UNDERGROUND CONSTRUCTION TECHNOLOGY
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Pipe Ramming in Running Soil Conditions

Case Study in Northern Florida

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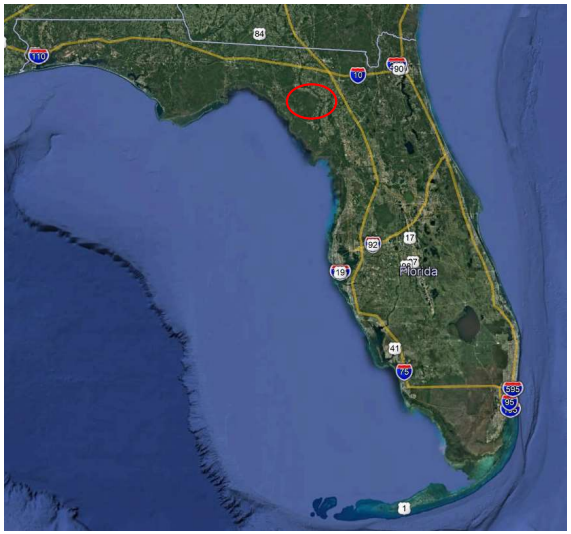
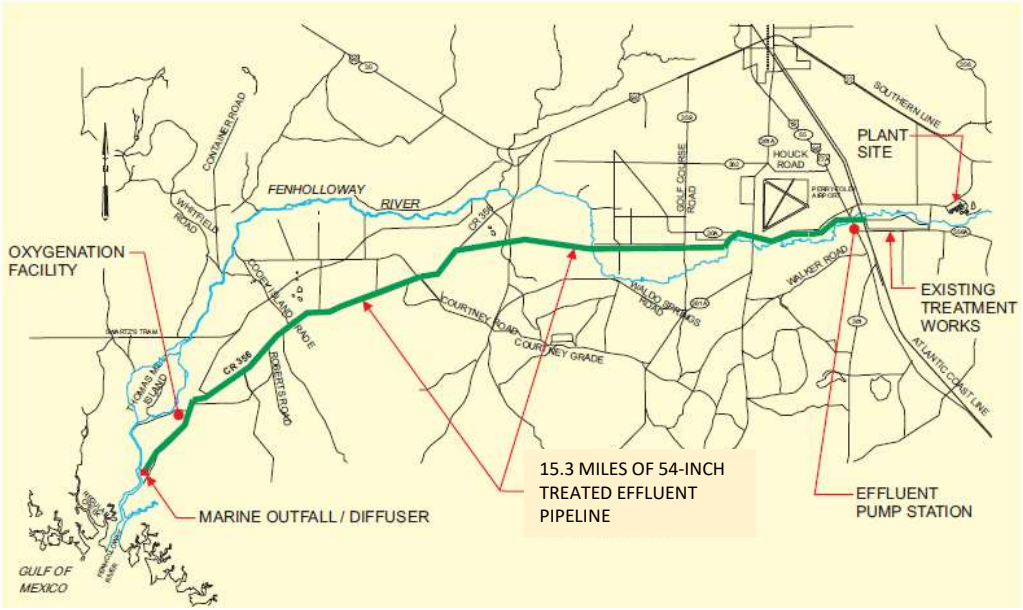
Agenda

- Project Description
- Pipe Ramming Risk Assessment
- Pipe Ram Installation
- Conclusions

Project Description

- Client: Paper Manufacturing Facility in Northern Florida
- Project: New treated discharge effluent pipeline to a marine outfall and diffuser in the Gulf of Mexico

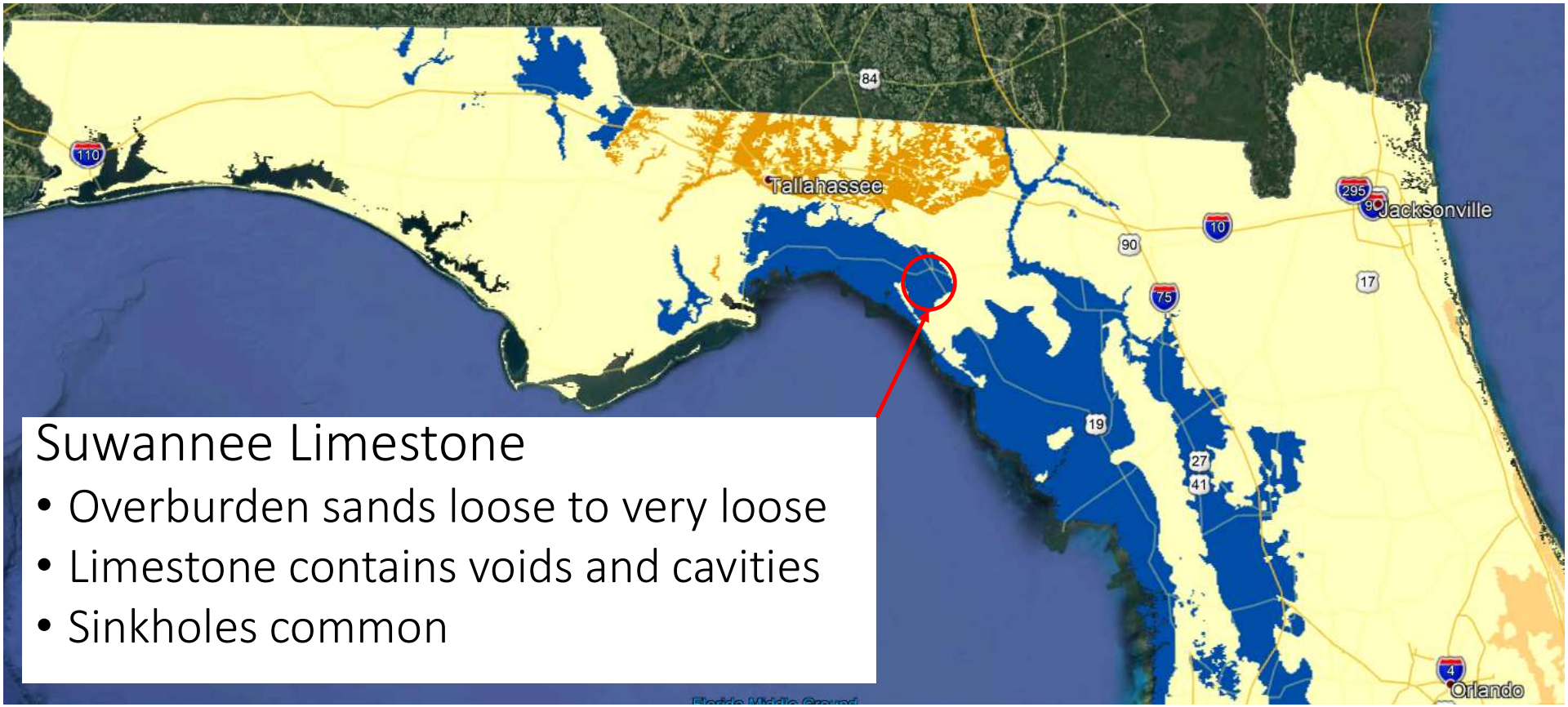




Project Description

- Preliminary alignment received permit approval ~25 years later
- Job was put out for construction as a work package for design-build
- Alignment included 72” tunneled critical road crossing
  - Contractor selected Jack and Bore
- Loose sands and running soils encountered during open cut installation led to a re-evaluation of tunnel methods.
  - Microtunneling
  - Pipe Ramming with Temporary Bulkhead

Risk Assessment



Suwannee Limestone

- Overburden sands loose to very loose
- Limestone contains voids and cavities
- Sinkholes common

Risk Assessment

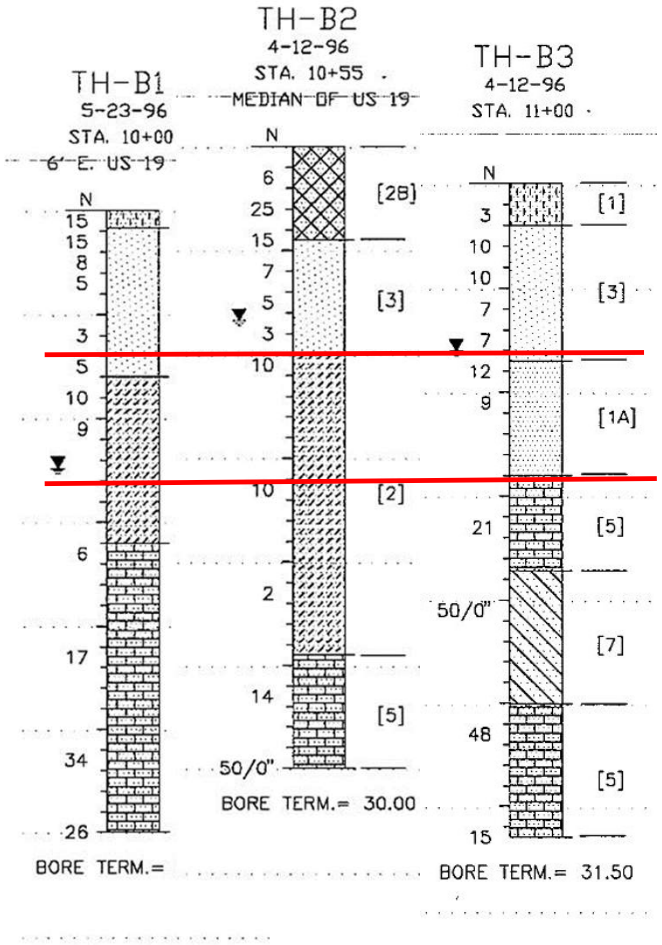
Geotechnical Report (1995)

- Borings along tunnel alignment

Medium to fine sand

Clayey sand

Sandy clay and weathered limestone



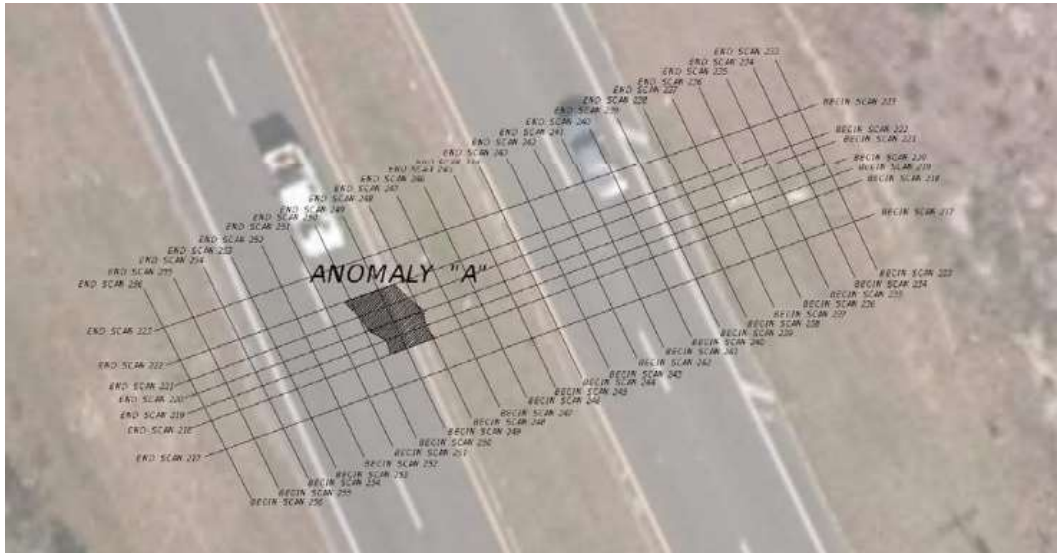
Risk Assessment

Two significant risk items:

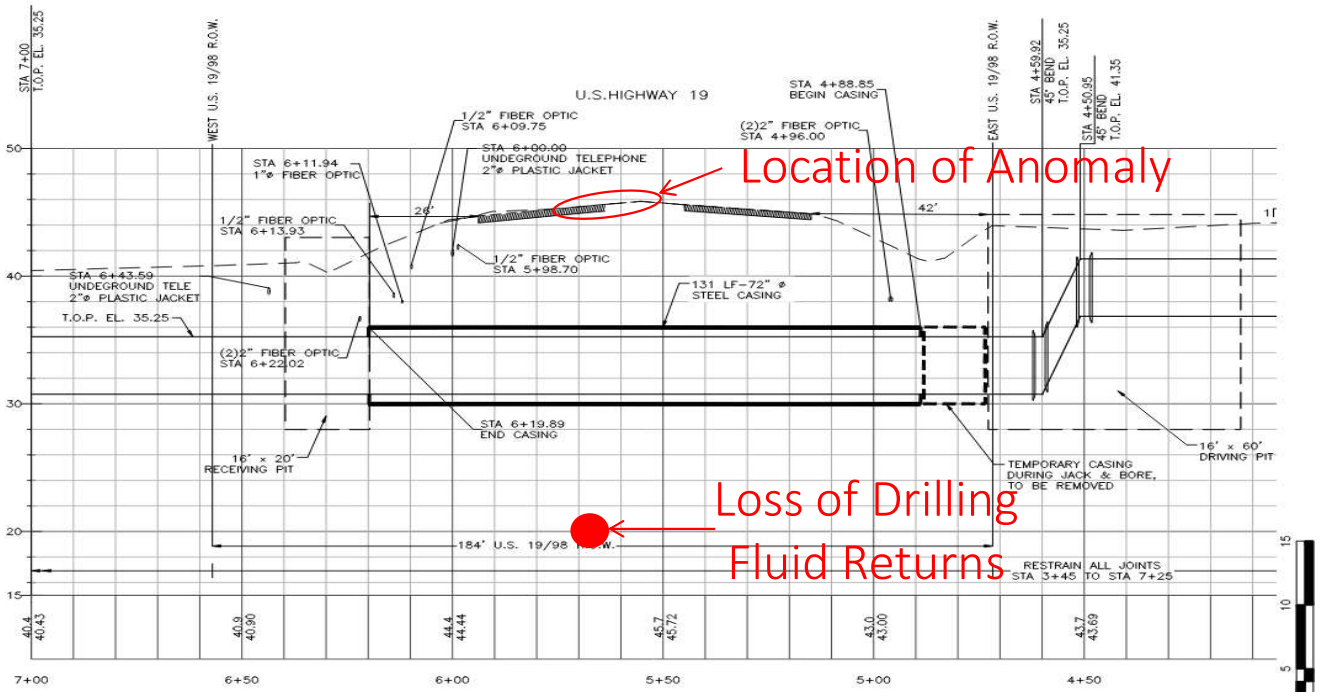
1. Surface settlement due to ground loss
2. Solution feature voids in alignment
   - Requested geophysical survey to further define this risk

Additional Geotech Work

- Ground Penetrating Radar identified an anomaly
- Two new borings at location of anomaly
  - At a depth of 26’ there was a 100% loss of drilling fluid circulation



Road Crossing Alignment



- Tunnel Elevation above this loss of returns area
- Borings confirmed presence of running ground overlaying tunnel alignment

Project Goals

- Pipe Ramming conditionally approved - stable soil plug required prior to crossing beneath the roadway.

- Two goals for establishing a stable system:
  1. No ground loss through the casing
     - Need stable soil plug (use temporary bulkhead to start)
  2. No ground movement when not ramming

Well Point System around Launch Shaft

Flowing / Running Sand

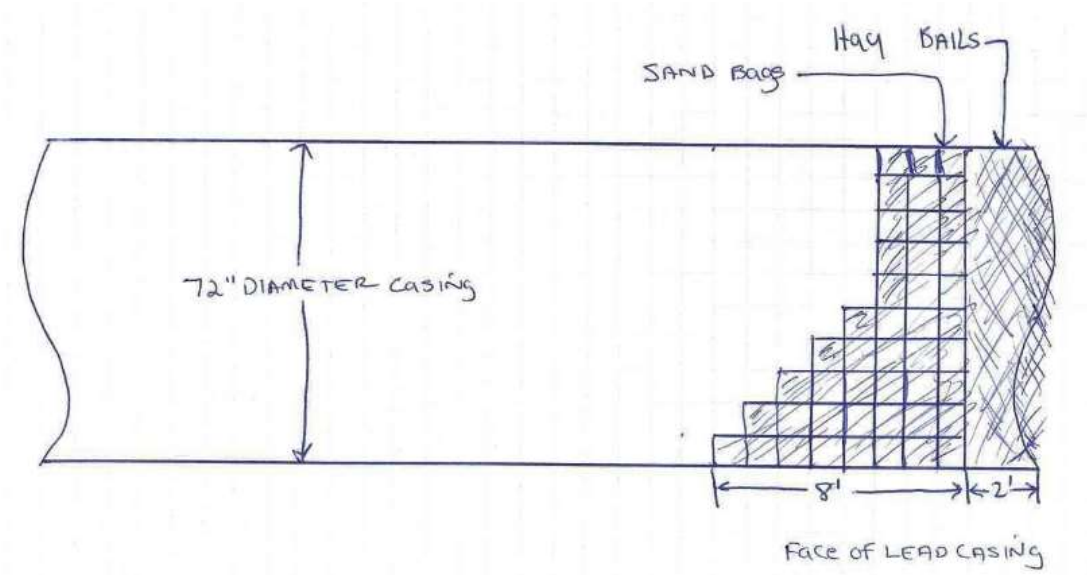
Pipe Ramming Recommendations

- Conditional approval for pipe ramming if stable plug achieved prior to reaching roadway.
- Risk mitigation measures
  - Stop work if don't achieve stable soil plug
  - Shifted launch pit further from edge of pavement
  - Designed bulkhead to create the soil plug
  - Developed a settlement monitoring plan
  - Reduced speed zone in area of crossing
  - Created contingency plans for identified risks

Temporary Bulkhead

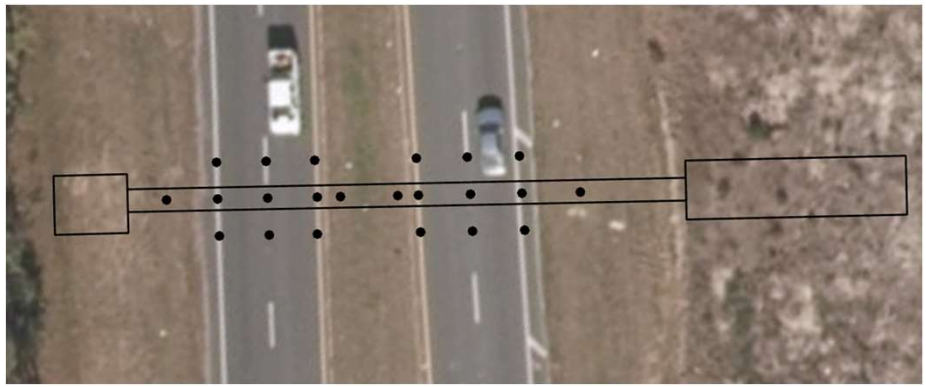
Designed to counterbalance the tendency for soil to run through the casing.

Soil will pile up behind the bulkhead and create a stable soil plug.



Settlement Monitoring Plan

- Settlement Monitors
  - Surface nail grid
  - Subsurface monitors
- Monitoring Frequency
  - Beginning and end of each workday
  - After each 10 feet of casing driven
- Settlement Readings
  - Stop to evaluate at ¼ inch
  - Road plates required at 1 inch



Other Mitigation Measures

- Traffic Control
  - Reduced speed zone on divided highway
  - Option for individual lane closures
  - Road plates required after 1” settlement
- 24-hour Work
  - Overnight observation of soil plug required
  - Emergency work if losing ground
  - Welding permitted overnight if desired
- Pipe Ramming Manufacturer technician required to be onsite at all times during ramming

Pipe Ram Setup - Equipment

- 24” Pipe Ram
  - 177 blows per minute
  - 1,700 cfm air

Pipe Ram Setup – Cutting Shoe

1” cutting shoe welded to the leading edge of the casing to direct excavated material into the pipe

Pipe Ram Setup – Temporary Bulkhead

Pipe Ram Setup – Steel Collar and Ram Cone



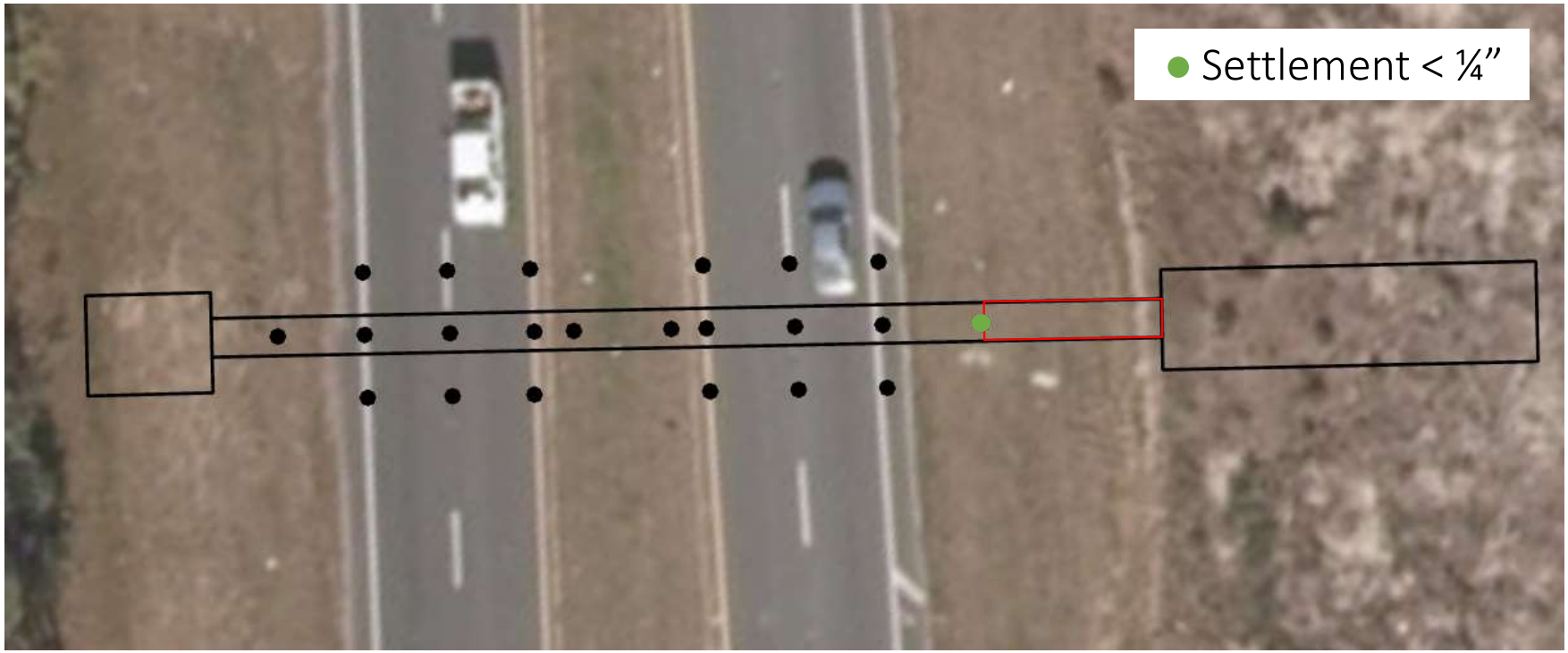
Able to monitor the holes in the ram cone for any ground loss through the casing

Construction Begins

Installation Progress

Clays/Fines content of soil in launch shaft provided good material standup

Installation Progress – Day 1



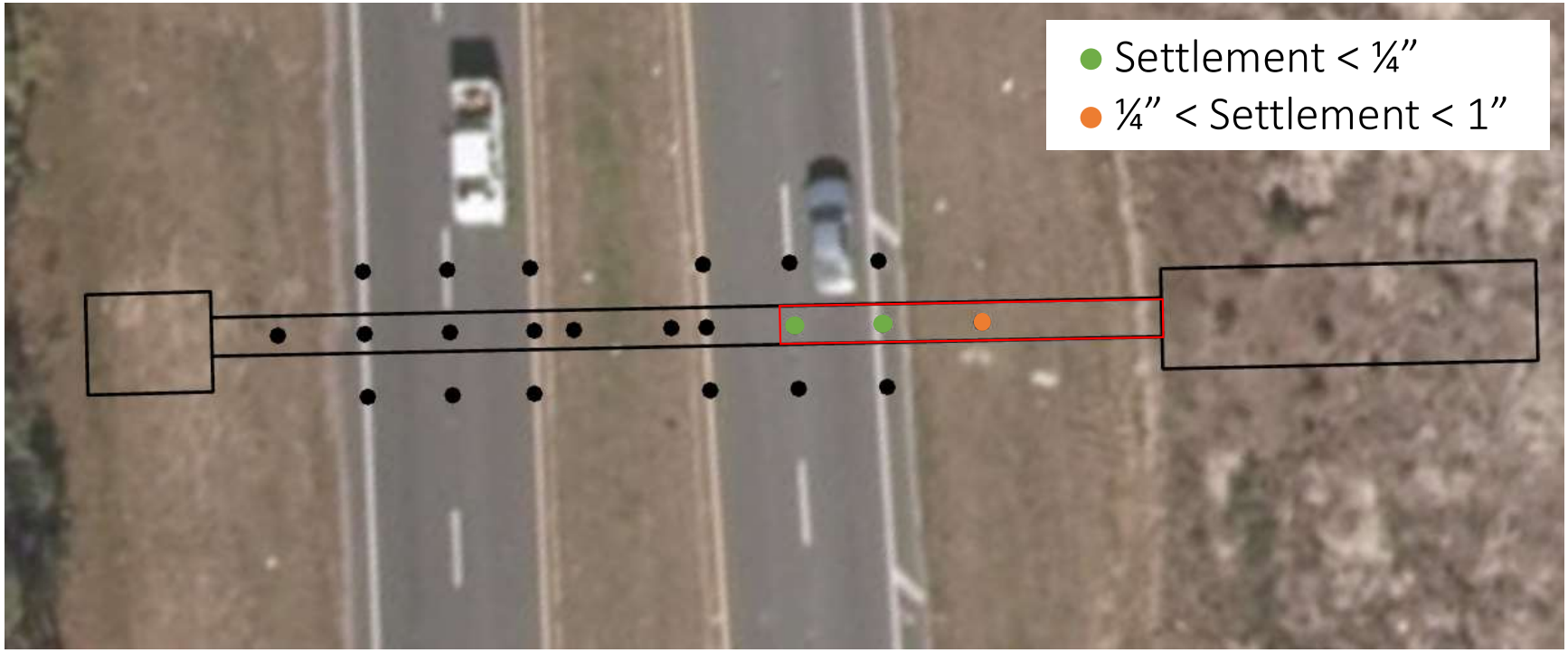
Settlement monitors checked after each 10’ of casing driven

Installation Progress – Day 1

- Bulkhead/soil plug inspection
  - Stable – no ground loss
- Evaluation at end of day
  - Stable soil plug (no ground loss)
  - No additional settlement (no ground movement when not ramming)

Goals for stable system achieved:
Approval granted to continue pipe ramming beneath roadway

Installation Progress – Day 2



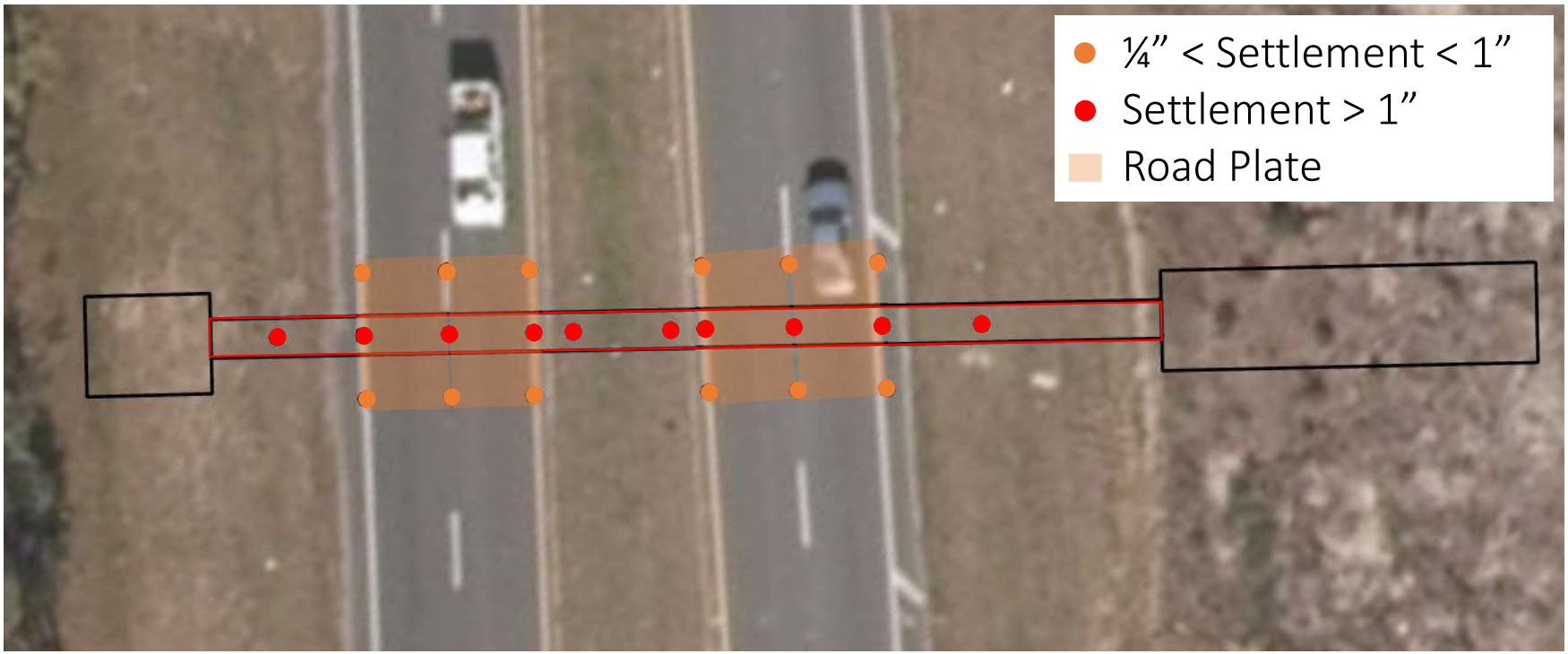
Settlement monitors checked after each 10’ of casing driven

Installation Progress – Day 2

- Bulkhead/soil plug inspection
  - Have achieved a true soil plug behind temporary bulkhead
  - Stable – no ground loss
- Evaluation at end of day
  - Stable soil plug (no ground loss)
  - No additional settlement (no ground movement when not ramming)

Despite minor settlement, goals for stable system still being achieved

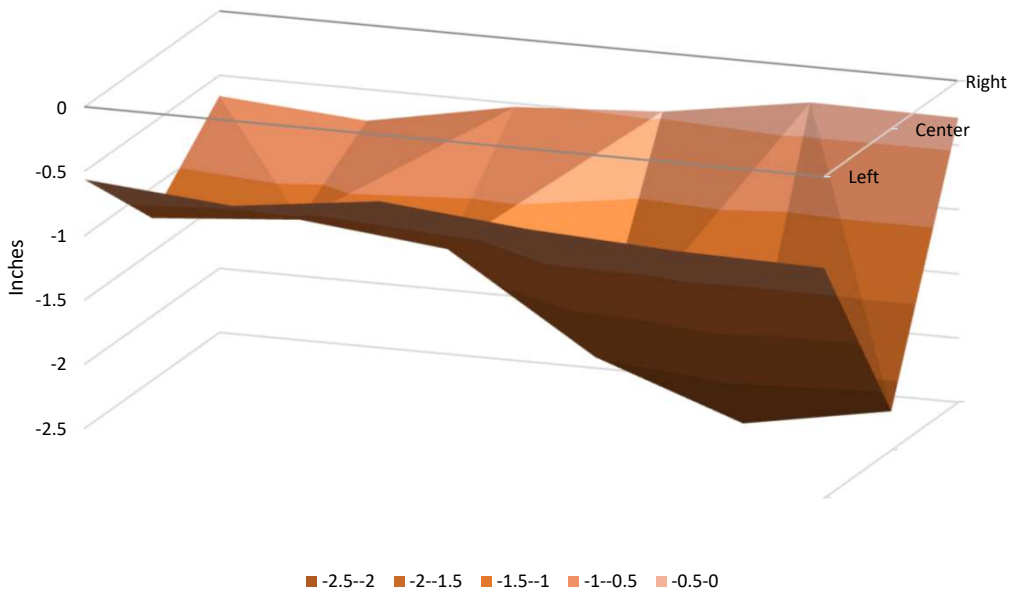
Installation Progress - Summary



Installation Progress – Summary

- Observed pattern in recorded settlement
  - Began to register when lead edge of casing crossed beneath monitor
  - Settlement increased in monitors previously passed
- Goals for a stable system achieved throughout (despite settlement)
  - No ground loss through casing pipe
  - No ground movement when pipe ram hammer was turned off
- Road plates had to be installed across all lanes of traffic
  - Installed using the staged lane closure contingency

Installation Summary - Surface Settlement



- Highest settlement recorded directly above the pipe
- Settlement decreased with distance from the hammer

Although settlement exceeded expectations, never observed anything indicating ground movement was out of control

Settlement Conclusions

- Not caused by:
  - Ground loss
  - Dewatering
- Likely caused by:
  - Mechanical consolidation of the soil due to vibration forces
    - No ground movement observed at any point when hammer was turned off
  - Backfill of the small annular space behind cutting shoe
  - High ramming rate

Case Study Summary

- Able to control the face in running/flowing ground conditions
  - No ground loss through casing
  - Temporary bulkhead provided base for stable soil plug to form
- Settlement
  - Higher than anticipated
  - Able to repair the road post-installation

Observed settlement was result of vibration from the hammer causing soil particle realignment and consolidation.

Pipe Ramming Applications

Pipe Ramming presented a cost savings in these ground conditions when compared to a 72” microtunnel

Where we would use it

- Locations where surface repairs are possible
- Where soil conditions allow the dewatered soil to “stand” on its own
- Controllable groundwater

Where we wouldn’t

- Under railroads
- Poorly graded sand (unless using other means of providing a stable face)
- Near or under a continuous water source

Questions?

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