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

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Invent the Future

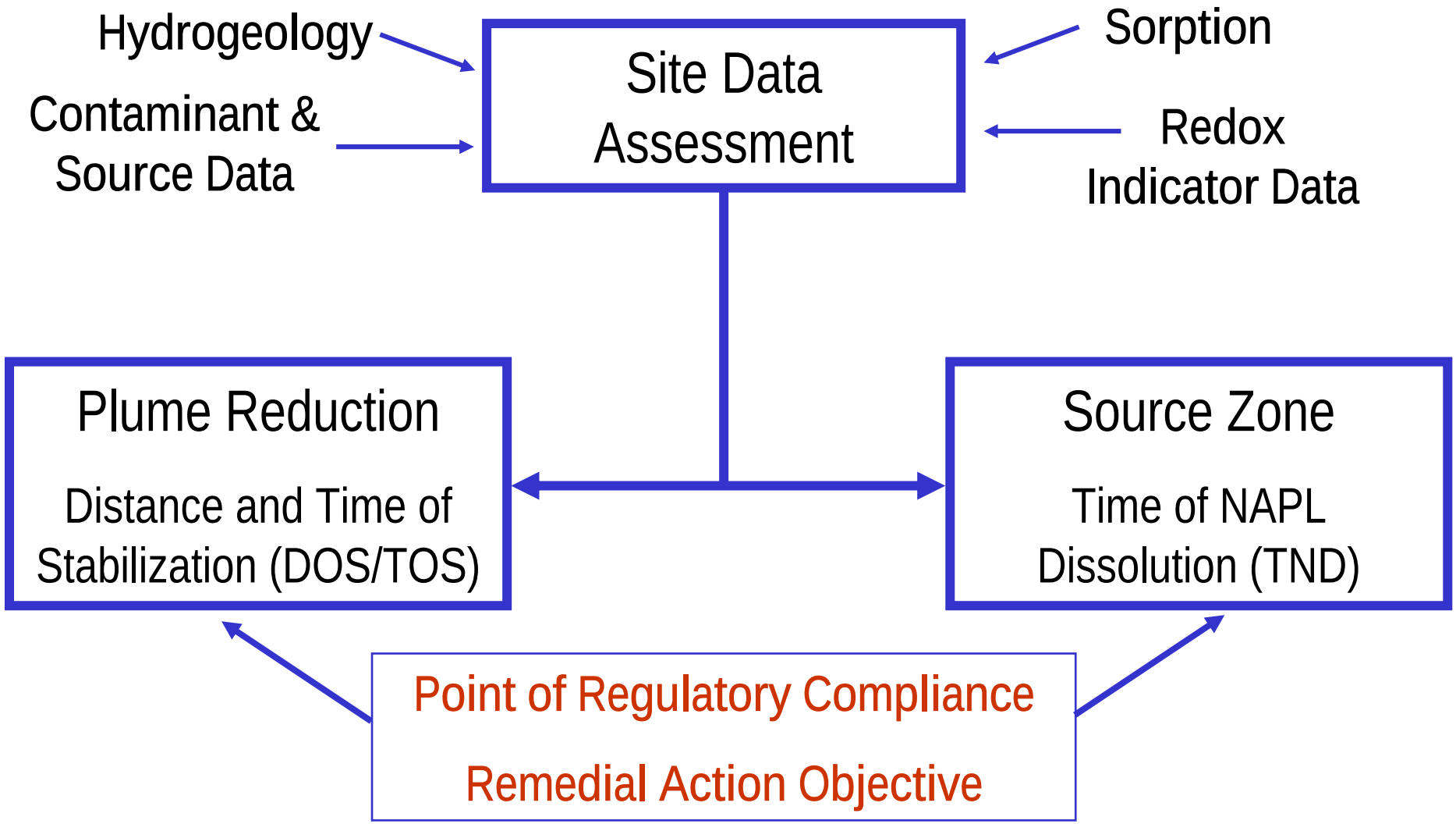
Background

- 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

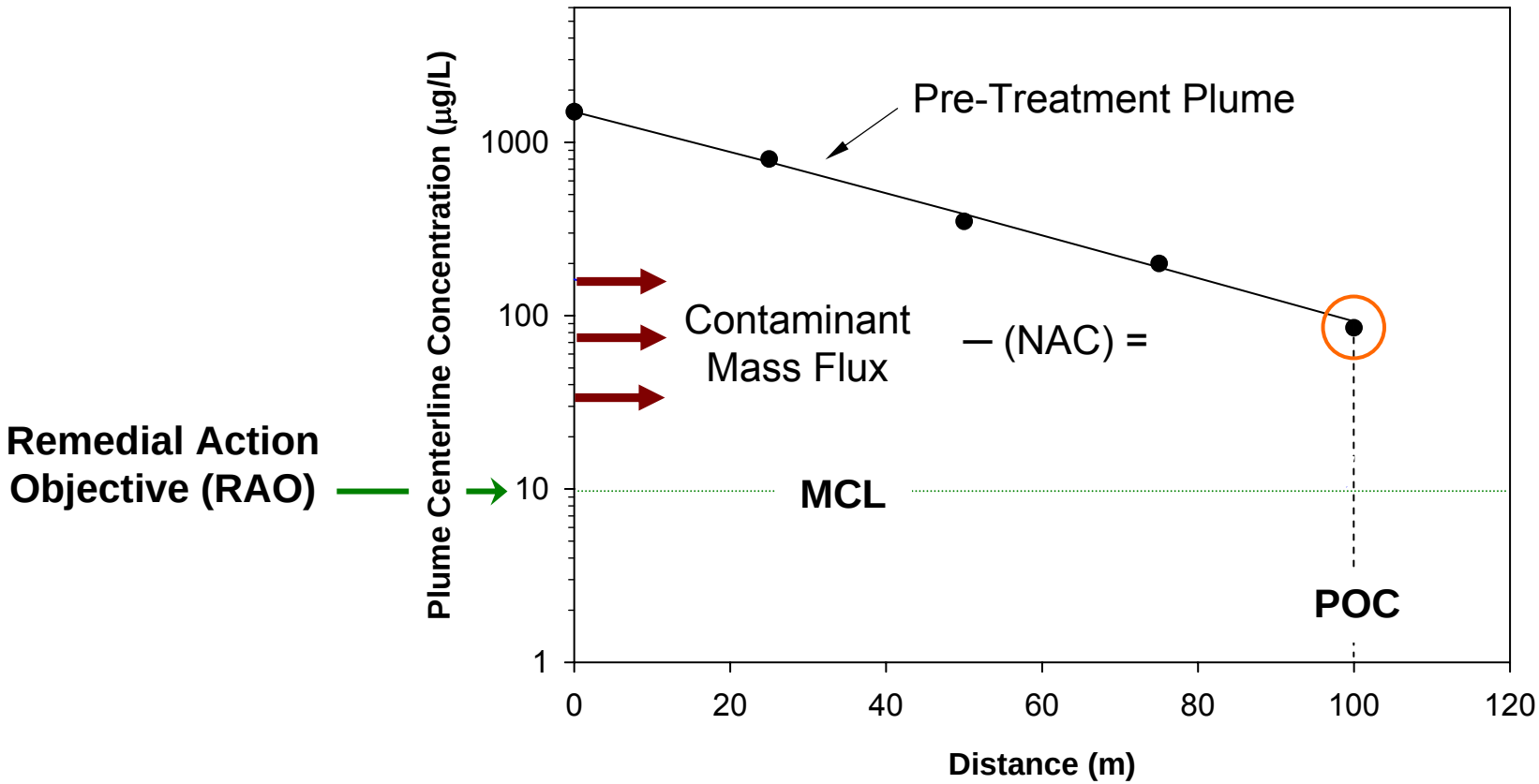
- Natural Attenuation Software (NAS) is a computational tool for evaluating the effect of source zone remediation on *plume reduction* and on *time of remediation* (TOR)
  - Screening tool for rapid and accurate solutions
  - Interactive software program that utilizes a Visual Basic platform
  - Enables 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



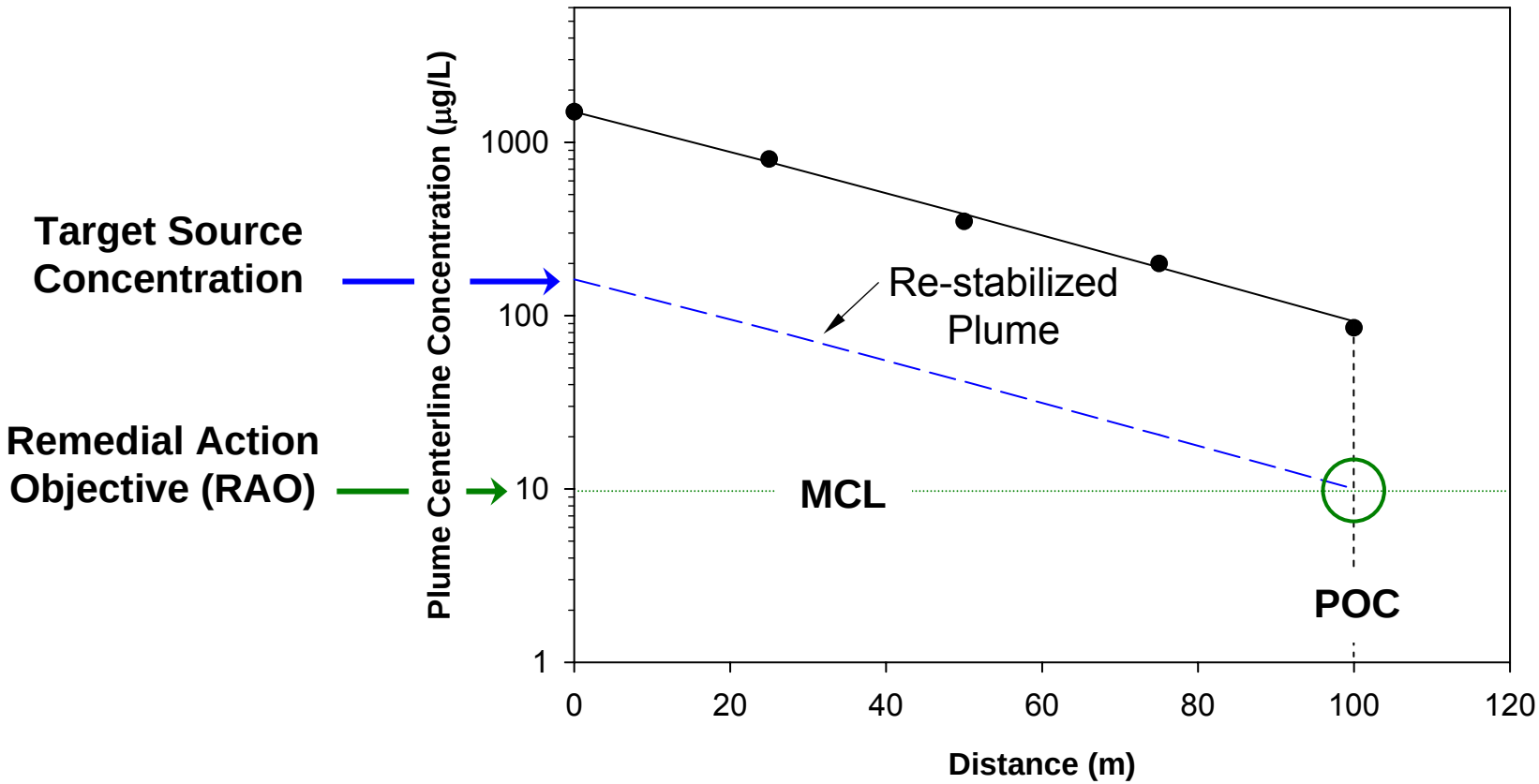
Distance of Stabilization

The *Distance of Stabilization* approach takes advantage of the *Natural Attenuation Capacity* (*NAC*) of the aquifer.



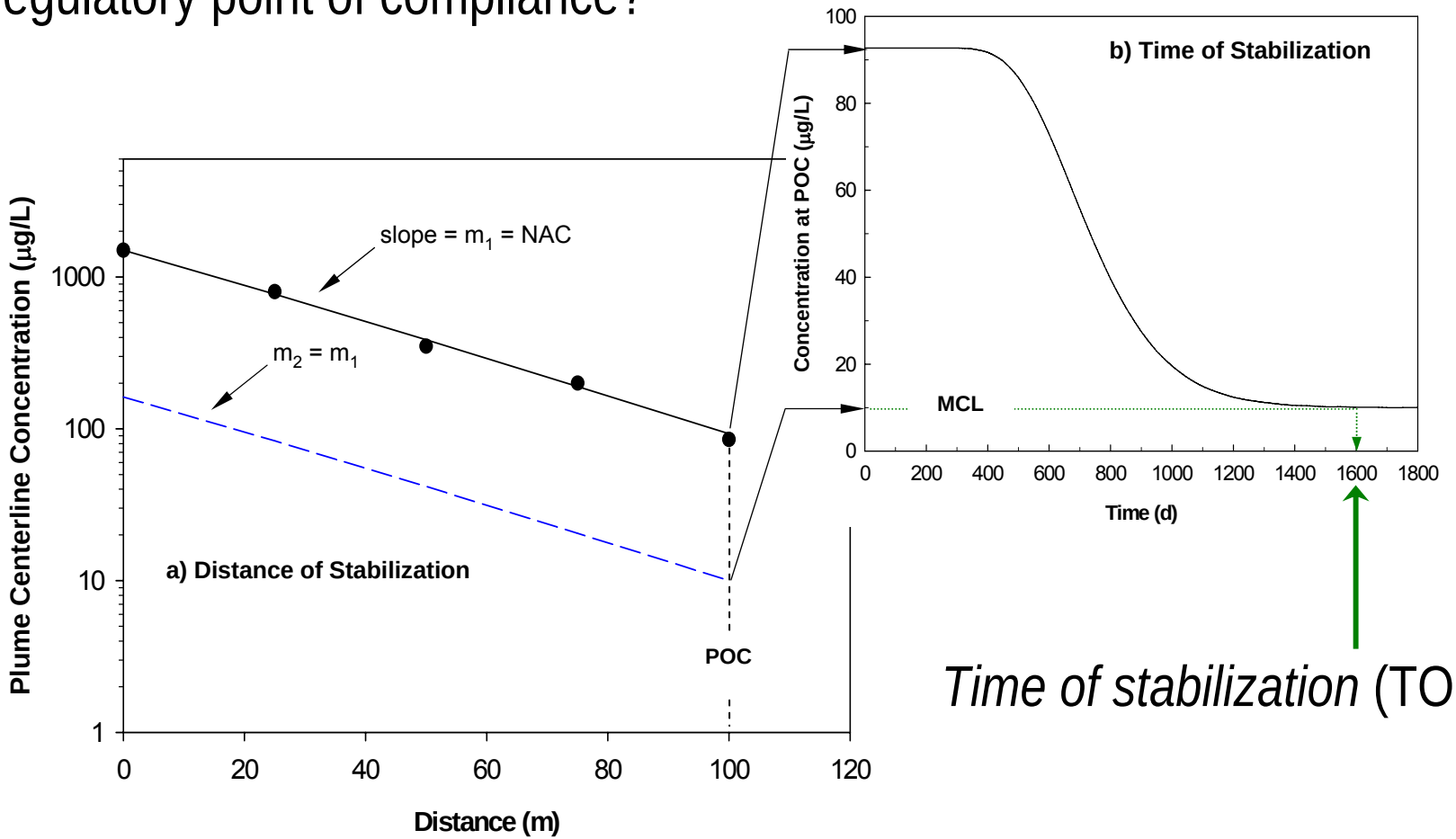
Distance of Stabilization

Source remediation can reduce the mass flux of contaminants, resulting in a smaller, stable plume where concentrations meet remediation goals.



Time of Stabilization

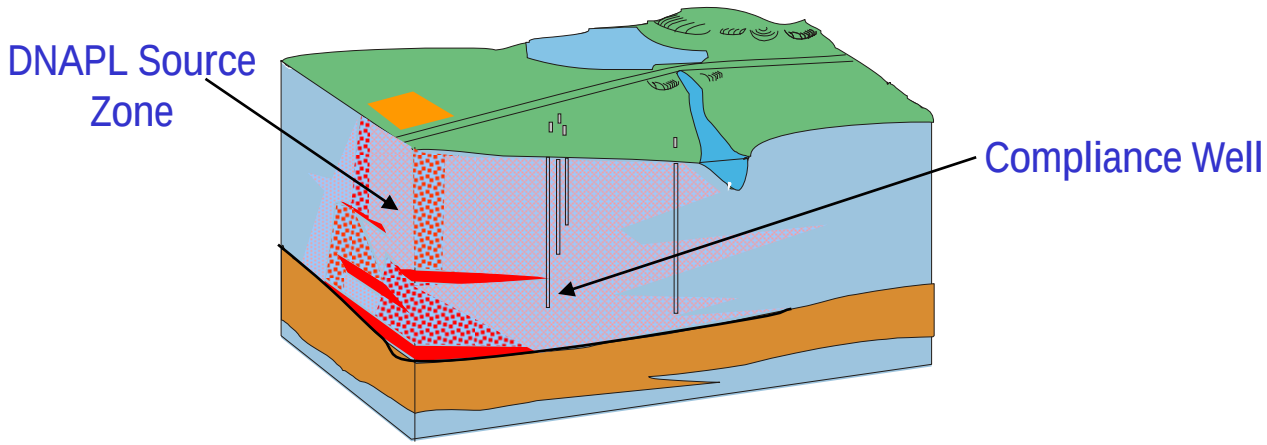
The question often posed is *when* will the RAO be reached at the regulatory point of compliance?



Time of stabilization (TOS)

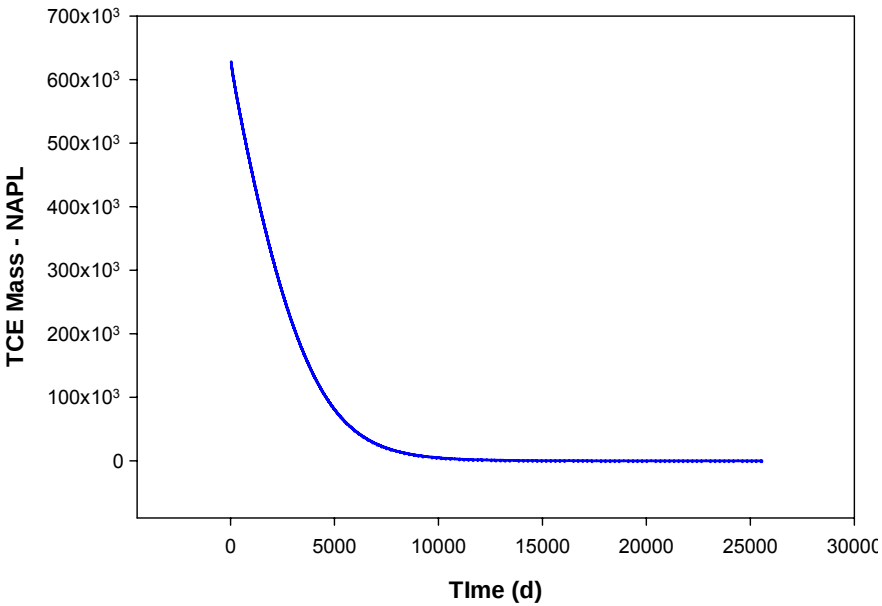
Source Depletion Model

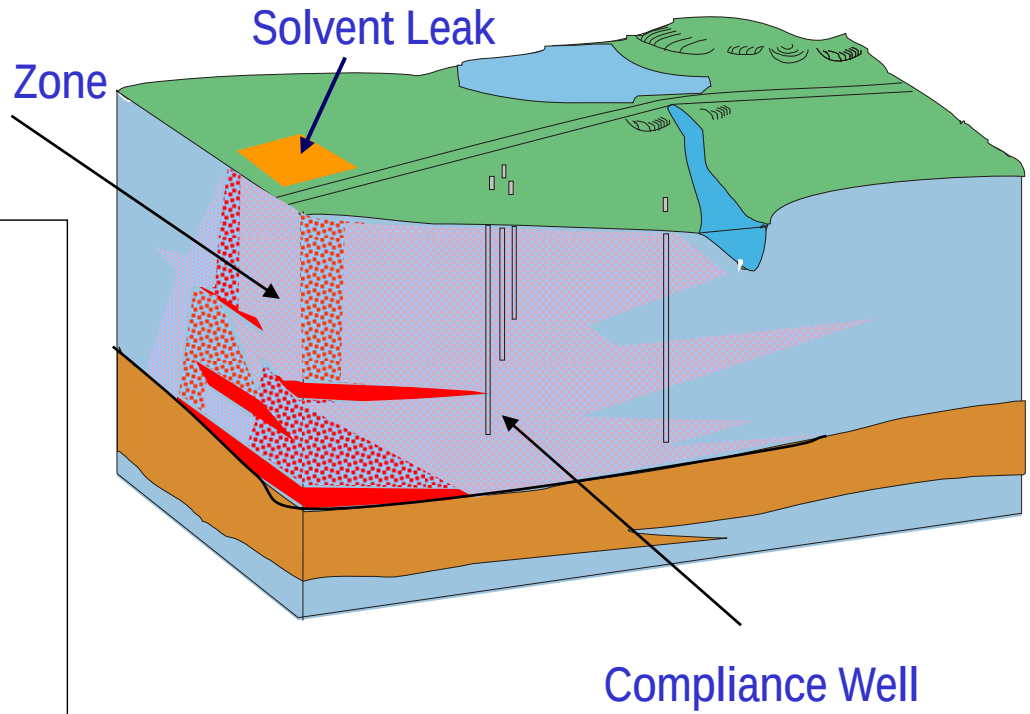
- *NAS* employs a mass-balance approach to the problem of source zone depletion
  - Numerical source-zone model is implemented using the code *SEAM3D*
  - Implements NAPL Dissolution Package – mass transfer function for multi-component mixtures



Source Depletion Model

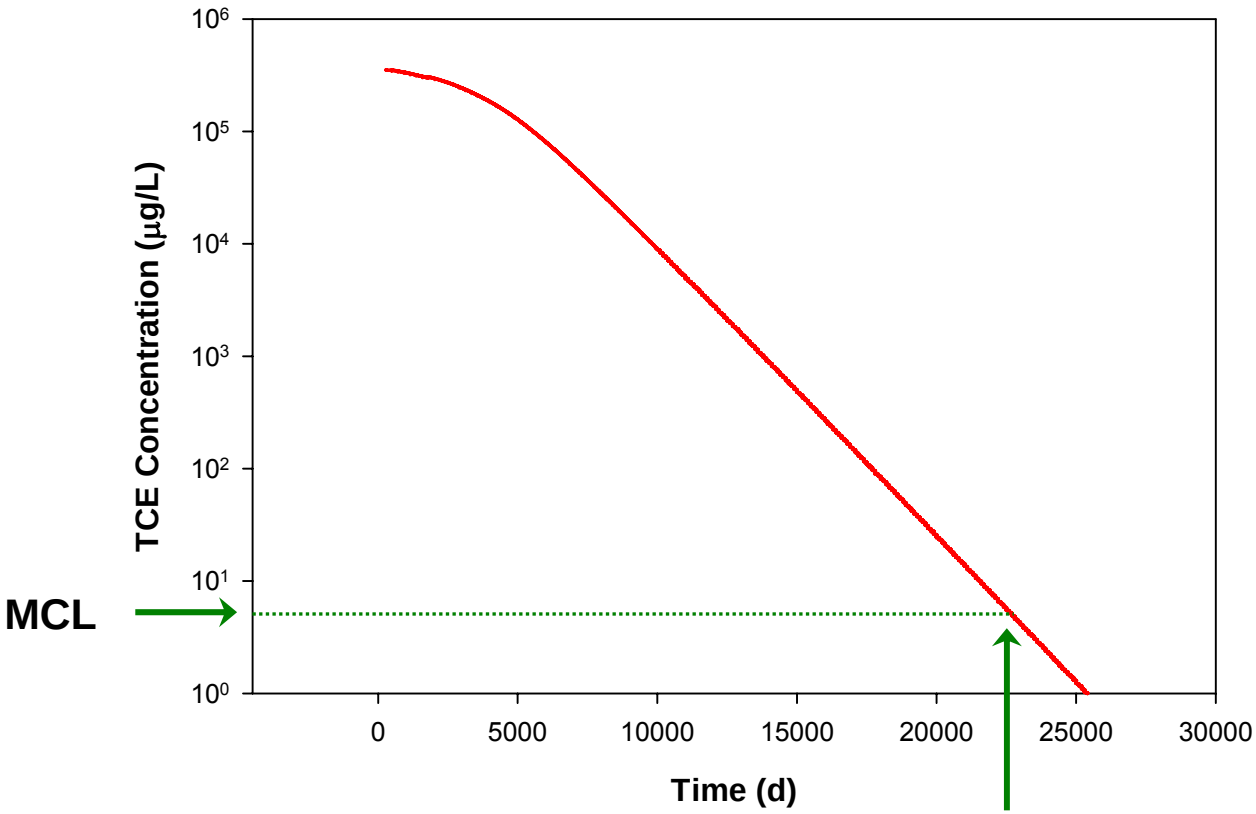
Based on estimates of source zone mass, composition, geometry, and mass flux, NAS/SEAM3D tracks each constituent over time in both the NAPL and aqueous phases





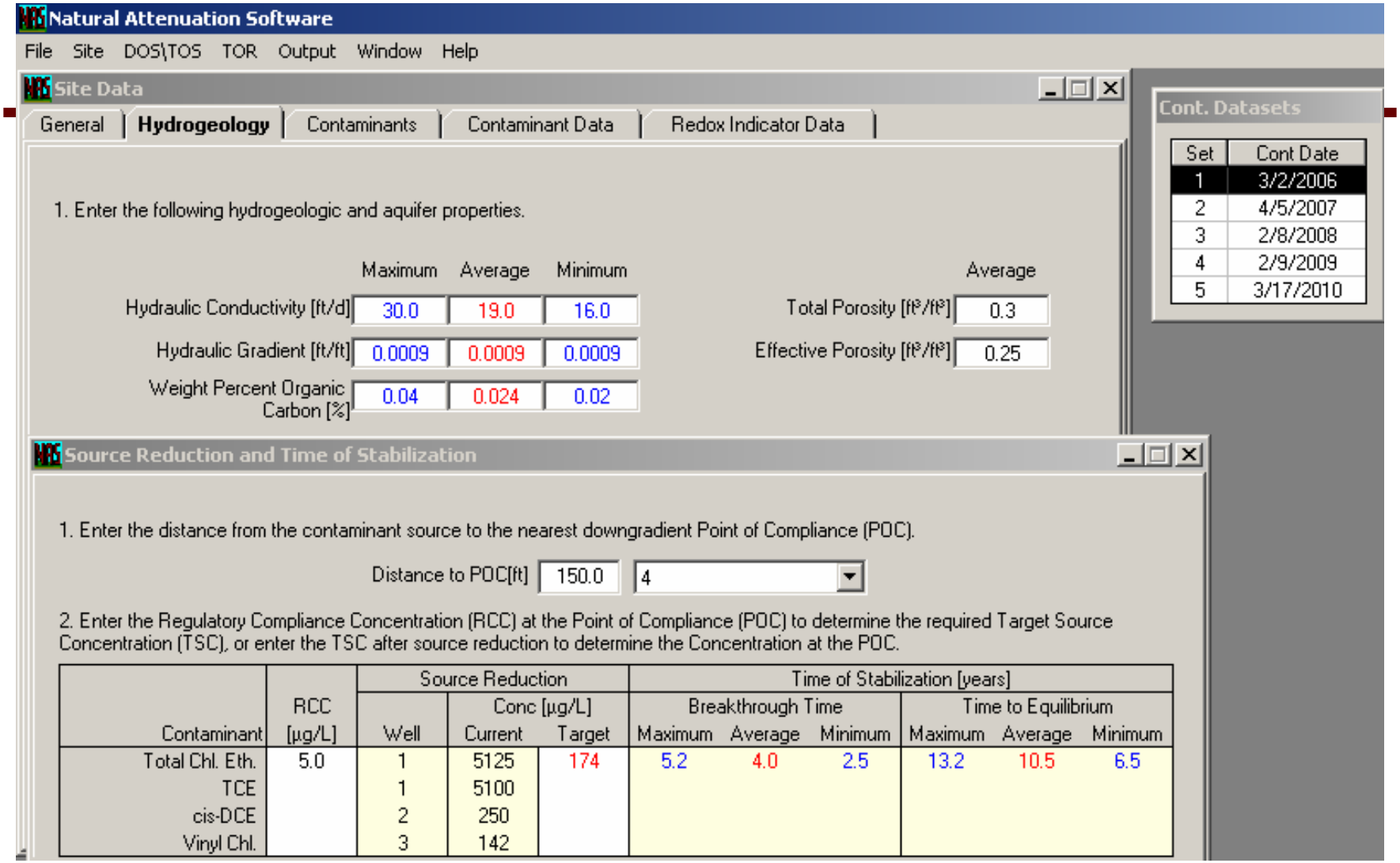
Time of Remediation (TOR)

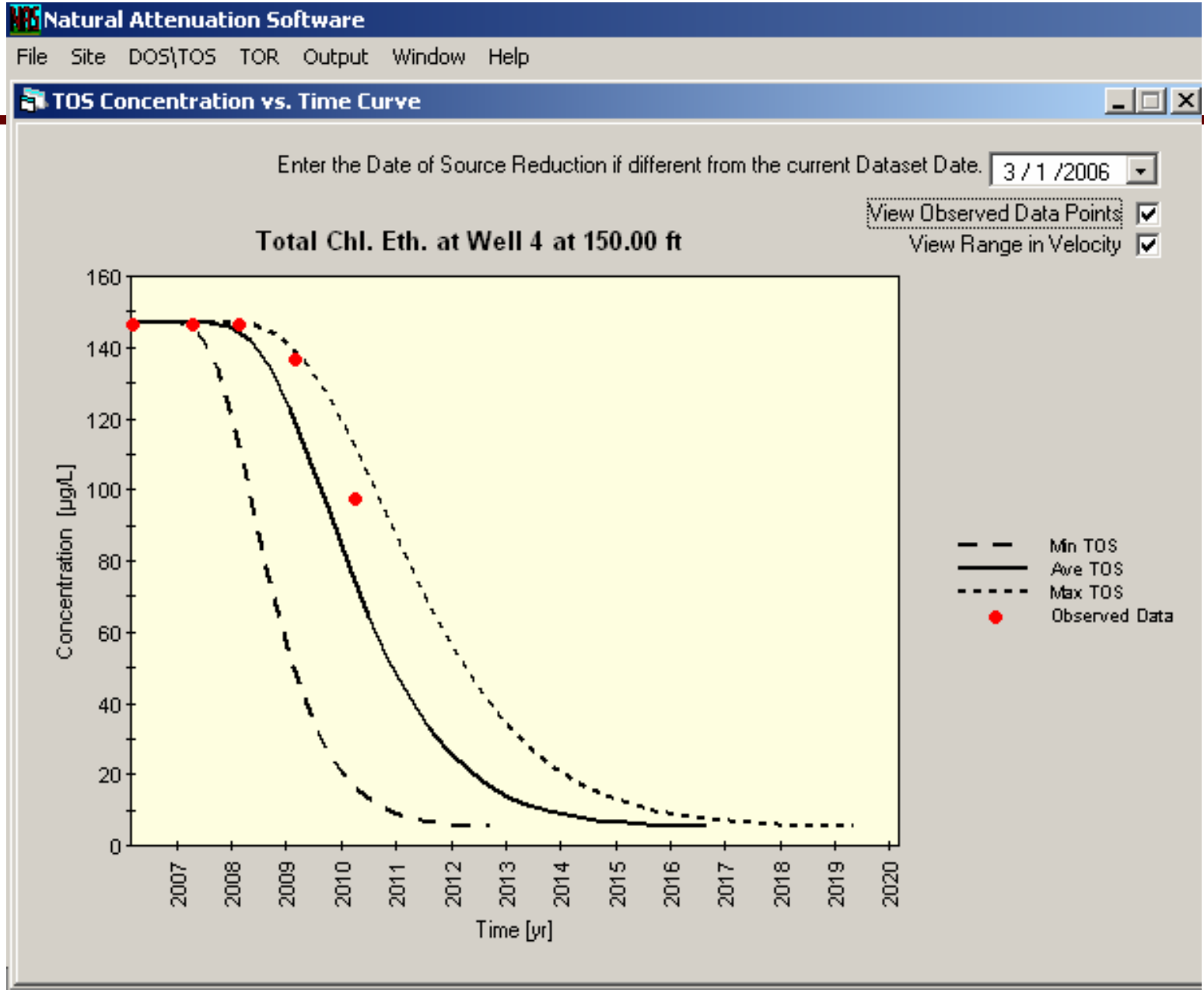
NAS processes the results to enable the user to query the result for a TOR estimate based on RAO (e.g., MCL)



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

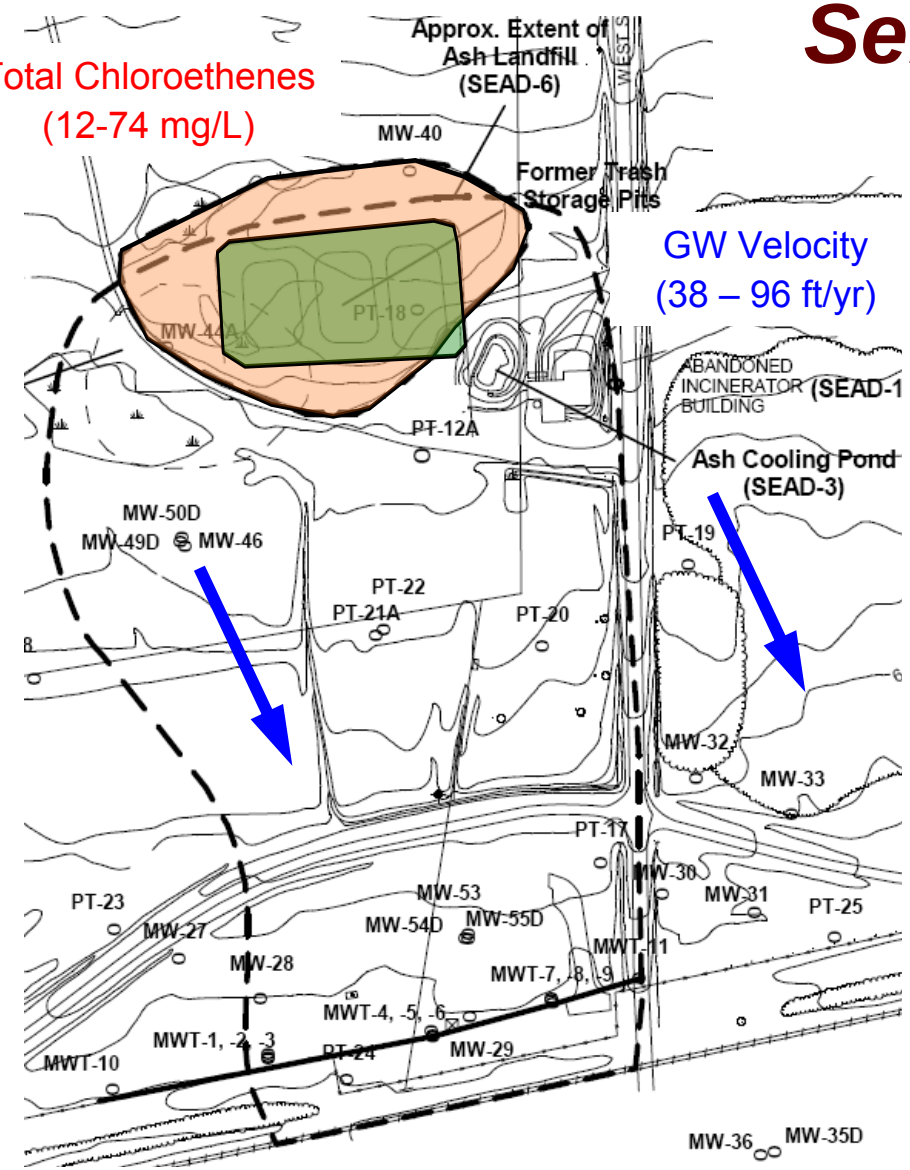

Natural Attenuation Software
File Site DOS\TOS TOR Output Window Help
Site Data
General Hydrogeology Contaminants Contaminant Data Redox Indicator Data
1. Enter the following hydrogeologic and aquifer properties.
Maximum Average Minimum
Hydraulic Conductivity [ft/d] 30.0 19.0 16.0
Hydraulic Gradient [ft/ft] 0.0009 0.0009 0.0009
Weight Percent Organic Carbon [%] 0.04 0.024 0.02
Average
Total Porosity [ft³/ft³] 0.3
Effective Porosity [ft³/ft³] 0.25
Cont. Datasets
Set Cont Date
1 3/2/2006
2 4/5/2007
3 2/8/2008
4 2/9/2009
5 3/17/2010
Source Reduction and Time of Stabilization
1. Enter the distance from the contaminant source to the nearest downgradient Point of Compliance (POC).
Distance to POC[ft] 150.0 4
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.
Contaminant RCC [µg/L] Source Reduction Well Conc [µg/L] Current Target Time of Stabilization [years] Breakthrough Time Maximum Average Minimum Time to Equilibrium Maximum Average Minimum
Total Chl. Eth. 5.0 1 5125 174 5.2 4.0 2.5 13.2 10.5 6.5
TCE 1 5100
cis-DCE 2 250
Vinyl Chl. 3 142


Natural Attenuation Software
File Site DOS\TOS TOR Output Window Help
TOS Concentration vs. Time Curve
Enter the Date of Source Reduction if different from the current Dataset Date.
3 / 1 /2006
View Observed Data Points
View Range in Velocity
Total Chl. Eth. at Well 4 at 150.00 ft
Concentration [µg/L]
160
140
120
100
80
60
40
20
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Time [yr]
Min TOS
Ave TOS
Max TOS
Observed Data

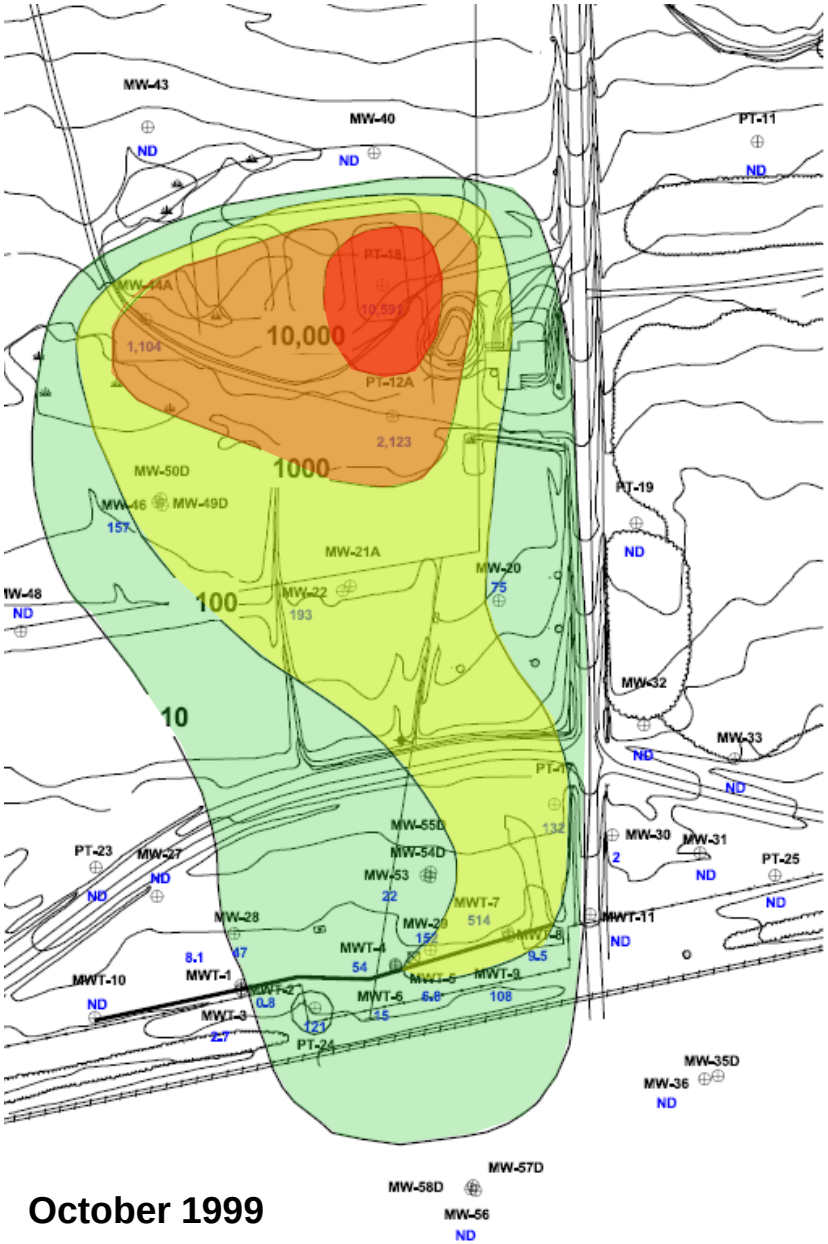
Site Demonstration (ESTCP)

- 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

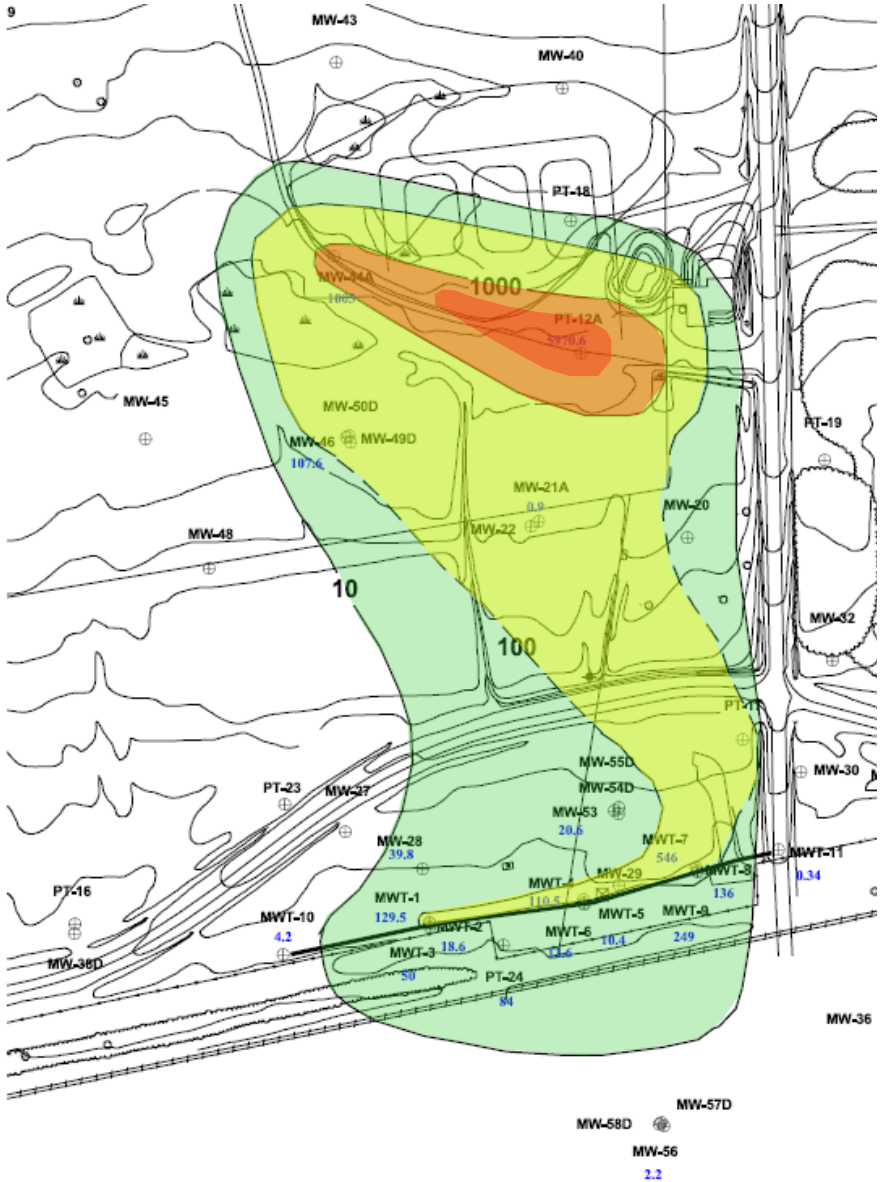
Seneca Army Depot (NY)



- 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



October 1999



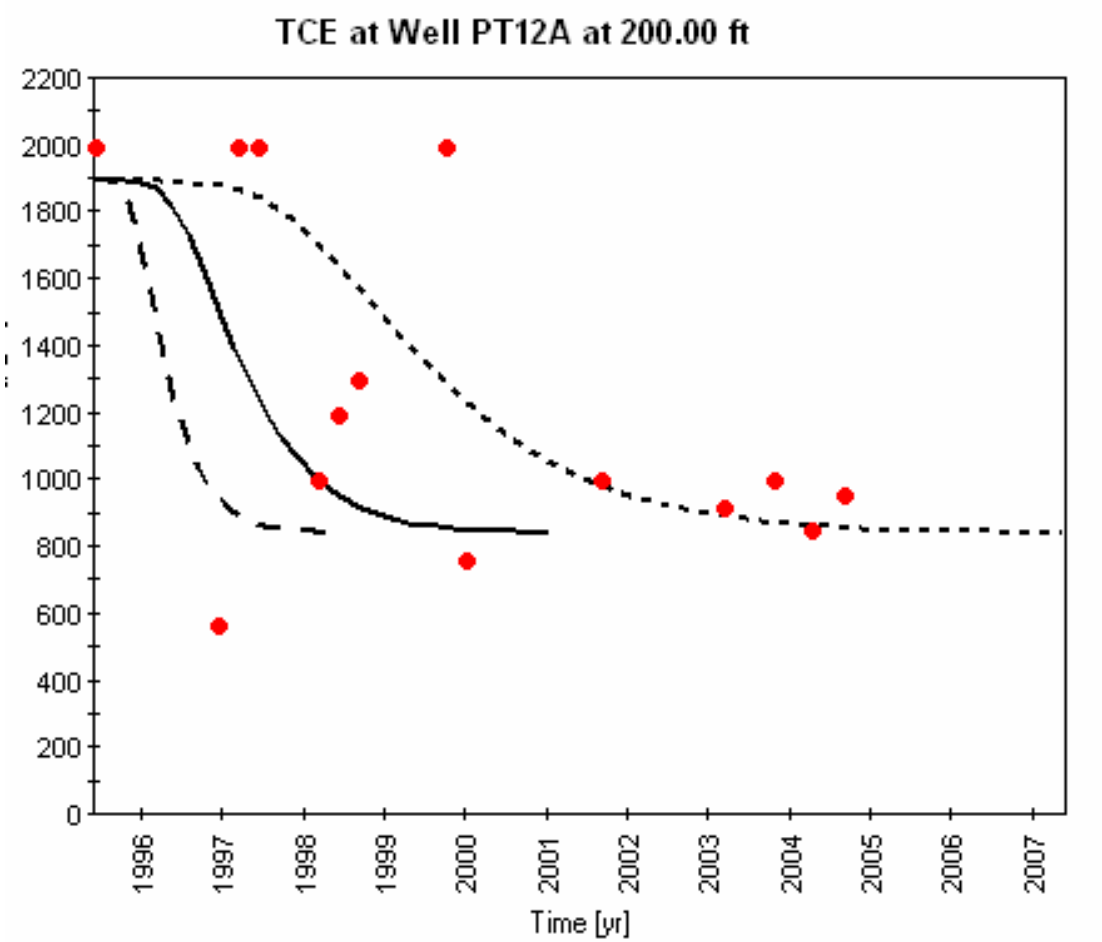
July 2003

TOS Estimates

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.

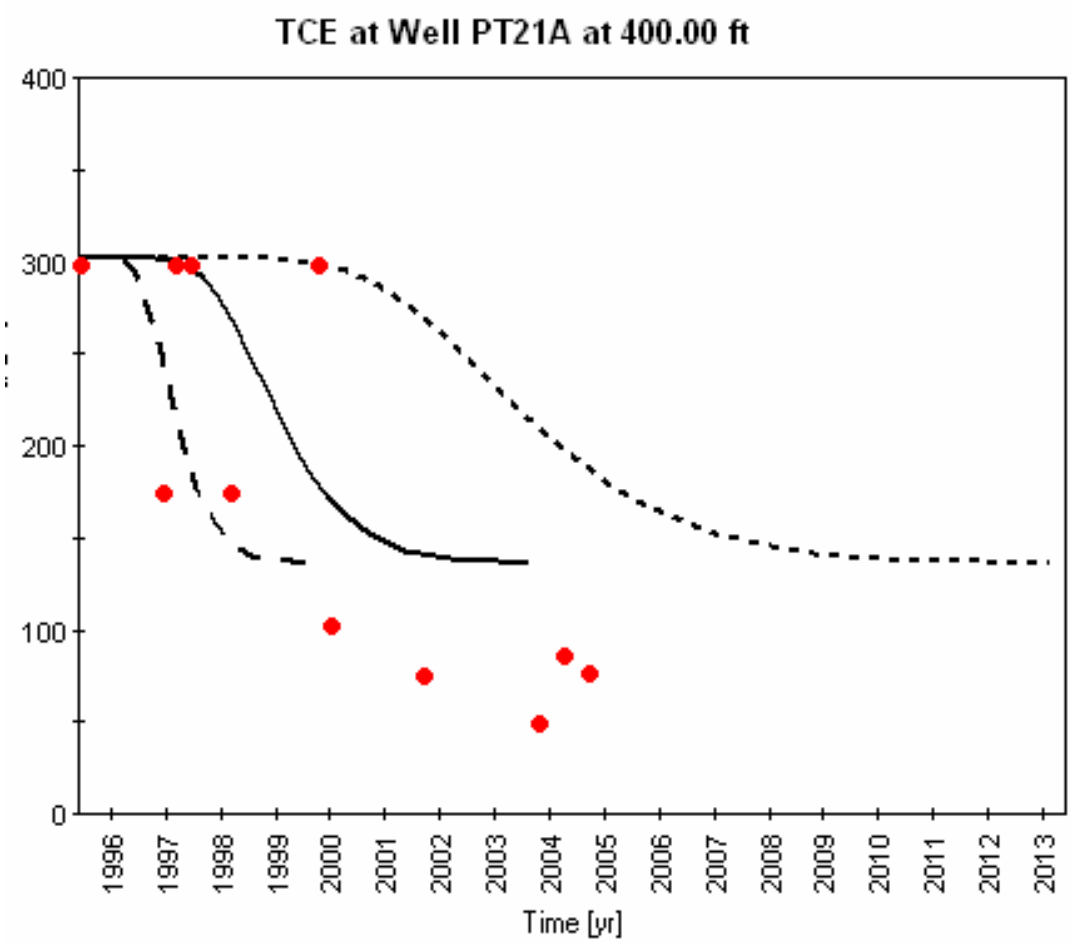
The solution captured the 10-yr trend in terms of equilibrium time and concentration



TOS Estimates

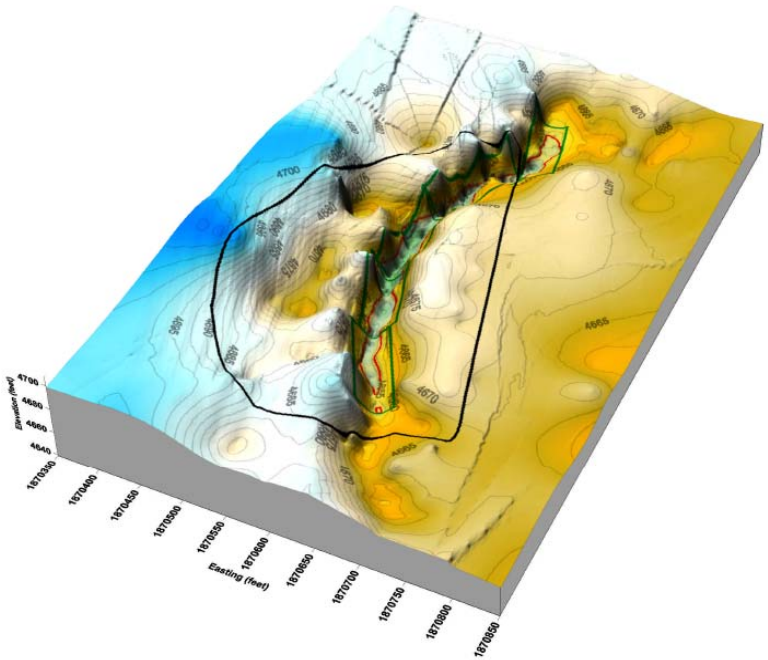
Keeping all input parameters the same as the previous simulation, the solution failed to accurately match the observed equilibrium concentration.

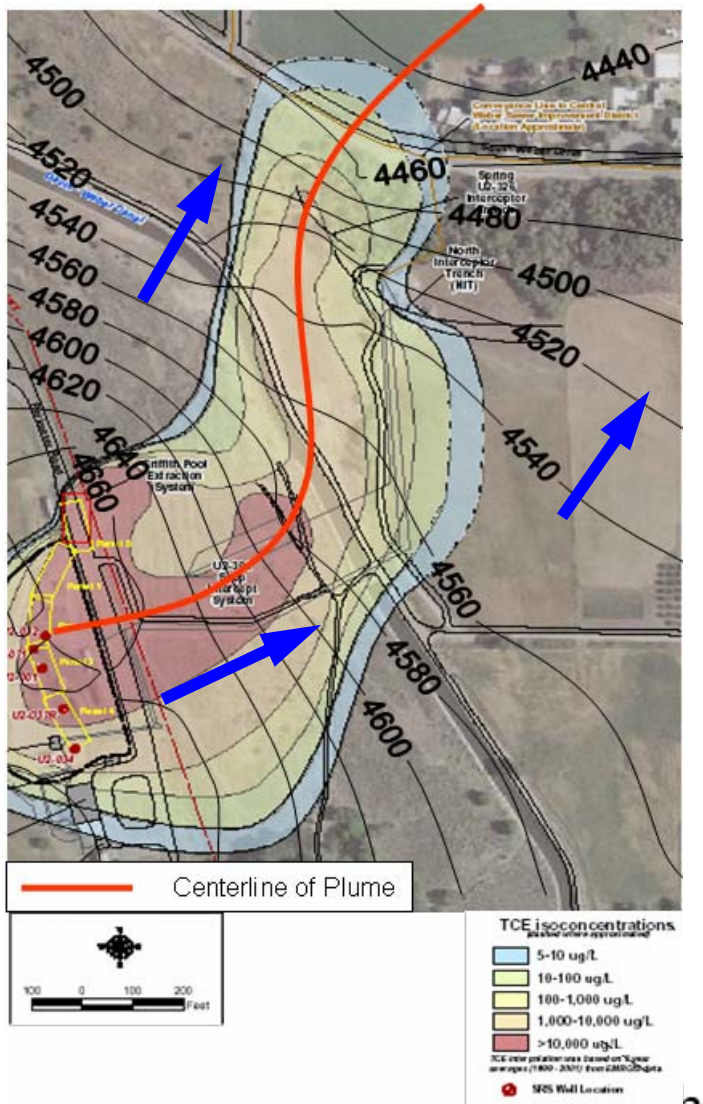
Consistency in the solutions is noted for the time of stabilization.



Hill AFB (UT) – OU2

- Source
  - Disposal of TCE (40-50k gal) in unlined trenches
  - Source Control - Containment wall



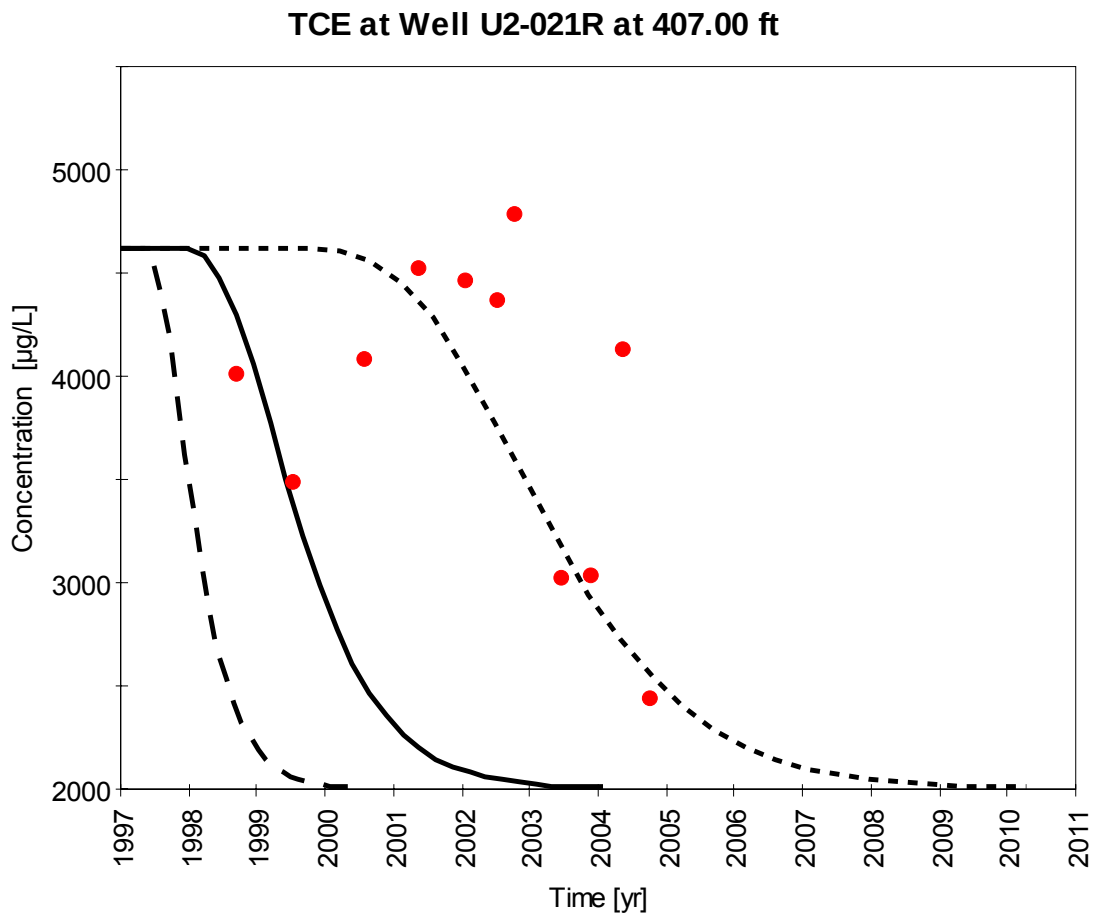


TOS Estimates – Scenario A

The **observed** source reduction served as input to the solution.

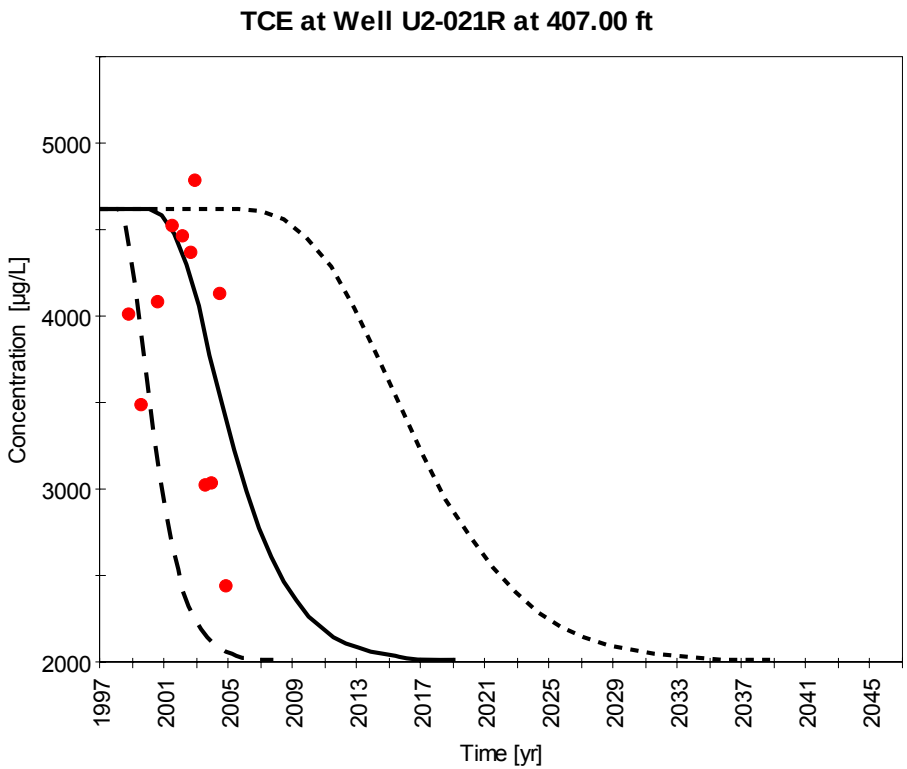
The concentration of TCE at a monitoring well downgradient of the wall (U2-085) dropped from 8 mg/L to 3.5 mg/L.

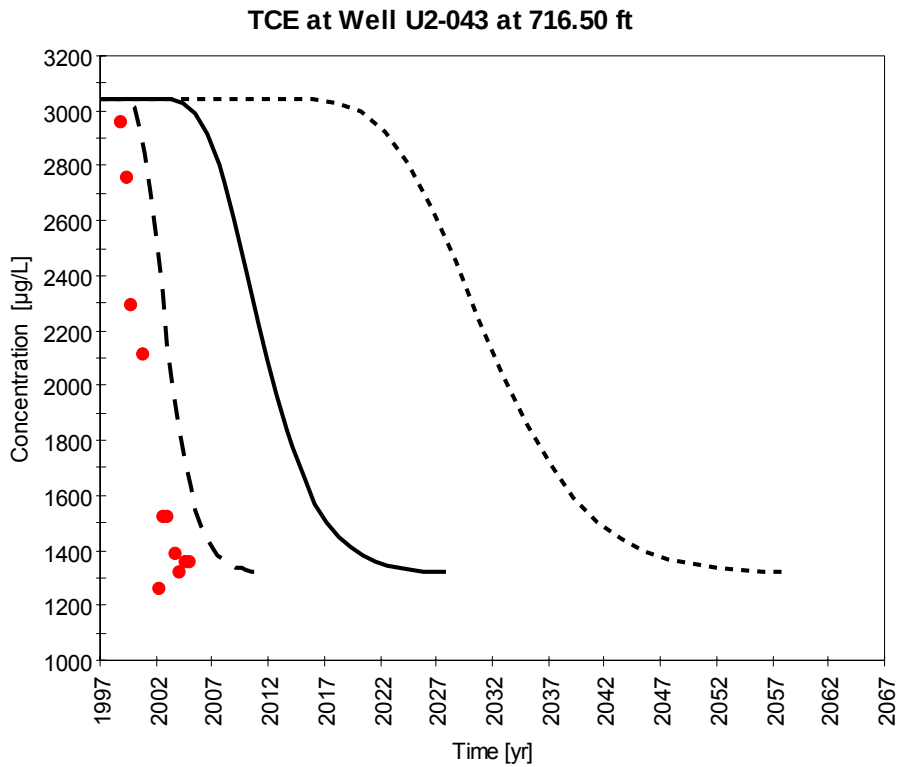
The solution captured the 8-yr concentration trend



TOS Estimates – Scenario C

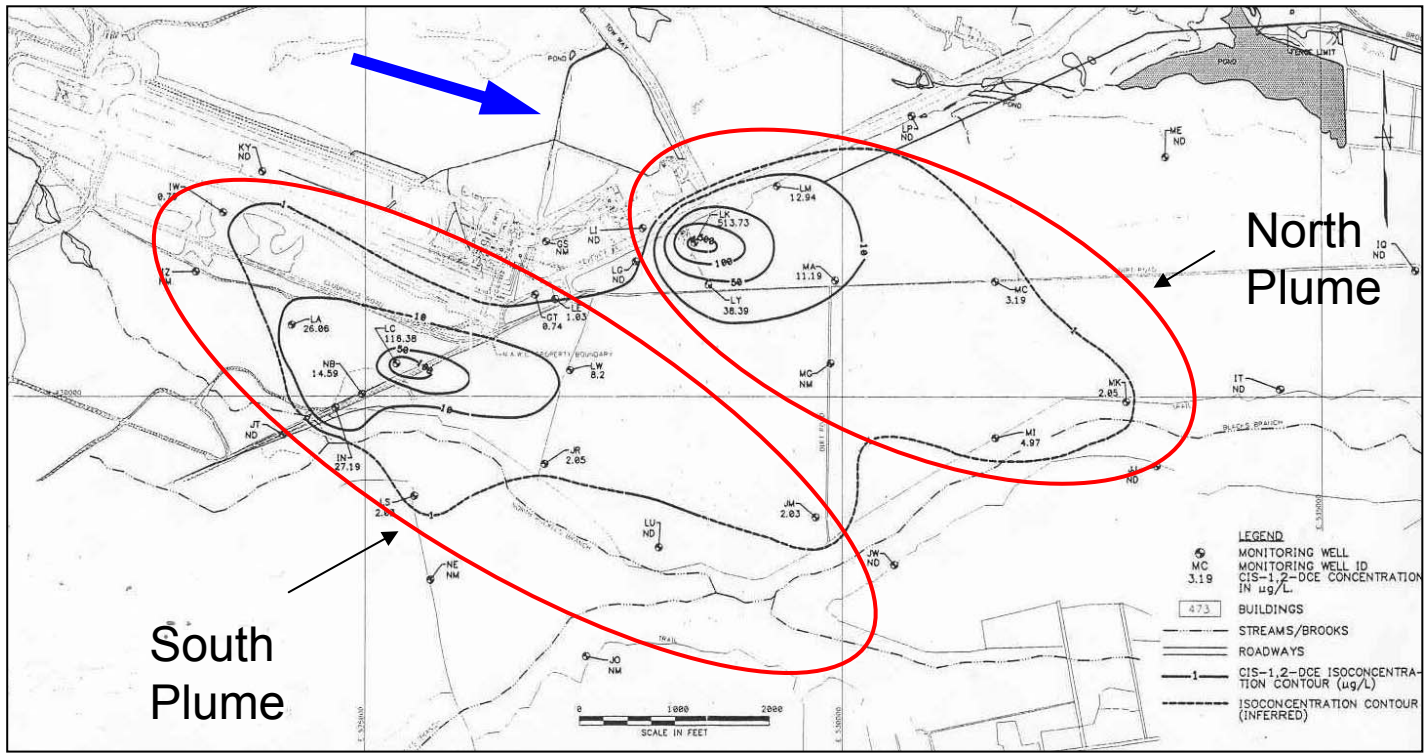
In Scenario C, hydraulic conductivity was based on the near-source formation and the hydraulic gradient was averaged over space to adjust for perturbations created by the recharge mound.



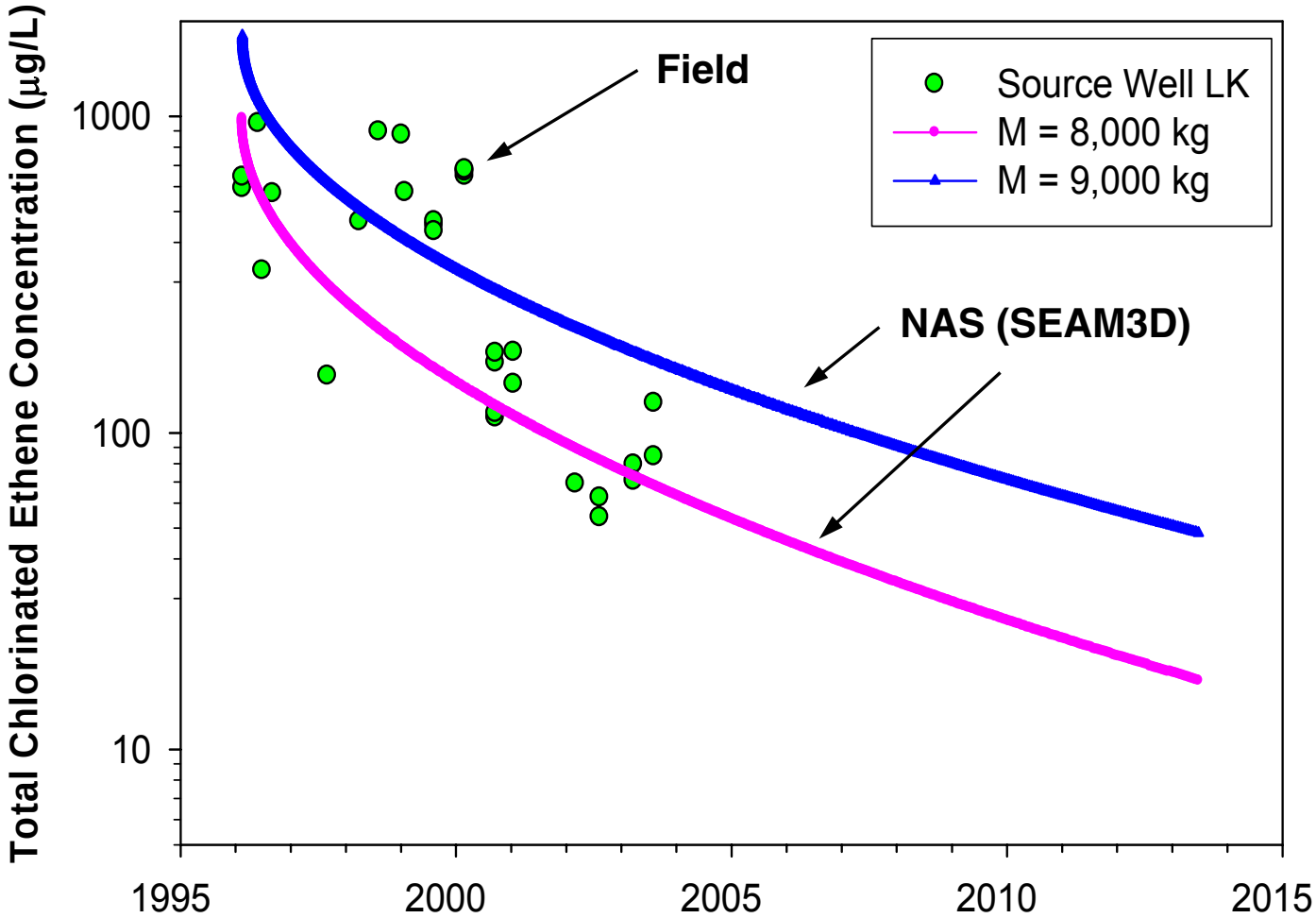


NAES Lakehurst, NJ

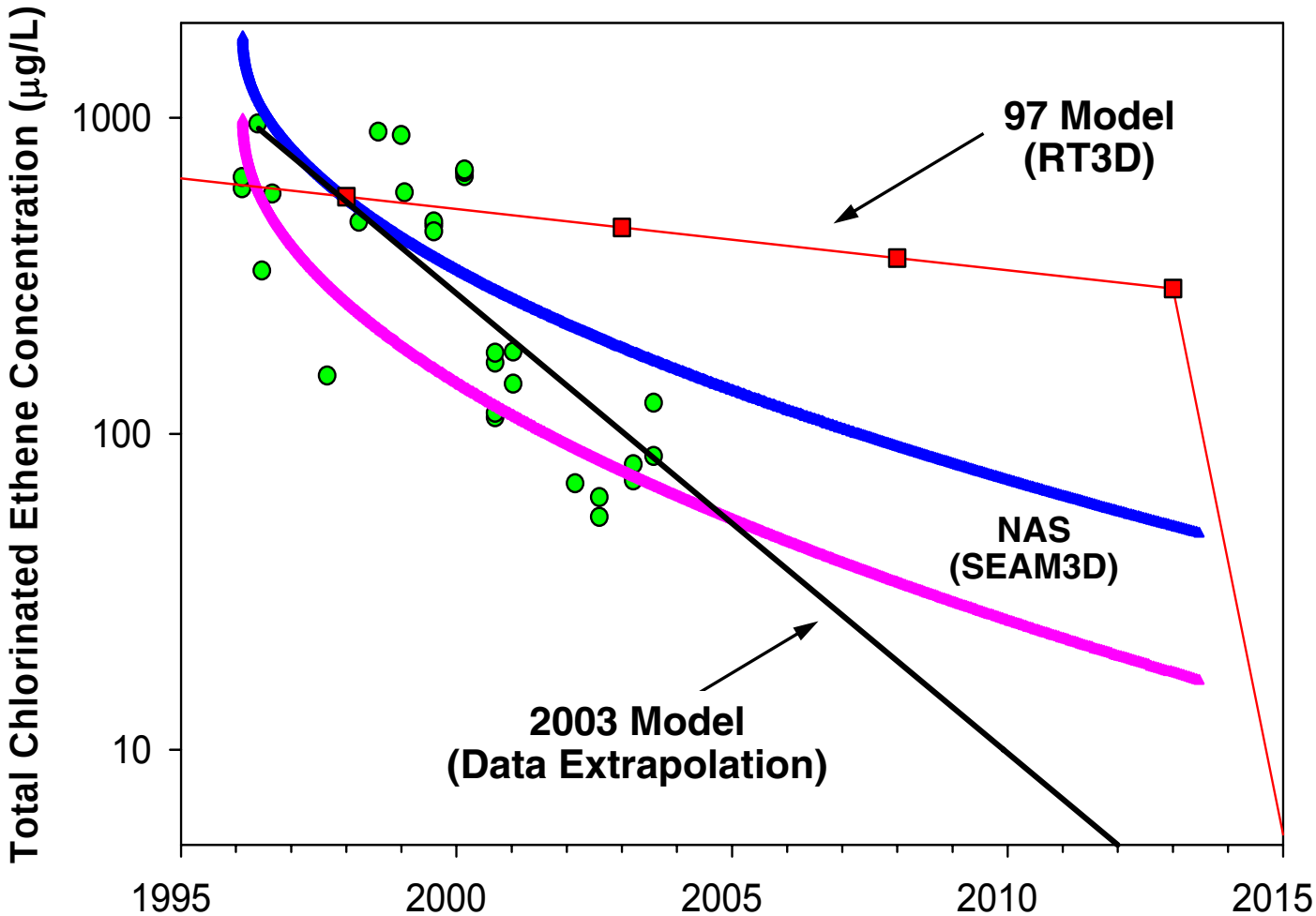
- Aircraft Mission Support
- Primary contaminants impacting surficial aquifer
  - TCE, 1-2,DCE and PCE



Mass Estimates Constrained Using NAS



Comparison of Predictive Tools



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.