Evaluating and Applying Site-Specific NAPL Dissolution Rates during Remediation

ER19-5223

Lloyd "Bo" Stewart
Praxis Environmental Technologies, Inc.

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Former Williams AFB, AZ

ESTCP

Website:

https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Persistent-Contamination/ER19-5223

Project Team

- **Lloyd "Bo" Stewart, Ph.D., P.E. – Principal Investigator**
  Principal Engineer at Praxis Environmental Tech., Inc.
- **Mark Widdowson, Ph.D., P.E. – Co-PI**
  Professor at Virginia Tech
- **Michael Kavanaugh, Ph.D., P.E., NAE – Technical Advisor**
  Senior Principal at Geosyntec Consultants
- **Rula Deeb, Ph.D., PMP, BCEEM – Technology Transfer**
  Senior Principal at Geosyntec Consultants
- **Jennifer Nyman, Ph.D., P.E. – Technology Transfer**
  Principal Engineer at Geosyntec Consultants

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Technical Objectives

Overall objective:

- Validate a practical and cost-effective method to assess source control at NAPL sites that is scientifically-based, process-centric, and at a level accessible to DoD site managers

Flip the modeling upside-down:

simplified flow model coupled with complex remedial processes

Specific technical objectives:

1. Compile research results for NAPL mass transfer coefficients
2. Incorporate results into a spatial-averaged remedial model with upscaling
3. Validate the approach with numerical modeling and application at well-studied and complex field sites
4. Obtain peer review of beta model implementations
5. Transfer the technology to DoD community and other stakeholders

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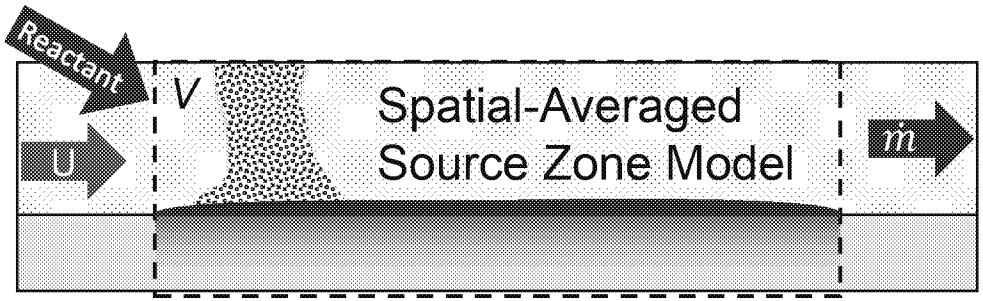
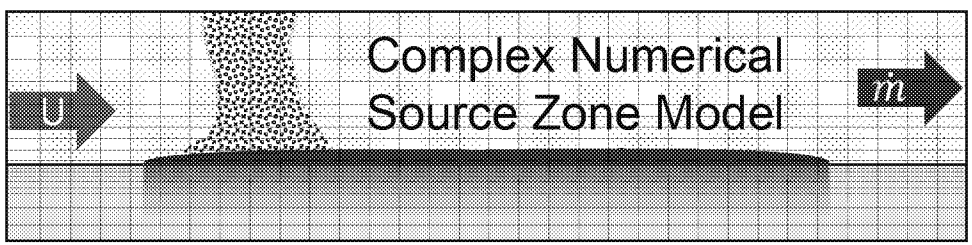
Technology/Methodology Description



- ***Spatial-averaged source zone model:*** Efficient framework for evaluating source control options
- Solution based on ***first principles of mass balances:*** Calculates changes in source concentration or mass flux over time
- Rapid evaluation of ***multi-scale, multi-rate remedial processes***

Current Approach:

- Problem is very difficult for GW-flow based models
- Volume-averaging focuses on remedial processes

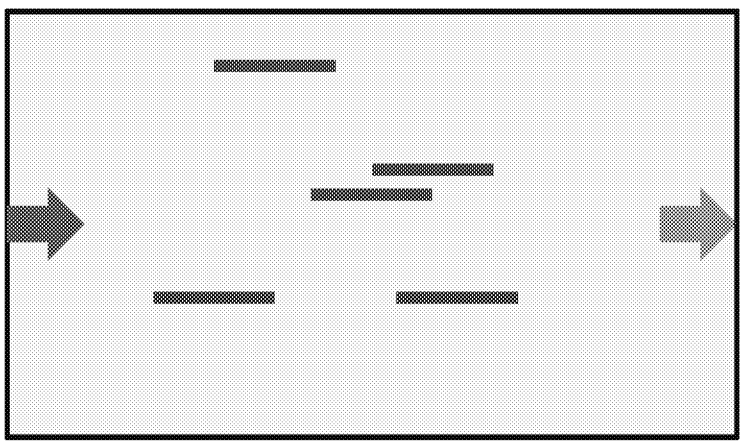


Mathematical Framework and Upscaling

Average discharge concentration from complex NAPL

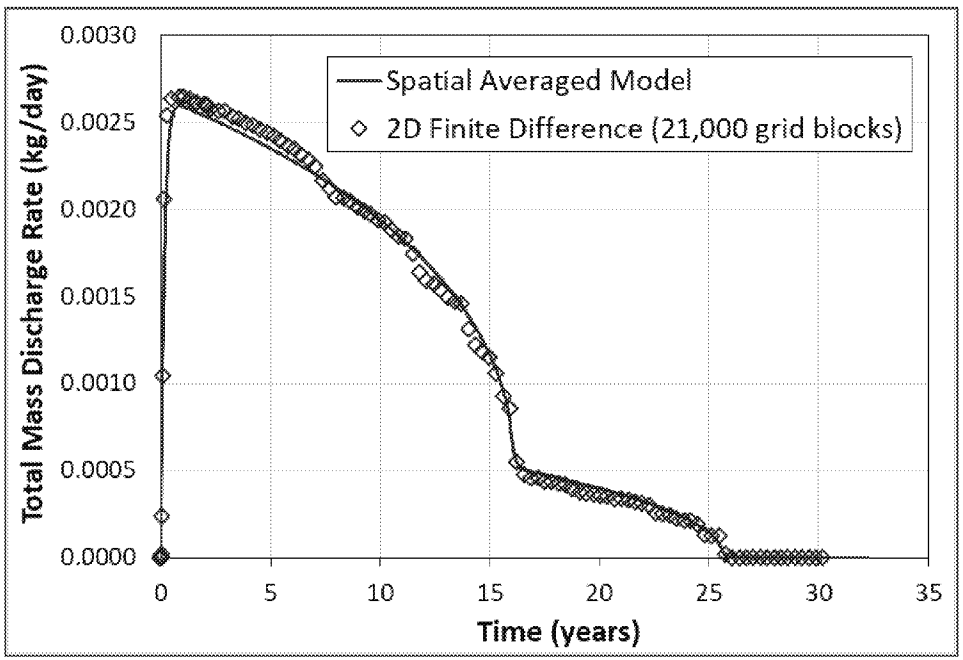
$$\phi R \frac{d\bar{C}}{dt} = -\frac{Q}{V_s}\bar{C} + \sum_{a=1}^{A} K_a (C^* - \bar{C})$$

Falta (2003) – multiple pools

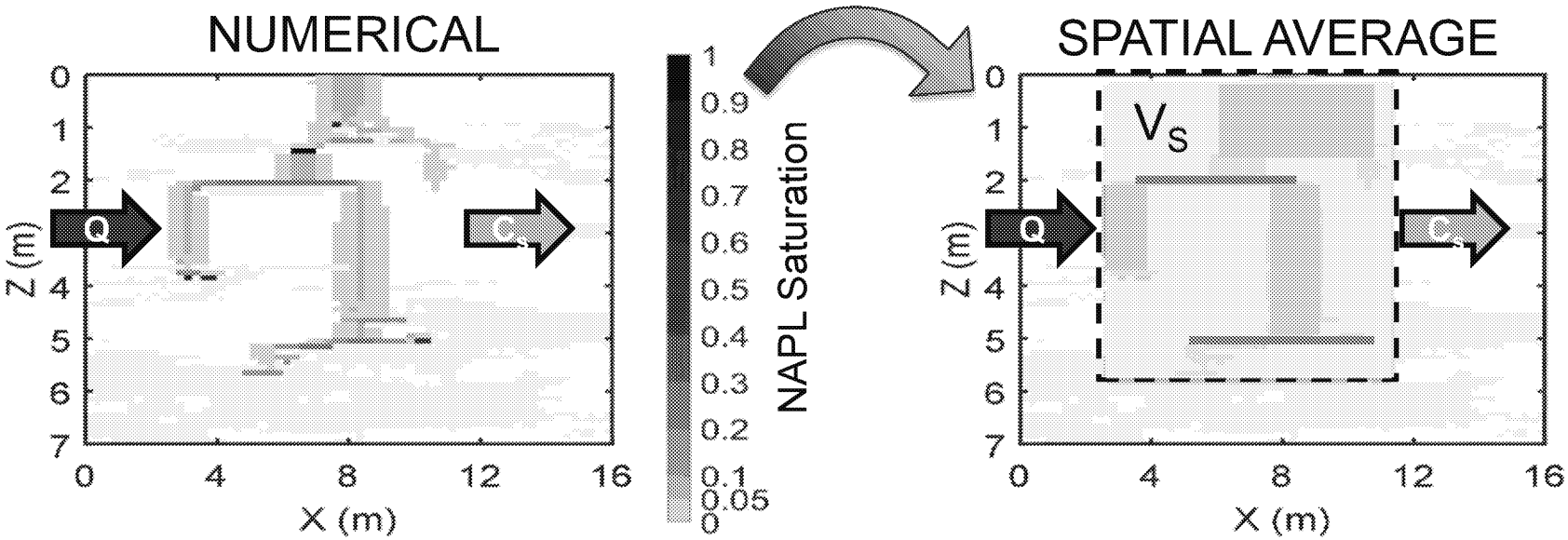


NAPL saturations, for a = 1 to A

$$\rho_n \phi \frac{dS_a}{dt} = -K_a (C^* - \bar{C})$$

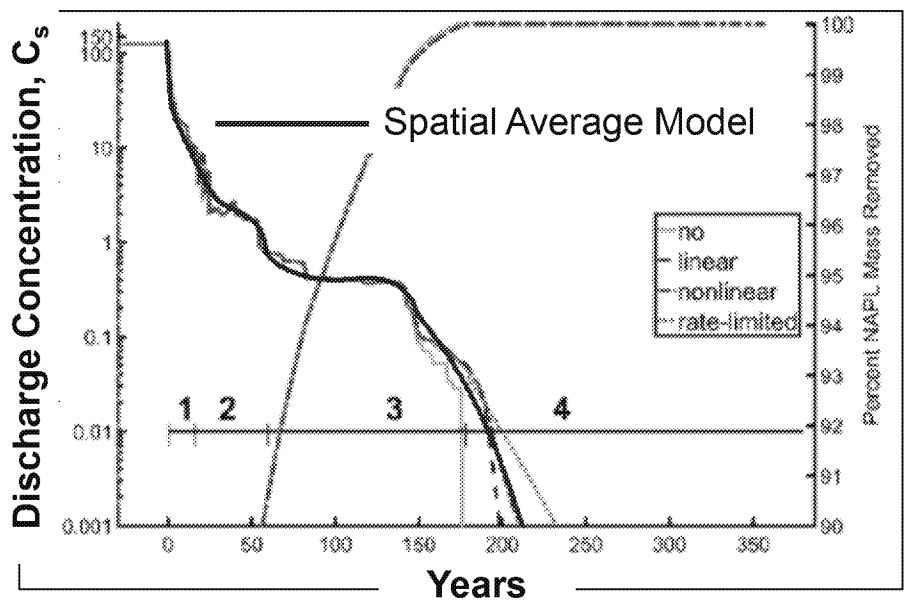


Realistic NAPL Distribution w/Back Diffusion



Pools (high saturation)

Ganglia (low saturation)



<u>Comparison of Discharge Conc</u>

Numerical Model

versus

Volume Average assuming:

- 5 NAPL masses
- back diffusion

Remediation Process Models

- Monitored Natural Attenuation
- Pump-and-Treat
- Enhanced Bioremediation
  - Substrate Injection
  - Bioaugmentation
- In Situ Chemical Oxidation
  - Permanganate, persulfate, catalyzed hydrogen peroxide
- Chemical Enhancement
  - Surfactant, Co-solvent
- Thermal Enhancement
  - Electrical Resistance Heating, Steam or Hot Injection
  - But NOT NAPL mobilization

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Site Description: Complex Demonstration

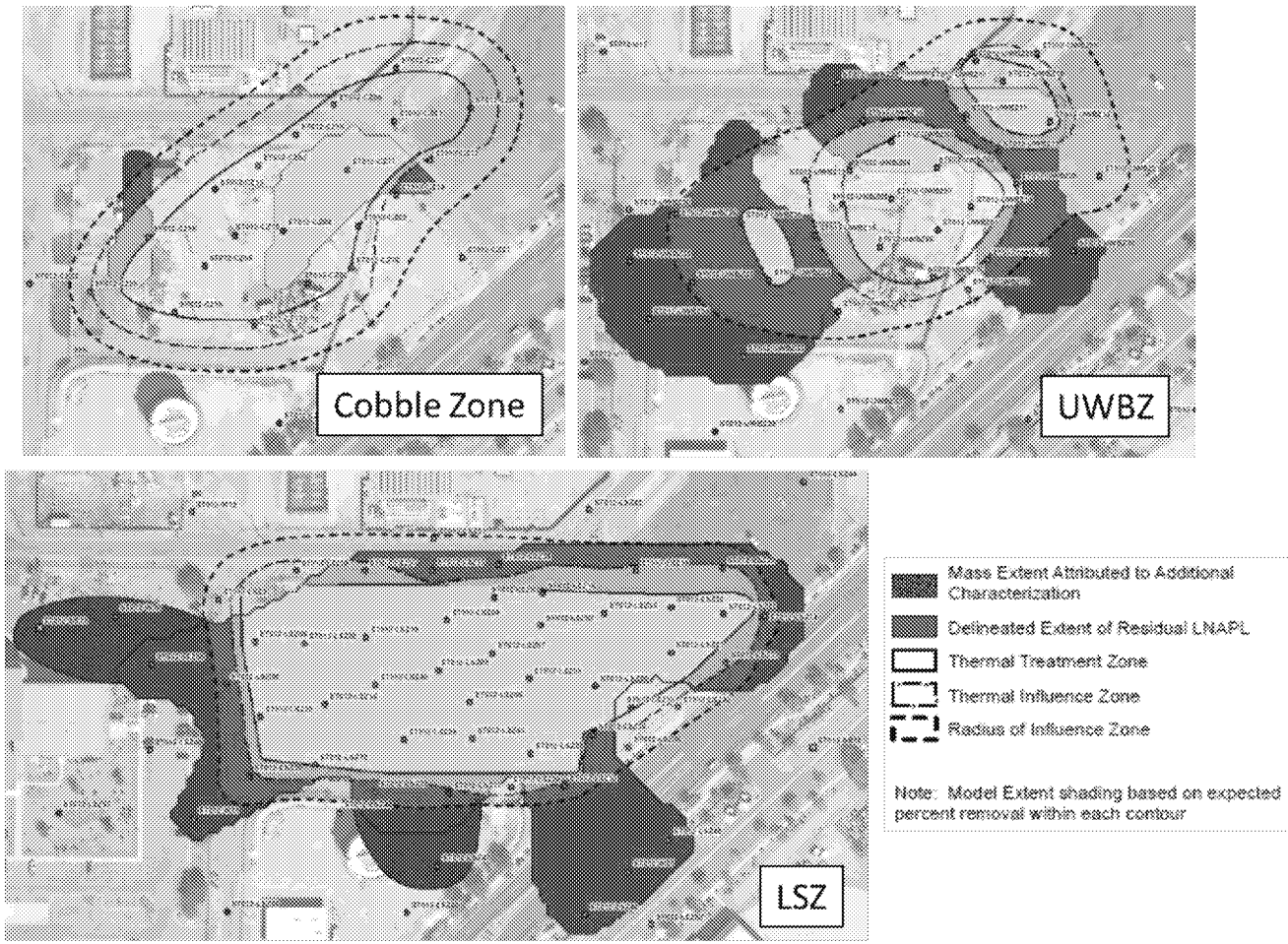
ST012, Former Williams AFB, AZ

Pre- and post-treatment data, NAPL recovery, and operating parameters available for the saturated zone:

- MNA (1980's-2008)
- Pump-and-treat (2008-2014)
- Pilot test of thermal enhanced extraction (2008)
- Steam enhanced extraction (2014-2016)
- Enhanced sulfate reduction (2018-present)
- ***Decision Point???***
- MNA (planned final remedy)

>2M gallons JP-4 fuel

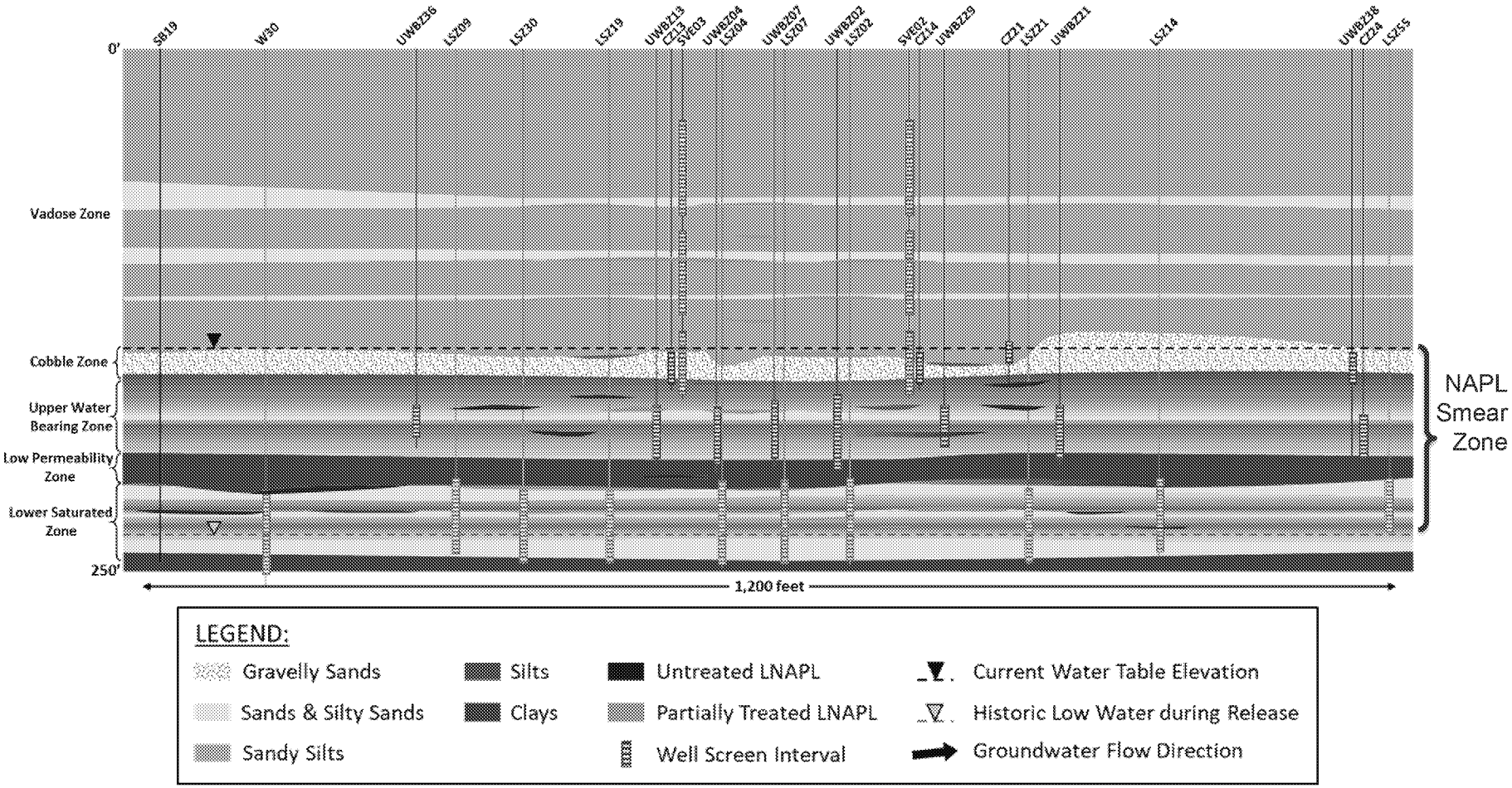
NAPL extent across the site (2018)



Site Description: Complex Demonstration

ST012, Former Williams AFB, AZ

NAPL Vertical Extent along the GW Flow Direction (2018)



Key Points

- Support tool applicable to *remedial decisions* at NAPL sites considering source control
  - Remedial process-centric approach
  - DEM/VAL for multiple remediation scenarios
- Targeted to DoD and regulatory community
  - *Site- and technology-specific modeling* is not based on a numerical groundwater flow model
- Response to regulatory concerns regarding source control and lifespan
  - "What *scientific justification* supports the remedial decision?"
- Web-based access

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ER19-5223: Evaluating and Applying Site-Specific NAPL Dissolution Rates during Remediation

Performers: Praxis Environmental Technologies, Inc., Virginia Tech, Geosyntec Consultants

Technology Focus

- Validate a novel, practical, and cost-effective method, the ***Volume-Averaged Source Zone Model***, to efficiently calculate changes in source concentration or mass flux over time at NAPL sites

Demonstration Sites

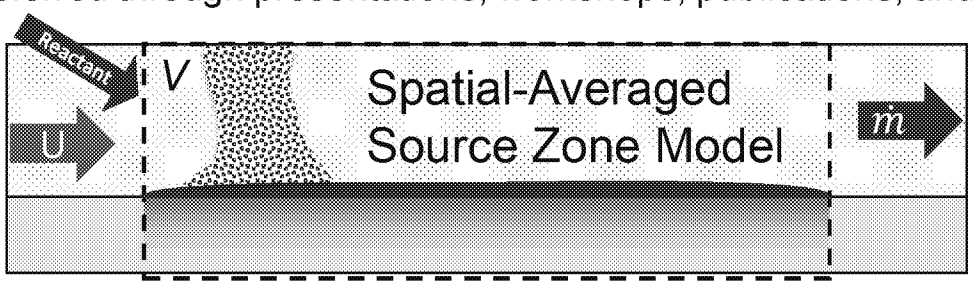
- Naval Submarine Base (NSB), Kings Bay, GA
- ST012, Former Williams AFB, AZ

Demonstration Objectives

- Incorporate previous mass transfer research into a volume-averaged remedial model with upscaling
- Validate the approach with numerical modeling and ***application at well-studied and complex field sites***

Project Progress and Results

- Project is in progress

Implementation

A ***web-based platform*** will be developed and provided to DOD remedial project managers and regulators
Technology will be transferred through presentations, workshops, publications, and a video