NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

SVE/SP PILOT STUDY REPORT

WORK ASSIGNMENT C007540-4.1

FORMER KLINK COSMO CLEANERS SITE
GREENPOINT/EAST WILLIAMSBURG
INDUSTRIAL AREA

SITE NO. 224130
KINGS (C) NY

Prepared for:
NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
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Remedial Bureau B

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SOIL VAPOR EXTRACTION / AIR SPARGE PILOT STUDY REPORT

FOR THE

FORMER KLINK COSMO CLEANERS SITE

EAST WILLIAMSBURG INDUSTRIAL AREA

SITE ID NO. 224130

BROOKLYN, KINGS COUNTY, NEW YORK

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NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
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1.0 INTRODUCTION

URS conducted a soil vapor extraction / air sparge (SVE/SP) pilot study at the former Klink Cosmo Cleaners Site (Site No. 224121) in Brooklyn, New York, between November 16th and 19th, 2015. This report summarizes the results of the pilot study, and assesses the effectiveness of SVE/SP as a viable remedial alternative for treating subsurface contaminants.

1.1 Objectives

The objectives of the SVE Pilot Study were to:

- Demonstrate mass reduction of tetrachloroethene (PCE) and trichloroethene (TCE) and estimate PCE and TCE mass removal rates via semi-quantitative and quantitative means.

- Develop SVE design parameter values including radius of influence (ROI), intrinsic permeability (k_i), locations and depths of extraction wells, system and extraction flow rates, and vacuum pressures.

The objectives of the SP Pilot Study were to:

- Develop SP design parameter values, locations and depths of sparge wells, including air injection flow rates and pressures.

2.0 PILOT PROGRAM

The pilot study was conducted between November 16th through 19th, 2015, along the south side of Richardson Street near the intersection of Vandervoort Avenue. Step and constant rate tests were performed at various vacuum pressures to determine its impact on the formation. The pilot study generally followed the procedures provided in the New York State Department of Environmental Protection (NYSDEC) approved SVE/SP Pilot Study Work Plan, dated September 2015 (included in Attachment A as a compact disk). Deviations to the approved plan are presented in Sections 3.1 and 3.2.

As part of the pilot study, two SVE wells (4-inch diameter), three SP wells (2-inch diameter), and four pairs of soil vacuum observation wells (OWs, 1-inch diameter) were constructed. The locations of the pilot study wells are shown on Figure 1. Boring logs and well construction diagrams for these wells are provided in Attachment A.

A trailer mounted SVE/SP treatment system (Unit 75), rented from ProAct Services Corporation of Southbury, Connecticut and was used for the pilot study. Components of the SVE/SP treatment system included:

- SVE – a 15 horsepower (HP) rotary claw blower, capable of 300 actual cubic feet per minute (acfm) with a maximum vacuum of 23 inches of mercury (Hg)
- SVE vacuum manifold equipped with vacuum and flow indicators, throttling valves, hoses and cam-lock connectors
- SP – a 15 HP rotary claw blower, capable of 125 standard cubic feet per minute (scfm) at 22 pounds per square inch (psi)
- SP manifold equipped with pressure and flow indicators, throttling valves, hoses and cam-lock connectors

A vapor-phase carbon adsorption system, installed outside near the treatment unit, was used to treat collected soil vapors prior to discharge to the atmosphere. The vapor phase system consisted of two parallel trains of two 200 pound (lb) 55-gallon drums constructed in series, with sampling points. Evoqua Water Technologies of Elizabeth, New Jersey provided the vapor phase carbon drums.

The treatment unit required a three-phase 230V, 200A electrical service. This was provided by a commercial 75 kilowatt (kW) trailer-mounted diesel generator rented from a local vendor. A plan view of the treatment system, equipment specifications, piping and instrumentation diagrams (P&IDs) for the SVE and SP systems are included in Attachment A.

2.1 SVE Scope of Work

A series of fifteen 30-minute stepped-vacuum tests were to be performed at various pressures followed by a 2-hour constant-vacuum test at the maximum achievable vacuum pressure. The stepped-vacuum testing was to be performed on well SVE-1 first, SVE-2 second, and finally, SVE-1 and SVE-2 simultaneously, until the maximum obtainable vacuum pressure was achieved (design maximum vacuum was 23 inches Hg).

The constant-rate test was to be performed on wells SVE-1 and SVE-2 simultaneously, at the maximum achievable vacuum pressure.

Soil vapor samples were to be collected in summa canisters before carbon treatment at the beginning and end of each stepped and constant flow rate test for laboratory analysis to quantitatively determine contaminant removal.

The planned sequence for conducting the SVE pilot study is detailed in the SVE/SP Pilot Study Work Plan. Because of system operating issues and time constraints not all sequences were performed.

2.2 SP Scope of Work

The SP pilot study was to be conducted following the SVE pilot study. A series of twenty-six 30-minute stepped-flow rate tests were to be performed at various air flow rates followed by a 2-hour constant-rate test at a single flow rate. Air was to be introduced through SP wells while SVE-1 and SVE-2 were both operating simultaneously at their maximum achievable vacuums.

Air sparge was to be initially applied in one SP well at a time. SP-1 was to be applied first, followed by SP-2, and then SP-3. Air sparge was then to be applied to two wells at a time. Wells SP-1 and SP-2 were to be applied first, followed by SP-1 and SP-3, and then SP-2 and SP-3. Finally, air sparge was to be introduced through wells SP-1, SP-2, and SP-3 simultaneously.

Constant-flow rate air sparge testing was to be performed through SP wells SP-1, SP-2, and SP-3 simultaneously while wells SVE-1 and SVE-2 were simultaneously operating at their maximum achievable vacuum pressures.

The planned sequence for conducting the SP pilot study is detailed in the SVE/SP Pilot Study Work Plan. Because of health/safety concerns for employees working in the adjacent building, time constraints, system operating issues, and unknown radius of influence created by the SVE system, not all sequences were performed.

3.0 PILOT STUDY

URS mobilized to the site on Monday, November 16th, 2015. The treatment unit was set up on the south side of Richardson Street between monitoring wells DEC-031 and DEC-044D. An initial start-up and shortened SVE step test was conducted at SVE-2 beginning at 1720 hours to see how the unit performed. Following set up, step tests were performed by incrementally raising the vacuum pressure by opening the valve at the vacuum manifold. Data collected during the pilot study that was used in the calculations is presented in Attachment B – SVE/SP Pilot Study Calculations.

3.1 SVE Pilot Study Procedures

Field data collected during the pilot study is presented in Table 1 – Pilot Study Field Data Summary. A total of five SVE step tests (Tests 1, 2, 3, 9, and 10) were performed. Test 1 was conducted at SVE-1 between 1930 and 2210 on November 16th. The initial test, performed on SVE-2 at 1720 on November 16th, appears as Test 2 in Table 1.2 - Pilot Study Field Data Summary. Test 3, performed on SVE-2 on November 16th was conducted between 2225 and 0044 (November 17). Tests 9 and 10, conducted on November 19th, were performed on SVE-1 and SVE-2, respectively.

During these tests, vacuum pressures were increased four times by throttling the valve inside the treatment system's vacuum manifold. Vacuum pressure measured inside the treatment unit at the vacuum extraction manifold that induced a vacuum at the SVE wells ranged between 2 inches Hg to 7.5 inches Hg (the maximum achievable vacuum) depending on the SVE well location and combined operation. The maximum vacuum pressure observed at the vacuum extraction manifold was well under the rated maximum value (23 inches Hg) of the SVE blower; possibly due to leaking hoses, piping, manifold connections and/or constraints attributed to the stratigraphy of the formation.

During the SVE tests, four rounds of data were collected at 10 to 12 minute intervals. Vacuum pressures were monitored and recorded inside the treatment unit at the vacuum extraction manifold, extraction wells (SVE-1 & SVE-2), observation wells (OW-1, OW-1D, OW-

2, OW-2D, OW-3, OW-3D, OW-4, & OW-4D), and monitoring wells (DEC-31, DEC-44, & DEC-141).

The volume of air extracted (standard cubic feet per minute – scfm) was also recorded during each monitoring interval. A planned step test with SVE-1 and SVE-2 was not performed as the throttling valve used to bring the vacuum pressure up incrementally could not be adjusted in small enough increments to balance the system and accurately record vacuum pressures; even while manipulating the make-up air.

Constant rate tests (Tests 7 and 11) were performed with SVE-1 and SVE-2 under full vacuum. Data were collected at approximately10-minute intervals only during Test 11. No incremental gauge readings were collected during Test 7 a purge run prior to initiating SP. Gauge readings were only collected at the beginning and end of Test 7 for use in the mass removal estimate.

While conducting the constant rate test on November 18, 2015, vacuum pressures at SVE-1 ranged from 2.5 to 3 inches Hg and from 0.5 to 2 inches Hg in SVE-2. During the constant rate test performed on November 19, 2015, the vacuum pressures in SVE-1 ranged from 1.25 to 1.5 inches Hg and from 2.5 to 2.75 inches Hg in SVE-2.

Summa canisters were collected near the beginning and end of each test, shipped to Pace Analytical Services, Inc. of Melville, NY, and analyzed for volatile organic compounds (VOCs) following USEPA Method TO-15.

Analytical data collected during the pilot study are presented in Table 2 – Soil Vapor Extraction Pilot Test Analytical Data. Semi-quantitative measurements of VOCs in the extracted soil gas were also made periodically with a photoionization detector (PID) and flame ionization detector (FID). PID/FID readings are provided on Table 1 – Pilot Study Field Data Summary.

3.2 SP Pilot Study Procedures

Three air sparge step-tests (Tests 4, 5 and 6) were performed on November 17th. Step tests were performed with SP-2 (Test 4) and SP-3 (Test 5) online separately and then SP-2 and SP-3 together (Test 6). At the time of the SP study, the capture zone (radius of influence) provided by operating SVE-1 and SVE-2 at their maximum capacity was unknown. As such, SP-1 was not brought online due to its proximity to the source area (northeast corner of the warehouse building) and health/safety concerns regarding potential fugitive PCE and TCE vapors entering the adjacent warehouse building affecting workers.

During the step tests, the air flow rates (scfm) were to be increased incrementally by 25 scfm every 30 minutes by opening the valve inside the treatment system's air supply manifold until the maximum flow rate produced by the compressor (125 scfm at 22 psi) was achieved. Four rounds of data were to be collected at each interval. As such, flow rates were to range between 25 and 125 scfm during each interval for each of the step tests. However, the air sparge compressor could not be adjusted to achieve the planned sequences.

The step test with SP-2 and SP-3 (Test 4 and Test 5) operating separately was not performed as the throttling valve used to increase the air flow could not be adjusted in small enough increments to balance the system and accurately record flow rate; even while manipulating the make-up air. As such, Tests 4 and 5 were conducted using approximately the same air flow rate.

The step test using both SP-2 and SP-3 (Test 6) was somewhat successful as the air flow rate was able to be raised evenly in increments of 5 to 10 scfm. However, pressure readings in the SP wells did not provide sufficient data for use in the calculations. It is unlikely that steady-state conditions were achieved during the pilot study.

The constant rate test was performed on November 18th with SP-2 and SP-3 (Test 8) operating together. Data was collected at approximately 10 minute intervals.

Summa canisters were collected near the beginning and end of each test, shipped to Pace Analytical Services, Inc. of Melville, NY, and analyzed for volatile organic compounds (VOCs) following USEPA Method TO-15.

Semi-quantitative measurements of VOCs in the extracted soil gas were also made periodically with a PID and FID. PID/FID readings are provided on Table 1.

4.0 CALCULATIONS

Calculations were performed to determine the following parameters:

- Mass reduction of PCE and TCE
- PCE and TCE mass removal rates
- ROI created by the SVE system
- Intrinsic permeability
- SVE well extraction rates
- SVE well vacuum pressures
- SP injection flow rates
- SP injection pressures

Each parameter is discussed in further detail in the paragraphs below. The data, rationale, and references used to calculate mass removal rates, ROI, k_i, flow rates and pressures are presented in Attachment B.

4.1 Mass Reduction

The mass of VOCs removed during the Pilot Study was calculated quantitatively based on the concentration of VOCs detected at the beginning and end of each test (Table 2), the average flow rate (Table 1), and operating duration recorded during each of the 11 tests (Table 1).

Table 3 – Estimate of Mass Removed during the Pilot Test provides a summary of the data and calculation used to determine the volume of VOCs removed during each of the 11 tests. The total mass removed over the 1476 minutes the treatment unit was operated was 5.13 pounds. The rate of removal = (5.13 lb / 1476 mins) x (60 min/hr) = 0.21 lb/hr, or 5 lb/day.

The percentage of PCE and TCE existing in the average total VOC concentration was calculated for each of the 11 tests and used to determine their mass reduction and mass removal rates. The mass of PCE removed during the pilot study was 5.1 lbs and the mass of TCE removed was 0.017 lbs.

The rate of removal was 4.95 pound/day (or 0.21 lb/hour) for PCE and 0.016 lb/day (or 6.8 x 10^{-4} lb/hour) for TCE. Removal rates are anticipated to decrease over time as contaminant mass is reduced.

Removal rates for VOCs increased approximately 5.9% when the SP system was online as shown on Table 3.

4.2 Radius of Influence (ROI)

The ROI is the furthest distance from the extraction well that soil and soil gas can be successfully treated by SVE. It is determined by placing a vacuum on the extraction well and measuring the vacuum that is achieved in nearby monitoring points, and then extrapolating the distance to a point where there is a slight vacuum. For the purposes of the calculation (Table 4 in Attachment B), the pressure at the farthest ROI distance was set at 1% of the vacuum pressure measured in the operating SVE wells.

Average ROIs, using SVE-1 as the extraction well, range between 31.3 ft to 31.9 ft. The average ROI induced by SVE-1 is approximately 32 ft. Average ROIs, using SVE-2 as the extraction well, range between 37.3 ft to 38.9 ft. The average ROI induced by SVE-2 is approximately 38 ft.

The vacuum contours shown on Figure 2 in Attachment B (SVE-1 operating at 45 inches H_2O) indicate that the ROI extends approximately 64 feet to the west and at least 26 feet to the east with a vacuum pressure of 0.75 inches H_2O at the fringe of the ROI. Figure 3 in Attachment B (SVE-2 operating at 39.5 inches H_2O) indicates that the ROI extends approximately 39 feet to the west and 66 feet to the east with a vacuum pressure of 1 inches H_2O at the fringe of the ROI. If the contours were extrapolated to reflect the 1% SVE well vacuum pressures used in the calculations the line would significantly extend the ROI in both cases.

A graphical estimate was developed in an attempt to predict the limits of the ROI based on gauge readings and distances from the SVE wells. The shaded data presented on Tables 1.9 and 1.10 was used to graphically determine the ROI created by SVE-1 and SVE-2, respectively. Vacuum gauge readings (inches H_2O – y axis) collected from the vacuum pressure monitoring wells (SVE, OW, and DEC wells) were plotted on a semi-log graph with the distance from the extraction well to the monitoring wells (x-axis). Graphically, the ROI is the intersection of the regressed vacuum distribution line, plotted exponentially, and the distance where the vacuum approaches atmospheric conditions. A horizontal line that reflects 1% of the vacuum observed in the extraction well was selected as the point where the vacuum in the formation approaches atmospheric conditions. As shown on the graphs the ROI created by SVE-1 (Figure 2) ranges between 65 and 75 feet and the ROI created by SVE-2 (Figure 3) ranges between 90 and 143 feet.

Based on the vacuum gauge pressure contours presented on Figures 2 and 3 in Attachment B, the calculated values shown in Table 4 in Attachment B, and graphs presented on Figures 2 and 3, URS believes that the ROI developed while operating the SVE system was at least 40 feet.

4.3 Intrinsic Permeability (k_i)

The intrinsic permeability is the measurement for the ability of fluids (groundwater and air) to pass through soils, and is typically used as an indicator to determine the effectiveness of SVE. Intrinsic permeability is a function of soil properties only, whereas hydraulic conductivity is a function of both soil and fluid properties. Using the hydraulic conductivity values provided in the Remedial Investigation Phase II Report, and as shown in Attachment B, k_i was calculated to be 5.55×10^{-8} cm^2. This corresponds to the permeability expected for fill, sand, gravel, and a sandy silt layer observed in the formation above the water table and corresponds to an environment that would be conducive to SVE remediation.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the location of the contaminant source, the nature and extent of contamination, and results of the pilot study, SVE is the preferred remedial technology for source contaminant reduction and URS recommends that it should be evaluated further in combination with other technologies, as part of a feasibility study prepared for this site.

5.2 Recommendations

5.2.1 Conceptual Design Layout for Source Perimeter Treatment

Figure 4 provides a conceptual design layout of SVE and SP wells for treating the contaminant source along the perimeter of the warehouse building. The following paragraphs and Attachment B provide the basis, assumptions, calculations and references used to develop the conceptual design.

5.2.2 Recommended Locations and Depths of Extraction Wells

Based on an ROI of 40 feet, four additional extraction wells will be installed on the sidewalk adjacent to the former Klink Cosmo building to remediate the source area. One of the additional extraction wells will be installed near the intersection of Richardson Street and Vandervoort Avenue, two additional extraction wells will be installed south of the intersection approximately 40 feet away from each other, and the remaining additional extraction well will be installed on Richardson Street between a SVE-1 and SVE-2, drilled on an approximately 15-degree angle to extend beneath the warehouse building (extending approximately 20 feet from the building perimeter). Figure 4 provides the locations of the existing and proposed extraction wells.

The screened interval of the new extraction wells will be increased from 10 to 15 feet as discussed in Attachment B.

5.2.3 Extraction Well Flow Rates

The total treatment area encompassed by the six SVE wells will total approximately 19,175 ft^2 (see Figure 4). Groundwater exists approximately 32 feet below grade. As such the treatment volume is 613,600 cubic feet (ft^3). At a soil porosity of 0.24 and extracting at least two pore volumes per day the vacuum extraction rate is 213 ft^3/ minute.

Assuming that the subsurface conditions are relatively homogenous, each SVE well will be designed to have an extraction flow rate of approximately 35 scfm. At 35 scfm per well, the total extraction rate would be 210 scfm.

5.2.4 Determination of Extraction Well Vacuum

The intrinsic permeability of 5.55×10^{-8} cm^2 was used to determine the vacuum pressure at the SVE wells. As shown in Table 5 (Attachment B), the vacuum in the extraction wells should be at least 50.2 inches H_2O.

5.2.5 Air Sparge Flow Rate

As described in Attachment B, the SP system should consist of eight 2-inch diameter wells spaced between 15 to 20 feet. A 3 foot screen length should be used for design of the additional sparge wells since subsurface conditions are relatively uniform in the treatment zone.

Assuming a one pore exchange rate and an SVE extraction rate equal to two times the sparging injection rate, the air sparging flow rate is 100 ft^3/ minute.

Operation of the air sparge system can vary from having all eight wells online or pulsing the system with a few wells online at one time. With all eight wells online, the air sparging rate per well would be 12.5 ft^3/ minute

5.2.6 Sparging Air Pressure

The data shows that the contamination was detected approximately 40 below ground surface (bgs) in wells the shallow aquifer to a maximum of approximately 80 feet bgs the deep aquifer. The air sparging pressure should be maintained between the minimum pressure necessary to induce flow and the pressure at which fracturing occurs. Because contaminants exist in both the shallow and deep aquifers beneath the site, air should be injected in two different zones.

As shown in Attachment B, an acceptable pressure range for the shallow aquifer is 5.4 to 32.8 psig. Injection pressures in the deep aquifer range between 22.6 and 62.0 psig. This exceeds the acceptable pressure range provided in the reference documents.

If the well screen is placed at 75 feet bgs, at the midpoint of DEC-031D, P_{min} would be 18.3 psig and $P_{fracture}$ would be 54.8 psig. The range of P_{min} for treating the shallow and deep aquifer is 5.4 to 18.3 psi (top of screen for deep aquifer set at 75 feet bgs). This is in the range of acceptable values for air sparge pressure. Actual operation of the air sparge system would warrant treatment of the shallow and deep aquifer to be conducted separately due to the fracture pressure when treating the shallow aquifer.