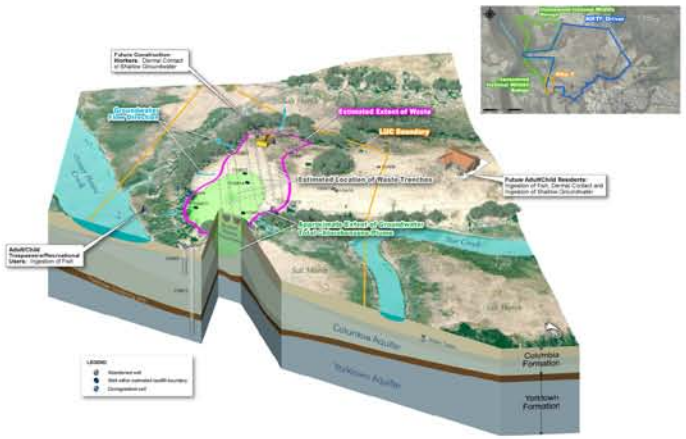
NAVFAC
Naval Facilities Engineering Command

Final

Attachment: Optimization Tools



May 2012

Optimization Tools: GTS

Geostatistical Temporal/Spatial Optimization Algorithm (GTS) – more technically complex monitoring optimization software that provides:

Trend Analysis

- Uses statistical tools to demonstrate trends and "out of bounds" data

Constituents of Concern (COCs) Assessment

- Narrows COCs down to most meaningful two or three for optimization (maximum of four)

Temporal Optimization

- Uses temporal variograms and iterative thinning to provide recommendations
- Optimizes monitoring frequency at individual wells
- Removes data points systematically until trend cannot be reconstructed

Spatial Optimization

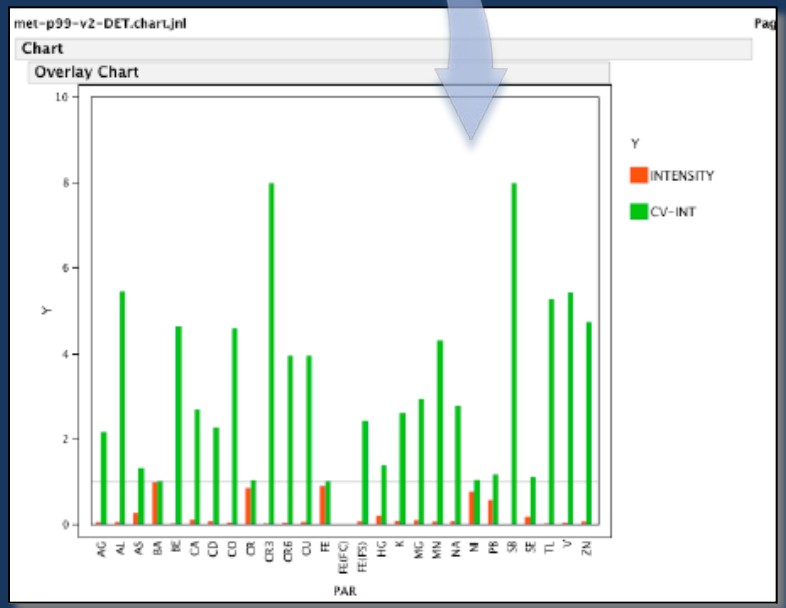
- Analyzes multi-well redundancy allowing for well network optimization
- Allows for comparison of baseline vs. optimized plume maps

Key Uses:

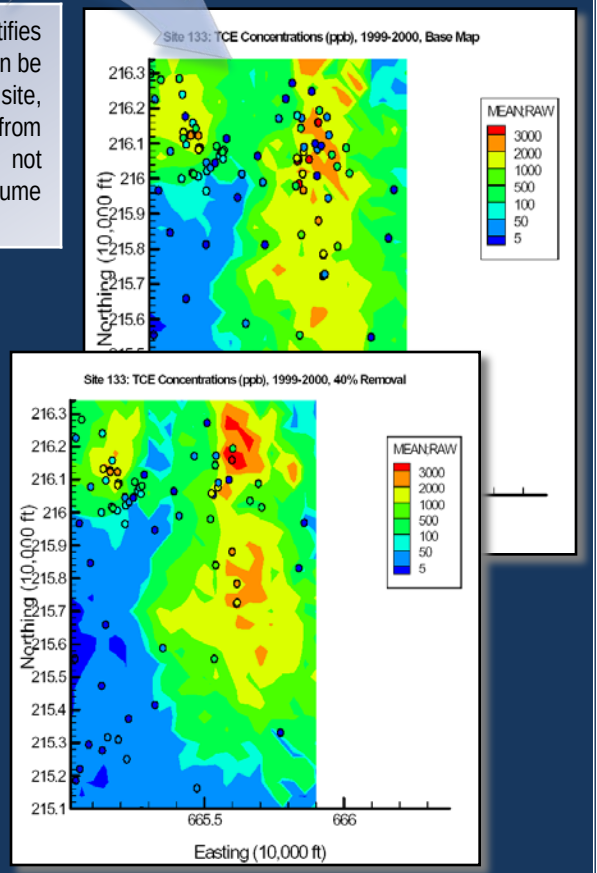
- Analyzes multiple sites at once
- Evaluates sites with several rounds of data from at least 10 to 15 wells
- Assists in developing an effective monitoring program at the startup of a remedy

Import files as tab-delimited text files

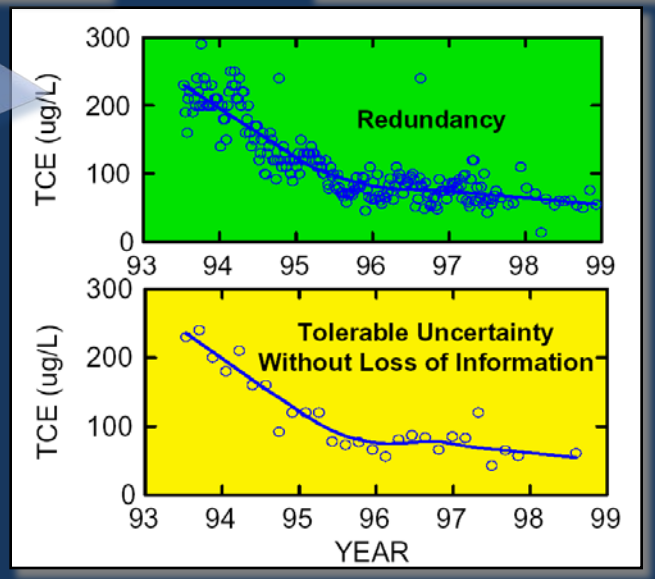
COC Assessment narrows the parameter list for evaluation down to the most meaningful COCs



Spatial optimization Tool identifies how monitoring well network can be reduced. For example, at this site, elimination of 40% of the wells from the monitoring network does not significantly modify the plume configuration.



Temporal Optimization Tool identifies how sampling frequency can be reduced. For example, at this site reduction from 240 data points to 27 data points results in similar trend lines. Reducing the sampling frequency based on this optimization evaluation could result in a 90% reduction in sampling and significant cost savings.



Optimization Tools: MAROS

Monitoring and Remediation Optimization Software (MAROS) – low cost, user friendly, and simple monitoring optimization software that provides:

Statistical Trend Analysis
- Evaluates data trends for individual wells/constituents of concern (COCs) using Mann-Kendall and Linear Regression

COC Analysis
- Identifies most appropriate COCs for evaluation based on toxicity, frequency, and mobility

Moment Analysis
- Analyzes plume mass and spread of plume over time
- Evaluates both source and tail stability of the plume

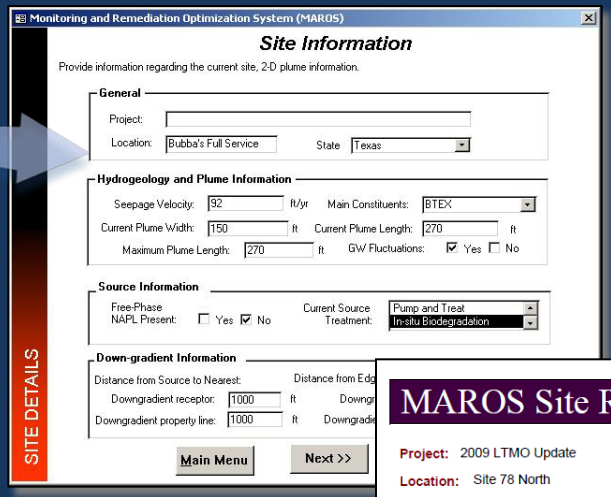
Power Analysis
- Evaluates data trends and sampling frequency
- Provides well by well recommendations for reducing sampling frequency for specific COCs

Redundancy Analysis
- Evaluates the need for specific sample locations using Delauney Triangulation
- Identifies new sample locations needed to delineate the plume boundary

Key Uses:

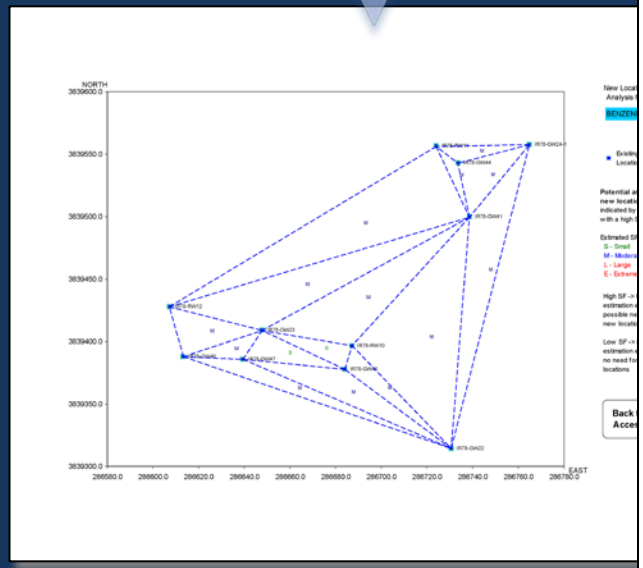
- Evaluates well by well for optimization of monitoring network for smaller sites
- Evaluates benefits for potential additional well locations
- Evaluates plume stability and data trends

Use software-specific data entry windows and Microsoft Excel or Microsoft Access data tables to import information



Comprehensive output summary includes site details and optimization recommendations

Redundancy Analysis identifies recommended sampling locations



MAROS Site Results

Project: 2009 LTMO Update
User Name: CH2M HILL
Location: Site 78 North
State: North Carolina

User Defined Site and Data Assumptions:

Hydrogeology and Plume Information:
Groundwater Seepage Velocity: 9.88 ft/yr
Current Plume Length: 600 ft
Current Plume Width 500 ft
Number of Tail Wells: 8
Number of Source Wells: 3

Source Information:
Source Treatment: Pump and Treat
NAPL is not observed at this site.

Down-gradient Information:
Distance from Edge of Tail to Nearest:
Down-gradient receptor: 3200 ft
Down-gradient property: 3200 ft
Distance from Source to Nearest:
Down-gradient receptor: 4000 ft
Down-gradient property: 4000 ft

Data Consolidation Assumptions:
Time Period: 1/19/1987 to 2/28/2009
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Plume Information Weighting Assumptions:
Consolidation Step 1. Weight Plume Information by Chemical
Summary Weighting: Weighting Applied to All Chemicals Equally
Consolidation Step 2. Weight Well Information by Chemical
Well Weighting: No Weighting of Wells was Applied.
Chemical Weighting: No Weighting of Chemicals was Applied.

Note: These assumptions were made when consolidating the historical montoring data and lumping the Wells and COCs.

1. Compliance Monitoring/Remediation Optimization Results:

Preliminary Monitoring System Optimization Results: Based on site classification, source treatment and Monitoring System Category the following suggestions are made for site Sampling Frequency, Duration of Sampling before reassessment, and Well Density. These criteria take into consideration: Plume Stability, Type of Plume, and Groundwater Velocity.

COC	Tail Stability	Source Stability	Level of Effort	Sampling Duration	Sampling Frequency	Sampling Density
BENZENE	PD	S	L	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	21
cis-1,2-DICHLOROETHYLENE	PD	PD	L	Continue remediation mechanism until reach stable trend or PRG met.	No Recommendation	21
TETRACHLOROETHYLENE(PCE)	S	S	M	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	21
TRICHLOROETHYLENE (TCE)	S	S	M	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	21
VINYL CHLORIDE	S	D	M	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	21

Note:
Plume Status: (I) Increasing; (PI)Probably Increasing; (S) Stable; (NT) No Trend; (PD) Probably Decreasing; (D) Decreasing
Design Categories: (E) Extensive; (M) Moderate; (L) Limited (N/A) Not Applicable, Insufficient Data Available

MAROS Version 2.2, 2006, AFCEE Saturday, November 07, 2009 Page 1 of 2

Optimization Tools - NAS

NAS (Natural Attenuation Software) - monitored natural attenuation (MNA) software that provides:

Three main interactive numerical and analytical solute transport modules that provide estimates for:

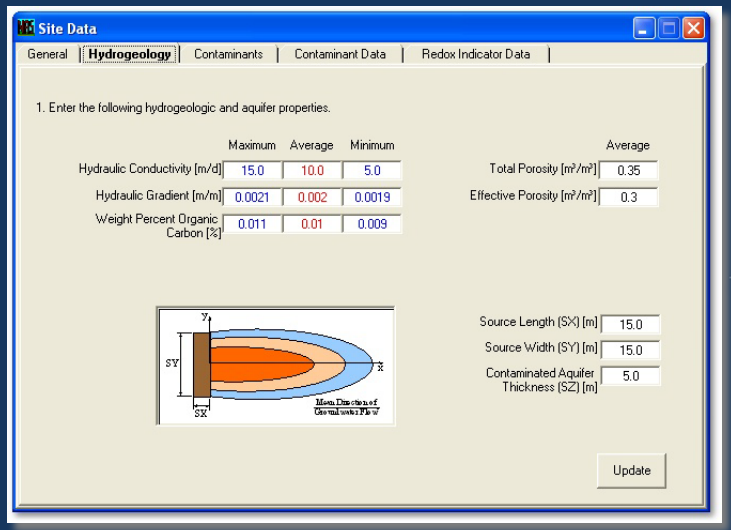
- Source concentration required for a plume to contract to within regulatory limits
- Time required for a plume to contract to within regulatory limits
- Time required for free phase contaminants to attenuate to a predetermined source concentration

The capability to model comingled plumes with constituents from multiple contaminant categories

Models advection, dispersion, sorption, non-aqueous phase liquid (NAPL) dissolution, and biodegradation

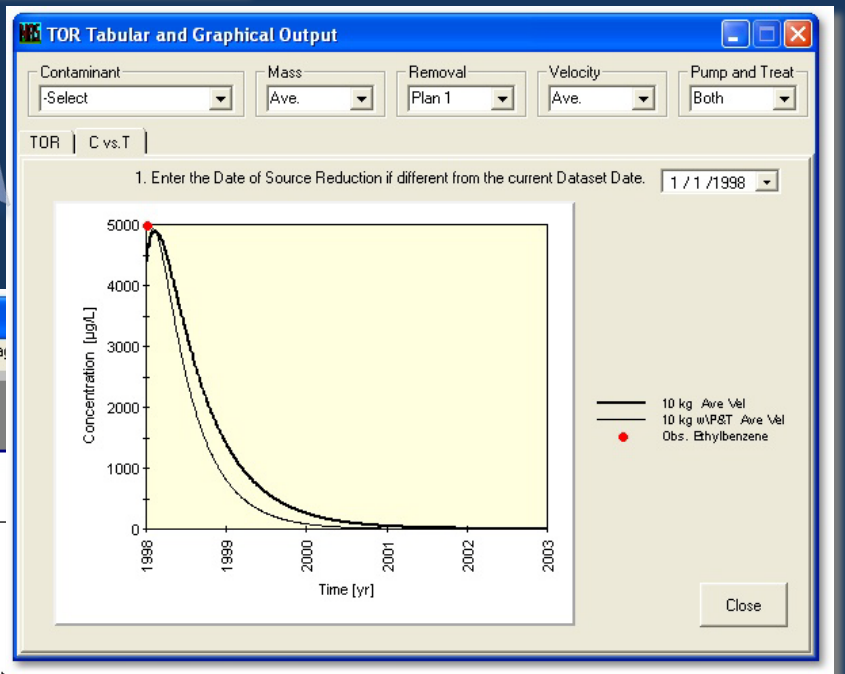
Key Uses:

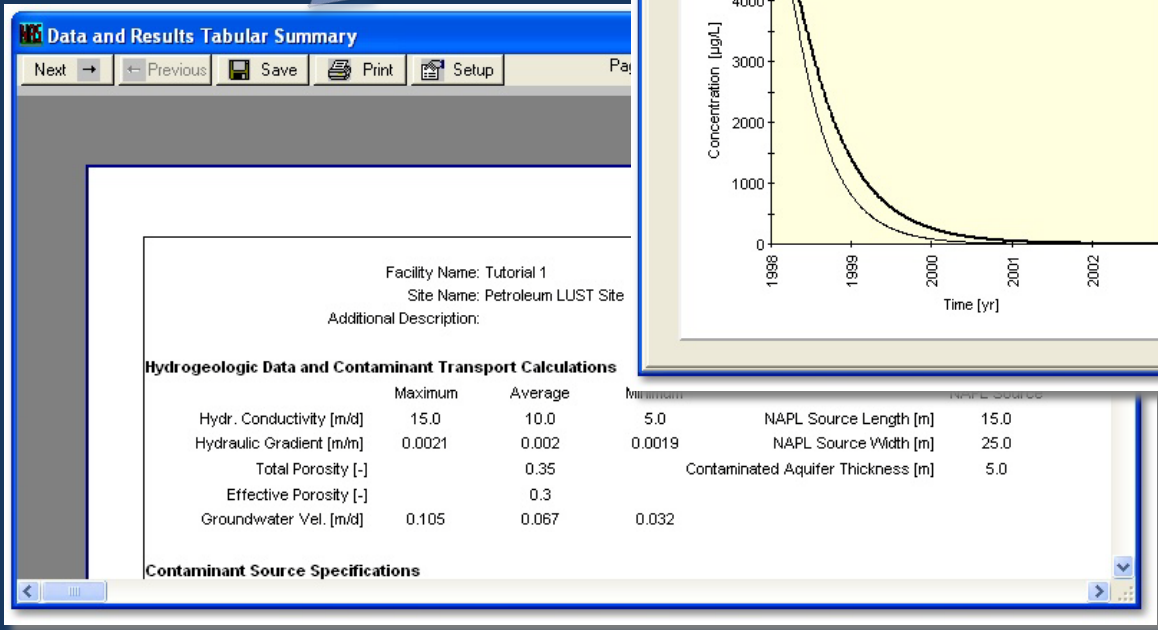
- Estimates remediation timeframes for MNA
- Designed for application to groundwater systems consisting of porous, relatively homogenous, saturated media such as sands and gravels, and assumes that groundwater flow is uniform and unidirectional
- Can provide comparisons for time of treatment between natural attenuation and pump and treat if data on pumping system are entered



Enter sites details into user-friendly input windows

Receive output in graphical and tabular form





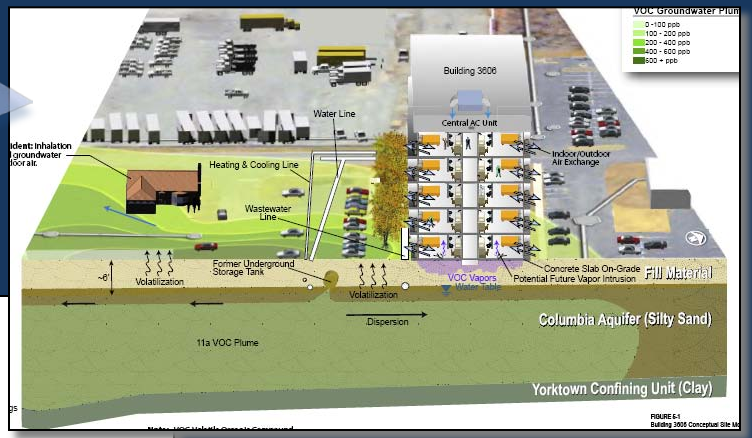
Widdowsen et al, 2012. Natural Attenuation Software. http://www.nas.cee.vt.edu/index.php.

Optimization Tools: Navy Vapor Intrusion Evaluation Tool

Navy Vapor Intrusion (VI) Evaluation Tool - tool that provides a step-by-step user interface for evaluating VI data and whether there is a complete exposure pathway including the following elements:

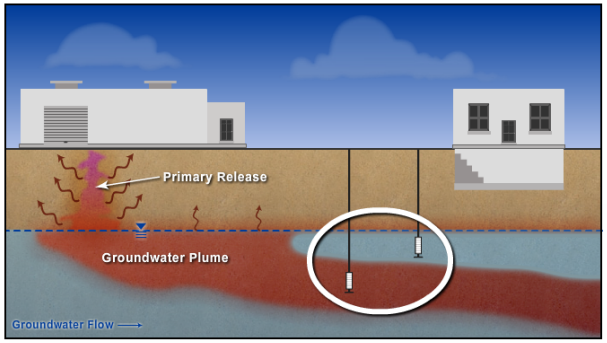
- Illustrated tutorials and tips on a wide range of VI topics
- An electronic repository for relevant site information to support the conceptual site model
- A question and answer interview interface for assessing data and drawing conclusions

Conceptual Site Model



Clean Water Lens

Local groundwater recharge (e.g., precipitation, irrigation, leaking pipes) and downward hydraulic gradients can result in a layer of clean, unimpacted water at or near the water table, which can act as a barrier to upward migration of VOCs.

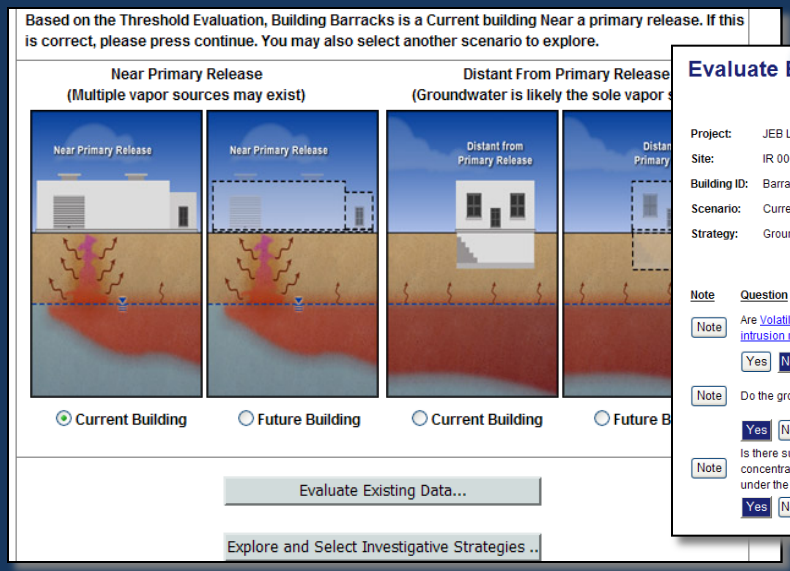


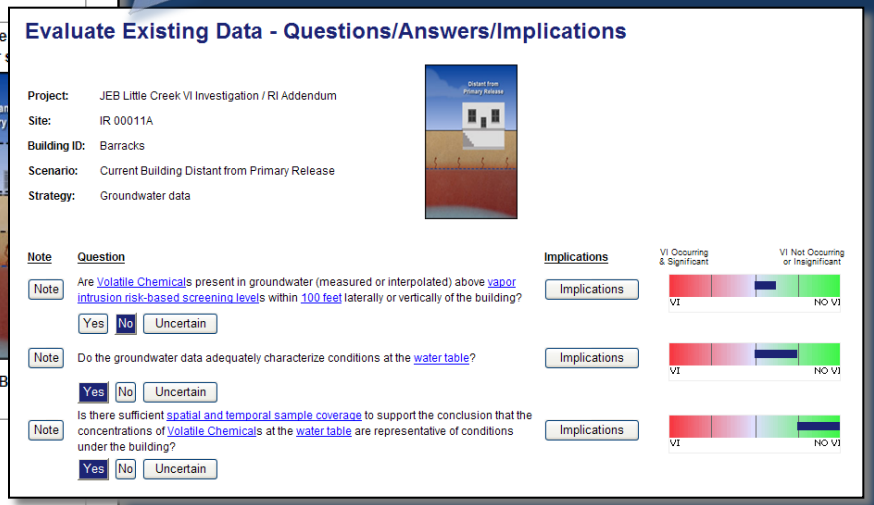
Why is this important?

Groundwater data at or near the water table provides stronger evidence when assessing the vapor intrusion pathway than deeper groundwater data which may not reflect water quality conditions at the water table.

Illustrated tutorials and tips

Site-specific, dynamic, interview-based data evaluation





Key Uses:

- Supports more rapid closure of vapor-intrusion sites
- Weighs the relative strengths of multiple lines of evidence
- Communicates state-of-the-practice information
- Supports team risk management decisions

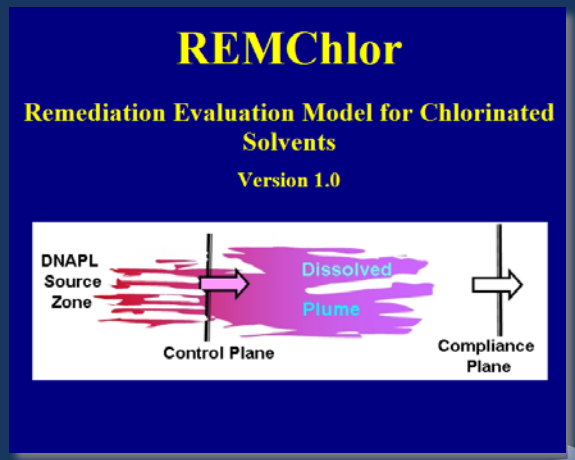
Optimization Tools: REMChlor

Remediation Evaluation Model for chlorinated solvents (REMChlor) - model used for simulating the effects of groundwater source and plume remediation. Simulates first-order sequential decay and production of several species (e.g., PCE to TCE to DCE, etc). The software is based on a power function relationship between source mass and source discharge. Decay rates and parent/daughter yield co-efficients within the plume are variable functions of time and distance.

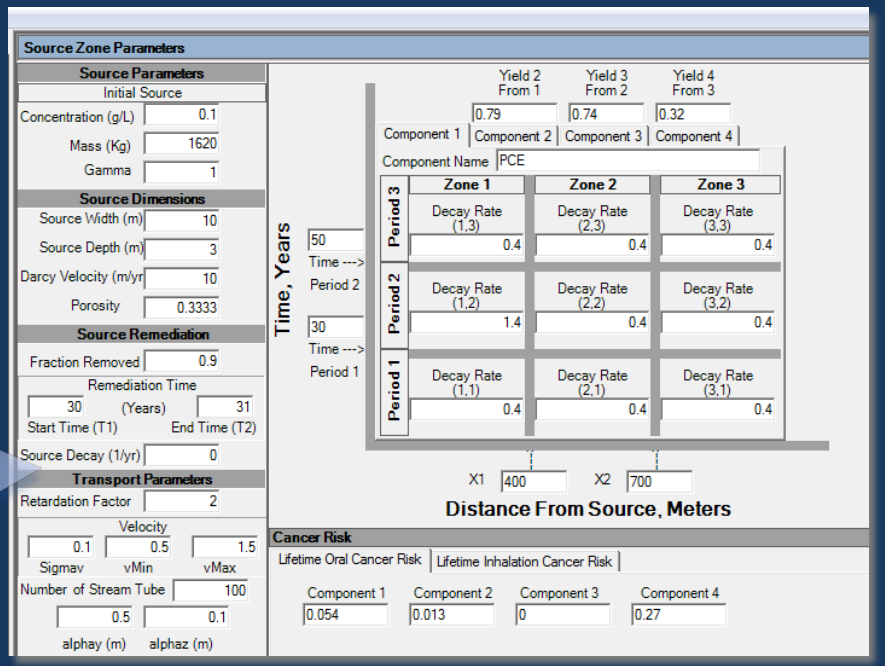
- Allows for greater flexibility in simulating differing conditions that may occur throughout the downgradient extent or lifetime of the plume
- Model allows simulating the inclusion of an enhanced biodegradation zone, such as might occur through the implementation of a biobarrier, in one portion of the plume, while simulating more naturally occurring conditions in other portions of the plume

Key Uses:

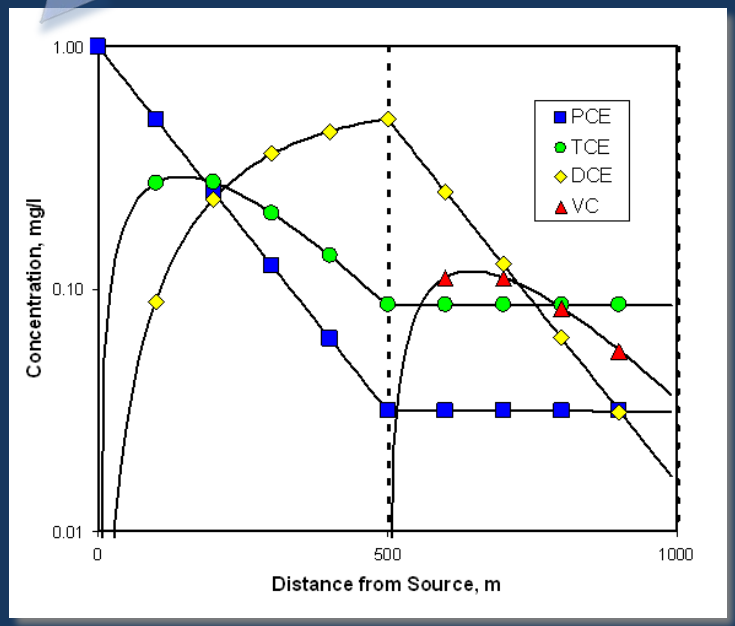
- Can accommodate and evaluate the impacts of partial source remediation at any time after the initial release
- Includes the ability to calculate cancer risks in the plume, assuming that contaminated water is used for drinking, bathing, and other household uses.

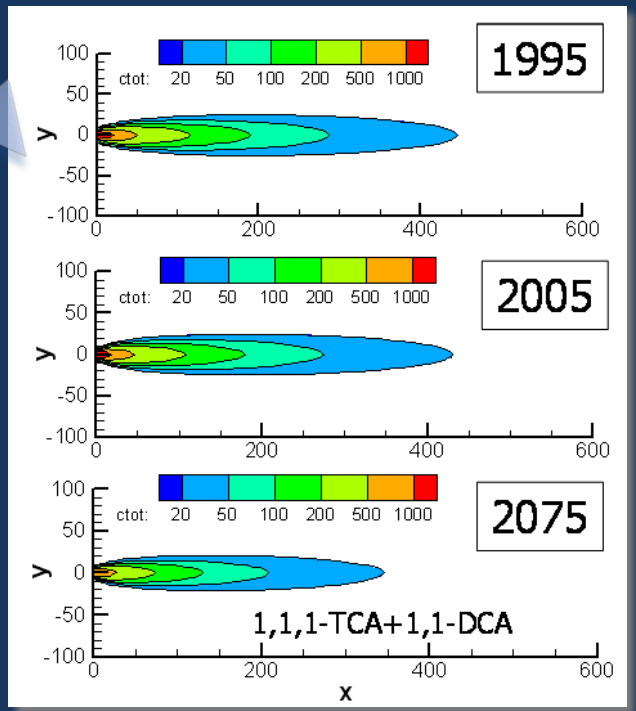


Visually intuitive model parameter input



Provides a variety of options for displaying the model output





Optimization Tools: Ricker Plume Stability Method

Ricker Plume Stability Method - optimization method that demonstrates plume dynamics in order to evaluate treatment effectiveness and monitored natural attenuation (MNA)

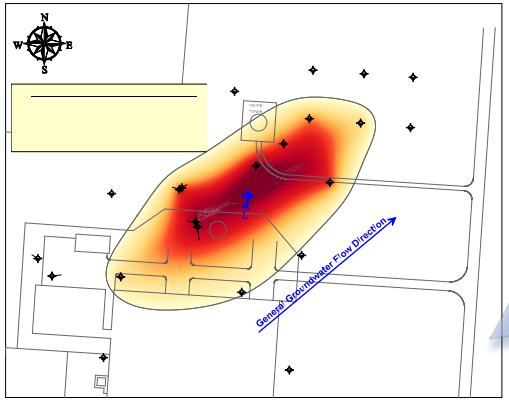
Plume Dynamics Evaluation

- Calculates and assesses historical trends in contaminant plume area
- Calculates average concentration, contaminant mass, and center of mass
- Calculates overall chlorinated volatile organic compound molar mass
- Spatially evaluates temporal changes in plume

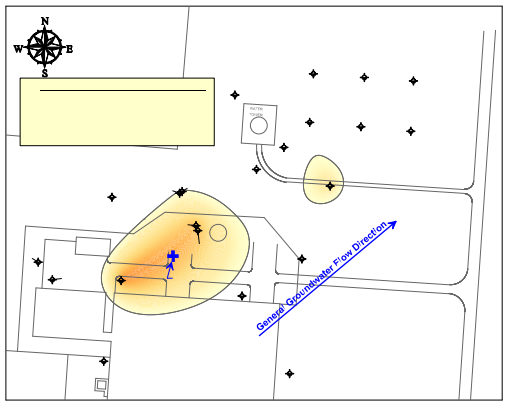
Key Uses:

- Demonstrates plume stability
- Helps determine if site is appropriate for MNA
- Evaluates classes of compounds
- Evaluates sites with established monitoring well networks and multiple years of data

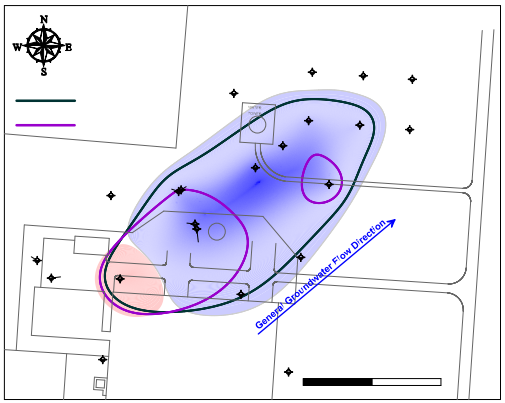
Dec-01 Plume



Mar-11 Plume

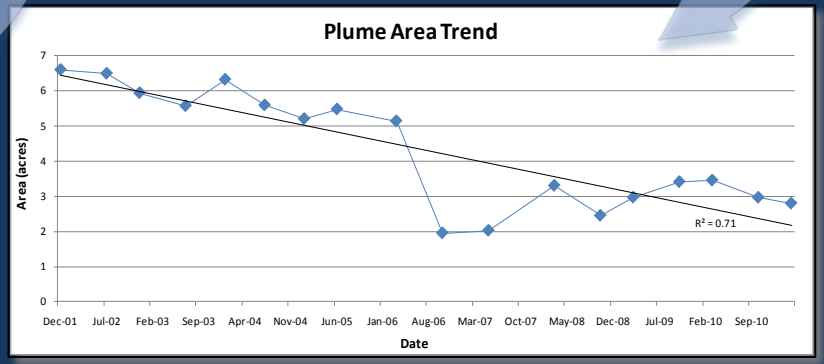


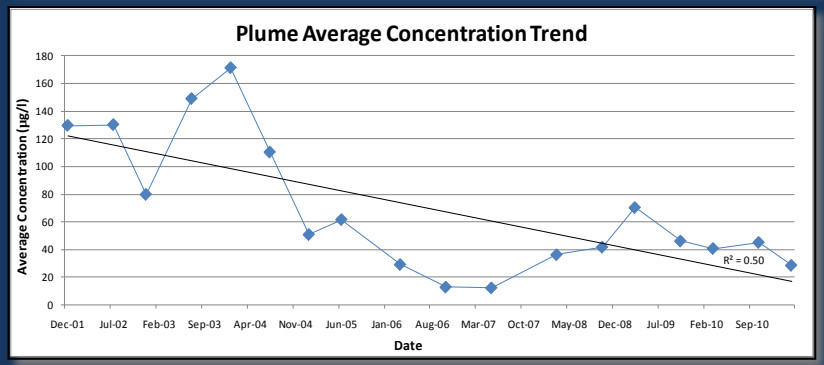
Concentration Difference

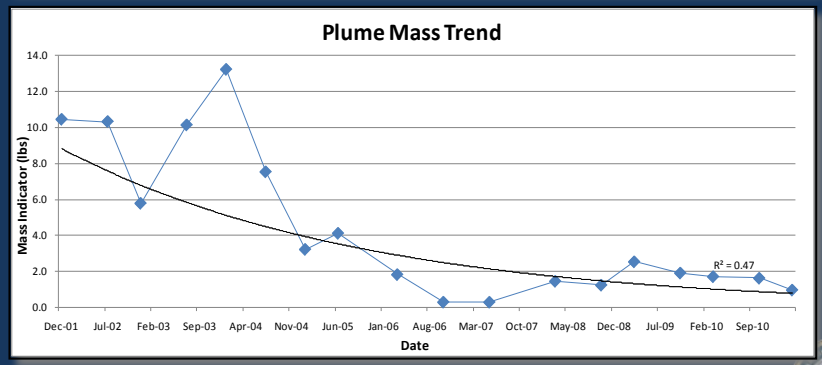


The concentration isopleth maps show the change in spatial plume extent over time. The concentration difference map shows areas and relative magnitude of concentration decreases (blue shading) and increases (pink shading) within the plume.

Trend graphs depicting temporal trends in plume stability characteristics assist in understanding plume dynamics.







Optimization Tools - SADA

Spatial Analysis and Decision Assistance (SADA) - combines multiple scientific models into a single user interface to provide:

- Visualization/GIS
- Statistical Analysis
- Geospatial Interpolation
- Geospatial Uncertainty Analysis
- Human Health Risk Assessment
- Ecological Risk Assessment
- Custom Analysis
- MARSSIM Module
- Area of Concern Frameworks
- Cost Benefit Analysis
- Sampling Designs
- Export to Arcview / Earthvision

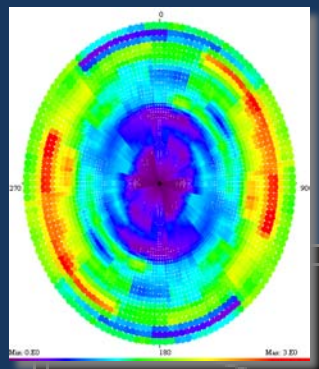
Key Uses:

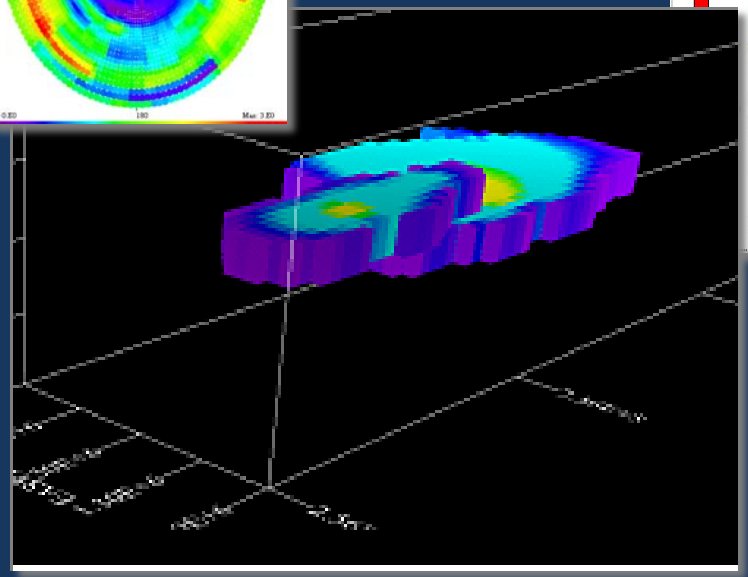
- Makes cost vs. clean up estimates based on the conceptual site model
- Creates human health and ecological risk contour and point maps
- Can be used to develop sample designs using systematic, random, judgmental, adaptive fill, high value, and boundary approaches

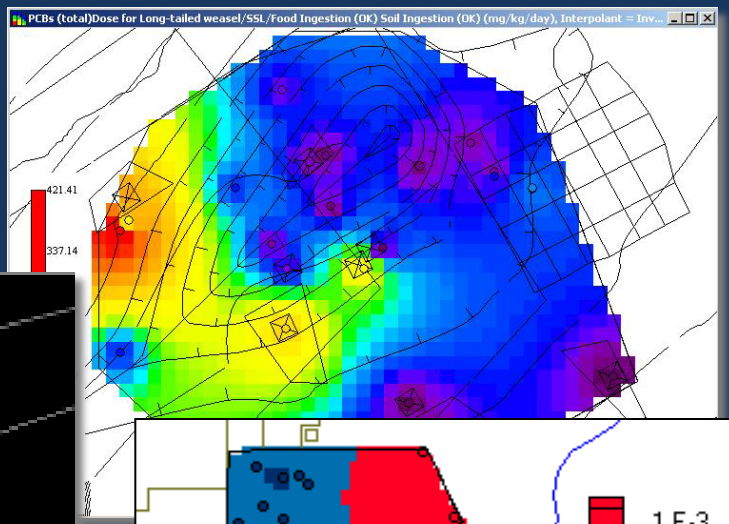
Data input files must be in comma delimited format (csv) or Microsoft Access

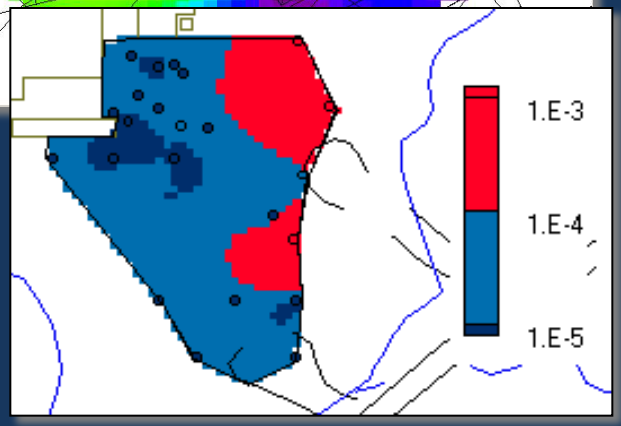
PROJECT NAME	PROJECT #	SAMPLE	SAMPLE ID	DATE COLL	DATE RECD	ANALYZED	TAI LAB #	ANALYTE	RESULT	PQL	UNITS	METHOD
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Aldrin	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	a-BHC	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	b-BHC	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	d-BHC	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	g-BHC, Lindane	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	4,4'-DDD	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	4,4'-DDE	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	4,4'DDT	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Dieldrin	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endosulfan I	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endosulfan II	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endosulfan Sulfate	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endrin	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endrin Aldehyde	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endrin Ketone	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Heptachlor	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Heptachlor Epoxide	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Methoxychlor	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Toxaphene	< 0.00500	0.005	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	alpha-Chlordane	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	gamma-Chlordane	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1016	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1221	< 0.00100	0.001	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1232	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1242	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1248	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1254	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1260	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/5/2002	02-A162603	Arsenic	< 0.0050	0.005	mg/l	6010B
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/5/2002	02-A162603	Barium	0.08	0.01	mg/l	6010B

Broad Set of output capabilities include 3-D models and risk contour maps









Optimization Tools: Sitewise™

SiteWise™ - series of excel spreadsheets used to calculate the environmental footprint of remediation in terms of sustainability metrics

Metrics that are calculated with the Sitewise™ tool include:

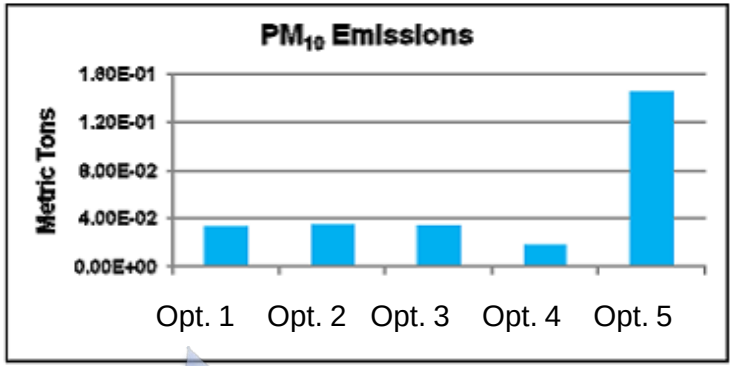
- Energy consumption
- Greenhouse gases emitted
- Criteria air pollutants emitted
- Water impacts
- Worker safety

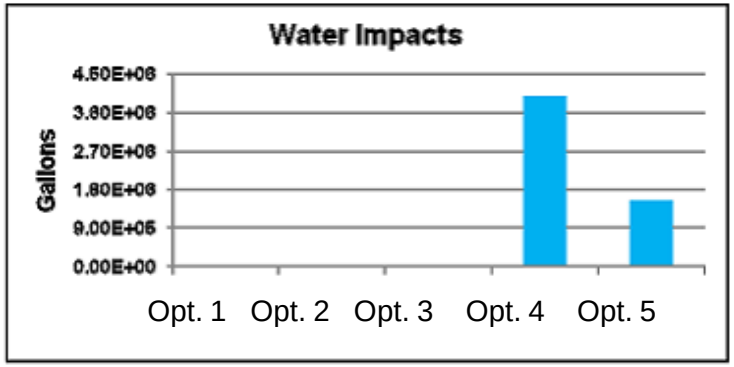
Sustainable Remediation - Environmental Footprint Summary

Alternative Enhanced Bioremediation — In situ Enhanced Bioremediation, MNA, Shallow Soil Excavation, and LUCs

Phase	Activities	GHG Emissions metric ton	Total Energy Used MMBTU	Water Impacts gallons	NO_x Emissions metric ton	SO_x Emissions metric ton	PM_{10} Emissions metric ton	Accident Risk Fatality	Accident Risk Injury
Remedial Investigation	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Action Construction	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.34	3.8E+00	NA	6.4E-04	9.4E-05	4.4E-05	2.1E-05	1.5E-03
	Transportation-Equipment	0.28	7.2E+00	NA	1.7E-03	2.2E-04	1.3E-04	7.2E-07	1.5E-04
	Equipment Use	6.36	6.7E+01	0.0E+00	2.6E-02	7.4E-03	2.5E-03	4.8E-06	2.0E-03
	Residual Handling	130.06	1.3E+03	0.0E+00	3.5E-01	4.8E-02	2.7E-02	3.7E-06	7.8E-04
	Sub-Total	137.04	1.40E+03	0.00E+00	3.78E-01	5.33E-02	3.01E-02	3.05E-05	4.50E-03

Input monitoring or remedy optimization details into a Sitewise™ worksheet organized by metric and phase of work





Receive output in quantitative and graphical form to allow for easy comparison of optimization options

Key Uses:

- Identifies tradeoffs and synergies associated with varying optimization and management and monitoring approaches
- Identifies and prioritizes methods to reduce the footprint of Remedial Action-Operation and Monitoring
- Incorporates Green and Sustainable Remediation metrics into a site closeout strategy
- Applies to any phase of the remedial action
- Supports team risk management decisions

Relative Impact

Management & Monitoring Alternatives	GHG Emissions	Energy Usage	Water Usage	NOx emissions	SOx Emissions	PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resources Lost
Option 1	Medium	Medium	High	Low	Low	High	High	High	user select	user select
Option 2	High	High	Low	High	High	Medium	Medium	Medium	user select	user select
Option 3	Medium	Low	Low	Low	Medium	High	Medium	High	user select	user select

Optimization Tools: Summit

Summit – more technically complex monitoring optimization software that provides:

Sample Optimization Module

- Identifies redundant sampling locations and/or frequencies
- Considers numerous sampling plans with fewer samples than baseline
- Allows for comparison of baseline vs. optimized plume maps
- Allows for comparison of trends at various sampling frequencies
- Calculates error where samples are removed
- Evaluates multiple constituents of concern simultaneously

Data Tracking/Evaluation Module

- Flags new sample results out of expectations
- Tracks relative plume mass over time

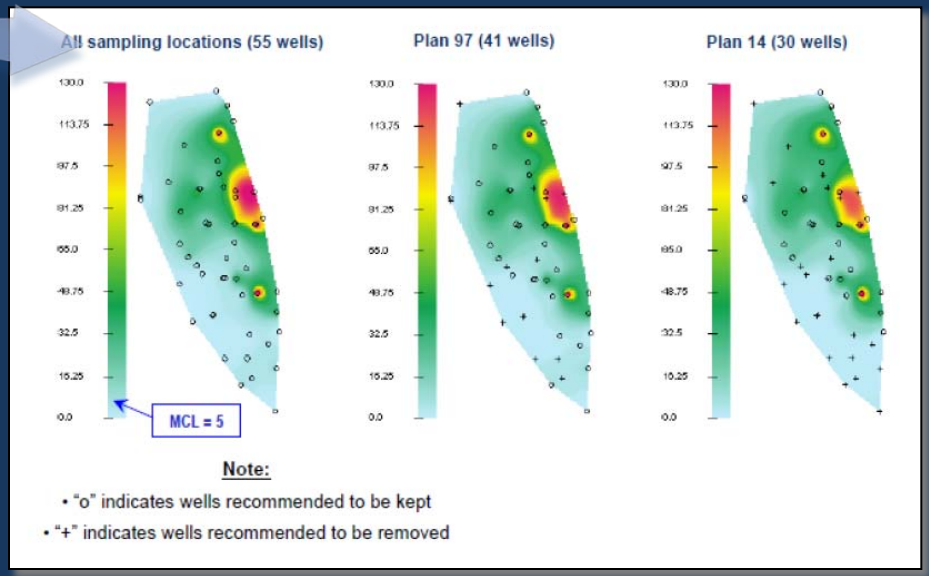
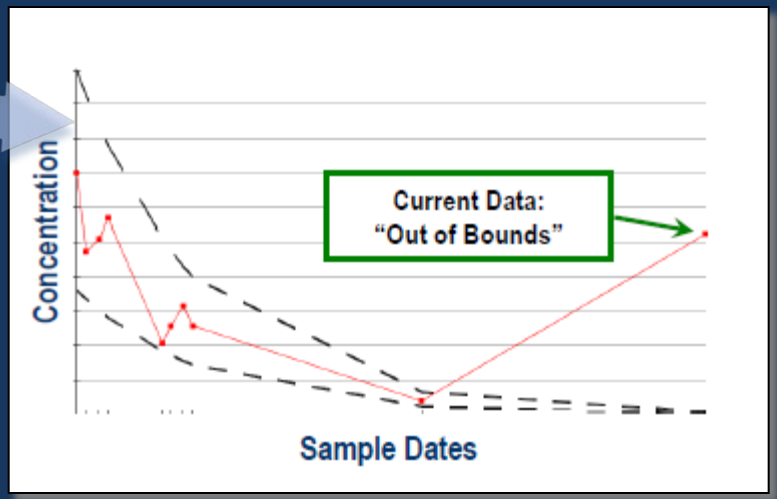
Key Use:

- Evaluates large, complex sites with numerous wells or high sampling frequency

Import data as comma-delineated text file

Date	SiteID	EastCoordinate	NorthCoordinate	c12DCE	CBenz	TCE
6/15/2009	BF-3	2180004	328510	0.05	0.42	1.1
6/15/2009	DD02	2179842	329632	0.05	0.05	0.36
6/15/2009	DD2D	2180118	329388	0.05	0.05	0.38
6/15/2009	S03M01	2178651	325488	1.7	0.05	8.8
6/15/2009	S03M02	2179135	325654	1	0.05	4.7

The Sample Optimization Module shows how the monitoring network can be reduced. For example, at this site the well network can be reduced from 55 to 41 wells with virtually no change in the plume configuration for the site. Reducing the well network to 30 wells results in a minimal change to the plume configuration. Therefore, the well network can likely be reduced to 30 wells at this site without resulting in any changes in the site management and monitoring approach.



The Data Tracking/Evaluation Module shows when new data collected are out of expected "bounds."