UST GUIDELINES FOR MONITORED NATURAL ATTENUATION (MNA)

UST Section
North Carolina Department of Environmental Quality
Division of Waste Management

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Introduction

Monitored natural attenuation (MNA) is the sum of natural processes that leads to the decreasing of environmental contaminant concentrations over time through their degradation into simpler chemical substances.

The primary objective of MNA is to demonstrate that natural processes will reduce contaminant concentrations in groundwater to levels below applicable risk-based regulatory standards before a point of compliance is reached by that contaminated groundwater. MNA as a remedial alternative is highly dependent on a good understanding of localized hydrogeologic conditions and may require considerable information and monitoring over an extended period.

The goal for any risk-based corrective action for a petroleum release should include remediation within the timeframes described in the UST Section's June 1, 2016 document entitled: *North Carolina Petroleum UST Release Corrective Action Phase Project Management: A Calibrated Risk-Based Corrective Action Decision & Implementation Guide* (i.e., up to 10 years of MNA to achieve plume stabilization and risk reclassification, or approximately 2 years of active remediation to aggressively address residual sources followed by MNA as described above.) These guidelines describe the use of MNA where applicable under Title 15A of the North Carolina Administrative Code (NCAC) Subchapter 2L .0106(l) as a standalone corrective action OR after active remediation has reached either asymptotic (steady state) conditions or a situation in which remediation can no longer be achieved through proven technologies and needs to be terminated or amended, per Title 15A NCAC 2L .0106(m).

There are certain site-specific conditions that can limit the effectiveness of MNA. The examples below include some situations where MNA alone may not be sufficient to properly address the risks posed by contamination in a timely and effective manner that remains protective of human health and the environment:

1. An advancing groundwater plume indicates that the natural attenuation capacity of the system is unable to control the migration of contaminants. This usually means that the contaminant plume concentrations are increasing, the contaminant plume is not stable, or contaminant plume may reach receptors at concentrations above regulatory limits. (Required by 15A NCAC 02L .0106(l)(3))

2. The contaminated media is difficult to assess (e.g. fractured bedrock aquifers, low permeability / highly heterogeneous formations, highly developed areas with limited access, etc.).

3. Contamination has impacted receptors or creates an imminent threat to receptors (e.g., drinking water wells, surface water, other environmental receptors).

   Points of exposure other than the property boundary are currently impacted (e.g., utility corridors, surface spills/uncapped near surface petroleum contaminated soils, and surface water bodies, etc.).

   One or more of the other completed exposure pathways (e.g., subsurface soil leaching to groundwater, surficial soil contamination, contaminated groundwater and/or soil vapor causing vapor intrusion) exists at the site, and no active remediation method has been proposed to eliminate them.

   Contaminant concentrations exceed groundwater standards established in 15A NCAC 02L .0202 beyond the relevant point of compliance. (e.g., at risk receptors, property boundary for off-site landowner consent with non-UST sites or UST sites if public water is not available, NAPL in

proximity to structures or property boundaries, etc.) (Required by 15A NCAC 02L .0106(l)(3), (4), & (5) and G.S. 143-215.104AA(e)).

4. Sources of contamination and/or mobile free product are present at the site, and no abatement or remedial method addressing these issues has been proposed or implemented. (Required by 15A NCAC 02L .0106(l)(1)

5. The contaminants of concern do not readily degrade or attenuate (e.g., MTBE, PAHs, or high molecular weight hydrocarbons).

6. Source water and well head protection areas are/will be impacted (Required by 15A NCAC 02L .0106(4) & (5).

Initial Screening (LSA and CSA)

Initial assessment activities include the Limited Site Assessment and the Comprehensive Site Assessment. The LSA will include at a minimum one well and total of up to four wells. At this point site specific conditions may already preclude the use of MNA.

The CSA must include a sufficient number of wells to determine direction of GW flow and to define the vertical and horizontal extent of contamination. These wells should be analyzed for the MNA performance parameters since MNA is required by rule to be used to the maximum extent possible. Mass contaminant calculations must be included in the CSA for all contaminated media of concern. For any CSA where a mass contaminant calculation was not done, a calculation should be included in the conclusions of the next monitoring report. When a sufficient number of sampling events and monitoring well points are available a fate-and-transport model must be performed to evaluate MNA feasibility. The scope of these calculations and models should cover both aggregate total contaminant mass and constituent-specific concerns, where applicable.

The MNA performance parameters provide insight into the microbial and biogeochemical reactions and processes that are occurring within the subsurface. As a result, the baseline sampling should include the following MNA performance parameters:

a. Dissolved Oxygen
b. ORP
c. pH
d. Temperature
e. Specific Conductivity
f. Nitrate + Nitrite Nitrogen
g. Nitrate Nitrogen
h. Nitrite Nitrogen
i. Ammonia Nitrogen
j. Total Organic Nitrogen
k. Total and Ferric Iron (+3)
l. Turbidity
m. Sulfate
n. Sulfide

o. Maximum Dissolved Methane
p. TOC/BOD/COD
q. Alkalinity
r. CO_2
s. Manganese

All of the above MNA performance parameters should be sampled at each background monitoring well, all performance monitoring wells, and all sentinel monitoring wells. Sentinel monitoring wells represent the closest downgradient uncontaminated well. Other performance parameters, such as microbiologic speciation, may be conducted where appropriate.

After the completion of the baseline sampling events, the MNA performance parameters may be re-evaluated to determine if the sampling frequency may decrease for a specific parameter or be removed from the corrective action sampling program entirely based upon its technical relevance (example: anaerobic conditions instead of aerobic conditions). It is necessary to determine after the baseline sampling events, which reactions and processes are driving the subsurface biogeochemistry. There also must be a comparison between source loading and plume attenuation capacity incorporating observed mass flux and projected contaminant decay rates. Any changes to the MNA performance parameter list must be approved by the UST Section.

Monitoring Well Network

An initial period of monitoring of an approved monitoring well network is needed to establish the effectiveness of MNA as a remedial option. An approved monitoring well network should be sampled for all MNA performance parameters on at least a semiannual basis for at least two calendar years (four semiannual sampling events) to establish baseline trends. An effective groundwater monitoring well network consists of compliance wells, performance wells, and sentinel wells. The performance wells are optimally selected to evaluate the effectiveness of MNA at reducing contaminant levels within the plume body, while the sentinel wells are used to detect plume movement into previously uncontaminated areas, toward adjacent properties and receptors. An appropriate groundwater monitoring well network captures data that adequately covers the horizontal and vertical extents of the groundwater plume.

After the baseline sampling events have been completed, a comprehensive sampling plan must be developed and approved that will allow for appropriate MNA screening models to be run (see Modeling below for details).

MNA Effectiveness

MNA is effective based upon the following technical and scientific demonstrations:

1. The reduction of the contaminant concentrations is caused by physical, chemical or biological attenuation of the contaminant;

2. The sampling analytical results show that the plume has stabilized horizontally and vertically in size and is not migrating; and

3. A statistical reduction in the contaminant concentrations along specific flow paths can be shown.

Plume stability (chemical, biological, and physical) must be determined in evaluating trends along specific flow lines within the contaminant plume and along the contaminant plume boundary. As with all reports submitted under Title15A NCAC 2L .0111, MNA reports shall include a discussion of the procedures and methods used to monitor progress, technical data obtained by those processes, calculations and models evaluating progress against the MNA timetable, and any conclusions and recommendations drawn from the professional evaluation of the data. It is important to note that site specific conditions may require the collection of additional technical information not routinely required at other sites to obtain a better characterization of the processes occurring at that facility.

To ensure that seasonal variability is properly evaluated, once the effectiveness of MNA has been confirmed, subsequent monitoring events may be scheduled at 9-month intervals for a minimum of 4 sampling events or on another schedule as recommended by the regional supervisor.

Modeling

Effective modeling is an essential part of developing and monitoring any MNA program. Fate-and-transport models (such as Domenico) should be used at the outset to determine if MNA is reasonably protective of potential receptors and should be reevaluated during routine monitoring to determine if the projections made in the initial model are consistent with observed results. Models must be updated regularly to ensure changing site conditions do not present an unacceptable risk to any potential receptor and to evaluate trends in mass flux and mass balance.

Modeling may also be used to evaluate whether a MNA Corrective Action Plan (CAP) may be terminated with site closure under a conditional NFA determination, as allowed under Title 15A NCAC 2L .0106(k). Trend analyses models, such as Mann-Kendall, may be used to confirm concentration trends for any applicable contaminant plumes have stabilized or are decreasing, potentially allowing for a reclassification of site risk based on the likelihood that nearby receptors will or will not be affected. Mann Kendell requires a minimum of 4 appropriately staggered events but works best with 8 or more events.

- High risk incidents with contaminant modeling trends that are stable or decreasing may be reclassified to intermediate risk with a revised receptor list. However, an NFA is not possible until all intermediate risk conditions are also satisfied.

- Intermediate risk incidents with stable or decreasing contaminant modeling trends and constituent concentrations below GCLs may be reclassified to low risk. If contaminant concentrations are below the GCLs but the contaminant modeling trend is unstable (no trend) or increasing, the risk cannot be reclassified. The contaminant modeling trend must be stable or decreasing while remaining below GCLs before the risk may be reclassified to low and an NFA issued.

Corrective Action Contingency

A corrective action plan that fails to achieve the requirements for cleanup as presented in the original plan may be terminated or amended by the Department. Accordingly, any proposed MNA CAP must include a list of metrics or triggering events that would indicate a failure or potential failure of the original plan to meet these requirements. Established responses to those triggering events should also be included as contingency corrective actions to reestablish compliance without the need for formal termination of the MNA CAP and replacement with an alternate active technology CAP.

If modeled contaminants are observed to migrate unexpectedly beyond a compliance boundary, such as a sentinel well, receptor or property boundary, active remediation should be considered, and at-risk receptor/property owners notified, if required.

If MNA is not performing in accordance with the objectives set forth in the approved CAP after the first five consecutive calendar years, the contingency plan must be implemented immediately. Also, if the contingency plan is found not to be effective at the site, then an alternate CAP that meets the requirements of Title 15A NCAC 2L .0106(j) must be submitted for approval.

Uncertainty associated with estimated rates of attenuation over extended periods of time is a major consideration with MNA. Hydrologic and geochemical conditions amenable to MNA can change due to (1) natural or anthropogenic causes, and (2) changes in the mobility of a plume over time. MNA should not be considered the only presumptive remedy but should be evaluated as part of, and in contrast with, with active remediation options to restore groundwater to its designated beneficial use considering cost, technical practicability, remedial objectives, and protection of human health and the environment.

Initial Screening of Monitored Natural Attenuation Applicability

(All questions must be "Yes" for MNA to be considered for the site)

Soil		
Has free product been recovered to the maximum extent practicable?	**NO** ⟹	**STOP, MNA is not a remedial option**
	YES ⟹	**MNA has the potential to be effective**
Will contaminant mass be degraded within a reasonable period of time?	**NO** ⟹	**STOP, MNA is not a remedial option**
	YES ⟹	**MNA has the potential to be effective**
Are adequate controls in place to ensure that no receptors come into contact with contaminated soil?	**NO** ⟹	**STOP, MNA is not a remedial option**
	YES ⟹	**MNA has the potential to be effective**
Groundwater		
Has free product been recovered to the maximum extent practicable?	**NO** ⟹	**STOP, MNA is not a remedial option**
	YES ⟹	**MNA has the potential to be effective**
Is the plume shrinking such that remediation objectives will be achieved within a reasonable time frame?	**NO** ⟹	**STOP, MNA is not a remedial option**
	YES ⟹	**MNA has the potential to be effective**
All receptors are >2 years of travel time from an unexpectedly migrating plume.	**NO** ⟹	**STOP, MNA is not a remedial option**
	YES ⟹	**MNA has the potential to be effective**