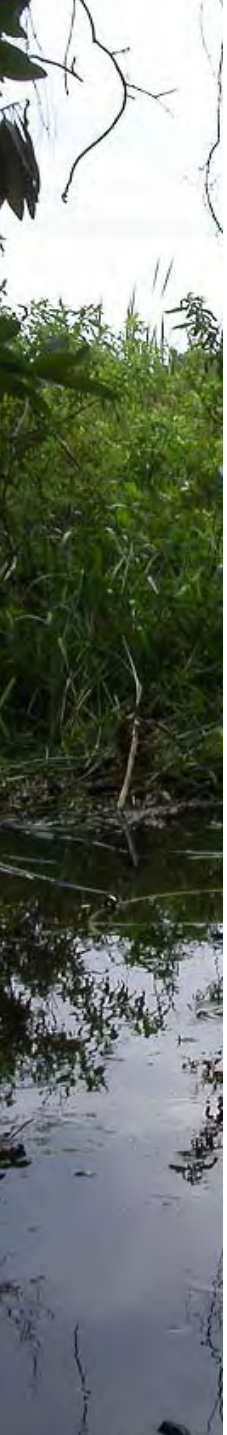

Evaluating Transport, Mass Flux and Attenuation at the Groundwater – Surface Water Interface

The International Conference on Remediation of Chlorinated and Recalcitrant Compounds

Monterey, California May 24, 2006

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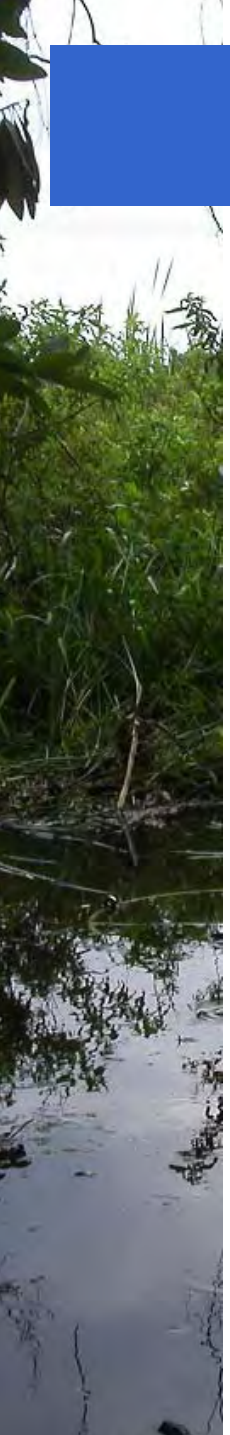
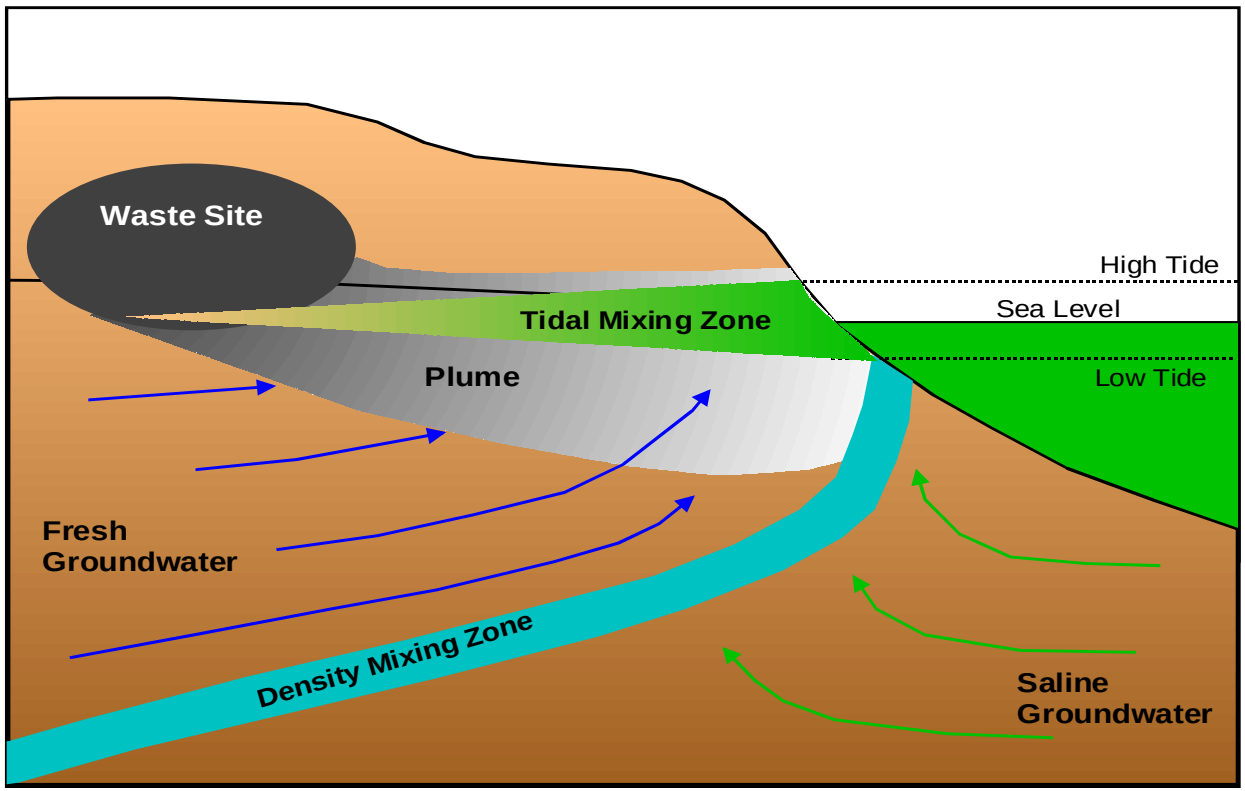


Outline

- Problem Background
- Tools and Technologies
- Field Demonstration – NTC Orlando
- Summary
- Questions/Comments

Background

- <u>Problem Statement:</u> Accepted technologies for assessing groundwater migration of contaminants from coastal landfills and hazardous waste sites to surface waters are lacking



Background

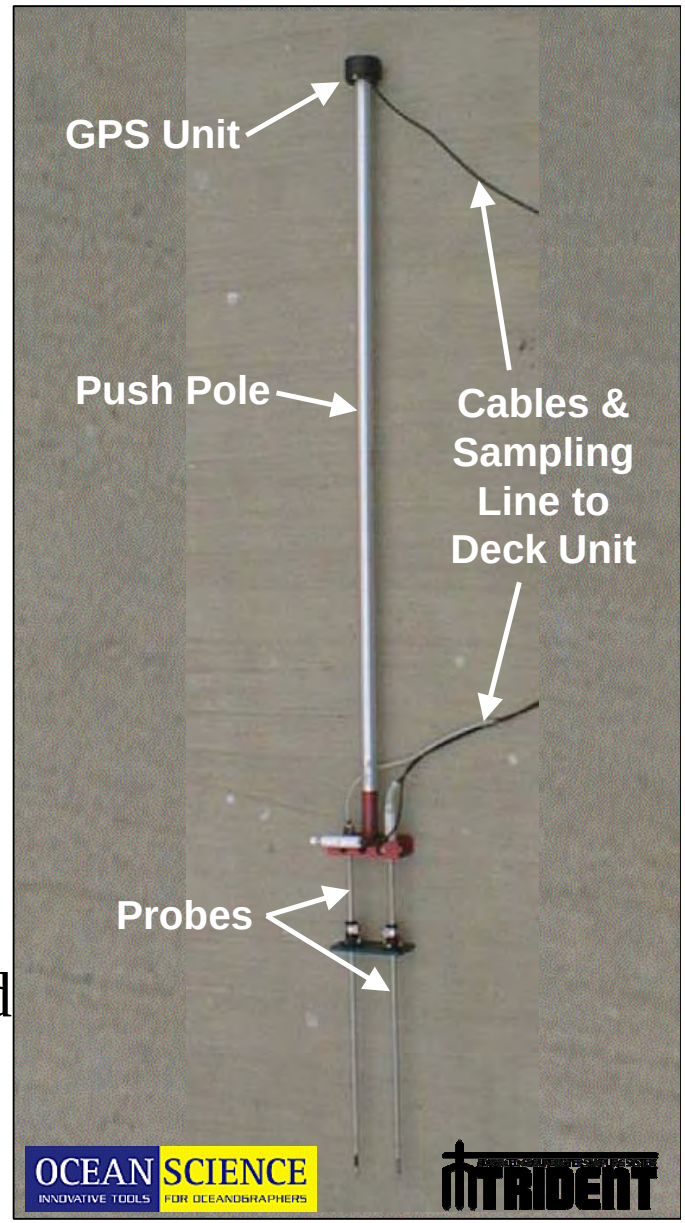
- Scope of the Problem: Cleanup sites with landfills/plumes located adjacent to harbors, bays, estuaries, wetlands, and other coastal environments
- A recent Navy review indicates potential for groundwater–surface water interaction at a large number of coastal landfills and hazardous waste sites

EFA/EFD	Groundwater Contamination	Tidal Infiltration	Groundwater Infiltration
Atlantic Division	29	14	16
EFA Chesapeake	14	4	10
Northern Division	20	10	18
EFA West	29	14	31
South West Division	19	15	13
EFA MidWest	3	0	3
EFA North West	6	8	10
Pacific Division	5	10	8
Southern Division	27	26	50
TOTALS	152	101	159

Technologies - Trident

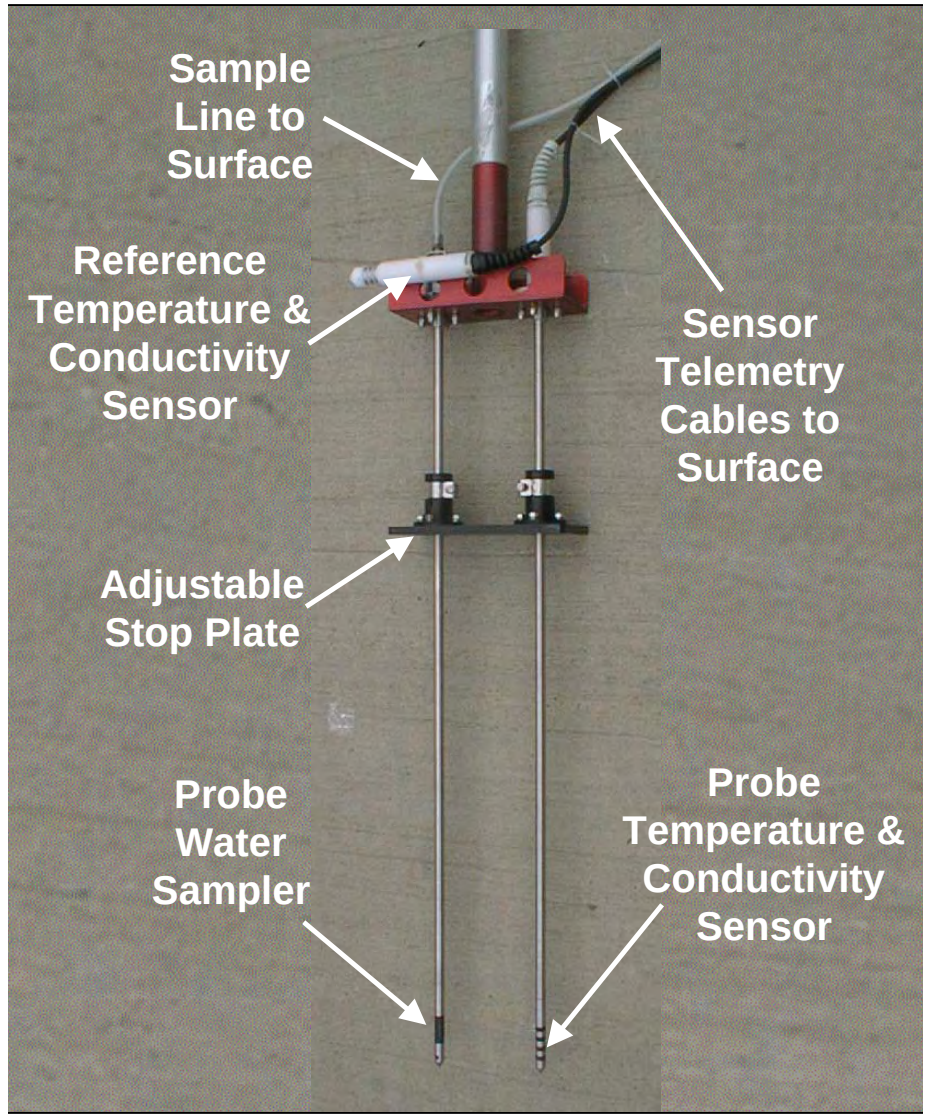
- TRIDENT Probe – *A flexible, multi-sensor water sampling probe for screening and mapping groundwater plumes at the surface water interface*

- Conductivity – detects contrast in salinity and/or clay content in unconsolidated sediments
- Temperature – detects groundwater by thermal contrast with surface water
- Porewater Sampler – allows contaminant characterization and detection of other groundwater-specific tracers



Trident Probe Components & Specifications

- Probe Length: 90 cm
- Stainless Steel Construction
- Conductivity:
  0-80 ± 0.01 mS/cm
- Temperature:
  –5-45° ± 0.001° C
- Porewater: Low-flow peristaltic pump collected through mesh screen at tip



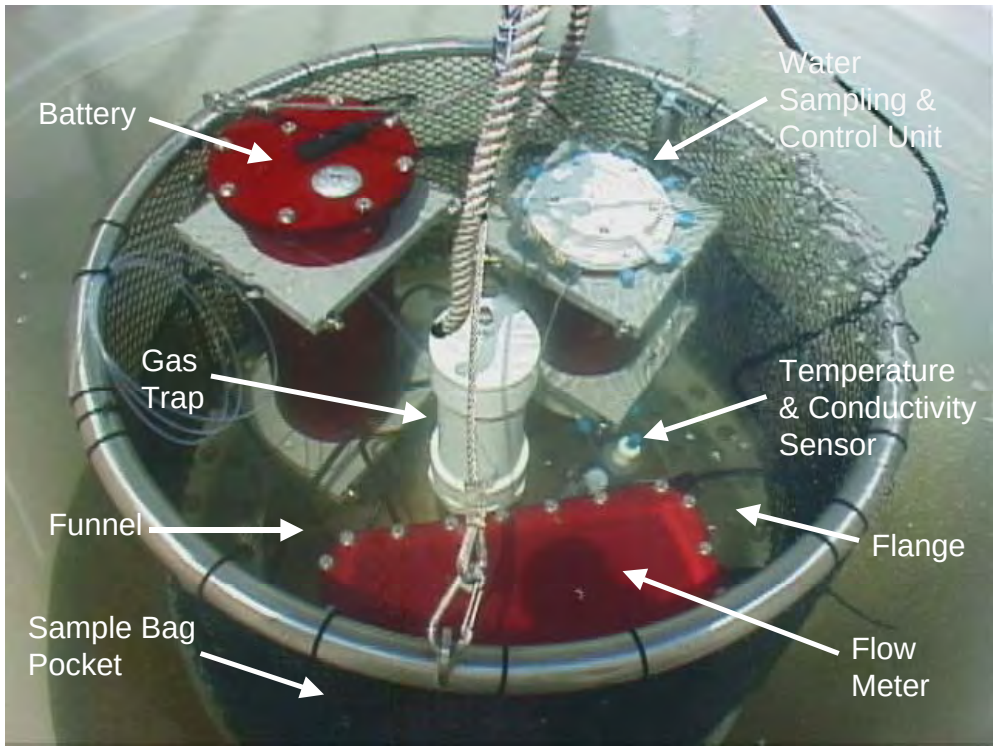
Technologies - UltraSeep

- ULTRASEEP System– *A modular, state-of-the-art seepage meter for direct measurement of groundwater and contaminant discharges at the surface water interface*

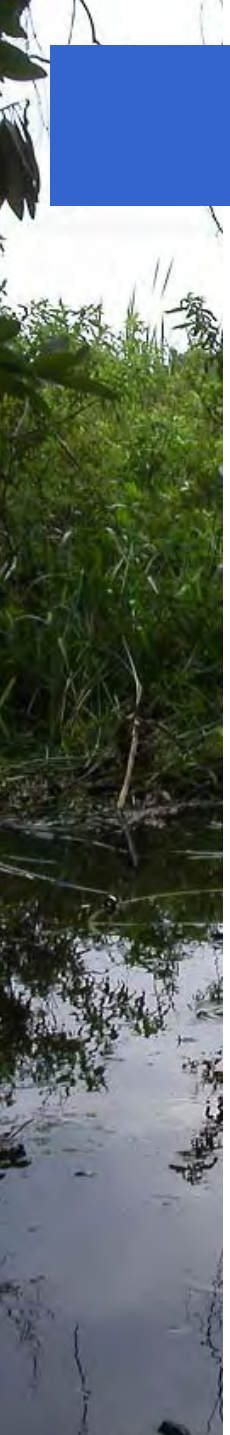
- Ultrasonic flowmeter – provides direct measurement of groundwater flow
- Water sampler - Low-flow peristaltic pump with sample selector valve and sample-bag array
- On-board sensors/controller - Temperature and conductivity on-board, controller stores data and controls sampling events

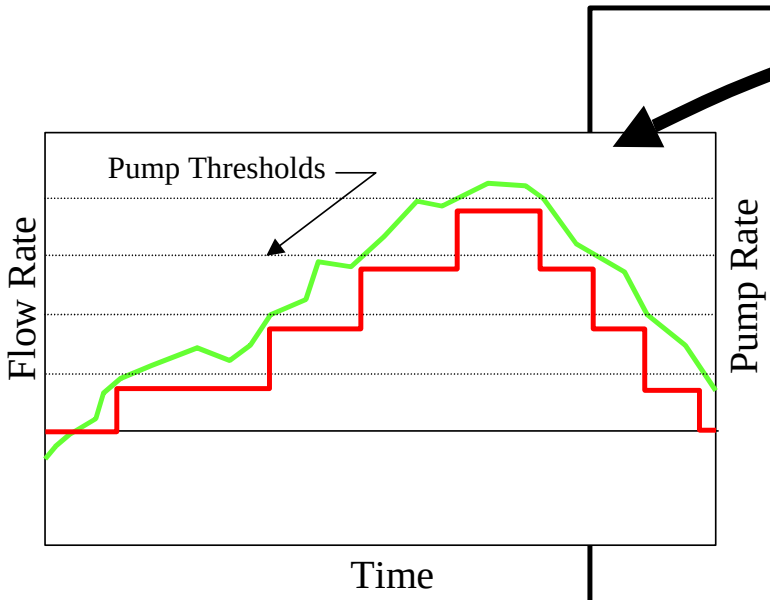
UltraSeep Components & Specifications

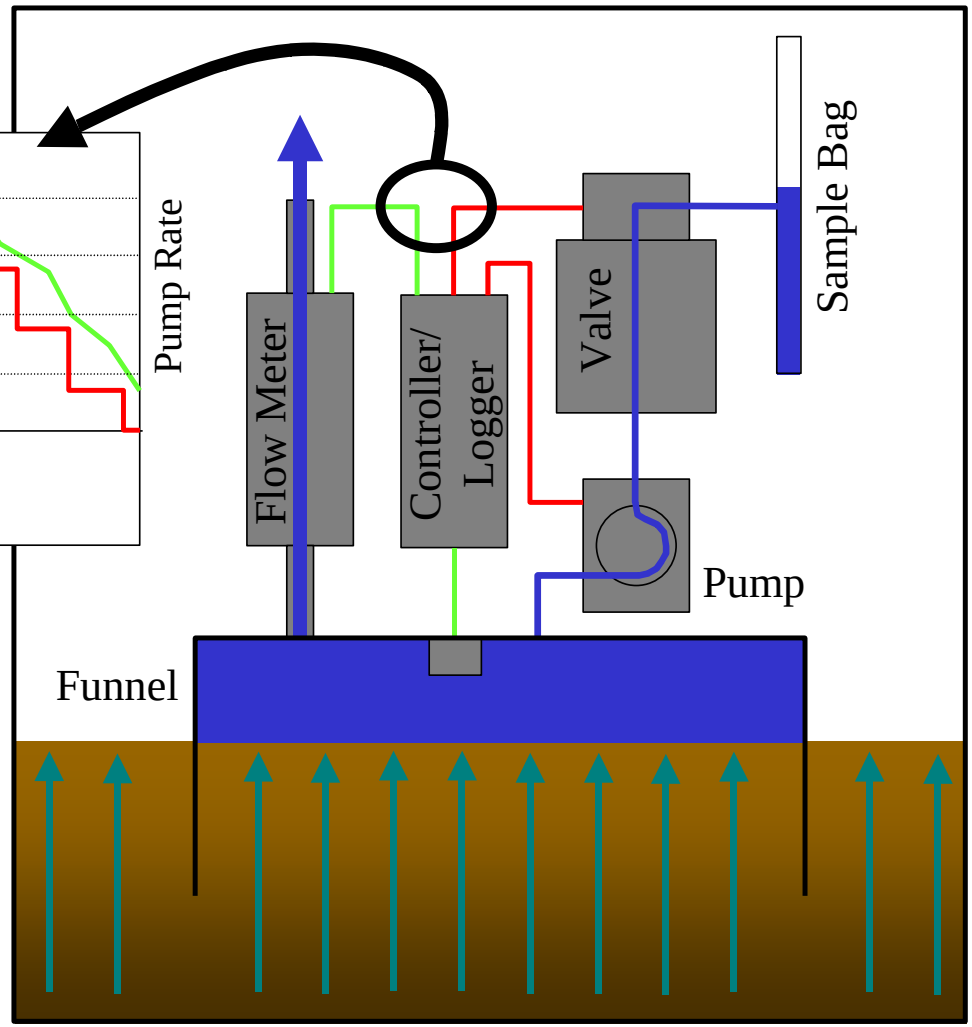
- Ultrasonic flowmeter: Detection of specific discharge or recharge in the range of 0.5 - 150 cm/d
- Water Sampler: Programmable collection at 0-11 mL/min via 10-port selector valve into pre-cleaned sample bags
- Conductivity: 0-80 ± 0.01 mS/cm
- Temperature: -5-45° ± 0.001° C
- Controller: Monitors flow, conductivity and temperature and controls sample sequence for deployment periods up to 4 days



UltraSeep Functional Schematic







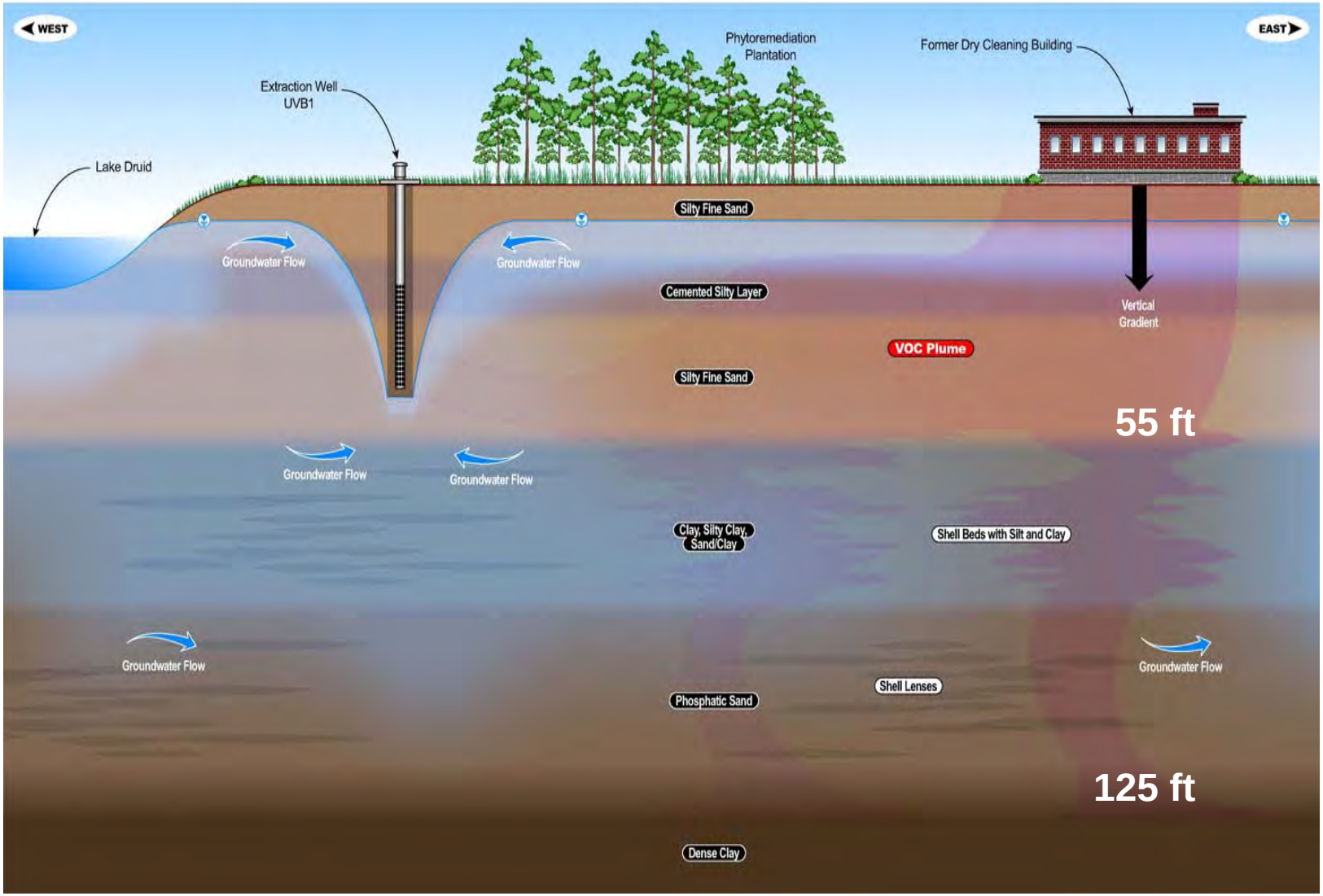
- Feedback control system regulates water sampling
- Maximizes sampling volume without restricting flow

NTC Orlando Demonstration Site

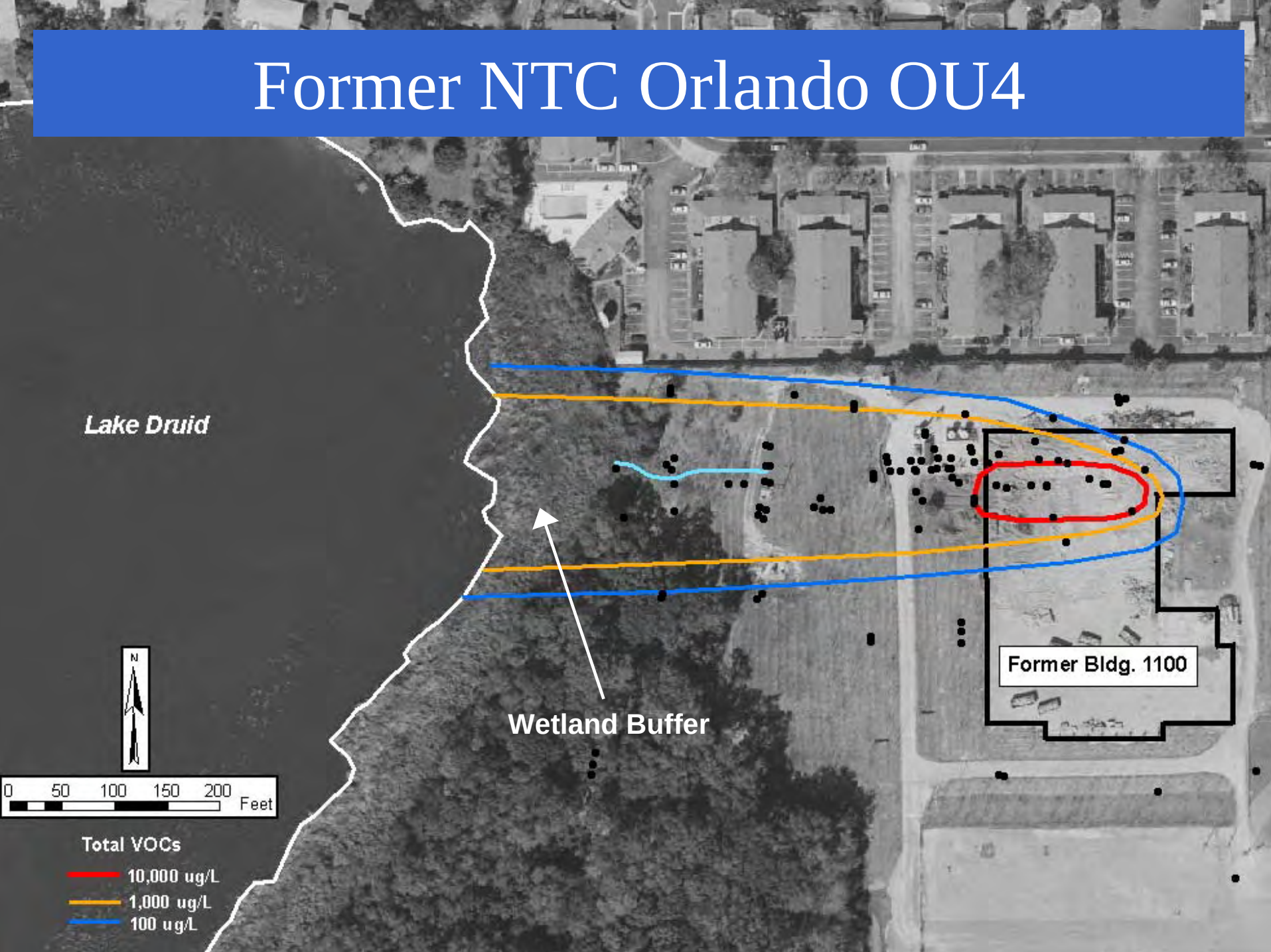
- Groundwater contaminated with VOCs at OU 4 is migrating toward Druid Lake and may pose an unacceptable risk to the environment
- The migration is currently being controlled by a pump and treat system

- Additional data are needed to determine if the VOCs will no longer pose an unacceptable risk to the environment when the pump and treat system is shut down.

Conceptual Site Model

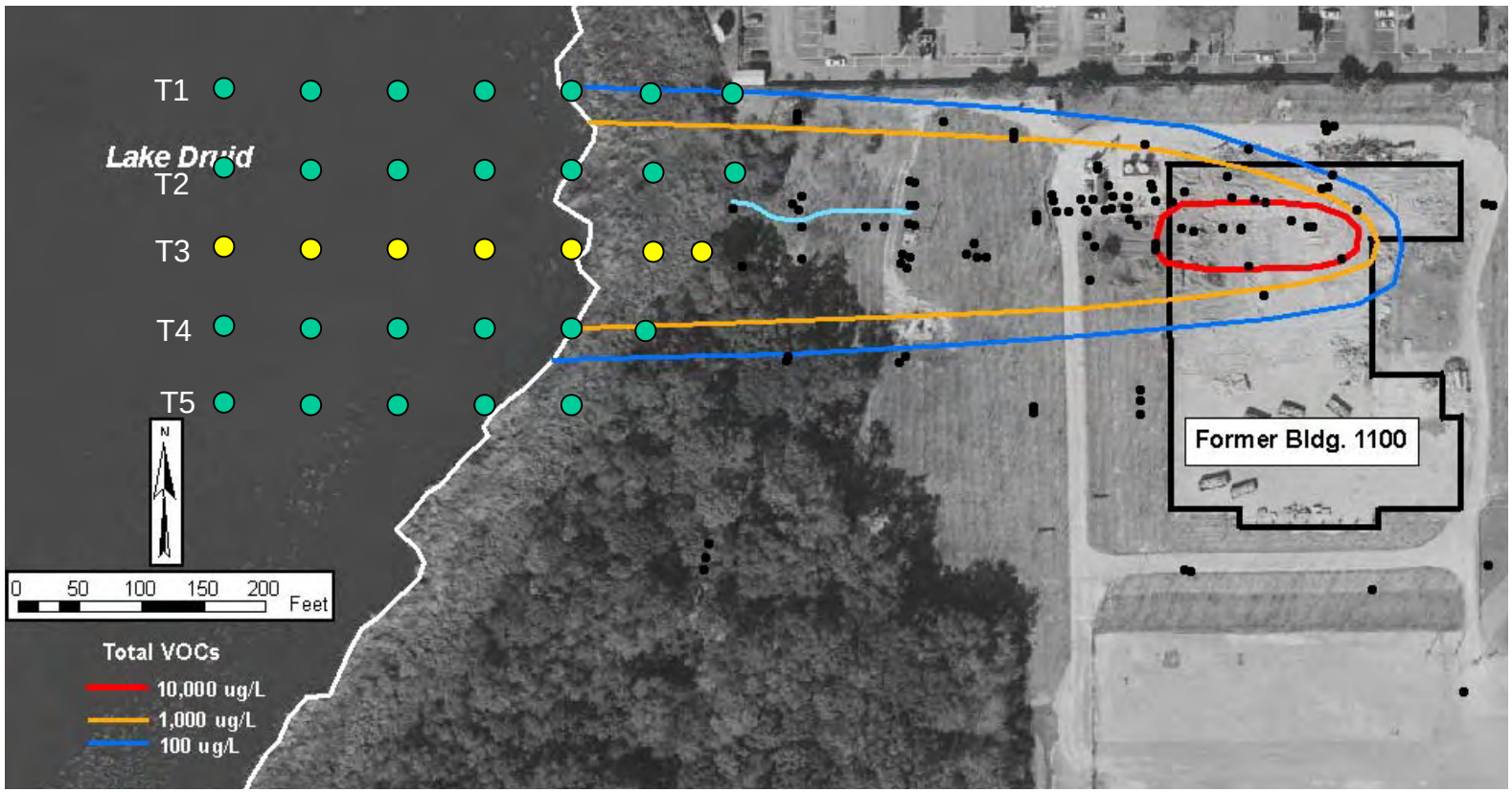


Former NTC Orlando OU4



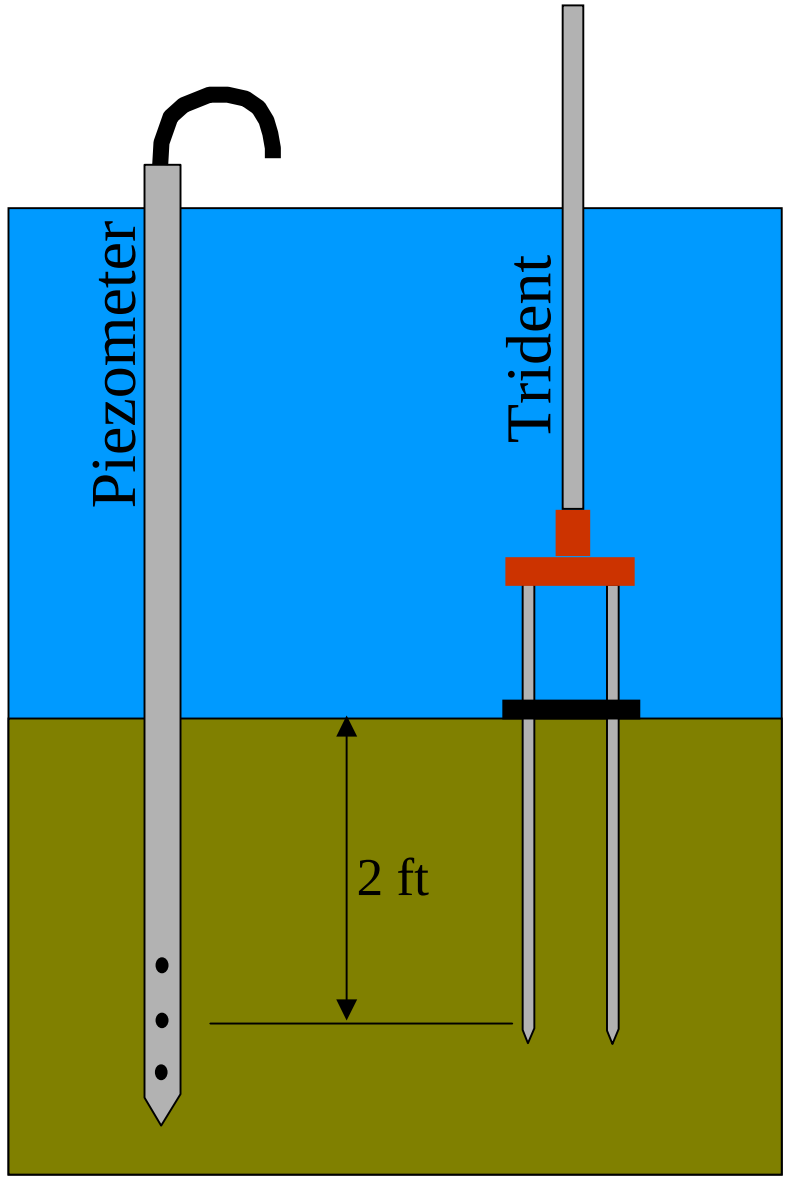
Experimental Design

- Pump and treat system shut down 30 days prior to demonstration
- Use Trident to map offshore groundwater and VOC discharge areas
- Use UltraSeep to quantify groundwater and VOC discharge in identified discharge areas
- Validate Trident and UltraSeep based on comparison to synoptically monitored piezometers



Trident Demo & Validation

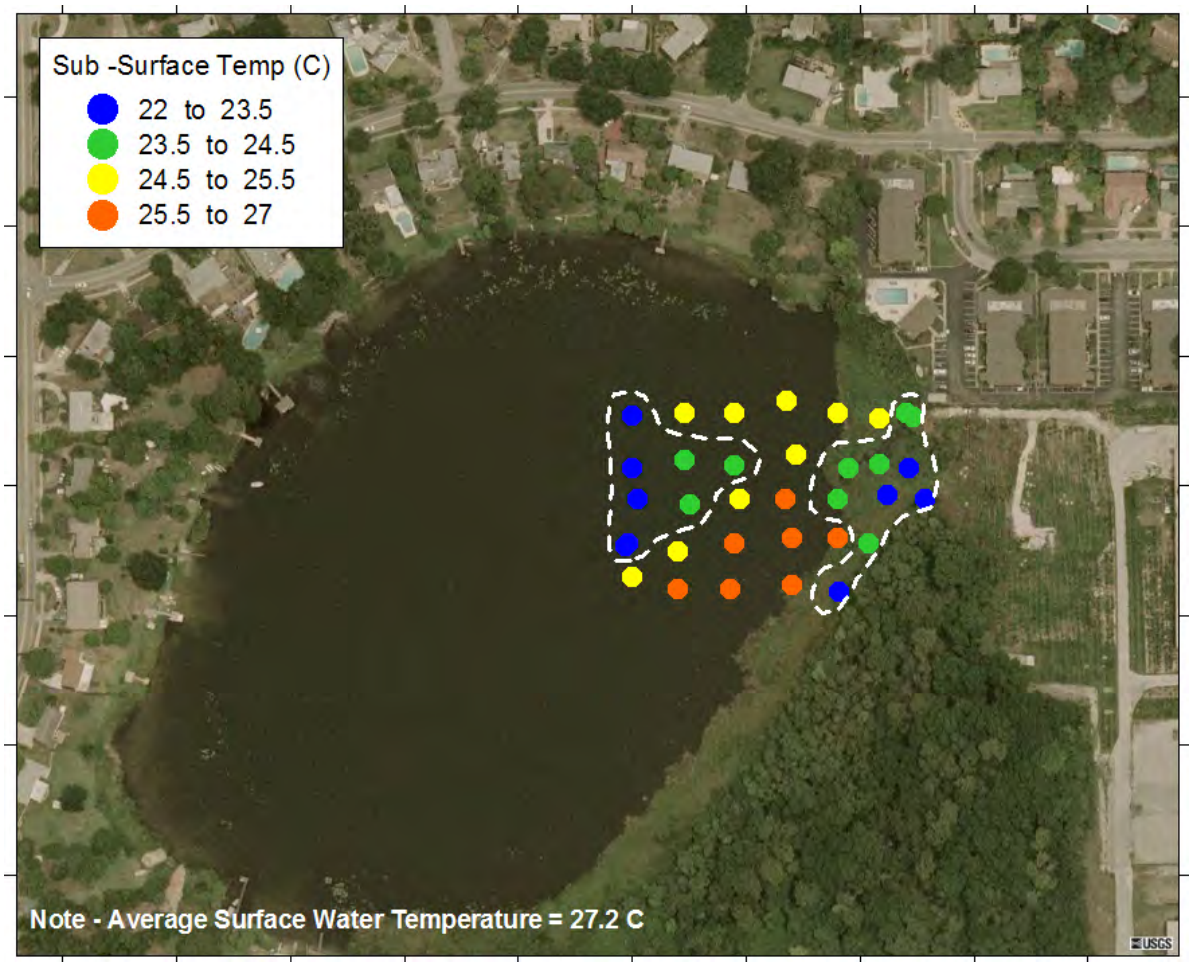
- Trident samples collected at 2 ft depth at 32 (+2) stations
- Validation 2 ft piezometer samples collected at 7 (+2) stations
- Trident results used to map discharge zones and identify UltraSeep stations



Trident Probe Deployment

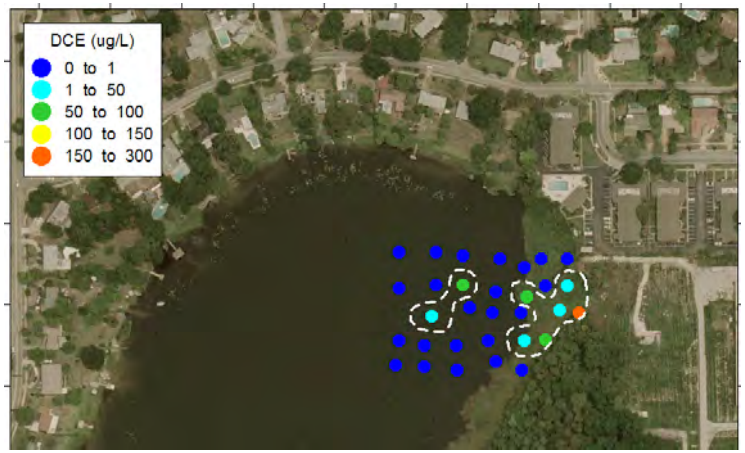
Trident - Sub-Surface Temperature

- Successfully identified two zones of potential groundwater discharge
  - Near-shore zone: extends ~50-100 ft offshore (~3-5 C cooler than surf)
  - Offshore zone: ~200-300 ft offshore (~3-5 C cooler than surf)



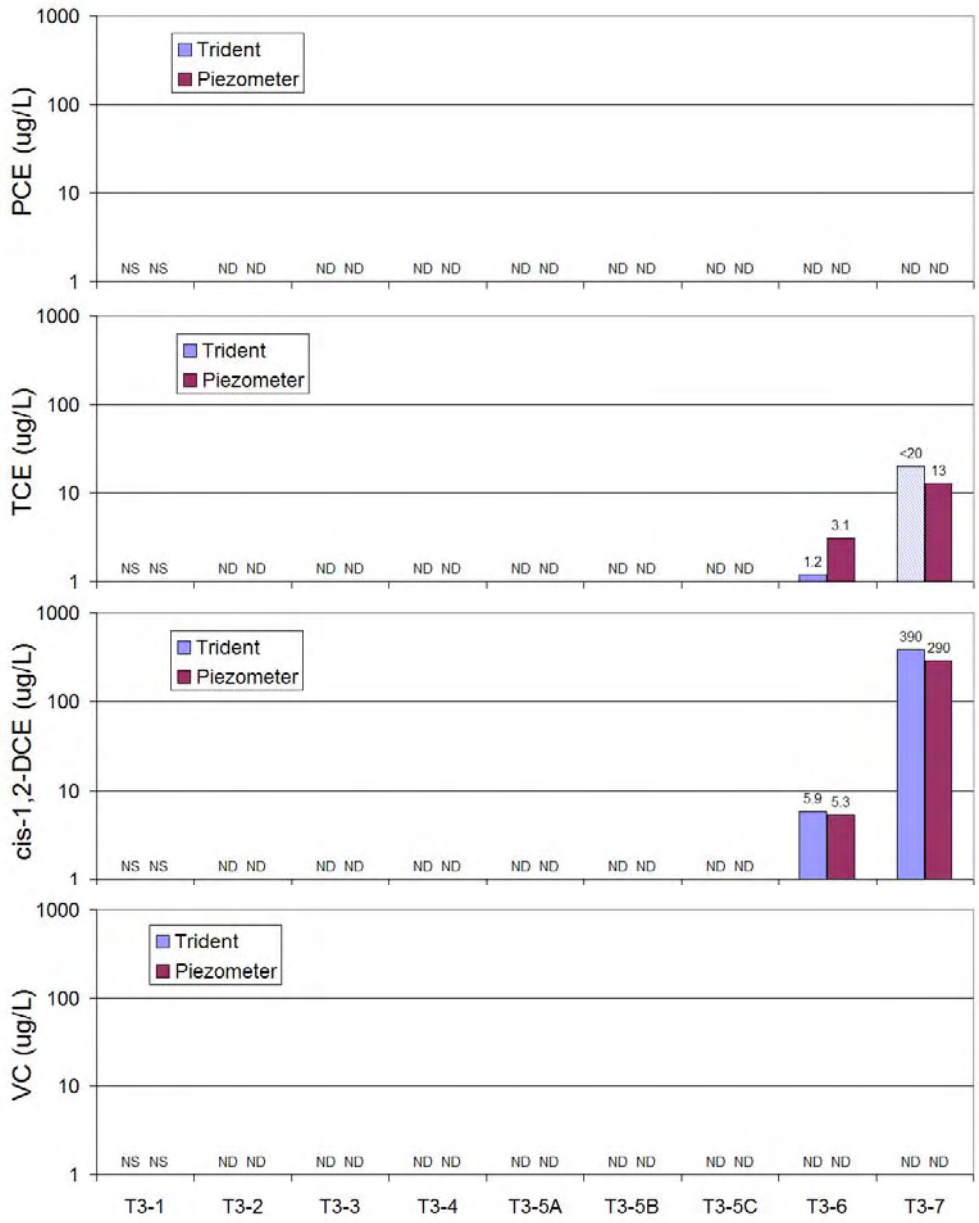
Trident - Sub-Surface VOCs

- Successfully mapped VOC distribution at 2’ bgs
  - VOCs concentrated in nearshore zone
  - Some VOCs detected in offshore zone as well (previously unknown)
  - All VOC detections within zones identified by Trident temperature



Trident – Piezometer VOC Validation

- Validation at 7 stations along transect 3
- All stations showed good agreement for target VOCs Trident vs. piezometers
  - No sample for station T3-1 due to excessive clay
  - High DL for TCE at T3-7 due to high DCE

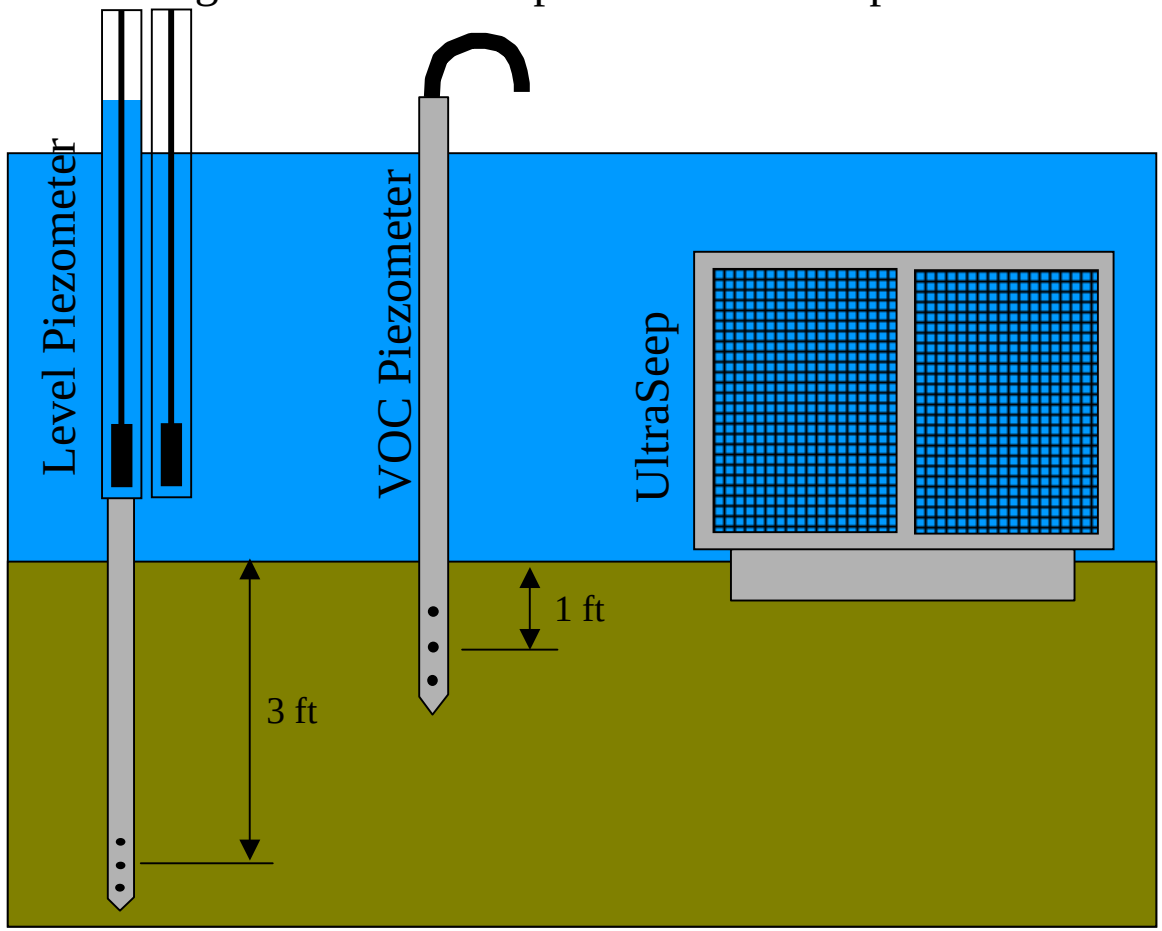


UltraSeep Demo & Validation

- Three stations extending offshore were selected for UltraSeep flow rate and discharge sampling based on Trident results
  - T3-7 had strong temperature signal and elevated VOCs (TCE, DCE)
  - T2-5 had moderate temperature signal and elevated VOCs (PCE, TCE)
  - T2-3 had moderate temperature signal and elevated VOCs (DCE, VC)

UltraSeep Demo & Validation

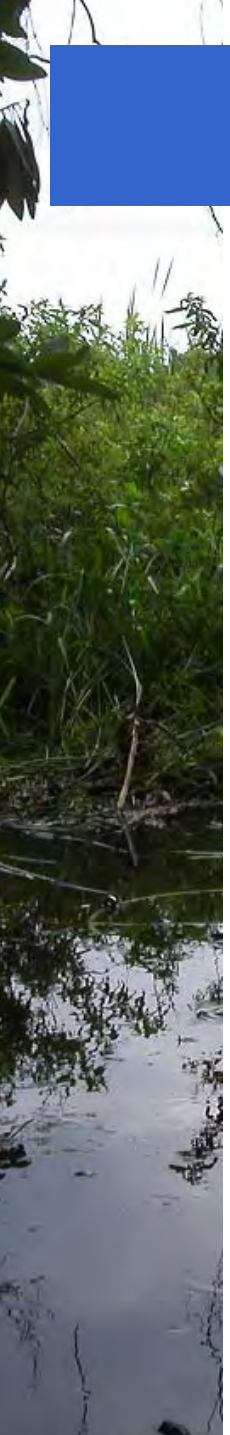
- At each UltraSeep station:
  - UltraSeep deployed for 24 hour period
  - Groundwater discharge validation 3/0 ft pressure-logging piezometers in triplicate w/ slug testing
  - VOC discharge validation 1 ft piezometers in triplicate



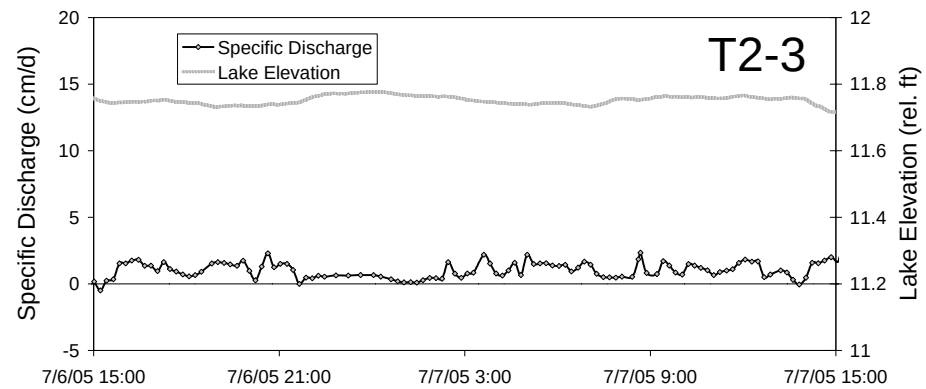
UltraSeep Deployment

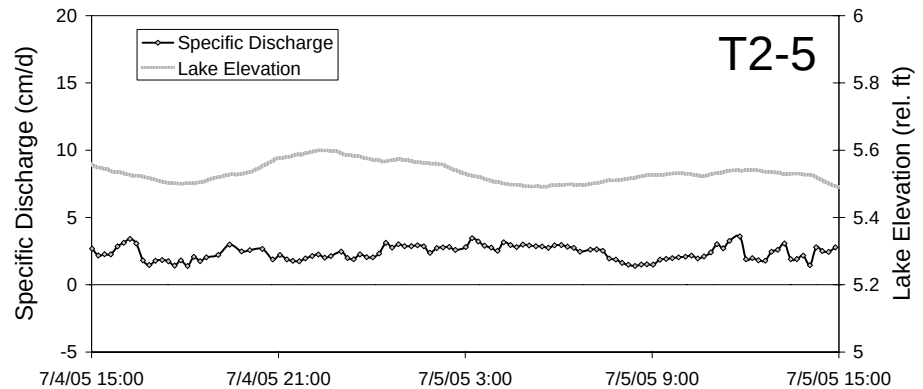
UltraSeep - Groundwater Discharge

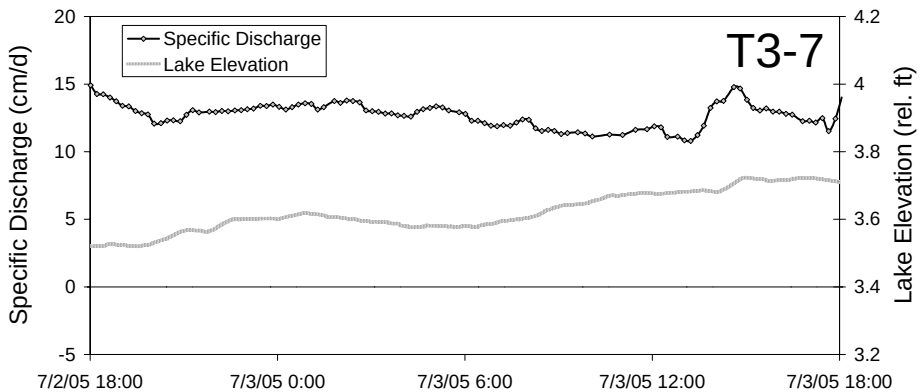
- All three stations showed groundwater discharge
- Strongest discharge near shore, weakest offshore
  - T2-3: 1.1 cm/d
  - T2-5: 2.4 cm/d
  - T3-7: 12.7 cm/d
- Lake levels fluctuate in response to rain events



Offshore



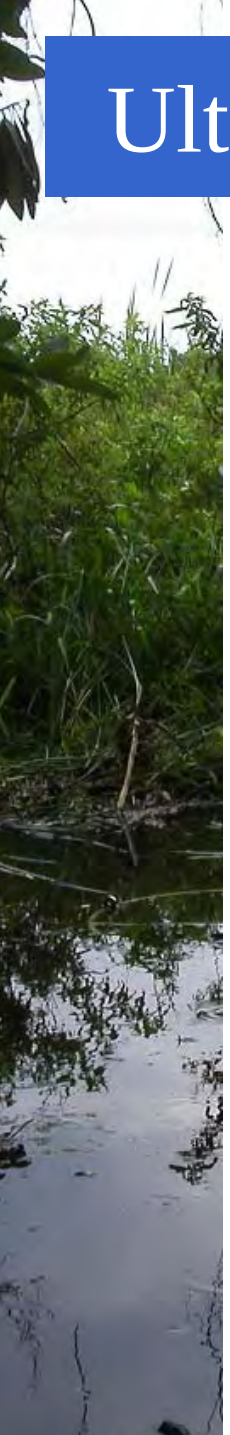


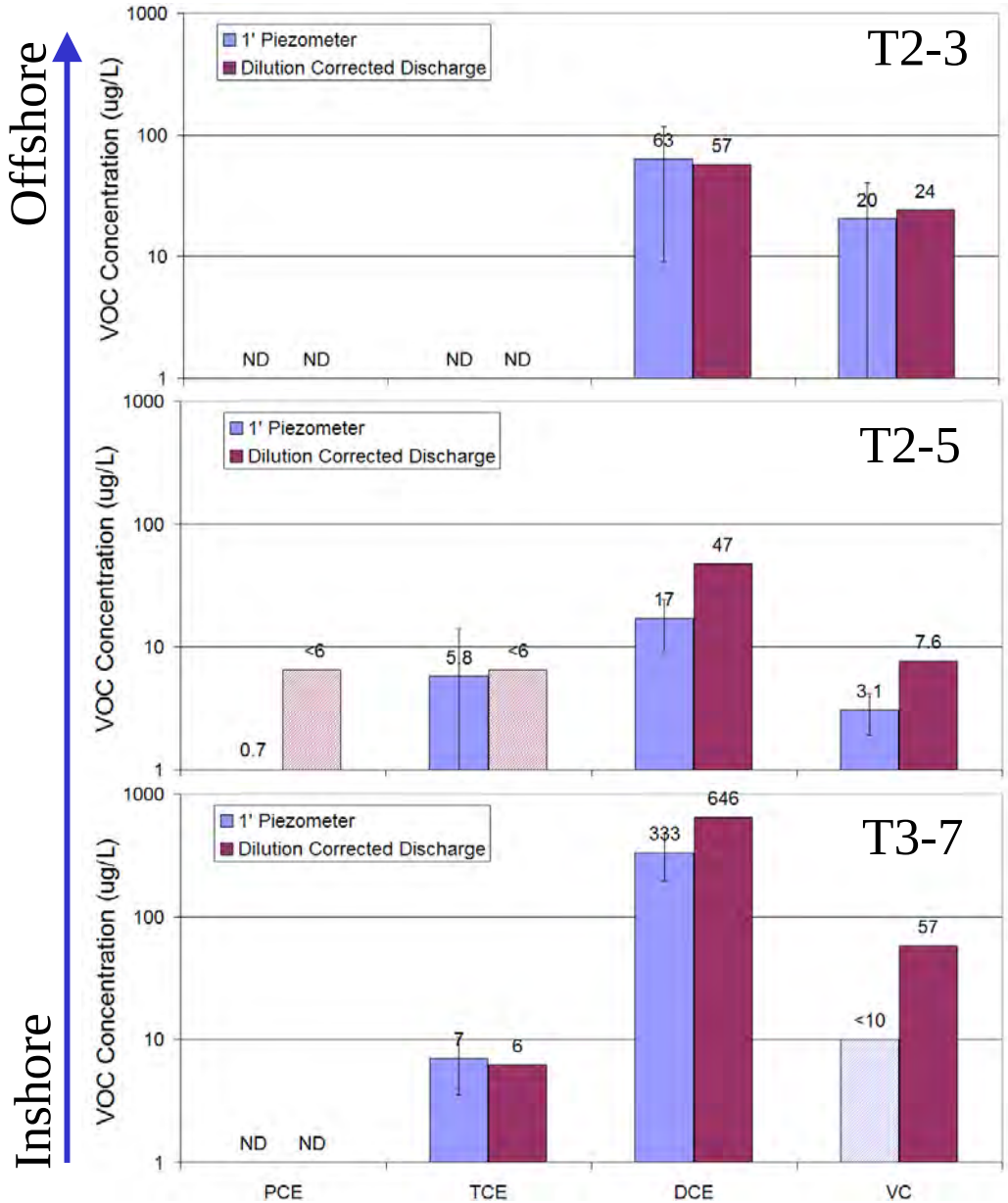


Inshore

UltraSeep - VOC Discharge Concentrations

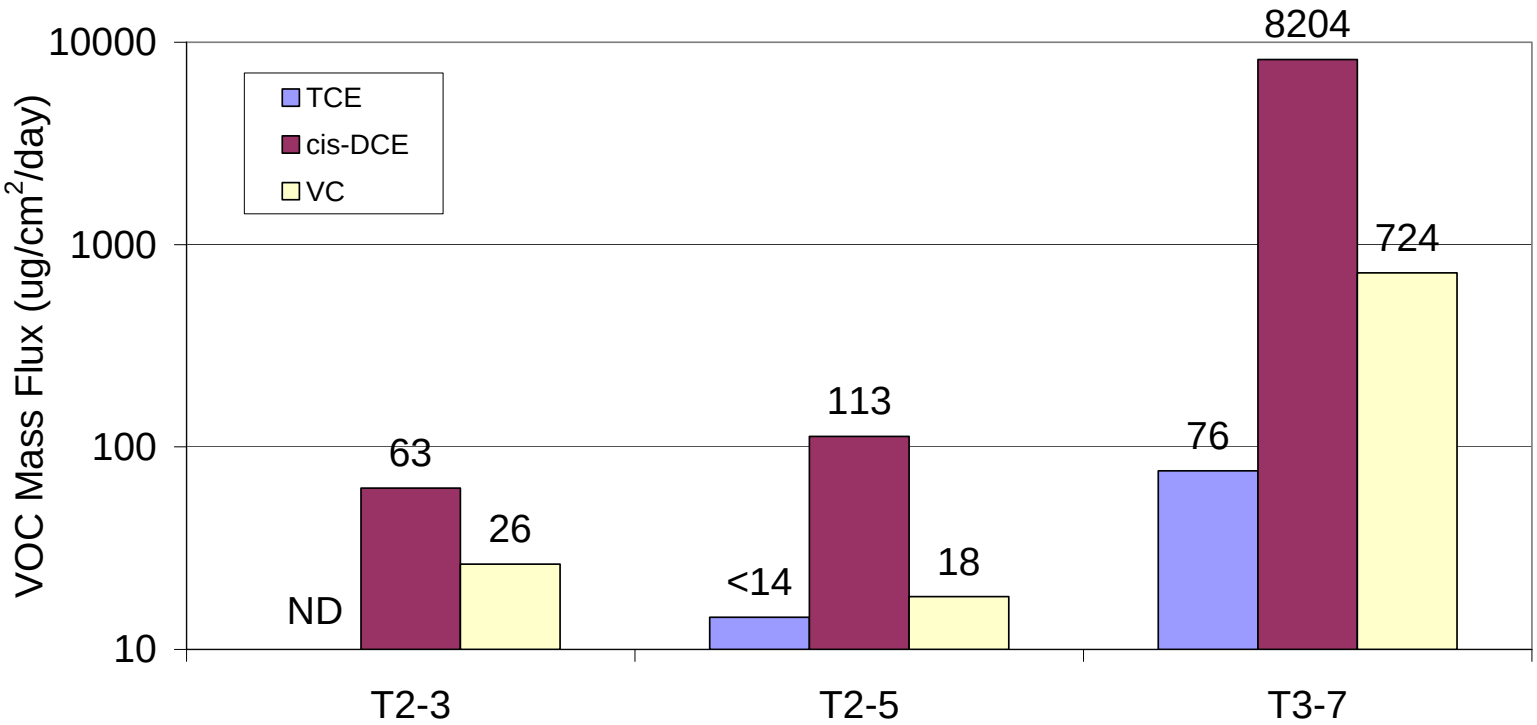
- Discharge compared to triplicate 1’ validation piezometers at each UltraSeep station
- Most stations showed good agreement
  - Low flow effects
  - VC at T3-7



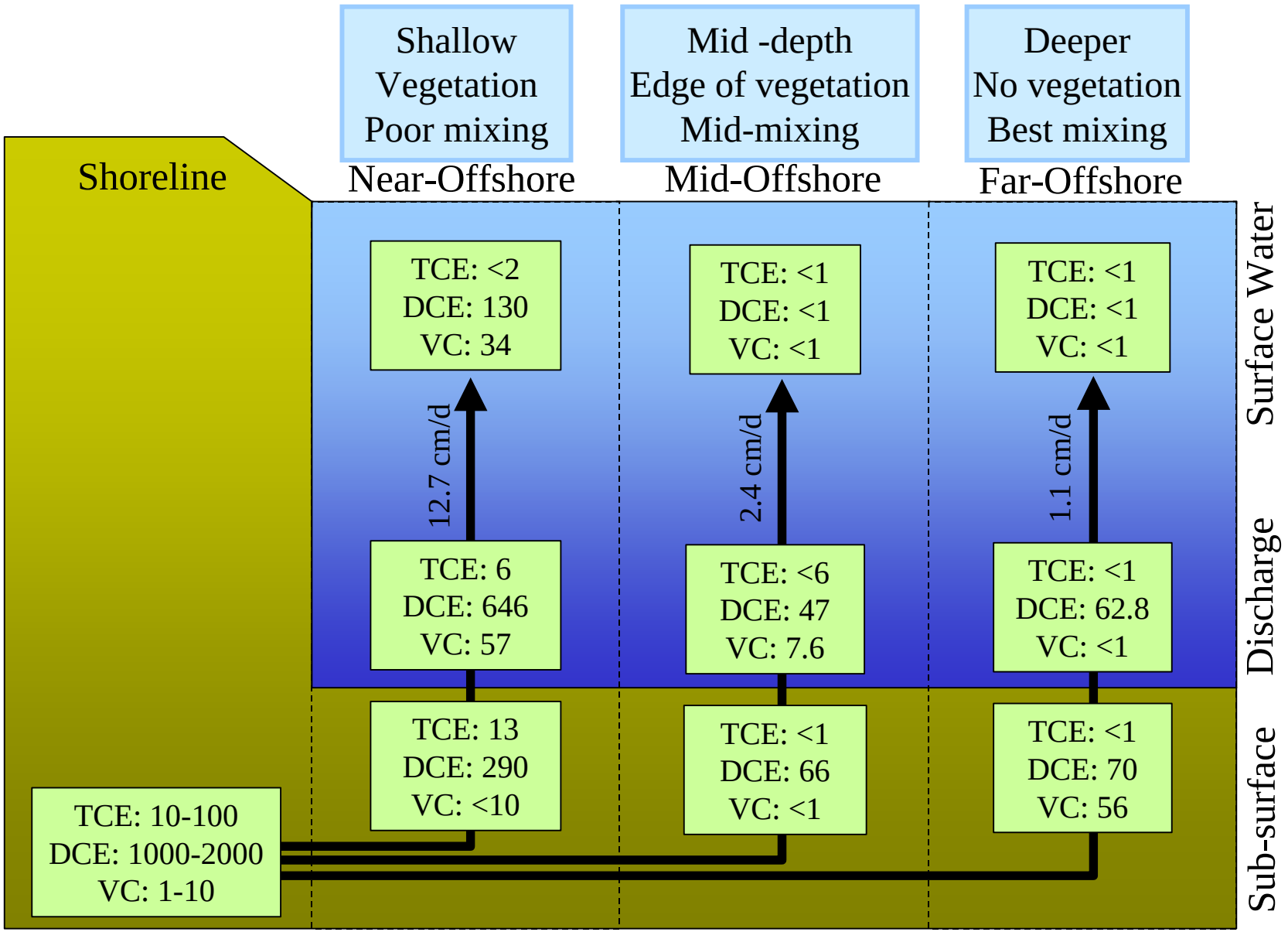


UltraSeep - VOC Mass Flux to Lake Druid

- Mass flux dominated by discharges to near shore zone (T3-7)
- Mass flux interacts with surface water mixing to determine surface water exposure

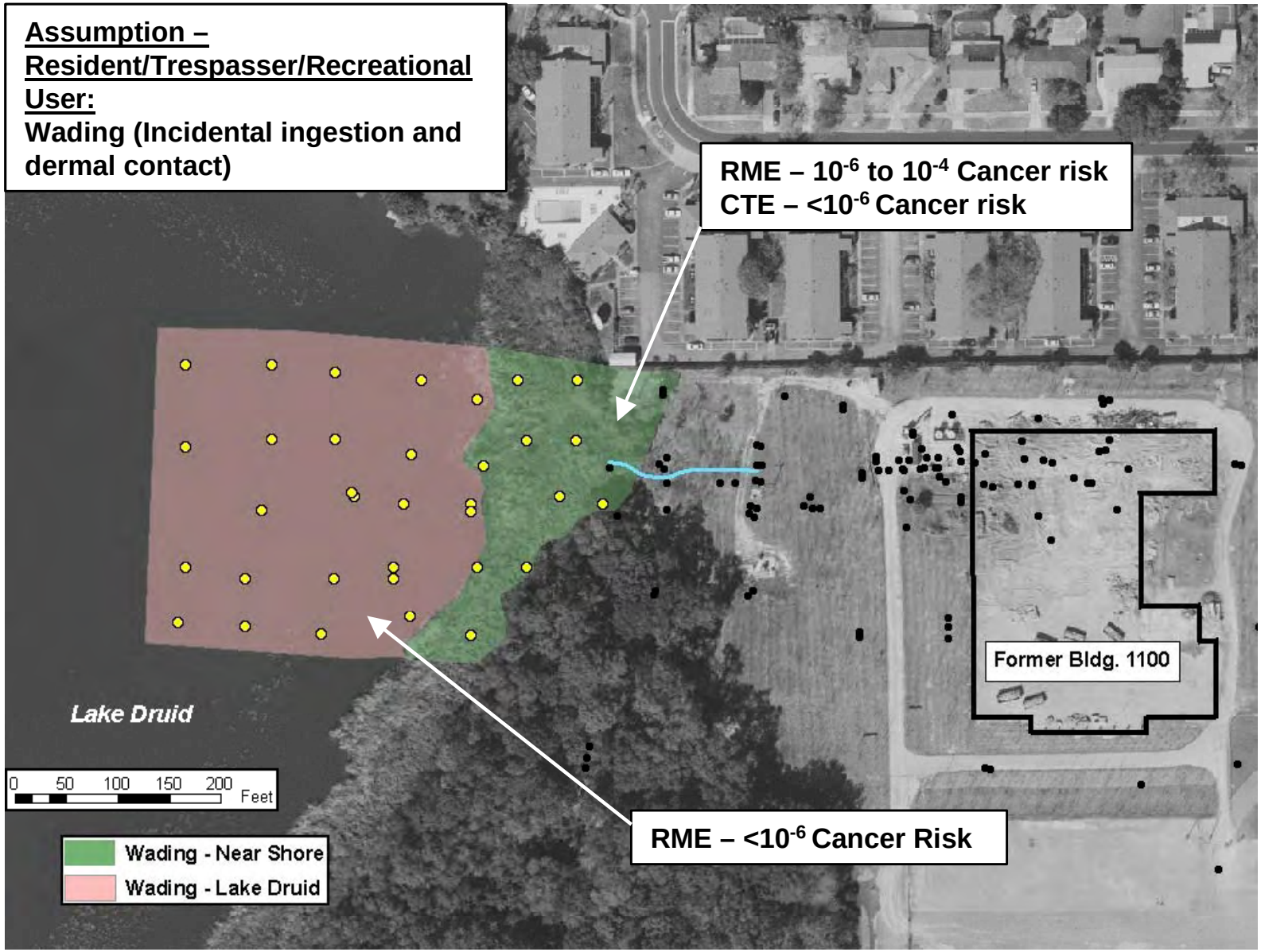


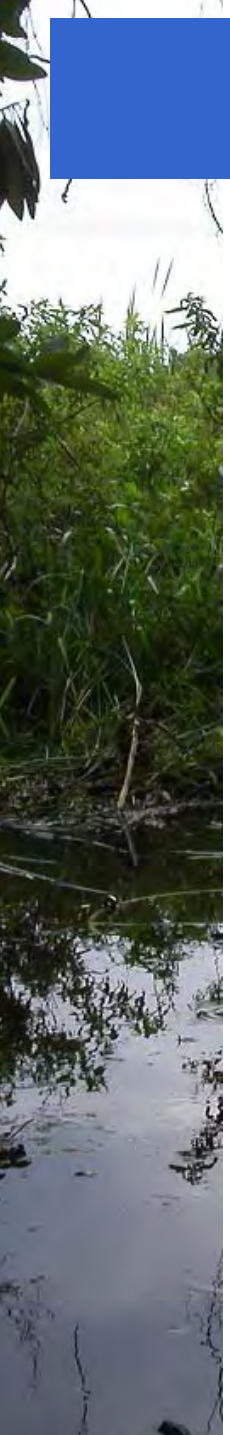
Transport, Mass Flux & Attenuation



Risk Evaluation

Assumption – Resident/Trespasser/Recreational User:
Wading (Incidental ingestion and dermal contact)





Summary

- Characterization
  - Trident temperature contrast was useful in identifying groundwater discharge zones
  - Trident water sampler mapped subsurface offshore VOC distribution
  - UltraSeep flow measurements confirmed and quantified groundwater discharge zones
  - UltraSeep discharge water allowed comparison of relative mass flux for different zones
- Validation
  - Trident and UltraSeep results are consistent with baseline validation piezometer results
- Exposure and Risk
  - Surface water exposure scenario is dominated by high discharge rate, high concentration and low mixing in near-shore zone
  - Risk based on CTE exposure parameters is minimal
- Remedy
  - Continue pump and treat system, monitor near shore discharge zone, then switch over to MNR

Questions/Comments