ANATOMY OF A LANDFILL AND REMEDIATION LESSONS LEARNED

D. P. Schofield,
Sandia National Laboratories, New Mexico

M. N. Creech, M. M. Mitchell,
GRAM, Inc.

J. Studer, P.E.,
InfraSUR, LLC

ABSTRACT

The Chemical Waste Landfill (CWL), a 1.9 acre landfill, was in operation at Sandia National Laboratories in Albuquerque, New Mexico (SNL/NM), between 1962 through 1985. The primary operation conducted at the CWL was the disposal of laboratory chemicals and solid waste. In the later years, 1981 through 1988, the CWL was used as an above ground drum storage area. The CWL underwent closure as an interim status landfill under the Resource Conservation and Recovery Act (RCRA), as implemented by the New Mexico Environment Department (NMED). The closure process for the CWL was initiated in 1988, although groundwater monitoring began in 1985. This paper discusses the expedited approach to closure used at the CWL, including lessons learned throughout the process.

INTRODUCTION

In 1990, trichloroethene (TCE) was detected above the regulatory limit in the groundwater at the CWL. Further investigation indicated that a soil gas plume of volatile organic compounds (VOCs) below the CWL was the source of elevated levels of TCE in the groundwater. An expedited approach was taken to reduce the environmental impact of the CWL, which included a Vapor Extraction (VE) Voluntary Corrective Measure (VCM) and a Landfill Excavation (LE) VCM.

The VE VCM was initiated to prevent further impacts to groundwater quality. It was determined that VE would accomplish this by partially removing the VOC plume and by allowing SNL/NM to gain control of the VOC plume. The LE VCM was initiated to remove the source of the plume. The success of the VE and LE VCMs was intrinsically linked, and is supported by ongoing soil gas and groundwater monitoring at the CWL. During the VCMs a great deal was learned about the CWL and the process of cleaning it up to risk-based standards. This paper will present the anatomy of the CWL and discuss challenges and solutions of the expedited closure approach. A primary focus of this discussion will be the lessons learned relative to operational procedures, waste management, and the regulatory process that were critical to the VCMs success.

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy under contract DE-AC04-94AL85000.

VAPOR EXTRACTION

The detection of TCE in groundwater at upward trending concentrations ranging up to 31 micrograms per liter (ug/l) prompted SNL/NM to initiate, with regulatory approval, a VCM program consisting of a VE remediation followed by a LE. Pilot testing in support of the VE VCM and technology development programs was conducted in 1995 and 1996 and including installation of a variety of vadose zone monitoring and remediation wells. Multi-purpose remediation wells to be used for vapor extraction, air injection, and soil gas monitoring were installed in the fall and winter of 1996 into early 1997. Start-up of the VE VCM occurred during the period early May through July 1997 and active extraction and air injection operations (including a continuous three month “rebound” observation period) ceased in July 1998 to make way for the LE VCM. Figure 1 displays a pilot test location. Approximately six months after the system was first started up, groundwater sampling and analysis demonstrated that no maximum contaminant levels (MCLs) were exceeded at any monitoring wells that were sampled. Although the VE VCM was originally designed to run for two years, the decision was made to halt process after only one year. This decision was based on dramatic decrease in vapor being removed from the system and the necessity to begin the LE VCM process.

Starting in July 1998 and continuing through the landfill excavation, ten (10) of the VE VCM wells were operated in passive vapor extraction mode. These wells had been fitted with Baro-Balls™ that act like low-pressure check valves for allowing soil gas flow out of the well but prohibiting atmospheric air entry to the vadose zone. Passive vapor extraction continues as of December 2004 and will continue beyond regulatory closure of the site, during the post-closure care period.

The active stage of the VE VCM involved injection of heated atmospheric air near the center of the landfill and immediately over the water table and extraction of VOC-laden soil gas above and around these injection points, at depth intervals corresponding to the Shallow Zone (SZ), Upper Intermediate Zone (UIZ), and Deep Zone (DZ). The act of heated air injection created pressurized zones within the vadose zone and the act of soil gas extraction created zones under vacuum. Soil gas flows from zones of high pressure to zones of low pressure. Thus, systematic gas movement throughout the vast majority of the soil gas plume was induced. Removal of TCE was enhanced via injection of dry, warm to hot air over the water table. The in-situ distribution of VOCs was disrupted by bulk soil gas flow and stripping-induced volatilization and removal. This intentional disruption was sustained for a total of approximately nine (9) months (after subtracting a three month period of no operations during which monitoring for VOC rebound effects occurred).

The active vapor extraction operations resulted in the extraction of approximately 400,000,000 cubic feet (cf) of soil gas from the vadose zone beneath and immediately adjacent to the former CWL. This represents a pore volume exchange of eight (8). Concurrent with the extraction operations, a total of 44,000,000 cf of atmospheric air was injected at two wells positioned within the landfill boundary and screened over the water table (approximately 485 feet (ft) below ground surface (bgs) at the time). The combined effect of air injection over the water table and the removal of large quantities of soil gas from the SZ and UIZ resulted in a strong upward directed bulk flow of soil gas through the vadose zone. The movement of VOCs, wherever present in the vadose zone, was predominantly upward and away from the water table.

Fig. 1. Pilot Testing of Active Vapor Extraction Operation in 1995/96

The mass of VOCs (TCE) extracted during active operations was 6500 lbs and including prior pilot testing efforts and passive VE VCM operations, an estimated total of 7000 lbs VOCs (TCE) was removed from the vadose zone. Passive venting has resulted in a finite but undetermined amount of VOC mass removal. An undetermined amount of VOC (TCE) mass was also removed as part of the LE VCM. At the completion of the LE VCM, 52,000 cubic yards (cy) of waste materials and soil/sediment had been excavated, including 241,650 cubic feet (ft^3) or 8,590 cubic yards (cy) of soil that required treatment for organic contamination. From early 1999 through February 2004 a significant portion of the CWL former disposal area was open to the atmosphere and additional volatilization of VOCs occurred. Based on the operational process, estimates of VOC and TCE mass removed by the LE VCM were not attempted.

Shortly after active vapor extraction and air injection was initiated groundwater TCE concentrations began to decline, and within six months of operations (by January 1998) TCE was no longer detected above the MCL at groundwater monitoring wells. Only one time since the VE VCM was completed has TCE been detected above the MCL at a CWL monitoring well. This detection occurred after 4 years passed, in June 2003 at MW2A, which has since been plugged and abandoned with the New Mexico Environment Department's (NMED) approval due to well damage and lack of water. Based upon an evaluation of all available data, it appears this one detection was anomalous (related to poor well integrity or "short circuiting") and does not reflect actual groundwater conditions.

LANDFILL EXCAVATION

In September of 1998, the LE VCM was initiated. The overall scope of the LE VCM was to completely excavate areas of the landfill where disposal had occurred. Excavation was planned in a sequential, area-by-area manner based upon a comprehensive review of existing information and investigation data. In each defined disposal area within the CWL, the excavation was to proceed to a depth sufficient to remove all landfill contents and associated contaminated soil, up to a maximum depth of 20 feet bgs. The main objective of the LE VCM was to remove the source for the VOC vapor plume, as well as other potential contamination sources, to mitigate the risk associated with the contamination, and to prepare the site for closure.

For context, it is important to understand that the LE VCM was initiated with a substantial degree of uncertainty. The most significant factor was the lack of detailed disposal records. Disposal records for the first 13 years of the 23-year disposal history were unavailable, incomplete, inaccurate, and/or contained vague waste descriptions resulting in unknown waste types and volumes. In addition, direct investigation methods to characterize the landfill contents, such as drilling and sampling, were very limited due to the dangerous nature of some of the buried waste (gas cylinders, potential unexploded ordnance [UXO], etc.).

For these reasons, the LE VCM excavation, waste management, and worker health and safety approaches evolved and changed significantly as more accurate information was gained through direct experience. The many challenges associated with excavation of the CWL were met by applying a philosophy of continuous process improvement based upon actual experience and feedback from the site workers and project staff. Figure 2 displays two changes to excavation operations made as result of field technician input. Originally, screening was accomplished using first a truck screen and then a table screen. Based on input by the field team, a mechanical screen and a conveyor system were brought in. The mechanical screen increased the efficiency of the screening process, resulting in an increased rate of excavation. The conveyor system reduced the necessity for field technicians to lift heavy items during debris segregation. The key to documenting and executing new approaches during the project (i.e., implementing the changes in a timely manner) was the close working relationship established among the staff at the DOE, the SNL/NM ER Project, and the NMED. Without this team approach and the active support of the NMED, expeditious implementation of key changes would not have been possible.

In addition to process/procedural changes, another major change was the implementation of the risk-based approach, developed in early 2000. The risk-based approach changed cleanup goals from background concentrations to risk-based criteria, consistent with the NMED-approved approach for other SNL/NM ER Project sites. Risk-based criteria were also developed to allow excavated soil to be returned to the excavation as backfill (“replaceable soil”), based upon soil sample analytical results.

Fig. 2. Process Improvements to Excavation Operations

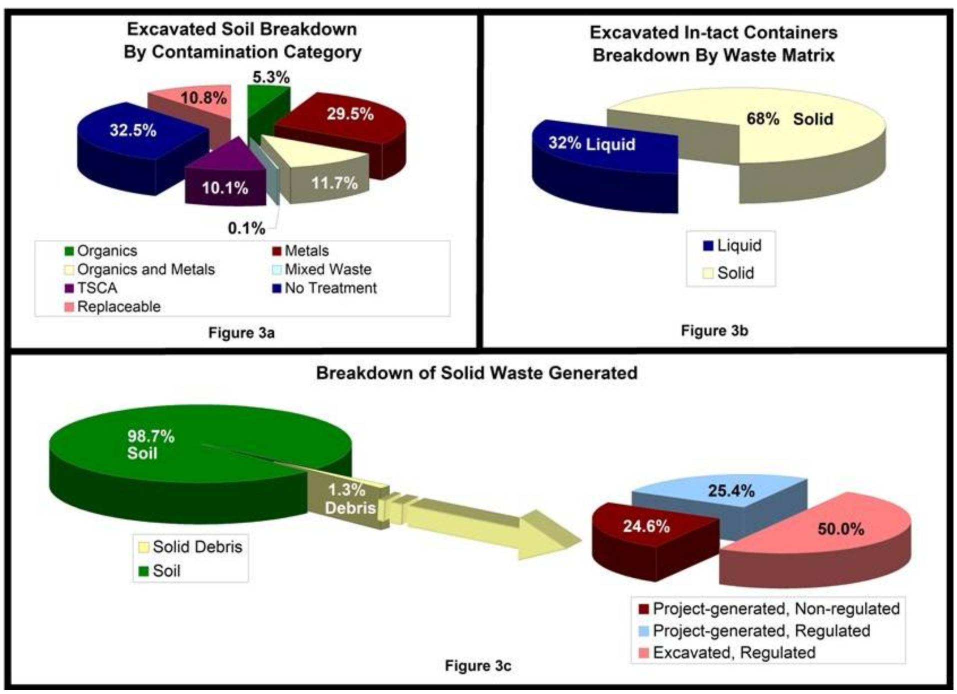

Fig. 3. Breakdown of Materials Generated During the LE VCM

Approximately 1,404,000 ft^3 (52,000 cy) of contaminated soil and debris was removed from the CWL. Excavation took place from September 1998 until February 2002, with the exception of one area where a portion of the sidewall was removed in January 2003 due to concentrations of benzidine above risk levels. Figure 3 displays the breakdown of materials removed from the landfill, as well as materials generated during the project. Soil excavated from the CWL constituted approximately 98.7% of the solid waste generated from the LE VCM. Prior to the risk-based approach, each 1,350-2,700 ft^3 (50-100 cy) of soil was characterized and sent to the CAMU. Once at the CAMU, the piles were place in a bulk staging area according to the treatment category associated with a given pile. Once the piles went into the bulk staging area, they were mixed together and the entire data set for each pile per treatment category was used to represent the soil in the staging area. Once the risk-based approach was in use, the data for each 2,700 ft^3 (100 cy) of soil was sent through a preliminary risk assessment, prior to staging the pile with other soil. As shown in Figure 3a, 32.5% of the excavated soil did not require treatment. This percentage is based on the soil that was transferred to the CAMU and was placed into a much larger pile. The majority of this soil was generated prior to the use of the risk-based approach. A risk assessment was performed on the data for the soil that did not require treatment, however, it did not pass risk criteria. It can be assumed that if the risk based approach had been initiated earlier in the project, a larger percentage of the soil that did not require treatment would have passed risk and would have been categorized as replaceable soil. Replaceable soil, or soil that passed risk assessment and could be used as backfill material, constituted 10.8% of the soil excavated from the CWL. This is not to say that this was an error in the process because space to stage soil at the CWL was a limiting factor to operational efficiency of the LE VCM. The use of the CAMU for storage and disposal provided far more benefit to the success of the project than having additional backfill material would have provided.

Treatment for organic contamination only was required for approximately 5.3% of the soil. Treatment for metal contamination only was required for about 29.5% of the soil. Approximately 11.7% of the excavated soil required treatment for both organic and metal contamination. An estimated 10.1% of the soil was managed as polychlorinated biphenyls (PCBs) contaminated waste, which is regulated by the Environmental Protection Agency (EPA) under the Toxic Substance Control Act (TSCA). This soil could not be treated under SNL/NM's permit but was placed into the CAMU cell without treatment under a risk-based disposal granted by the NMED. Finally, 0.1% of the excavated soil was characterized as mixed waste and disposed of at an off-site facility.

Approximately 2,000 intact chemical containers were successfully removed from the landfill. As shown in Figure 3b, 68% of the chemicals removed were solid and 32% of the chemicals were liquid. The size of containers exhumed ranged from tiny vials to 55-gallon drums. However, very few containers larger than 2 liters were excavated. Many solids were found in plastic bags. The majority of the liquids exhumed were acids, bases, and oxidizers. Solid chemicals exhumed ranged from powders and salts to resinous clumps.

Solid debris, excavated and project-generated, constituted approximately 1.3% of the bulk waste generated during the LE VCM. Early in planning process for the VCMs, DOE and Sandia decided that the contents of the landfill would be listed waste based on the disposal records. Therefore, any item excavated from the landfill that was not fully containerized was automatically treated as hazardous waste under RCRA. Along with the excavated materials, certain items used within the work area were also categorized as project-generated listed waste. These items were disposed of as hazardous, TSCA regulated, mixed waste, or a combination of the three categories. Items that could be released through decontamination or were used in processes for which it was know that the items did not come in contact with the landfill soil were categorized as project-generated non-regulated (not listed hazardous) waste. It is estimated that of the solid debris generated through the LE VCM, 50% was excavated, and therefore regulated. Project-generated solid debris was divided into regulated, which was about 25.4%, and non-regulated, which was about 24.6%. Although the solid debris is only 1.3% of the bulk waste generated during the LE VCM, it is interesting to note that project-generated solid debris was equal to excavated solid debris.

REGULATORY PROCESS

By taking the path of an expedited VCM approach, the typical regulatory process was altered. The CWL Closure Plan contained provisions for corrective action and included a requirement for a Corrective Measures Study (CMS). Prior to preparing a CMS and proposing final remedies, DOE and Sandia applied the presumptive remedy philosophy by forging ahead to voluntarily reduce the soil gas plume and remove the source. Although the VCM approach required a modification to the Closure Plan, which required approval by NMED, the VCMs were not considered approved final remedies. Therefore, taking the expedited approach brought a certain amount of risk to the process. Each change in the operational strategy required NMED approval. During the LE VCM alone, four Interim Change Notice (ICN) requests for the Sampling and Analysis Plan (SAP) and two ICN requests for the Waste Management Plan (WMP) were submitted and approved. Because of the dynamic nature of the VCM approach, communication between Sandia, DOE, and NMED was paramount to success. The approval received during the VCMs were more on the line of approvals to proceed, not necessarily approvals indicating that the process would be accepted as a final remedy. To ensure that the two VCMs produced site conditions that are protective of human health and the environment, DOE and Sandia documented the VCM results in the CMS Report submitted to the NMED in December 2004. This report develops and recommends several final corrective action components including an alternative RCRA final cover designed for semi-arid conditions. Approval of the CWL CMS is expected in early 2005.

CONCLUSION

Looking back, many things can be learned from the VCMs performed at the CWL. This approach requires a dynamic, process-improving philosophy. Keeping in mind that what appears to work in a planning document, may not work in reality is key. Part of maintaining a dynamic process is keeping a strong line of communication between the entire team. As stated earlier, many of the safety concerns identified during the LE VCM were addressed through suggestions and ideas presented by the workers out in the field. Feedback from the entire team is essential to success.

Another key part of maintaining a dynamic process of this nature is communication with the regulators. There is a level of programmatic risk involved in expediting clean-up. The main risk being that an enormous amount of work can be done without having a final remedy approved. The risk can be alleviated to some extent by continually providing information and obtaining feedback from the regulators. In dealing with a great deal of uncertainty, as was the case with the LE VCM, it is imperative that a working relationship be maintained with the regulatory agency.

The combination of the VE VCM and LE VCM resulted in the elimination of the original source of VOCs and significant reductions in the total mass and average concentration representative of the entire soil gas plume. The soil gas plume was pushed upward and concentrations in the soil gas, pore water, and sediment phases significantly reduced. The remaining total VOC mass associated with the soil gas, pore water, and sediment within the soil gas plume in July 1999 was estimated to be 2900 pounds. A recent estimate of remaining mass in the soil gas plume based upon the September 2004 monitoring data (over five years later) is 400 lbs. The change in the soil gas plume due to the VCMs has dramatically decreased the risk of contamination reaching groundwater. The two VCMs together provided a degree of success that may not have been realized with just using one or the other approaches.