Analysis of *Escherichia coli* within Sediment Basins on Active Construction Sites

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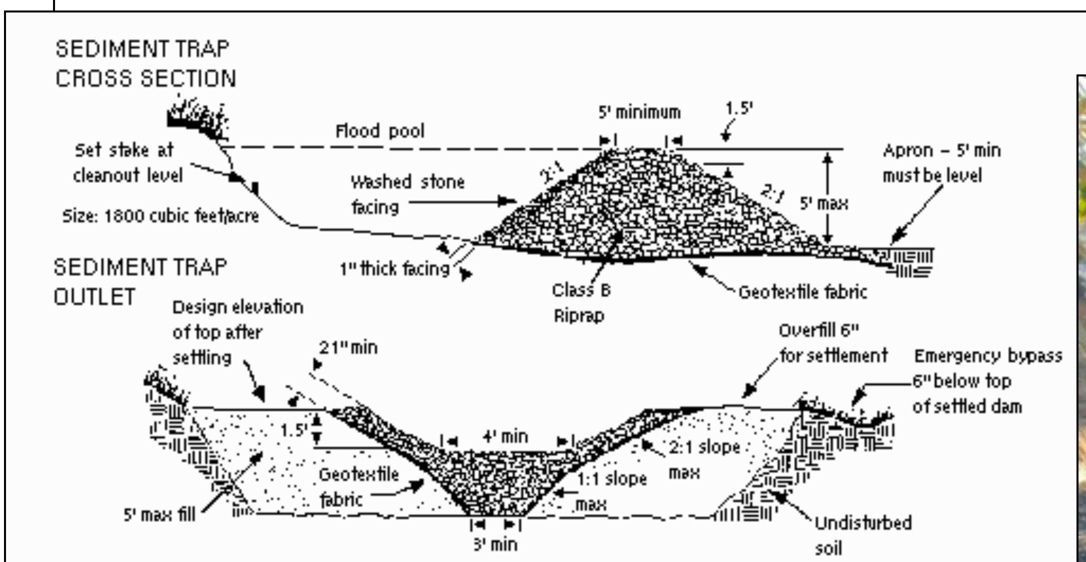
Background

- In South Carolina, sediment reduction plans must be implemented for construction land disturbance activities over 1 acre.
- Basins are designed to allow suspended particles to settle before water is discharged downstream.
- Basins must achieve a designed trapping efficiency that is > 80%.



(Walker, 1996)

Background

- Sediment basins highly variable for controlling sediment and other pollutants.
- Reasons include,
  - Improper construction.
  - Improper maintenance.
  - Soil type.
  - Atypical storm events.

http://ian.umces.edu/imagelibrary/displayimage-search-0-999.html

Background

- Pathogenic bacteria have been shown to attach to fine particles over larger sand particles.
  - Fine sediments provide protection for bacteria.
  - Bacteria can live for extended periods of time in sediments.
- Sediment basins may harbor pathogenic bacteria.

Goals and Objectives

To better understand the existence, persistence, transport, and fate of *Escherichia coli*, an indicator bacteria in sediment basins.

1. Analyze the density of E. *coli* with respect to particle size.
2. Evaluate the density of E. *coli* with respect to sediment depth over time.
3. Understand the relationship between E. *coli* density and storm hydrographs.

Site Information

- Five sediment basins in Anderson, SC.
  - Soil was predominantly Cecil series (sandy clay loam topsoil, clay subsoil).
  - Average yearly rainfall is 125 cm.
  - Historical average temperature is 16.4 degrees Celsius.
  - Pond ages range from <1 to 4 years old.

Methods: E. *coli* Density v. Particle Size

- Sediment was collected using a long handle polyethylene dipper to collect representative samples from outlet to inlet of basins.
- Pipette analysis was performed for each sample to separate particles by size.
- Subsamples were then analyzed for E. *coli*.

Methods: E. *coli* Density v. Sediment Depth

- Sediment cores were collected using a coring device.
- Cores were taken at 1, 3, 5, and 10 DSLR when possible.
- Cores were divided into subsamples at representative depths and analyzed for E. *coli*.

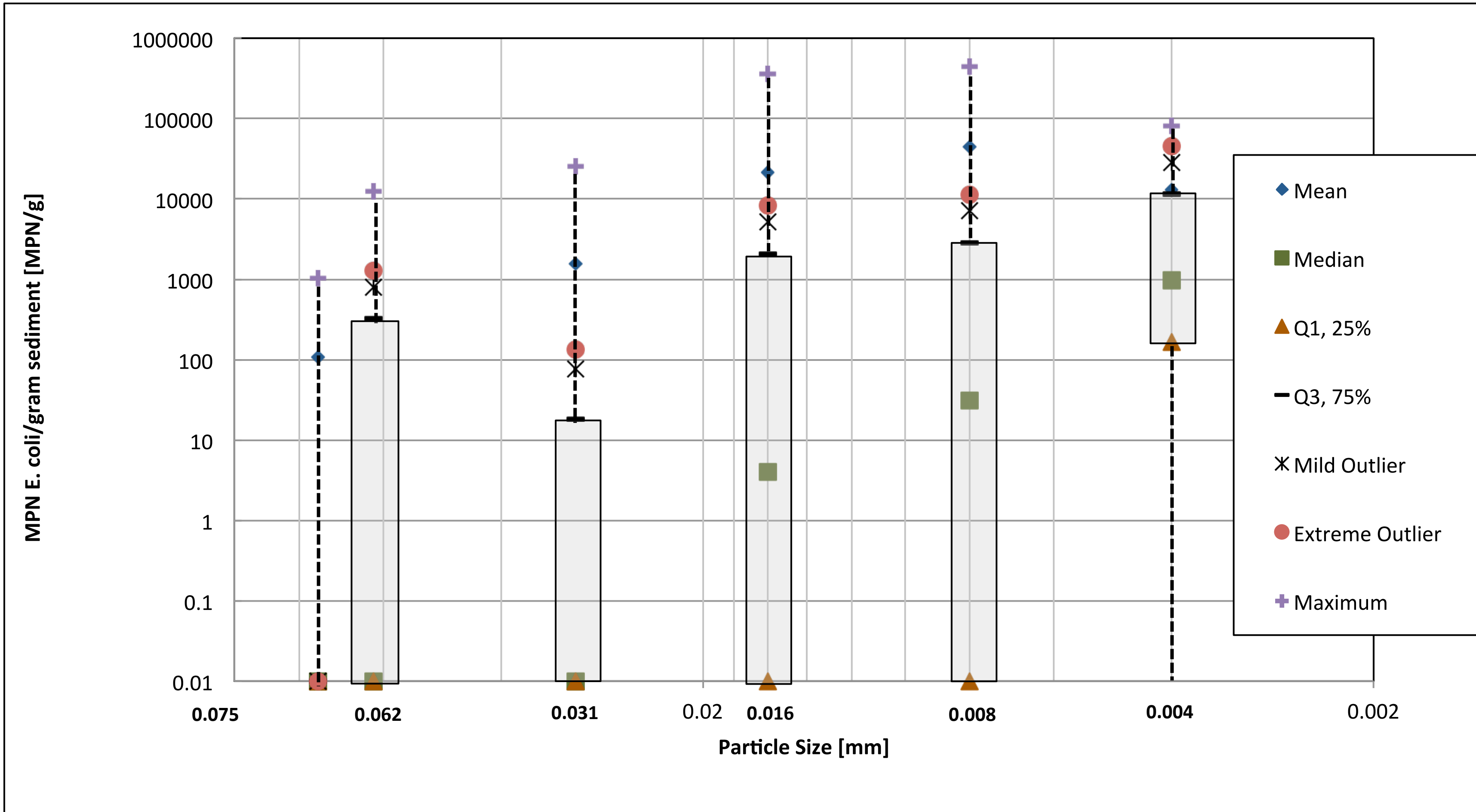
Methods: E. *coli* Density v. Hydrograph

Runoff data was gathered using ISCO samplers and flow data modules.

Methods: E. *coli* Enumeration

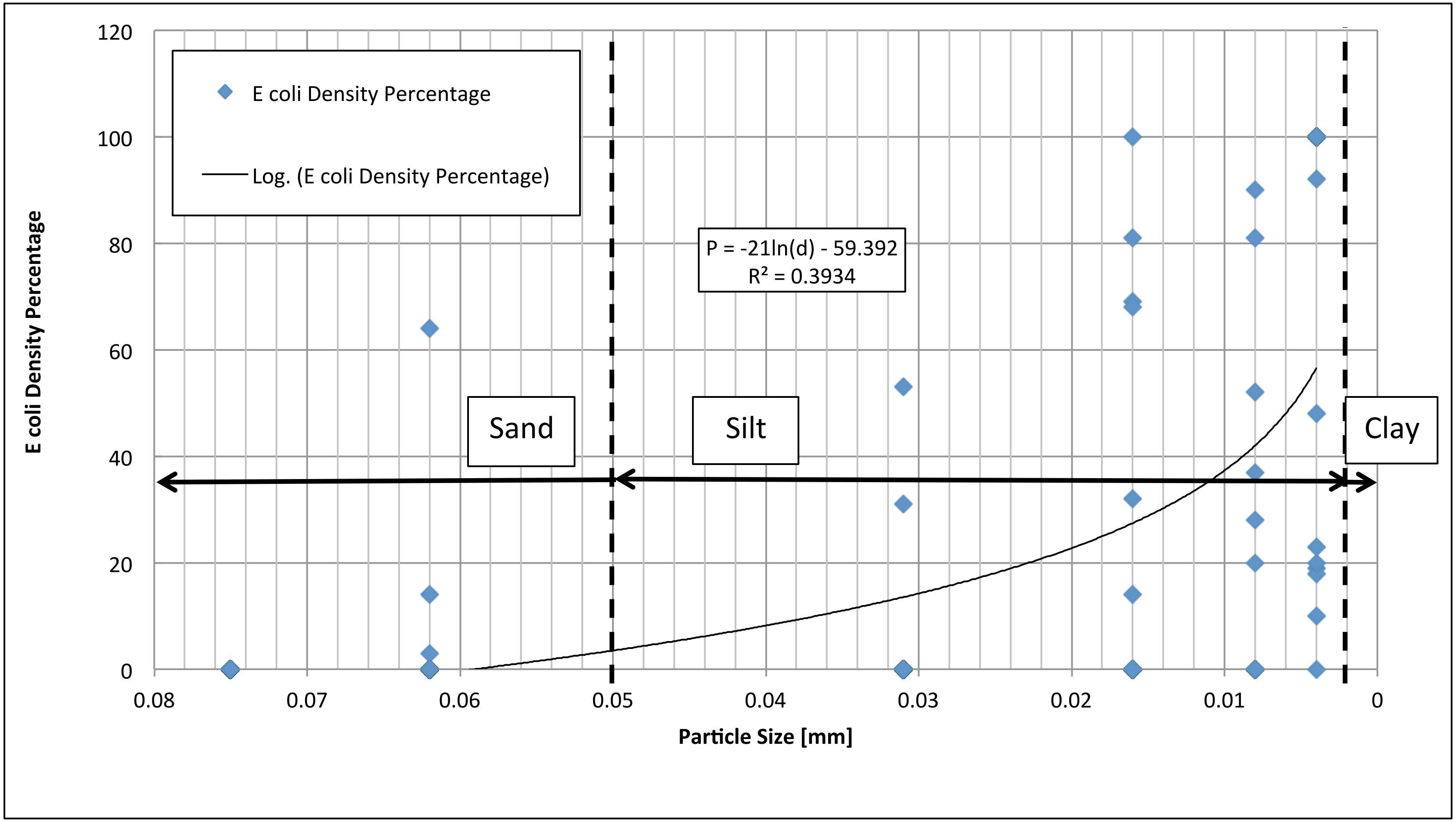
- Samples were mechanically shaken for one minute at 200 rpm.
- E. *coli* was enumerated by Colilert enzyme substrate assay procedure.
  - Ranges of 0.1 to 10 mL sample dilutions were analyzed with the QuantiTray 2000.

Results: E. *coli* Density v. Particle Size



Log Transformed Box and Whisker Plot of E. *coli* with Respect to Particle Size.

Results: E. *coli* Density v. Particle Size



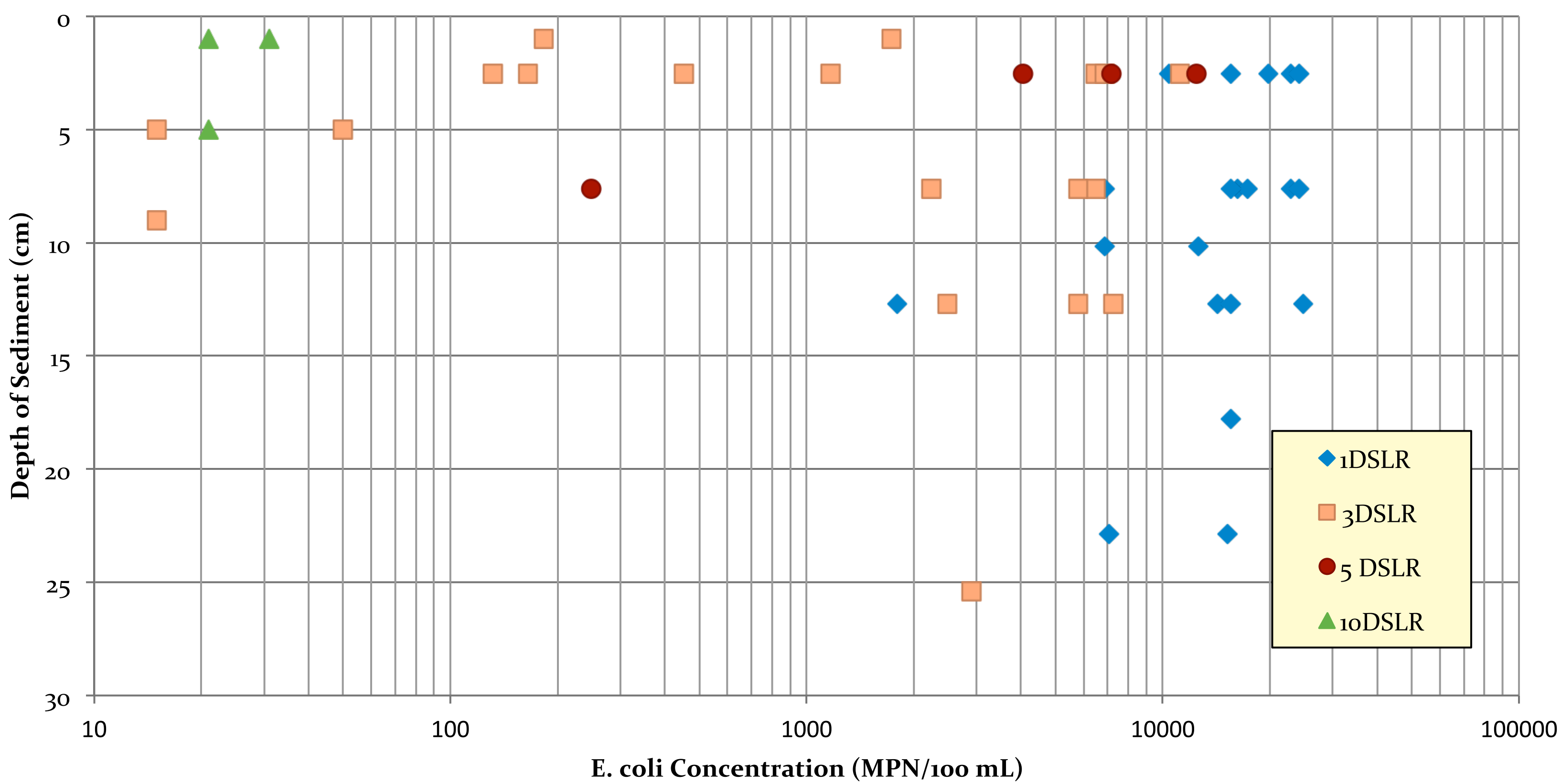
Line Fit Plot of E. *coli* Percentage as a Function of Particle Size

Results: E. *coli* Density v. Particle Size

KEY OBSERVATIONS: Objective 1

- Variable nature of E. *coli* produced an $R^2 = 0.39$.
- P-value reveals a significant correlation of increasing E. coli density with decreasing particle size. ($p < 0.001$).
- This result is supported by literature (Characklis et al, 2005) and (Oliver et al, 2007).

Results: E. *coli* Density v. Sediment Depth



E. *coli* density with respect to sediment depths for basins BC, CH-2

Results: E. *coli* Density v. Sediment Depth

Net die-off rates of E. *coli* for DHC and CH-2:

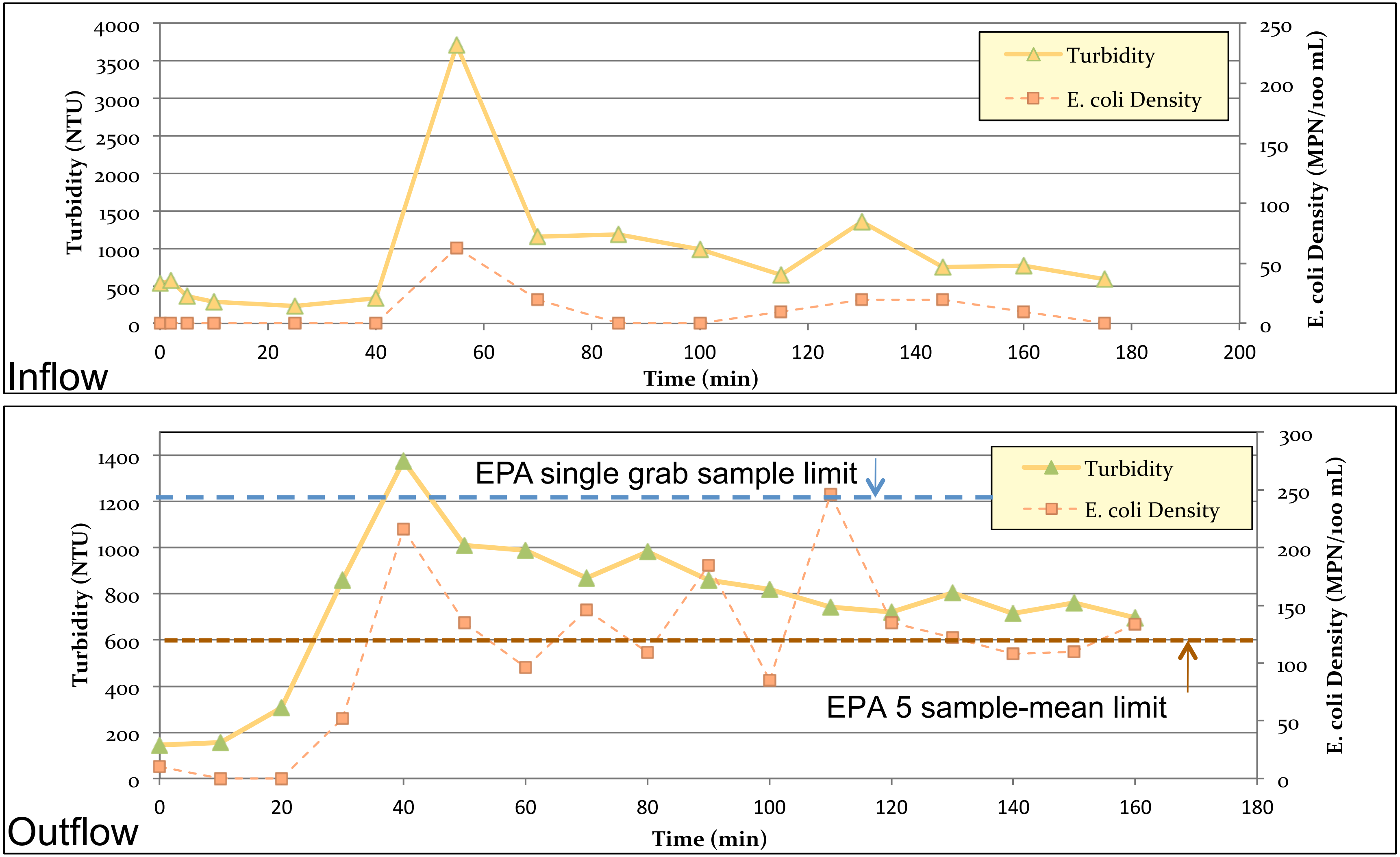
	Net Die-off Rate [MPN/day]	
Pond Information	**Water Column**	**Top 2.54 cm (1 in) of Sediment**
CH-2 March 9 - 13	12011.5	1910.4
DHC March 9 - 13	101.5	54.9

Results: E. *coli* Density v. Sediment Depth

KEY OBSERVATIONS: Objective 2

- Over time, the net die-off of E. *coli* in bottom layers are greater than those in the top layer of sediment.
- Top layer densities also persist much longer than densities in the water column.
- Findings did not provide evidence that organisms are reproducing in the sediment.

Results: E. *coli* Density v. Hydrograph



WHE, March 9, 2011: Turbidity and E. *coli* Densities over Time

Results: E. *coli* Density v. Particle Size

KEY OBSERVATIONS: Objective 3

- Turbidity in the inflow illustrates a first flush effect. The outflow turbidity remains relatively constant throughout the event.
- E. *coli* levels in the outflow can exceed the US EPA limit of 126 cfu/100 mL for a 5-sample geometric mean as well as the single 235 cfu/100 mL grab sample.

Conclusions

1. E. *coli* densities increase with decreasing particle size. Particle sizes less than 0.004 mm contain the highest levels of bacteria.
2. The top 2.54 cm (first inch) of sediment typically contains the highest densities of E. *coli*, especially as time increases after a rain event.
3. *E. coli* levels in sediment decrease with time, indicating that if any *E*. *coli* growth occurs, it is overcome by net die off. However, sediment in these basins appears to provide protection for *E*. *coli*.

Conclusions

4. E. *coli* response to turbidity shows that E. *coli* are attached to fines that are not readily trapped during rain events.
5. Finally, resuspension within basins can result in E. *coli* levels greater than US EPA limits in the outflow; the result is that,

   sediment basins can contribute to impairment of South Carolina surface waters.

Next Steps

- As basins have been proven ineffective in controlling construction derived sediment associated bacteria, alternative sediment reduction practices should be further researched.
  - Polyacrylamide (PAM), grassed buffers
- **In order to control bacteria, turbidity must be controlled.** Therefore future focus should be placed on minimizing turbidity in the outflow of sediment ponds.

Acknowledgements

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