



Natural Attenuation Monitor

August 2005

Issue 4

This publication is published by the US DOE Monitored Natural Attenuation and Enhanced Attenuation for Chlorinated Solvents Technology Alternative Project to provide to all interested parties the latest information on this project.

Table of Contents

	Page
Overview of MNA/EA Project	3
A Phased Approach to Characterization and Monitoring	4
EACO Team: Merging Science and Regulations	5
Scenarios – A Tool to Support Characterization, Monitoring, and Decisionmaking Associated with MNA and EA	6
Key Project Documents	7
Published MNA/EA Project Documents	7

Note to Readers: The Monitor is now available on the Savannah River Site public webpage at www.srs.gov under Documents and Publications.

The Natural Attenuation Monitor is published under the direction of the U.S. Department of Energy MNA/EA for Chlorinated Solvents Technology Alternative Project. Editor is Karen Vangelas at the Savannah River National Laboratory, 803-725-5223. Please send information, comments, or questions to karen.vangelas@srnl.doe.gov.

On the Cover: Savannah River National Laboratory personnel preparing soil core samples for irreversible sorption studies being conducted by Bob Riley of PNNL.

Overview of MNA-EA Project

As we approach the end of Fiscal Year 2005, we are making good progress in this project and are sustaining our momentum. We were well represented at Battelle's 8th International In-Situ and On-Site Bioremediation Symposium in Baltimore in June. Members of the Technical Working Group (TWG) and PIs presented five papers on their work. The titles of the papers are listed on pages 7 – 9, if you would like to read them.

We have completed three documents, which are being peer reviewed at this time. The documents are on the mass balance concept, enhancements, and a systems approach to monitoring. The documents address the backbone topics of the project and document the conceptual bases the project is establishing. Once the reviews are completed and each document is finalized, we will be glad to provide electronic copies to interested readers and users.

We are working closely with the Enhanced Attenuation: Chlorinated Organics (EACO) Team of state regulators and industry. We thank Judie Kean and Kimberly Wilson, the co-chairs, for writing a column for this issue of the *Natural Attenuation Monitor*. Shortly we will participate in the review meeting for their *Resource Guide of Available Materials for Monitored Natural Attenuation and Enhanced Attenuation*. The EACO and DOE Teams are doing well working together on common issues; we are making good progress.

The Summer 2005 issue of the *Federal Facilities Environmental Journal* reprinted our description of a third generation R&D structure. The paper, *Accelerating Environmental Cleanup at DOE Sites: Monitored Natural Attenuation/Enhanced Attenuation—A Basis for a New Paradigm*, was published initially in the Winter 2004 *Journal of Remediation*.

We are looking for case study data from multiple

sites to validate our approach to the mass balance and enhanced attenuation concepts. The Departments of Defense and Energy have numerous sites for which such data are available. Our goal is to include sites from both agencies to show broad application of the results from the project.

Our work in characterization and monitoring was a good basis for program planning deliberations on performance monitoring at a June 2005 workshop, in Butte, MT. The workshop was successful. A summary of the deliberations is available as *Summary Report of Performance Monitoring Workshop*, June 21-23, 2005. Participants included technology developers, end users, regulators and academicians. Along with representatives from DOE's Office of Legacy Management and Environmental Management, EPA and DOD representatives participated. I especially thank Brian Looney, Savannah River National Laboratory; Tyler Gilmore, Pacific Northwest National Laboratory; and Jody Waugh, S.M. Stoller, who are members of the TWG for chairing the discussion sessions. If you would like a copy of the Summary Report please contact me.

We have one year remaining in the project before the two teams convene to write the technical guidance for the next generation of monitored natural attenuation – enhanced attenuation. Our rate of progress and maintaining schedule has been excellent. It is in this guidance that we will integrate the results of the field and applied research studies with the conceptual developments of the TWG.

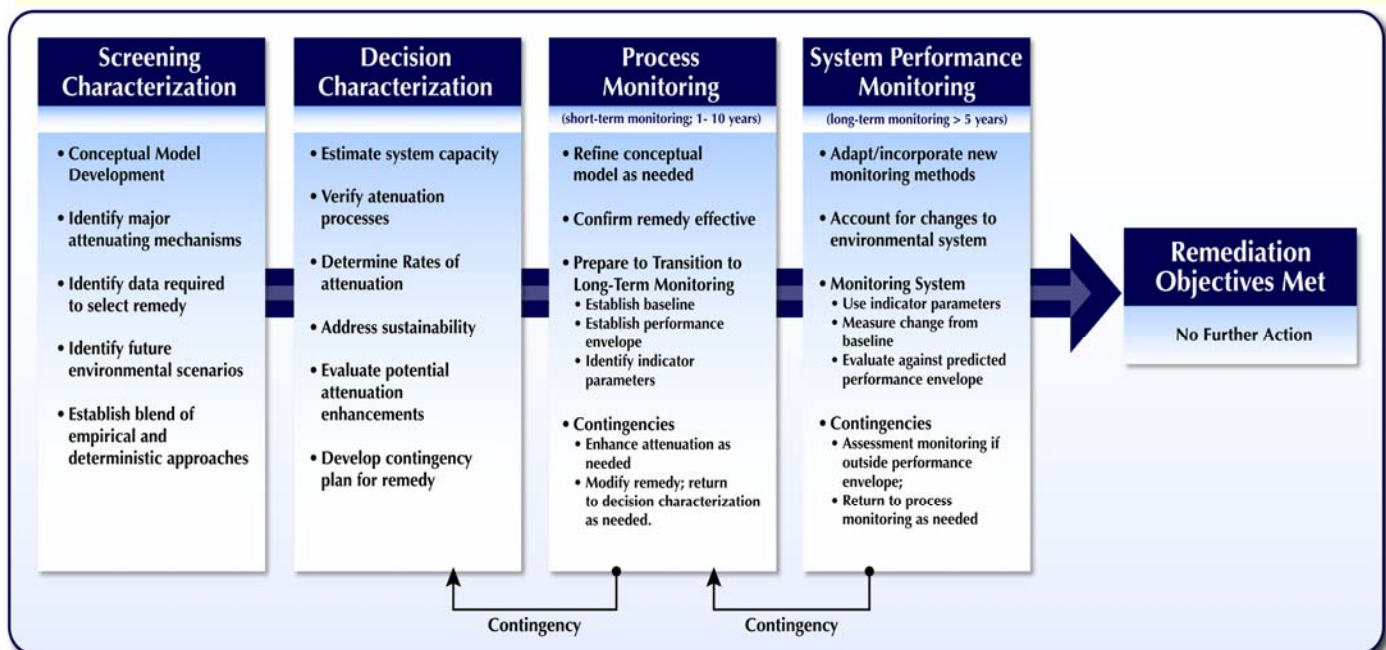
If you have questions or comments, I am at Claire.sink@em.doe.gov.

Claire H. Sink, Project Manager
U.S. Department of Energy
Project Manager



A Phased Approach to Characterization and Monitoring

Characterization efforts to support monitored natural attenuation (MNA) decisions can be challenging and costly as the attenuation processes that are covered under MNA include a variety of physical, chemical, and biological processes. Monitoring of sites where MNA is a component of the remedy can be expensive. This assumes traditional monitoring methods of sampling well networks for traditional suites of analytes occurs for the 10s to 100s of years that many of these sites will require monitoring. Cutting costs while maintaining the level of environmental protection may require a new approach by the responsible parties for these sites. An important paradigm shift that is occurring at many facilities within the DOE complex is a move to combining sites based on geographical location and/or watershed into an area or systems approach. This will result in characterization, remediation, and monitoring being conducted on a system-wide basis.



This systems approach is based on a four phased process that expands both characterization and monitoring into two phases each, see the figure above. First is *screening characterization* where one answers the question of whether MNA is potentially viable. An example of activities in this phase is collecting samples that when analyzed provide information on whether the system is capable of sustaining biological processes. If any processes considered under MNA are viable, the next step is the *decision characterization* phase that identifies the significant attenuation processes. Examples of the questions answered in this phase are: Is reductive dechlorination viable? How much of a contribution to the attenuation capacity does reductive dechlorination make? What, if any, is the influence of dispersion on the attenuation capacity of the system? If the two characterization phases indicate MNA is a viable component in the remediation of the system in question, then the *process monitoring* phase begins. In this phase, one verifies whether the natural attenuation capacity of the system is sufficient or if Enhanced Attenuation processes should be evaluated. Also in this phase, the envelope in which the system must operate to meet the remediation goals is defined and the non-traditional parameters that indicate the system is operating within the envelope are identified. The last phase is *system performance monitoring* and is what most people call the long-term monitoring phase of cleanup. This phase may continue for decades and will verify that the system is operating as ex-

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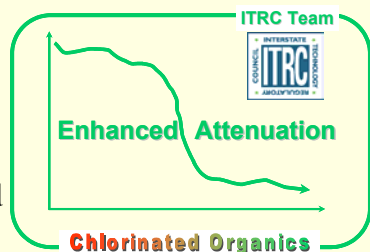
(Continued from page 4) A Phased Approach to Char. & Monitoring expected. This fourth phase is where a paradigm shift has the potential for significant cost savings depending on the size of the system and the duration of the monitoring. It is in this phase where monitoring moves away from traditional sampling of monitoring wells for site specific chemical contaminants and towards parameters that indicate the system is operating as designed.

This four phased approach is designed to streamline characterization and monitoring efforts resulting in reduced baseline project costs. The concept of the phased approach can be broadened beyond characterization and monitoring for MNA to an approach that considers characterization and monitoring of waste units contributing to a single groundwater plume. When combined with the mass balance concept, a comprehensive approach for characterizing, remediating, and monitoring a site can be developed. This should result in accelerated cleanup at costs below existing baselines.

EACO Team : Merging Science and Regulations

By Judie Kean and Kimberly Wilson

Collaboration of state regulators and scientists from the DOE complex on the ITRC Enhanced Attenuation: Chlorinated Organics (EACO) Team has created a unique situation for the development of technical guidance and tools that will support accelerated cleanup within the DOE complex, and present to regulators innovative tools and approaches to MNA/EA. An interesting outcome of the DOE participation on the EACO Team, is the realization that the regulators are more willing to consider the use of new technologies, tools, and concepts than the DOE technical folks thought they would be. Standard practice has been for DOE sponsored scientists to develop new tools and technical guides within the confines of the scientific com-



munity, not actively including the regulator community. Through our joint efforts the DOE team has identified areas that from a technical point of view are perfectly viable, but from a regulator perspective may not be acceptable in any or some situations.

As of the end of July 2005, the ITRC team has: (1) developed a Web-based database that will be used to capture significant information regarding MNA/EA at the national level; (2) completed and populated a web-based survey for state regulators regarding the use of MNA and the introduction of new concepts and; (3) initiated work on a Resource Guide which will provide specific references and concepts of MNA/EA at the national level. It is anticipated by the end of October 2005, that the survey information will provide an opportunity to publish a white paper, and an evaluation document regarding specific state regulations regarding the use of MNA and importance of new approaches to the scientific documentation of MNA.

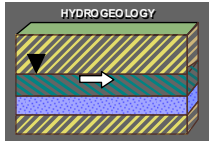
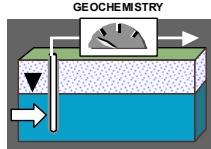
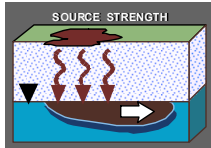
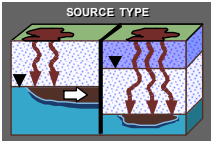
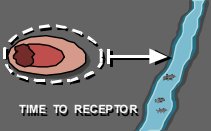
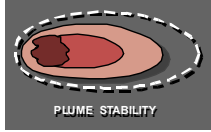
Because of the interconnectedness of the regulators and the DOE end users in selecting and agreeing to environmental remediation plans, the collaboration of these two entities during the development process of new environmental cleanup technologies, tools and guides will promote accelerated acceptance and implementation during the investigation and remediation process. The ITRC EACO co-team leaders, Judie A. Kean, and Kimberly Wilson, believe this ongoing collaboration between ITRC and DOE should be a model for future research/developmental efforts in the environmental and waste management areas.



EACO Team discussing Resource Guide.

Scenarios – A Tool to Support Characterization, Monitoring, and Decisionmaking Associated with MNA and EA

Researchers from Groundwater Services, Inc. and Pacific Northwest National Laboratory are leading a study to assist site owners, regulators and environmental service professionals to evaluate MNA and EA. The effort is based on the fact that different sites have different conditions. These differences effect at-tenuation processes, the type and amount of data needed, and the decisionmaking process. Past attempts at a “one size fits all” scoring system to help interpret data and support decisions have had limited success. The new approach works like a taxonomic key to determine which of about 15 scenarios each potential site fits in. Once a scenario is assigned, the likely attenuation mechanisms, most important data, modeling needs, and enhancement options are identified.

Factors that Define a Scenario: Both Primary and Modifying.		
Primary Info	Options	Icon
Hydrogeologic Setting	<ul style="list-style-type: none"> • Simple, faster flow regime • Simple, slower flow regime • Faster flow with significant heterogeneities • Slower flow with significant heterogeneities • Fractured porous rock 	
Geochemical Environment	<ul style="list-style-type: none"> • Aerobic • Anoxic • Anaerobic 	
Modifying Factors	Options	Icon
Source Strength	<ul style="list-style-type: none"> • Strong • Medium • Weak 	
Source Type	<ul style="list-style-type: none"> • Vadose Zone Source • Submerged Source • Mixed Vadose/Submerged Source 	
Travel Time to Receptor	<ul style="list-style-type: none"> • Travel time < 2 years* • Travel time 2—5 years* • Travel time > 5 years* • (or use travel time based on degradation rate calculation) 	
Plume Stability	<ul style="list-style-type: none"> • Expanding • Stable • Shrinking 	

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The product of the research will be a decision guide that provides a framework that links MNA evaluation and the associated decision logic to key site characteristics. As shown in the table, MNA scenarios are based on a combination of hydrologic and geochemical settings for a site as well as several modifying factors. By applying a taxonomic system such as this, users of the decision guide can determine which scenario best describes their plume (or segment of their plume). The information in the scenario will then be pertinent to the conditions at the site and may aid in making decisions that are properly matched to site-specific needs.

The Scenarios guide will be available at the completion of the MNA/EA project, in late 2006.

Key Project Documents

The MNA/EA Technical Working Group has drafted three documents that provide a detailed technical summary of the core elements of this project. These reports will help technical professionals, regulators and interested parties examine the scientific underpinnings of the project and facilitate open interaction and feedback to assure that the final product of the DOE effort is scientifically valid and reasonable. Each document covers one of the three key areas of development for this project: mass balance, enhanced attenuation, and characterization and monitoring. At this time, these three documents are in various stages of peer review. The peer review was convened by US DOE project manager. Participants represent academia, federal and state regulator agencies. Upon completion of the peer review, the documents will be finalized and made available to the public. It is anticipated that these documents will be publicly available by December 31, 2005.



In brief, the documents covering the three key areas of development emphasize:

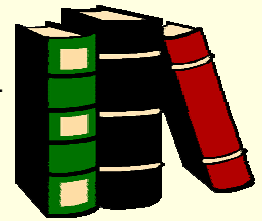
- 1) Mass Balance—Providing the technical basis for the mass balance concept that relies on evaluating plume stability in terms of loading and attenuation;
- 2) Enhanced Attenuation—Defining and developing concepts for sustainable actions to make the overall attenuation response more

robust; and

- 3) Characterization and Monitoring—Developing tools and techniques that support data needs for implementing the mass balance concept and enhanced attenuation technologies.

Published MNA/EA Project Documents

A running list of all documents that are products of this project will be presented here. Documents will be added to the list once they have been approved for public release. Most documents will be available from the US DOE Office of Scientific and Technical Information's (OSTI) website (www.OSTI.gov). Each listing includes the document title, hot link, and short description. Previously presented documents will not include a description.



Multiple Lines of Evidence Supporting Natural Attenuation: Lines of Inquiry Supporting Monitored Natural Attenuation and Enhanced Attenuation of Chlorinated Solvents. WSRC-TR-2003-00331. Todd H. Wiedemeier, M. J. Barden, W. Z. Dickson (T.H. Wiedemeier & Assoc.), D. Major (GeoSyntec). This document will be available through the US DOE, OSTI, Oak Ridge, TN, December 2004. As of this printing, this document has not been posted on the OSTI website. The

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(Continued from page 7) Published MNA/EA Project Documents

focus of this document is on the meaning and use of the lines of evidence for determining the efficacy of natural attenuation and enhanced remediation of chlorinated solvents.

Five papers were presented at the Battelle sponsored 8th International *In Situ* and On-Site Bioremediation Symposium, held June, 2005 in Baltimore, Maryland. Battelle Press publishes the proceedings. The titles and authors are:

Next Generation – Monitored Natural Attenuation and Enhanced Attenuation – Chlorinated Solvents. Karen M. Vangelas, B. B. Looney (SRNL), K. M. Adams, C. H. Sink (US DOE).

Empirical and Deterministic Methods for Assessing Monitored Natural Attenuation. Francis H. Chapelle, B. G. Campbell (USGS), B. B. Looney (SRNL), T. H. Wiedemeier (T.H. Wiedemeier & Assoc.), C. H. Sink (US DOE).

Enhancements to Natural Attenuation Processes: New Approaches to Plume Management. Thomas O. Early (GEO Consultants), B.B. Looney, M. Heitkamp (SRNL), R.C. Borden (N.C. State Univ.), G.R. Wein (BSRI), T.H. Wiedemeier (T.H. Wiedemeier & Assoc.), D.W. Major (GeoSyntec), C.H. Sink (US DOE).

Push-Pull Tests to Determine In Situ Site Wide Natural Attenuation Capacity and Microbial Activity at Savannah River CMP Pits and C-Area. Eric J. Raes (Engineering & Land Planning), J. Istok, J. Jones, J. Fields (Oregon State Univ.), B. B. Looney, K. M. Vangelas, M. Millings (SRNL), G. Davis, A. Peacock (Microbial Insights, Inc.), J. Parker, J. Zhou (ORNL).

Electron Shuttles in Redox Processes: Characterization, Quantification, and Remediation Optimization. Partick W. McLoughlin and R.J. Pirkle (Microseeps).

One paper was presented at the American Society of Civil Engineers (ASCE), World Water & Environmental Resources Congress 2005, held May, 2005 in Anchorage, Alaska. ASCE publishes the

proceedings. The title and authors are:

Monitored Natural Attenuation and Enhanced Attenuation for Chlorinated Solvent Plumes – It's all about balance. Karen M. Adams (US DOE), K. M. Vangelas, B. B. Looney (SRNL), F. Chapelle (USGS), T. Early (GEO Consultants), T. Gilmore (PNNL) and C. H. Sink (US DOE).

One article was published in the journal Federal Facilities Environmental Journal, Summer 2005, Volume 16, Number 2. Published by Wiley Publishers. The article and authors are:

Accelerating Environmental Cleanup at DOE Sites: Monitored Natural Attenuation/Enhanced Attenuation – A Basis for a New Paradigm, Claire H. Sink, Karen M. Adams (US DOE), Brian B. Looney, Karen M. Vangelas (SRNL), Norman H. Cutshall (Legon).

Previously included papers and documents.

Two articles were published in the journal Remediation, The Journal of Environmental Cleanup Costs, Technologies, & Techniques, Winter 2004, Volume 15, Number 1. Published by Wiley Publishers. The articles and lead author are:

Accelerating Environmental Cleanup at DOE Sites: Monitored Natural Attenuation/Enhanced Attenuation – A Basis for a New Paradigm, C. H. Sink (US DOE).

Historical Analysis of Monitored Natural Attenuation: A Survey of 191 Chlorinated Solvent Sites and 45 Solvent Plumes, T. M. McGuire (GSI).

Scientific Basis for Monitored Natural Attenuation and Enhanced Passive Remediation for Chlorinated Solvents – DOE Alternative Project for Technology Acceleration Implementation Plan (www.osti.gov/bridge/product.biblio.jsp?osti_id=810006&queryId=1&start=0), WSRC-RP-2003-00286, US DOE OSTI, Oak Ridge, TN, February 20, 2003.

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(Continued from page 8) Published MNA/EA Project Documents

Historical and Retrospective Survey of Monitored Natural Attenuation: A Line of Inquiry Supporting Monitored Natural Attenuation and Enhanced Passive Remediation of Chlorinated Solvents (www.osti.gov/bridge/product.biblio.jsp?osti_id=820972&queryId=1&start=0), WSRC-TR-2003-00333, US DOE OSTI, Oak Ridge, TN, October 20, 2003.

Summary Document of Workshops for Hanford, Oak Ridge and Savannah River Site as part of the Monitored Natural Attenuation and Enhanced Passive Remediation for Chlorinated Solvents - DOE Alternative Project for Technology Acceleration (http://www.osti.gov/bridge/product.biblio.jsp?osti_id=821098&query_id=0), WSRC-RP-2003-1044, US DOE OSTI, Oak Ridge, TN, October 20, 2003.

Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets (www.osti.gov/bridge/product.biblio.jsp?osti_id=822824&queryId=2&start=0), WSRC-TR-2003-00328, US DOE OSTI, Oak Ridge, TN, February 2004.

Baseline Natural Attenuation Processes: Lines of Inquiry Supporting Monitored Natural Attenuation of Chlorinated Solvents (www.osti.gov/

[bridge/product.biblio.jsp?osti_id=828468&queryId=1&start=0](http://www.osti.gov/bridge/product.biblio.jsp?osti_id=828468&queryId=1&start=0)), WSRC-TR-2003-00329, US DOE OSTI, Oak Ridge, TN, May 18, 2004.

Five papers were presented at the Battelle sponsored Remediation of Chlorinated and Recalcitrant Compounds, 4th International Conference, held May, 2004 in Monterey California. Battelle Press publishes the proceedings. The titles and lead author are:

A Mass Balance Approach to Monitored Natural Attenuation, F. Chapelle (USGS).

Facilitating MNA and Enhanced Passive Remediation (EPR) of Chlorinated Solvents, B. B. Looney (SRTC).

Trends in Monitored Natural Attenuation Application at Chlorinated Solvent Sites, C. J. Newell (GSI).

Putting the Third Line of Evidence First—Advances in Molecular Technologies, D. W. Major (GeoSyntec).

Characterization and Monitoring Strategy for Monitored Natural Attenuation, T. Gilmore (PNNL).