

Arsenic Fate and Transport in Red Cove, Fort Devens

Fort Devens Superfund Site

OU01 – Shepley's Hill Landfill

OU11 – Plow Shop Pond

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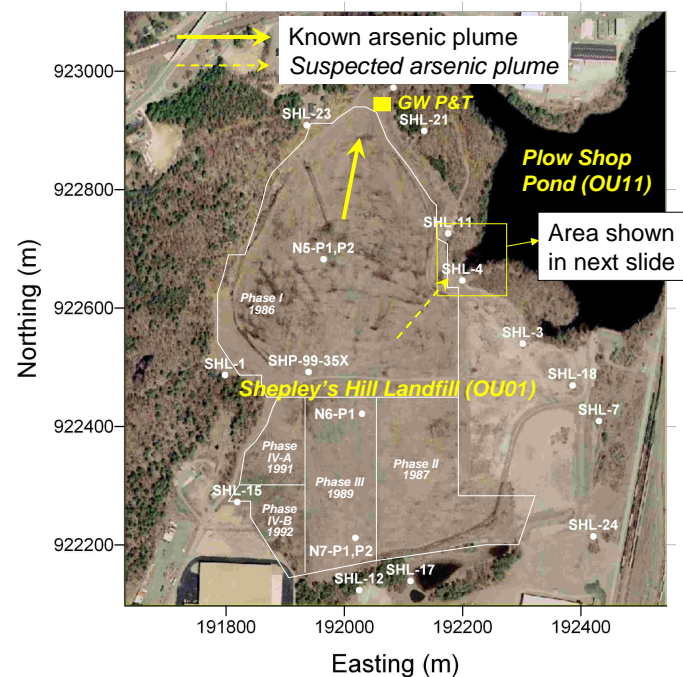
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MassDEP – Lynne Welsh, Brian Duvall, Hui Liang

Gannett Fleming, Inc. – Carol Stein, Dave McTigue, Todd Finlayson

Site access and coordination of field activities made possible by:
Robert Simeone (Dept of Army - BRAC), Dave Reault (ECC), Marc Grant (AMEC)

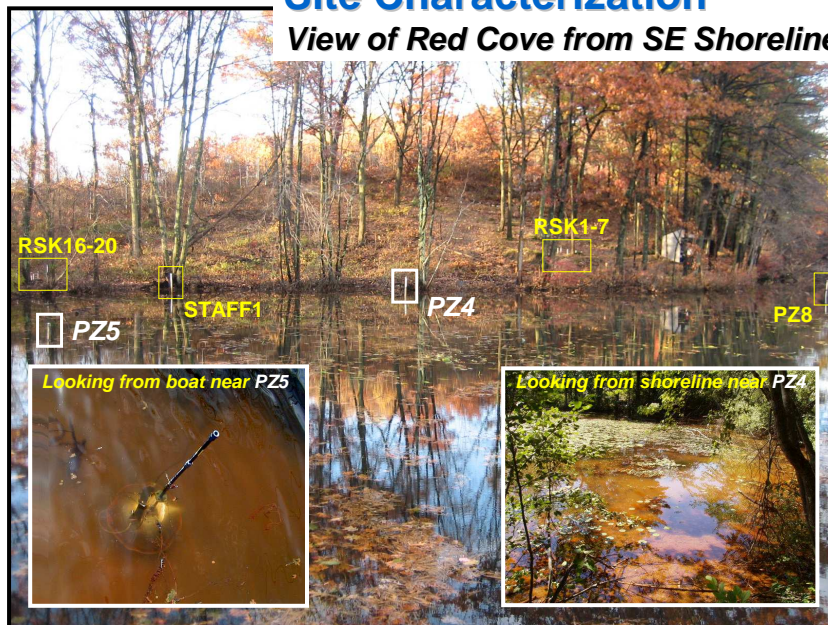
1



2

Site Characterization

View of Red Cove from SE Shoreline



3

Plow Shop Pond Sediment (<0.3 m)

Arsenic Concentration (mg/kg)

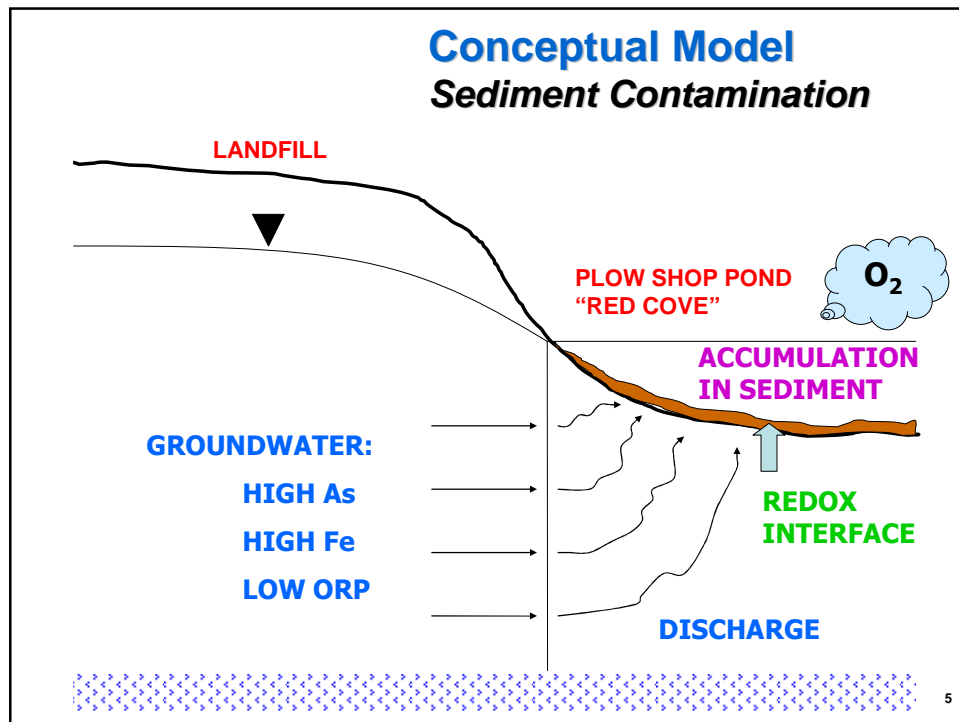
Red Cove:
Geom. mean
1400 mg/kg
n = 12

Max:
6800 mg/kg

Whole Pond:
Geom. mean
217 mg/kg
n = 107

GW discharge appears
to be the primary
source of elevated
arsenic contamination
in Red Cove sediments

4

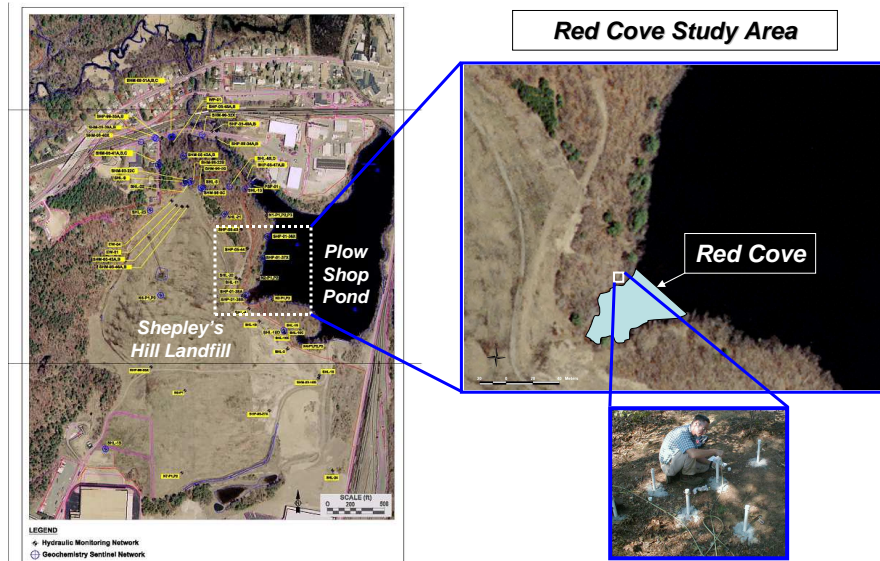


Project Objective *Site Characterization to Support Cleanup*

- Project Goals
 - Identification of the mobile form of arsenic in groundwater
 - Identification of the process(es) controlling arsenic uptake onto Red Cove Study Area sediments
 - Evaluation of the stability of arsenic associated with Red Cove Study Area sediments
- Site Characterization
 - GW hydrology and chemistry in Red Cove Study Area
 - Sediment chemistry including arsenic speciation in Red Cove
 - SW chemistry in Red Cove
- Provide recommendations for GW & sediment remedies, where applicable

6

Site Characterization Area of EPA/ORD Study

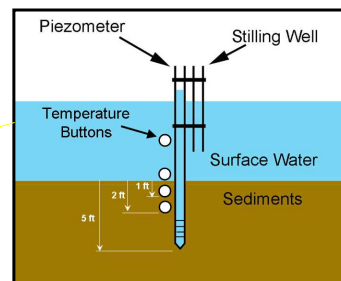


GW Monitoring Network

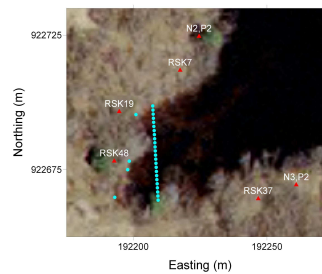
- Screened at water table or nested 5-ft screens across saturated overburden

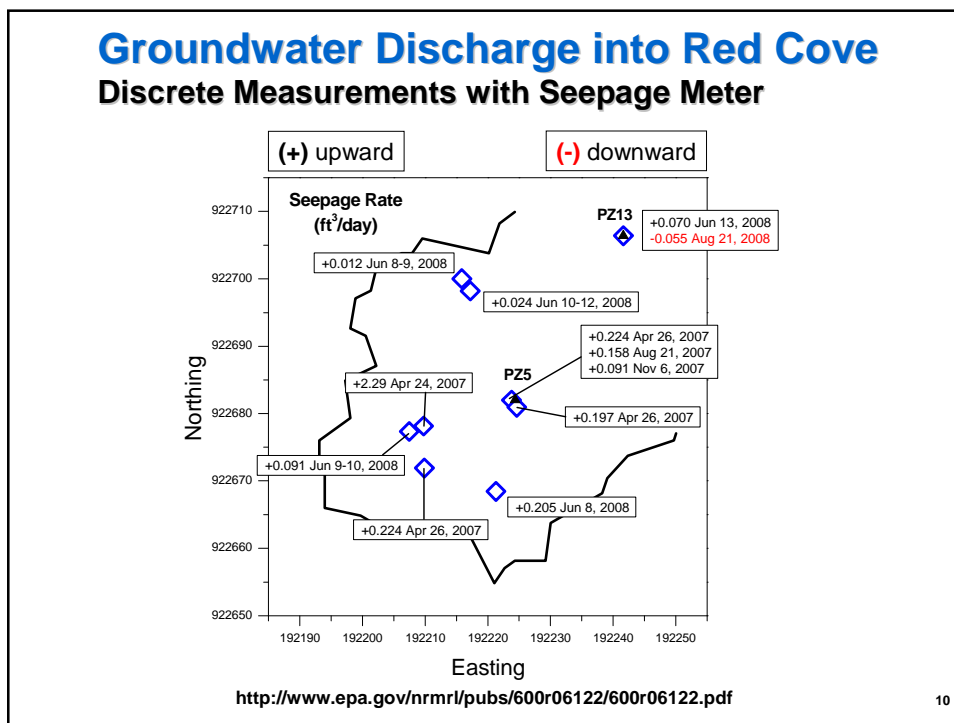
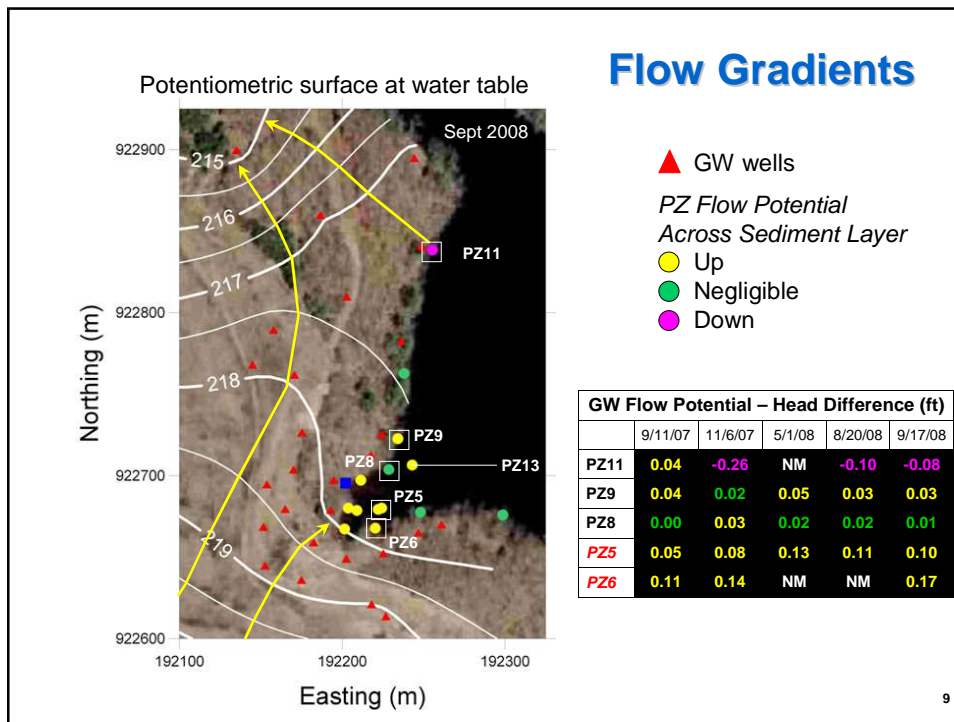


- Flow gradient across sediment layer



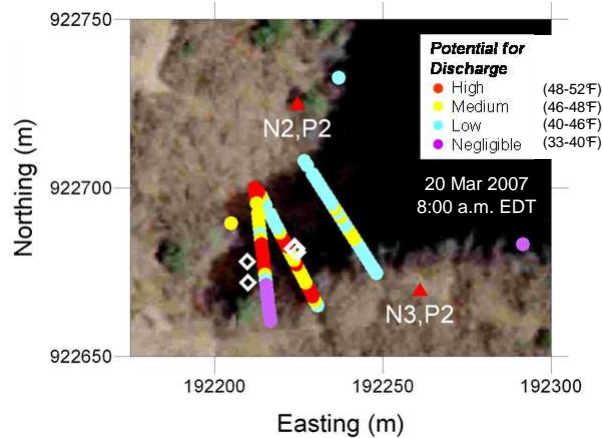
- Temperature of RSK GW and sediment pore water (1 ft depth)





Sediment Pore Water Temperature Classed Posting Map – Temperature Buttons

- Groundwater temperature range was 49-51 °F (transducers)
- Select locations where the seepage meter was deployed in Red Cove are plotted as white diamonds.

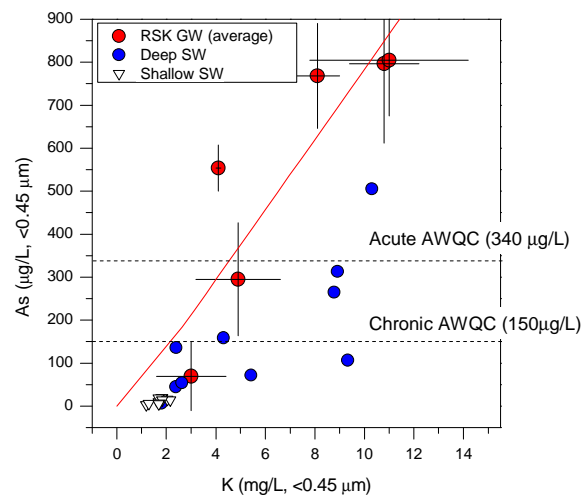


11

Water Chemistry Comparison

RSK Groundwater vs. Red Cove Surface Water

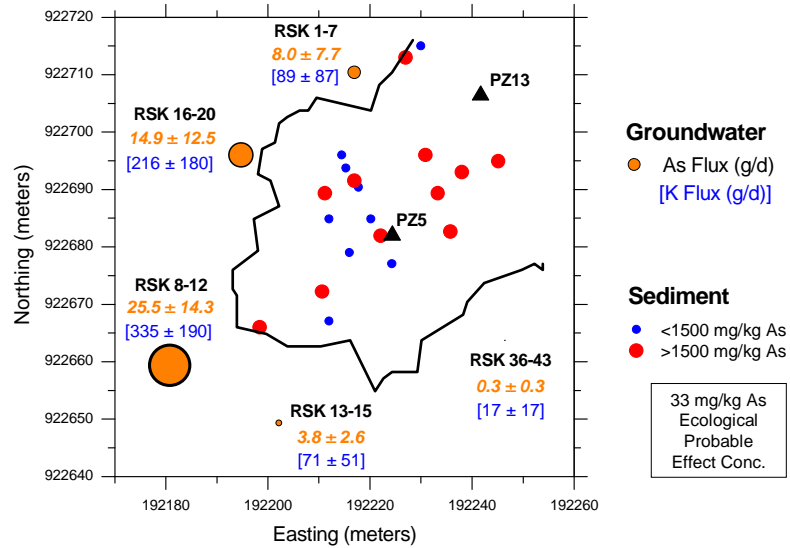
- Highest As in upgradient GW wells generally associated with high K concentration
- Shallow SW has consistently low K concentration



12

Flux of As from Overburden Aquifer

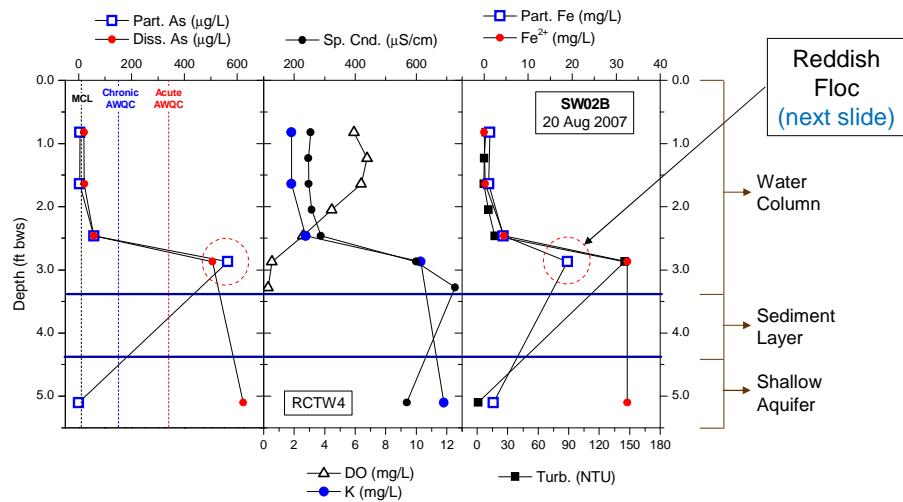
RSK Well Clusters



13

Red Cove Surface Water – As & Fe

- High particulate Fe in SW from GW discharge of Fe^{2+} (adjacent to PZ5)
- Oxidation & precipitation of Fe^{2+} captures As, but only after contact with DO in SW

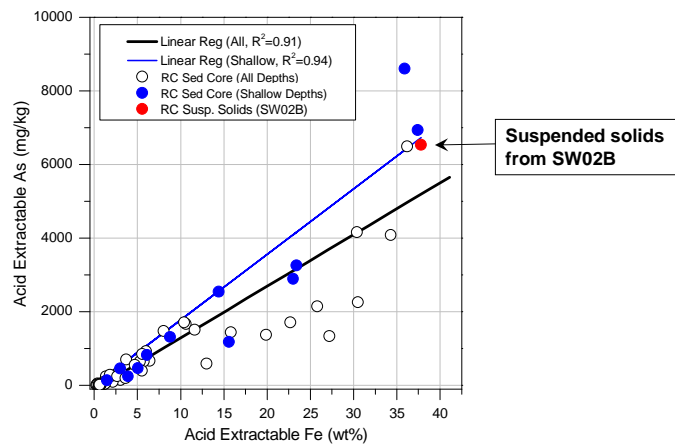


14

Red Cove Surface Water

Relationship between Suspended Solids & Shallow Sediments

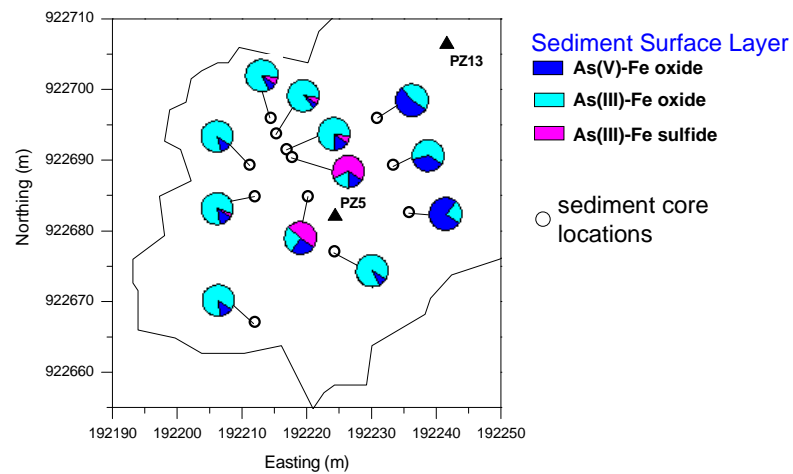
- Significant correlation between Fe and As in sediments
- Concentration of As in suspended solids from Fe precipitation consistent with highest concentrations in shallow sediments



15

Shallow Red Cove Sediments

- Sediment As associated with Fe-bearing minerals (mostly ferrihydrite)
- Predominantly As(III) in western & central transect; As(V) more significant in eastern transect
- High As concentrations and greater As(V) in eastern transect due to less GW discharge and more oxidizing condition (ferrihydrite more stable)

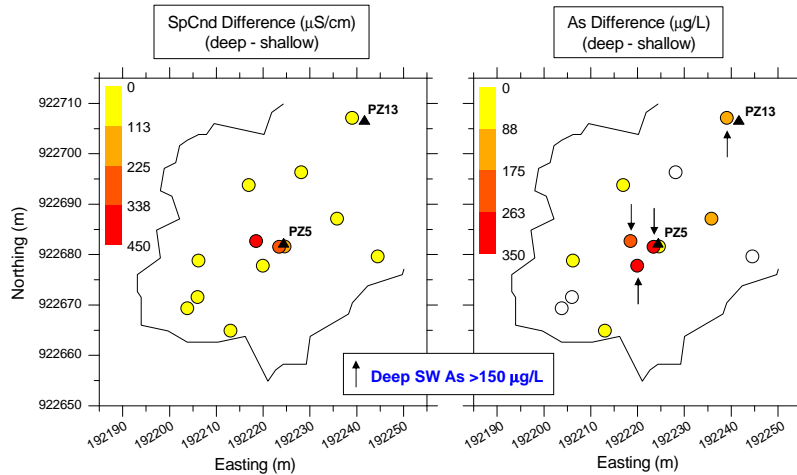


16

Site Characterization: Chemistry

Specific Conductance vs. Arsenic in SW

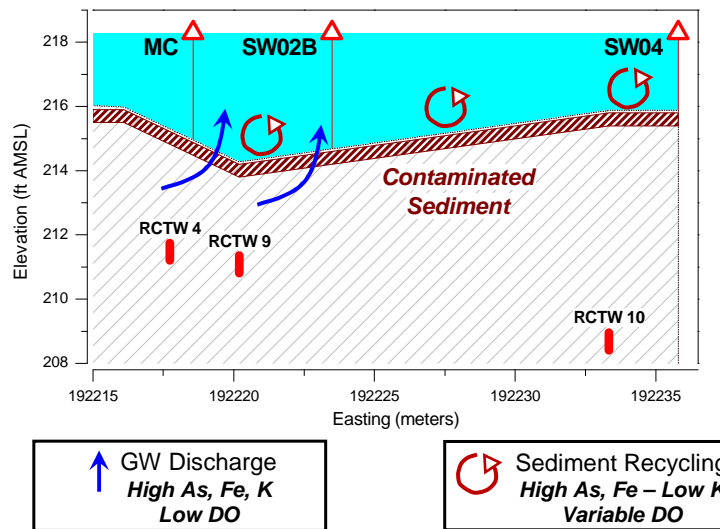
- Difference in specific conductance between deep & shallow SW a good indicator of plume discharge
- Arsenic in deep SW water affected by *plume & sediment dissolution*



17

Fate of As from GW Discharge

Sequestration, but potential instability...



18

Project Findings

Q: Does groundwater discharge into Red Cove?

Yes - measured flow gradients around and within cove demonstrate potential for discharge.

Q: What is the spatial extent of arsenic plume discharge into Red Cove?

Mapped concentrations of arsenic in groundwater around cove perimeter (RSK well clusters) along with GW flux measurements show **greatest flux from west of cove**; data from RCTW wells underlying cove show **maximum concentration in central portion of cove**.

Q: What is the magnitude of arsenic flux discharging into Red Cove?

Calculated flux from measured distribution of hydraulic conductivity, flow gradients, and arsenic concentration in saturated overburden indicate **flux of 20-60 g/day**.

Q: What are the chemical forms of arsenic within the plume and sediments?

Arsenic in GW and deep SW predominantly As(III); dominantly As(III) or As(V) bound to iron oxides in sediments (limited association of As(III) with iron sulfides in central part of Red Cove)

19

Fortuitous Findings

Q: Does the groundwater extraction system at the north end of the landfill capture arsenic plume discharge at Red Cove?

Extraction system operation initiated March 2006 with an increased extraction rate beginning July 2007. Measured groundwater potentiometric surface and seepage within Red Cove from April 2007 to Sept 2008 indicates **plume at Red Cove is not captured**.

Q: What is the distribution of arsenic concentrations as a function of depth within surface water of Red Cove?

Arsenic above AWQC only within deep surface water (<2 ft above sediment surface); dominantly As(III).

Q: Are there physical or chemical parameters that can be used to map groundwater discharge into Red Cove?

Temperature, specific conductance & K concentration; concurrence between multiple parameters better, limited validation w/ direct measure best.

Q: What is the source of "reddish floc" observed in water column and shallow sediments?

Precipitation of ferrous iron (Fe²⁺) following GW discharge and/or diffusion from sediments. (Not re-suspension of sediments.)

20

Current Status – Risk Characterization in Plow Shop Pond by Army

- Hydrologic and chemistry data from Red Cove Study Area used to design approach to select locations for risk characterization to assist differentiating between sediment contamination zones within and outside of locations of plume discharge
- Sampling points include: 1) locations with & without plume discharge, and 2) locations with As(III) vs. As(V) in sediments
- Risk characterization derived from weight-of-evidence approach based on chemistry, survey of macroinvertebrate populations, and sediment toxicity tests
- Graded approach for selection of locations for sediment toxicity – visual observations for “floc” or “no floc” followed by contaminant concentrations in surface water and sediment pore water.

21