Natural Attenuation System (NAS) – Software for Assessing Combining Source Area Remediation with Natural Attenuation

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Background

- NAVFAC, US Geological Survey, and Virginia Tech collaborated to produce technical guidance for assessing Monitored Natural Attenuation (MNA) as a remedial strategy at US Navy sites:
  - Systematic methodology and decision-making framework for implementing MNA in conjunction with source zone remediation (USGS WRIR 03-4057).
  - Computational tool for estimating the effects of combining source zone remediation with MNA.
Background

- Natural Attenuation Software (NAS) is a computational tool for evaluating the effect of source zone remediation on *plume reduction* and on *time of remediation* (TOR)
  - Screening tool for rapid and accurate solutions
  - Interactive software program that utilizes a Visual Basic platform
  - Enables the user to input site-specific data
  - Solutions are determined based on site-specific remedial action objective (RAO)
  - Post-audit feature for evaluating in-progress sites
NAS – Structure and Function

Hydrogeology
Contaminant & Source Data

Site Data Assessment

Sorption
Redox Indicator Data

Plume Reduction
Distance and Time of Stabilization (DOS/TOS)

Source Zone
Time of NAPL Dissolution (TND)

Point of Regulatory Compliance
Remedial Action Objective
The *Distance of Stabilization* approach takes advantage of the *Natural Attenuation Capacity (NAC)* of the aquifer.
Source remediation can reduce the mass flux of contaminants, resulting in a smaller, stable plume where concentrations meet remediation goals.
The question often posed is *when* will the RAO be reached at the regulatory point of compliance?
NAS employs a mass-balance approach to the problem of source zone depletion

- Numerical source-zone model is implemented using the code SEAM3D
- Implements NAPL Dissolution Package – mass transfer function for multi-component mixtures
Based on estimates of source zone mass, composition, geometry, and mass flux, NAS/SEAM3D tracks each constituent over time in both the NAPL and aqueous phases.
NAS processes the results to enable the user to query the result for a TOR estimate based on RAO (e.g., MCL)
Post-Audit Data Analysis

**Goal:** Improve TOS/TOR estimates with integration of long-term performance monitoring data

- Import monitoring data for the comparison of predicted versus observed trends
- Develop revised TOS/TOR concentration vs. time curves
1. Enter the following hydrogeologic and aquifer properties.

<table>
<thead>
<tr>
<th>Property</th>
<th>Maximum</th>
<th>Average</th>
<th>Minimum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Conductivity [ft/d]</td>
<td>30.0</td>
<td>19.0</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Gradient [ft/ft]</td>
<td>0.0009</td>
<td>0.0009</td>
<td>0.0009</td>
<td></td>
</tr>
<tr>
<td>Weight Percent Organic Carbon [%]</td>
<td>0.04</td>
<td>0.024</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Total Porosity [ft²/ft²]</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective Porosity [ft²/ft²]</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Enter the distance from the contaminant source to the nearest downgradient Point of Compliance (POC).

Distance to POC [ft]: 150.0

2. Enter the Regulatory Compliance Concentration (RCC) at the Point of Compliance (POC) to determine the required Target Source Concentration (TSC), or enter the TSC after source reduction to determine the Concentration at the POC.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>RCC [µg/L]</th>
<th>Source Reduction</th>
<th>Time of Stabilization [years]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Conc [µg/L]</td>
<td>Breakthrough Time Maximum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Well</td>
<td>Minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current</td>
<td>Maximum</td>
</tr>
<tr>
<td>Total Chl. Eth.</td>
<td>5.0</td>
<td>1</td>
<td>5125</td>
</tr>
<tr>
<td>TCE</td>
<td></td>
<td>1</td>
<td>5100</td>
</tr>
<tr>
<td>cis-DCE</td>
<td></td>
<td>2</td>
<td>250</td>
</tr>
<tr>
<td>Vinyl Chl.</td>
<td></td>
<td>3</td>
<td>142</td>
</tr>
</tbody>
</table>
Site Demonstration (ESTCP)

- PIs applied NAS at eight (8) chlorinated solvent sites that encompassed a range of conditions including hydrogeologic setting and source control options
- NAS was evaluated by comparing results to long-term performance data (>8 yr)
- Performance metrics were
  - Accuracy
  - Versatility
  - Reliability
  - Applicability
Total Chloroethenes (12-74 mg/L)

GW Velocity (38 – 96 ft/yr)

Ash Landfill (38 yr)
- Solid waste incineration and ash disposal

Primary contaminants impacting groundwater
- TCE, 1-2,DCE and VC

Surficial aquifer impacted
- Glacial till
- Fractured weathered shale
The observed source reduction served as input to the solution.

The concentration of total chloroethenes in the source well (PT-18A) dropped from 12 mg/L to 5.9 mg/L.

The solution captured the 10-yr trend in terms of equilibrium time and concentration.
Keeping all input parameters the same as the previous simulation, the solution failed to accurately match the observed equilibrium concentration.

Consistency in the solutions is noted for the time of stabilization.
Hill AFB (UT) – OU2

Source

• Disposal of TCE (40-50k gal) in unlined trenches
• Source Control - Containment wall
The observed source reduction served as input to the solution.

The concentration of TCE at a monitoring well downgradient of the wall (U2-085) dropped from 8 mg/L to 3.5 mg/L.

The solution captured the 8-yr concentration trend
In Scenario C, hydraulic conductivity was based on the near-source formation and the hydraulic gradient was averaged over space to adjust for perturbations created by the recharge mound.
NAES Lakehurst, NJ

- Aircraft Mission Support
- Primary contaminants impacting surficial aquifer
  - TCE, 1-2,DCE and PCE
Mass Estimates Constrained Using NAS

- **Source Well LK**: M = 8,000 kg
- **M = 9,000 kg**

**NAS (SEAM3D)**

**Field**

- Total Chlorinated Ethene Concentration (μg/L)
- Time (1995 to 2015)
Comparison of Predictive Tools

![Graph showing the comparison of predictive tools for Total Chlorinated Ethene Concentration (μg/L) over time from 1995 to 2015. The graph includes data points and lines representing different models: 97 Model (RT3D), NAS (SEAM3D), and 2003 Model (Data Extrapolation).]
Conclusions

- **Natural Attenuation Software (NAS)** provides a reliable platform and framework for implementing analytical and numerical solutions for combining source zone remediation with MNA.

- **Plume reduction** – NAS was effective in predicting the time of stabilization at monitoring wells following source remediation and a reduction in source zone contaminant concentrations.

- **Source zone depletion** – NAS was also effective in capturing depletion time trends of a multi-component NAPL using a mass balance approach.

- **Training** – NAS is widely available. NAS training has been delivered at a number of venues throughout the US over the last four years.