COMMONLY ASKED QUESTIONS REGARDING THE USE OF NATURAL ATTENUATION FOR CHLORINATED SOLVENT SPILLS AT FEDERAL FACILITIES

This brochure was developed through a partnership among the U.S. EPA, Air Force, Army, Navy, and Coast Guard.

Do federal, state, and local regulations allow natural attenuation as an option for remediation of chlorinated solvents?

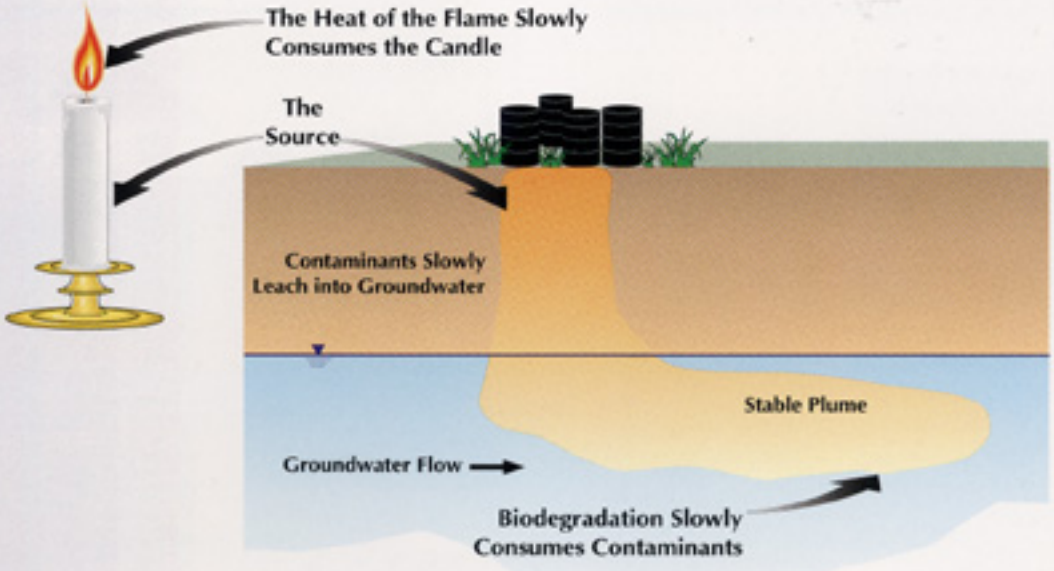
Natural attenuation is recognized by the EPA as a viable method of remediation for soil and groundwater that can be evaluated and compared to other methods of achieving site remediation as a part of the remedy selection process. The selection of natural attenuation as a component of any site remedy should be based on its ability to achieve remediation goals in a reasonable timeframe and protect human health and the environment. EPA recognition of natural attenuation extends to sites regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); and underground storage tank (UST) regulations. Natural attenuation is not a default option or a "presumptive remedy." As with any remedy, it must comply with state groundwater use classifications and standards.

"Under certain site conditions, and if properly documented, natural attenuation can be a viable option for remediating sites as a stand-alone option or in conjunction with other engineered remediation." Jim Woolford, Director, EPA's Federal Facilities Restoration and Reuse Office

What is natural attenuation?

When chlorinated solvents such as trichloroethene (TCE) or perchloroethene (PCE) are spilled or leak into the soil or groundwater, several natural processes can occur to destroy or alter these chemicals. These processes, known collectively as natural attenuation, include adsorption to soil particles, biodegradation of contaminants, and dilution and dispersion in groundwater. Many contaminants are prevented from migrating off the site because they are adsorbed to soil particles. Although biodegradation does not occur at all chlorinated solvent sites, it can be an important process in destroying these contaminants. Dilution and dispersion do not destroy contaminants, but can significantly reduce their potential risk at many sites.

"Intrinsic" and "passive" remediation are other terms which have been used to describe the combined effect of these processes. Dr. John Wilson of the EPA compares natural attenuation in groundwater to the flame of a candle. The source of the flame is the wax of the candle just as the source of the groundwater contamination is the concentrated solvents trapped in the soil. The flame appears steady because the wax is destroyed in the flame as fast as it is removed from the candle. In the same way, many groundwater plumes will reach "steady state" at some distance from the source, when biological reactions are able to destroy contaminants as they enter the groundwater from the soil. Eventually, the candle is consumed by the flame just as the contaminants in the soil and groundwater can be attenuated through biodegradation and other natural processes.



How is natural attenuation different from the "do nothing" approach?

Natural attenuation is sometimes mislabeled as the "do nothing" or "walk away" approach to site cleanup. The truth is that natural attenuation is a proactive approach that focuses on the verification and monitoring of natural remediation processes rather than relying totally on "engineered" processes.

Before natural attenuation can be proposed for any site, significant soil and groundwater data must be collected and evaluated to document that natural attenuation is occurring and to estimate the effectiveness of natural processes in reducing contaminant concentrations over time. If natural attenuation is selected as the preferred site remedy, the party responsible for site cleanup must commit to long-term monitoring to verify that the contaminants pose no risk to human health or the environment and that natural processes are reducing contaminant levels and risk as predicted. Land use and groundwater use are generally controlled on these sites to prevent human exposure to contaminants.

How does natural attenuation of chlorinated solvents differ from natural attenuation of petroleum products such as fuels?

Because chlorinated solvents are synthetic chemicals, they tend to be more resistant to natural biodegradation processes. However, significant evidence now exists that biochemical reactions can also break down chlorinated compounds in the soil and groundwater. These processes are harder to predict and are effective at a smaller percentage of sites compared to petroleum-contaminated sites. Despite these limitations, significant progress has been made in understanding the fate and transport of chlorinated solvents and the role of natural attenuation.

Chlorinated solvents also migrate differently than petroleum hydrocarbons. Because chlorinated compounds have a greater density than water, they tend to sink rapidly into the aquifer. When large quantities of solvent are released, they will sink until they encounter an impermeable layer where they form small pools which serve as a long-term source of groundwater contamination. These untreated sources dissolve slowly over time, contaminating large volumes of water.

How can you tell if natural attenuation may work at a site?

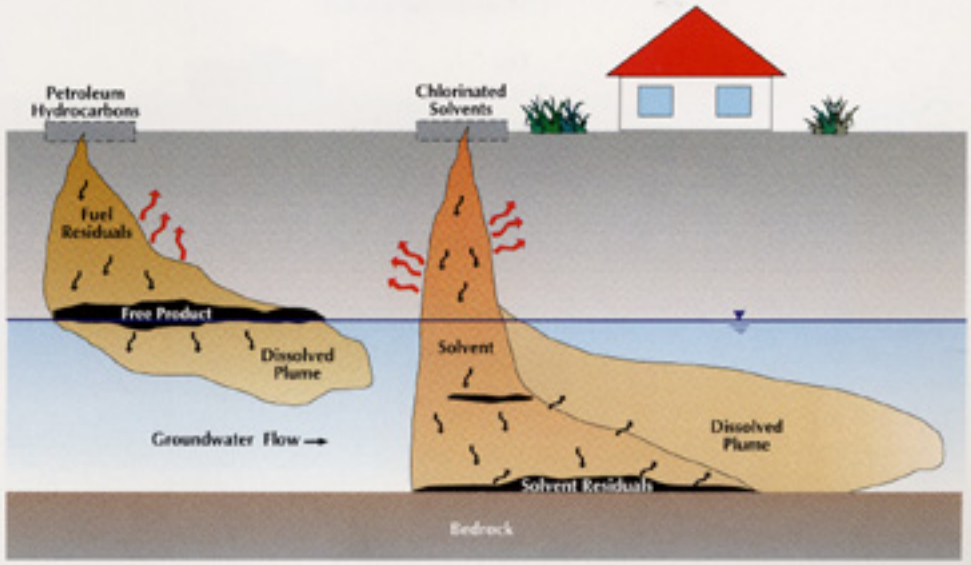
Experts in the science of natural attenuation have identified several good indicators or lines of evidence that can be used to prove that natural processes are reducing contaminant concentrations. The following lines of evidence are useful in documenting the natural attenuation of chlorinated solvents:

- Historical trends indicating a decrease in contaminant concentrations, as well as a stable or retreating plume. A stable or retreating plume generally indicates that contaminants are being destroyed as fast as they are dissolved into the groundwater.

- Favorable geochemical conditions. Biological reactions will change the chemical composition of the groundwater. One condition which is particularly favorable for chlorinated solvent destruction occurs in groundwater that has been completely depleted of oxygen and nitrate. Depleted levels of sulfate and elevated levels of dissolved methane are also favorable conditions.

- Breakdown or "daughter" products. Chlorinated solvents are often destroyed by biochemical reactions which remove one chlorine atom at a time from the "parent" or original solvent. When these breakdown products are detected in the groundwater, it provides evidence that contaminant destruction is underway. It is important for biodegradation to be complete, because some breakdown products may be more toxic than parent compounds.

- Laboratory "microcosm" studies. These studies can be used to simulate aquifer conditions and to demonstrate that native bacteria can create the necessary biochemical reactions to destroy contaminants of concern. This technique is sometimes required for chlorinated solvent sites because the biochemical reactions are more complex and more difficult to predict than reactions on petroleum-contaminated sites.



The Air Force Center for Environmental Excellence is developing a comprehensive natural attenuation protocol (Draft Technical Protocol for Natural Attenuation of Chlorinated Solvents in Groundwater) for chlorinated solvent sites. This document describes how this evidence can be collected during site investigation activities and how it can be interpreted to estimate the contribution of natural attenuation in the remediation process.

Will natural attenuation be effective on all chlorinated sites?

Definitely not. Some chlorinated solvent contamination has impacted large quantities of groundwater which will be required for some beneficial use. There are risks associated with the continued migration of these plumes into public drinking water supplies and some form of engineered remediation is needed at these sites. On sites where no current risk to public health or the environment exists, natural attenuation can play an important role in reducing future risk if institutional controls (e.g., deed restrictions and zoning ordinances) can be implemented. Scientists are beginning to observe certain site profiles where natural attenuation has a higher probability of being integrated into the remediation process. These include:

- Sites where chlorinated solvents are spilled with other petroleum compounds (the best biochemical reactions for degradation are produced).
- Sites where the soil contains high levels of natural organic matter, such as swampy areas or former marshlands.
- Sites where shallow (unused) groundwater is separated from deeper groundwater by a thick, low-permeability clay layer.
- Sites where there is little or no source remaining due to active remediation.

Why are chlorinated solvent spills so common at federal facilities?

Chlorinated solvents were developed as superior cleaning solutions for removing grease and carbon buildup from metal parts. For over 40 years they were widely used by U.S. industry and the federal government for a variety of equipment cleaning tasks.

Prior to environmental laws restricting their use, these compounds were often stored in drums or underground storage tanks and disposed of in the sanitary sewer, in evaporation ponds, or mixed with fuels and burned. These solvents have created significant groundwater contamination at many federal facilities. Since 1976, when RCRA was established, the use and disposal of these solvents have been carefully regulated and many chlorinated solvents have been replaced with less harmful substitutes.

Can natural attenuation achieve site cleanup goals?

Natural attenuation may be effective in achieving cleanup goals at some sites, particularly when these goals are based on site-specific risk reduction. For example, if contaminant migration is limited to shallow groundwater, and groundwater use can be controlled, natural attenuation may eventually achieve cleanup goals on some sites. However, natural attenuation is more likely to play a role in cleaning up a portion of a chlorinated site. Natural attenuation is more likely to clean up areas that have lower levels of contamination. Such areas are normally found outside of highly contaminated source areas, or at sites with relatively small source areas.

What are some of the potential advantages and limitations of natural attenuation?

Potential Advantages

- Less generation or transfer of wastes.
- Less intrusive and disruptive than engineered methods.
- Can be combined with active remedial measures or used to remediate a portion of the site.
- Remediation costs may be lower than with active remediation.

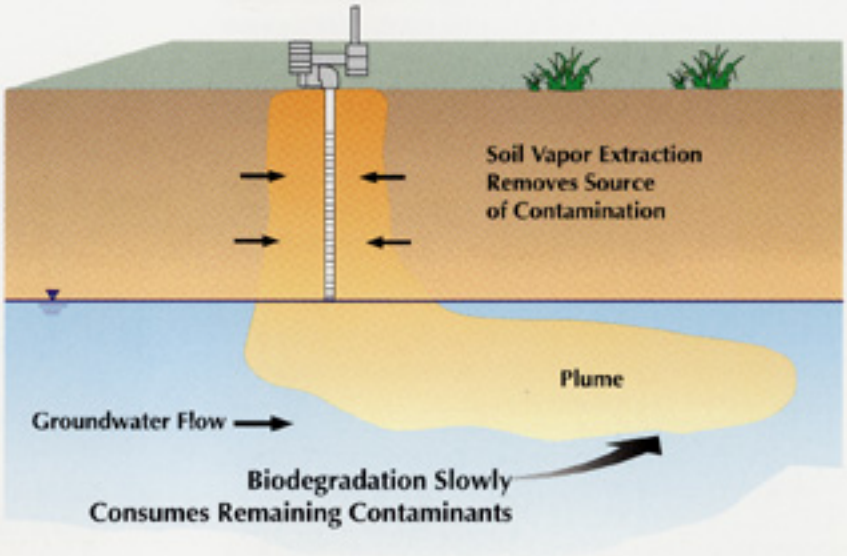
Potential Limitations

- May require more time to achieve cleanup goals and requires a commitment to long-term monitoring. On some sites, long-term monitoring costs can be excessive.
- If natural attenuation rates are too slow, the plume could continue to migrate.
- Incomplete biodegradation can create new, more toxic contaminants.
- Land and groundwater use controls are often required.

Can natural attenuation processes be enhanced to speed up the cleanup process?

Natural attenuation may be successfully combined with other remediation techniques to achieve cleanup goals within a reasonble time frame. Engineered approaches that may be used in conjunction with natural attenuation include hydraulic containment, soil vapor extraction, source removal, and pump-and-treat methods. In addition, non-toxic organic compounds may be added to enhance the breakdown of contaminants.

Again, the candle provides a useful illustration of how active and natural remediation can be combined. If the top of the candle (the source) is cut off and removed, the flame (plume) will exist for only a fraction of the original time. Soil vapor extraction, free product recovery, soil excavation, and groundwater extraction in the source area are all methods of reducing or containing the source of solvent contamination. The rate at which the candle burns can also be increased by improving the conditions for combustion. As mentioned previously, many chlorinated solvents actually degrade faster in the absence of oxygen under anaerobic conditions. Researchers are now developing methods of adding highly biodegradable organic compounds to increase the natural bacteria population in the groundwater which will consume available oxygen and create these favorable conditions. Regardless of whether an engineered remediation or natural attenuation is used, controls on groundwater use will be required on most chlorinated solvent sites.



What if natural attenuation does not work at a site?

As with any remedy, if monitoring results indicate inadequate progress, it will be necessary to reevaluate the remedial action plan. If this occurs, the remediation project manager would consider implementing an engineered approach for all or part of the plume.

This brochure was developed through a partnership among the U.S. EPA, Air Force, Army, Navy, and Coast Guard. If you would like additional information about natural attenuation and its application at federal facilities, you may fax your request to the National Center for Environmental Publications and Information at (513) 489-8695 or contact the following agency home pages on the Internet:

EPA - http://www.epa.gov
Air Force - http://www.afcee.brooks.af.mil
Army - http://aec-www.apgea.army.mil:8080
Navy - http://www.nfesc.navy.mil
Coast Guard - http://www.dot.gov/dotinfo/uscg