Success with Soil Vapor Extraction, 200-PW-1 Operable Unit, Hanford Site, Richland, Washington – 14017

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ABSTRACT

In the 200 West Area of the Hanford Site in Washington State, the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib were used from 1955 to 1973 for soil column disposal of liquid wastes containing carbon tetrachloride. Carbon tetrachloride in liquid waste volatilizes in the vadose zone, making soil vapor extraction (SVE) the preferred remediation technology. Between 1992 and 1997, SVE systems operated at the disposal sites to recover 74,851 kg (165,018 lb) of carbon tetrachloride. A rebound study was conducted in 1997 to determine changes in carbon tetrachloride vapor concentrations following temporary shutdown of the systems. Based on the results and the declining carbon tetrachloride recovery rates, only one SVE system (alternating between waste sites) operated from April through September between 1998 and 2008, and was in standby mode the remainder of the year, to allow soil vapor concentrations to rebound. Two new SVE systems operated for 6 to 8 months annually from 2009 to 2012. By 2012, annual recovery of carbon tetrachloride had dropped to 162 kg (257 lb). From 1992 through 2012, SVE operations have recovered 80,107 kg (176,604 lb) of carbon tetrachloride from the vadose zone.

In 2011, the Record of Decision for the 200-PW-1 Operable Unit, which includes the carbon tetrachloride waste sites, identified a final cleanup level of 100 parts per million by volume (ppmv) for carbon tetrachloride in soil vapor and specifies that soil vapor concentrations will be further refined and assessed to ensure groundwater protection. Since soil vapor concentrations in all of the SVE wells were below the 100 ppmv cleanup level, SVE operations were not performed in 2013 to allow for a longer rebound period. Carbon tetrachloride concentrations will be re-evaluated in 2014, and a decision will be made at that time whether SVE operations will be continued.

INTRODUCTION

Soil vapor extraction (SVE) has been used since 1992 to remove carbon tetrachloride from the vadose zone within the 200-PW-1 Operable Unit, which is located in the 200 West Area of the Hanford Site. The primary sources for this carbon tetrachloride are three waste sites (216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib) used from 1955 to 1973 for the disposal of waste liquids from historical Plutonium Finishing Plant process operations (Fig. 1). Fig. 1 shows all of the wells located in the vicinity of the three waste sites that are used to support SVE operations. The purpose of the SVE operations in the vicinity of these waste sites is to mitigate the threat of carbon tetrachloride vapors migrating through the soil column and contaminating the underlying groundwater.

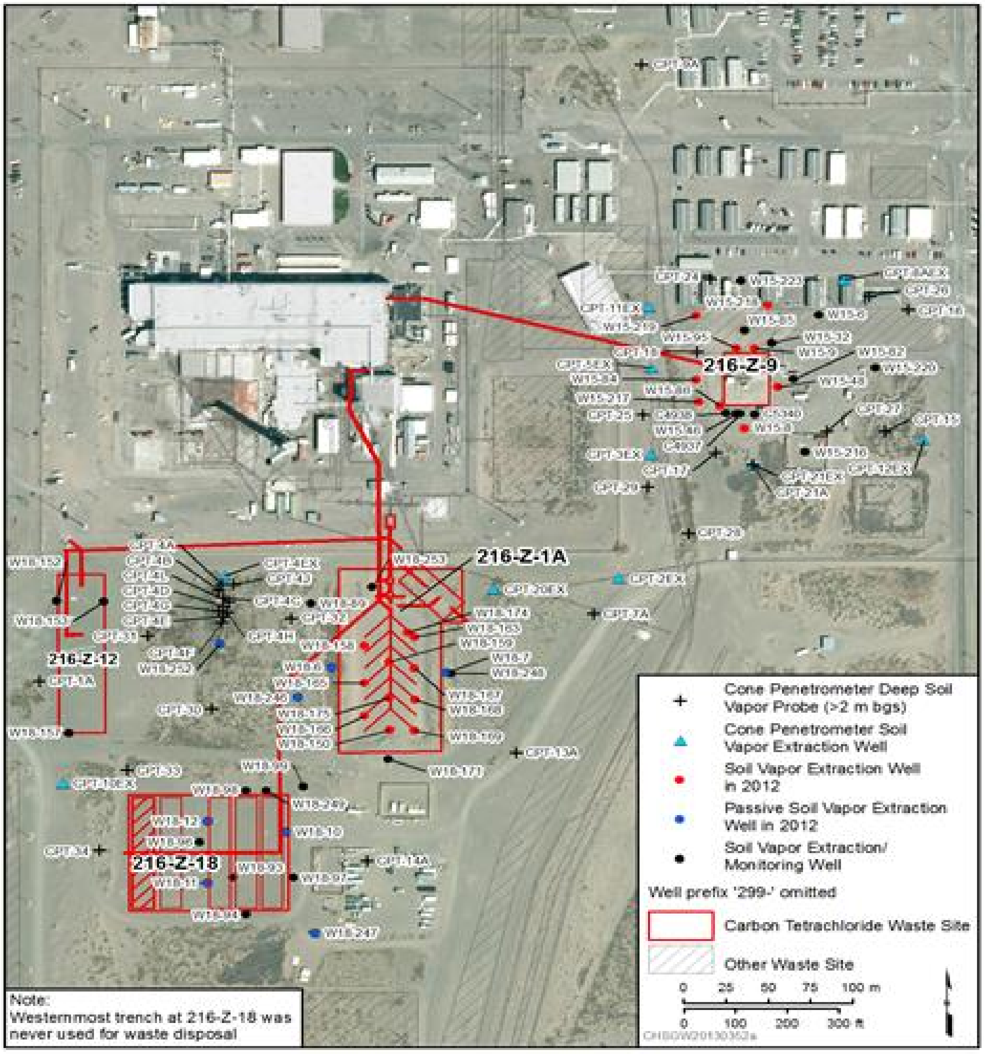

Fig. 1. Map showing the three primary carbon tetrachloride waste sites in the 200-PW-1 Operable Unit.

SVE was first implemented as an interim action in 1992 [1]. More recently, SVE is being implemented to meet the requirements of the CERCLA Record of Decision for the 200-PW-1 Operable Unit, which was finalized in September 2011 [2]. The Record of Decision selected SVE as the final remedial action for carbon tetrachloride contamination in the vadose zone. While both passive and active SVE operations have been performed at the 200-PW-1 Operable Unit, the focus of the following discussion is only on active SVE operations because substantially larger volumes of carbon tetrachloride have been removed using active SVE.

METHODOLOGY

The 200-PW-1 Operable Unit SVE operations use a vacuum system to extract vapor-phase carbon tetrachloride from either above and/or below a low-permeability caliche layer (Fig. 2). Most wells are screened above the underlying water table, and most well screens/casing diameters are between 10.2 and 20.3 cm (4 to 8 in.). As shown in Fig. 2, the extracted vapor passes sequentially through a flow meter, an air/water separator, a heat exchanger, and finally granular activated carbon (GAC) canisters. Any vapor-phase carbon tetrachloride that is present is removed by the GAC before the treated air is released to the atmosphere. Air samples are routinely collected for laboratory analysis to ensure that air discharge release limits are met. During SVE operations, GAC canisters typically require changeout every few weeks; several times a year a shipment of spent GAC canisters are sent offsite for regeneration.

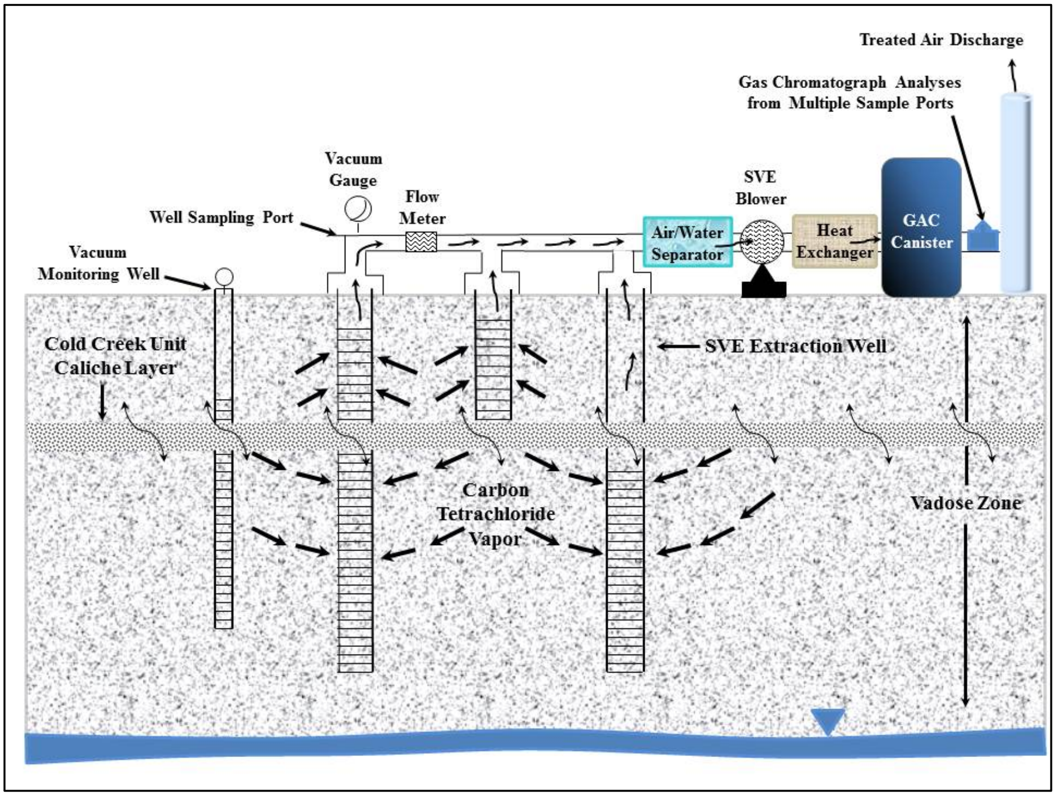

Fig. 2. Schematic of a soil vapor extraction system.

Between 1992 and 1997, three SVE systems (14.2, 28.3, and 42.5 m^3/min [500, 1,000, and 1,500 ft^3/min]) were operated continuously throughout the year to recover carbon tetrachloride from the vadose zone. During these first years of SVE operations, 74,851 kg (165,018 lb) of carbon tetrachloride were removed. The SVE systems were not operated in 1997 so a rebound study could be conducted to determine the increase in carbon tetrachloride vapor concentrations following temporary shutdown of the systems. Based on the results of the rebound study and the declining carbon tetrachloride recovery rates, only the 14.2 m^3/min (500 ft^3/min) SVE system was operated between 1998 and 2008. Rather than operating year-round, this single system was typically operated only from April through September, alternating between the 216-Z-9 Trench and the 216-Z-1A Tile Field/216-Z-18 Crib. The SVE system was maintained in standby mode for the remainder of the year to allow vapor concentrations to rebound. More recently, two new 14.2 m^3/min (500 ft^3/min) SVE systems were operated simultaneously for 6 to 8 months each year from 2009 to 2012. By 2012, the annual recovery of carbon tetrachloride had dropped to 162 kg (357 lb). From 1992 through 2012, approximately 80,107 kg (176,604 lb) of carbon tetrachloride have been removed from the vadose zone through the processing of 118 billion m^3 (4,167 billion ft^3) of soil vapor (Fig. 3).

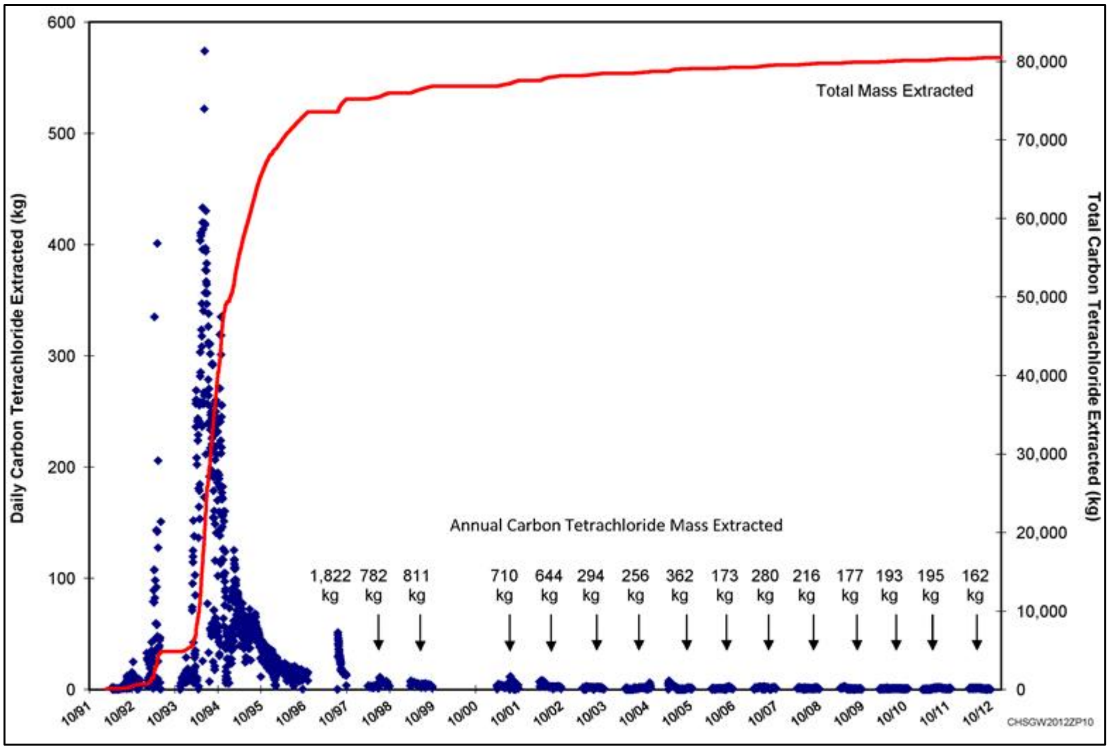

Fig. 3. 200-PW-1 Annual carbon tetrachloride mass extracted by soil vapor extraction.

Vapor samples are routinely collected from many of the wells shown in Fig. 1 to support decisions regarding which wells should be placed online and how long the wells should remain online. The number of wells placed online at any one time varied from year to year and is influenced by the concentrations of carbon tetrachloride detected in each well. For example, in 2012, SVE operations at the 216-Z-9 Trench began with five SVE wells online. Eight additional SVE wells were placed online later that year (for a total of 13 wells). In contrast, SVE operations at the 216-Z-1A Tile Field began with five SVE wells online, and then six more wells were added later that year (for a total of 11 wells).

RESULTS

Fig. 4 illustrates the difference between the concentration of carbon tetrachloride at the end of the operational cycle for each year and the maximum concentration of carbon tetrachloride detected during the next operational cycle following the rebound period. For example, the concentration of carbon tetrachloride at the end of the 1999 operational cycle was 28 ppmv. At the beginning of the next operational cycle in 2001, the maximum concentration had increased to 224 ppmv. Due to the success of SVE operations, a steady decrease in the rebound in carbon tetrachloride concentrations was observed over time (Fig. 4). Fig. 5 illustrates the significant decrease in carbon tetrachloride concentrations in SVE wells since SVE operations began. Carbon tetrachloride concentrations in soil vapor extracted from the 216-Z-9 wells declined from approximately 30,000 ppmv at startup in 1993 to a maximum of 14 ppmv in 2012. Carbon tetrachloride concentrations in soil vapor extracted from the 216-Z-1A/216-Z-18 wells declined from approximately 1,500 ppmv at startup in 1992 to a maximum of 11 ppmv in 2012.

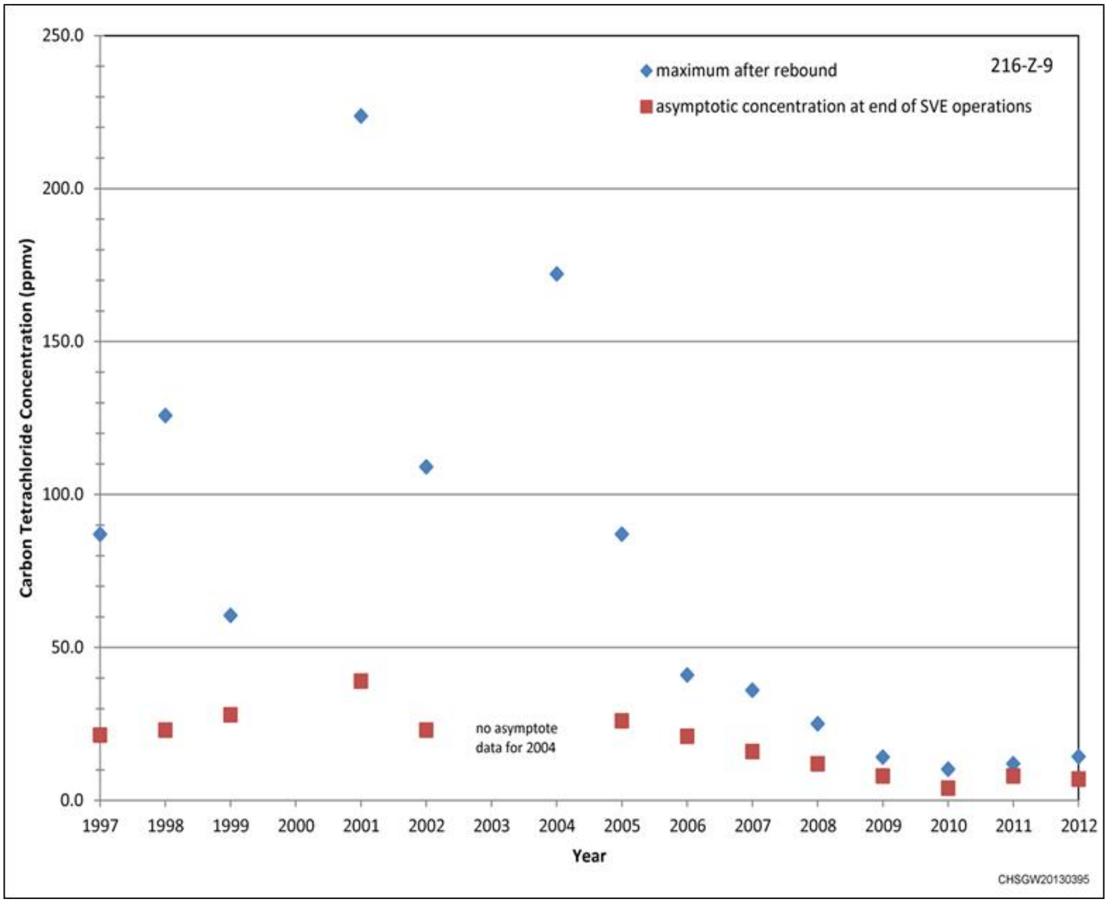

Fig. 4. Observed rebound in carbon tetrachloride concentrations in vapor extracted from 216-Z-9 Site, 1997 through 2012.

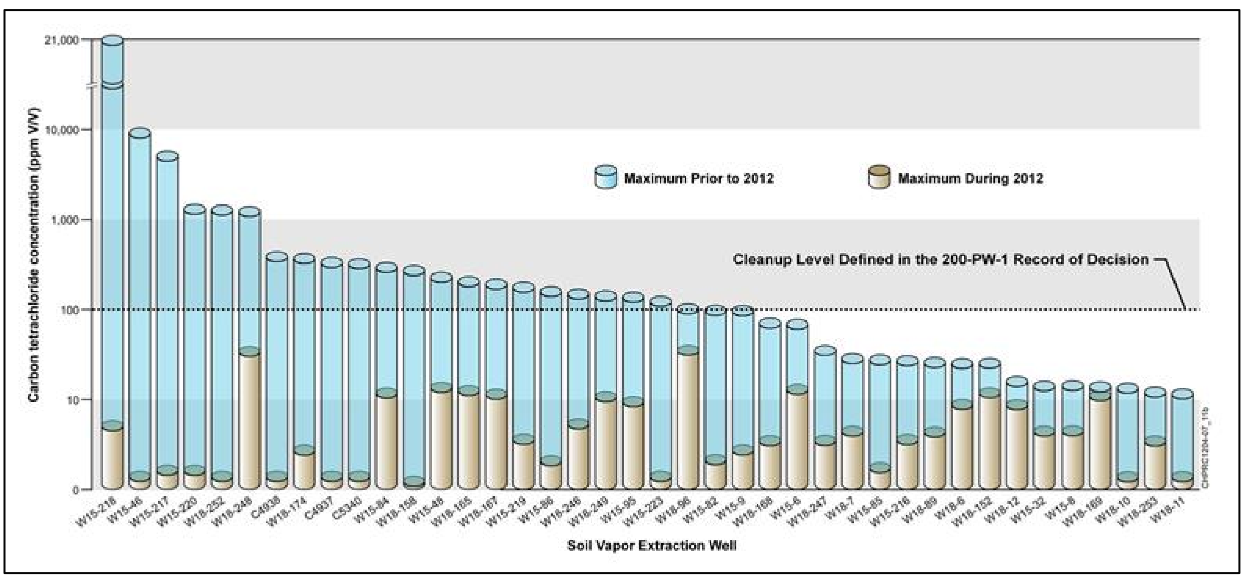

Fig. 5. Carbon tetrachloride concentrations in 200-PW-1 soil vapor extraction wells between 1992 and 2012.

Because carbon tetrachloride concentrations in all of the SVE wells have now decreased to well below the 100 ppmv cleanup level specified in the final Record of Decision [2], the U.S. Environmental Protection Agency has approved a one-year rebound study. A plan is currently being prepared that addresses the various steps that would be needed to permanently discontinue SVE operations if concentrations of carbon tetrachloride in all of the SVE wells remain below the cleanup level.

CONCLUSIONS

Between February 1992 and October 2012, SVE was implemented in the vicinity of three Hanford disposal sites (216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib) to recover carbon tetrachloride from the vadose zone. Soil vapor has been extracted from more than 50 wells in the vicinity of these disposal sites, many of which have two or more screened (or perforated) intervals for vapor extraction. The well screens are positioned in the relatively permeable sands and gravels above and/or below the lower permeability Cold Creek unit, which is located approximately 38 to 45 m (125 to 148 ft) below ground surface.

While three SVE systems (14.2, 28.3, and 42.5 m^3/min [500, 1,000, and 1,500 ft^3/min]) were operated continuously in earlier years to recover carbon tetrachloride, more recently the two new 14.2 m^3/min (500 ft^3/min) SVE systems were only operated for 6 to 8 months each year. To date, approximately 80,107 kg (176,604 lb) of carbon tetrachloride have been removed from the vadose zone [3]. With continued extraction, the rebound of carbon tetrachloride vapor concentrations has gradually declined. For example, in 2001 the carbon tetrachloride concentrations in the vadose zone near the 216-Z-9 Trench rebounded from 28 ppmv in the fall of 1999 to 224 ppmv in the spring of 2001 (an eight-fold increase). In contrast, in 2012 the concentrations near the 216-Z-9 Trench rebounded from 8 ppmv in the fall of 2011 to 14 ppmv in the spring of 2012.

In 2011, a Record of Decision was issued that identifies 100 ppmv as the final cleanup level for carbon tetrachloride in soil vapor within the 200-PW-1 Operable Unit [2]. At this time, the concentration of carbon tetrachloride in all of the SVE wells is well below this cleanup level. For this reason, SVE operations were not performed in 2013 to allow carbon tetrachloride concentrations to rebound for the entire year. Carbon tetrachloride concentrations will be re-evaluated in the spring of 2014. A plan is currently being prepared that addresses the various steps that would be needed to permanently discontinue SVE operations if concentrations of carbon tetrachloride in all of the SVE wells remain below the cleanup level.

REFERENCES

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