Reducing Cost of Chlorinated Volatile Organic Compound Remediation by Transitioning from Active to Passive Soil Vapor Extraction; 20157

John Bradley*, Monique Rabin*, and Karen Adams**
*Savannah River Nuclear Solutions
**United States Department of Energy
ERD-EN-2019-0051 Rev 0

ABSTRACT

Areas of high chlorinated volatile organic compound (cVOC) contamination at the Savannah River Site (SRS) have been undergoing remediation via soil vapor extraction, sometimes coupled with thermal treatments to enhance extraction rates. These active systems are effective in removing large amounts of contaminant mass from the subsurface and mitigating the impacts to groundwater. However, as extraction rates decline, costs must be evaluated with respect to the benefit of continued active operation. A decision framework for identifying conditions when a transition to a more passive remediation is appropriate has been developed with state and federal regulatory agencies.

Two remediation areas have recently been transitioned from active soil vapor extraction (ASVE) to passive soil vapor extraction (PSVE) at the SRS. Performance evaluation goals including plume stabilization, overall mass removal trends, environmental sustainability and costs were considered in transitioning from active remediation to passive technologies at both sites.

At the Dynamic Underground Stripping (DUS) project at the M-Area Settling Basin, ASVE was combined with steam injection to extract cVOCs during active operations. Steam injection occurred from September 2005 to September 2009. DUS utilized 63 steam injection wells, 34 active vapor extraction wells, and 3 active soil vapor extraction units (SVEUs). Two active SVEUs had 60 horsepower blowers; the third had a 25-horsepower blower.

Mass removal was closely tracked during DUS operations; over 181,437 kilograms (400,000 pounds) of cVOCs were removed while active steam injection occurred. After steaming was stopped, ASVE continued.

The 34 active wells were evaluated in 2012. The ASVE wells were grouped into categories of high, medium, and low extraction rates. High producing wells remained connected to a single active SVEU. Low producing wells were abandoned, and the medium producing wells were transitioned to PSVE (Microblowers^{TM}). Microblowers^{TM} utilize a dedicated blower per well and are solar powered. This passive technology provides energy, maintenance, and operation costs savings while still providing an efficient reduction in cVOC migration to groundwater.

In 2018, the remaining ASVE wells were evaluated again. The purpose of this testing was to identify which wells removed the most mass. An optimal well configuration was determined. The criteria to discontinue ASVE was removal of less than 18 kilograms (40 pounds) per week of cVOCs. After 3 months of shutdown (rebound conditions), 2.7 kilograms (5.9 pounds) of cVOCs per week were being removed.

Data from the rebound test justified ending ASVE and transitioning wells with higher extraction rates to PSVE. Wells that had depleted the cVOC mass within their zone of influence were abandoned. Performance data from existing PSVE wells justified ending PSVE at wells with depleted extraction rates. Currently the system has 16 PSVE wells operating.

Another ASVE system was being used to treat cVOC contaminated soil at the A-Area Miscellaneous Rubble Pile (AMRP) at SRS. System operation began in 2004, with 7 ASVE wells connected to a 60-horsepower blower. Mass removal rates and contaminant concentrations remained consistently low over the ASVE lifespan at AMRP. This indicated that mass removal was diffusion limited. With this data, the 7 ASVE wells were transitioned to PSVE in 2017. Twelve pressure monitoring points were also transitioned to PSVE wells. AMRP currently has 19 PSVE wells operating.

Both transitions from active to passive remediation had concurrence from the United States Environmental Protection Agency and the South Carolina Department of Health and Environmental Control. These transitions ensure that only the necessary amount of energy is being exerted to remediate the environment.

INTRODUCTION

Since 1994, active vadose zone treatment has been occurring at the M-Area Settling Basin at the Savannah River Site. The M-Area Settling Basin was a 30,283,294 liters (8 million gallons) earthen basin that received fluids from the M-Area manufacturing facilities via a process sewer. During its operation from 1958 to 1985, an estimated 907,185 kilograms (2 million pounds) of degreasing solvents consisting of tetrachloroethylene (PCE), trichloroethylene (TCE), and other VOCs were released to the basin. Although the basin was intended to allow the solvent to evaporate, much of the solvent seeped into the subsurface, contaminating the soil and groundwater. The M-Area Settling Basin was closed using a Resource Conservation and Recovery Act (RCRA)-style cap in 1989.

The groundwater in this location is treated by an active pump and treat system utilizing many groundwater recovery wells and air stripping. The vadose zone was initially treated by ASVE. The TCE and PCE was present as dense non-aqueous phase liquids (DNAPLs) below the more permeable sand layers in pockets on impermeable clay lenses. To address the DNAPL pockets and speed the remedial timeframe, DUS was begun in 2005. ASVE was combined with steam injection to extract cVOCs during active operations. Steam injection occurred from September 2005 to September 2009. DUS utilized 63 steam injection wells, 34 active vapor extraction wells, and 3 active SVEUs. Two active SVEUs had 60 horsepower blowers; the third had a 25 horsepower blower.

Steam injection and vapor extraction removed a significant amount of mass from the subsurface. Mass removal was closely tracked during DUS operations; over 181,437 kilograms (400,000 pounds) of cVOCs were removed while active steam injection occurred. After steaming was stopped, ASVE continued. However, mass removal plummeted as the remedial system had largely completed its mission. ASVE removed the small quantities of solvent that remained. By 2012, over 204,117 kilograms (450,000 pounds) of cVOCs (from both vapor and groundwater) had been removed from the former DUS site. Figure 1 provides an aerial view of the ASVE system after steam injection had ceased with one active SVEU remaining.

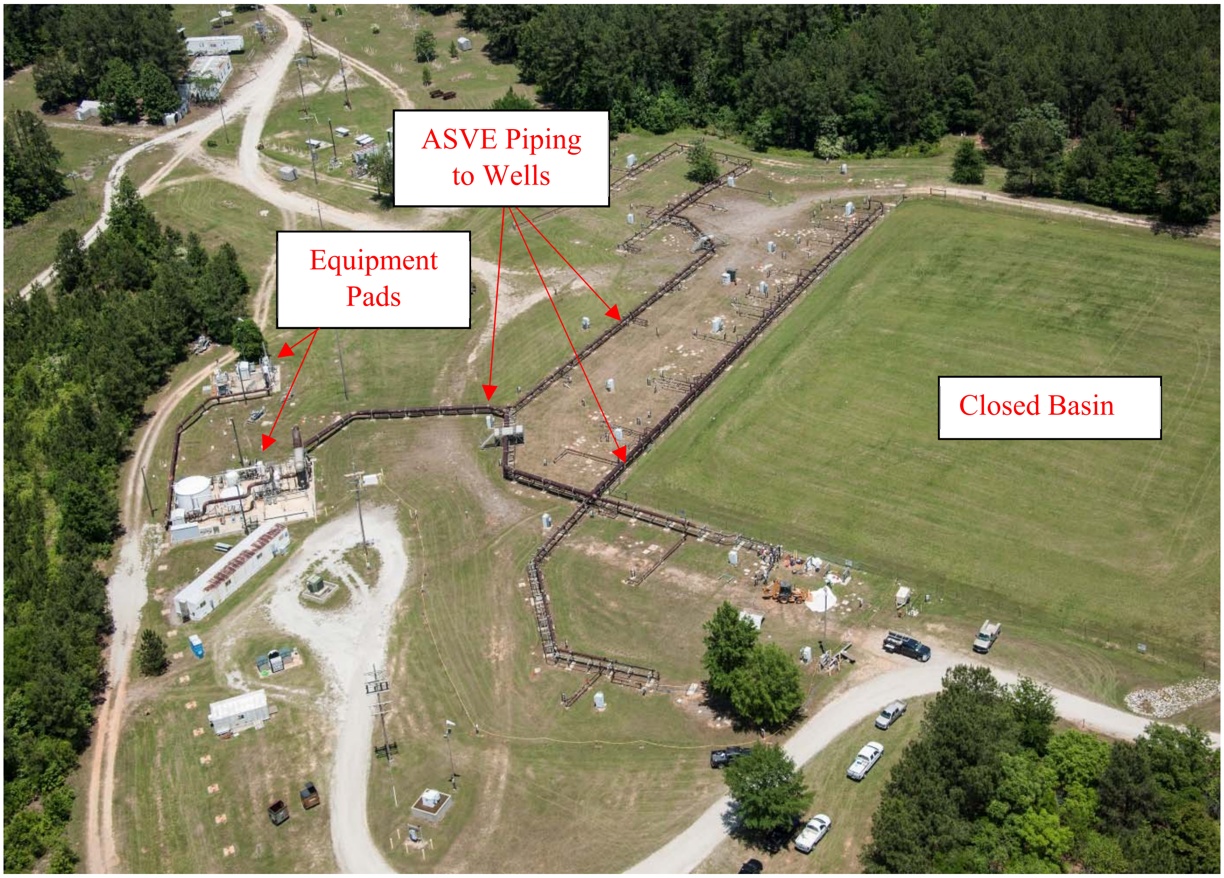

Figure 1. **ASVE System Near the M-Area Settling Basin**

Similarly, active vadose zone treatment began in 2004 at the AMRP at the SRS. This treatment was selected to address TCE and PCE that were identified as constituents of concern (COCs) with respect to their potential to leach to groundwater. The COCs were a resultant of disposal activities that began in the early 1950s. System operation began with 7 ASVE wells connected to a 60-horsepower blower. Mass removal rates and contaminant concentrations remained consistently low over the ASVE lifespan at AMRP. This indicated that mass removal was diffusion limited.

With this data, the 7 ASVE wells were transitioned to PSVE in 2017. Twelve pressure monitoring points were also transitioned to PSVE wells. AMRP currently has 19 PSVE wells operating. Each well has a dedicated Microblower™ that is solar powered. Figure 2 shows the PSVE wells with solar panels adjacent to the SVEU that was formerly utilized at the AMRP. PSVE mass removal has declined slightly after this transition but remains comparable to ASVE mass removal.

Figure 2. ASVE System at the AMRP Site

DESCRIPTION OF METHODS AND RESULTS

At the former DUS site, mass removal declined after steaming was stopped. The 34 active vapor extraction wells were each individually sampled and evaluated in 2012. This was important since each well can have a radius of influence greater than 30 meters (100 feet) during ASVE.

The ASVE wells were grouped into categories of high, medium, and low extraction rates. High producing wells (wells with ASVE rates greater than 0.45 kilogram (1 pound) per day) remained connected to the single active SVEU. Low producing wells (wells with ASVE rates less than 0.045 kilogram (0.1 pound) per day) were abandoned, and the medium producing wells (wells with ASVE rates between 0.045 and 0.45 kilogram (0.1 and 1 pound) per day) were transitioned to PSVE (Microblowers^{TM}).

Microblowers^{TM} utilize a dedicated blower per well and are solar powered. This passive technology provides energy, maintenance, and operation costs savings while still providing an efficient reduction in cVOC migration to groundwater. Microblowers^{TM} are appropriate as a polishing step during remedial activities, especially when mass transfer limits remediation speed. Microblowers^{TM} are relatively inexpensive and simple to design and deploy.

As Table I shows, in some years PSVE surpassed ASVE in mass removal at the former DUS site.

Table I. Mass Removed from the Former DUS Site via ASVE and PSVE

Year	Kilograms Removed via Active SVE	Kilograms Removed via Passive SVE
2005	41,604	
2006	91,191	
2007	42,415	
2008	22,246	
2009	2,324	
2010	1,454	
2011	2,650	
2012	1,202	
2013	629	
2014	147	
2015	10	20
2016	157	135
2017	107	110
2018	112	114
2019	95	28

In 2018, the remaining ASVE wells were evaluated again. The purpose of this testing was to identify which wells removed the most mass. An optimal well configuration was determined. After 3 months of shutdown (rebound conditions), 2.7 kilograms (5.9 pounds) of cVOCs per week were being removed. The A/M Area of SRS (which includes the former DUS site and AMRP) has a shutdown criterion for ASVE of less than 18 kilograms (40 pounds) per week of total cVOCs being removed.

Data from the rebound test justified ending ASVE and transitioning wells with higher extraction rates to PSVE. Wells that had depleted the cVOC mass within their zone of influence were abandoned. Performance data from existing PSVE wells justified ending PSVE at wells with depleted extraction rates. Currently the system has 16 PSVE wells operating.

At the AMRP site, mass removal had remained consistently low (see Figure 3). The transition from ASVE to PSVE was not a difficult one as the shutdown criterion for ASVE of less than 18 kilograms (40 pounds) per week of total cVOCs being removed had already been realized.

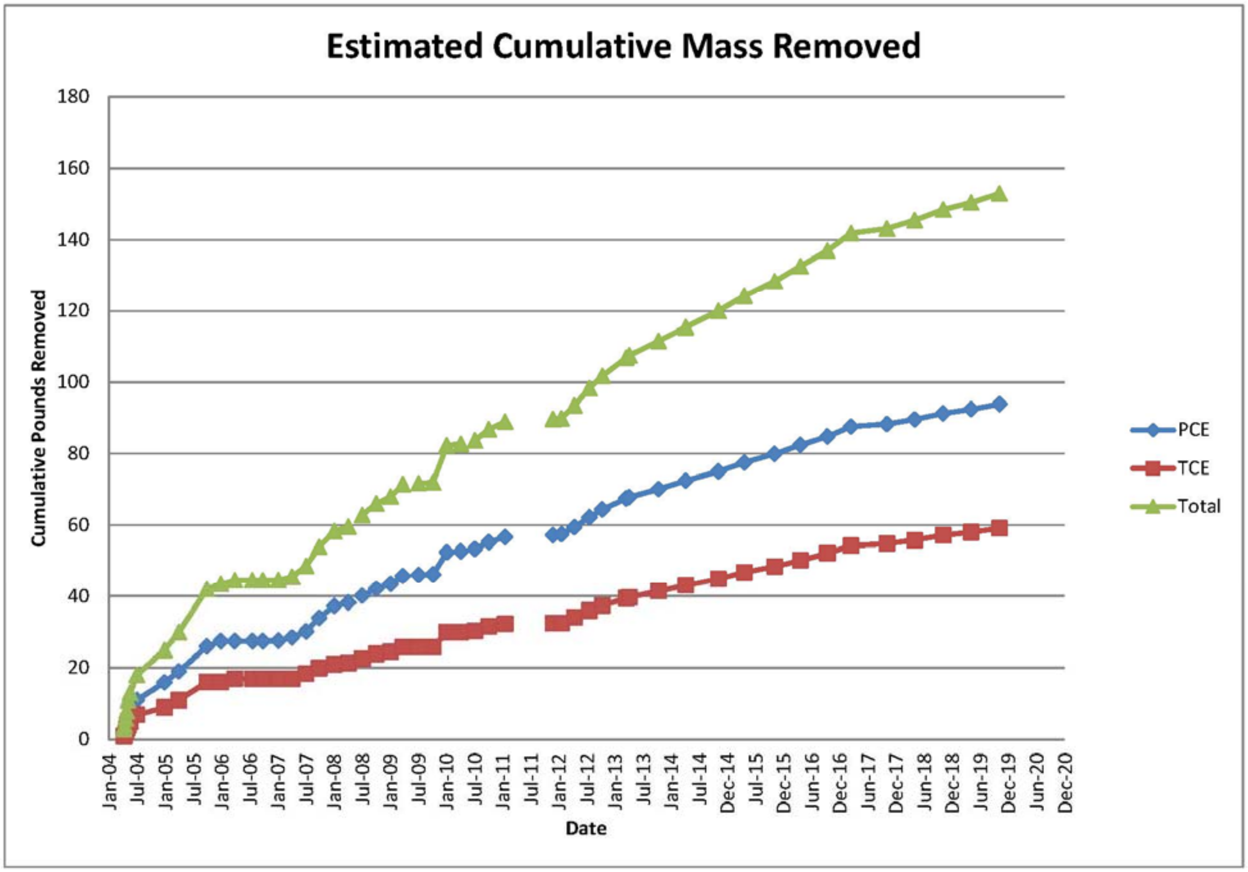

Figure 3. cVOC Mass Removal from the A-Area Miscellaneous Rubble Pile

DISCUSSION OF COST SAVINGS

There is an evolution of operating costs as systems are reduced to fewer components (e.g. steam injection ceases, blowers are taken off line, etc.) and switched from ASVE to PSVE. In addition to the energy savings associated with discontinuing the use of the large (e.g. 60 horsepower) blowers, there is also a significant reduction in costs associated to operation and maintenance. These systems operate with a programmable logic controller that include interlocks to protect the system from abnormal operating conditions, however personnel are required for monitoring and recording via daily rounds. Routine instrument calibration is necessary to comply with permitting and reporting requirements. More complicated systems, like ASVE coupled with steam injection require a control room, with a constant operator presence. Preventative and corrective maintenance costs are significant and increase with the age of the equipment. Cost savings from discontinuing ASVE at the former DUS site have been calculated to be $200K per year.

PSVE systems require little maintenance or oversight during operation. The energy costs are minimal, battery replacement for back-up power. Operations and maintenance costs for PSVE have been estimated to be <$1,000 per year per well.

CONCLUSIONS

The use of ASVE is an effective tool in remediating contaminated vadose zones. However, as extraction rates decline, costs must be evaluated with respect to the benefit of continued active operation. At the former DUS site and at the AMRP, the transition from PSVE to ASVE will save money while still delivering environmental remediation and sustainability.