



**CHARLOTTE**  
ENGINEERING & PROPERTY  
MANAGEMENT

# Lessons Learned in the Design, Construction, and Monitoring of a Large Scale Regenerative Stormwater Conveyance (RSC)

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August 25, 2016

## Missions of Charlotte Storm Water Services:

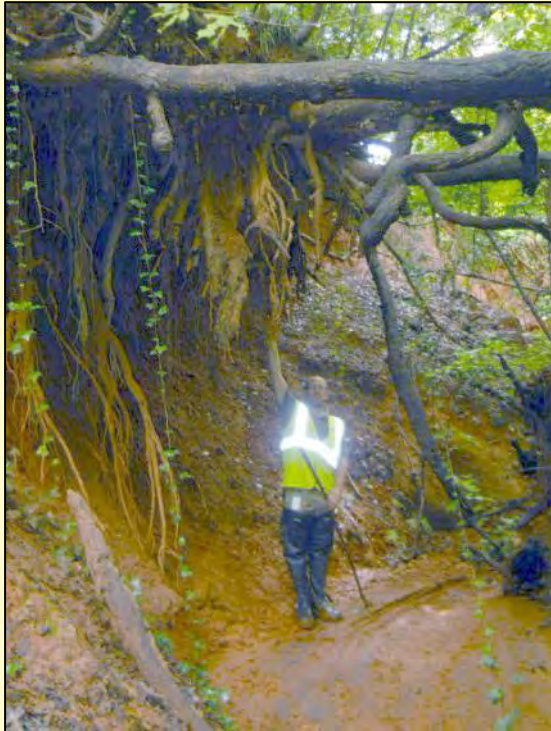
- Maintain SW infrastructure
- Reduce flood risks
- Improve water quality





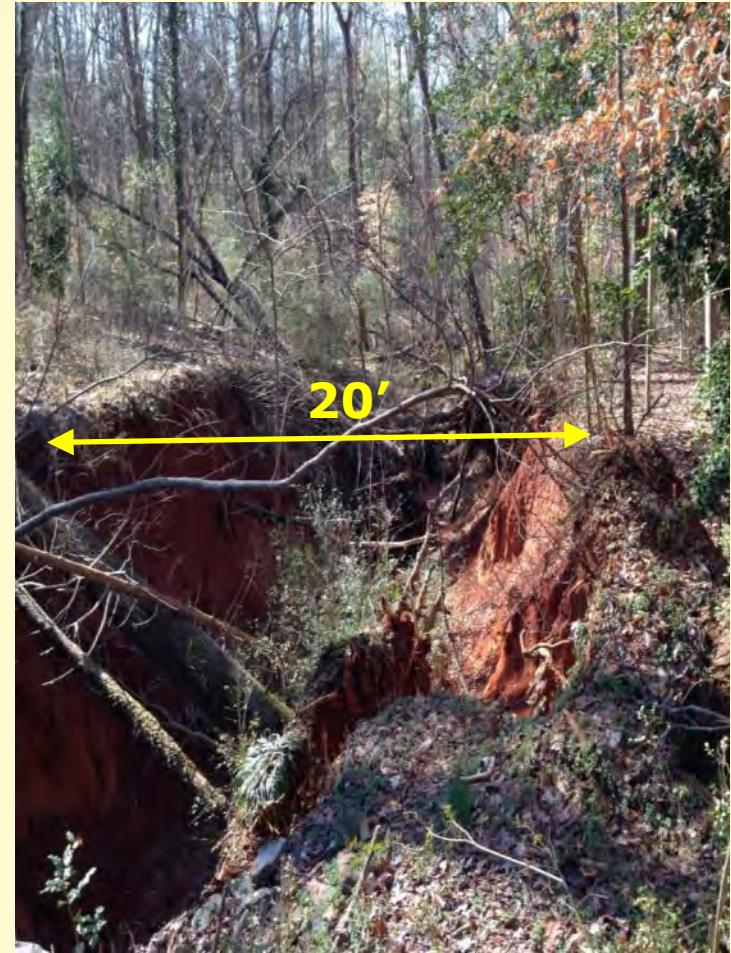
# Linda Lake Pre-Existing Site Conditions

- Severe erosion at a SW outfall
  - Tree Loss
  - Public Safety Concerns
  - Water Quality Degradation





# Linda Lake Pre-Existing Site Conditions





# Linda Lake Pre-Existing Site Conditions





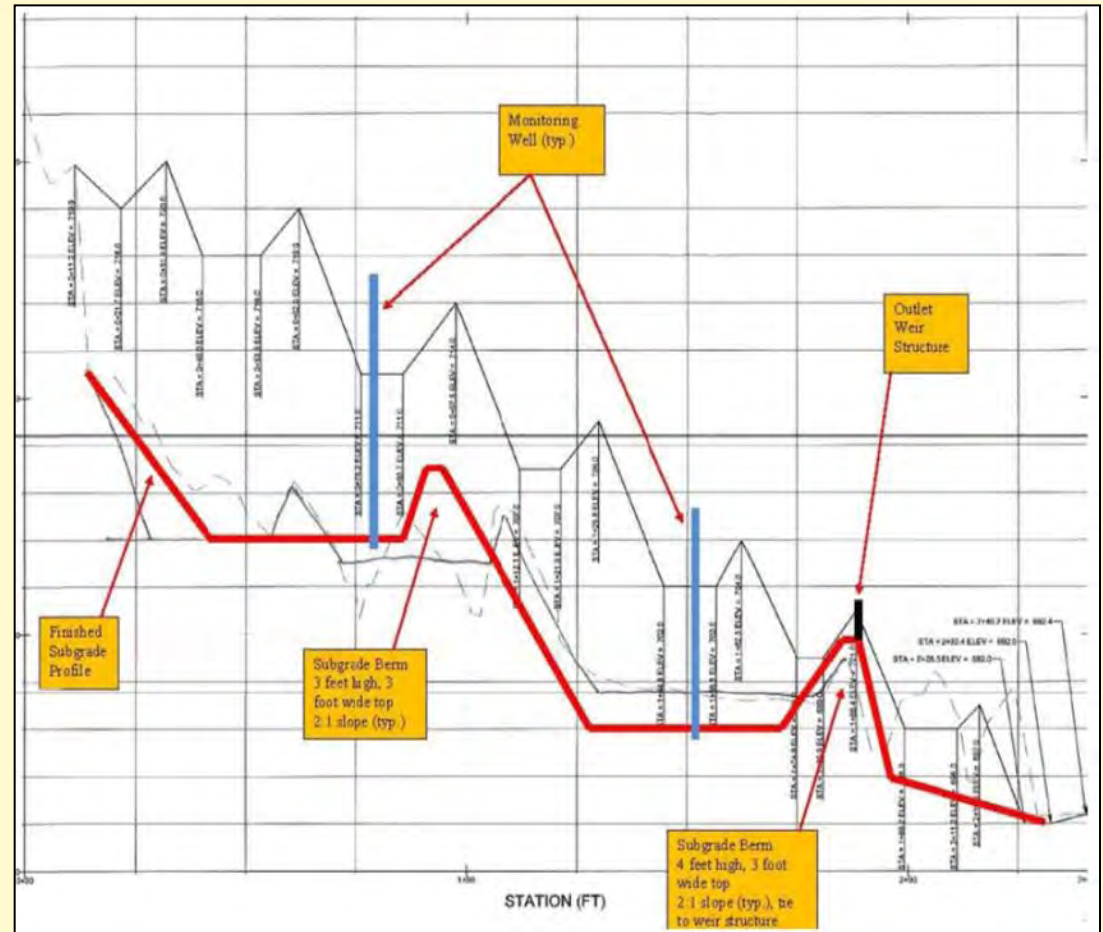
# Linda Lake Project Goals

1. Address citizen request for service
2. Improve Public Safety
3. Improve water quality
  - Arrest erosion
  - Watershed attenuation
  - Improve nutrient removal
4. Implement Pilot RSC project
  - First RSC installed and monitored in Charlotte
  - Evaluate RSC as an Alternative Mitigation Strategy

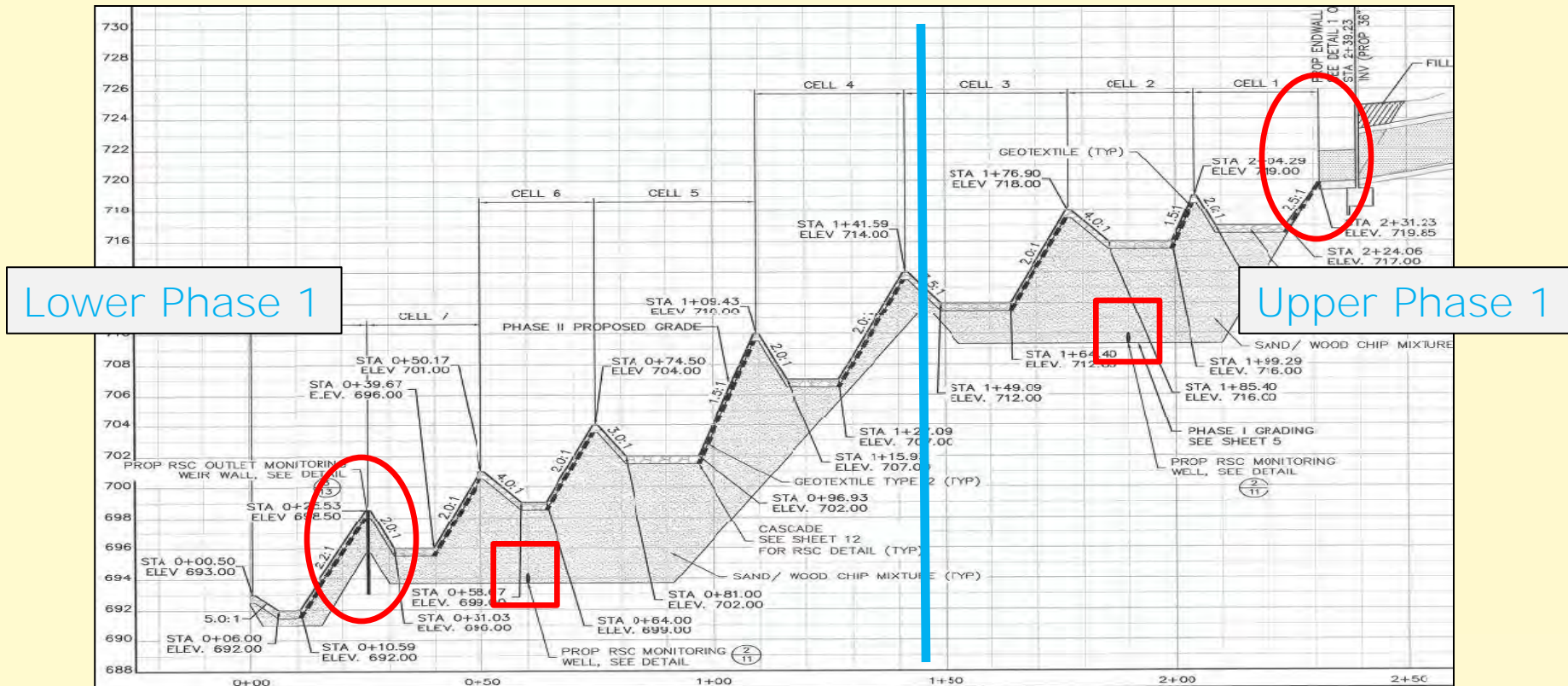




- Phase I grading to establish known dimensions (for monitorability)
- Internal berms to promote denitrification and infiltration



- Monitoring
  - Inlet/Outlet weirs to monitor discharge and water quality ○
  - Groundwater wells to monitor for hydrology □





## Construction (clearing)



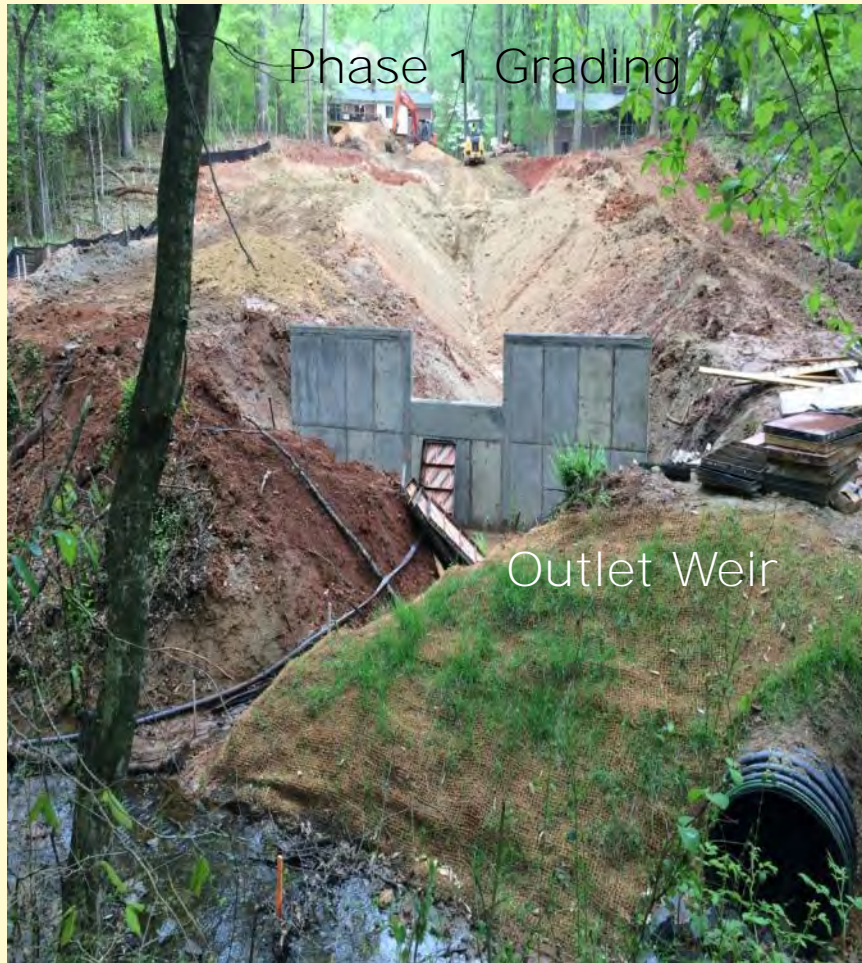
1/29/2015



3/16/2015



## Construction (phase 1 grading)



4/13/2015



5/11/2015



## Construction (Phase 2 media)



## Construction (Phase 2 cascades)





## Construction (inlet weir)



## Construction (Complete)





## Problem Identification (Ponding)

- Ponding in Cell 3 and concerns with mosquitos





## Problem Identification (Ponding)

- Thick layer (5mm) of clay covering the cobble





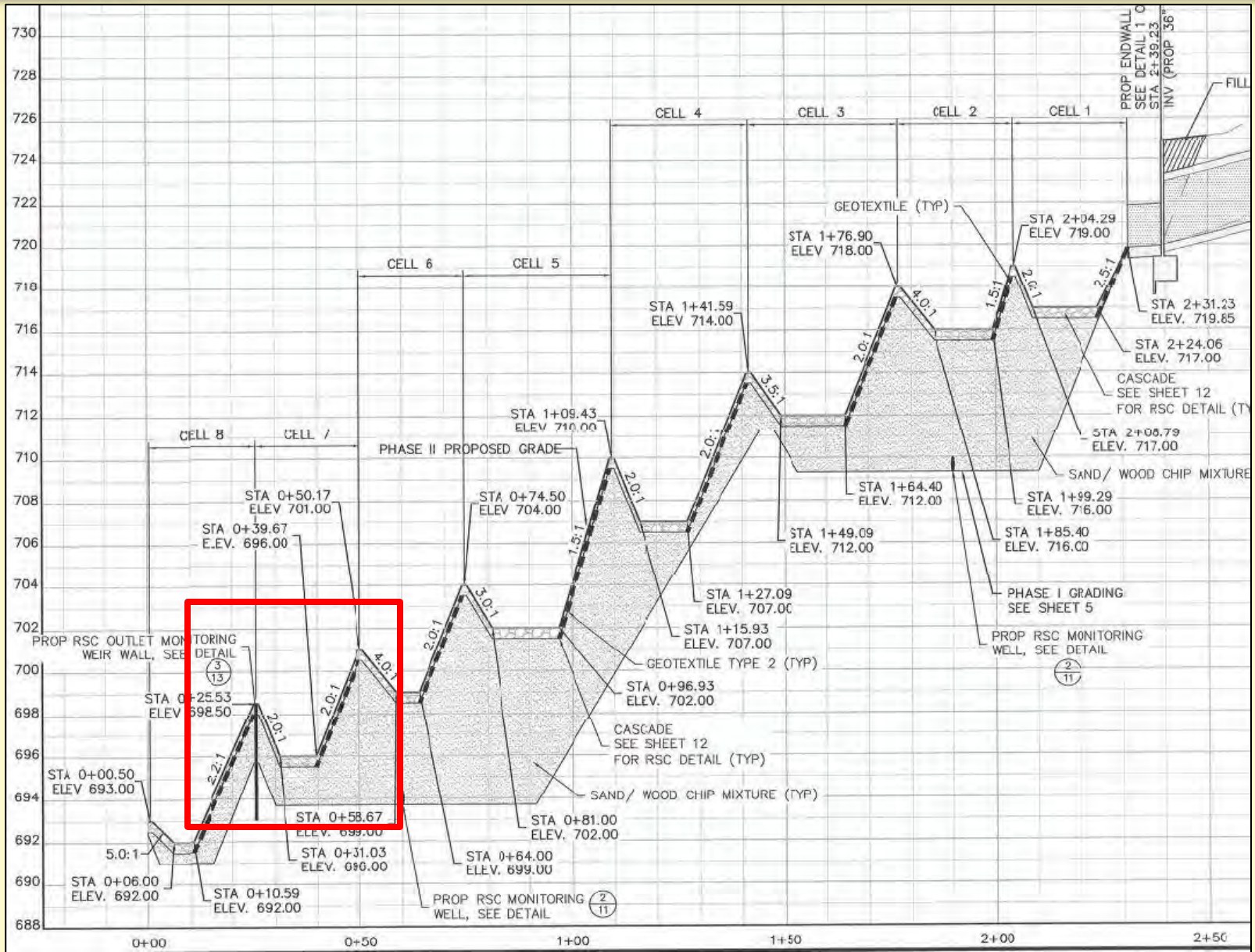
## Problem Identification (Ponding)

- Standing water in cells 4, 5, 6, and 7 by weir



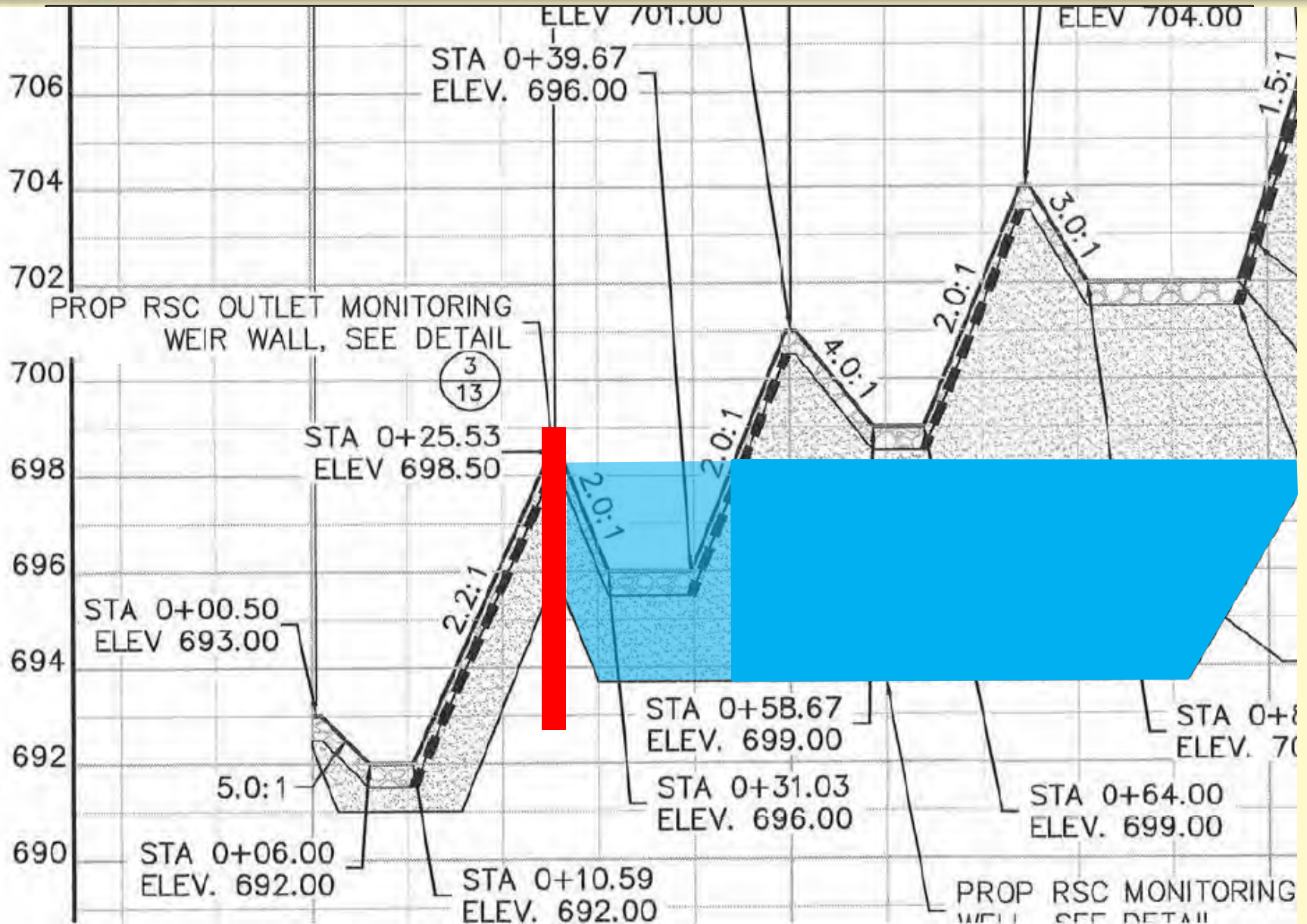


# Diagnosis (Ponding Cell 7)





# Diagnosis (Ponding Cell 7)



## Diagnosis (Ponding)

- Clay within the cobbles in the bottom of cells





## Diagnosis (Sources of Clay)

- Ring of Clay in Cell 2





## Diagnosis (Sources of Clay)

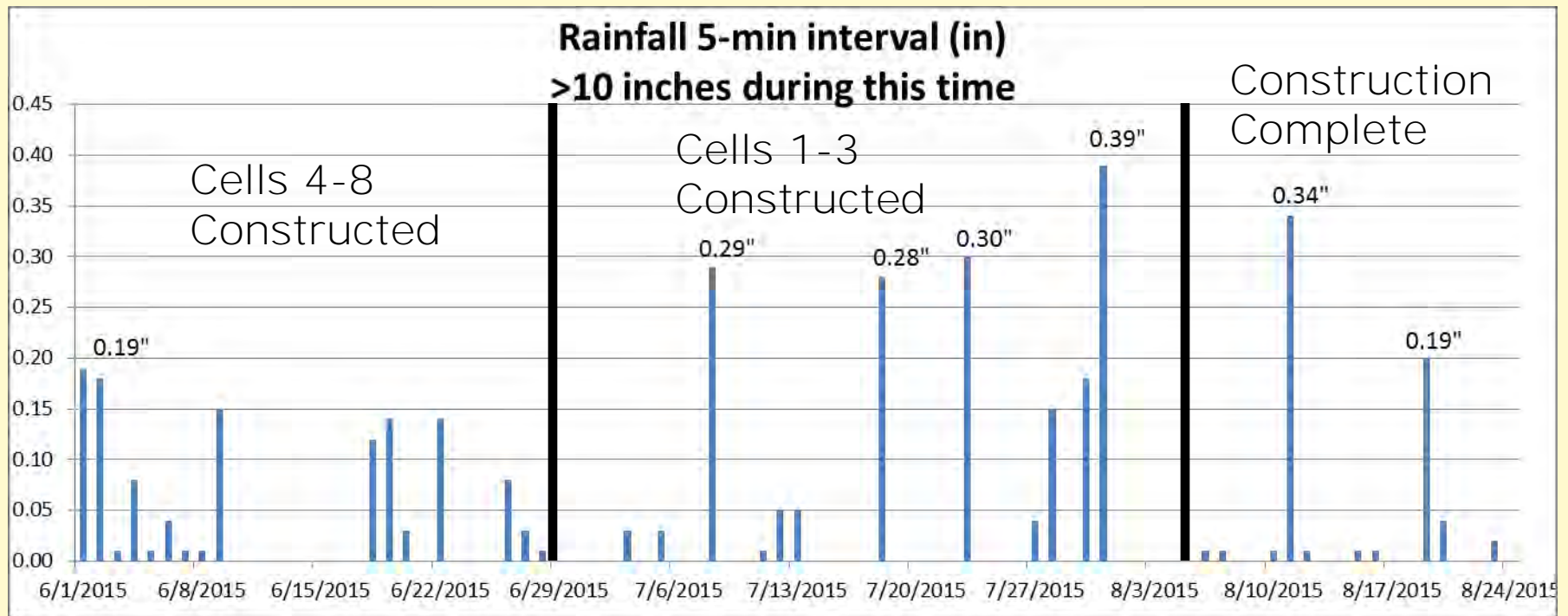
- Rill Erosion along the inner slope of the Cells





## Diagnosis (Construction Timing)

- Significant rainfall throughout the phase 2 media installation and cascade construction period



## Initial Retrofit (protect the cells)

- Waddles around cells stopped additional sediment





## Initial Retrofit (Clean out the clay)

- Washing clay in Cell 1





## Initial Retrofit (Clean out the clay)

- Standing water in Cell 1





## Initial Retrofit (Clean out the clay)

- Cobble removed and the clay being shoveled out





## Initial Retrofit (Clean out the clay)

- Ponding continued after cleaning

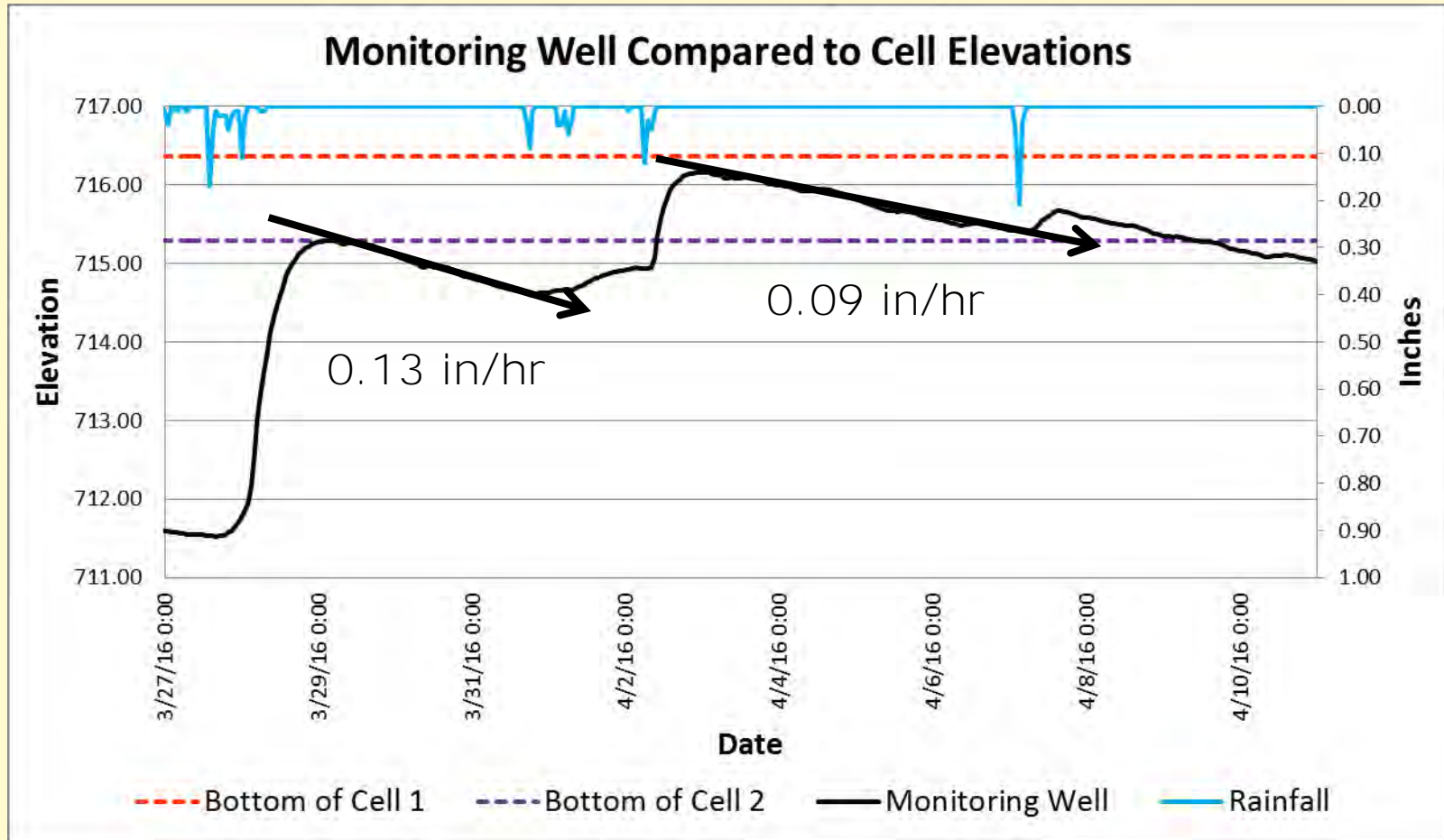


## Diagnosis (Time Lapse Video)





# Diagnosis (Monitoring Well Data)

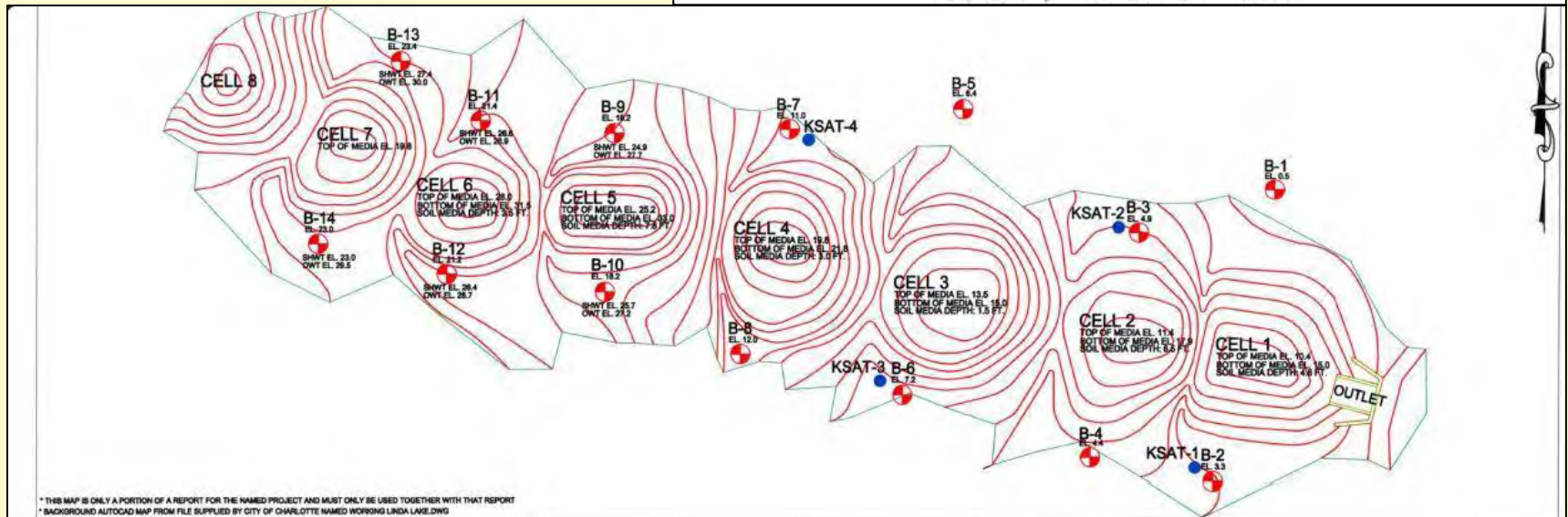


# Diagnosis (groundwater)

- Seasonal water table influence in Cells 5-7
  - ? Reduced infiltration due to media compaction
  - ? Slow permeability of surrounding soil

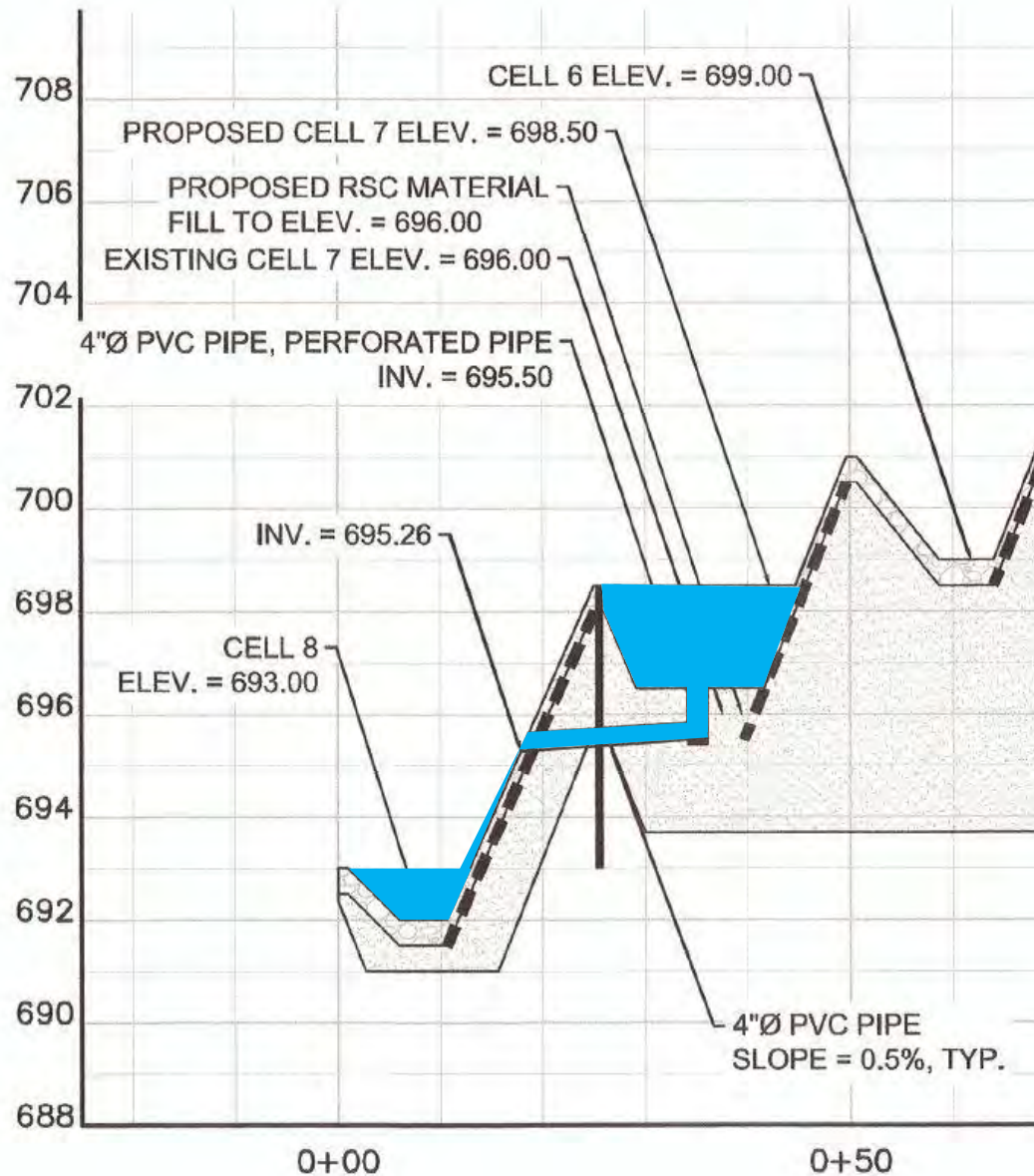
**SOIL EVALUATION AND TESTING SERVICES  
LINDA LAKE REGENERATIVE STORMWATER CONVEYANCE  
PROJECT**

Prepared for:  
Charlotte-Mecklenburg Storm Water Services  
600 East Fourth Street  
Charlotte, North Carolina 28202

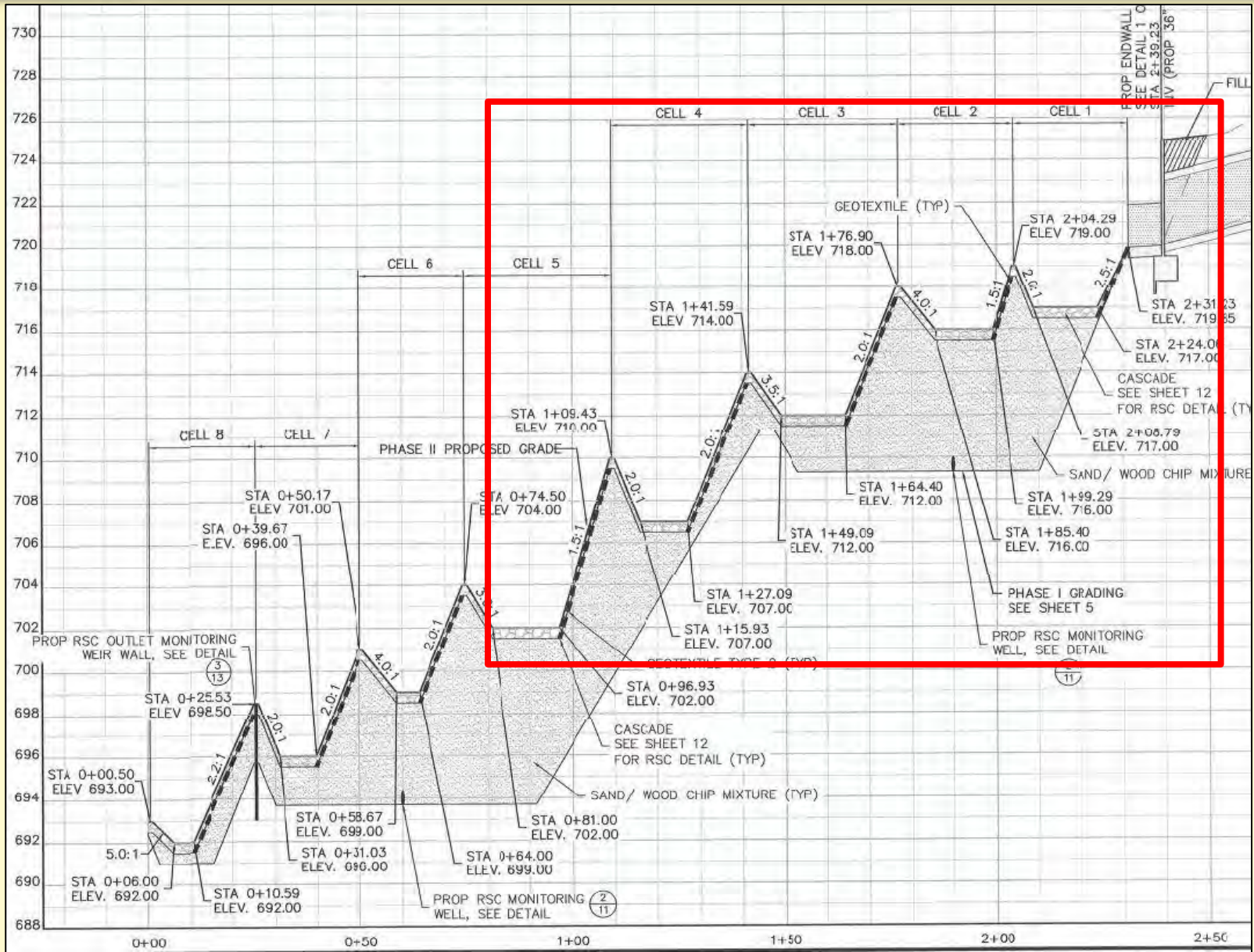




# Retrofit Plan (Cell 7 bypass)



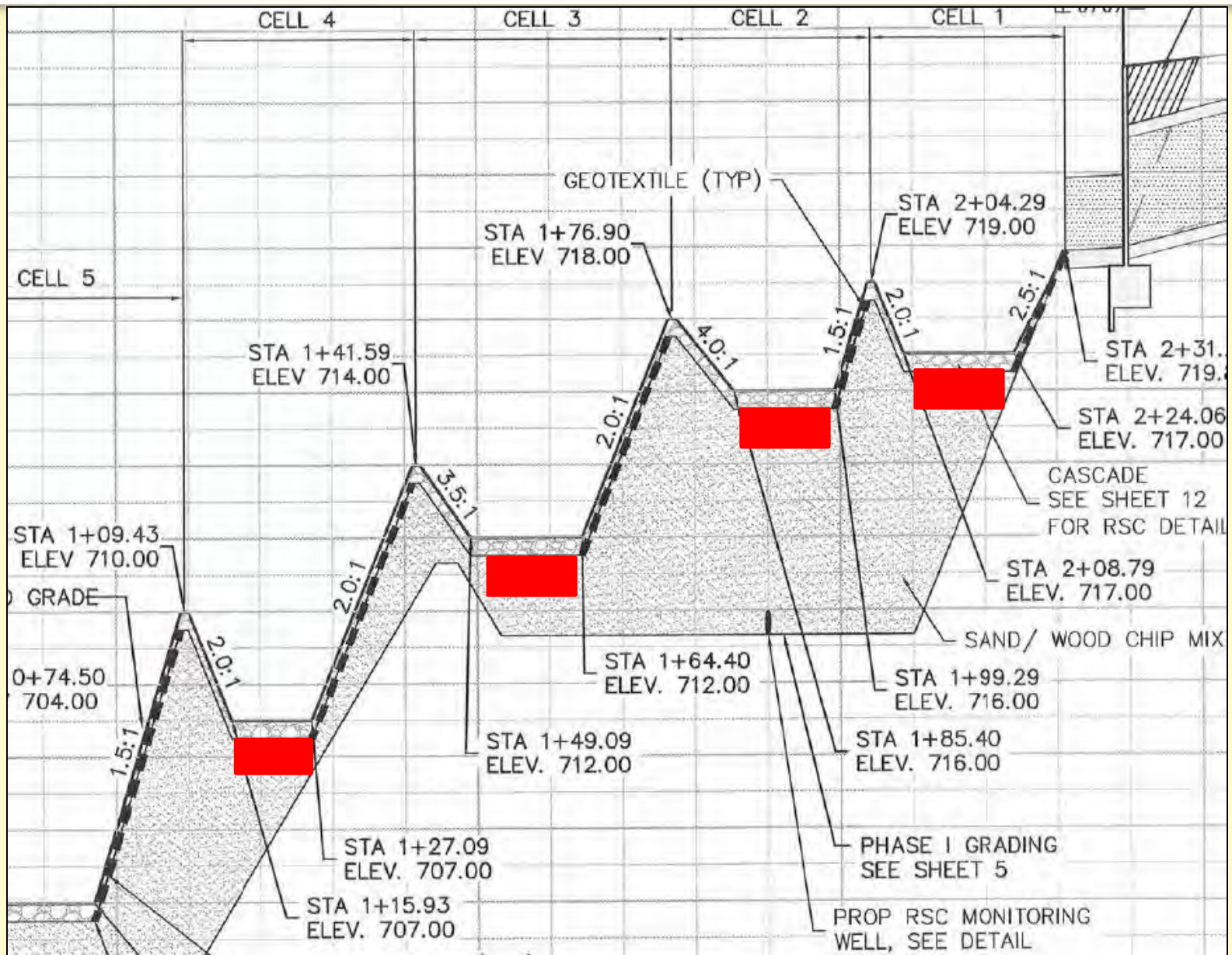
# Retrofit Plan (Upper Cells 1-4)





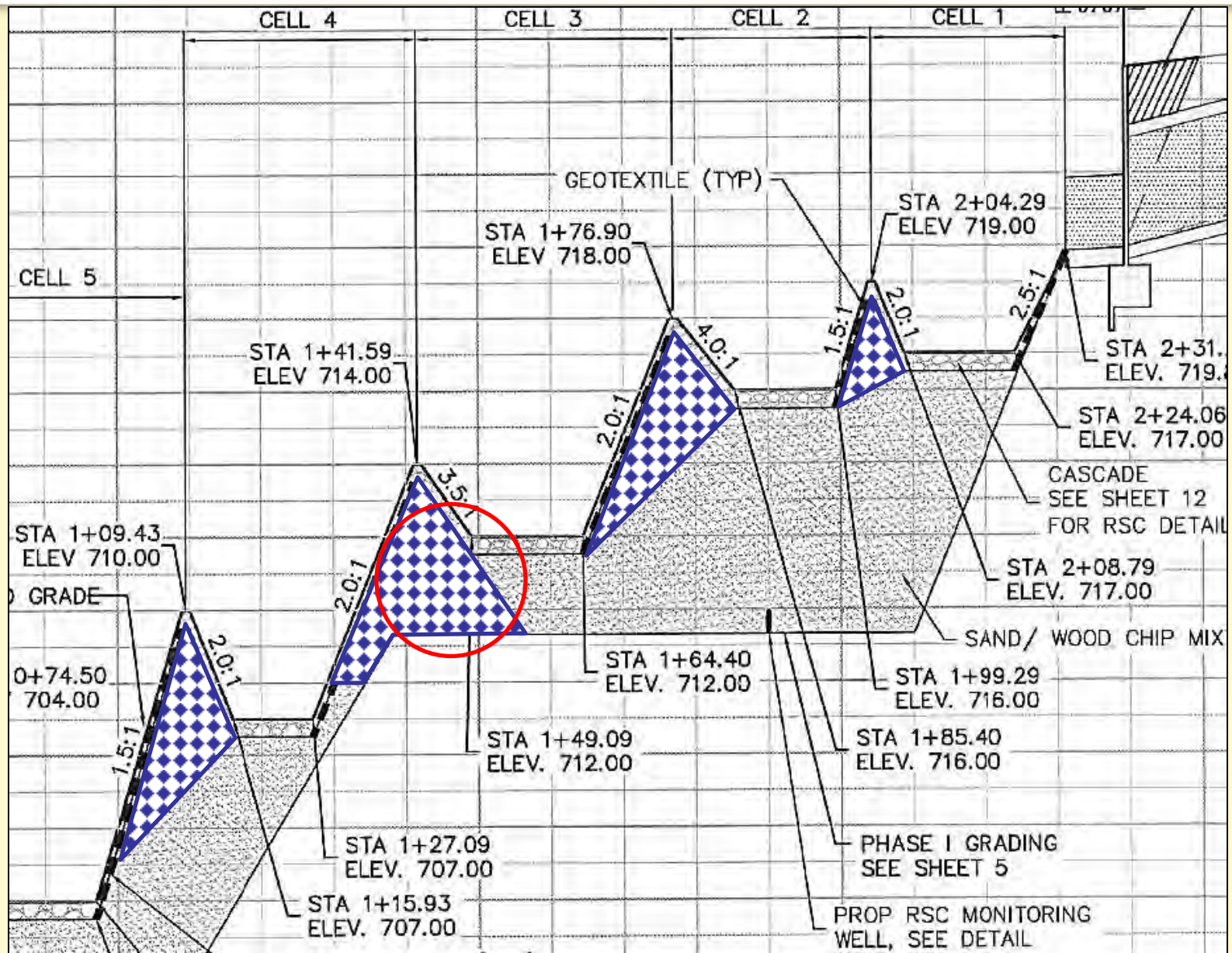


# Retrofit Plan (Replace Media)



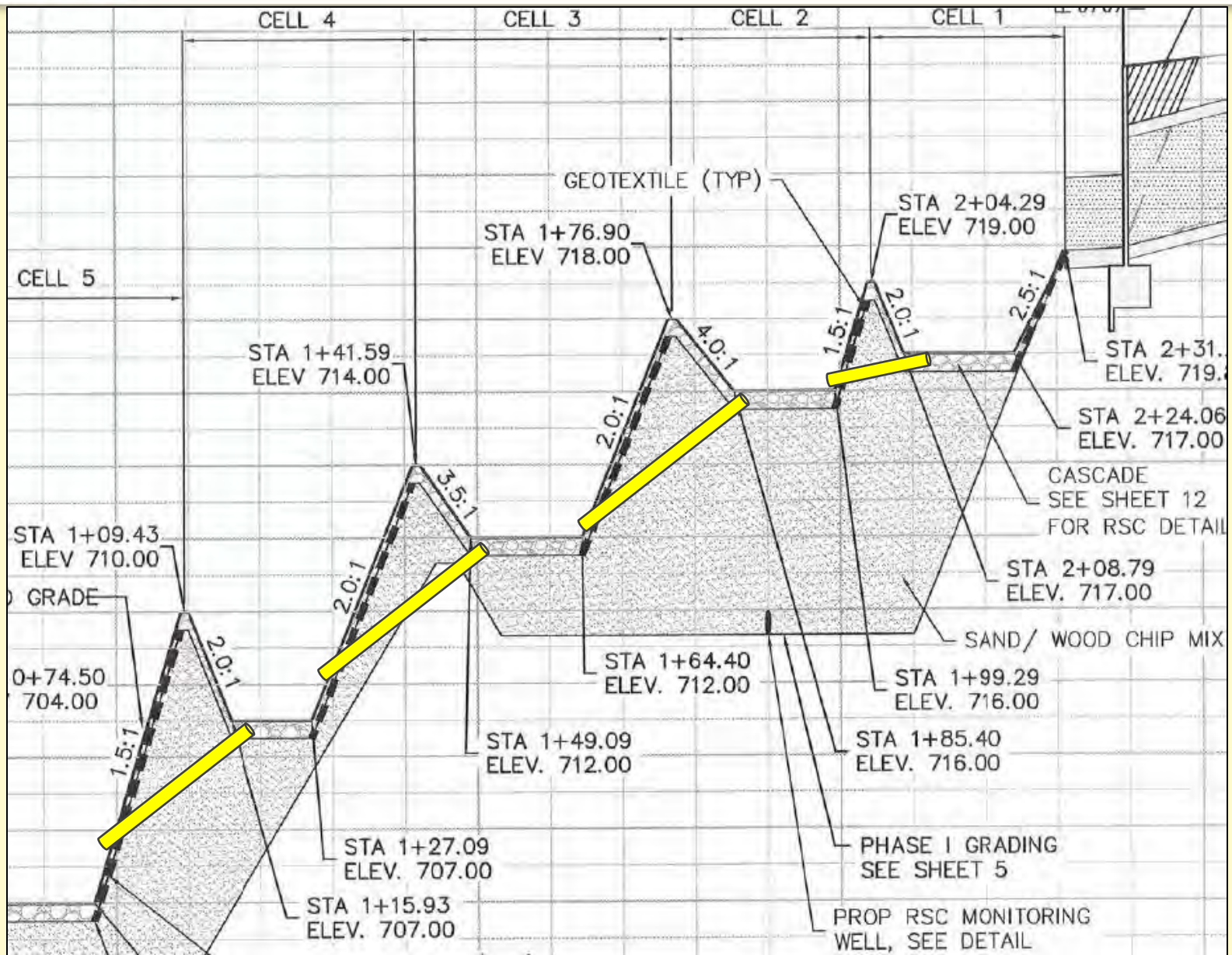


# Retrofit Plan (Berm Replacement)



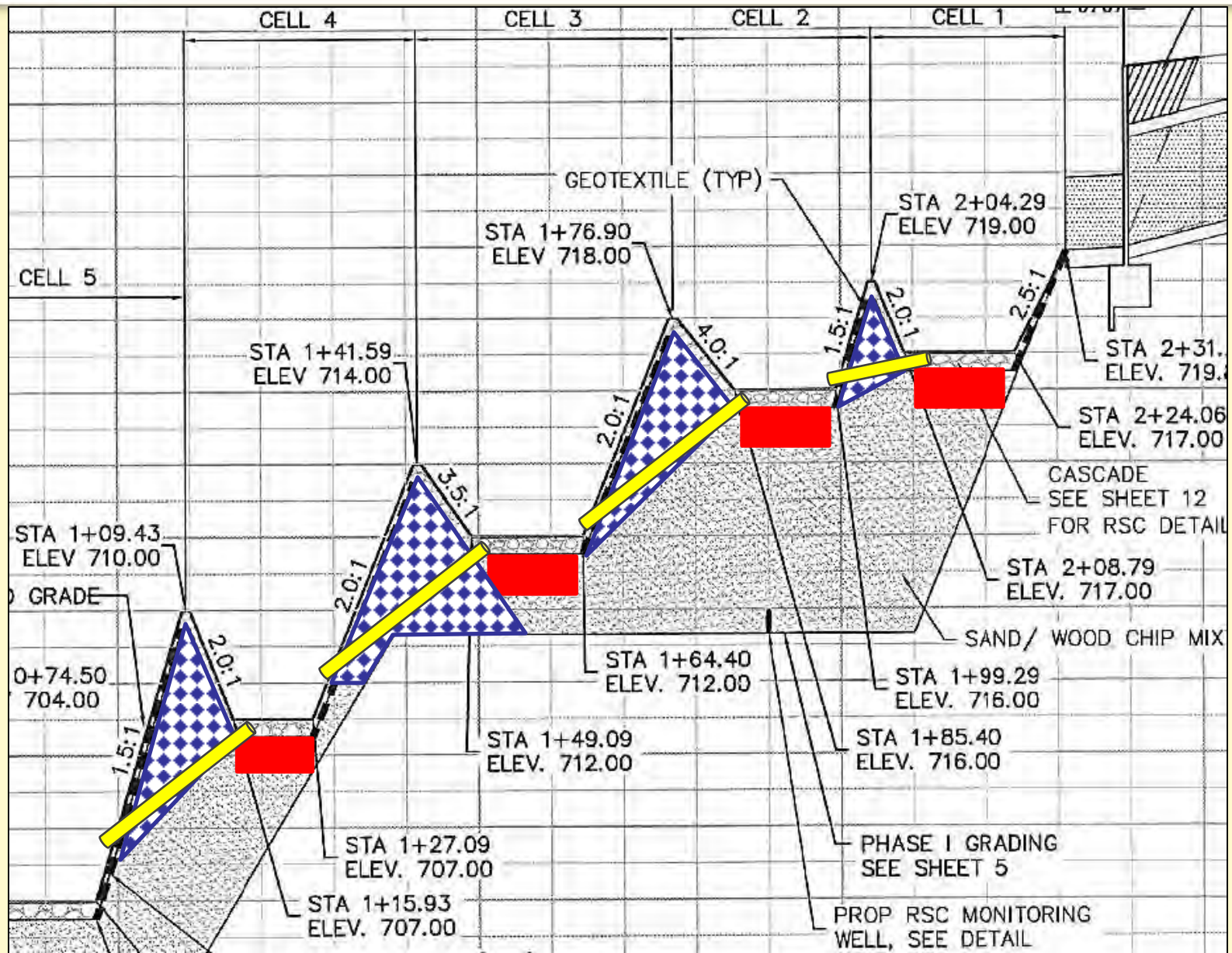
# Retrofit Plan (Bypass Pipes)

insurance





# Retrofit Plan (Sequencing)



## Retrofit (Summary)



New  
Cobble

Berm  
replaced  
with rip rap  
and  
subballast

Cells lined  
with filter  
fabric

Media replaced  
with #57 stone



## Retrofit (Cell 1 and 2 Complete)



## Retrofit (Erosion Control)





## Retrofit (Time Lapse)



## Evaluation (Time Lapse)





## 1. Communication among project team

- Importance of citizen satisfaction (time, standing water, mosquitos)
- When trying new things goals should be fully understood to identify when something is going wrong
  - Designed ponding at outlet weir was missed in plan review
  - Upper Phase I berm and Cell 3 elevation was so tight, the tolerances allowed for ponding
  - Amount of fill for Phase I grading meant less media volume so less potential treatment

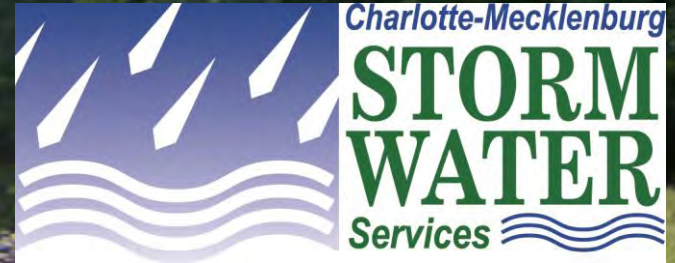
## 2. Erosion Control and Construction Sequencing

- When placing infiltration media in a clay substrate, maintain strict EC measures and stabilize all exposed areas immediately
  - Erosion control should be tailored to the specific project and not general requirements
  - **Don't allow exposed clay within the cells, even covered by cobble.**
- As work is completed, sequence construction and EC to protect your investment
  - It may add time during initial construction but can save time by preventing retrofits.
  - **Don't** allow exposed clay to wash into infiltration media



3. Pilot Projects will have unforeseen challenges and inherently result in lessons learned
  - Design Alterations for Monitoring
    - Extensive clearing for Phase 1 dimensions exposed clay material surrounding media (see erosion control)
    - Outlet monitoring weir required water to back up causing ponding

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# Concrete Sand (ASTM C-33/ NC 2S)

**Table 4**

CELL / SAMPLE NUMBER	% GRAVEL	% SAND / SAND TYPE %	% SILT	% CLAY
Cell 1 / S-1	3.7%	89.6% (4.4% Coarse, 49.2% Medium, 36.0% fine)	4.2%	2.5%
Cell 2 / S-2	4.9%	87.8% (5.9% Coarse, 48.4% Medium, 33.5% fine)	4.3%	3.0%
Cell 3 / S-3	4.4%	86.8% (6.6% Coarse, 47.4% Medium, 32.8% fine)	5.8%	3.0%
Cell 4 / S-4	2.9%	88.2% (4.3% Coarse, 46.0% Medium, 38.0% fine)	5.8%	3.0%
Cell 5 / S-5	3.7%	89.4% (4.8% Coarse, 45.1% Medium, 39.5% fine)	4.3%	2.5%
Cell 6 / S-6	3.6%	90.9% (3.6% Coarse, 47.7% Medium, 39.5% fine)	4.0%	1.5%