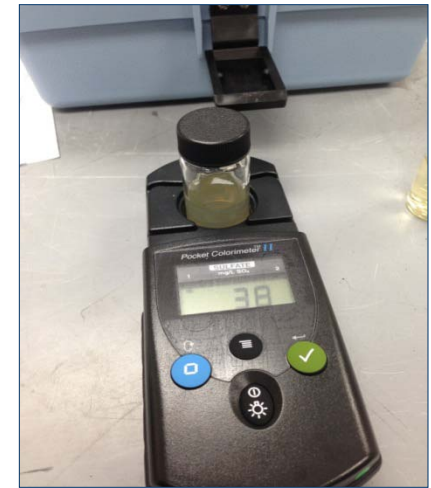
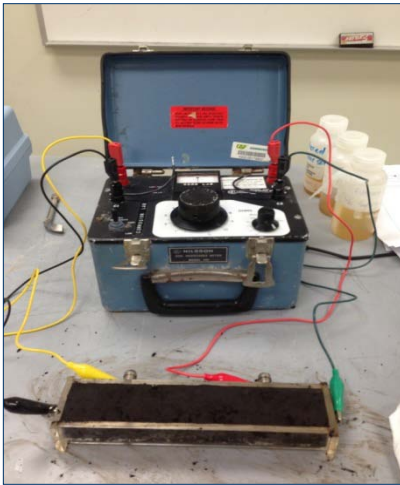


# Organic Laboratory Samples





# Laboratory Testing



# Organic Soil Properties

- ◆ Organic Content = 50-65% (ASTM D 2947-00)
- ◆ Moisture Content = 260-300% (ASTM D 2974-00)
- ◆ pH = 5.5-7 (ASTM D 4972)
- ◆ Resistivity = 5 k $\Omega$ -cm (FM 5-551)
- ◆ Chloride Content = 590 ppm (FM 5-552)
- ◆ Sulfate Content = 35 ppm (FM 5-553)

# Soil Mixing Considerations

- ◆ Soil Type
- ◆ Organic Content
- ◆ Moisture Content
  - Dry or Wet Mixing
- ◆ Binder Type
  - Cement, Slag, Fly Ash, Etc.
- ◆ Binder Content
- ◆ pH of the Soil
  - Low pH detrimental to reactivity of cement
- ◆ pH Modifiers
  - Soda Ash, pot ash, lye, lime, pearl ash, etc
- ◆ pH Modifier Content
- ◆ Mixer Type
- ◆ Mixing Energy

# Initial Soil Mixing

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- ◆ 100 – 300 pcy Cement
- ◆ Dry & Wet Mixing
- ◆ Starting Soil pH Range from 6 to 9
  - Soda Ash
- ◆ Moisture Content (265 to 450%)
- ◆ 4x8 inch Cylinders



# Soil Mixing

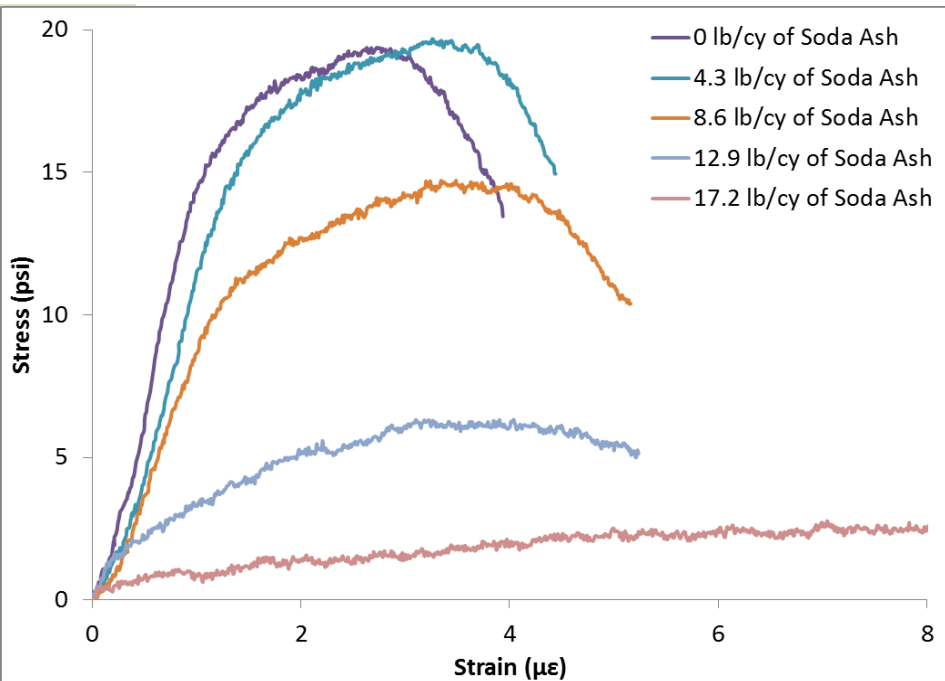


# Unconfined Compression Testing

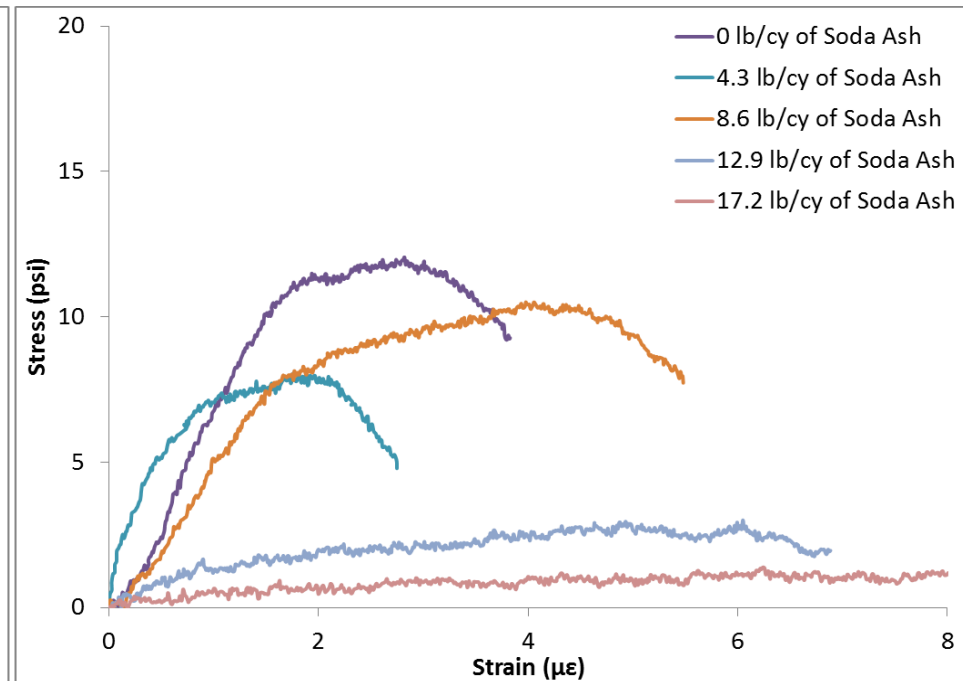


# Soil Mixing Results

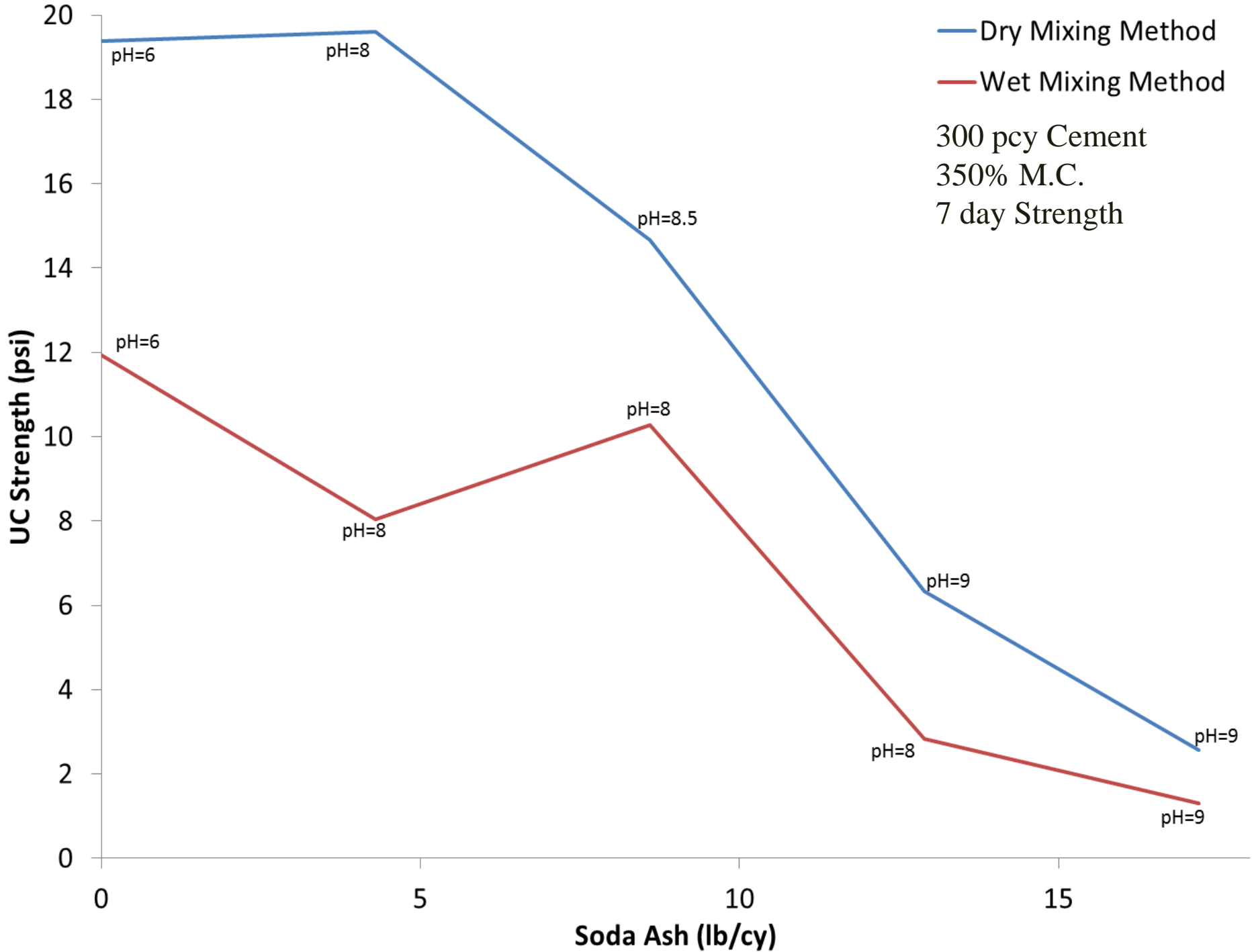
- ◆ 350% Moisture Content
- ◆ 7 day Strength
- ◆ 300 pcy Cement



Dry Mixing Method



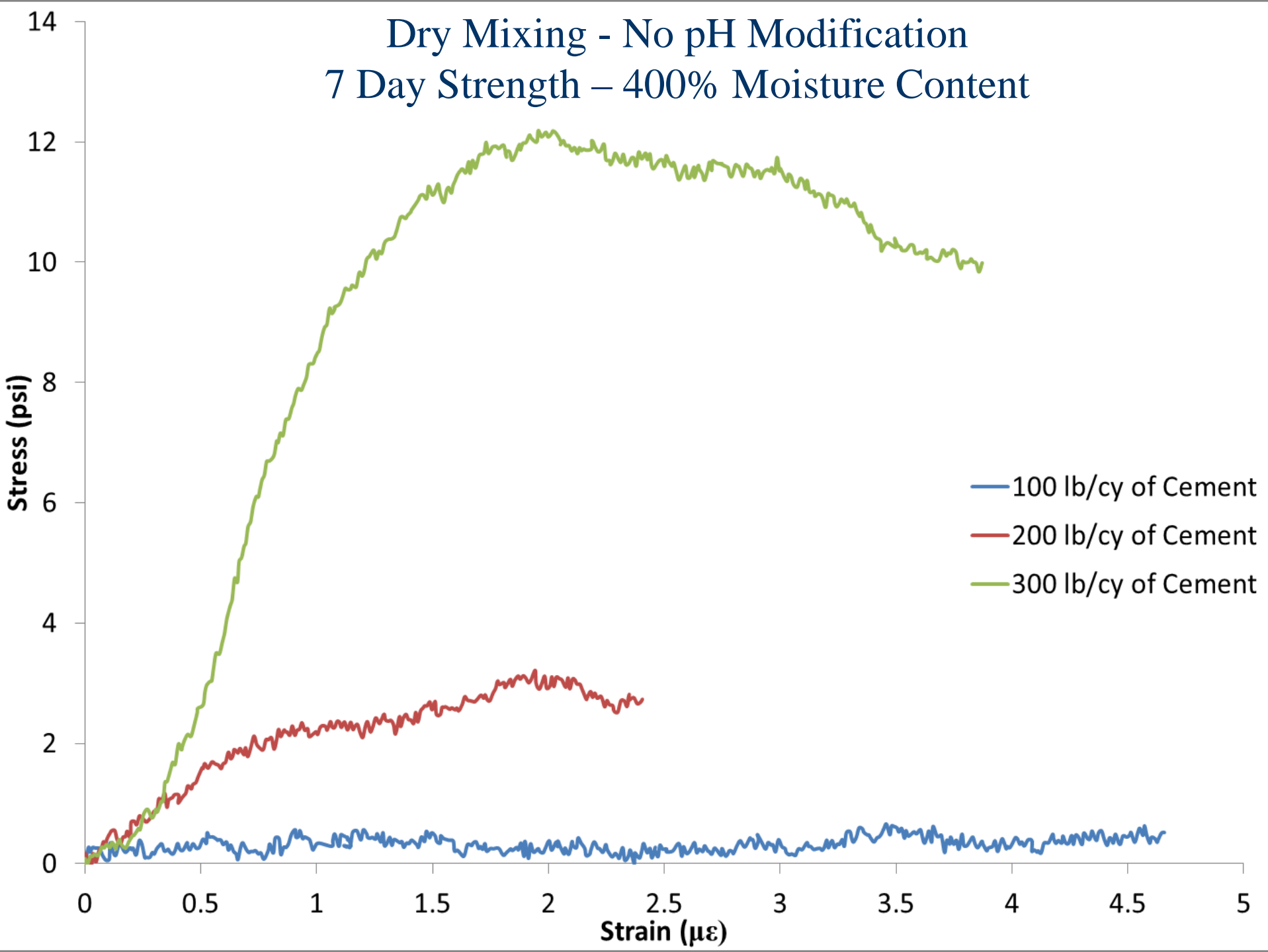
Wet Mixing Method





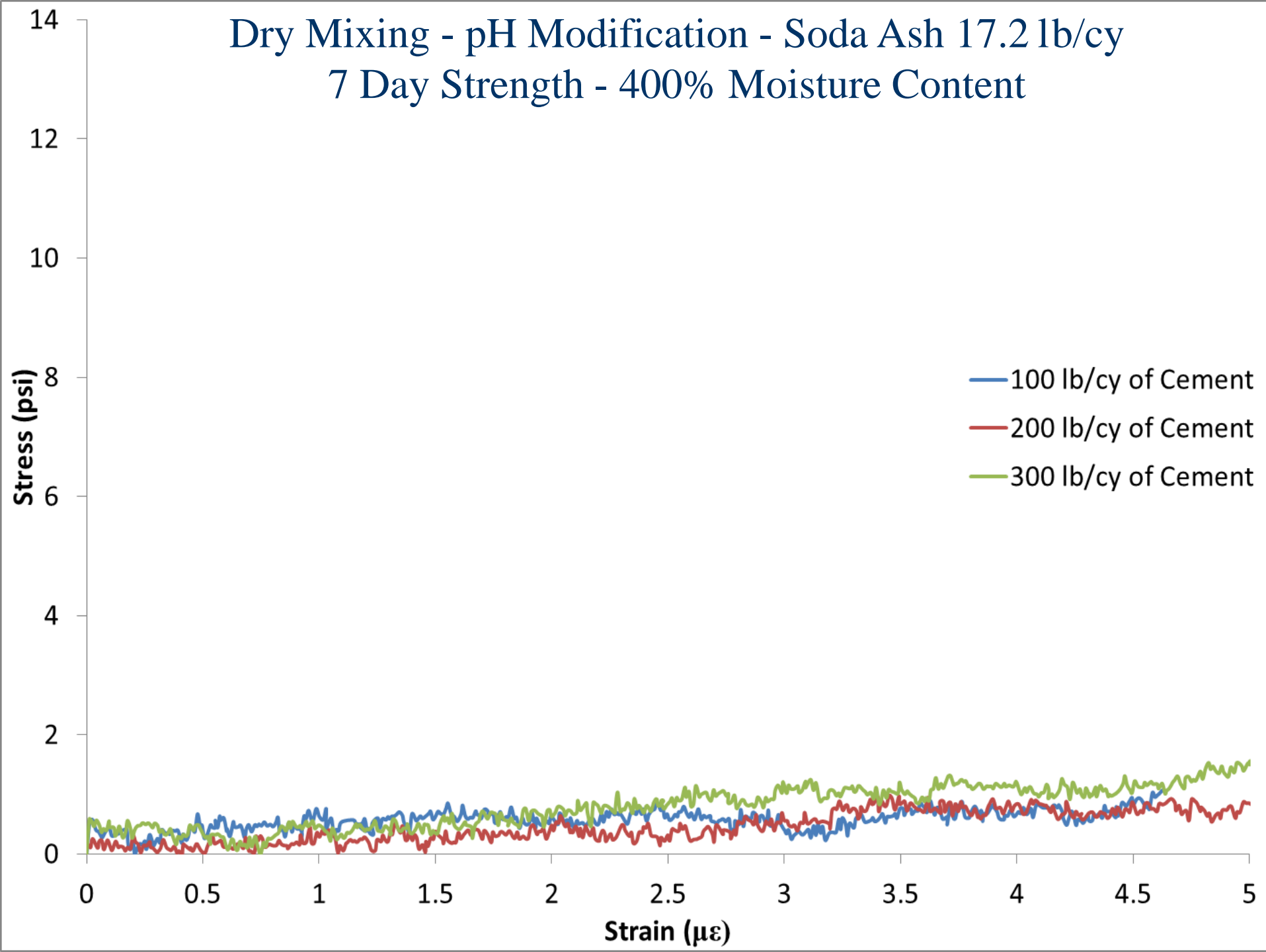
# Dry Mixing - No pH Modification

## 7 Day Strength – 400% Moisture Content



# Dry Mixing - pH Modification - Soda Ash 17.2 lb/cy

## 7 Day Strength - 400% Moisture Content



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# Case Histories

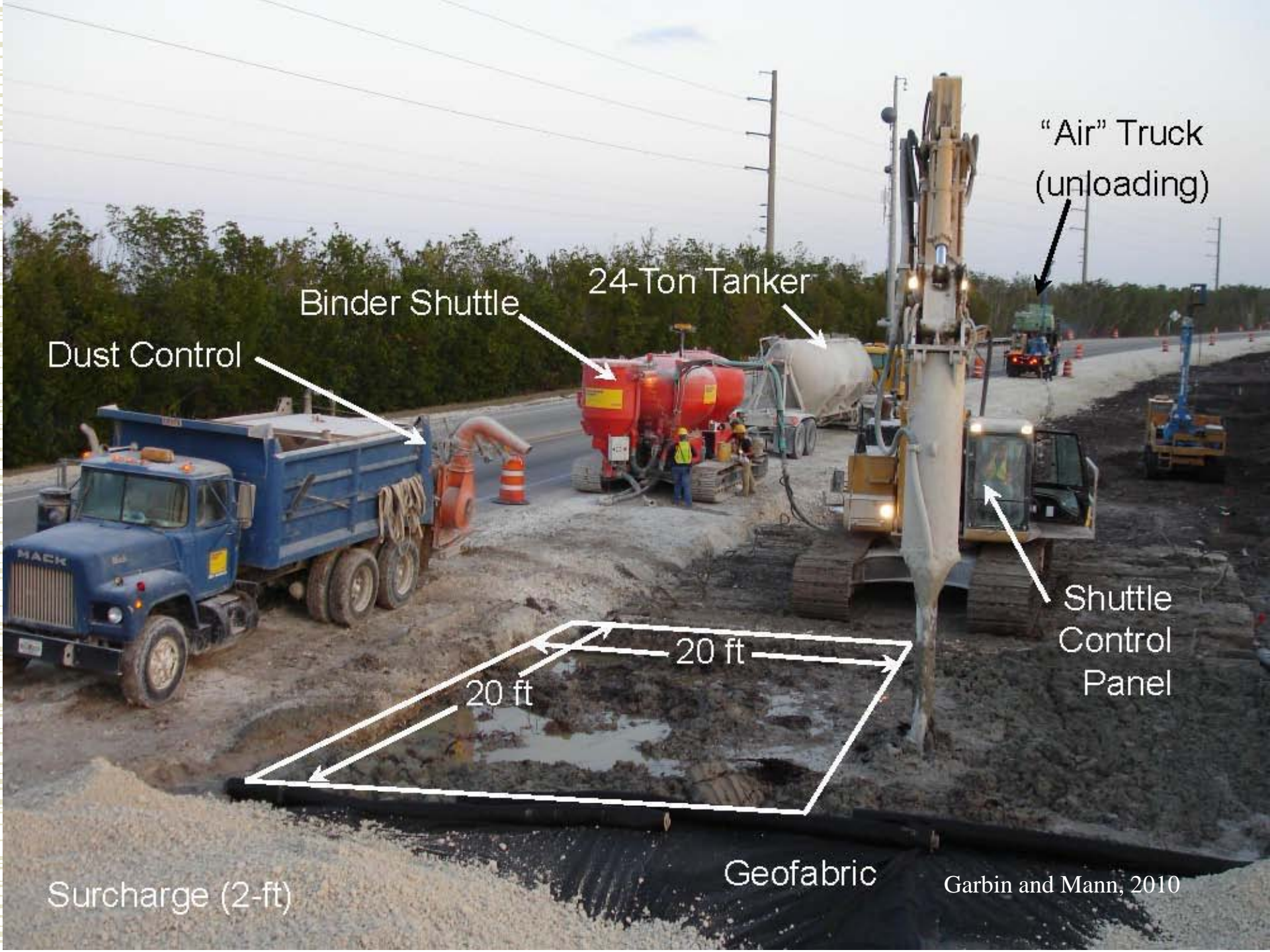
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- ◆ District 1: SR 33 North of Polk City
- ◆ District 2: SR 100 in Putnam County  
The Rail and Trail Bike Path
- ◆ District 5: SR 46 in Sanford
- ◆ District 6: US-1 Jewfish Creek
- ◆ Turnpike: Milepost 284.7 in Lake County

# US-1 Jewfish Creek

- ◆ Florida Keys 2005
- ◆ 18 miles, 40ft Widening, Northbound
- ◆ 10-15 ft of Organic Silts
- ◆ 40-60% Organic, 85 – 650% m.c.
- ◆ Dry Soil Mixing
  - 200-300 pcy (75% slag / 25% cement)





“Air” Truck  
(unloading)

24-Ton Tanker

Binder Shuttle

Dust Control

Shuttle  
Control  
Panel

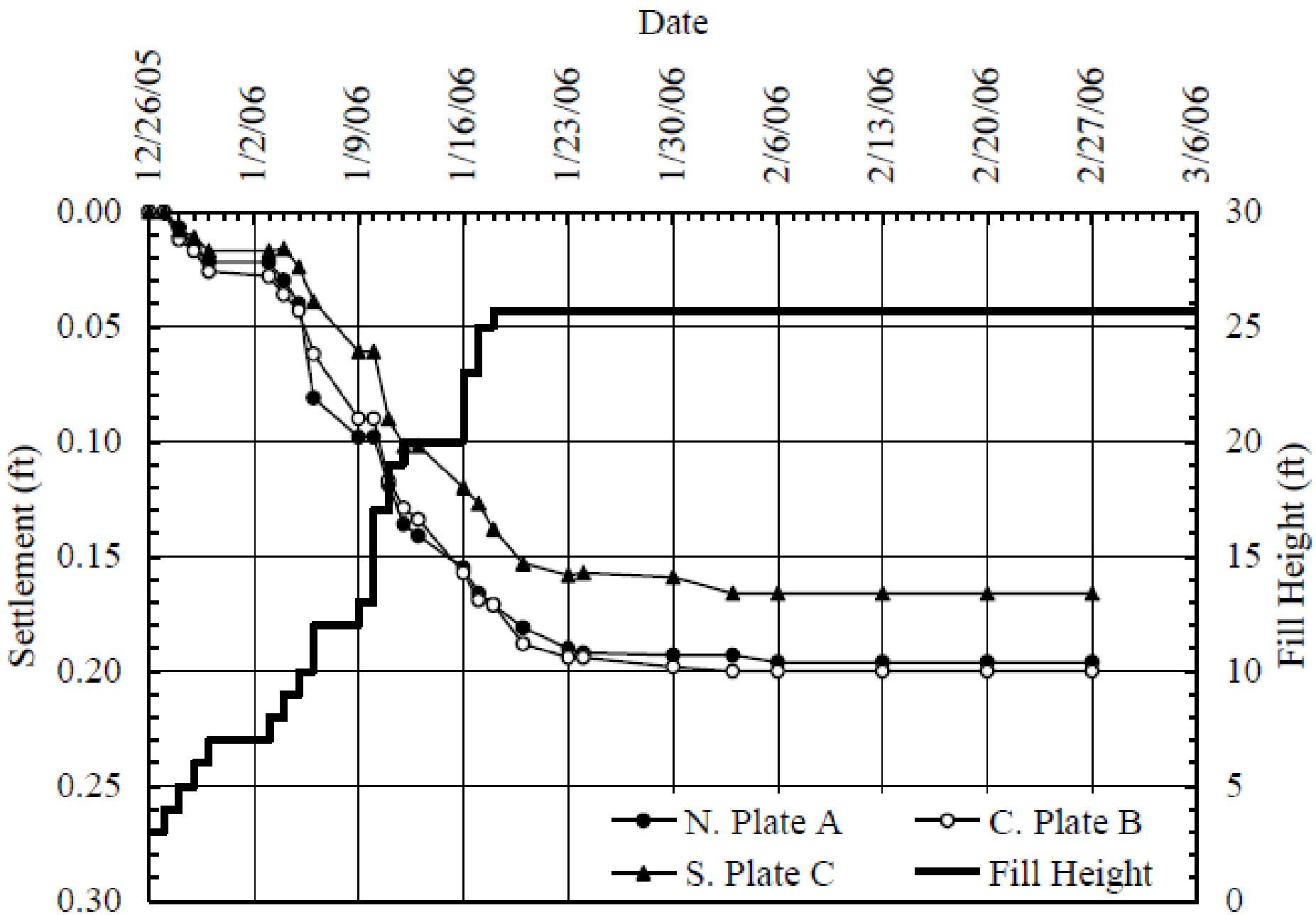
20 ft

20 ft

Surcharge (2-ft)

Geofabric

Garbin and Mann, 2010







1177+0

2009







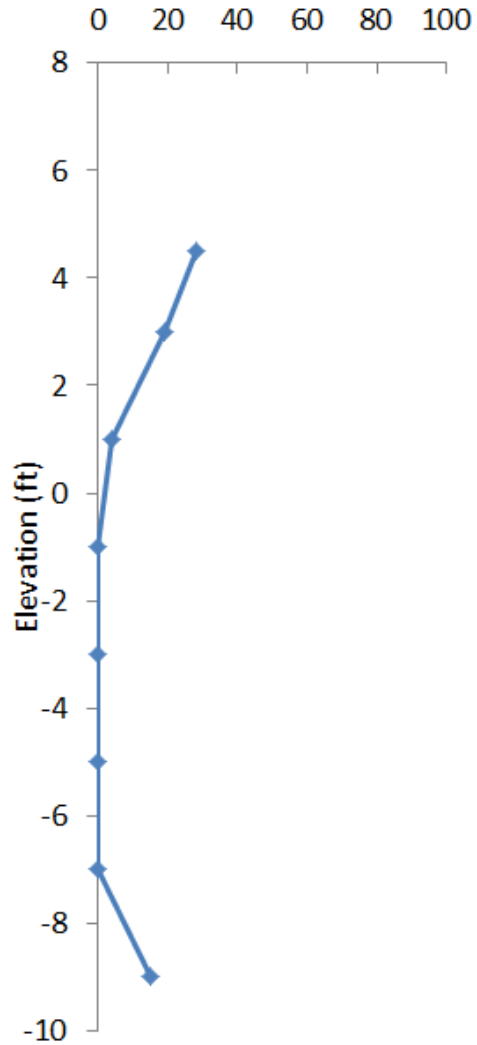




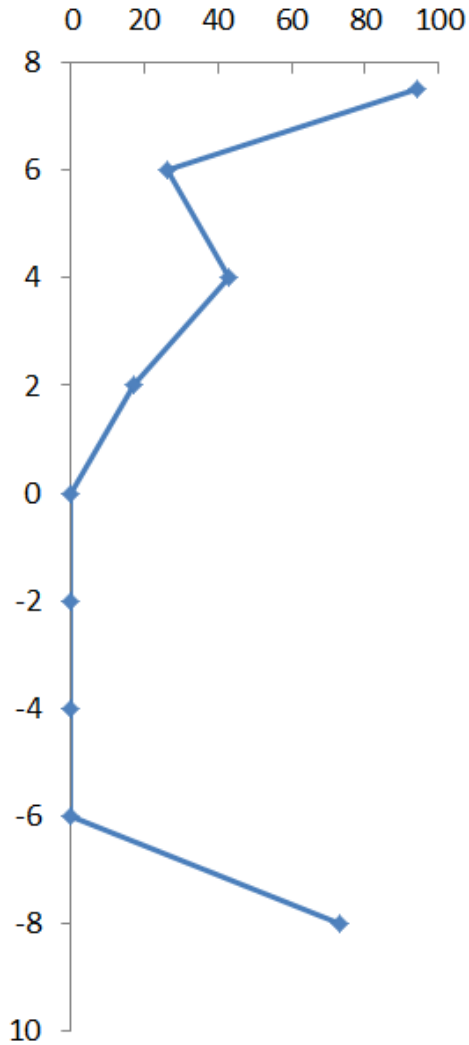


# US-1 Jewfish Creek 2009 Borings

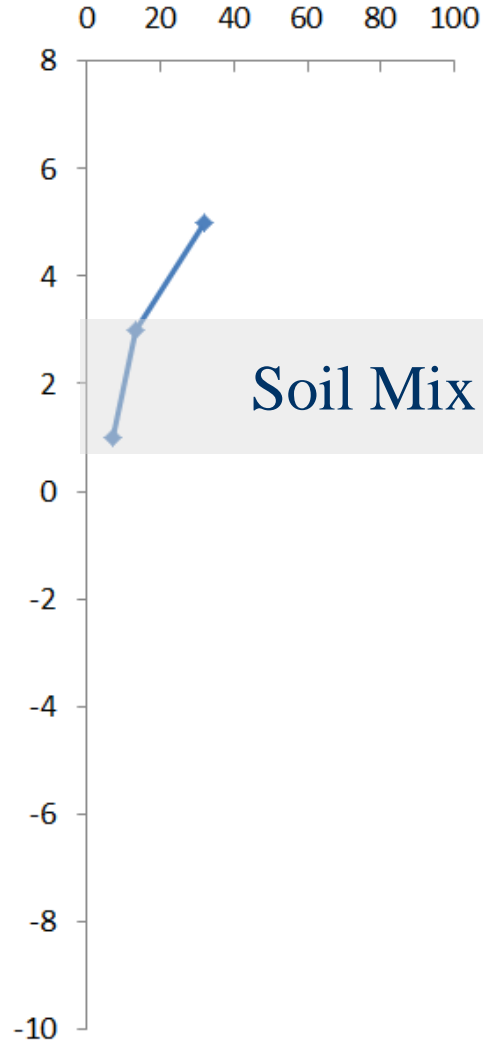
CB-1 STA 1302+00



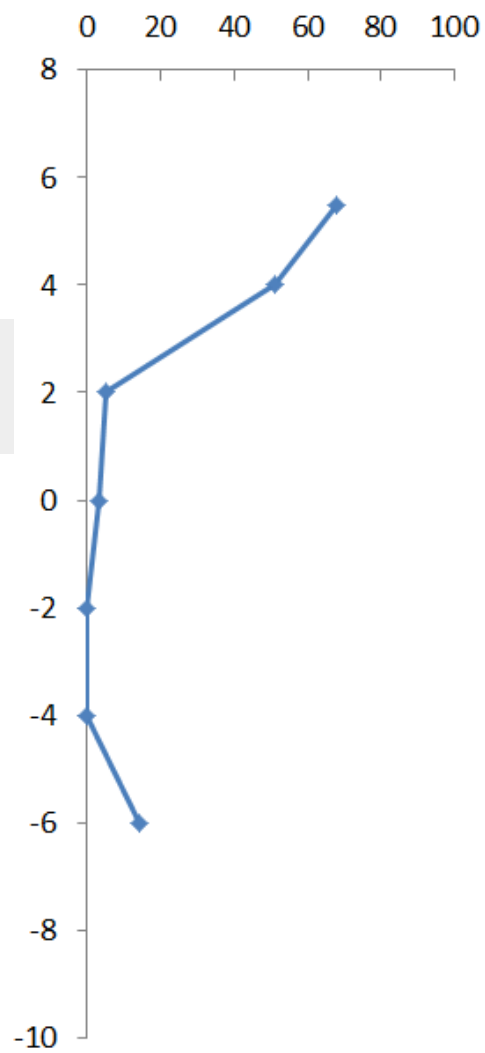
CB-2 STA 1335+00



CB-3A STA 1445+85



CB-3 STA 1446+01







# US 1 Jewfish Creek Survey

- ◆ Station 1325 to 1350
- ◆ 2009 & 2010 Surveys
  - Parsons Brinckerhoff
  - Southbound Shoulder
- ◆ May 2013
  - USF
  - Northbound Shoulder
- ◆ July 2013
  - North & Southbound Shoulders







1

5

STA 1350

Overseas Hwy

S Dixie Hwy

1

5

S Dixie Hwy Overseas Hwy

1

STA 1325

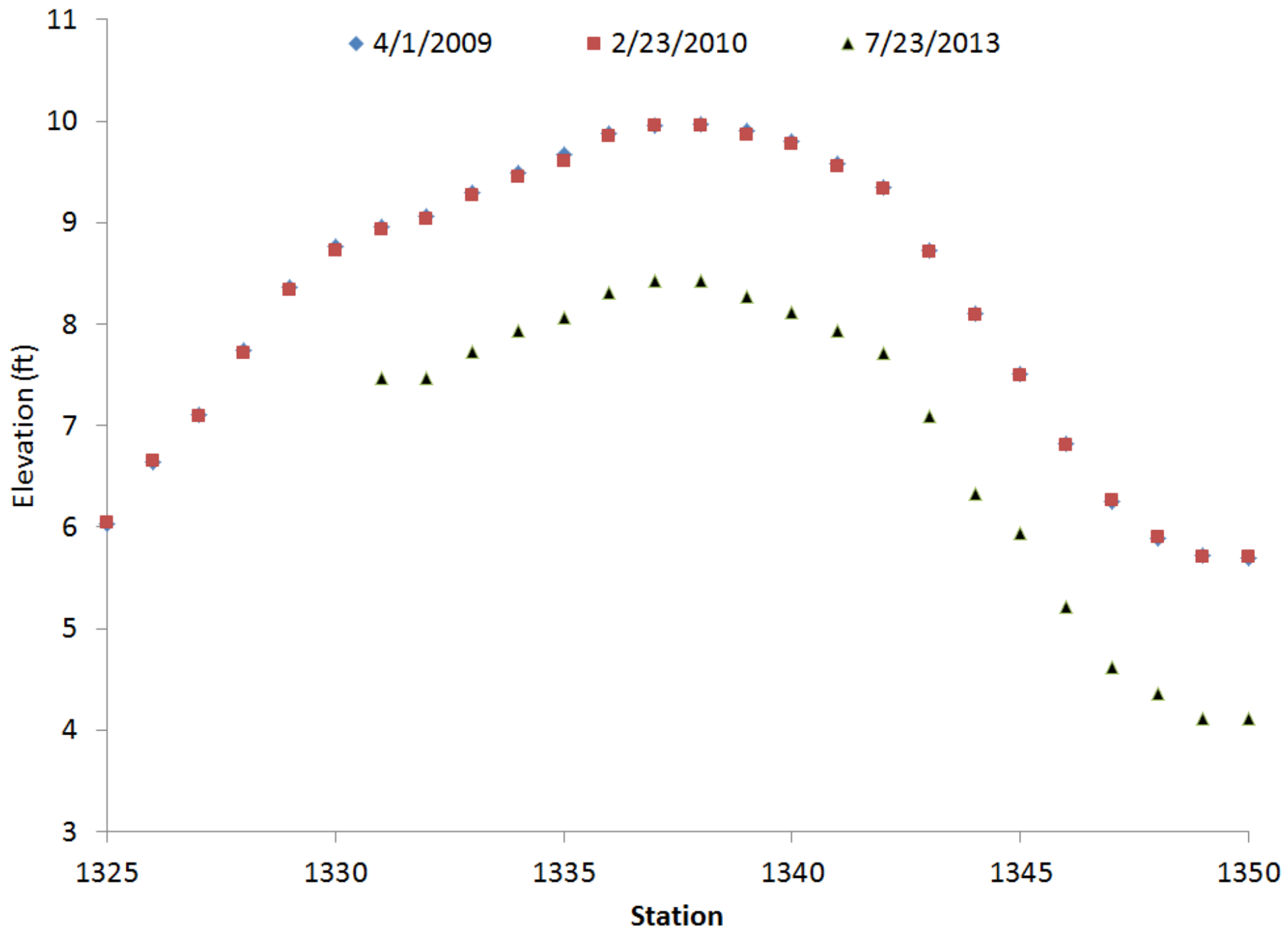
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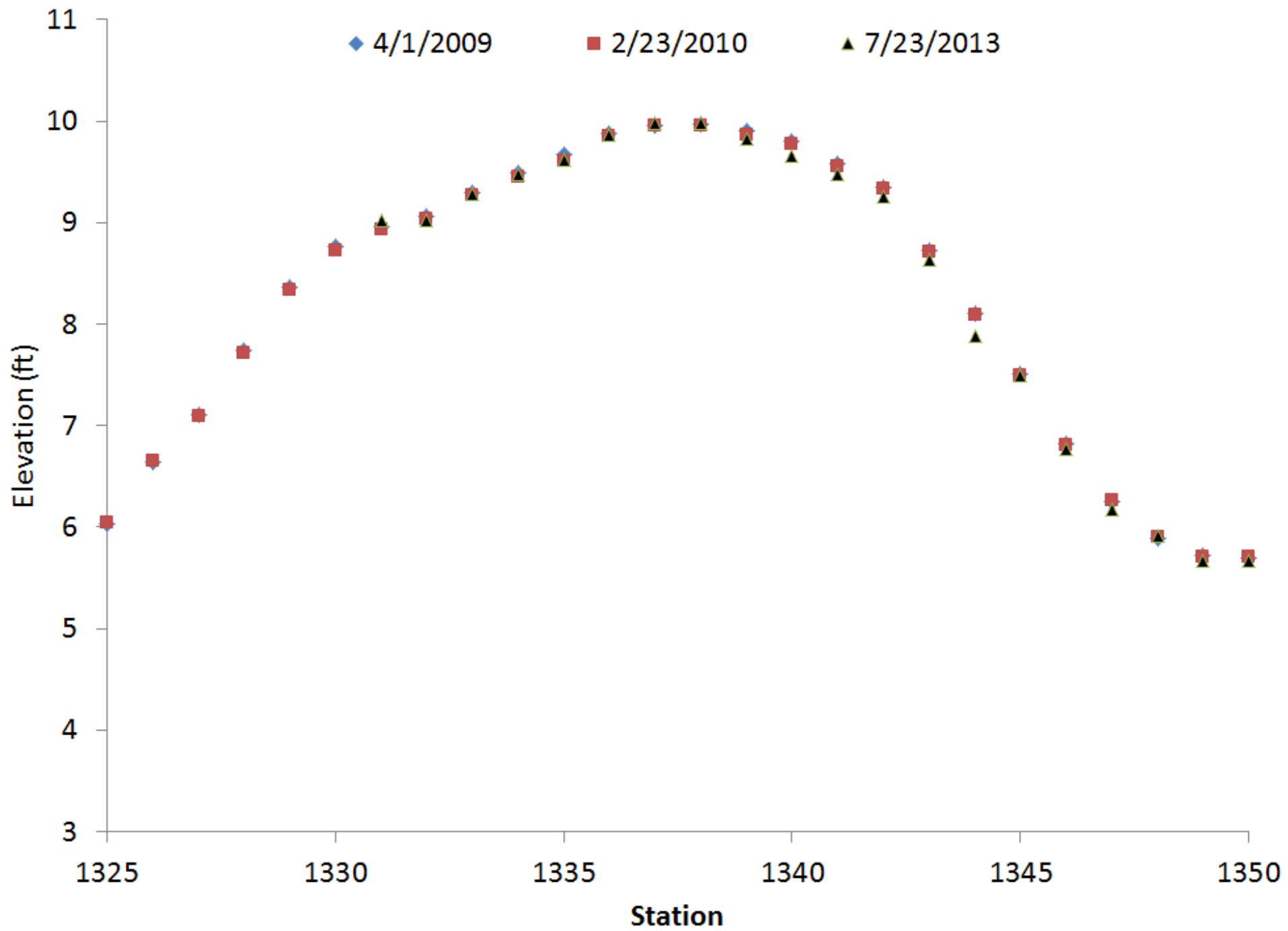
1

5

S Dixie Hwy







# State Road 33 Polk City

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- ◆ 1000ft roadway through Green Swamp
- ◆ 70 years of Settlement
- ◆ 2006 Boring at the Lowest Section
  - 43 inches of asphalt
  - 5 – 6ft of Sand & 72ft of organic material  
(competent bottom not found)











BM

P1

P2

P3

P4

P5

P6

Survey Site

P7

P8

P9

P10

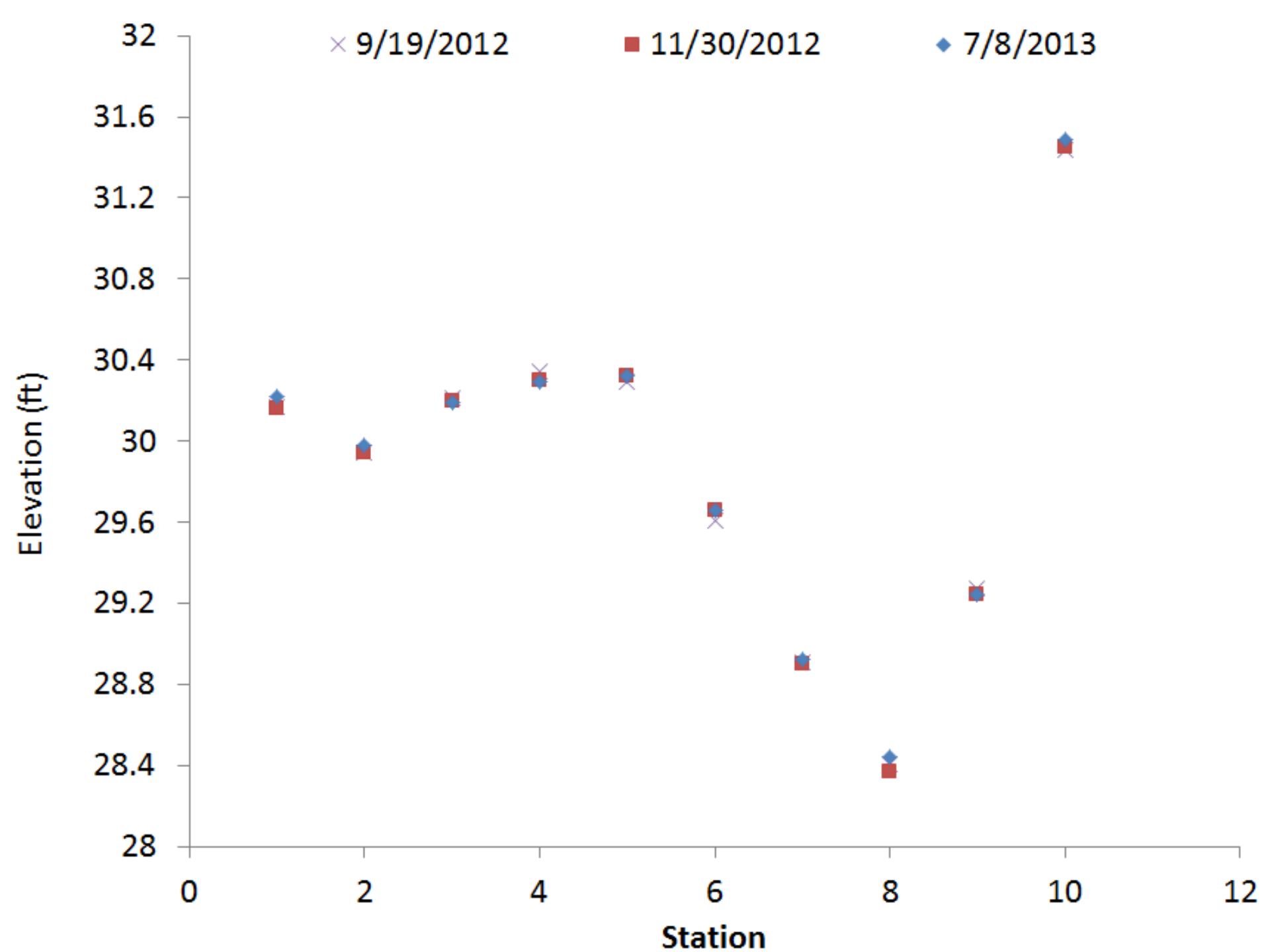
P11

33

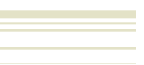
Appaloosa Hill Rd

© 2012 Google

Google earth







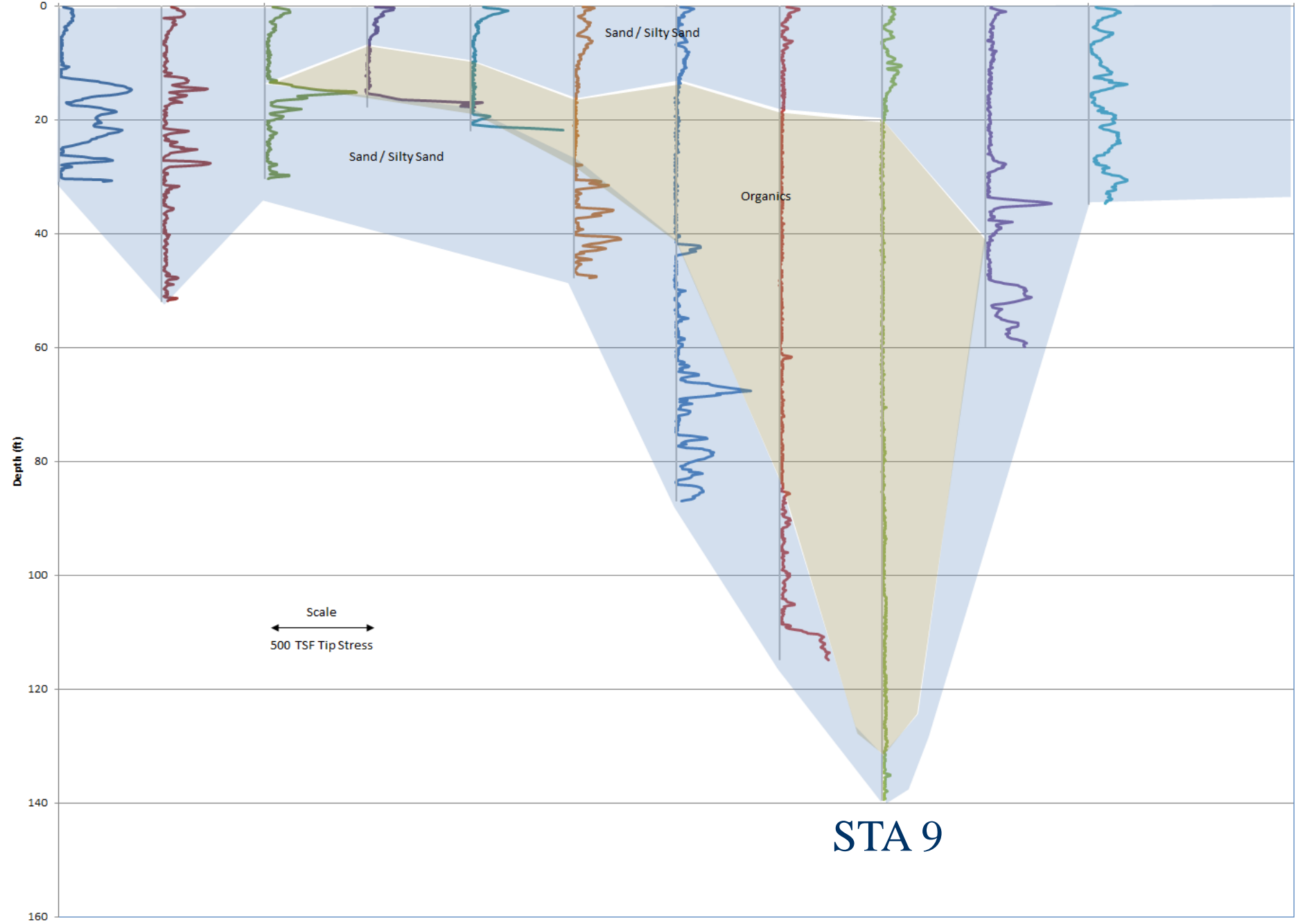
# STA 1

# STA 11

CPT Tip Resistance

Soundings 1 through 11 (left to right)

North to South at 100ft spacing



Scale  
500 TSF Tip Stress

# STA 9



# Marco Island Executive Airport

- ◆ 2011 Project
- ◆ Dry Soil Mixing
  - 400pcy cement
- ◆ Silty-Organics
- ◆ Survey Taxiway
  - January 2013
  - March 2013

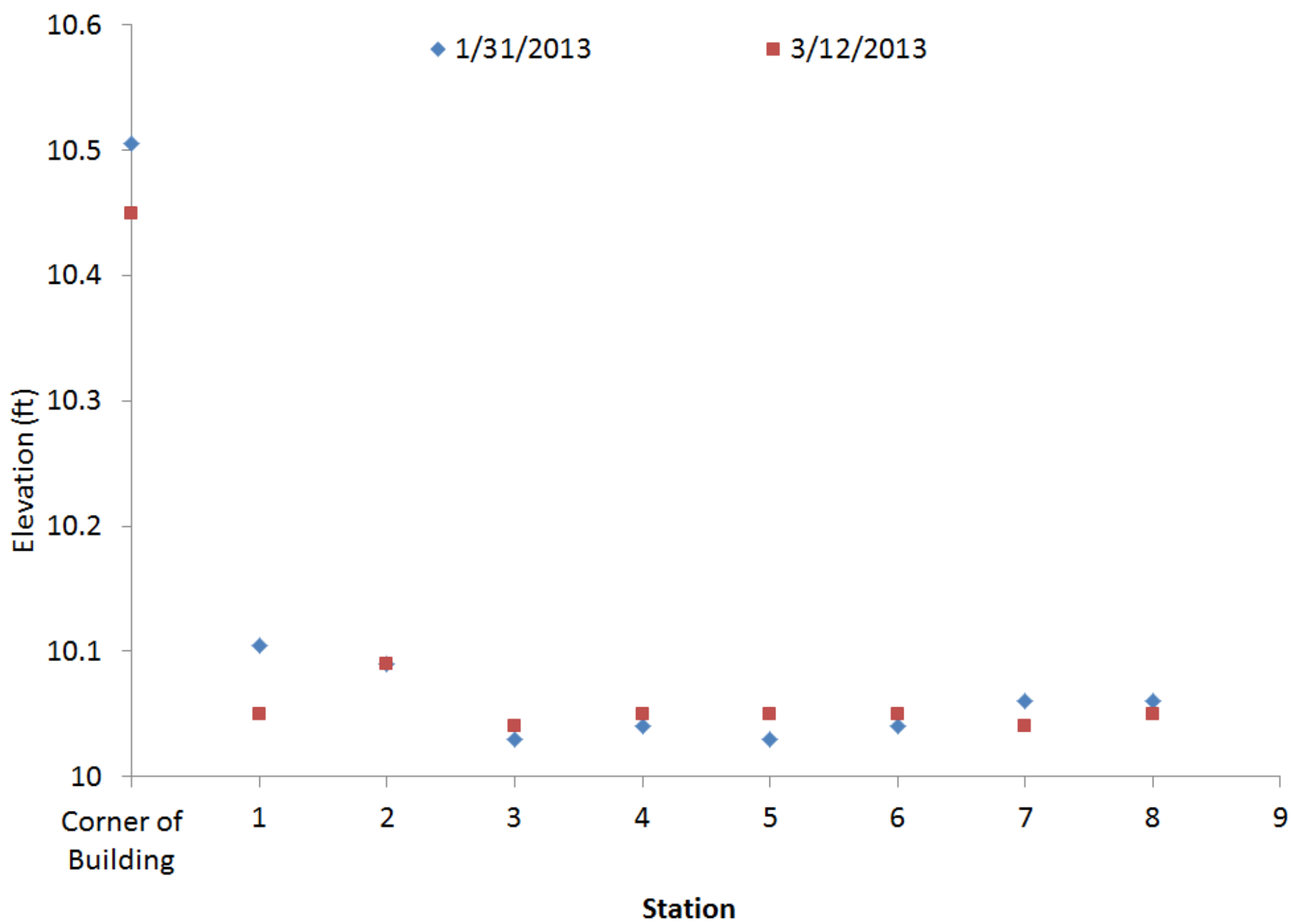




# Macro Island Airport Dry Soil Mixing









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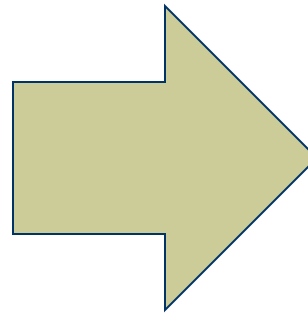
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# Guidelines for Soil Mixing

- ◆ Soil Type?
- ◆ Organic Content?
- ◆ Soil Strength?
- ◆ pH?
- ◆ Moisture Content?
- ◆  $\Delta$  Stress?
- ◆ Depth of Formation?
- ◆ ???



**Acceptable  
Methods!**



# Future Work

- ◆ Soil Mixing
  - Vary Mixing Energy / Type
  - Vary Binder Type (Fly Ash, Slag, etc.)
  - Lower pH Soil
  - pH Modifiers
  - Time Dependency
  - Larger Scale Mixing
- ◆ Guidelines
- ◆ Long-term Performance Monitoring
- ◆ Cost Evaluations

# Questions?

