Assessing Microbial Indicator Transport in Onsite Wastewater Mound Systems

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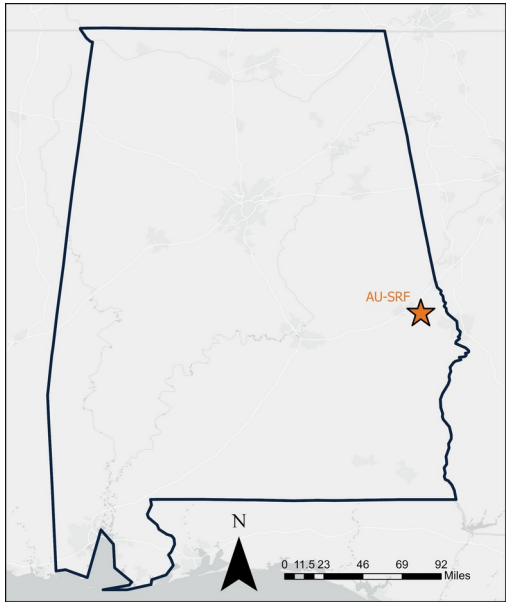
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Study Site

- Auburn University Stormwater Research Facility
- Field-scale research facility used to study water and wastewater treatment systems
- This study focuses on an approximately 30-year-old mound system





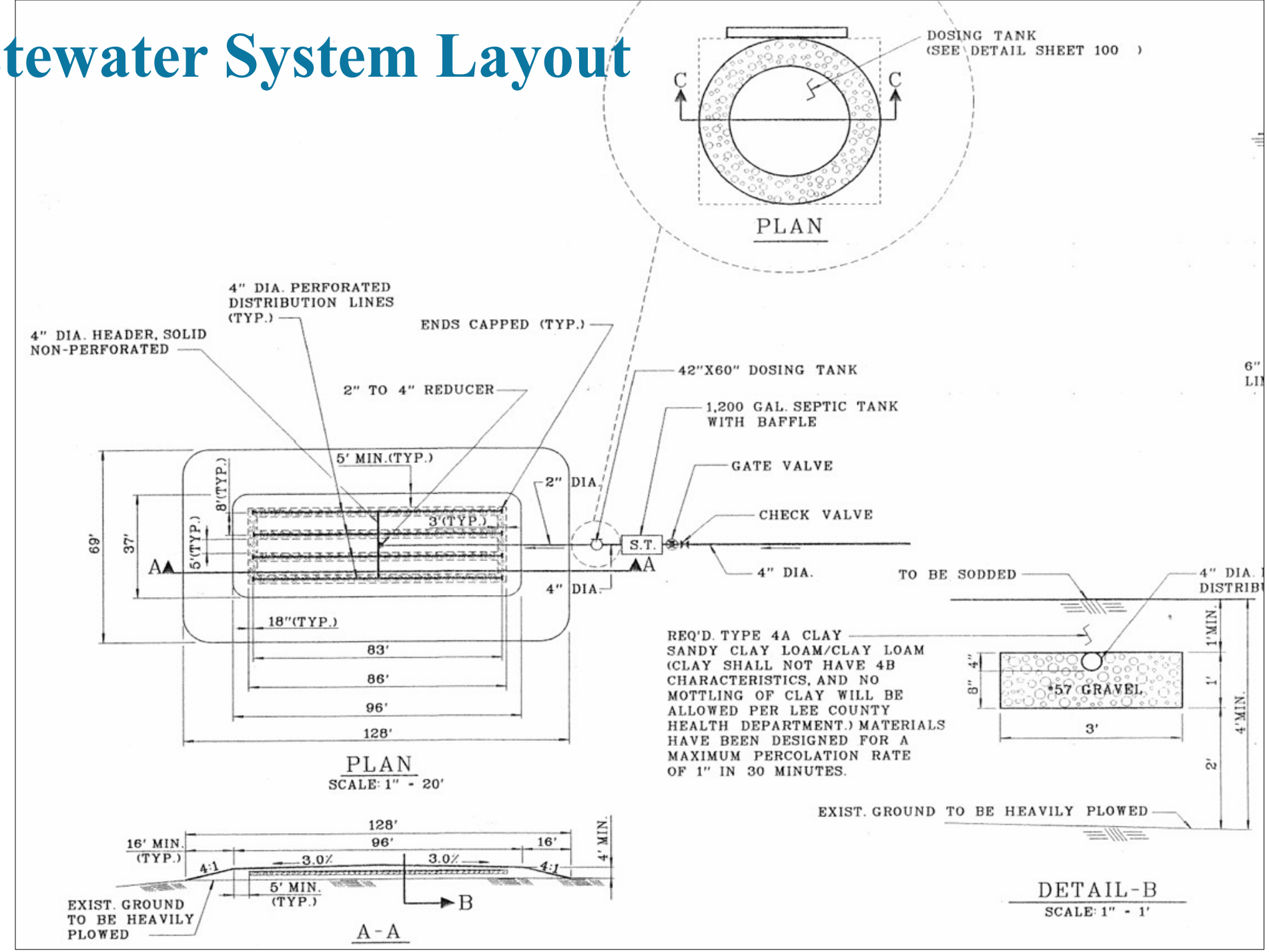
Why Study an Aging Mound System?

- Provides an opportunity to evaluate treatment under real field conditions
- Long-term operation may change soil structure, hydraulic pathways, and treatment performance
- Water and microorganisms may move differently through the mound and underlying native soil
- Preferential flow could allow contaminants to travel deeper or faster than expected
- Field monitoring is needed to better understand potential risks to groundwater





Onsite Wastewater System Layout



The Knowledge Gap

- Microbial transport in full-scale mound systems remains difficult to predict
- Most transport relationships are developed from laboratory or controlled-column studies
- Field soils are heterogeneous and may contain preferential flow paths

Study Objectives

1	2	3	4
Assess the vertical movement of water and microbial indicators through a functioning onsite wastewater mound system under controlled dosing conditions.	Characterize contaminant transport processes, including microbial retention and attenuation, to better understand potential pathways to groundwater and human exposure.	Establish baseline hydraulic and microbial transport conditions for comparison with future changes in wastewater loading.	Provide field-based evidence to support mound-system monitoring, design, siting, operation, and maintenance.

Overall Study Approach

1

Site Characterization

- Evaluate the mound system
- Collect soil samples
- Characterize baseline soil and hydraulic conditions

2

Instrument Installation

- Install suction lysimeters
- Install TEROS 12 sensors
- Connect sensors to ZL6 data loggers

3

Controlled Dosing

- Apply a known water volume
- Add tracers
- Record flow rate and duration

4

Continuous Monitoring and Porewater Collection

- Monitor soil moisture, Electrical conductivity (EC), and temperature
- Collect porewater at multiple depths
- Record and analyze samples in the laboratory

5

Data Interpretation and Future Comparison

- Compare hydraulic and microbial responses
- Evaluate retention and attenuation with depth
- Establish baseline conditions for future increased loading

Tasks 1: Site Characterization

1

- Evaluate the mound system
- Collect soil samples
- Characterize baseline soil and hydraulic conditions

Mound-System Evaluation

- Approximately 30 years old
- Currently connected to one bathroom
- Low and irregular wastewater loading
- Preliminary evaluation needed before controlled experiments

Preliminary Hydraulic Evaluation

- Verified pump and float operation
- Measured dosing-tank water levels
- Recorded pump run time
- Estimated water volume delivered to the mound



Dosing tank used to distribute wastewater to the mound system

Controlled loading tests showed:

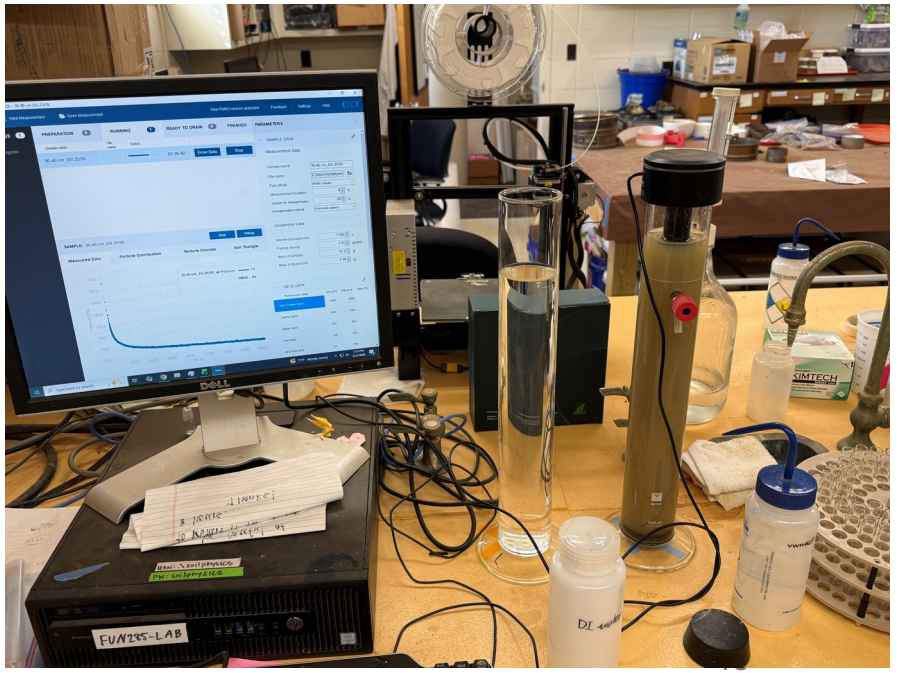
- Tank dimensions**: 42-in diameter × 60-in depth**
- Pump start level: **25.4–25.9 in**
- Pump stop level: **10.8–11.1 in**
- Average drawdown: **~14.7 in**
- Estimated dose volume: **~88 gal/cycle**
- Pump flow rate: **~37 GPM**

Approximately 88 gallons were delivered to the mound during each pumping cycle.

Soil Sampling and Characterization

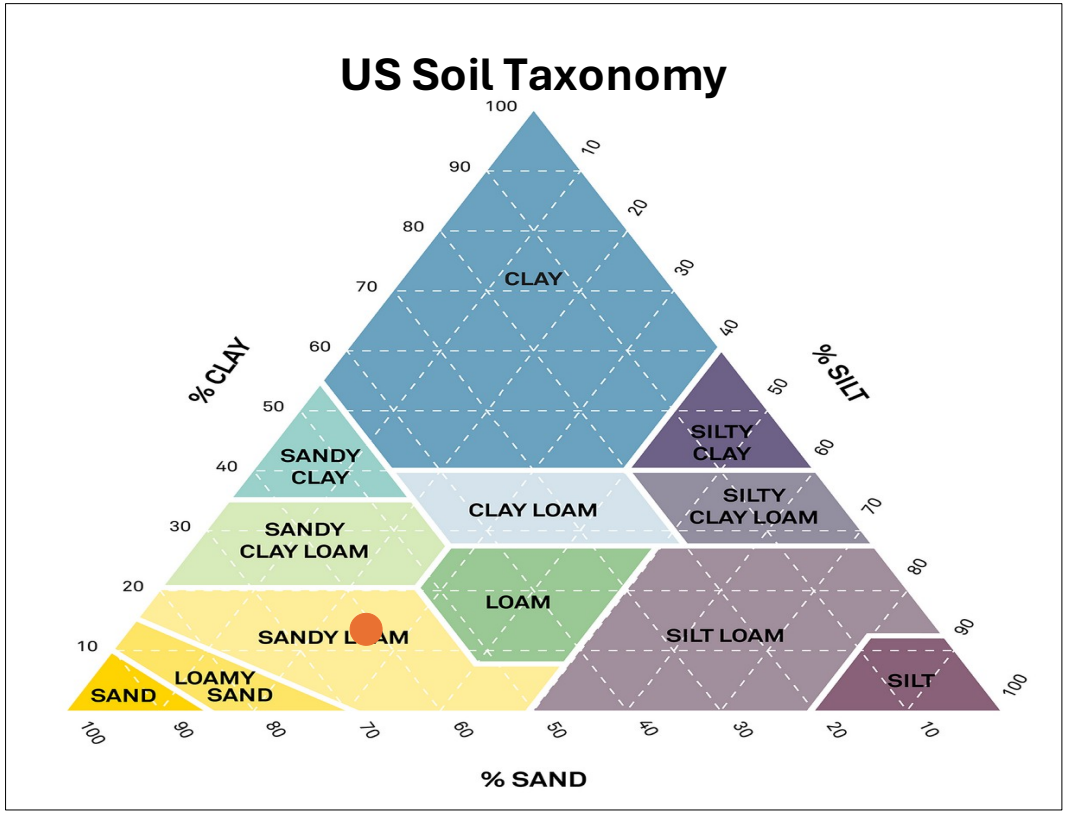
- Soil collected across the mound and underlying soil profile
- Samples collected at multiple depths
- Samples transported to the laboratory
- Texture determined using sieve and hydrometer analyses
- Additional hydraulic testing planned





Preliminary Soil-Texture Results

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture
0-20	61.12	25.20	13.68	Sandy Loam
20-30	40.89	12.45	46.67	Clay
30-40	82.51	15.26	2.23	Loamy Sand
40-50	75.92	13.83	10.25	Sandy Loam
50-60	75.14	15.60	9.27	Sandy Loam
60-70	74.57	14.53	10.90	Sandy Loam
70-80	73.46	17.22	9.31	Sandy Loam
80-90	61.96	26.41	11.63	Sandy Loam
90-100	60.80	29.46	9.74	Sandy Loam
100-110	57.60	31.94	10.47	Sandy Loam
110-120	52.88	37.62	9.51	Sandy Loam
120-130	56.47	35.45	8.08	Sandy Loam
130-140	66.62	25.51	7.86	Sandy Loam
140-150	58.61	39.29	2.09	Sandy Loam
150-160	57.72	37.01	5.27	Sandy Loam
160-170	50.55	36.92	12.53	Loam
170-180	44.80	38.14	17.06	Loam
180-190	43.52	36.84	19.64	Loam
190-205	46.84	35.39	17.76	Loam



The soil profile was predominantly sandy loam, with localized clay and loamy sand layers near the surface and a transition to loam below 160 cm. The depth-weighted average texture was sandy loam.

Tasks 2: Instrument Installation

2

- Install suction lysimeters
- Install TEROS 12 sensors
- Connect sensors to ZL6 data loggers

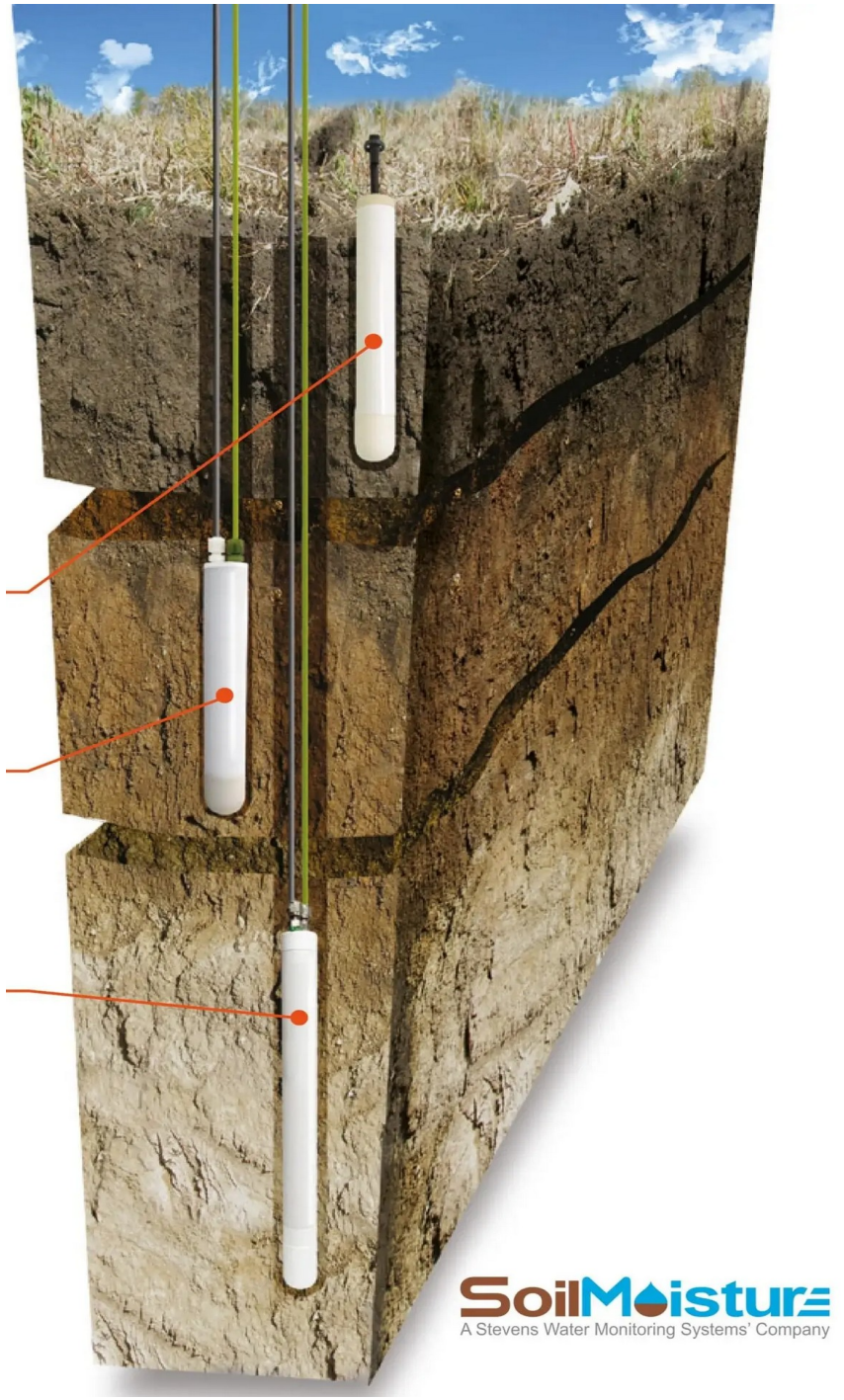
Monitoring Design

- Monitor vertical transport below the distribution bed
- Combine porewater sampling with continuous sensor measurements
- Install instruments at multiple depths
- Compare hydraulic and microbial responses over time and depth



Suction Lysimeters

- Collect porewater from unsaturated soil
- Vacuum draws water through a porous ceramic cup
- Planned installation at 1, 2, 3, and 4 ft below the gravel layer
- Samples will be analyzed for tracers, *E. coli*, and HF183



TEROS 12 Sensors

- Measure volumetric water content
- Measure bulk electrical conductivity
- Measure soil temperature
- Provide continuous data between sampling events



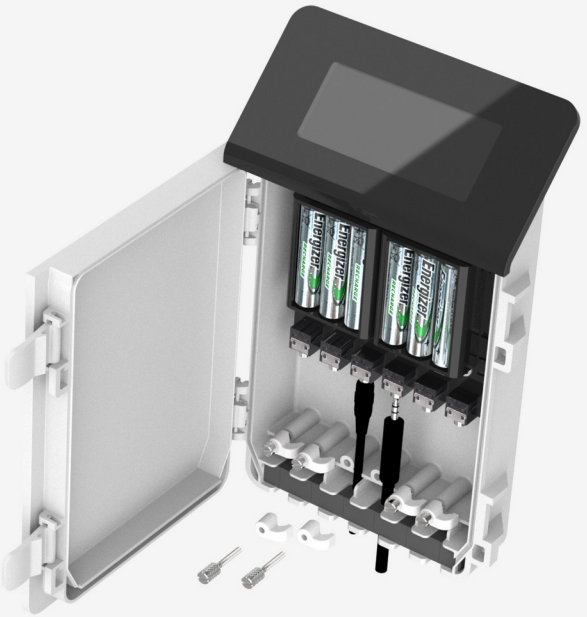


Measurement	What it helps show
Soil moisture	Wetting-front arrival and drainage
Electrical conductivity	Salt-tracer movement
Temperature	Changes in subsurface conditions

ZL6 Data Loggers and Continuous Monitoring

- Connect TEROS 12 sensors to ZL6 data loggers
- Record measurements at regular time intervals
- Record and store moisture, EC, and temperature data





Planned configuration: 12 TEROS 12 sensors connected to three ZL6 data loggers

Tasks 3 : Controlled Dosing

3

- Apply a known water volume
- Add tracers
- Record flow rate and duration

Controlled Dosing Design

- Apply a known water volume directly to the dosing tank
- Evaluate 300 and 600 gallon loading conditions
- Apply the 600-gallon load as two 300 gallon dosing events
- Record dose volume, flow rate, duration, and pump operation

Proposed Tracers

Tracer approach

- Fluorescent microspheres at approximately 1, 5, and 50 μm
- An inert water tracer, such as D_2O
- A viral surrogate

Purpose

- Compare particle transport at different sizes
- Track water travel time
- Evaluate retention and attenuation with depth

Tasks 4: Monitoring and Porewater Collection

4

- Monitor soil moisture, EC, and temperature
- Collect porewater at multiple depths
- Record and analyze samples in the laboratory

Monitoring and Sampling Schedule

- Collect background samples before tracer application
- Continuously record soil moisture, Electrical conductivity (EC), and temperature
- Collect porewater at 6, 12, 18, 24, 48, and 72 hours after tracer introduction
- Adjust sampling frequency based on hydraulic and tracer responses

Porewater Collection

Collection procedure

- Create a vacuum using the PM5 pump Clamp the lysimeter tubing to maintain the vacuum
- Allow porewater to collect through the ceramic cup
- Retrieve the sample using the 1900K50 syringe kit
- Record depth, collection time, and sample volume





Laboratory Analysis

	Operational Conditions		Experimental Conditions	
Category	Wastewater Parameter	Operational Analysis	Surrogate Parameter	Experimental Tracer Analysis
Bacteria	Total coliforms	IDEXX Colilert	Fluorescent microspheres (~1 µm)	Fluorescence microscopy
	E. coli			
	HF183	qPCR		
Protozoa			Fluorescent microspheres (~5 µm and ~50 µm)	Fluorescence microscopy
Water Tracer			D_2O or another inert water tracer (proposed)	Stable-isotope analysis (method pending)

Integrating Sensor and Laboratory Data

- Align sensor and porewater results by time and depth
- Compare moisture and EC responses with tracer detection and arrival time
- Evaluate *E. coli* and HF183 detection at each depth
- Assess transport, retention, and attenuation with detph

Tasks 5: Data Interpretation and Future Comparison

5

- Compare hydraulic and microbial responses
- Evaluate retention and attenuation with depth
- Establish baseline conditions for future increased loading

Planned Data Interpretation

1. Compare sensor responses across monitoring locations
2. Determine wetting-front arrival time and drainage behavior
3. Identify areas of greater or delayed water movement
4. Use hydraulic responses to refine lysimeter placement
5. Compare tracer and microbial detection by depth



Current Project Status

✓ Soil-profile characterization

✓ Dosing-tank and float evaluation

✓ Preliminary hydraulic-loading assessment

✓ Monitoring locations identified

Currently underway

→ Install lysimeters and TEROS sensors

→ Establish baseline vadose-zone conditions

→ Conduct tracer experiments

→ Evaluate microbial breakthrough and attenuation

Anticipated Outcomes

- Baseline hydraulic and contaminant-transport dataset
- Improved understanding of water and microbial-indicator movement
- Identification of suitable lysimeter locations and monitoring depths
- Framework for future before-and-after loading comparisons
- Field evidence to support mound-system monitoring and management

Thank you

Questions ?

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