MINIMIZING CHARACTERIZATION-DERIVED WASTE AT THE DEPARTMENT OF ENERGY SAVANNAH RIVER SITE, AIKEN, SOUTH CAROLINA

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ABSTRACT

Environmental restoration activities at the Department of Energy Savannah River Site (SRS) utilize innovative site characterization approaches and technologies that minimize waste generation.

Characterization is typically conducted in phases, first by collecting large quantities of inexpensive data, followed by targeted minimally invasive drilling to collect depth-discrete soil/groundwater data, and concluded with the installation of permanent multi-level groundwater monitoring wells.

Waste-reducing characterization methods utilize non-traditional drilling practices (sonic drilling), minimally intrusive (geoprobe, cone penetrometer) and non-intrusive (3-D seismic, ground penetration radar, aerial monitoring) investigative tools. Various types of sensor probes (moisture sensors, gamma spectroscopy, Raman spectroscopy, laser induced and X-ray fluorescence) and hydrophobic membranes (FLUTe™) are used in conjunction with depth-discrete sampling techniques to obtain high-resolution 3-D plume profiles.

Groundwater monitoring (short/long-term) approaches utilize multi-level sampling technologies (Strata-Sampler, Cone-Sipper, Solinst Waterloo, Westbay) and low-cost diffusion samplers for seepline/surface water sampling. Upon collection of soil and groundwater data, information is portrayed in a Geographic Information Systems (GIS) format for interpretation and planning purposes.

At the SRS, the use of non-traditional drilling methods and minimally/non intrusive investigation approaches along with in-situ sampling methods has minimized waste generation and improved the effectiveness and efficiency of characterization activities.

INTRODUCTION

The Savannah River Site (SRS) is a U. S. Department of Energy (DOE) facility occupying 310 square miles in southwest South Carolina (Figure 1). The site was set aside in 1950 as a controlled area for production of nuclear materials for national defense. The DOE and its contractors are responsible for the operation of the SRS. Westinghouse Savannah River Company (WSRC) currently manages and operates the site. Chemical and radioactive wastes are byproducts of nuclear material production processes.

The SRS is located on the Upper Atlantic Coastal Plain Physiographic Province. The SRS is situated on the Aiken Plateau of the Atlantic Coastal Plain at an approximate elevation of 300 feet above mean sea level (amsl). The Atlantic Coastal Plain consists of a southeast-dipping wedge of unconsolidated and semi-consolidated sediments. The sediments primarily consist of alternating beds of sands, silts, and clays. Depth to groundwater varies and with numerous water-bearing units beneath the site that provide for industrial and drinking water uses.

The SRS has varying topography and is mostly forested with only 10 % of the site utilized for industrial purposes. Four major streams originate on the SRS with one stream that flows continuously through the site. There are also two man-made constructed ponds that were used as cooling ponds. The SRS is bordered to the west by the Savannah River and is surrounded by farmlands and small communities.

More than 40 years of operation have resulted in the identification of previous waste disposal areas, commonly referred to as waste units. Many of the waste units, scattered throughout the site, have been exposed to varying environmental conditions that have allowed contaminants from buried waste to migrate into and contaminate the vadose zone and shallow groundwater. To characterize and remediate these waste units and the resultant soil and groundwater contamination, an environmental restoration program was formed through interaction and cooperation with the United States Environmental Protection Agency (USEPA) and the South Carolina Department of Health and Environmental Control (SCDHEC).

Waste management is one of the more time consuming and costly part of environmental characterizations. As part of the day to day operations, aqueous and non-aqueous waste is generated which must be characterized, managed, and disposed of appropriately. Various investigative tools are utilized, depending on the identified need of the program, to collect waste, soil, and water samples so as to make necessary decisions for remedial action. Most of the contamination is found in the vadose zone and shallow groundwater beneath the waste units. Types of contamination found in the vadose zone and groundwater are heavy metals (i.e., arsenic, mercury, lead), volatile organic compounds [(i.e., trichloroethylene (TCE), perchloroethylene (PCE)], and radionuclides (i.e., tritium, cesium-137, iodine-129).

A cost effective approach to minimizing investigative-derived waste (IDW) is through planning and the use of appropriate technologies. Coupled together, these two approaches can effectively minimize the cost associated with managing and disposing of IDW.

Strategy

At the SRS, Expedited Site Characterization (ESC) is being utilized as a planning tool to facilitate waste unit characterizations and subsequently reduce IDW. This process allows for the use of a dynamic Work Plan to be used that is flexible to field changes. Much of the ESC process involves the use of existing data to guide future characterizations.

The DOE, USEPA, and SCDHEC have endorsed ESC for use at the SRS. Over the years, ESC has undergone changes in cooperation with the USEPA and SCDHEC that has enabled SRS to complete characterizations within the timeframe allotted to achieve the three year field start to record of decision as defined by the Federal Facility Agreement (3). Therefore, ESC becomes an important part of the overall program in meeting previous agreements.

A key component to ESC is the ability of having a dynamic Work Plan. This dynamic Work Plan enables judgement-based decisions to be made in the field towards identifying future characterization efforts while meeting project objectives (1). These decisions allow for a limited number of field mobilizations by integrating a multidisciplinary team. Whenever available, non-intrusive and minimally intrusive technologies are used during waste unit characterizations. Overall, the ESC process provides for higher quality of information collected over a shorter period of time at a lower cost (4).

ESC integrates many components into the overall process of waste unit characterizations. Figure 2 depicts a typical flow diagram that is used during planning for field deployment (4). The ESC process is flexible and is neither waste unit nor contaminant dependent. The overall process involves (a) the assembly of a broad-based technical core team, (b) participation by the technical core team throughout planning, deployment, and evaluation, (c) utilization of existing data through an exhaustive evaluation, (d) a site visit by the technical team to understand physical conditions, (e) decision by technical team on the use of minimally intrusive or non-intrusive technologies, (f) the use of a dynamic Work Plan that is flexible to changing field conditions, (g) simultaneous interpretation of data in conjunction with field activities, and (h) continual communication amongst the technical team.

By implementing the steps listed above, a broad-based characterization plan can be developed that would address the project need for making informed decisions along with minimizing IDW. The use of planning is a powerful tool that makes better use of the available money to perform the work. Definition of objectives and other information are essential for efficient planning, collection of available data, development of conceptual site models, performance of reconnaissance site investigations by using non-intrusive methods, and detailing future site investigations (3).

Technologies

As discussed previously, planning is a major component of minimizing IDW; however, the appropriate technology also plays an integral part. Typical waste-reducing characterization methods utilize non-traditional drilling practices (sonic drilling), minimally intrusive (geoprobe, cone penetrometer), and non-intrusive (3-D seismic, ground penetrating radar, aerial monitoring) investigative tools. Various other types of sensor probes are used in conjunction with depth-discrete sampling techniques to obtain high resolution 3-D plume profiles.

A primary component to the generation of IDW during waste unit investigations is from drilling activities. Over the years, SRS has employed the use of traditional drilling practices (i.e., mud rotary). However, traditional drilling practices result in large quantities of aqueous and non-aqueous IDW (> 6 cu. yd.) that must be managed and disposed of appropriately. This practice alone can be so costly that the actual work performed to meet project goals is limited. To reduce the amount of IDW that is generated, non-traditional drilling (sonic drilling) has been employed at SRS. This drilling technique allows for minimal amount of aqueous and non-aqueous IDW (< 55 gal) to be generated thereby drastically reducing the management and disposal costs. Sonic drilling involves the use of high frequency resonant vibrations coupled with casing rotation of open-ended steel pipe that allows the steel pipe to advance into the subsurface. No drilling fluids are needed to aid as a lubricant, remove cuttings, and maintain borehole stability. Another benefit of sonic drilling is the speed at which the system works to achieve the desired depth while providing for quality samples.

Sonic drilling has been used primarily for the installation of monitoring wells. Only recently has sonic drilling been utilized in depth-discrete sampling within the same borehole. To collect depth-discrete samples, an Isoflow$^{\text{TM}}$ system is used to obtain groundwater samples without the worry of drilling mud infiltration and limitations on the number of times a sampler (i.e., Hydropunch II$^{\text{TM}}$) can be used within the same borehole. The Isoflow$^{\text{TM}}$ is comprised of a screen, temporary packer, and pump that is set into the sediments below the end of the drill casing. The packer is inflated to seal the drill casing and groundwater is brought to the surface via a pump. This technology allows for depth-discrete site characterizations to be performed quickly and without the need for the installation of numerous permanent monitoring wells while reducing the amount of IDW that is generated.

Minimally intrusive technologies are also used in large part during initial characterizations and source identification. Types of minimally intrusive technologies used at the SRS are the geoprobe and cone penetrometer. Both of these technologies employ the principal of "pushing" small diameter steel rods into the subsurface to collect various types of data. The difference between the two is the depth at which each operates. The geoprobe is normally used in shallow applications (<30 ft) while the cone penetrometer is used in deeper applications (> 30ft). Both technologies are used extensively at the SRS as part of the initial and subsequent waste unit characterizations. Both technologies generate little or no aqueous IDW. Non-aqueous IDW is typically not generated. These technologies allow for rapid deployment and mobilization to collect quality data that can be used to make more efficient defined field decisions on the next step of waste unit characterizations.

Coupled with depth-discrete sampling technologies, many sensors are available that can be used to gather additional data while limiting the generation of IDW. These technologies are used prior to defining a sampling program where other more intrusive technologies are used to discern the vertical and horizontal extent of contamination. Some of the sensors that are used at the SRS are moisture sensors, gamma spectroscopy, Raman spectroscopy, laser induced and X-ray fluorescence, and hydrophobic membranes [(i.e., Ribbon non aqueous phase liquid (NAPL) sampler, FLUTe™)].

Many of the sensors are easily adapted to geoprobe and cone penetrometer equipment. The sensors provide real-time data at depth-discrete intervals as the sensor is advanced into the subsurface. The data that are provided by the sensors allows for better definition of where more specific data are needed. Moisture sensors measure the amount of water tension exhibited on a probes porous membrane. These data identify areas of saturated sediments that could later be sampled to identify preferential contaminant flow paths. Gamma and Raman spectroscopy measure radionuclide activities in the sediments. These sensors provide a gross activity level per depth and do not distinguish specific radionuclides. Laser induced and X-ray fluorescence sensors are used for the detection of volatile organic compounds (i.e., TCE, PCE). Depths of high concentrations are identified for sampling via other more targeted means to determine specific chemical constituents.

Hydrophobic membranes are coated, porous membranes that either have a chemical impregnated in the membrane to assist in detecting the presence of contamination. The type of contamination that is being investigated will decide the type of chemical that is used on the membrane. These membranes are typically used for the detection of volatile organic compounds (i.e., TCE, PCE). As the chemical comes in contact with the contamination, the chemical reacts with the contamination thereby leaving a mark on the membrane. This too provides for discrete depths at which contamination is concentrated and where specific sampling may be required.

The use of sensors provides excellent visual and electric signals of contamination at depth-discrete intervals. These sensors allow development of a detailed characterization plan. By focusing on those areas of concern, the amount of IDW generated is less than if a "shotgun" approach were employed to characterize the waste unit.

Prior to field deployment of intrusive technologies, SRS projects use non-intrusive technologies to gather preliminary information to direct future waste unit characterizations. Ground penetrating radar, historical aerial photography, electrical resistance tomography, and seismic are just a few of the non-intrusive technologies that are typically used. Any of these technologies used separately or coupled together provide a wealth of information to define more intrusive waste characterization methods. By using non-intrusive technologies, no IDW is generated.

CONCLUSIONS

Waste unit investigations at the SRS can generate excessive amount of IDW that will need to be managed and disposed of appropriately. SRS is working with DOE, USEPA, and SCDHEC to adapt and modify the planning and characterization phases of waste unit investigations.

Prior to ESC, traditional methods of investigations resulted in scattered data, unnecessary IDW, and difficulty in meeting project goals. The ESC method was adopted to provide a more efficient method of planning and waste unit investigation. The scientific method is incorporated in the ESC process whereby sound technical decisions are used to solve waste unit investigations (4). The key to the ESC process is the ability of utilizing a dynamic Work Plan where field decisions can be made and changed by qualified personnel based on changing field conditions. By allowing decisions to be made when needed, waste unit investigations can be managed effectively and the generation of IDW can be managed more efficiently.

To complement the ESC process, a continual review and search for minimally intrusive and non-intrusive investigative technologies are being aggressively deployed at SRS to gather high quality data at lower costs while still maintaining project objectives and minimizing IDW.

REFERENCES

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Fig. 1. Location of the Savannah River Site

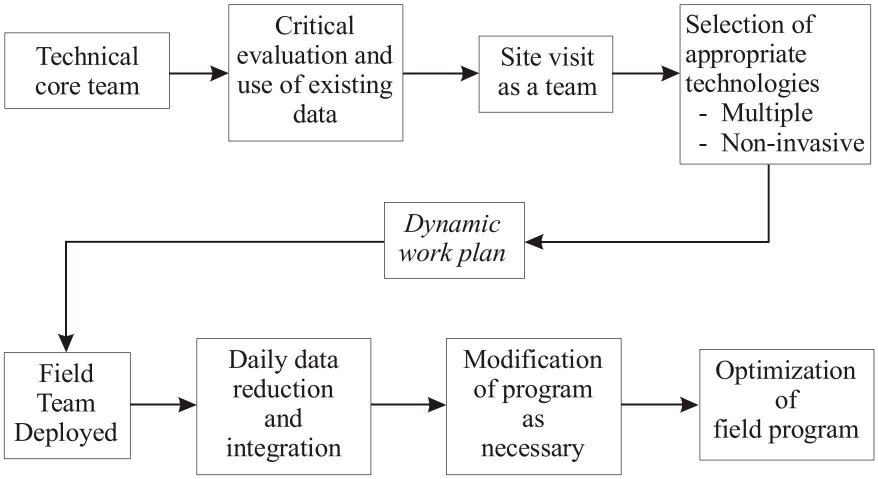

Fig. 2. Site Characterization Planning Flow Diagram (modified from Burton, et al.)