

Long-Term Groundwater Monitoring and Stability/Trend Evaluation (Plume Stability)

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Plume Stability

- ▶ Why do it? How?
- ▶ What is the state of things in Missouri?
- ▶ What are other, nearby states requiring?
- ▶ Closing Thoughts

Plume Stability

»» Why Do It? How?

Why Do It?*

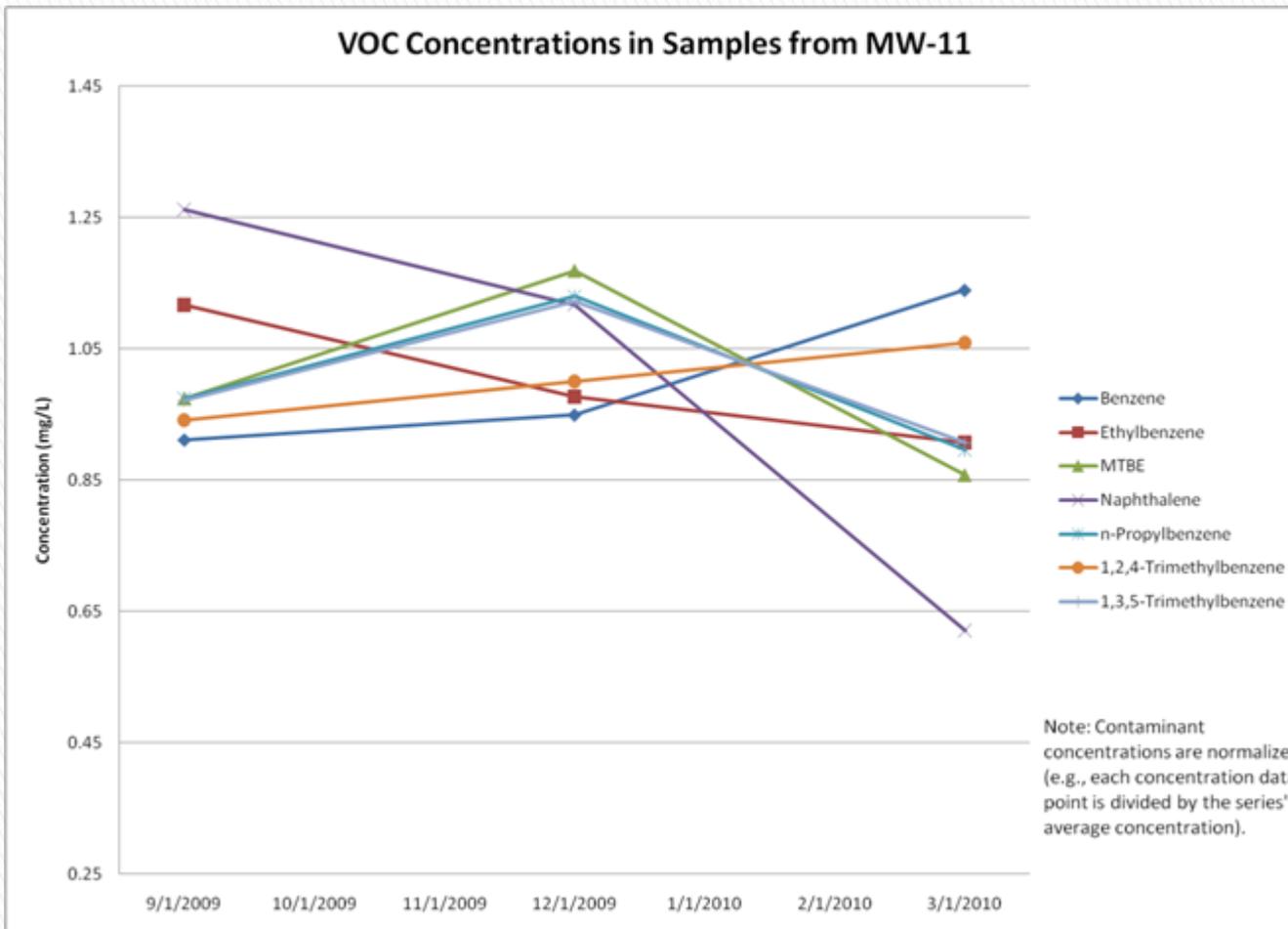
- ▶ Detect changes in conditions that may reduce the efficacy of remedy
- ▶ Identify potentially toxic and/or mobile transformation products
- ▶ Verify that the plume(s) is not expanding above levels of concern
- ▶ Assess effectiveness of cleanup or treatment system
- ▶ Evaluate whether advances in technologies or approaches could improve the ability of a remedy to achieve cleanup goals
- ▶ Verify no unacceptable exposure to down gradient receptors
- ▶ Detect new releases of contaminants that could affect the effectiveness of remedy
- ▶ Demonstrate effectiveness of institutional controls
- ▶ Verify attainment of short-term, intermediate, or final goals

Why Do It? (RBCA Concepts)

- ▶ All RBCA closures are equally protective of human health and environment
 - ▶ Risk is addressed through evaluation of all aspects of the site, not just concentrations
 - ▶ Conceptual Site Model is the foundation of this process
 - ▶ Conceptual Site Model and exposure scenarios are “forward-looking,” so there must be a good handle on where things are headed...if not, the foundation is bad
- 

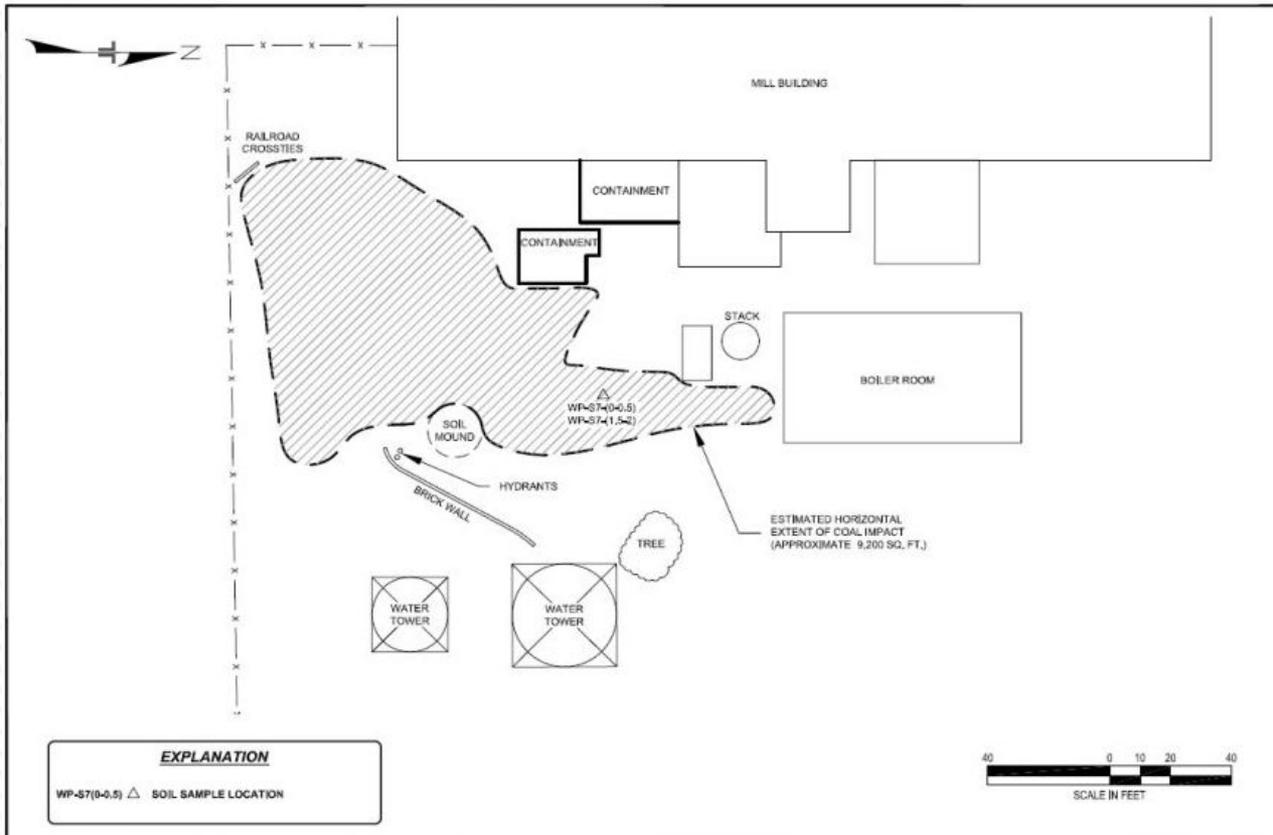
How to Do It? -- Qualitatively

- ▶ Concentration vs. Time Plots
 - ▶ Concentration vs. Distance Plots
 - ▶ Concentration Contour Maps
- 



Concentration vs. Time Plots

Caution: Scales/Presentations can be misleading. Data shown above is “normalized.”



EXPLANATION
 WP-S7(0-0.5) △ SOIL SAMPLE LOCATION



Project Mgr:	CBB	Project No.:	73097015
Drawn by:	FTK	Scale:	AS SHOWN
Checked by:	CBB	File No.:	73097015
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COAL STORAGE AREA OF IMPACT - WARREN PLANT
 PHASE II ENVIRONMENTAL SITE ASSESSMENT
 AUGUSTA ROAD
 WARRENVILLE, AIKEN COUNTY, SOUTH CAROLINA
 USEPA COOPERATIVE AGREEMENT NO BF-95405308

FIG. No.
 6b

Concentration Contour Maps

How to Do It? – Statistically

- ▶ Mann–Kendall
 - ▶ Mann–Whitney
 - ▶ Regression Analysis
- 

Mann-Kendall.xlsx - Microsoft Excel

Home Insert View Page Layout Formulas Data Review View Developer Get Started Acrobat

Normal Page Layout Page Break Views Custom Full Workbook Views

Formula Bar

Zoom 100%

View Side by Side Synchronous Scrolling Reset Window Position Window

Save Workspace Switch Windows

Macros

A1

State of Wisconsin Department of Natural Resources
Mann-Kendall Statistical Test Form 4400-215 (2/2001)
Remediation and Redevelopment Program
 Notice: This form is the DNR supplied spreadsheet referenced in Appendices A of Comm 46 and NR 746, Wis. Adm. Code. It is provided to consultants as an optional tool for groundwater contaminant trend analysis to support site closure requests under s. Comm 46.07, Comm 46.08, NR 746.07, NR 746.08, Wis. Adm. Code. Use this form or a manual method when seeking case closure under those rules. Earlier versions of this form should not be used.
 Instructions: Do not change formulas or other information in cells with a blue background, only cells with a yellow background are used for data entry. To use the spreadsheet, provide at least four rounds and not more than ten rounds of data that is not seasonally affected. Use consistent units. The spreadsheet contains several error checks, and a data entry error may cause "DATA ERR" or "DATE ERR" to be displayed. Dates that are not consecutive will show an error message and will not display the test results. The spreadsheet tests the data for both increasing and decreasing trends at both 90 percent and 90 percent confidence levels. If a declining trend is present at 90 percent but not at 90 percent, a site is still eligible for closure under Comm 46 and NR 746 provided that other conditions in those rules are met. If an increasing or decreasing trend is not present, an additional coefficient of variation test is used to test for stability, as proposed by Wiedemeier et al. 1995. For additional information, refer to the Interim Guidance on Natural Attenuation for Petroleum Releases, dated October 1999. Refer to the guidance for recommendations on data entry for non-detect values.

Site Name = _____ EPRTS No. = _____ Well Number = _____

Event Number	Sampling Date (most recent last)	Concentration (leave blank if no data)					
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Mann Kendall Statistic (S) =	0.0	0.0	0.0	0.0	0.0	0.0
Number of Rounds (n) =	0	0	0	0	0	0
Average =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Standard Deviation =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Coefficient of Variation (Cv) =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Error Check, Blank if No Errors Detected	nc4	nc4	nc4	nc4	nc4	nc4
Trend ≥ 90% Confidence Level	nc4	nc4	nc4	nc4	nc4	nc4
Trend ≤ 90% Confidence Level	nc4	nc4	nc4	nc4	nc4	nc4
Stability Test, If No Trend Exists at 90% Confidence Level	nc4	nc4	nc4	nc4	nc4	nc4

Data Entry By = _____ Date = _____ Checked By = _____

THIS BLOCK OF CELLS IS USED TO SEARCH FOR DATA ENTRY ERRORS

DATA ERR	Event Number	0	0	0	0	0	0	0	0	0
CHECKS	1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Checks for data with values less than zero or test (a spac is seen as test in Error Minus one shown if no error.	2	-1	-1	-1	-1	-1	-1	-1	-1	-1
	3	-1	-1	-1	-1	-1	-1	-1	-1	-1
	4	-1	-1	-1	-1	-1	-1	-1	-1	-1
	5	-1	-1	-1	-1	-1	-1	-1	-1	-1
	6	-1	-1	-1	-1	-1	-1	-1	-1	-1
	7	-1	-1	-1	-1	-1	-1	-1	-1	-1
	8	-1	-1	-1	-1	-1	-1	-1	-1	-1
	9	-1	-1	-1	-1	-1	-1	-1	-1	-1
	10	-1	-1	-1	-1	-1	-1	-1	-1	-1

Data error in column? no err no err no err no err no err no err

Site = 0 EPRPTS = 0 Well = 0

Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9	Event 10	Sum Flows
										0
										0
										0
										0
										0
										0
										0
										0
										0
										0
										0

Mann Kendall Statistic (S) = 0

THIS BLOCK OF CELLS USED TO FIND ERRORS IN DATES

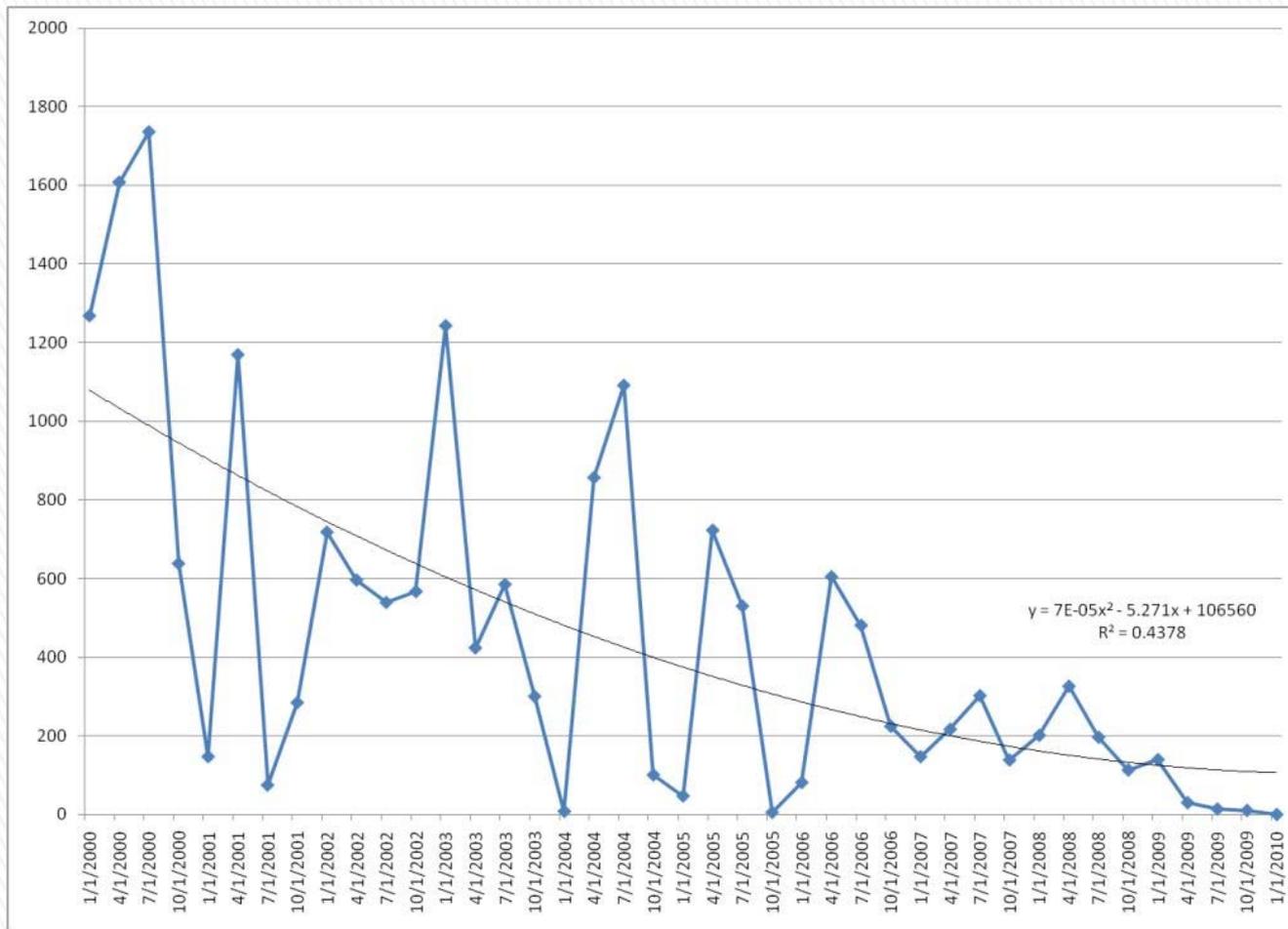
DATE ERR	Date	Test in Date?	Consecutive?	Data vs no date?
CHECKS	BLANK	-1	-1	-1
	BLANK	-1	-1	-1
Checks	BLANK	-1	-1	-1

Site = 0 EPRPTS = 0 Well = 0

Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9	Event 10	Sum Flows
										0
										0
										0
										0
										0
										0
										0
										0
										0
										0
										0

Mann-Kendall

Simple, Easy-to-Understand
 Spreadsheets Abound



Regression Analysis

How to Do It? – Quantitatively

- ▶ Total Plume Mass
 - ▶ Center of Mass Approach
 - ▶ Mass Flux Approach
- 

How to Do It? – Critical Elements

- ▶ Must have sufficient data
 - Site-specific
 - Unfortunately can't be one-size-fits-all
- ▶ Interpretation of Results
 - Many ways to evaluate the data
 - Other factors affect sample concentrations
 - Depth to Groundwater, NAPL
 - Seasonal Fluctuations
 - Sampling Techniques/Methods/Personnel
 - Analytical Methods
 - Others...

Plume Stability

- »» What is the State of things in Missouri?

Missouri Brownfields / Voluntary Cleanup Program

- ▶ “Wells must be monitored at a frequency and for a period of time...to clearly demonstrate plume trends...and that...concentrations in the downgradient wells are below the delineation levels.”
 - ...AND REMAIN BELOW DELINEATION LEVELS!
 - ▶ Site-specific plan approved by the Department, no mandate on specific evaluation procedure
 - ▶ Appendix C (Representative Concentration) requires quarterly sampling for a minimum of 1–2 years
 - ▶ Appendix M (Background) requires quarterly sampling for a minimum of 1 year
- 

Missouri LUST

- ▶ “Groundwater monitoring must be conducted for a period of time sufficient to show a reliably consistent trend.”
 - ▶ Site-specific plan approved by the Department
 - ▶ No mandate on specific evaluation procedure
 - ▶ Quarterly samples for 1–3 years, most sites will require 2 years
- 

Plume Stability

- »» What do Other, Nearby States Require?

Illinois Regulations

- ▶ “Compliance with groundwater remediation objectives...shall be demonstrated by comparing the contaminant concentrations of discrete samples at each sample point to the applicable groundwater remediation objective.” [35 IAC 742.225(a)]
- ▶ No Explicit Requirement for Plume Stability Evaluation
- ▶ “Samples shall be collected in consecutive quarters for a minimum of one year for each well” [35 IAC 742.410(3)]
- ▶ No Explicit Requirement for Plume Stability Evaluation

Demonstrating
Compliance

Determining Area
Background

Illinois in Practice

- ▶ When demonstrating compliance with objectives, four consecutive quarters required
 - No explicit instructions on threshold criteria or how to evaluate data
 - Typically comparison of each quarter's result to objectives
- ▶ Single groundwater measurement typically required for pathway exclusion

Iowa Land Recycling Program

- ▶ Eight Consecutive Quarters with...
 - 75% of Measurements Below \leq Standard, and
 - No Single Measurement $> 10X$ Standard
- or-
- 95UCL on the Mean for each well \leq Standard

- ▶ Department May Accept Four Consecutive Quarters with...
 - “Adequate” monitoring indicating decreasing trend,
 - Fate and Transport parameters “fully” evaluated,
 - Concentrations along downgradient property boundary are \leq Standard in all quarterly samples,
 - Age of plume is well known, and
 - Physical remediation is conducted

Iowa LUST Exit Monitoring Criteria

- ▶ Three most recent consecutive samples from all wells show steady/declining trend
 - ▶ Most recent levels below target levels
 - ▶ No increase $>20\%$ from first to third sample (over any three consecutive samples)
 - ▶ No increase $>20\%$ from previous sample
 - ▶ At least 6 months between sampling events (i.e., at least one year of monitoring)
 - ▶ For Soil Leaching to Groundwater, Three Annual Events Required
- 

Kansas

▶ Monitored Natural Attenuation Policy

- MNA Proposal must demonstrate stable/shrinking plume
- Minimum of four consecutive quarters

▶ Reclassification Plan Guidelines

- Data from four consecutive, evenly-spaced events
 - Minimum of a two-year period
- 

Arkansas

- ▶ No Formal Regulatory Requirement
- ▶ Arkansas implements Region 6's Corrective Action Strategy, incorporating EPA Guidance by reference.
 - *Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action for Facilities Subject to Corrective Action Under Subtitle C of the Resource Conservation and Recovery Act, EPA EPA530-R-04-030, April 2004*
- ▶ The guidance offers few specific details.
 - Program should be flexible and easily adaptable
 - For a period after achieving compliance
 - Sufficiently long enough to verify that no rebound will occur
 - Continuing "as long as necessary"

Plume Stability

»» Closing Thoughts

Closing Thoughts

- ▶ Understanding plume stability and overall trends are part of the foundation of any RBCA cleanup.
 - ▶ Conceptual Site Model / Exposure Evaluations are critical components and are forward-looking
 - ▶ Variety of approaches between states...No right or wrong way
- 

Closing Thoughts

- ▶ Communication is key between regulator and consultant, especially when interpreting results
 - Must agree on what is sufficient data
 - May not know until “near the end”
 - ▶ Some pathways may deserve different treatment (e.g., Soil Leaching)
 - ▶ Each site/circumstance is different
 - Objectives for monitoring
 - Site physiography
 - ▶ Flexibility important
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Thank You and Questions

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