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Monitored Natural Attenuation for Soil and Groundwater

In its 2000 session, the Wyoming Legislature created new opportunities, procedures, and standards for voluntary remediation of contaminated sites. These provisions, enacted as Articles 16, 17, and 18 of the Wyoming Environmental Quality Act and implemented by the Wyoming Department of Environmental Quality (DEQ), will govern future environmental cleanups in Wyoming.

This Fact Sheet provides general direction for evaluating monitored natural attenuation (MNA) as a remedy option and implementing MNA when it is selected as the remedy. This process includes:

- *Gathering and evaluating site characterization data to determine whether natural attenuation is occurring or has the potential to occur.*
- *Comparing MNA to one or more other remedy options, including an active remedy unless DEQ deems comparison with an active remedy unnecessary.*
- *Where appropriate, selecting a remedy that includes MNA and proposing a remediation plan, e.g., a performance and monitoring plan.*
- *When selected, implementing a remedy that includes MNA.*

When considering or evaluating MNA as a potential remedy option, Volunteers should work closely with DEQ on collecting the proper data during site characterization, as well as consulting Fact Sheet #8 Site Characterization and the MNA references listed at the end of this document. Volunteers in the VRP must also work closely with DEQ on remedy evaluation, selection, and implementation. Fact Sheet #21 Remedy Selection includes more information on this subject.

This Fact Sheet provides general direction for evaluating and implementing MNA for sites contaminated with petroleum hydrocarbons, chlorinated compounds, metals, or other contaminants. DEQ believes this Fact Sheet will capture the majority of sites proposing to use MNA as a remedy to cleanup soil or groundwater. However, all sites need to be considered individually in consultation with DEQ to evaluate MNA as a remedy option and to implement MNA when it is selected as the remedy. Additionally, the DEQ believes there are important concepts which will be discussed throughout the Fact Sheet. These concepts are:

- *There are many site specific variables that affect the rates and effectiveness of natural attenuation processes, including the properties of the contaminant(s) and the soil and groundwater physical and chemical characteristics.*
- *Although more commonly used in groundwater, MNA can sometimes be an appropriate remedy to address contamination in the unsaturated zone as well. Volunteers need to consult with DEQ for MNA soil remedies.*

- *MNA is commonly used to address contamination from petroleum hydrocarbons, but can also in certain circumstances be effective at addressing contamination from other compounds, such as chlorinated compounds or metals.*
- *Where feasible, DEQ prefers source removal to reduce contaminant mass. In fact, for the remedy to be effective, MNA will usually require source removal. Source control actions or source removal may include tank removal, active remediation to remove or destroy nonaqueous phase liquids (NAPL), and removal or treatment of highly contaminated soil.*
- *MNA can be used to address residual contamination after implementation of other more aggressive remedies.*

This Fact Sheet provides references to existing guidance (see Section 8), which should not be interpreted to mean that DEQ agrees with every aspect of each guidance document nor should references to specific guidance preclude use of other guidance. Volunteers are encouraged to bring new or updated information to the attention of DEQ.

1. What is natural attenuation, and what is monitored natural attenuation?

Natural attenuation is a broad term that encompasses a number of contaminant transformation processes that are naturally occurring. Natural attenuation is defined as the reduction in mass or concentration of a compound in soil or groundwater over time or distance from the source due to naturally occurring biological, chemical, and physical processes, such as biodegradation, dispersion, dilution, immobilization, sorption, and volatilization. Only biodegradation and volatilization result in significant reductions of total contaminant mass from soil and groundwater.

Biodegradation, which relies upon microorganisms to convert contaminants to less harmful compounds, is the dominant natural attenuation mechanism for reducing mass and contaminant concentrations. In most cases, to support remediation by natural attenuation, the Volunteer will need to show that contaminant mass is being reduced through biodegradation within a time frame that is comparable to that offered by active remediation. For some inorganic contaminants or compounds not subject to biodegradation, other attenuation processes such as dilution, chemical transformation, or sorption may serve to reduce or limit concentrations.

For the most part, this Fact Sheet focuses on the processes related to biodegradation, although some information contained here may be extrapolated to other attenuation processes. When considering mechanisms other than biodegradation, Volunteers should consult with DEQ early in the site characterization and remedial planning stages.

By definition, MNA involves monitoring of contaminant concentration and natural attenuation parameters that provide an indication of the effectiveness of natural attenuation and progress being made to achieve remedy goals. In general, MNA does not include remediation methods that require human intervention beyond monitoring. However, institutional controls, such as use restrictions, may be needed in conjunction with MNA to ensure protection of human health and the environment.

MNA also may be just one component of a site wide remedy that involves active remediation measures or as part of a follow up to active remediation.

Remediation by natural attenuation may be viewed incorrectly as a “do nothing” remedial alternative with potentially lower overall remediation costs. However, MNA involves significant site characterization requirements, which are necessary to construct an acceptable site conceptual model and to design an adequate long term monitoring plan. Also, long term monitoring for remediation by natural attenuation can represent significant cost and a continued funding commitment. Therefore, when the overall costs of MNA are considered in comparison to the costs of other remedy options, it is oftentimes more cost effective to implement an active remedy. EPA guidance on the use of MNA (OSWER Directive 9200.4 17P) provides a set of factors Volunteers may want to consider when evaluating MNA as a potential remedy option.

2. How do I determine if MNA is a potential remedy option?

The effectiveness of MNA as a potential remedy in both the short term and long term will need to be demonstrated to DEQ through technical analyses to support natural attenuation as a remedy option.

The first step in determining if MNA may be a potential remedy for a site is to perform a thorough site characterization with appropriate data and analysis. Volunteers should refer to Fact Sheet #8 (*Site Characterization)* for more information about site characterization requirements for VRP sites. Site investigation recommendations for a site where MNA may be a remedy option are also described in the *Guidance on Natural Attenuation for Petroleum Releases* (WDNR 2003) and in the appendix of the *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites* (ASTM 1998).

During site characterization, information is gathered so that a site conceptual model can be developed to support decisions about potential remedies. When natural attenuation is being considered either as the sole remedy for a site or as a component of a remedy, site investigation needs may be greater than if only active remedies are considered. This is because a thorough understanding of the processes controlling contaminant migration and attenuation is required, as well as an understanding of how these complex processes are likely to change over time. Because the results of initial investigations often do not contain adequate data to assess contaminant trends over time, long term monitoring is typically necessary to assess data trends.

It is also important in the early stages to determine the feasibility of MNA by evaluating the site's potential for natural attenuation (i.e., whether natural attenuation is occurring or has the potential to occur). This involves collection of site specific data sufficient to estimate hydrologic and geochemical conditions amenable to natural attenuation. At sites where there is insufficient data to determine if natural attenuation is occurring, other evidence (described below in Section 3B) will need to be collected.

Ultimately, DEQ will determine whether MNA is an appropriate remedy at a specific site and will take into consideration a number of factors when making decisions, including the potential for contaminants to be effectively addressed through natural attenuation processes, stability of the

contaminant and its potential migration, and an assessment of risks to both human health and the environment. All of these factors will be supported by data that must be collected either during the initial site investigation process or, in some cases, during active remediation.

3. What data are needed to demonstrate MNA is an appropriate remedy and when should those data be collected?

At sites where the Volunteer is considering the use of MNA as part or all of the remedy, it is important to collect data to support the following lines of evidence during the site characterization phase or at other phases as dictated by the site specific characterization process. Collecting information early in the site investigation process is generally recommended as it will ensure that DEQ has the appropriate information to make decisions about remedial actions.

Many approaches are available to assess natural attenuation processes and each site will present site specific challenges. Therefore, as stated earlier, it is important for the Volunteer to work closely with DEQ to ensure the collection of adequate data to support any remedy decisions that include MNA.

DEQ advocates using the three lines of evidence approach which include:

- Primary line—Contaminant mass, contaminant concentration, and plume geometry trends over time. Data generally collected during site characterization process.
- Secondary line—Trends in geochemical parameters indicative of natural attenuation processes (e.g., biodegradation) occurring. Data collected either during site characterization process or possibly during active remedy implementation.
- Additional lines—Microbial studies and other analysis demonstrating that degradation is occurring or has the potential to occur.

Because it can take years to establish a primary line of evidence, generally, data needed for primary and secondary lines of evidence of natural attenuation are collected concurrently. If data from the primary and secondary lines of evidence are inconclusive, additional data may be collected to determine if natural attenuation is occurring or has the potential to occur. For all lines of evidence, Volunteers should plan to collect evidence (e.g., groundwater monitoring and analyses) and track results throughout the course of the remedy.

A. Primary Line of Evidence

At a minimum, primary lines of evidence are required to demonstrate the viability of remediation by MNA. For sites which have sufficient historical monitoring data, the primary lines of evidence will often be adequate to demonstrate remediation by MNA.

In groundwater, the primary line of evidence for remediation by natural attenuation is provided by observed plume stability or reductions in plume geometry (size) and observed reductions in concentrations of the constituents of concern at the site. Plume status and geometry is a complex issue and is very dependent on site specific circumstances. It is possible for part of a plume to be

increasing in size, while other parts of the plume decrease. Different portions of a plume may actually contain different constituents of concern if there are multiple sources. All of these factors must be considered when evaluating this first line of evidence.

In order to show that the plume is not expanding in a downgradient, lateral, or vertical manner, monitoring wells must be located in proper positions to completely evaluate the plume's stability and track plume behavior. To allow for plume characterization, monitoring wells will need to be located both within the contaminated area (downgradient, as well as cross gradient) and around the perimeters of the plume boundary. Wells must be placed in or adjacent to the source area, along the flow line paths in the direction of the plume's migration and downgradient of the plume as points of compliance wells. Upgradient well(s) also are needed to provide baseline data.

If monitoring of the contaminant plume does not indicate plume stability and/or reductions in contaminant concentrations, it may be necessary to gather evidence and estimate decay rates in the source area. In an unsaturated source area, the primary line of evidence for remediation of organic contaminants by natural attenuation is provided by analytical results demonstrating mass reduction. Where feasible, DEQ prefers source removal to reduce contaminant mass. Sometimes contamination may remain in the source zone (e.g., residual NAPL) that is acting as a long term ongoing source of contamination in groundwater. An estimation of the time it will take for this source area contamination to degrade must be performed to determine how long the groundwater and/or soil may be affected. Estimates of attenuation rates are based on temporal and/or spatial trends of geochemical indicators.

B. Secondary Line of Evidence

In most cases, unless the data used in the primary lines of evidence dictates otherwise, DEQ will require the collection of secondary lines of evidence to demonstrate the nature and rates of natural attenuation processes. As stated previously, often data for secondary lines of evidence are collected concurrently with the data required to establish primary lines of evidence. Secondary lines of evidence for remediation by natural attenuation are observed by changes in concentrations of geochemical parameters within the contaminant plume that indicate natural attenuation is occurring. These geochemical changes are caused primarily through biodegradation.

Once the distribution of the geochemical indicators relative to the contaminant plume is identified, the assimilative capacity of the saturated zone can be determined to evaluate the site's potential for natural attenuation processes, particularly biodegradation. The assimilative capacity of the saturated zone, once established, can be used to estimate a remediation time frame.

C. Additional Lines of Evidence

Additional lines of evidence usually are not necessary to evaluate the fundamental performance of the natural attenuation remedy, but more often are collected if the first two lines of evidence are not conclusive or to determine if augmentation (e.g., oxygen injection) is feasible. Additional lines of evidence can be provided by collecting microbiological information and by further analyzing primary and secondary lines of evidence. The presence of microorganisms capable of degrading the contaminants present at a site is a good indicator of the viability of natural attenuation.

For all lines of evidence, there are various mathematical methods and computer models that can be used to assess natural attenuation processes, including estimates of the contaminant decay rate in groundwater and source areas necessary to show that contaminant mass and concentration are decreasing, as well as for calculating the geochemical trends and assimilative capacity outlined in the secondary lines of evidence above. A list of possible methods and approaches to use in meeting these data requirements are provided in guidance (*WDNR Guidance on Natural Attenuation for Petroleum Releases*, 2003). Several computer models such as BIOSCREEN, BIOPLUME, SourceDK (http://www.gsi-net.com/Software/SourceDK.htm) and SESOIL (DEQ uses the version sold by SEVIEW) also are available to provide information on plume(s) stability and rate of decay at a site. For additional guidance on the use of modeling during the MNA evaluation, please contact DEQ.

For more information or guidance about lines of evidence, please refer to the documents cited in Section 8.

Once the site's potential for natural attenuation has been determined, DEQ will decide if it is appropriate to consider MNA as a remedy option.

4. How will DEQ decide if it is appropriate to consider MNA as a potential remedy option?

The evaluation of whether remediation by MNA is appropriate at a site requires the Volunteer to exercise the same care and professional judgment as with any other remedial option by:

- Collecting site characterization information that is adequate to evaluate a site's potential for remediation by natural attenuation.
- Conducting a detailed evaluation of information collected to understand natural attenuation processes occurring at the site.
- Determining whether remediation by natural attenuation should be considered the most appropriate and/or cost effective remedial alternative based on the site conceptual model, site setting, and other considerations.

DEQ usually will require an MNA remedy to be compared to at least one active remedy, unless DEQ deems comparison with an active remedy unnecessary. For guidance on remedy selection in the VRP and for specific information on the major decisions and actions required to determine the appropriateness of applying and implementing remediation by MNA, please refer to Fact Sheet #21 *Remedy Selection* and to the guidance referenced in Section 8.

A. Conditions Where MNA is Not an Appropriate Sole Remedy

Some sites will require remedies other than MNA. In general, the conditions where MNA should not be the sole remedy to address groundwater contamination include:

- Source water protection areas.

- Well head protection areas.
- Advancing groundwater plume.
- Fractured bedrock contamination.
- Contamination that has impacted receptors or creates an imminent threat to receptors (e.g., drinking water wells, surface water, other environmental receptors)
- Presence of recoverable NAPL.

B. Conditions Where MNA May Be Appropriate as a Sole Remedy

MNA may be appropriate as a sole remedy at sites that meet some or all of the following favorable conditions:

- Contamination currently not posing risk to human health or the environment.
- No active source of contamination. (An active source is any area of contaminant that is being released to the plume faster than it can be attenuated.)
- Plume perimeter is static or retreating, or the site was otherwise determined to have the potential for natural attenuation.
- Access to the impacted media can be controlled, if necessary (e.g. by using institutional controls), over the time period that the remedy will remain in effect.
- The resulting transformation products do not present a greater risk, due to increased toxicity and/or mobility, than the original contaminants.
- No demand for the affected resource (e.g., contaminated groundwater) is likely over the time period that the remedy will remain in effect.

As with any other remedial alternative, MNA should be selected as the preferred or primary remedial option only where it meets all relevant remedy selection criteria (see Fact Sheet 21 *Remedy Selection*), including a time frame that is reasonable, on balance, compared to that offered by other technically and economically feasible remedial alternatives.

5. If a monitored natural attenuation remedy is selected, what are the performance requirements for remedy implementation?

Once DEQ and the Volunteer agree on a remedy, the remedy decision is documented in a remedy agreement that specifies requirements for implementation, including performance objectives. If the remedy agreement (RA) specifies MNA as the remedy or as one component of a remedy, performance objectives, optimization measures, augmentation measures and, possibly, contingent remedies may need to be described.

A. Establishing Performance Objectives and a Performance Monitoring Plan

The performance objectives for MNA include standards for remedy implementation that are site specific. For all VRP sites, cleanup levels for groundwater are set equivalent to established federal drinking water standards or site specific, risk based levels developed using exposure factors based

on the assumption that groundwater may be used as a drinking water source. For more information on developing site specific, risk based standards for groundwater, refer to Fact Sheet #11 *Risk Assessment*. Cleanup levels are also set to preserve the existing groundwater classification. For more information on groundwater cleanup levels, see Fact Sheet #13 *Groundwater Cleanup Levels.*

For soil, site specific approaches to calculating soil cleanup levels to protect groundwater are listed in Fact Sheet #12 *Soil Cleanup Levels*, along with default soil cleanup levels.

At sites where MNA is being implemented, regular monitoring is used to evaluate progress toward meeting cleanup levels. Assessing the performance of a remedy during implementation is essential to determining whether remediation objectives are being achieved in a reasonable amount of time. It is important to establish a baseline for contaminants during site characterization of the site at the beginning of the monitoring program to enable progress to be measured. Periodic monitoring enables the Volunteer and DEQ to determine a remedy's effectiveness over time. Performance monitoring is of even greater importance for MNA than for other types of remedies due to the potentially longer remediation time frames, potential for ongoing contaminant migration, and other uncertainties associated with using MNA.

The guidance documents referenced in Section 8 of this Fact Sheet all include guidance on development of monitoring programs. Section 3 of the *Guidance on Natural Attenuation for Petroleum Releases* (WDNR 2003) describes recommendations for monitoring, geochemical indicator parameters of natural attenuation, methods for collecting and analyzing samples, monitoring for contaminants of concern, monitoring schedules, and data reporting. The appendix of the *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites* (ASTM 1998) gives detailed guidance on monitoring considerations, such as sampling parameters and methods, analytical methods, modeling methods, and interpretation of natural attenuation indicators. *Designing Monitoring Programs to Effectively Evaluate the Performance of Natural Attenuation* (Wiedemeier 2002) also describes guidelines for designing monitoring programs effectively to evaluate the performance of MNA.

All monitoring programs should accomplish the following:

- Demonstrate that natural attenuation (e.g., biodegradation) is occurring according to expectations (e.g., mass reduction, timeframe).
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other parameters) that may reduce the efficacy of any of the natural attenuation processes.
- Identify any potentially toxic and/or mobile transformation products.
- Determine if the plume(s) is/are expanding laterally, vertically, or downgradient.
- Ensure no potential impact to downgradient receptors.
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy.
- Demonstrate the efficacy of institutional controls.

- Detect changes in the overall conditions that were the basis for the remedial design.
- Verify attainment of remediation objectives.

The monitoring interval for a site depends on site characteristics and existing data. Depending on site specific conditions, the monitoring interval is typically set quarterly for the first one or two years of remedy implementation and then annually thereafter. Performance monitoring should be specified in the remedy agreement, but at a minimum should continue until remediation objectives have been achieved, and longer if necessary. Typically, monitoring is continued for a specified period (e.g., one to three years) after remediation objectives have been achieved to ensure that concentration levels are stable and remain below target levels.

DEQ will establish one or more criteria to signal unacceptable performance of MNA as the selected remedy and to indicate when to evaluate whether implementation of a contingency remedy would be necessary, such as:

- Contaminant concentrations in soil or groundwater at specified locations exhibit an increasing trend not originally predicted during remedy selection.
- Near source wells exhibit large concentration increases indicative of a new or remobilized release.
- Monitoring results indicate the plume may be migrating or expanding.
- Contaminant concentrations are not decreasing at a sufficiently rapid rate to meet the remediation objectives.
- Changes in land and/or groundwater use will adversely affect the protectiveness of the MNA remedy.

In establishing performance criteria, care is needed to ensure that sampling variability or seasonal fluctuations do not unnecessarily trigger a contingency. Establishing such criteria should help prevent the need to reopen the remedy agreement.

6. What if the performance objectives are not met?

In the event that MNA is not achieving performance objectives and any DEQ-approved augmentation measures (e.g., oxygen injection) are not effective, then implementation of a contingency remedy may be required. Contingencies may include a new cleanup technology or an approach specified in the remedy agreement that functions as a backup remedy in the event that the selected remedy fails to perform as anticipated. Contingencies are especially necessary in the remedy agreement where MNA's ability to meet remediation expectations is uncertain and based predominantly on predictive analyses.

Conditions for when to evaluate contingency options have to be clearly written in the remedy agreement. An example of a remedy agreement contingency requirement that includes the flexibility to evaluate new technologies is as follows:

If MNA is not performing in accordance with the objectives set forth in this remedy agreement after five years, the Volunteer will implement soil vapor extraction or an alternative technology approved by DEQ after evaluating available new technologies.

For more information on remedy agreements, please refer to Fact Sheet #21 *Remedy Selection*.

7. How can I get more information about the VRP?

To learn about VRP sites that may exist in your community, obtain copies of other VRP Fact Sheets/guidance documents, get answers to your questions, or volunteer for the program, contact DEQ at (307) 777-7752 or through the VRP website at: http://deq.state.wy.us/volremedi/index.asp.

The VRP website includes all of the Fact Sheets and other guidance documents for the VRP. This website is updated frequently and includes the latest information about DEQ's progress in developing guidance, policy, and other supporting documents for the VRP.

8. References

For additional information regarding monitored natural attenuation, the Volunteer is referred to the following documents.

API 2003. *Groundwater Remediation Strategies Tool*. American Petroleum Institute. Pub. No. 4730; December 2003. Available at: http://www.api.org/ehs/groundwater/upload/4730_Final.pdf

ASTM 2004. *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites*. American Society for Testing and Materials. E 1943-98; 2004. (To purchase a copy, go to http://www.astm.org and type natural attenuation into the site search engine.)

CDLE 2002. *Monitored Natural Attenuation in Ground Water Guidance Document. Division of Oil and Public Safety, Colorado Department of Labor and Employment*. June 2002. Available at: http://oil.cdle.state.co.us/OIL/Technical/Guidance%20Documents/MNA%20DOC%2006-17-02.pdf

DOE 1999. *Site Screening and Technical Guidance for Monitored Natural Attenuation at DOE Sites.* Department of Energy. March 1999. http://www.sandia.gov/eesector/gs/gc/na/mnatoolbox.pdf

EPA 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*. Environmental Protection Agency. EPA/600/R 98/128, 1998. Available at: http://www.epa.gov/oerrpage/superfund/resources/gwdocs/protocol.htm

EPA 1999a. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. Office of Solid Waste and Emergency Response, Environmental Protection Agency. Directive Number 9200.4 17P, 1999. Available at: http://www.epa.gov/swerust1/directiv/d9200417.pdf

EPA 1999b. *Monitored Natural Attenuation of Chlorinated Solvents* (Fact Sheet). Environmental Protection Agency. EPA/600/F 98/022, 1999. Available at: http://www.clu-in.org/download/remed/chl-solv.pdf

EPA 1999c. *Monitored Natural Attenuation of Petroleum Hydrocarbons* (Fact Sheet). Environmental Protection Agency. EPA/600/F 98/021, 1999. Available at: http://www.clu-in.org/download/remed/pet-hyd.pdf

EPA 1999d. *Ground Water Issue Paper: Microbial Processes Affecting Monitored Natural Attenuation of Contaminants in the Subsurface*. Environmental Protection Agency. EPA/540/S 99/001, 1999. Available at: http://www.clu-in.org/download/remed/microbial.pdf

ITRC/ISB 1998. *Closure Criteria Focus Group Report*. Interstate Technology and Regulatory Cooperation Work Group. 1998. Available at: http://www.itrcweb.org/Documents/ISB-4.pdf

ITRC 1999. *Natural Attenuation of Chlorinated Solvents in Groundwater: Principles and Practices*. Interstate Technology and Regulatory Cooperation Work Group. 1999. Available at: http://www.itrcweb.org/Documents/ISB-3.pdf

USAF. *Overview of the Technical Protocol for Natural Attenuation of Chlorinated Aliphatic Hydrocarbons in Ground Water Under Development for the U.S. Air Force Center for Environmental Excellence*. Technology Transfer Division, U.S. Air Force Center for Environmental Excellence. Available at: http://www.afcee.brooks.af.mil/products/techtrans/monitorednaturalattenuation/OverviewMNA.pdf

USGS 2003. *Methodology for Estimating Times of Remediation Associated with Monitored Natural Attenuation*. U.S. Geological Survey. USGS Water Resources Investigations Report 03 4057; 2003. Available at: http://water.usgs.gov/pubs/wri/wri034057/pdf/WRIR-03-4057.pdf

Wiedemeier 2002. *Designing Monitoring Programs to Effectively Evaluate the Performance of Natural Attenuation*. Wiedemeier, T.H., and Haas, P.E. Ground Water Monitoring and Remediation 22, no. 3, Summer 2002. Available at: http://www.afcee.brooks.af.mil/products/techtrans/MonitoredNaturalAttenuation/ltm.pdf

WDNR 2003. *Guidance on Natural Attenuation for Petroleum Releases*. Bureau for Remediation and Redevelopment. Wisconsin Department of Natural Resources. PUB RR 614, March 2003. Available at: http://dnr.wi.gov/org/aw/rr/archives/pubs/RR614.pdf

Refer to http://www.epa.gov/swerust1/oswermna/mna_news.htm for upcoming guidance and new documents on monitored natural attention.