In Situ Stabilization Protects Groundwater at the 009 Site

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Based on the results of recent studies it appears in situ stabilization can work to protect groundwater from toxic waste at the 009 Superfund Landfill. The 009 dumpsite is a source of toxic contamination for residents along Spur 25 in Brunswick, GA.

In 1992 the EPA proposed in situ stabilization to control future toxaphene toxicity at the site. In situ stabilization uses underground mixing of concrete and buried waste to prevent further spread of toxins. In situ stabilization is an experimental approach for treating pesticides. Accordingly, in 1993 the EPA required laboratory and field studies to determine if in situ will work at this site.

The results of these studies show that in situ can be used at the 009 site. Although not all of the studies provide clear results there was enough information to conclude that the site will show greater long-term stability with in situ treatment, and is less likely to impact ground water in future years.

Background

The Hercules 009 Landfill was created out of a roadbed borrow pit in the mid 1970's using pesticide sludge from manufacturing operations. Located in Glynn County along the Golden Isles Parkway the site is also bordered by an elementary school, a neighborhood, and several businesses. The site was closed in 1980 after toxaphene waste was found in nearby streams. Later studies found very widespread contamination throughout the adjacent neighborhood and schoolgrounds. The full extent of contamination in the schoolgrounds and along the highway remains unknown at this time. Local residents and businesses are now on public water supplies as a precaution against groundwater contamination.

Toxaphene is a carcinogenic pesticide banned in the United States. Toxaphene is linked to organ (kidney and liver) damage and causes mutation and cancer under laboratory conditions.

The site became a Superfund in the mid 1980's and the Environmental Protection Agency (EPA) is the lead agency overseeing the cleanup. The 1993 Record of Decision (ROD) specifies both primary and alternate cleanup methods. The Responsible Party-- Hercules Incorporated-- tested an experimental procedure called in situ ("in place") stabilization. In situ is experimental at this site since until recently the technique was not used for pesticides. If in situ fails then the company must dig up the soil to extract the toxaphene.

Tests Mandated by the Record of Decision

The EPA has seven goals to meet for every cleanup: overall protection; legal compliance; effectiveness; cost; reduction of toxicity, mobility or volume; and community acceptance.

During the Feasibility Study for the 009 Site several alternative technologies were examined and two methodologies were specified: in situ stabilization and chemical extraction. Chemical extraction provides the best overall protection since the site will have no long-term toxaphene concern. Extraction has wider community acceptance for the same reason. The EPA chose in situ stabilization as a primary alternative and required on-site studies to determine if cleanup goals are met. If waste is not isolated from ground water flow by underground cement mixing then chemical extraction is required for the site.

The EPA established scientific criteria for the site studies. Three broad goals must be met using a combination of laboratory and field studies: determine cements for the highest degree of immobilization; confirm performance under worse-case environmental conditions; and evaluate long-term permanence for ground water protection. Specifically, the stabilization must achieve a minimum compressive strength of 50 psi (pounds-per-square-inch); a permeability of less than 1 X 10-6 cm/sec after stabilization; a 90 percent reduction in toxaphene mobility; and a treated leachate concentration of less than 0.2 ppm.

Minimum compressive strength: This is the ability of the ground to support objects and to resist erosion. Both laboratory and field studies show that cement formulations meet this criteria.

Permeability of less than 10-6 cm/sec: Permeability is the ability of water to flow through a material. To ensure long-term stability it is important to reduce ground water flowing into the toxaphene sludge. Toxic waste dumps need a water tight lining to prevent water flow from entering into the waste disposal area. At the 009 Site studies have failed to establish the presence of a liner or other permanent barrier to the entry of flowing water. The in situ stabilization process is intended to limit water flow into the buried waste. The studies show that underground mixing of concrete is homogenous enough to form a monolith when concentrated cement formulations are used. The resulting monolith reduces the flow of water through the sludge layers, thus meeting this criteria.

A 90 percent reduction in toxaphene mobility, and a treated leachate concentration of less than 0.2 ppm: These factors are important only if water is allowed to interact with site sludge.

Unfortunately, this data is ambiguous due to problems in analyzing toxaphene in treated water. From the information provided it is not readily apparent that these criteria are met. However, the permeability data of in situ stabilized sludge shows that water would not enter the monolith in amounts that would cause leaching concerns.

Studies on Treatability

Over the last three years studies required by the EPA were performed as mandated in the Record of Decision. These studies are a comprehensive test of ability of cement to prevent the interaction of toxaphene and groundwater. To test the cement three kinds of studies were done:

Laboratory "Benchtop" tests, site soil characterization, and an on site trial of in situ using the cement and equipment that would be used to remedy the site .

Laboratory studies These studies focused on choosing a cement formulation for use in the field demonstration. Site soils were taken to a laboratory and mixed using several different cement formulations. Some of the formulations used different ratios of cement to soil, ranging from 15% mixtures up to 50% (equal amounts). Some trials used different kinds of cements or chemical binders to trap toxaphene. All of the resulting hardened mixtures were tested under simulated environmental conditions for strength, stability, and reduced water migration. Finally, the solidified cement/soil mixtures were broken up and the toxaphene extracted. The purpose was to find ratios of cement and soil that were strong, hardened rapidly, and would limit the flow of groundwater. The higher cement/soil ratios (around 30%) were the strongest, solidified the fastest, and reduced water flow to the highest degree. However, all of the cement formulations worked well. Studies showed that there was no real advantage when using an organic binder.

One problem was prevalent throughout these studies. The cement formulations leached a material that interfered with Gas Chromatography (GC) analysis of toxaphene. These studies use the Toxicity Characteristic Leaching Procedure (TCLP) to determine the degree to which toxaphene leaches from the cement. Hercules' contract lab worked to prevent this problem, but in the end

there is no firm data on immobilization of toxaphene using the TCLP protocols. However, in all fairness the TCLP data is less critical in this case than the water permeability data.

Water permeability findings show that water will not easily flow through the solidified waste. Leaching is proportional to flow, so reducing permeability also reduces leaching. Therefore, the TCLP data problem is not very important in making a decision on proceeding with in situ.

Characterization of Soil

As reported in previous TAR newsletters (Volume 4, Number 2, August 1995) studies conducted at the site revealed deeper toxaphene contamination than previously thought, and numerous buried objects. The site was tested using metal detectors and the presence of metallic debris mapped. Several pits were dug into the landfill and the presence of concrete and other construction debris noted. Also, "grab" samples were taken into the site at various depths to characterize the waste profile. These studies suggested that in situ stabilization needed to be deeper than called for in the Feasibility Study. Further, the numerous buried objects raised concern that the site could not be mixed well enough to thoroughly trap the waste.

On site in situ field trial

The on site in situ trial was designed to test concrete formulations that showed promise during the Benchtop studies. Also, the process tested methods of immobilization to ensure that site soils could be treated without interference from buried objects. The trial was conducted at the 009 Landfill to depths of 20-25 feet underground. This depth is sufficient to ensure that the main mass of toxaphene will be treated. The studies show that the concrete mixture may need to be more concentrated at the north end of the site to compensate for the differences in soil type. Some of the material was removed and tested after solidifying underground. These tests, demonstrating both strength and low ground water permeability, indicate a successful experiment. At one time a collar used to guide the underground mixing augers broke during operations. This may have occurred from encountering underground debris. After repairs the stabilization continued without further problems. It does not appear that buried objects significantly interfered with the technology as carried out at this site.

Ground Water Model

The Final Treatability study produced by Hercules includes an elaborate ground water computer simulation. This study is not required by the EPA and is not necessary for determining the effectiveness of cement to decrease water/site soil interactions. The Glynn Environmental Coalition contracted Disposal Safety Incorporated to review this model with respect to the cleanup objectives for 009. A full copy of this report (Groundwater Transport Modeling in Hercules' Treatability Study; March 30, 1996) is available from the Coalition. The discussion is summarized here.

Ground Water Transport Modeling

Memo to the GEC from Disposal Safety Inc.

This memo has been prepared solely for the guidance of the Glynn Environmental Coalition in interpreting information available to it. Other users should satisfy themselves independently as to the facts and conclusions contained herein. In particular, such users should refer to the original sources of information rather than to this memo. This memo is not intended for use in any real estate or other transaction, and should not be used or relied upon for such purposes.

Section 4 of the Treatability Study examines the potential for toxaphene to migrate from the site via the ground water. However, EPA's ROD does not require ground water transport modeling, which has limited relevance to the issue of treatability, so why has Hercules expended a significant amount of effort to modeling and included it in the treatability study?

The likely answer is contained in the study's Executive Summary, which states that the purpose of ground water modeling is to:

... evaluate the appropriateness of in situ technology performance criteria specified in the ROD, and the effectiveness of in situ stabilization in providing ground water quality relative to other remedial options.

It thus appears that a major purpose of this section is to support Hercules' arguments against the remedy and performance criteria specified in the ROD. Although the transport model has little bearing on the effectiveness of in situ treatment, which makes most of the content of this section extraneous and irrelevant to the Treatability Study, this work is worth summarizing because potential toxaphene migration via the ground water is so important.

Hercules' consultant uses mathematical modeling to predict the potential for the ground water to transport toxaphene from the site via two mechanisms: transport via sorption to migrating colloid-sized particles and dissolved-phase transport.

Colloid transport: As the ground water travels through the aquifers, particles suspended in the water are often filtered out by the soil. However, there are cases where very tiny soil particles (called colloids) can travel through the aquifer along with the water without being filtered out. Whether this occurs or not is mostly controlled by sizes of soil grains that make up the aquifer and the size of the colloids suspended in the ground water. Since toxaphene is known to sorb (or adhere) to soil grains, Hercules' considered the possibility that toxaphene might be carried through the aquifer as colloids. The Treatabilty Study used a published mathematical rule of thumb, based on soil and aquifer grain sizes, to evaluate this possibility. Based on the measured sizes of the grains making up the toxaphene sludge, the landfill dirt, and the surrounding aquifer Hercules consultant concluded that colloid transport will not occur.

Dissolved Transport: To predict the rate and extent to which toxaphene dissolved in the ground water might migrate away from the landfill, Hercules' consultant used a computer model called AT123D. This model, first published in 1981, incorporates fundamental properties of the aquifer, the contaminant, surface soils, and the climate to predict toxaphene migration over time. To simulate conditions at the 009 Landfill site, Hercules' consultant had to specify the required input values in to the model. Some of these values were based on properties measured at the landfill, others were assumed based on the values published in the scientific literature.

Hercules' consultant used the AT123D model to predict the degree of toxaphene migration 100 years in to the future under three scenarios:

A continuation of current conditions (no further remedial actions), In Situ treatment of the sludge and soil, and Capping the soil with a multi-layer cap that is impervious to water.

In all cases, the AT123D model predicts little or no transport in ground water and toxaphene concentrations that are less than drinking water standards at the property boundary.

Evaluation: The modeling approach appears to be generally sound; however, there are some questionable input parameters which cast doubt on the validity of the exact predicted transport distances. For example, Hercules' consultant assumes a toxaphene solubility in water of 0.55 mg/L and a Koc of 210,000 ml/g (Koc is a measure of a chemicals tendency to sorb to organic carbon, which can be related to its tendency to migrate in dissolved form through aquifer). These values are somewhat different from other published sources. For example, the Groundwater Chemicals Desk Reference (Montgomery and Welkom, 1990) lists a Koc value that is 140 times smaller than that used by Hercules' consultant (the lower the value, the more readily a chemical can move). Also, the Reference lists a range of published water solubilities (0.4, 0.74, 1.75, 3 and 3 mg/L) that yield an average value of 1.78 mg/L. This value is nearly three times higher than that used by Hercules consultant (the higher the value, the greater the solubility of toxaphene in ground water). As shown in the sensitivity study (Appendix Q), the AT123D model is most sensitive to these two parameters.

Despite these problems, the fundamental conclusion that toxaphene migrates very slowly in the dissolved form is likely to be correct. This conclusion, however, is neither new nor surprising, since in 1992 Hercules had already stated in the Remedial Investigation report (page 4-15) that the chemical characteristics of toxaphene indicate that it will be largely immobile in soils and groundwater. The transport modeling merely restates this same finding in a more quantitative way. Furthermore, past and present ground-water monitoring has not shown compelling evidence of a toxaphene plume.

Despite Hercules' argument to the contrary the recent transport modeling results do not appear to be significant enough to compel a reconsideration of the soil/sludge treatment remedy chosen by the EPA. As shown by the 1993 Record of Decision, in which the EPA repeatedly cites the lack of a toxaphene plume in support for no immediate action on groundwater remediation, EPA has already factored into its remedy selection the low expectation for toxaphene transport by ground water.

Furthermore, data collected in the Treatability Study support EPA's cautious approach to remediation. As shown in Figures E-1 through E-3 of Appendix E, soil samples collected from different depths show numerous instances in which clear toxaphene "hits" were recorded as much 14 feet into the undisturbed native soil. This is as much as 20 feet below the observed toxaphene sludge layer. Although it is possible that these "hits" were caused by the coring equipment dragging down contamination from above (which would indicate sloppy technique), it could also indicate that toxaphene does exhibit slightly more than the expected mobility in the aquifer. ---Steven Amter,

Senior Hydrologist, Disposal Safety

Discussion

Will in situ make the landfill safe?

Probably, yes. The main concern with toxaphene is mutagenicity and carcinogenicity. However, toxaphene is a mixture of many different chemicals and the actual cancer and mutation causing chemicals are not known. The model for movement of toxaphene chemicals in the environment is based on testing a few of the chemicals and it is not known if the cancer-causing chemicals move at the same speed, or slower or faster. The safest long-term remedy is the soil extraction option.

Considering how little is known about toxaphene and the ambiguity in many of the site studies the community is justified in asking for the soil extraction remedy.

In situ stabilization will decrease water flow in the dumpsite soil and greatly decrease any potential future movement of the toxaphene chemicals. The dumpsite will be safer with in situ stabilization than without it.

Are there any options besides in situ stabilization and extraction?

No. The EPA considered several capping options during the feasibility study and Hercules has proposed reopening the ROD to reconsider capping. Placing a cap over the landfill only prevents occurrence of any more erosion spills such as those that occurred in the early 1980's. Capping does not reduce ground water flow throughout the dump. Complete removal is the appropriate treatment for carcinogenic compounds in contact with groundwater.

The EPA has asserted in situ as a compromise between the communities desire for full removal and Hercules' preference of inexpensive treatment.

Conclusions

The 009 landfill is in the heart of Brunswick's expanding commercial and residential areas. Nearly 20,000 tons of pesticide residue with a long environmental fate is buried in an unlined pit in contact with the shallow ground water. This waste will remain toxic for centuries. Local residents impacted by the pollution and a majority of the community preferred that the toxaphene waste be removed. Removal costs are quite high due to the problems of moving a toxic waste dump in such an urbanized area. Since it is well known that toxaphene dissolves poorly in water the Environmental Protection Agency promoted in situ stabilization as a remedy for this site. In theory, the underground mixing of concrete and contaminated soil would form a relatively water tight mass that protects the aquifer for generations and produces no fugitive toxins that might trouble neighbors. The community agreed to abide by the findings of a scientific study to determine if toxaphene contaminated soils would form a water resistant monolith using in situ stabilization.

The results of this study do indicate that in situ is a practical treatment for this waste. Unfortunately, Hercules has used the Treatment Study to advance a plan that would leave buried waste untreated. It is unclear at this time if treatment will actually begin, or if more studies and models will be attempted.

The Environmental Protection Agency is urged to ignore challenges to the Record of Decision and complete this cleanup in a timely manner.

Written by R. Kevin Pegg, Ph.D.; edited by Dr. Mary S. Saunders. Copies of the report are available from the GEC, at the Glynn County library, or at **www.enviro-isues.net** on the Internet.

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