APPENDIX B

MONITORING STRATEGY

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Alternative 2 (Natural Attenuation/Monitoring) and Alternative 3 (Extraction, Treatment, and Discharge) have been selected as interim remedies that will be implemented at the North, East, and West Industrial Operable Unit (NEWIOU) sites with groundwater contamination. This appendix discusses natural attenuation and application of this interim remedial action, and presents the approach for incorporating natural attenuation monitoring into the current Travis Air Force Base (AFB) groundwater monitoring program. The strategy for monitoring effectiveness of the extraction and treatment systems is also included. All groundwater sites in the NEWIOU will be monitored.

B.1 Monitoring of Natural Attenuation Sites

Natural attenuation of dissolved fuel and chlorinated hydrocarbon compounds has been demonstrated at many sites in the U.S. over the past decade. This alternative has been selected as an interim remedial action for groundwater at one Installation Restoration Program (IRP) site (LF006) in the NEWIOU. However, natural attenuation will be evaluated at seven other sites in the NEWIOU. The Air Force Center for Environmental Excellence (AFCEE) together with the United States Environmental Protection Agency (U.S. EPA) have drafted technical protocols on remediation of fuel and chlorinated solvents in the subsurface (Wiedemeier, 1995; Wiedemeier, 1996). The protocol for natural attenuation of chlorinated solvents (the “protocol”) was used to develop the approach at Travis AFB since it is the most applicable to the NEWIOU groundwater sites. This protocol will be adopted for use at Travis AFB for implementation of the natural attenuation/monitoring alternative. For mixed plumes, i.e., sites with both chlorinated and non-chlorinated volatile organic compounds (VOCs), such as SD034, both protocols will be used. For such sites, the presence of petroleum contaminants of concern (COCs) can facilitate the degradation of chlorinated solvents. The Travis AFB Petroleum-Only Contaminated Sites (POCOS) workplan will also be relevant for studying natural attenuation at sites with petroleum contamination.

The protocol defines natural attenuation as follows: “The term “natural attenuation” refers to naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media.”

The Groundwater Interim Record of Decision (IROD) also expands the above definition to include the following statement: “In addition, natural attenuation/monitoring will be protective of human health and the ecosystem.”

Natural attenuation, while including all of the above factors, often has biodegradation as a primary mechanism for reducing contaminant concentrations. While there is often chemical composition data concerning dissolved contaminant plumes, additional groundwater samples are often required to determine the potential for natural attenuation to remediate contamination within an acceptable time frame.

The majority of the dissolved phase contamination at the nine sites consists of dissolved chlorinated solvents and their associated breakdown products such as 1,2-dichloroethene (1,2-DCE), and vinyl chloride. In general, chlorinated solvents are less biodegradable than fuel hydrocarbons since they are essentially man-made chemicals which are often toxic to microorganisms in the subsurface. Chlorinated aliphatic hydrocarbons can be biodegraded through three primary pathways, which are:

- Electron acceptor reactions (reductive dechlorination);
- Electron donor reactions; and
- Cometabolism.

The goals of monitoring the groundwater for natural attenuation are to determine the affect of natural attenuation on contaminant concentrations and secondarily to identify pathways that are available for biodegradation of dissolved contaminants. Insufficient amounts of substrate, variable dissolved oxygen concentrations, or the abundance of other compounds like iron can influence the extent and degree of biodegradation of the dissolved contamination. These factors can vary between each site, so each site needs to be evaluated separately. Natural attenuation must be monitored in order to determine whether the risks associated with the dissolved hydrocarbon contamination are being contained or reduced to acceptable levels.

Section 2 of the protocol presents a specific protocol for implementing natural attenuation, which will be followed at Travis AFB. This section lays out the following nine key steps to this protocol:

1. Review available site data and develop preliminary conceptual model. Determine if receptor pathways have already been completed. Respond as appropriate.

2. Apply the screening process described in Section 2.2 of the protocol to assess the potential for natural attenuation. (Figure B-1 shows generalized locations of wells for screening.)

3. If natural attenuation is selected as potentially appropriate, perform site characterization to support natural attenuation.

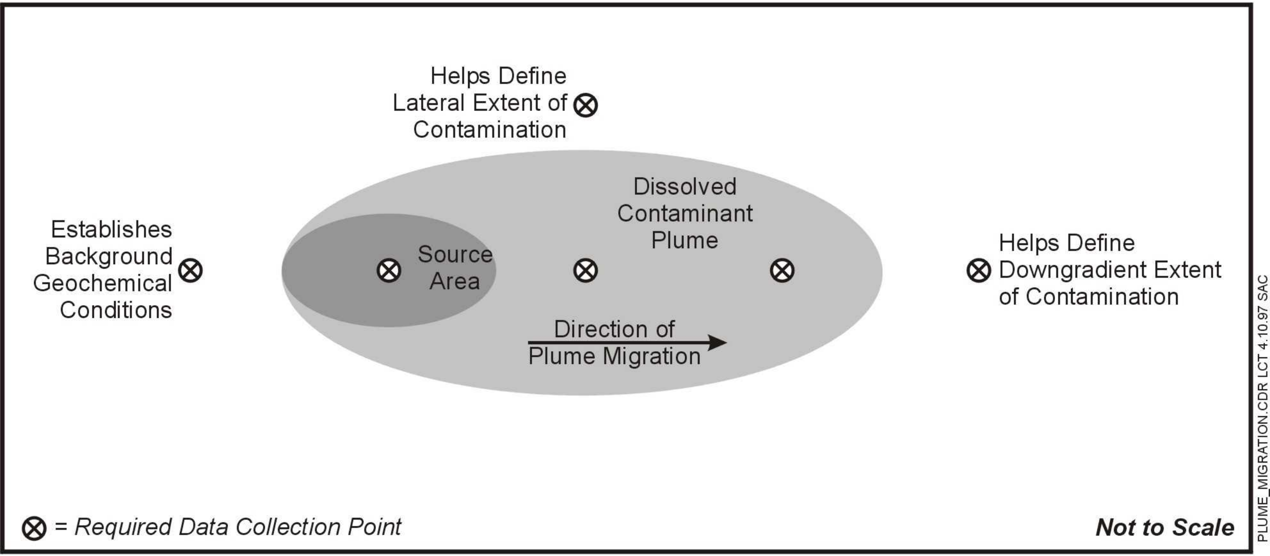
4. Refine conceptual model based on site characterization data, complete pre-modeling calculations, and document indicators of natural attenuation.

5. Simulate natural attenuation using analytical or numerical solute fate and transport models that allow incorporation of a biodegradation term, as necessary.

6. Identify potential receptors and exposure points and conduct an exposure pathways analysis.

7. Critically and realistically evaluate practicability and potential efficiency of supplemental source control. Compare the benefits of source removal to the practicability and potential efficiency of source removal.

Figure B-1. General Locations for During Screening Phase



(Adapted from Wiedermeirer, et al, 1996)

8. Prepare long-term monitoring and verification plan for the selected alternative - natural attenuation alone or in concert with supplemental remediation systems.

9. Present findings to regulatory agencies and negotiate for the selected alternative.

These steps are described in more detail in the protocol. For the Travis AFB NEWIOU groundwater sites, some of these steps have already been completed during the Remedial Investigation/Feasibility Study (RI/FS) process.

Information will be collected during the interim period to determine if natural attenuation will work at a site. The following situations would support the viability of natural attenuation at a site:

- The hydrogeology and the contamination transport and fate issues of the site are well understood;
- Contamination sources have been identified and have been, or will be, appropriately remediated;
- The natural attenuation processes at work at the site have been characterized and determined to be capable of achieving the required cleanup levels or objectives in a feasible time frame;
- Historical data indicating a consistent decline in contaminant concentrations over time, and a retreating or stable plume;
- Hydrogeologic or chemical data that can indirectly demonstrate the type(s) of natural attenuation processes active at the site, and the rates at which those processes are reducing contamination levels. For example, indicator compounds such as oxygen, nitrate, sulfate iron (II), methane and contaminant daughter products are often used to estimate the potential for contaminants to be attenuated through biodegradation.

Use of monitored natural attenuation offers several potential advantages, such as the potential to lower overall remediation costs, particularly at large sites. However, natural attenuation also has potential disadvantages. The main one is that cleanup time is sometimes significantly longer than active remediation and responsibility must be assumed for long term monitoring and associated costs. In addition, site characterization may be more complex and costly.

Some compounds are more prone to naturally attenuate than others. For instance, many of the regulated components of fuel hydrocarbons (e.g., benzene, toluene, ethylbenzene and xylene [BTEX]) often biodegrade to non-toxic compounds in the subsurface under a variety of environmental conditions. Other compounds, such as certain chlorinated volatile organics (e.g., trichloroethylene) are less prone to biodegrade than BTEX, but may do so in certain conditions. Other factors to consider are whether natural attenuation will result in the creation of daughter products whose toxicity is greater than the parent, or whether contaminants will be transferred to other media. Where conditions are favorable, natural attenuation may reduce contaminant mass or concentration quickly enough to safely incorporate it as part of the overall site remedy.

At Travis AFB there is a potential for all contaminated groundwater to migrate along sewer lines and other preferential pathways. Alternative 3 (extraction) will be implemented at some sites to control migration of contaminated groundwater along preferential pathways. At other sites where the remedy selection is deferred until the final ROD, precautions will be taken to ensure that preferential migration does not occur at these sites.

The Air Force will develop a Natural Attenuation Assessment Plan (NAAP) which establishes a method to implement Alternative 2 during the five-year interim period. The schedule for submitting a NAAP Work Plan will be included in the Groundwater NEWIOU RD/RA Work Plan. The NAAP will describe the Air Force's approach for assessing natural attenuation at LF006, the deferred sites, deferred portions of plumes, and will incorporate information from the AFCEE Pilot Study at SD036. The NAAP will be based on the EPA/AFCEE document "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater" (Wiedemeier, et al, 1996). The NAAP will include a Natural

Attenuation Decision Matrix which provides a methodology to assess the effectiveness of natural attenuation. The Natural Attenuation Decision Matrix will include methods to:

- Determine which portions of plumes are appropriate for Alternative 2 and/or 3;
- Identify where additional characterization is needed;
- Identify wells for groundwater monitoring and analytical parameters;
- Develop methods to determine migration rate of plume;
- Determine “trigger action” to implement contingency action;
- Predict timeframe for site cleanup;
- Identify modeling needs;
- Incorporate results from SD036 Pilot Study into NAAP; and
- Update NAAP as needed.

Recommendations for Groundwater Monitoring

Monitoring will follow the guidelines in the protocol and will consist of locating groundwater monitoring wells and developing a groundwater sampling and analysis strategy. This plan will be used to monitor plume conditions over time and to verify that natural attenuation is occurring at rates sufficient to stabilize the plume. The long-term monitoring plan will be developed based on site characterization data and the results of solute fate and transport modeling.

The long-term monitoring plan will include two types of monitoring wells. Long-term monitoring wells are intended to determine if the plume is stable. Point-of-compliance (or point-of-action) wells are intended to detect movements of the plume outside the negotiated perimeter of containment, and to trigger an action to manage potential expansion.

Compliance wells are used to determine if a violation (non-compliance) has occurred, as measured by a significant exceedance of water quality objectives (MCLs) or a detection at some concentration in a well that was previously uncontaminated. Compliance wells may be located outside of the plume and/or at the water quality objective isopleth. The contaminant plume is managed to prevent a significant increase in contamination at these wells.

Trigger wells (point-of-action wells) should be located upgradient of compliance wells within the plume, and data from these wells should be used to predict the likelihood that the plume will migrate to the compliance well within a given timeframe. Management actions should be taken to insure that a violation does not occur.

The final number and placement of long-term monitoring and point-of-compliance/action wells should be based on the behavior of the plume as revealed during the initial site characterization and on regulatory considerations. The results of a solute fate and transport model may be used to help site the long-term monitoring and point-of-compliance wells. In order to provide a valid monitoring system, all monitoring wells will be screened in the same hydrogeologic unit as the contaminant plume. This generally requires detailed stratigraphic correlation. To facilitate accurate stratigraphic correlation, detailed visual descriptions of all subsurface materials encountered during borehole drilling or cone penetrometer testing will be prepared prior to monitoring well installation.

A groundwater sampling and analysis plan will be prepared in conjunction with point-of-compliance and long-term monitoring well placement. For long-term monitoring wells, groundwater analyses will likely include VOC constituents of concern, dissolved oxygen, nitrate, iron (II), sulfate, and methane. For point-of-compliance wells, groundwater analyses will be limited to VOC constituents of concern. Except at sites with very low hydraulic conductivity and gradients, quarterly sampling of long-term monitoring wells is likely to be recommended during the first year to confirm plume stability and to determine baseline data. Based on the results of the first year’s sampling, the sampling frequency may be reduced to annual sampling. The sampling will be coordinated with Travis AFB Groundwater Sampling and Analysis Program (GSAP) and annual results published as an element of the GSAP Annual Report.

B.2 Monitoring of Extraction, Treatment, and Discharge Sites

Alternative 3 (Extraction, Treatment, and Discharge) is the selected interim alternative for groundwater at 12 IRP sites. The extraction strategy includes remediation of off-base contamination, source control, and migration control. The objectives of these interim actions are:

- **Off-base Remediation** – Reduce the off-base groundwater concentrations to Interim Remediation Goals (IRGs) for each of the compounds.
- **Source Control –** Remove floating petroleum product and secondary sources of VOC contamination (dense nonaqueous phase liquids [DNAPLs]).
- **Migration Control –** Prevent migration of contaminated groundwater during the period of the IROD.

During the design task, all sites will be evaluated in regards to the selected remedies that were identified for each site. The task will specify the location of each monitoring well included and will identify the location and design of any additional monitoring wells that will be needed. The existing groundwater monitoring wells should be evaluated for suitability, and additional wells should be installed if needed. Historical groundwater sampling results will be used to help minimize duplicate analyses that have already been performed. All groundwater sites will be reviewed for natural attenuation.

The Air Force will also develop a strategy for evaluating migration into and out of storm drains. The objective is to evaluate the effectiveness of actions taken to address groundwater/surface water interactions. Any monitoring will be coordinated with the Travis AFB Stormwater Program.

The monitoring wells (location and screen interval) and the analyses (methods and frequency) needed to collect the data to support the evaluation of the extraction system will be defined in the detailed design for each site. The data will then be reported and evaluated annually as part of the GSAP Annual Report prior to the formal five-year period to assess if the objectives of the interim actions are being met.