Research to Improve Characterization of Groundwater Contamination and Remediation Performance for Sites with Impacts to Surface Water

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Center for Environmental Solutions and Emergency Response

Disclaimer

The views expressed in this presentation are those of the author(s) and do not necessarily represent the views or the policies of the U.S. Environmental Protection Agency.

Who am I? How did I get here?

Kindergarten through Undergraduate:

- Grew up in rural Missouri with a private well
- High school senior research project to measure nitrate concentration in two rural ponds (Mr. Ed Sebaugh)
- Pursued Civil Engineering degree (followed path of older brother); Univ. Missouri-Rolla (now MST)
- Junior year got a part-time job at USGS District Office in Rolla (internships & coops are useful)
- NSF-Research Experiences for Undergraduates during summer after junior year; spent a couple months at Univ. of Notre Dame

Who am I? How did I get here? Pt.2

Graduate to Present:

- Decided to pursue graduate degree in Environmental Engineering (good advice from faculty mentor, Dr. Paul Munger)
- Clemson University – one of the first graduate programs in U.S. (plus there was a pig roast!)
- Final part of doctoral research at Savannah River Site (Department of Energy)
- Post-doctoral position at University of Delaware (Soil Science Department)
- Thought academic track was in the cards, but…

Who am I? How did I get here? Pt.3

Present:

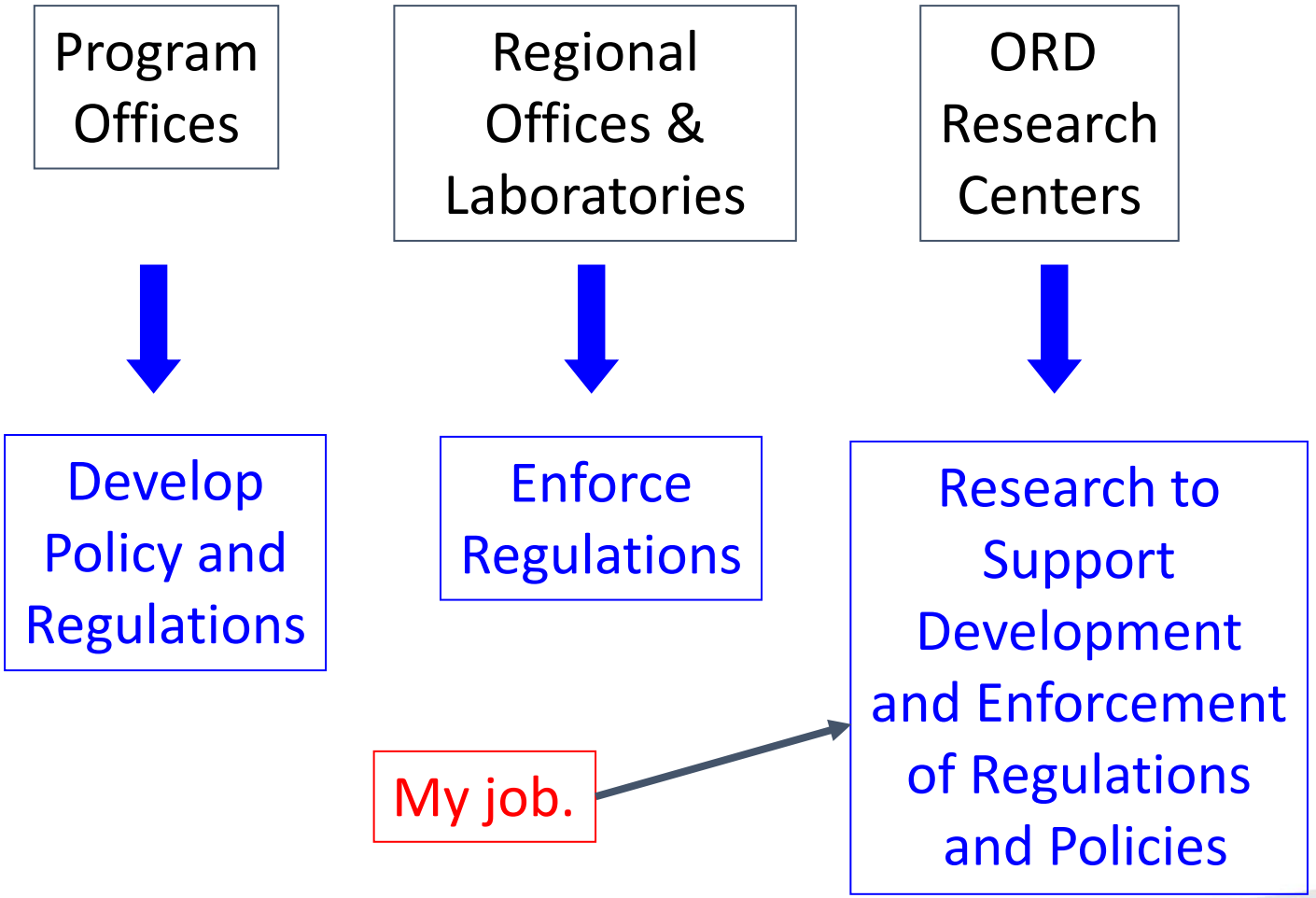
- Several nibbles for faculty positions, but no bites
- Applied for research position with EPA/ORD based on an advertisement in EOS…success!
- Worked 8 years in ORD research lab in Ada, OK (lab pre-dates the EPA)
- Transferred to ORD research lab in Cincinnati 2007 (also pre-dates EPA)
- Started with a “firm” grasp of what I could do; have spent subsequent years getting “re-educated” and trained to the practical reality

Who am I? How did I get here? Pt.4

Here and Now:

- COVID – EPA travel shut down
- Research needed to continue – local field sites were needed (Hamilton County Soil & Water Conservation Service)
- Cooper Creek (Blue Ash) introduced me to UC Geosciences faculty (they are here today)
- Next came TEMMS (Miamitown – Great Miami River) – a treasure for UC
- Hopeful that there is smoked brisket in my future (remember the prime objective…)

General Organization of the USEPA

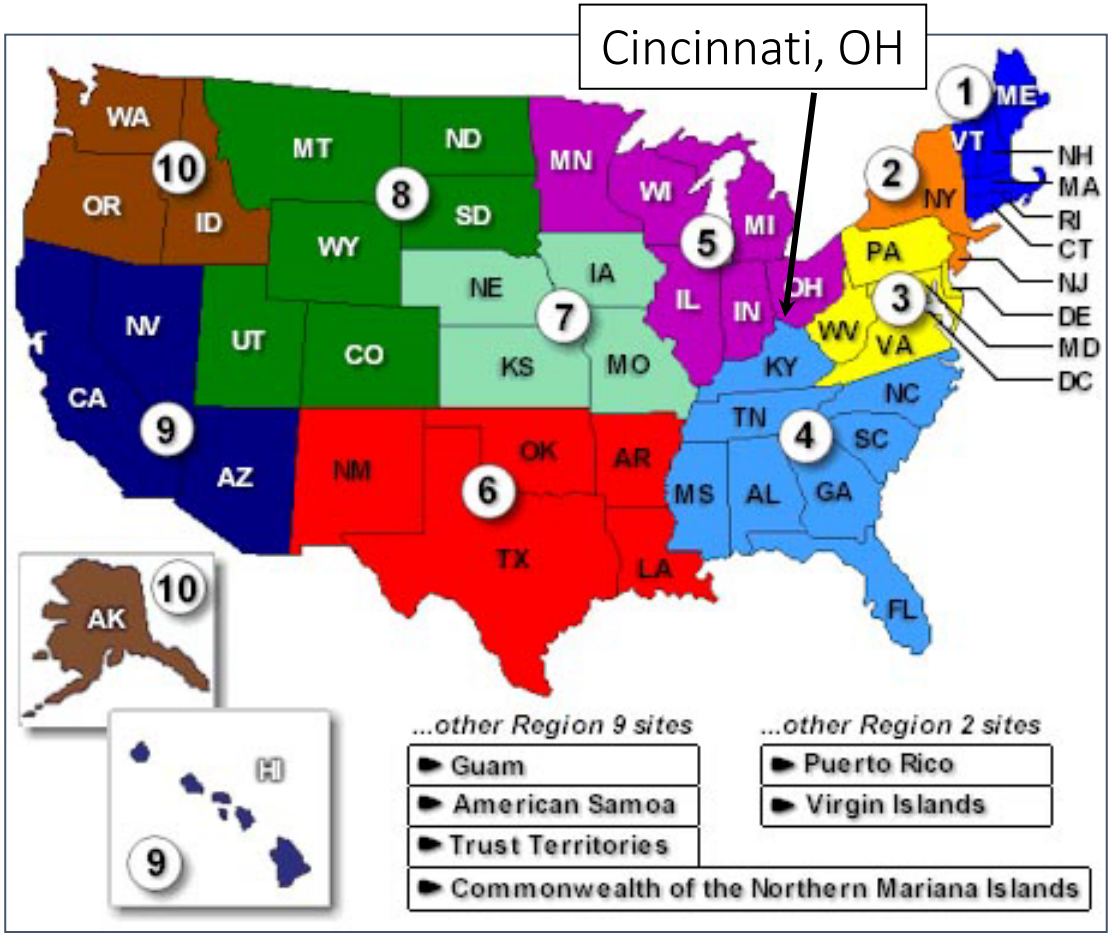


What guides the Agency's work?

The efforts of the Agency are bound by Federal laws:

- Clean Water Act (CWA)
- Toxic Substances Control Act (TSCA)
- Resource Conservation and Recovery Act (RCRA)
- Comprehensive Environmental Response and Cleanup Act (CERCLA) (aka Superfund)
- Others…

USEPA Regions in the United States

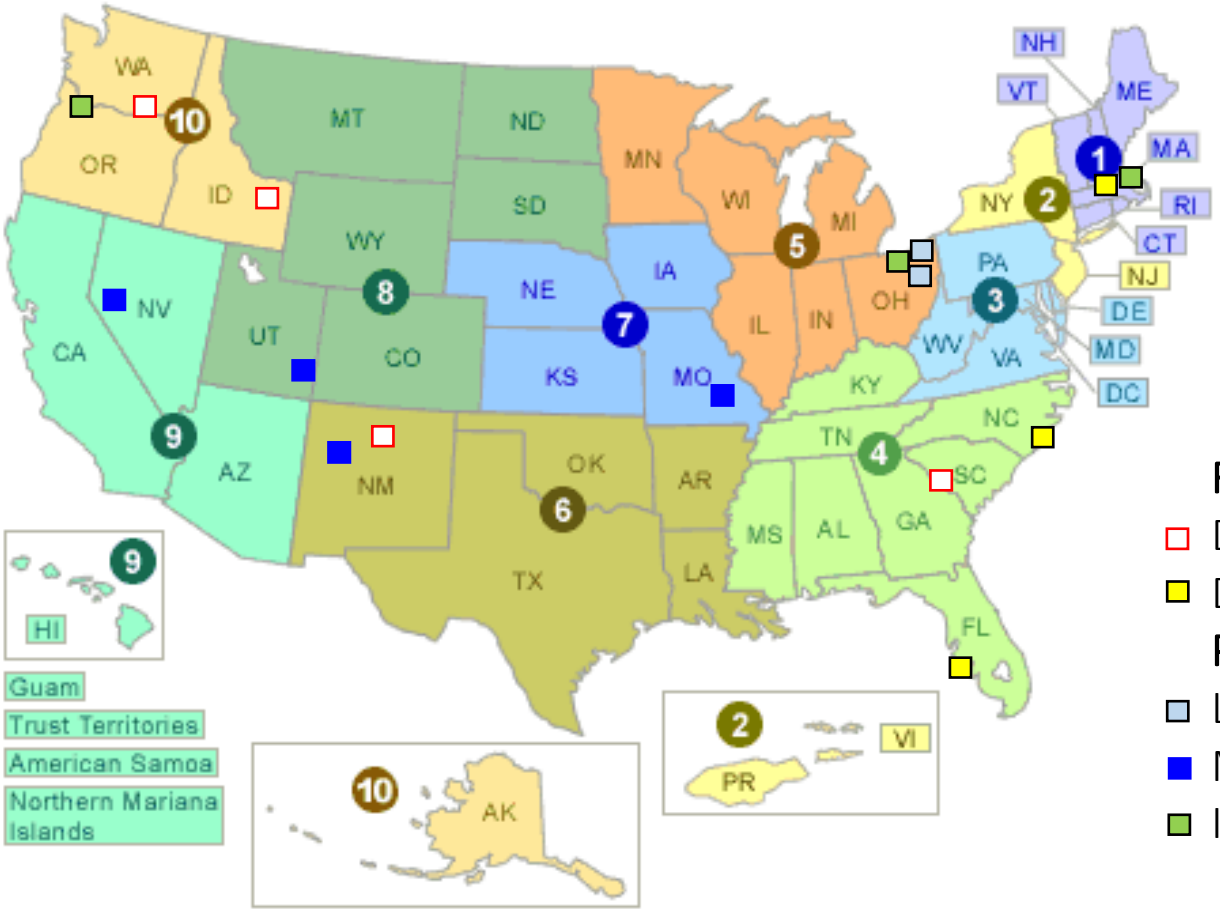


Region 5 Office
Chicago, IL

What does my job entail?

1) **Conduct applied research:**
   - Laboratory systems mimicking real environmental settings
   - Development of methods for environmental characterization
   - Field research at contaminated sites – characterization & remediation
   - Publish research
2) **Provide technical assistance to Regional Offices at specific contaminated sites:**
   - Technical review of site documents
   - Participate in technical meetings & negotiations
   - On-site technology demonstrations/evaluations
3) **Provide technical assistance to Program Offices:**
   - Review technical documents (guidance, methods)
   - Prepare technical reports summarizing state-of-the-science

Locations for Technical Support & Field Research



Federal Sites

- DOE Facility
- DOD Base

Private Sites

- Landfill
- Mining & Mill Tailings
- Industrial

Technical Support to Regions

Anaconda Copper Mine Site

~5500 meters

Yerington, Nevada

Onion fields
(groundwater irrigation)

Sludge & Dewatering Lagoons

Tailings Piles

Pit Lake

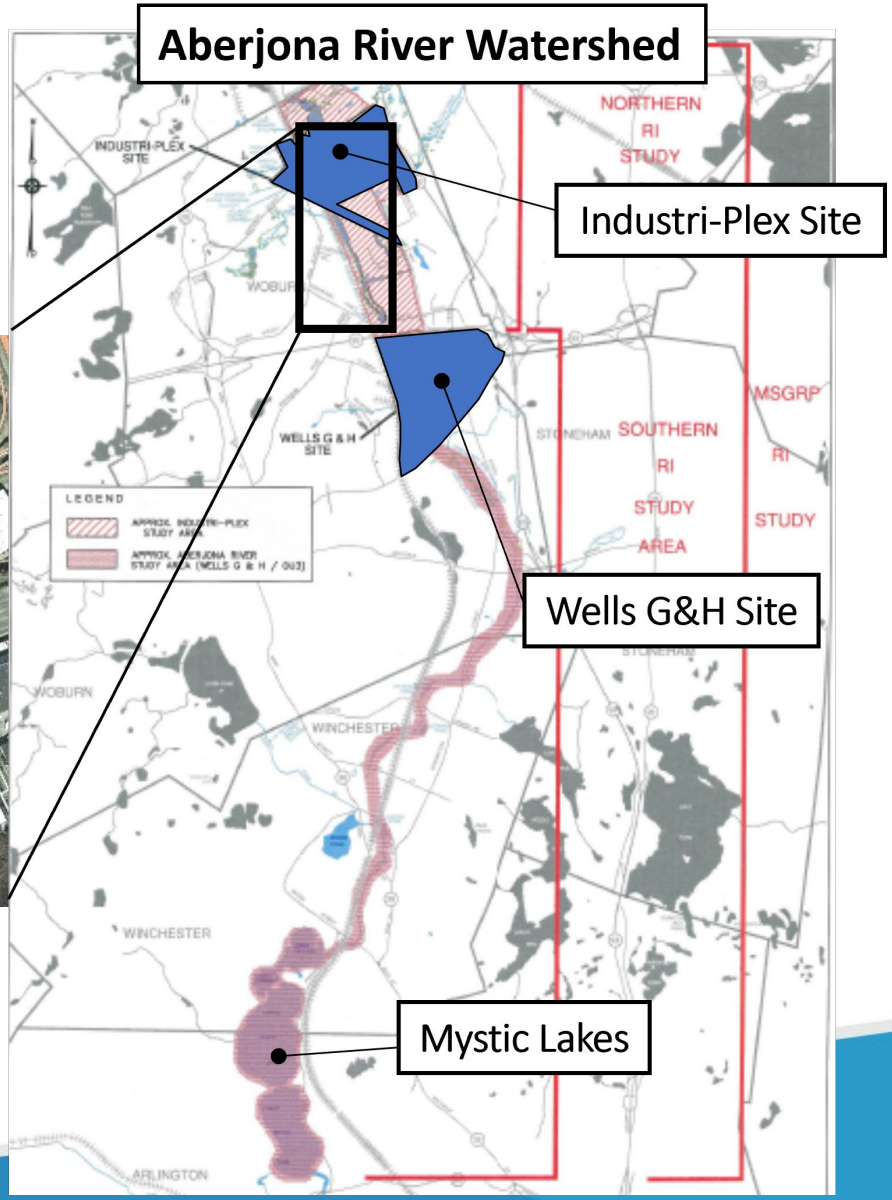
Technical Support to Regions

Industri-Plex Superfund Site

Woburn, Massachusetts

Early 1990s

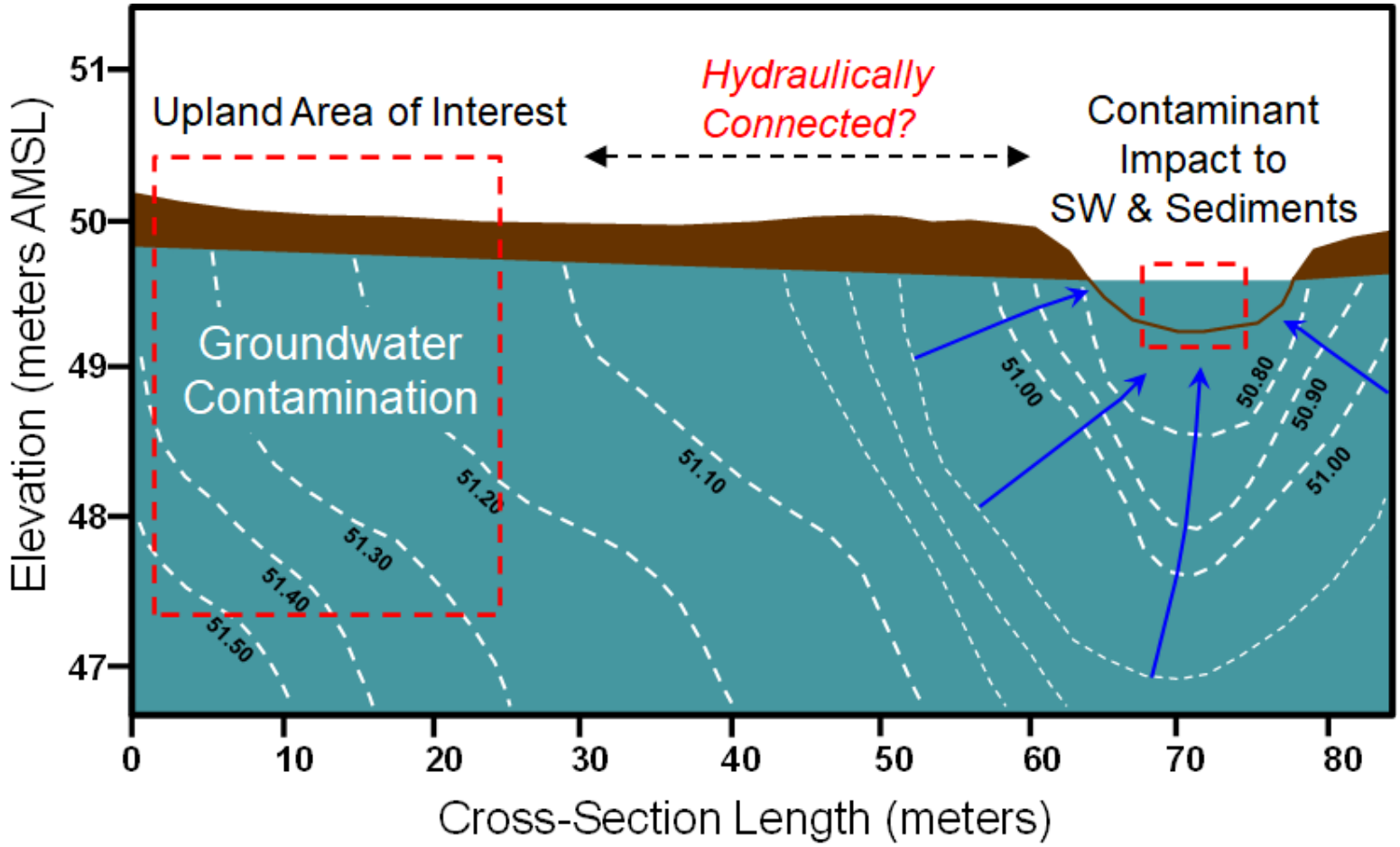
Post-2005



Now to the Nitty Gritty…

- You were asked to review two publications for this seminar:
  - Ford, R.G., Acree, S.D., Lien, B.K., Scheckel, K.G., Luxton, T.P., Ross, R.R., Williams, A.G. and Clark, P., 2011. Delineating landfill leachate discharge to an arsenic contaminated waterway. Chemosphere, 85(9), pp.1525-1537.
  - Ford, R.G., Lien, B.K., Acree, S.D. and Ross, R.R., 2021. Spreadsheet tools for quantifying seepage flux across the GW-SW interface. Water Resources Research, 57(1), p.e2019WR026232.
- What qualifies this as “research” and how does it improve the “environment”?
  - Techniques to facilitate collection of data to assess dynamics of water flow in a cost-effective and reliable way
  - Support remedy selection and evaluate performance

A General Conceptual Site Model

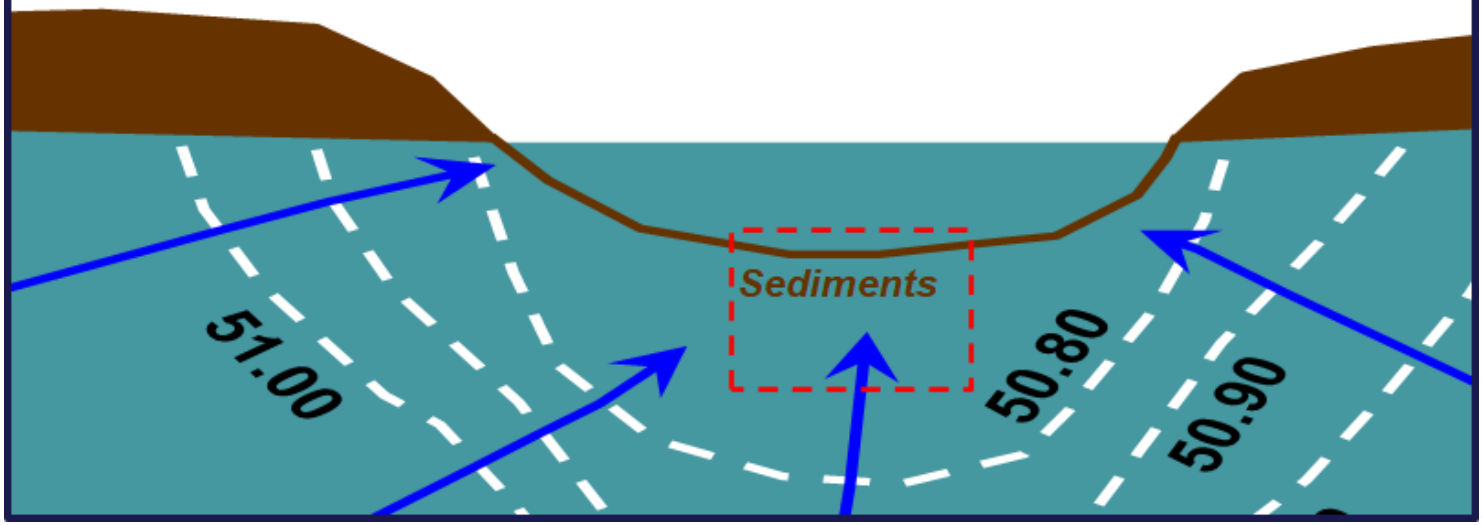


A General Conceptual Site Model cont.

Questions at the GW/SW Transition Zone:

- Spatial variation of exchange flow?
- Temporal variability of exchange flow?
- Magnitude and direction of exchange flow?

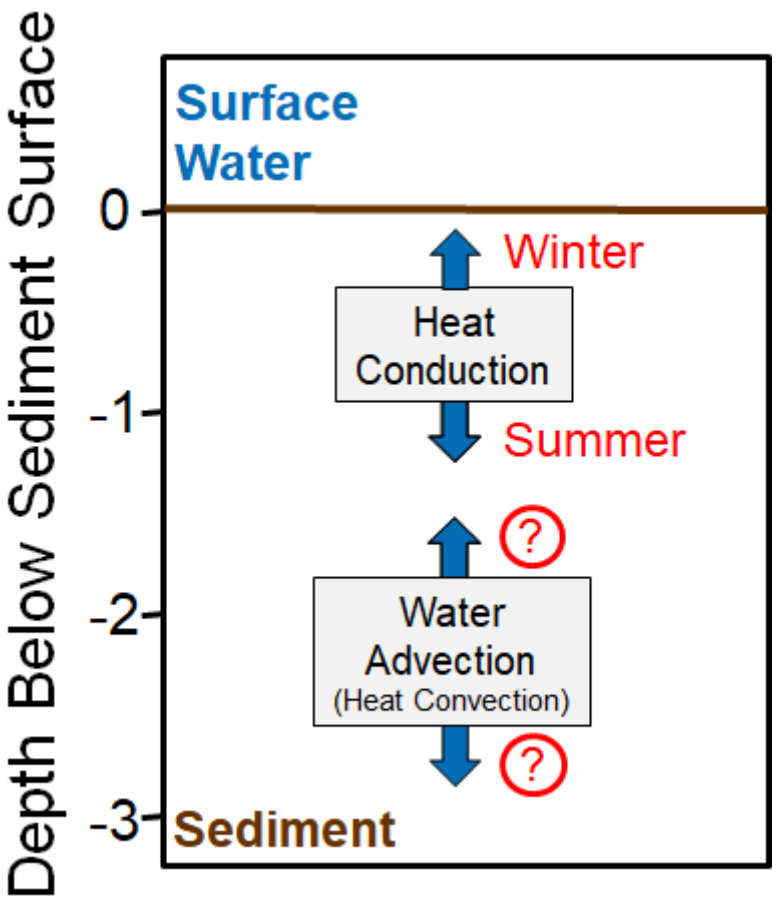
- ***Can we identify and track plume discharge?***



Developing and Testing Monitoring Tools

- Bob Lien – development of calculation tools within Excel
- Provides background and technical guidance on appropriate application of technology
- Illustrates use of spreadsheet-based analysis tools for calculating seepage flux magnitude and direction from sediment temperature profile data

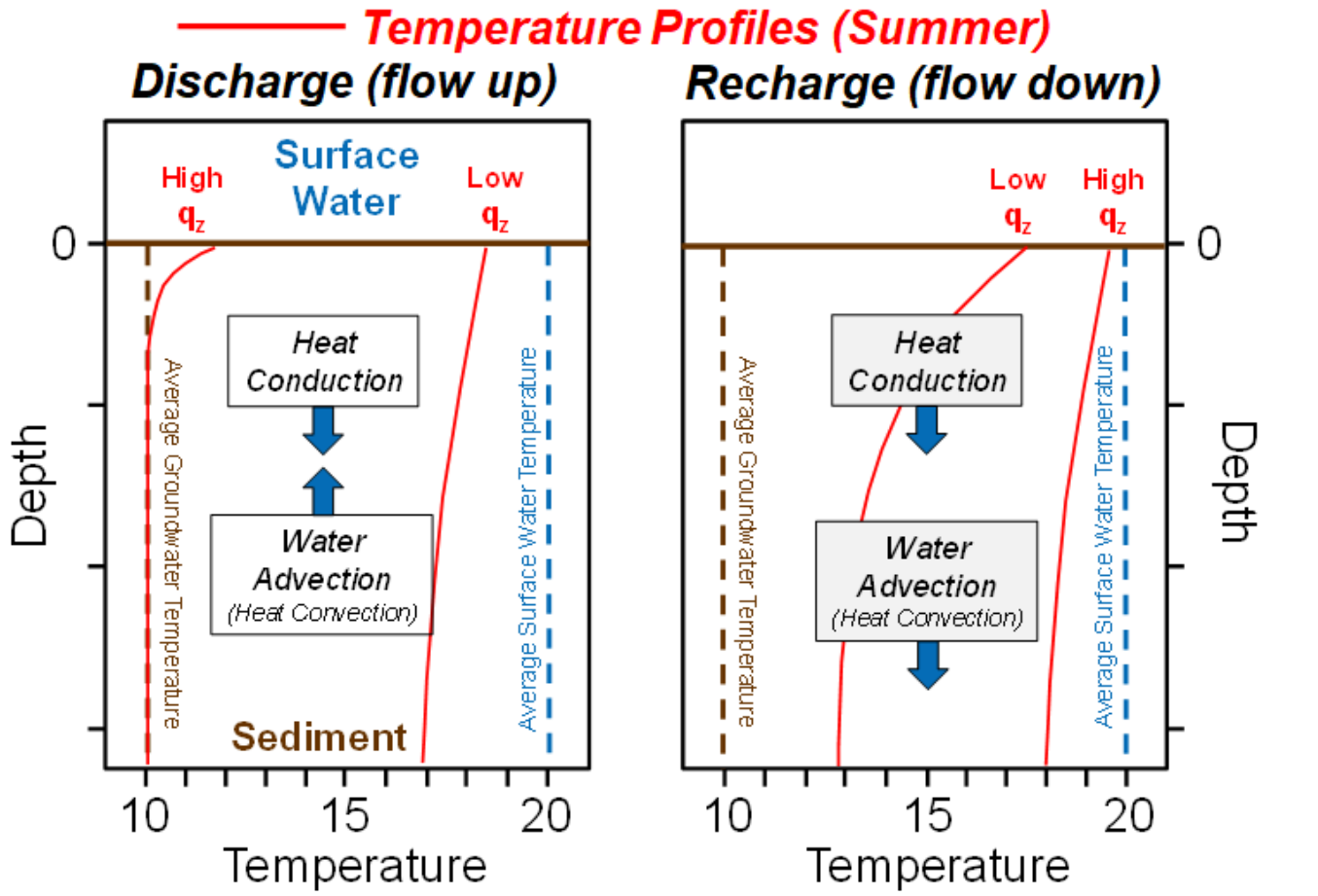
Modeling Seepage Flux (qz) pt.1



- Heat conduction influenced by GW-SW temperature gradient
- Heat convection influenced by flow up (discharge) or flow down (recharge)
- Shape of temperature profile influenced by magnitude and direction of GW flow

Adapted from: Conant (2004) Ground Water, 42:243-257

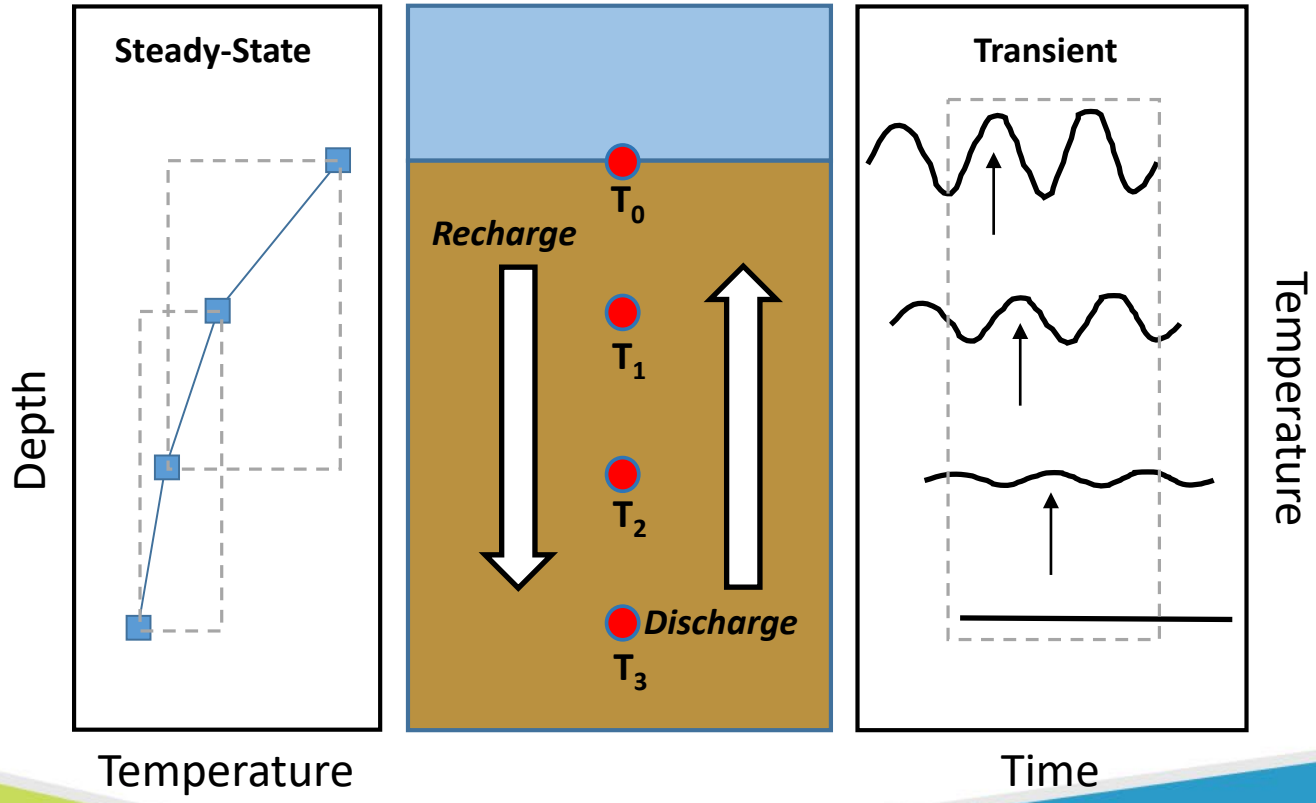
Modeling Seepage Flux (qz) pt.2



Adapted from: Conant (2004) Ground Water, 42:243-257

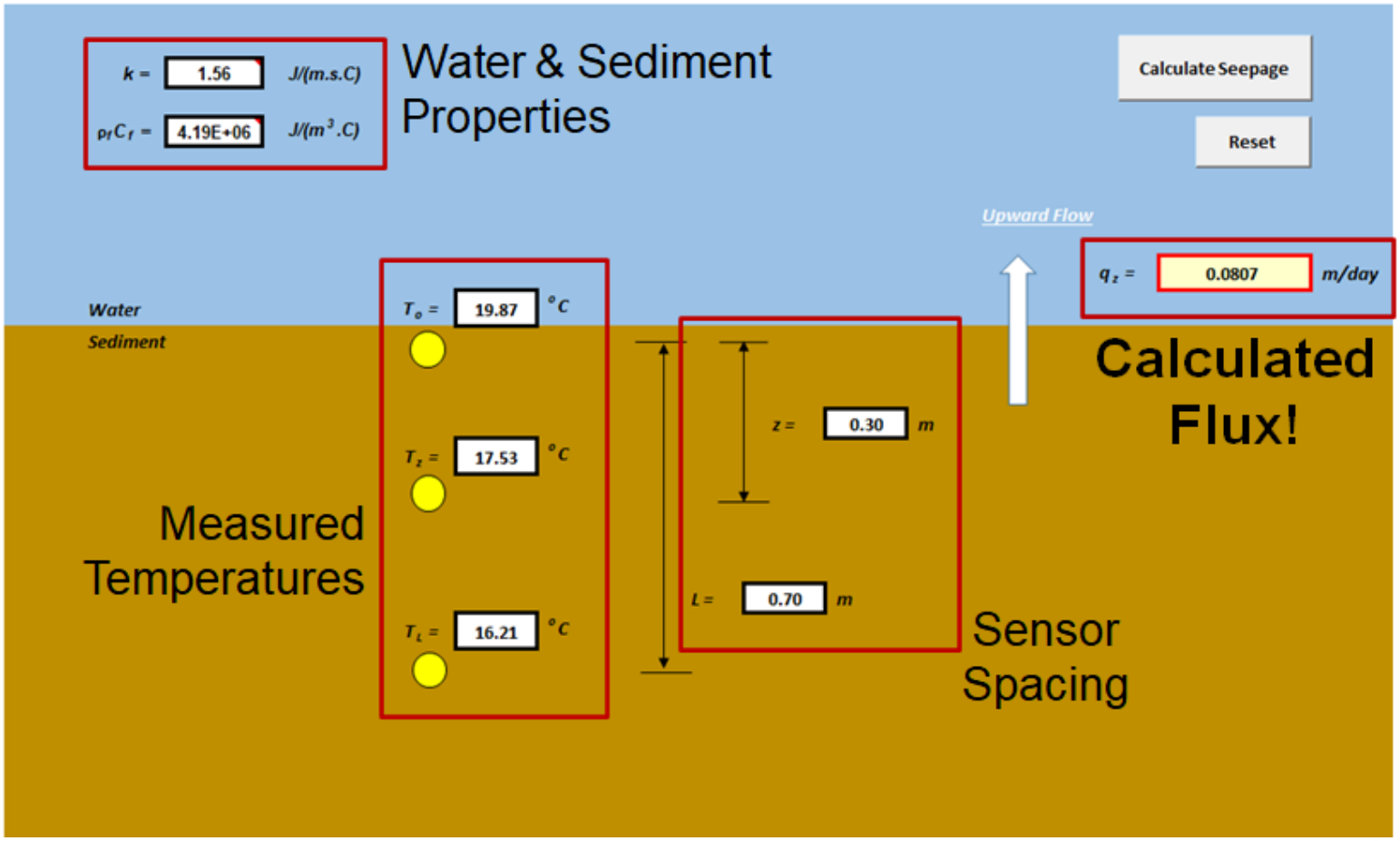
Modeling Seepage Flux (qz) pt.3

- Steady-State and Transient Model Systems
  - temperature contrast across vertical boundaries
  - sediment properties (heat transport, transmissivity)
  - direction and magnitude of seepage flow

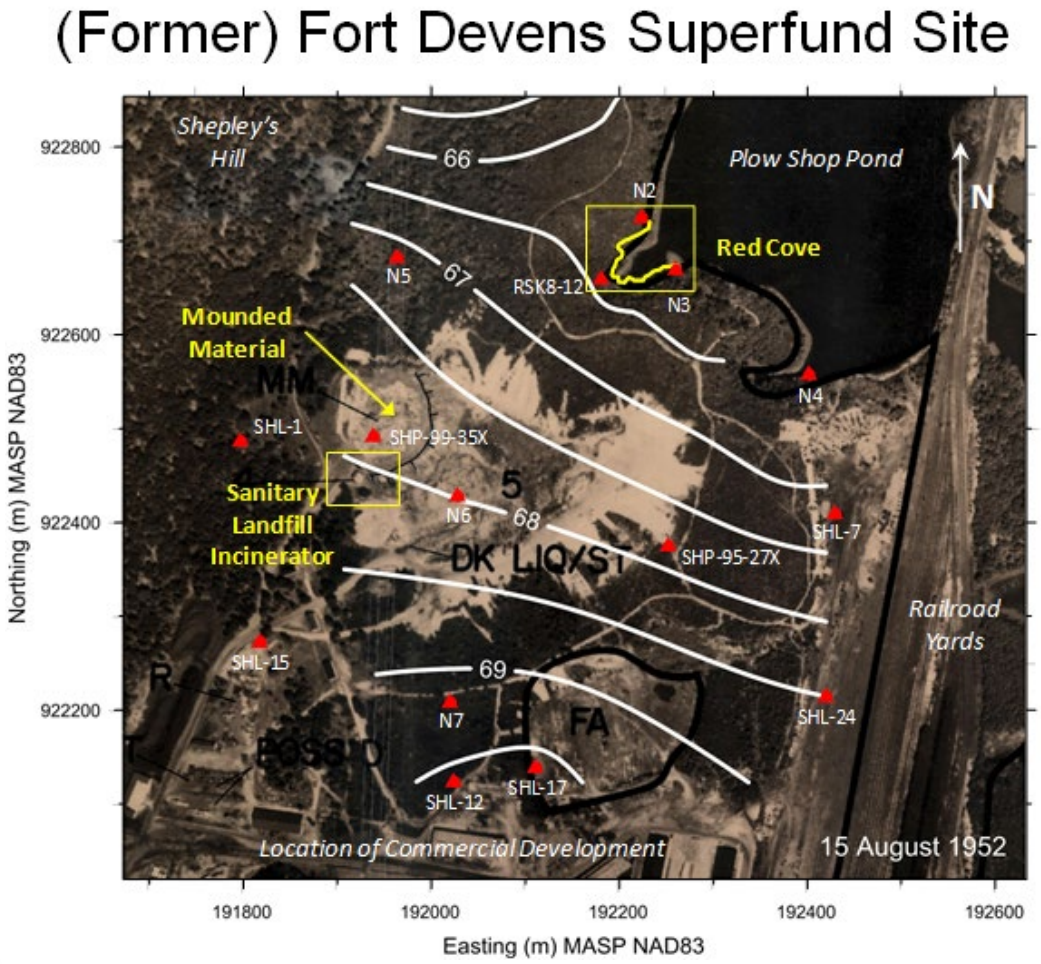


Modeling Seepage Flux (qz) pt.4

- Steady-State Workbook - Spreadsheet-based calculation tool



Application Illustration - Diagnose Problem



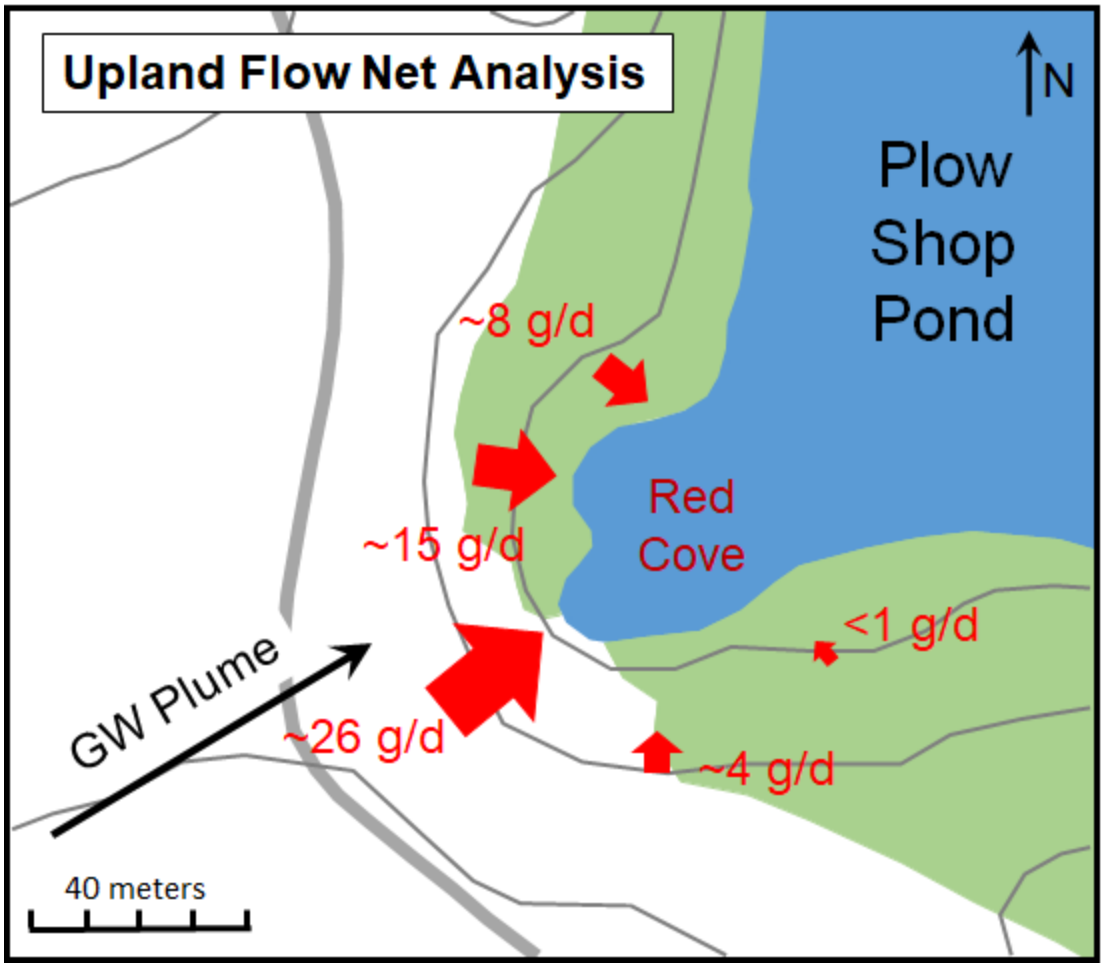
- Historical, un-lined landfill
- Arsenic contamination in GW derived from waste and natural sources
- Contaminated groundwater discharging to part of adjacent recreational lake (Red Cove)

Application Illustration – Diagnose Problem pt.1

Picture of cove from north shore

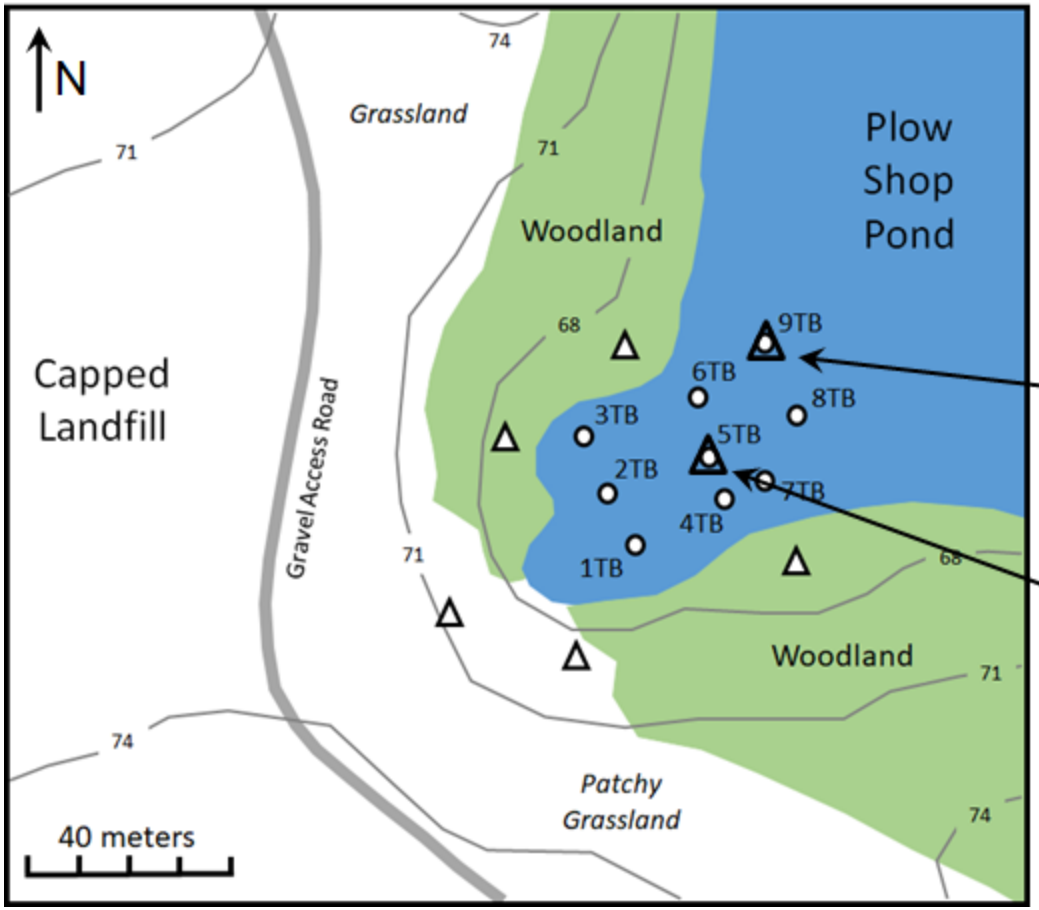
Picture at central cove from boat next to contaminated seepage area

Application Illustration – Diagnose Problem pt.2



- Arsenic plume flowing from landfill toward cove
- Nested piezometers used to evaluate magnitude & distribution of arsenic flux

Application Illustration – Diagnose Problem pt.3



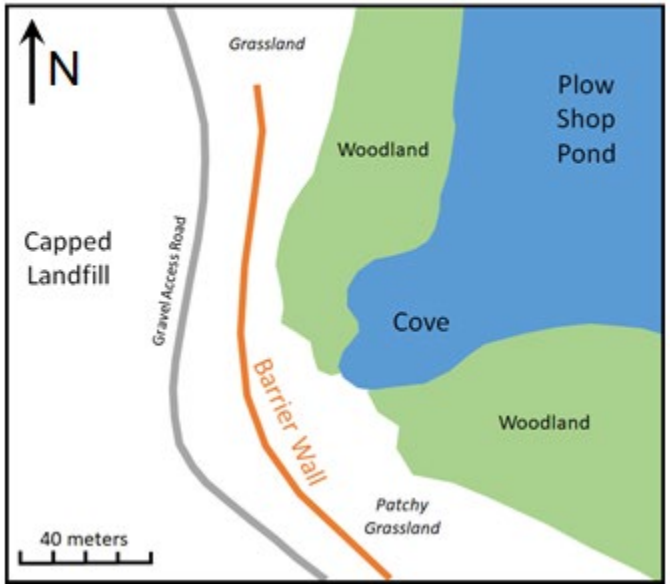
Seepage Flux
Aug-Sep 2011

9TB (PZ13)
2.0 ± 0.9 cm/d

5TB (PZ5)
14.3 ± 1.0 cm/d

Application Illustration – Problem Addressed

Hydraulic Barrier Wall (2012)

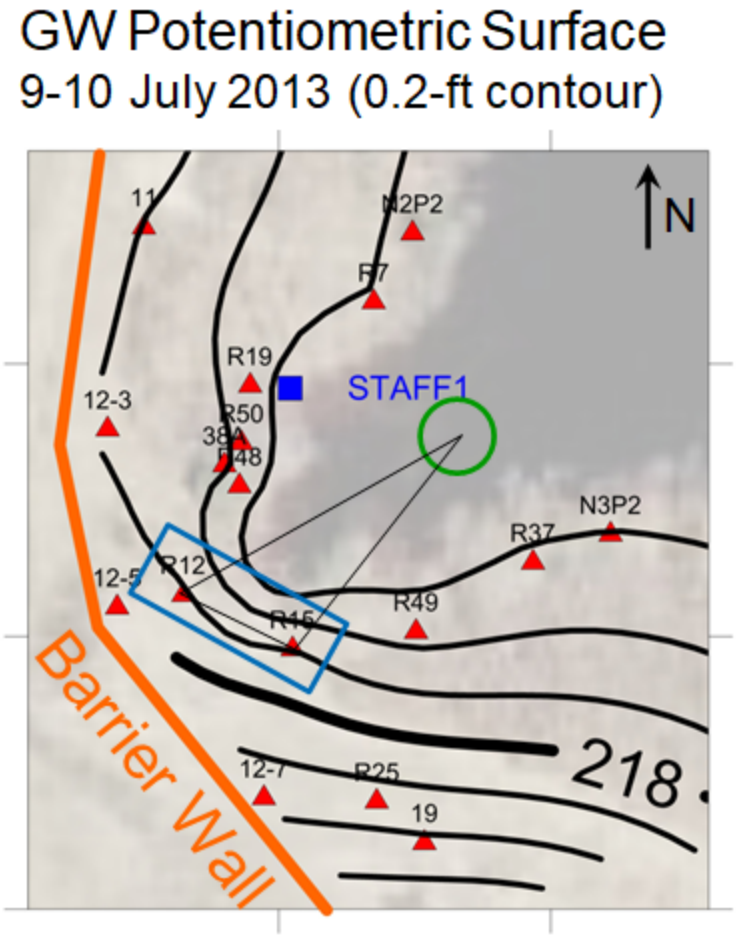


Sediment Removal in Cove (2013)

Monitoring Remedy Performance

- Does remedy influence GW-SW hydraulics?
- Does groundwater show recovery trend?
- Does surface water show recovery trend?

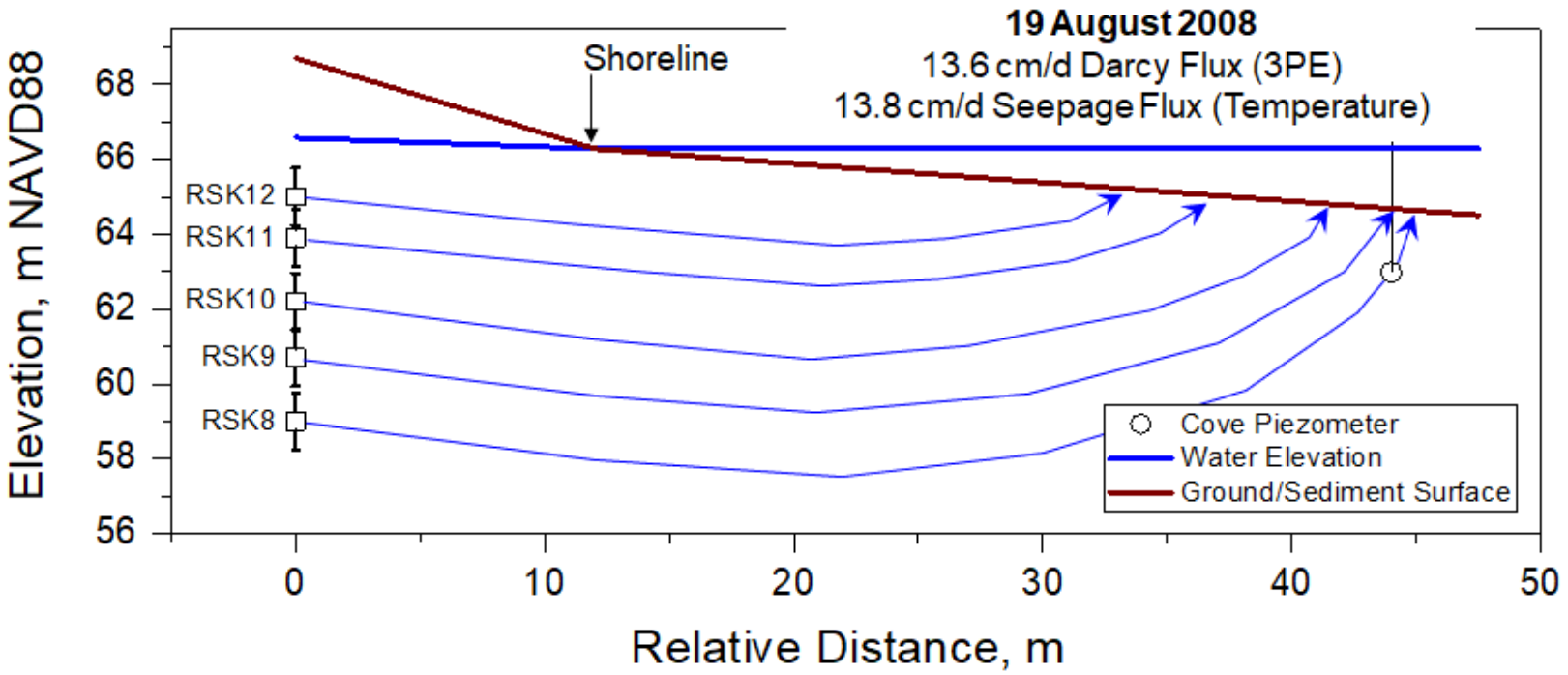
Application Illustration – Assess Recovery pt.1



- Limited monitoring during 2012-2013 due to remedy construction activities
- Upland GW monitoring recommenced 2012 (RSK12, RSK15, SW)
- Cove monitoring recommenced 2014 (green circle)

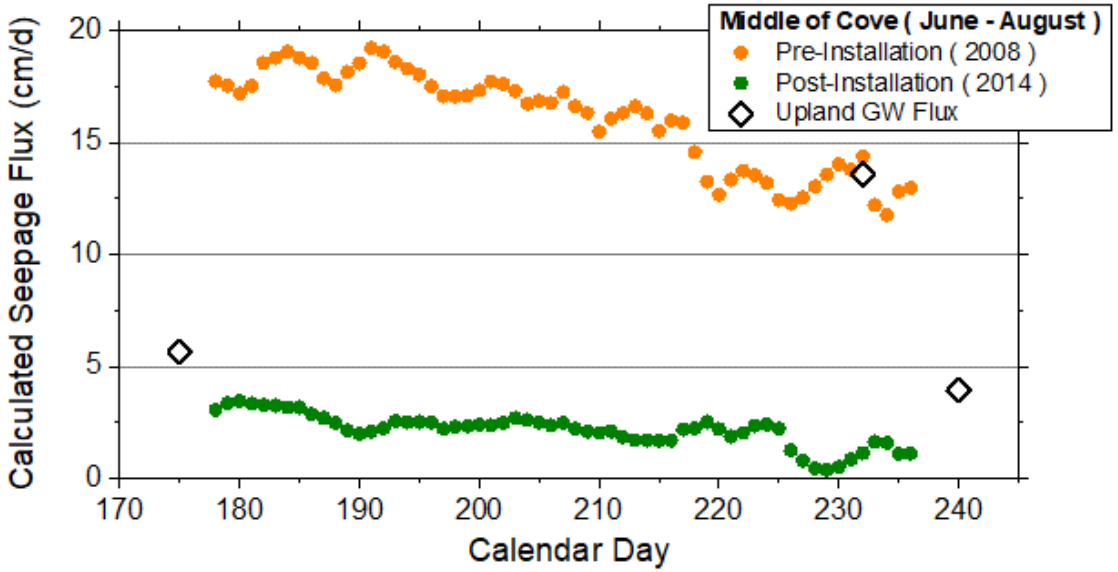
Application Illustration – Assess Recovery pt.2

- Compare upland GW flux to cove seepage flux
  - Darcy Flux (3PE) = “Effective Porosity” x “GW Velocity”
- Flow conservation indicates independent measures should be comparable

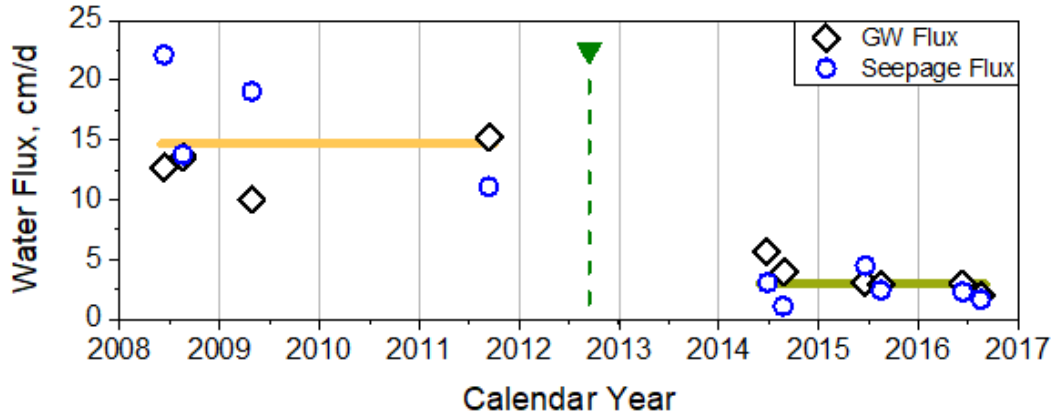


Application Illustration – Assess Recovery pt.3

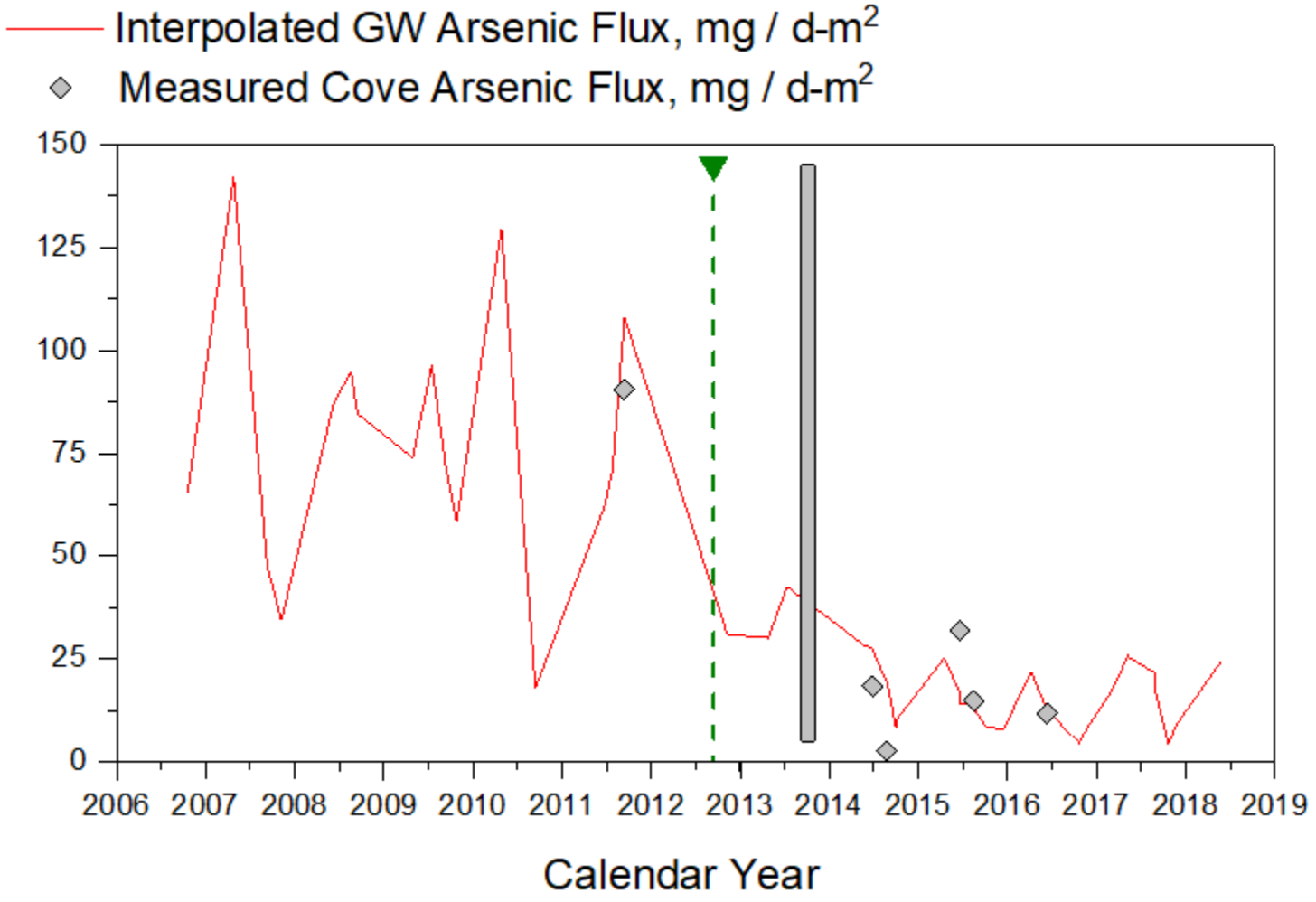
Sediment Temperature Profile Method



Comparison over entire monitoring period…



Application Illustration – Assess Recovery pt.4



Application Illustration – Assess Recovery pt.5

BEFORE

AFTER

Application Illustration – Summary

- Methods to assess groundwater flow and seepage flux are relatively easy to implement and provide for great flexibility in site monitoring
- There is a range of equipment choices and mathematical tools that can be matched up with available resources
- Knowledge gained from determination of water flux benefits assessments of degradation, design of reclamation efforts, and monitoring of restoration success.

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