Free-Product Recovery and Site Remediation

Using Horizontal Trenching, Soil Vapor Treatment and Groundwater Extraction

Case Study

by Eric P. Sanderson, David B. Twedell, H. Stanton Johnston, Jr., and Maureen Farrell

Overview

Sites with soil and groundwater impacted by petroleum hydrocarbons have been remediated using a variety of traditional techniques. However, when the site impacted lies within a very confined downtown area of an expanding metropolitan city, a more complex array of technologies must be considered. The Law Enforcement Center (LEC) site is the worst known underground storage tank (UST) released to date in the city of Charlotte, N.C. A cost-effective free-product recovery, soil vapor and groundwater extraction system is being piloted using new horizontal trenching technologies and state-of-the art equipment.

On-site low permeability soil required that an alternative to standard recovery wells be developed for groundwater recovery and vapor extraction. Operation and maintenance of the large number of recovery wells required would have been extremely costly over the expected lifetime of the project. Although horizontal trenching was the best solution to the operation and maintenance cost, many problems were encountered during installation.

The system installed consists of a series of seven interconnected horizontal trenches varying from 18 to 23 feet in depth. These horizontal trenches were installed using new technology developed by Horizontal Wells, a division of Horizontal Dewatering Systems. The trenches installed through approximately 8 feet of free-product were placed around the perimeter of the site, and spaced evenly throughout the site to ensure total capture of the product and dissolved contaminant plumes.

Site History

The LEC underground storage tank site is located within the downtown area of Charlotte, N.C. This site was used by the city of Charlotte police department as a fueling facility from approximately 1975 to 1990. Two 10,000-gallon USTs resided at this facility within an approximate annual throughput of 750,000 gallons. In the spring of 1990, the tanks were identified as leaking and were removed. During the removal operation, approximately 4,500 gallons of gasoline filled the excavation. The examination of the USTs following removal indicated the presence of many holes approximately 3/4- to 1-inch diameter in both tanks. Also, the fittings of the associated piping exhibited gross corrosion and were leaking.

Initial borings and monitoring-well installations conducted in June 1990 indicated a substantial amount of free-floating petroleum product on the groundwater table, together with an associated amount of soil vapor contamination. Subsequent to this discovery, remedial action in the form of free-product recovery and a site characterization/assessment were initiated.

Site Specific Geology and Hydrogeology

The site is located in the Charlotte Belt of the Piedmont physiographic province of North Carolina (Meinzer, 1923; Brown, et al., 1985). This region is characterized by an igneous intrusive bedrock of the Precambrian and Paleozoic age underlain with a layer of soil and weathered rock, ranging in thickness from 0 to 150 feet (Aller, et al., 1987; LeGrand, 1967).

The groundwater source for this area is the unconfined soil and crystalline rock aquifer system, with the larger porosity soil and weathered rock regolith acting as an undergrown reservoir and the fractured bedrock acting as an interconnected system of pipelines transmitting water to springs, streams or wells. Well yields in the Charlotte area ranged from 9 to 50 gallons per minute (gpm) (LeGrand and Mundorff, 1952; Aller, et al., 1987.).

Site specific borings indicate red-brown to tan and orange-tan silty sand with weathered rock fragment extending a depth of 12 to 25 feet below land surface (bls). A clay soil lense was evident in the surficial sediments in the northern portion of the site. A light grey to medium grey granitic type igneous rock was encountered on the average from 25 feet bls to a depth of 188 feet bls. Water bearing fractures were evident in the rock at depth of 30, 50, 85 and 185 feet. The surface of the rock encountered was highly weathered.

Site specific permeability data for the unconsolidated soils ranged from a low of 0.022 feet per day to a high of 81 feet per day.

Contamination Assessment

Twenty-two shallow monitoring wells ranging in depth from 17.5 to 37.5 feet were installed on-site between June 1990 and February 1992. The shallow wells were installed in stages, until the horizontal extent of free-product and dissolved petroleum constituents in the groundwater were delineated. In addition, three deep-monitoring wells of 53 feet, 87 feet and 188 feet were installed, to delineate the vertical extent of dissolved petroleum constituents in groundwater.

In coordination with monitoring-well installations, a series of soil borings were also initiated, to further delineate the extent of soil contamination in key areas on-site. As a result of the soil and groundwater assessment, the extent of free-product, soil and groundwater contamination was delineated for the site.

As a result of the installation of groundwater monitoring wells on-site, a detailed map indicating the direction of groundwater flow was developed. The water table elevations on-site ranged from 10.5 bls to 22 bls, and the general direction of groundwater flow was estimated to be toward the south.

Corrective Action Plan

In addressing the petroleum hydrocarbon contamination found in the soil and groundwater at the site, the low permeability soils and fractured bedrock made it difficult to apply common vertical recovery well theory and methodology. As a result, horizontal trenches were determined to be the most effective and feasible alternative.

A three-phase Corrective Action Plan (CAP) was proposed for the remediation of the site. Phase one consists of free-product recovery, soil vapor recovery, and containment of the down gradient side of the dissolved plume. Phase two includes recovery of the contaminated groundwater in the shallow aquifer. Phase three involves recovery of the deeper groundwater contamination.

Free-product recovered during phase one of the CAP is pumped through a 25-gallon-per minute (gpm) oil/water separator where the product and groundwater are separated by specific gravity. The free-product is temporarily stored on-site for eventual recycling and the groundwater sent to the groundwater treatment system. A vacuum pump is used to recover the contaminated soil vapor as well as aid in the recovery of free-product through vaporization.

The recovered soil vapor is treated with a 500-cubic feet per minute (cfm) Baker Furnace, Inc. thermal oxidizer before venting to the atmosphere. Once a majority of the free-product has been removed from the ground, the groundwater can continue to be recovered with a minimum amount of product smearing onto the native soils.

Both QED SOLO Model SP4000A pneumatic and Grundfos Model 5-E electric submersible groundwater recovery pumps are used in phase two of the CAP to recover the contaminated groundwater in the shallow aquifer. Total fluids are pumped from two of the trenches to the oil/water separator and the separated groundwater is then pumped through the groundwater treatment system. Groundwater from the remaining five trenches is pumped directly through the treatment system because no free-product has been detected in the areas of influence of these trenches. Once contaminant concentrations are significantly reduced, phase three of the remediation is initiated. During phase three, one deep vertical recovery well is used to recover contaminated groundwater in the deep aquifer. This well is placed in an area where it intersects the maximum number of known fractures to ensure capture of the deeper plume.

A low profile air stripper was chosen as the primary remediation technique for the contaminated groundwater treatment. Shallow tray strippers are more compact in design than common air stripping towers, thus offering a less obtrusive presence at the site. The 3/16-inch aeration holes on each tray are designed to minimize fouling due to iron or bacteria. This feature is essential at this site due to the high iron concentration. The treated groundwater is discharged to the sanitary sewer system on-site; however, due to stringent permitting conditions, a NPDES discharge permit for surface disposal is presently being sought as an alternative.

CAP Implementation

Implementation brought several challenges. The first challenge was adequately and effectively communicating the project scope for all bidders by requesting bids in a format that was necessary for comparison. The project scope also had to allow for flexibility on the part of the respective bidders for system installation and field changes. To assist in this effort, a typical Construction Specification Institute formatted project manual was used.

The second challenge surfaced in weighing financial savings/costs against less traditional, potentially safer installation methods. This proved to be a rather simple solution as safety (both to workers and the general public) and public perception were deemed of greater importance over more traditional approaches.

The third challenge was not identified until construction had begun. The trenching machine's inability to effectively operate in the partially weathered rock zone, and in several cases, even in the dense silty sands at the site was further complicated by the high variability in depth to the competent