Coastal Contamination Migration Monitoring

RTDF Workshop
Groundwater – Surface Water Interaction
October 29, 2002

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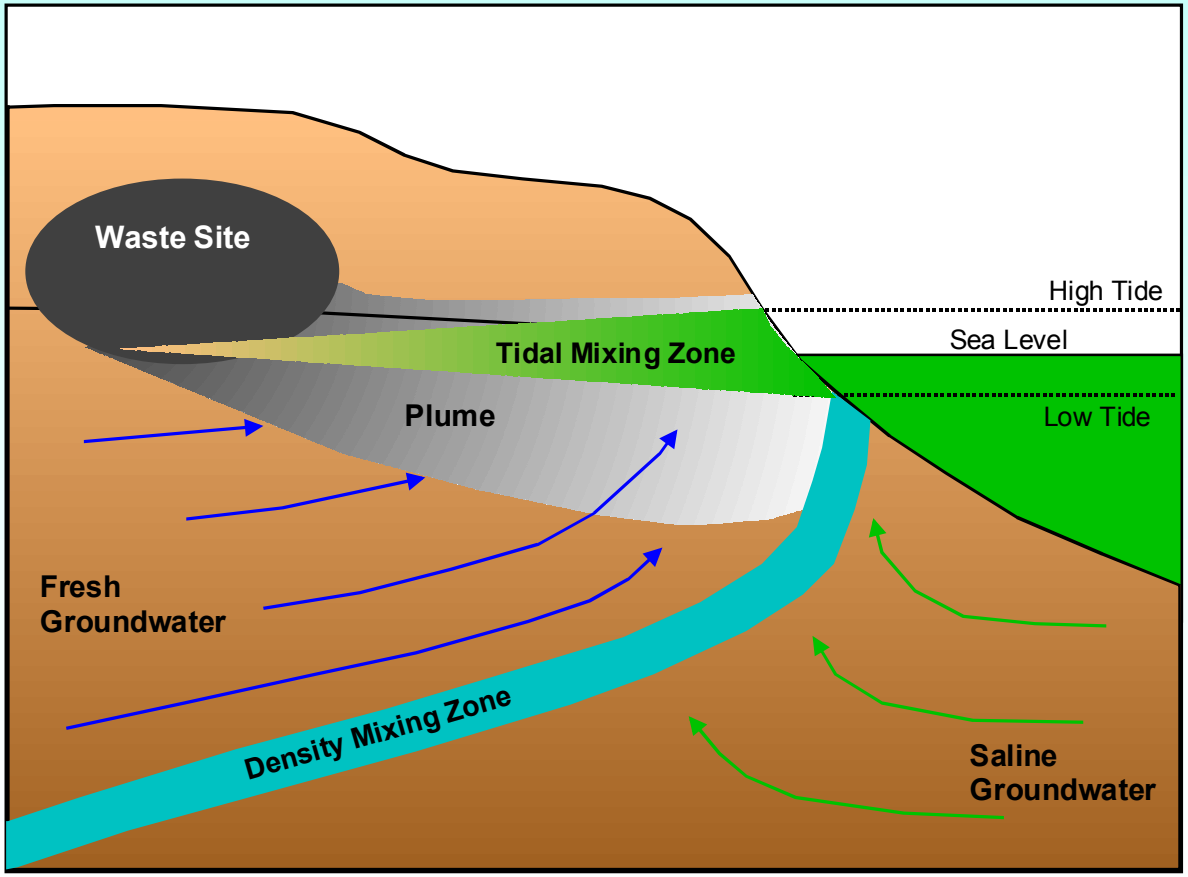
Groundwater – Surface Water Interaction Zone



Contaminated Groundwater Discharging to a Surface Water Body

- Does the groundwater interact with surface water?
- Where does the groundwater impinge?
- Are contaminants migrating?
- What regulations apply?
- Is there significant attenuation?
- Point of exposure vs. point of compliance

Scope of the Navy Problem

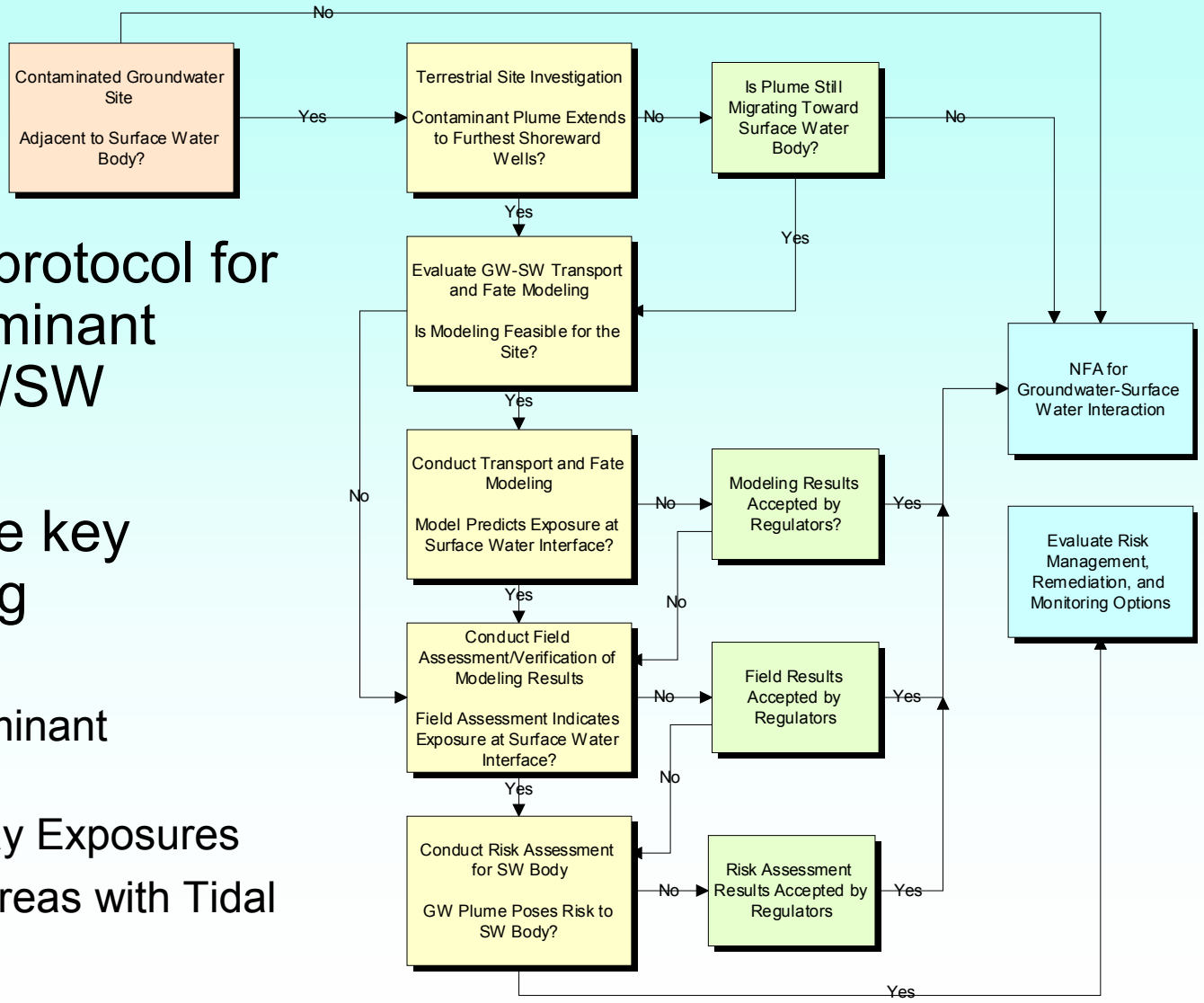
Cleanup sites with landfills/plumes located adjacent to harbors, bays, estuaries, wetlands, and other coastal environments

- **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

Generalized Approach and Technology Gaps

- Typical Navy protocol for coastal contaminant sites with GW/SW Interaction
- Identified three key areas requiring development
  - Flow & Contaminant Detection
  - In-situ Bioassay Exposures
  - Modeling for Areas with Tidal Influence



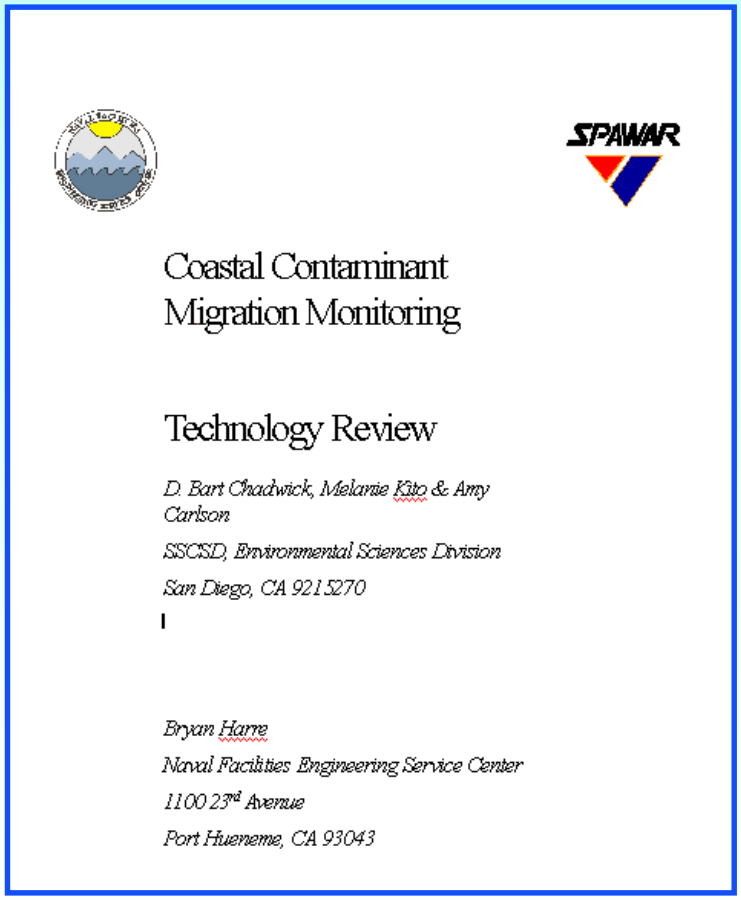
Technology Selection

Technologies Evaluated

- Flow Detection
- Contaminant Detection

Technologies Selected for Development & Demonstration

- Temperature/Conductivity/Pore water Probe
- Ultrasonic Multi-sample Seepage Meter



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Coastal Contaminant Migration Monitoring

Technology Review

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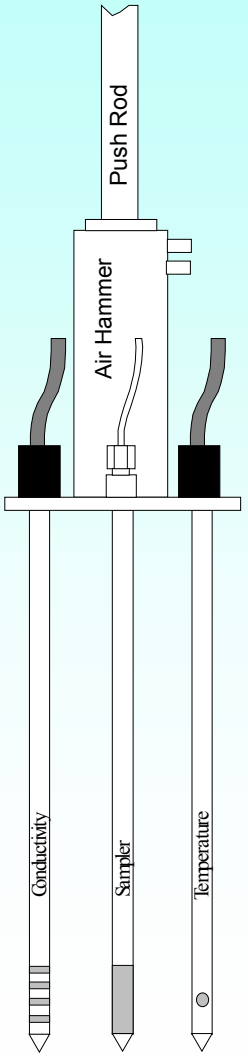
TRIDENT Probe

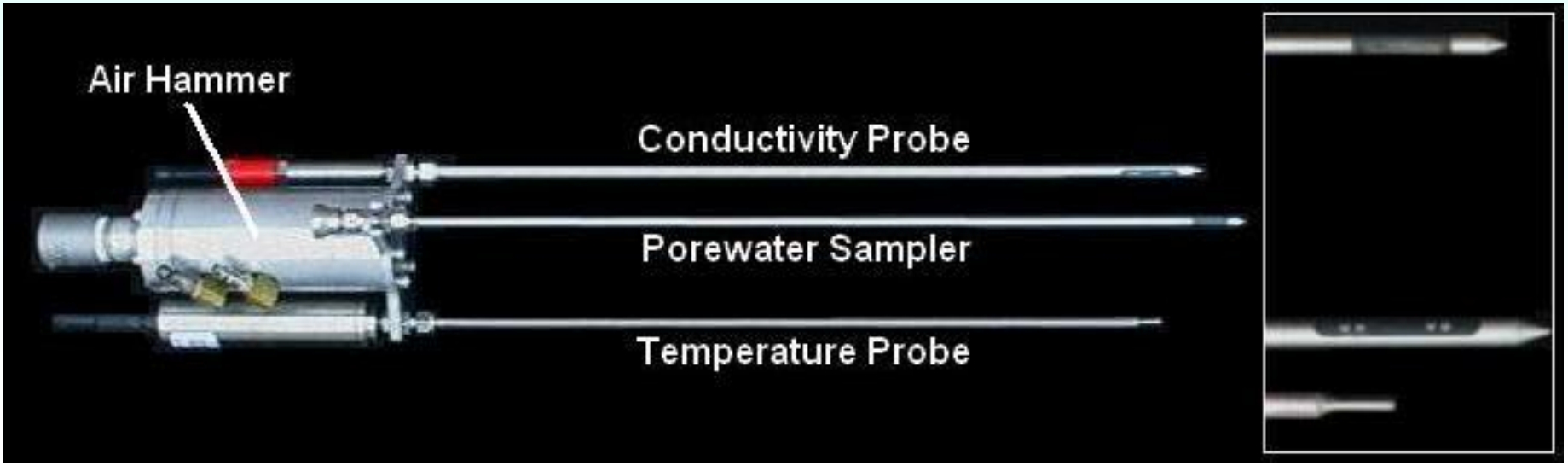
A flexible, multi-sensor water sampling probe for screening and mapping groundwater plumes at the surface water interface



- **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**

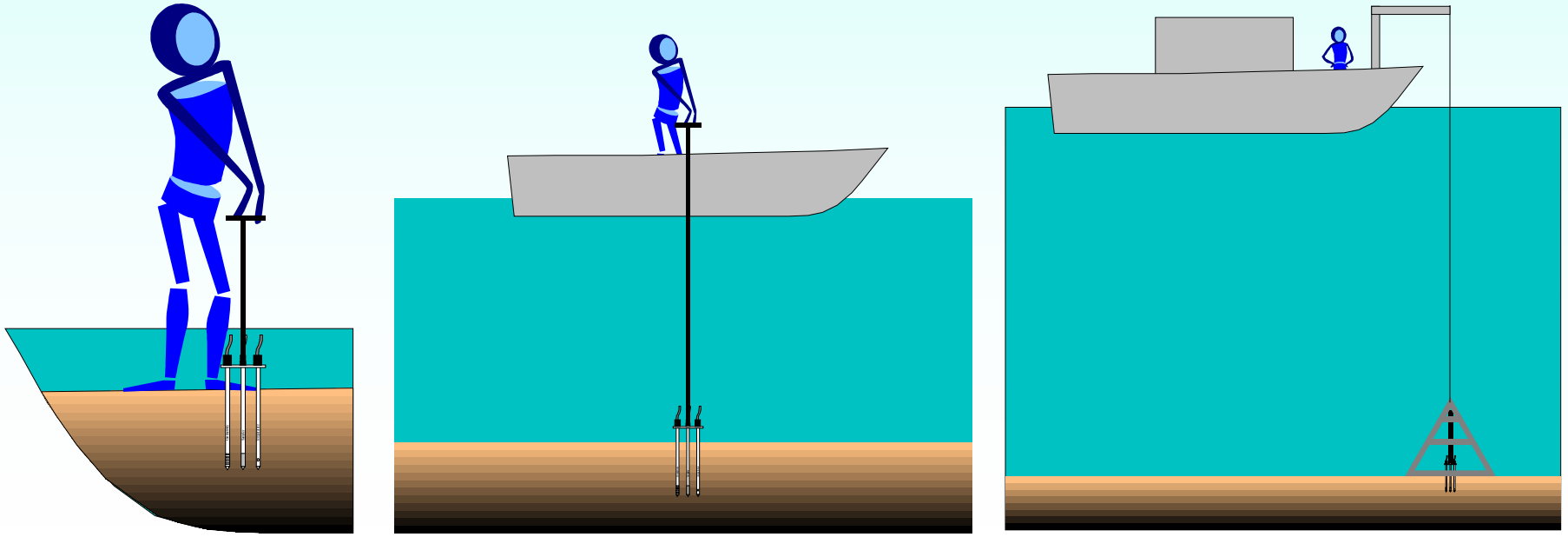
TRIDENT Technical Specifications

- **Probe Length: 60cm**
- **Stainless Steel Construction**
- **Conductivity: 0-70 ± 1 mS/cm**
- **Temperature: –5-35° ± 0.001° C**
- **Porewater: Vacuum collected through mesh screen with pore size ~240 µm**



TRIDENT Field Deployment

- **Very Shallow (0'-3')** - Manual Deployment from Shore
- **Shallow (2' – 30')** – Manual Deployment from Small Boat
- **Deep (30'- 60')** – Remote Deployment with Bottom Lander or by diver



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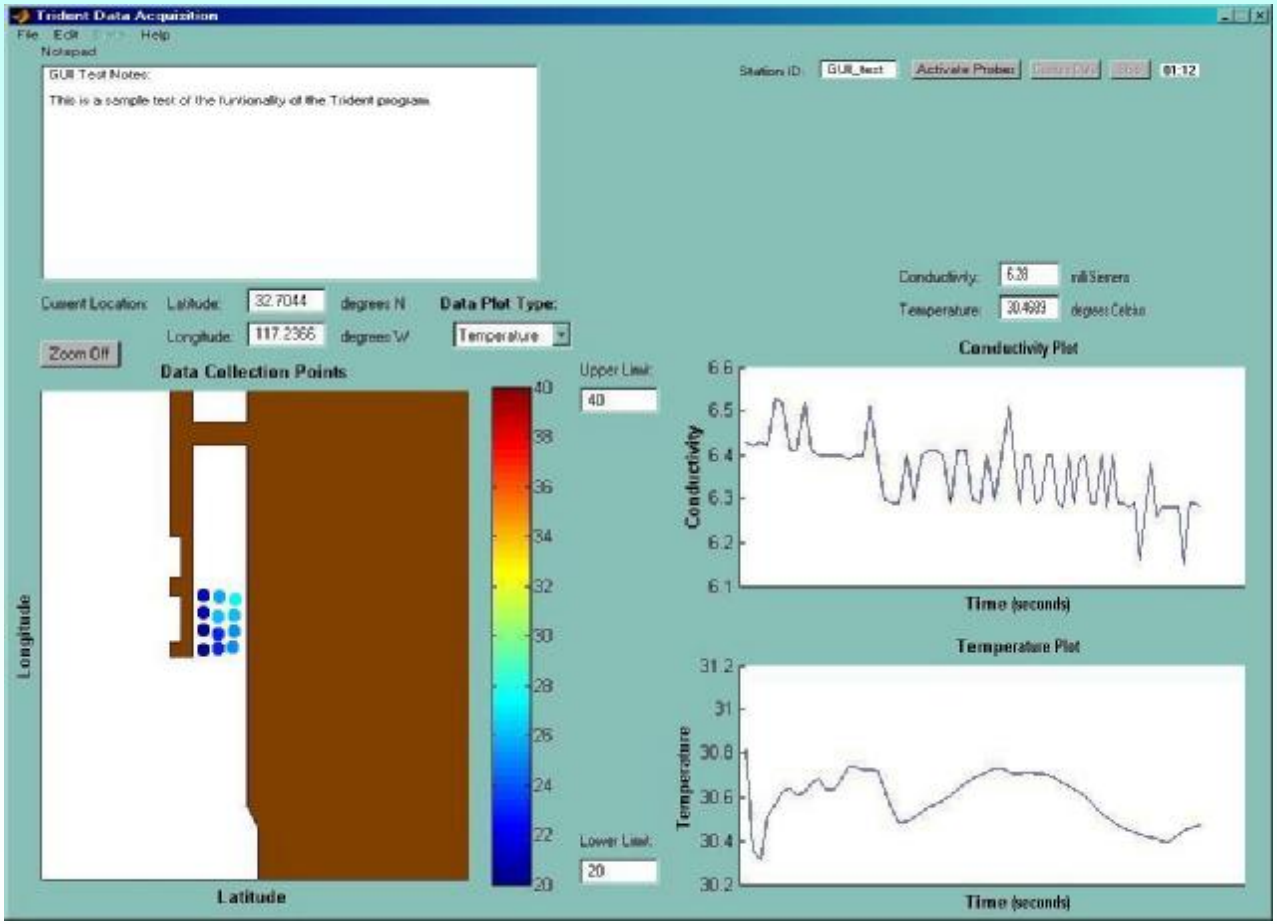
TRIDENT Probe User Interface

- **Integrates GPS, temperature and conductivity signals**
- **Provides real-time display of spatial distribution**
- **Allows input of auxilliary water quality measurements**



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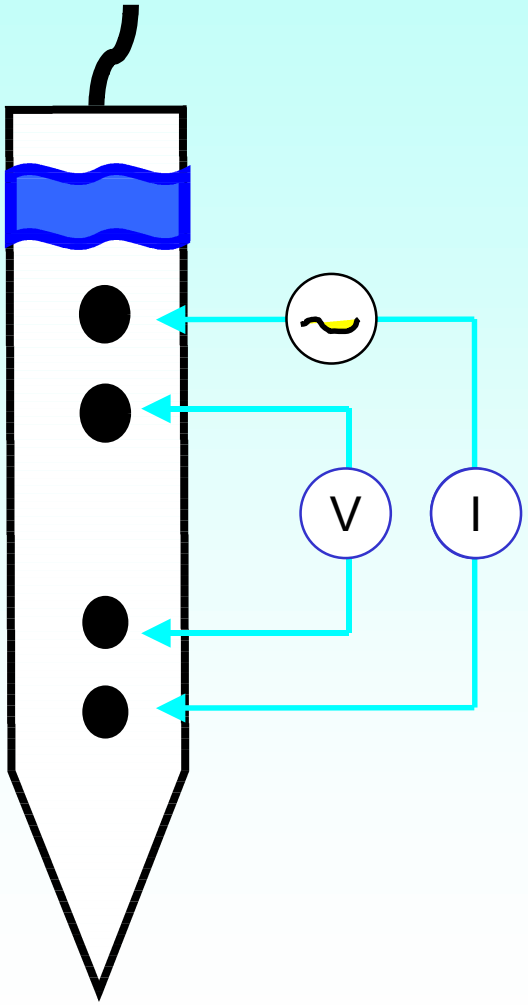
TRIDENT Conductivity Probe Configuration

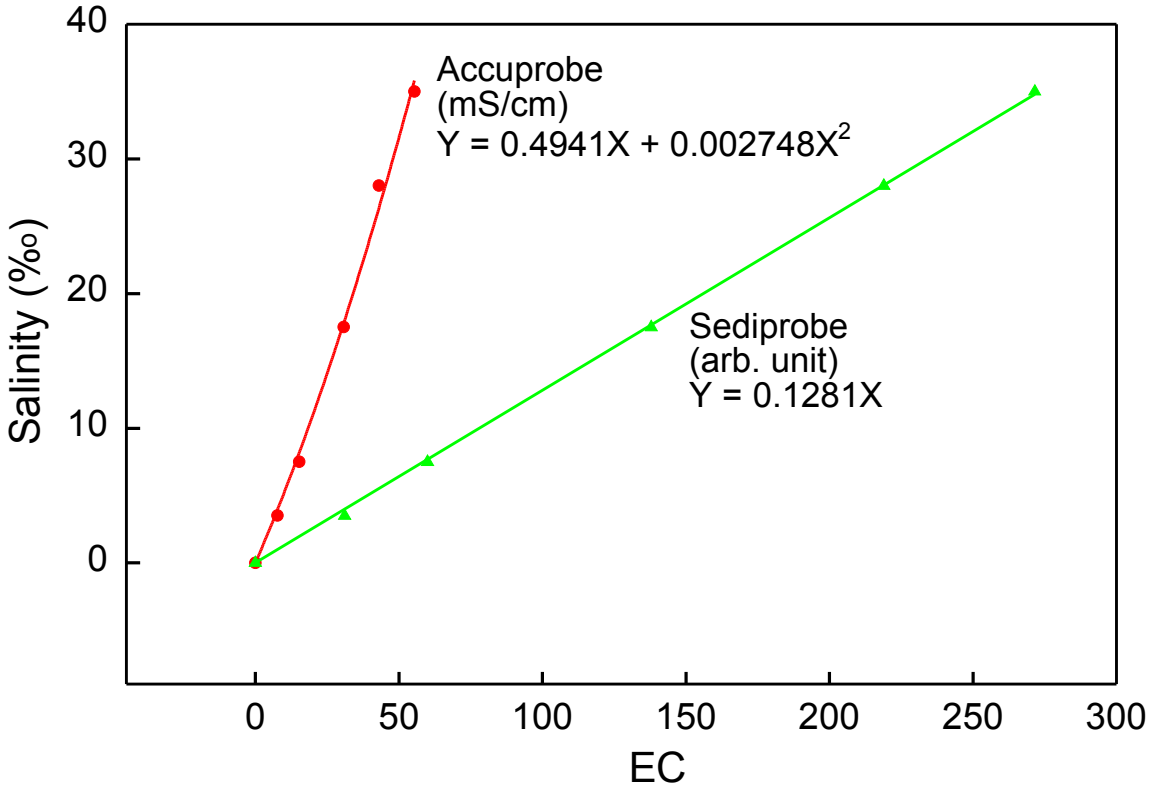
- Custom built submersible four electrode probe
- Utilize “Wenner” or dipole modes to measure resistance across electrodes
- Developed in consultation with Geoprobe
- Compatible with standard Geoprobe deck unit and software



TRIDENT Conductivity Probe Calibration Test

- **Calibrated in solution over broad range of salinity**
- **Calibration curve developed against standard laboratory Accuprobe system**
- **Final values corrected to standard temperature (25 C)**

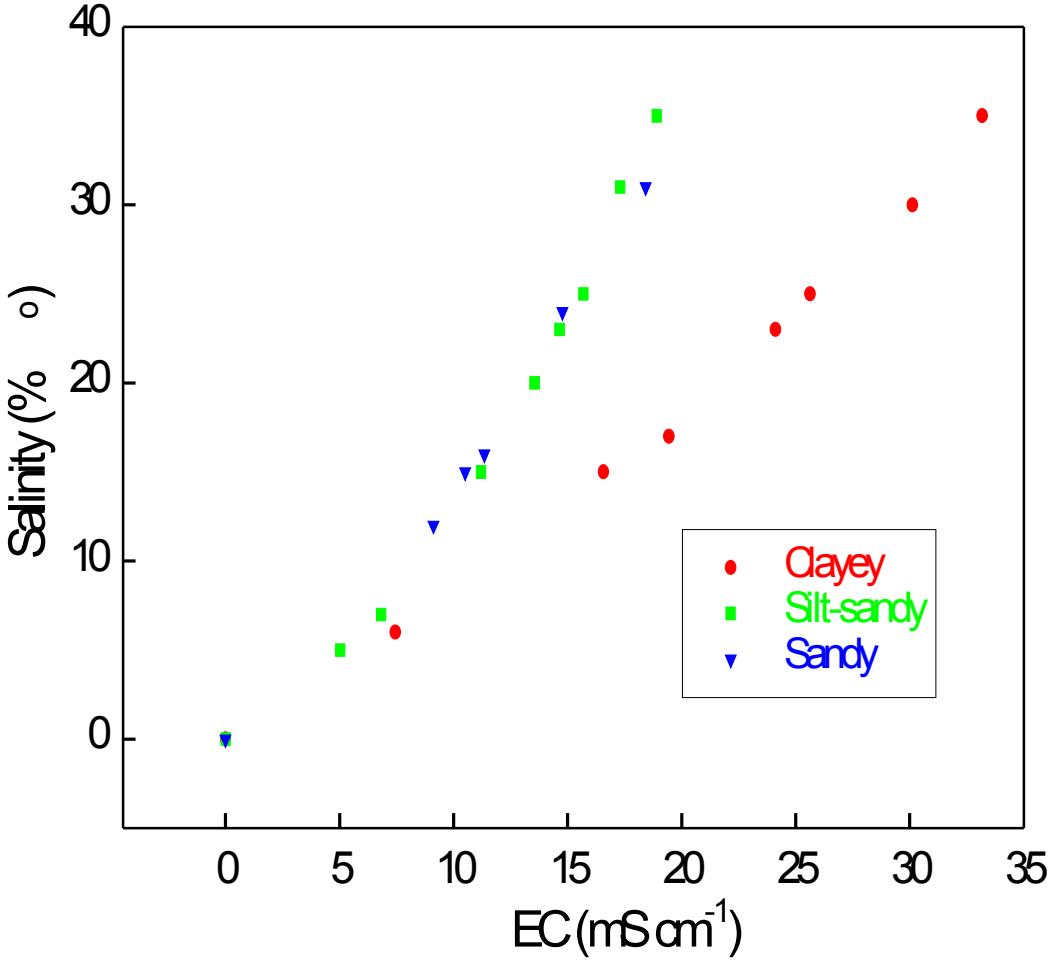
Figure 2. Water salinity vs. electrical conductivity (EC) at 25°C measured by Sediprobe and Accuprobe



TRIDENT Laboratory Sediment Testing

- Testing conducted in a range of sediment types
- Probe response found to be stable and repeatable
- Conductivity of clayey sediments is enhanced by surface conductance of the clay particles
- *Important characteristic is that low salinity and low clay both manifest as low conductivity*

Figure 5. Electrical conductivity of marine sediments



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TRIDENT Probe Field Test Summary

- **Trident and probe components have been field tested at a number of sites**

Test Site	Capability Tested	Deployment Mode
North Island Site 9	Porewater	Shallow Deep
Anacostia River	Porewater	Very shallow Shallow
Eagle Harbor	Porewater	Very shallow Shallow Deep
Kellog's Beach	Conductivity Temperature Porewater	Very shallow
SSC-SD Pier 159	Conductivity Temperature	Shallow
Naval Station Paleta Creek	Conductivity	Deep (Diver)
North Island Site 9	Conductivity Temperature Porewater	Shallow
Naval Station Site 1	Fall 2002 Demo	Deep

TRIDENT Probe Field Test – Kellogg's Beach

- Initial test at Kellogg's Beach storm drain site
- Test in very-shallow water mode

- Profiled conductivity and temperature at ~6" depth intervals along a 100' transect
- Collected porewater confirmation samples for salinity

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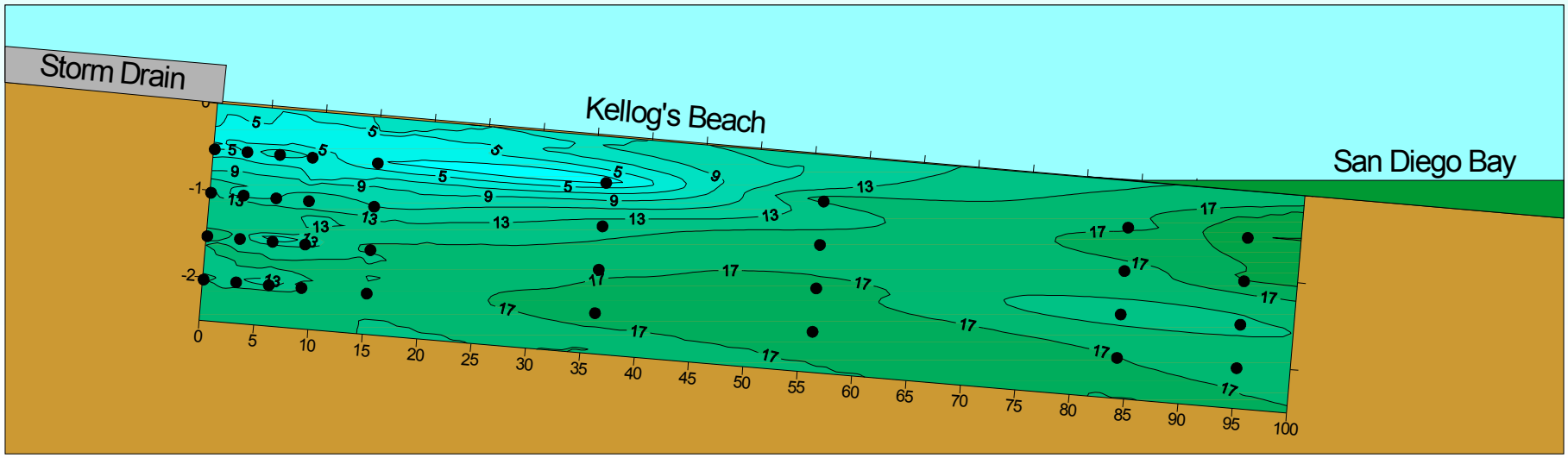
TRIDENT Probe Field Test – Kellogg's Beach

- Successfully deployed and profiled system on site
- Mapped conductivity clearly delineated freshwater plume
- Entire transect completed in ~ 2 hours including collection of water samples



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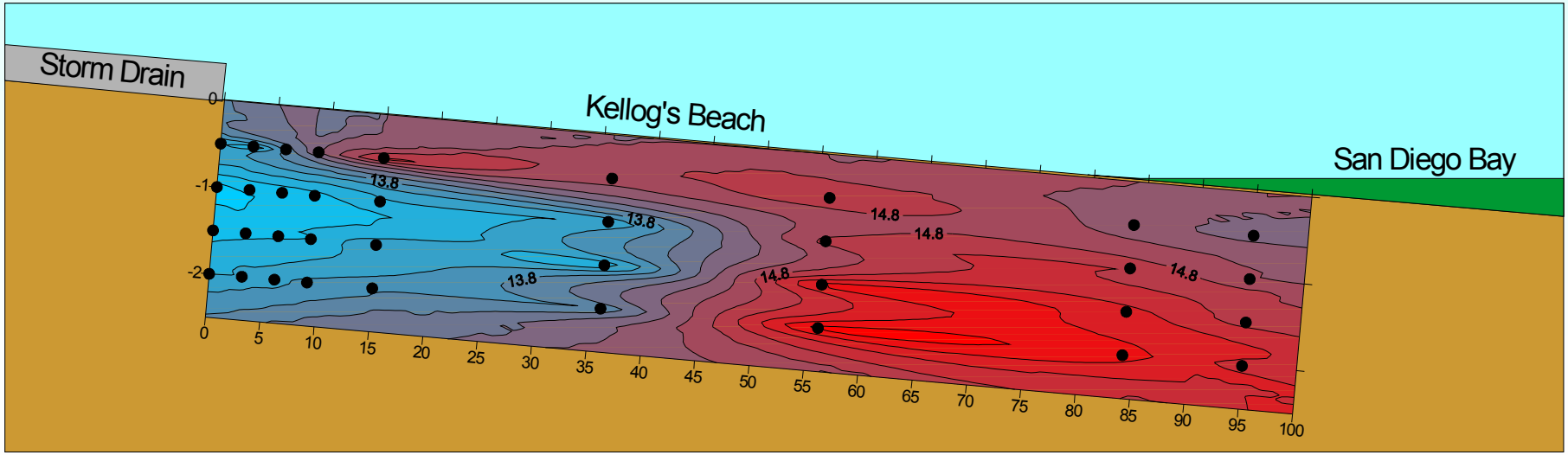
TRIDENT Probe Field Test – Kellogg's Beach

- **Successfully collected simultaneous temperature profiles**
- **Temperature distribution also useful in delineating plume, but results appear confounded by near-surface heating**
- **Temperature data also important to as a correction for the conductivity response**



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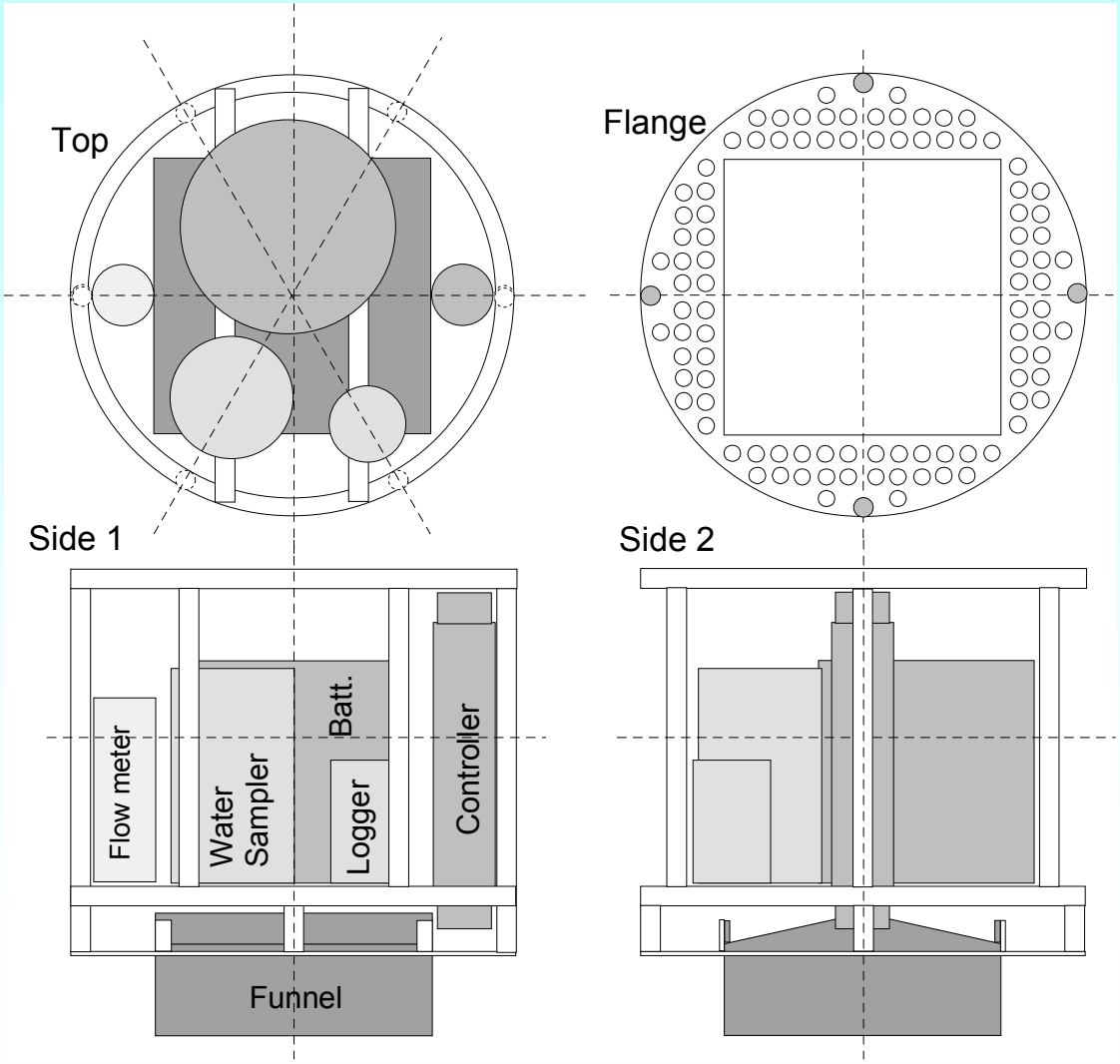
ULTRASEEP Meter

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 Specifications

- **Ultrasonic flowmeter: Accurate detection of specific discharge or recharge in the range of 0.1 - 150 cm/d**
- **Water Sampler: Programmable collection by time or flow condition at 0.2-20 mL/min via 6-port selector valve into pre-cleaned teflon bags**
- **Conductivity: 0-7 ± 0.001 mS/cm**
- **Temperature: -5-35° ± 0.001° C**
- **Controller: 8/12-Channel I/O, 128 MB memory, RS-232 and 1-2 amp power switching**



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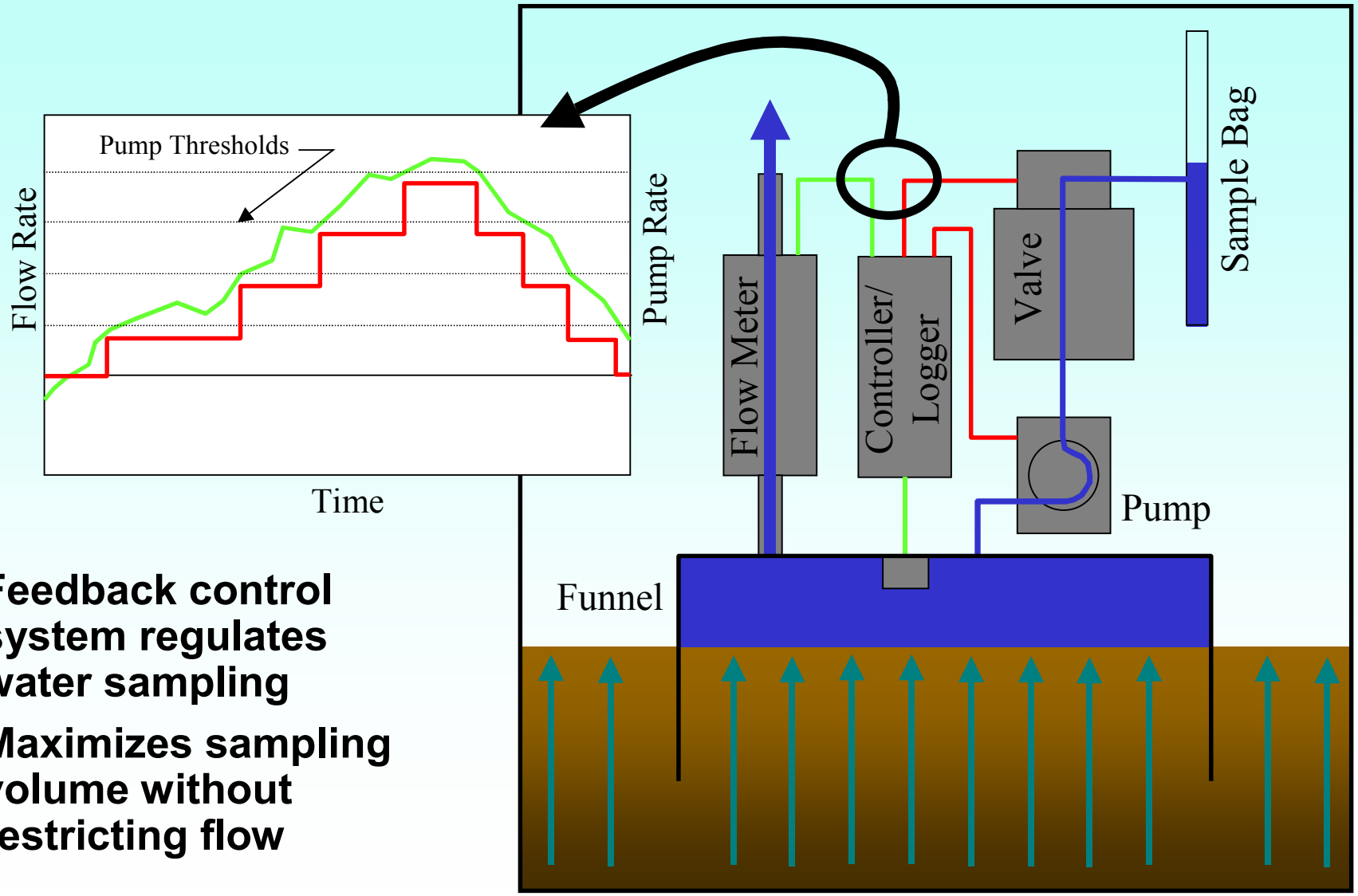
UltraSeep Functional Schematic



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

Sample Bag


Battery
ESM Controller
Logger
Water Sampler
Flow Meter
Funnel

ULTRASEEP – Field Testing Summary

Test Site	Capability Tested	Deployment Mode
North Island Site 9	Bag Sampler	Diver
Anacostia River	Ultrasonic Meter Bag Sampler (Independently)	Diver
Eagle Harbor	Ultrasonic Meter Bag Sampler (Independently)	Diver
Naval Station Paleta Creek	Ultrasonic Meter	Diver
North Island Site 9	Integrated Meter June 2002 Demo	
Naval Station Site 1	Integrated Meter Fall 2002 Demo	

Anacostia River Field Test

- Six stations sampled in Anacostia River
- Measured in flow/sensor mode in shallow water

- Independently tested water sampling system
- All deployments by diver

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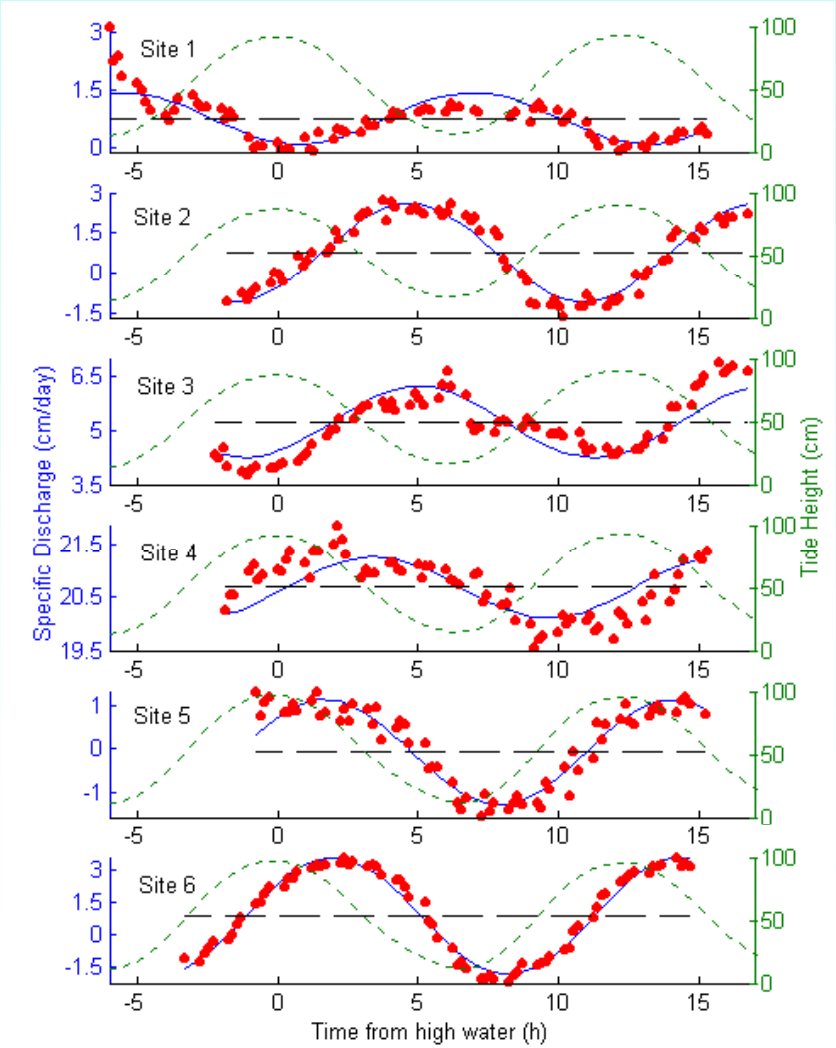
Anacostia River Field Test

- Successfully resolved low-level tidally driven seepage at all sties
- Ultrasonic meter provides significant improvement in flow detection over “bag” type samplers
- Water sampling system tested successfully at all stations but requires integration with flow meter to improve control over sample volumes



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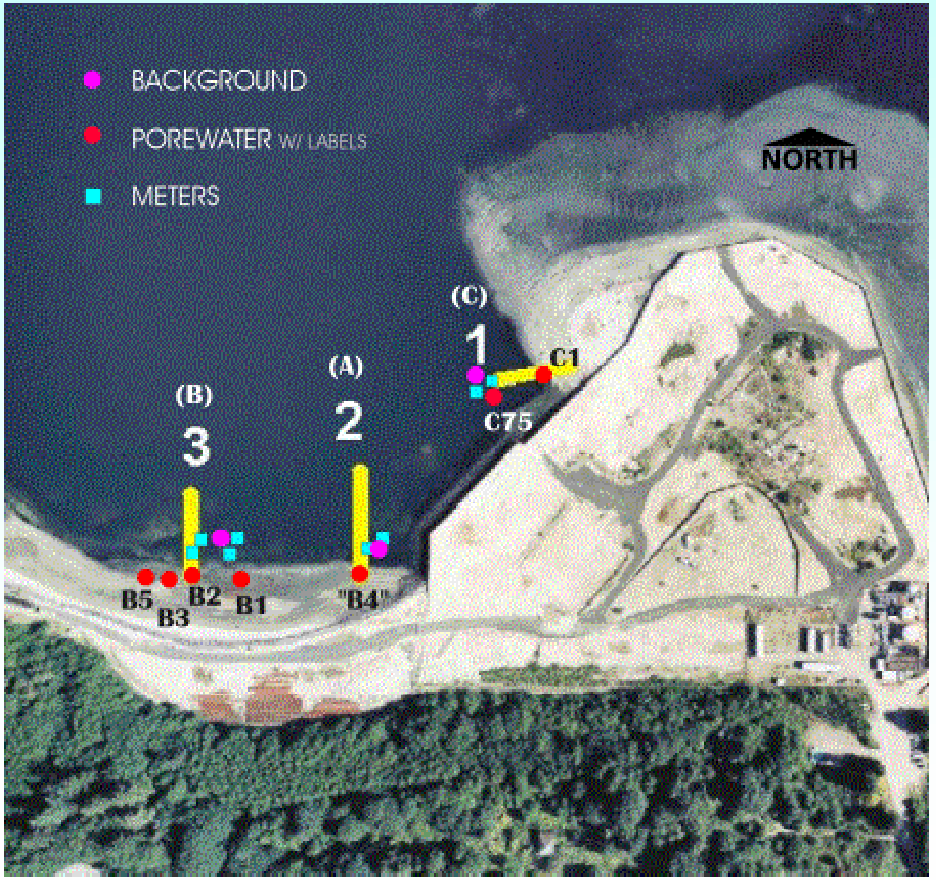
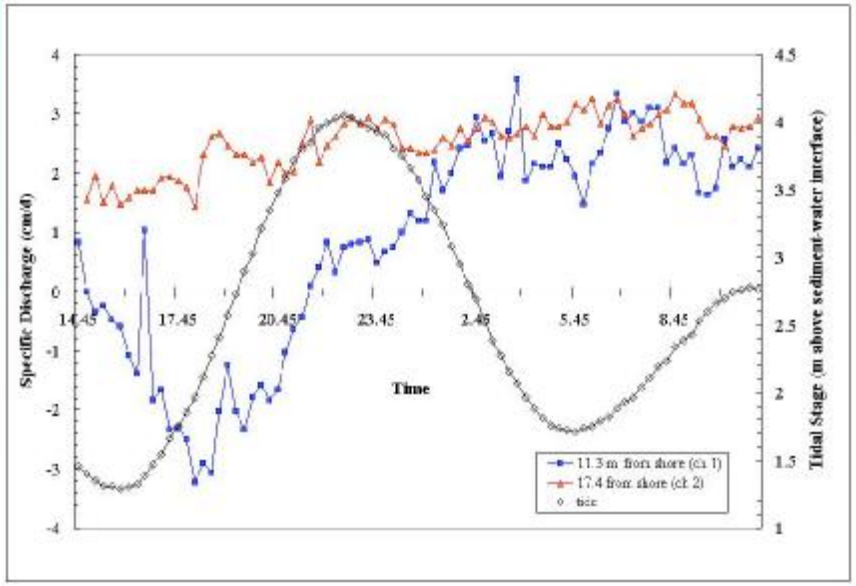
Eagle Harbor Field Test

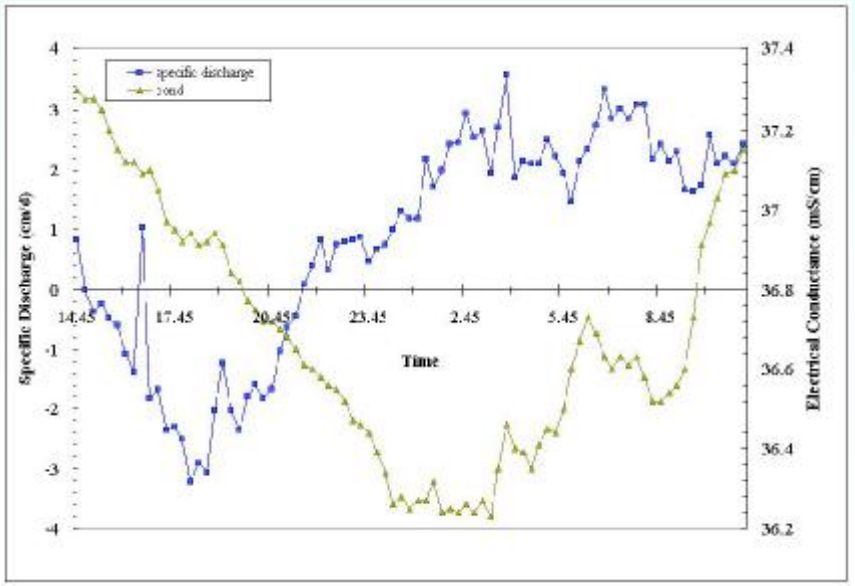
- EPA Superfund site
- Sample 8 stations on 3 transects off Wycoff Facility (deep water)
- Measured in flow/sensor mode



Eagle Harbor Field Test

- Successfully measured groundwater exchange rates at all 8 stations
- Detected non-tidal and tidal flow signals at rates from –5 to 5 cm/day
- On-board conductivity sensor provides additional evidence of freshwater discharge during and after low tide





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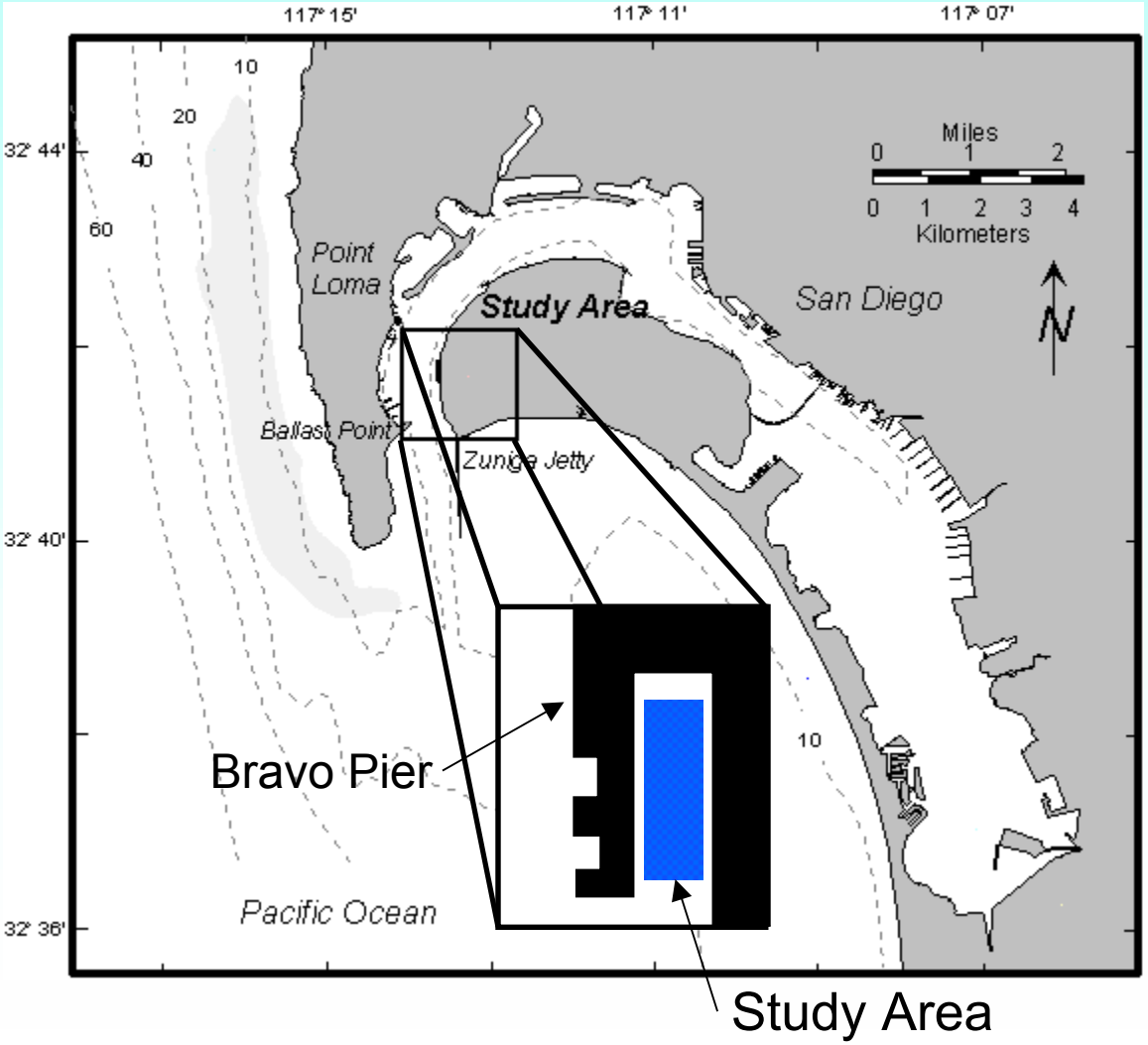
Demonstration Study – North Island Site 9

- **Originally tidal marshland, was filled beginning in 1930s with dredge material from San Diego Bay**
- **Chemical waste disposal site from 1940s through 1978**
- **Estimated 300000-800000 gallons/year of chemical waste including solvents caustics, acid, metal carbides, etc.**



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TRIDENT Probe – North Island Site 9

- Full-scale test at North Island Site 9
- Test in shallow water mode
- Evaluated mooring and push protocols

- Mapped conductivity and temperature at ~2' depth across ~100m X 200m area
- Collected porewater samples at all stations for salinity and VOCs

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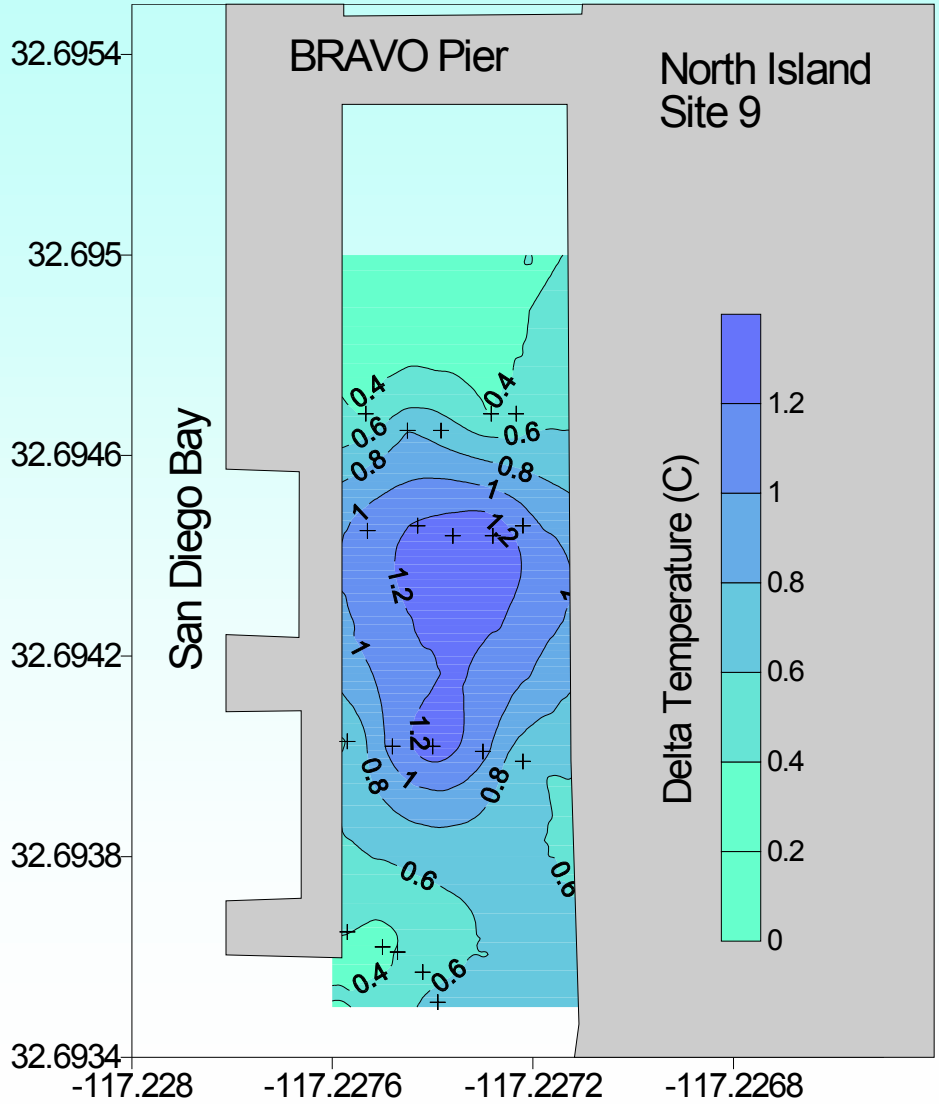
Trident Probe – Temperature Mapping

- Trident probe used to map out temperature contrast between surface water and subsurface (2') pore waters
- Temperature contrast mapping indicated area where cooler groundwater could be entering the Bay



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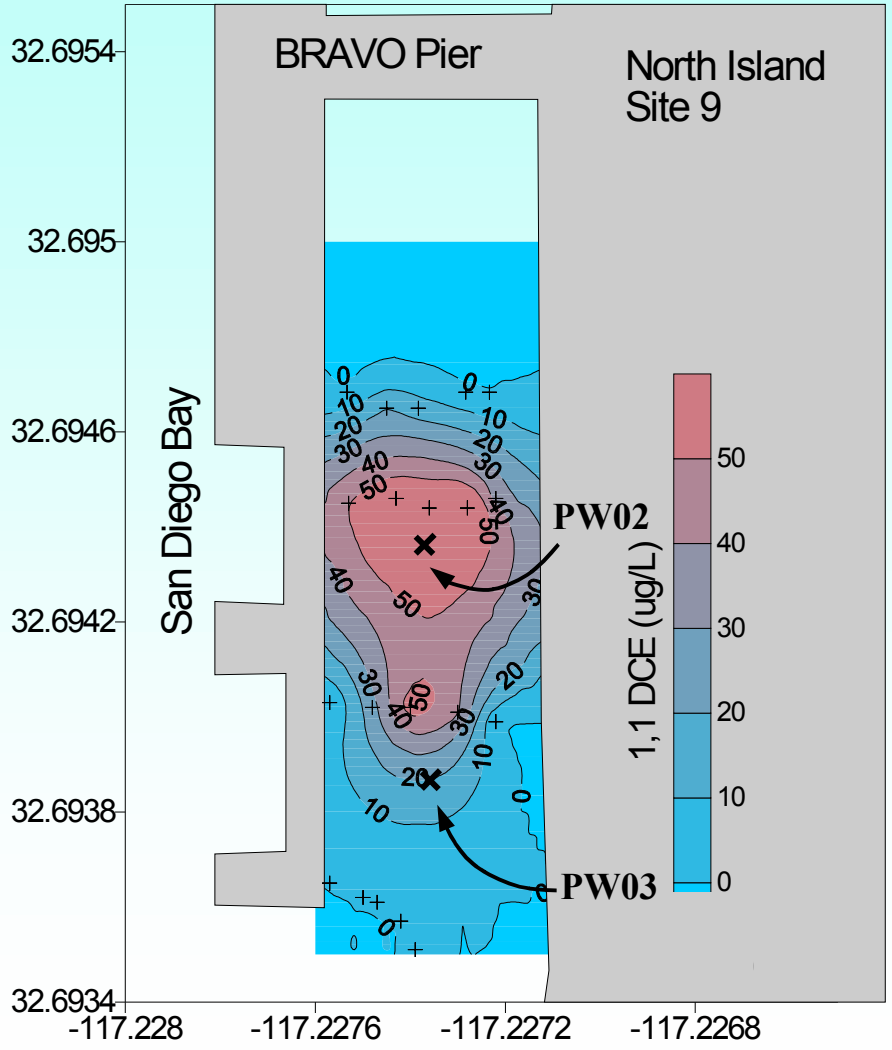
Trident Pore Water Sampler – DCE Mapping

- Trident pore water probe used to collect subsurface (2') samples at 20 stations
- Pore water samples were analyzed for target VOC compounds
- Mapping isolated area where VOCs seep into the Bay



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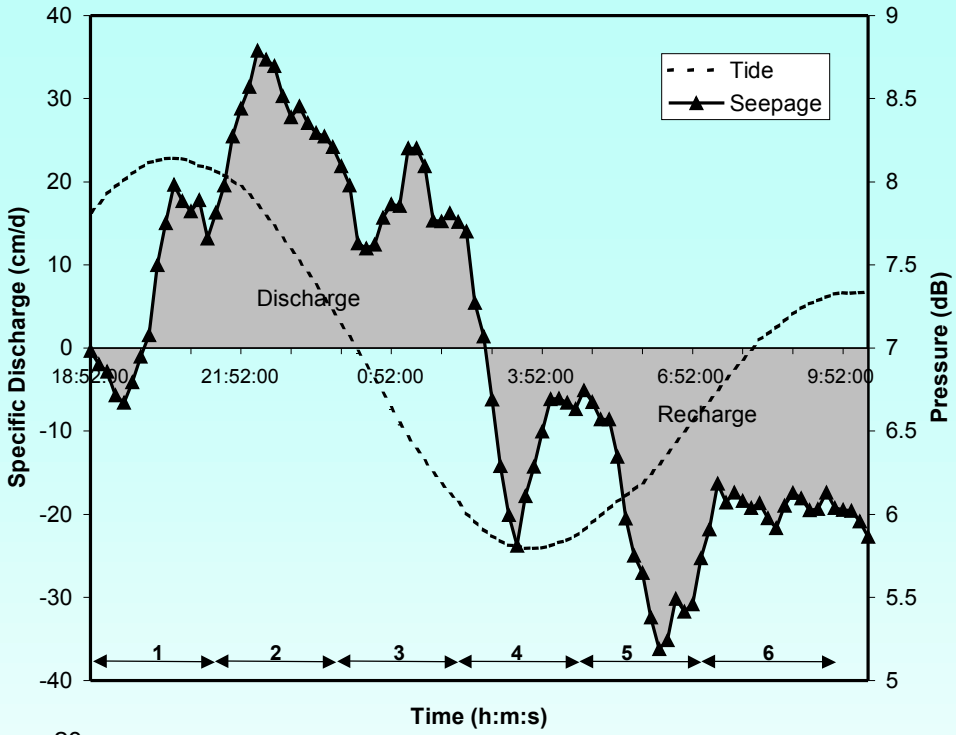
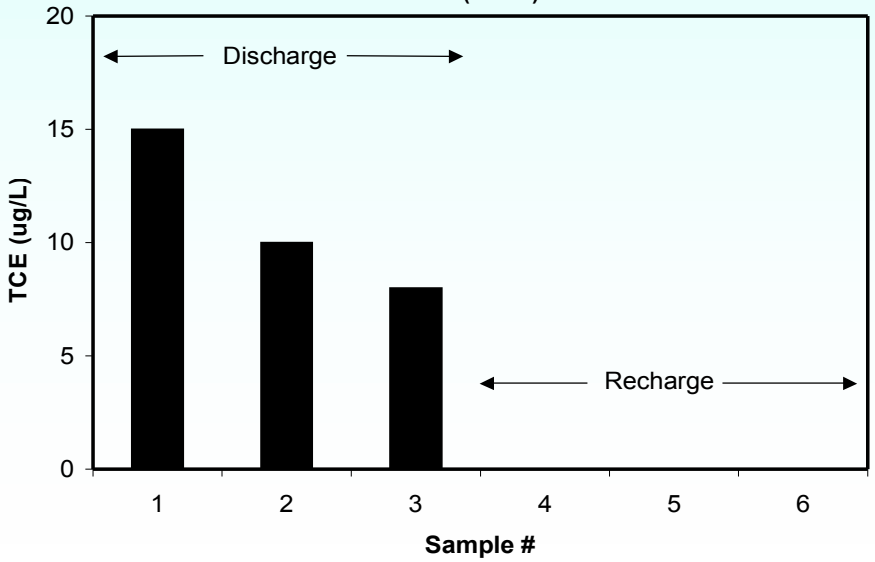
UltraSeep Flow and Chemistry

- UltraSeep deployed in areas where the Trident Probe indicated potential groundwater seepage
- UltraSeep meter shows tidal variation in seepage rates
- TCE and other VOCs detected in UltraSeep samples during discharge periods





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Conclusion

- Developed and demonstrated Trident probe for rapid screening of GSI sites based on conductivity, temperature and porewater collections under a variety of conditions
- Demonstrated ultrasonic seepage meters as stand alone flow devices and with integrated water sampling and sensors for temperature and conductivity at a range of sites
- Together with traditional shoreside sampling and modeling these tools can provide improved assessment for GSI sites

Future Work

- Upcoming site assessments at Naval Station San Diego and Pearl Harbor
- Parallel testing of passive diffusion samplers to extend capability to areas where porewater samplers are not effective (high fines)
- Development and demonstration of in-situ bioassessment techniques to support risk assessment at GSI sites