51025

AECOM
101 Research Drive
Columbia, SC 29223
www.aecom.com

803-254-4400 tel
803-776-6676 fax

October 1, 2020

Ms. Kim Kuhn
Bureau of Land and Waste Management
SC Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

Regarding: Pilot Study Work Plan
Shakespeare Composite Structures Site
Newberry, South Carolina
SCDHEC VCC Number 14-6271-RP

Dear Ms. Kuhn:

On behalf of Signify North America Corporation, please find attached the Pilot Study (PS) Work Plan for the Shakespeare Composite Structures Site (the Site) located in Newberry, South Carolina. The PS Work Plan includes plans for multiple in-situ field tests at the Site. Attachments to this plan include an Underground Injection Control (UIC) Permit application and monitoring well permit applications. A copy of the UIC Permit application will be submitted to the South Carolina Department of Health and Environmental Control's (SCDHEC) Water Monitoring Assessment and Protection Division, under separate cover, within the next week for review.

Should you have any questions regarding the PS Work Plan please feel free to contact me at your convenience.

Sincerely,

AECOM Technical Services, Inc.

Scott E. Ross, P.G.
Project Manager
803-201-9662
scott.ross@aecom.com

cc: Mr. Dean Weeks – Signify North America Corporation

125

AECOM

Pilot Study Work Plan Shakespeare Composite Structures Site

RP-VCC-14-6271-RP
Signify North America

AECOM Project No.: 60635197
October 2020

Pilot Study Work Plan

Table of Contents

Figures

Tables

Attachments

List of Acronyms

ABC®-Olé	Anaerobic Biochem ® Olé
ABC®+Olé	Anaerobic Biochem Plus® Olé
AECOM	AECOM Technical Services, Inc.
bgs	below ground surface
BSTS	bench-scale treatability study
cis-1,2-DCE	cis-1,2 – dichloroethene
CVOCs	chlorinated volatile organic compounds
DHB	*Dehalobacter spp.*
DHC	*Dehalococcoides*
DO	dissolved oxygen
DOT	Department of Transportation
ERD	enhanced reductive dechorination
EVO	emulsified vegetable oil
FS	feasibility study
ft	feet
ft/ft	feet per foot
ft/day	feet per day
ft/yr	feet per year
g/kg	grams per kilogram
IDW	investigation derived waste
ISB	in situ bioremediation
ISCR	in situ chemical reduction
ISCO	in situ chemical oxidation
ISB	in situ bioremediation
$KMnO_4$	potassium permanganate
MCLs	maximum contaminant levels
mg/L	milligrams per liter
MNA	monitored natural attenuation
msl	mean sea level
ORP	oxidation reduction potential
PSWP	Pilot Study Work Plan
psig	pounds per square inch gauge

List of Acronyms (cont'd.)

PVC	polyvinyl chloride
Redox Tech	Redox Tech, LLC
RemOx®S	RemOx®S ISCO reagent
RI	remedial investigation
ROI	radius of influence
RP-VCC	responsible party-voluntary cleanup contract
RP	responsible party
SCDHEC	South Carolina Department of Health and Environmental Control
Signify	Signify North America
SiREM	Laboratories
TCE	trichloroethene
TOD	total oxidant demand
UIC	underground injection control
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VCC	voluntary cleanup contract
VOCs	volatile organic compounds
ZVI	zero valent iron

Section 1. Introduction

The Shakespeare Composite Structures Site (the "Site"), located in Newberry, South Carolina is participating in a voluntary cleanup program with the South Carolina Department of Health and Environmental Control (SCDHEC). The Site is currently listed as responsible party – voluntary cleanup contract (RP-VCC) number RP-VCC-14-6271-RP. As part of the RP-VCC process the Site has undergone a Remedial Investigation (RI), which was completed in November 2018. The RI efforts delineated a plume of dissolved phase chlorinated volatile organic compounds (CVOCs) in Site groundwater. Based on the results of the RI, it is anticipated that an active groundwater treatment remedy will be required for at least a portion of Site groundwater. The RP for the Site [Signify North America – (Signify)] has previously conducted and will be conducting several activities that will be incorporated into a Feasibility Study (FS) for potential remedial altenatives to treat CVOC-impacted groundwater. Previously completed activities include a bench-scale treatability study (BSTS) that was conducted between September 2019 and January 2020. A BSTS Report was generated following the conclusion of the BSTS that summarized the results of the laboratory-based evaluation of multiple in situ remediation options and also recommended the performance of a field-scale pilot study.

This document serves as the Pilot Study Work Plan (PSWP) for proposed field-scale pilot study activities for Site-related CVOC-impacted groundwater. This PSWP has been developed to describe the implementation of the proposed pilot study activities and associated performance monitoring related to CVOC contamination located in shallow and intermediate zone groundwater where the highest concentrations of CVOCs have been detected during previous Site investigations CVOC impact in bedrock groundwater exists but at much lower concentrations and therefore is not addressed by this pilot study.

1.1 Facility and Site Setting

The Site is located on US Highway 76, approximately 1 mile northwest of Newberry, South Carolina **(Figure 1-1**). The Site is centered on the Valmont Composite Structures facility (the Facility, formerly known as Shakespeare Composite Structures), and includes several surrounding properties (**Figure 1-2**). The facility was originally opened to produce fiberglass products, and it has continued to be used for this manufacturing process. Operations at the facility include the design and manufacture of large fiberglass utility poles and cross arms and a variety of other fiberglass outdoor products such as posts, signs, sheet piling, and signposts. Manufacturing is conducted inside two separate buildings – the Main Building and the Pole Winder Building.

In addition to the Facility property, the Site includes several surrounding properties (**Figure 1-2**). General land use surrounding the facility consists of agricultural, residential, undeveloped, and commercial/light industrial properties (AECOM Technical Services, Inc. [AECOM], 2018).

Topography of the Site is generally flat on the Facility property. Land surface elevations generally decrease to the southwest, west, and north moving away from the Facility property. Surface elevations range from approximately 562 feet (ft) mean sea level (msl) on the east side of the Facility to less than 520 ft msl along an unnamed intermittent stream located to the north of the Facility.

A more detailed description of the facility's operation, surrounding property usage, and site topographic setting information is included in the RI Report (AECOM, 2018).

1.2 Previous Investigations

Several phases of investigative efforts have been performed at the Site. This includes multiple investigative efforts prior to execution of the VCC. The pre-VCC investigative efforts that were conducted include:

- Phase II Environmental Site Assessment – Collection of initial soil and groundwater samples from the Shakespeare facility (February through April 2014);
- Site Investigation – Collection of additional soil and groundwater samples from the Shakespeare facility along with several groundwater samples from surrounding private parcels (May 2014 through August 2014); and
- Expanded Investigation - Collection of additional shallow groundwater samples and evaluation of shallow bedrock for impacted groundwater on surrounding properties (August through September 2014).

An RP-VCC between the SCDHEC and Philips Electronics North America Corporation (PENAC) was executed in September 2014. Once this VCC was executed, additional investigative efforts were performed as part of the RI process.

The RI was implemented in two phases, beginning in 2014 after execution of the VCC. The RI was conducted to further evaluate the vertical and/or horizontal extent of previously identified CVOCs in soil and groundwater; assess additional potential areas of interest for secondary sources of VOCs that could be contributing to soil and/or groundwater impacts; evaluate potential vapor intrusion pathways; determine risk to potential human and ecological receptors; and provide additional data needed to develop a remedial strategy for the Site.

RI efforts determined that the source areas for CVOCs present in groundwater originated from historical operational practices that impacted groundwater beneath the western portions of the Main and Pole Winder Buildings located on the Facility property. CVOCs subsequently migrated both horizontally and vertically within groundwater away from the identified source areas and impacted multiple aquifer depth intervals (shallow, intermediate, and bedrock) beyond the Facility property.

In general, the water table at the Site is encountered in the fine sands and silts and clays of the residuum. Groundwater is encountered at depths ranging from approximately two ft below ground surface (bgs) near the northern end of the Site and on the Dickert property to as deep as approximately 18 ft bgs on the former Shakespeare Composite Structures facility. Groundwater beneath the Site is mainly encountered under unconfined conditions.

As a result, the direction of groundwater flow beneath this Site, particularly in the shallow (water table) zone follows topography, with flow components to the west and northwest. CVOCs have migrated within the water table and saprolite zones primarily through natural dispersion. Vertical migration downgradient of the source areas within the saprolite and into underlying granitic bedrock was influenced primarily by numerous privately-operated water supply wells located to the west and southwest of the Facility. Groundwater elevation and flow maps for the shallow and intermediate zones are provided as **Figures 1-3 and 1-4**, respectively.

Based on the groundwater elevations determined during the most recent measurement event (June 2018), the average horizontal hydraulic gradients for the shallow and intermediate zones were determined to be 0.016 feet per foot (ft/ft) to the west-northwest and 0.014 ft/ft to the west-northwest, respectively. A downward gradient between the shallow and intermediate zones was observed across the Site during the June 2018 event. During Phase II of the RI, hydraulic conductivity tests (slug tests) were conducted on select shallow and intermediate zone monitoring wells. The results of the slug tests indicated an average hydraulic conductivity of 0.80 feet per day (ft/day) and 0.72 ft/day for the shallow and intermediate zone, respectively. Based on an assumed effective porosity of 0.25, the calculated ground velocity for the shallow groundwater zone is approximately 0.05 ft/day or 18.25 feet per year (ft/yr). Using an assumed effective porosity of 0.3, the calculated ground velocity for the intermediate groundwater zone is approximately 0.03 ft/day or 10.95 ft/yr.

The RI defined the extent of CVOC-impacted groundwater at multiple aquifer depth intervals. Analytical results were screened against United States Environmental Protection Agency (USEPA) maximum contaminant levels (MCLs) to identify compounds of interest in groundwater beneath the Site. Concentrations of trichloroethene (TCE), cis-1,2 Dichloroethene (cis-1,2-DCE), and vinyl chloride (VC) exceeded their respective MCLs in several groundwater samples collected from the Site. Of these, TCE was the most frequently detected chemical in groundwater samples collected at the Site. The elevated concentrations of CVOCs are most widespread in shallow zone groundwater (upper portion of the water table aquifer). TCE and cis-1,2-DCE also exceeded their respective MCLs in one or more samples collected in the intermediate (saprolite) zone.

Because TCE was detected most frequently and at the highest concentrations in Site groundwater, the results for this compound have been used to represent the extent of impact in the shallow and intermediate groundwater zones. **Figures 1-5** through **1-6** depict the extent of TCE in shallow zone and intermediate zone groundwater beneath the Site based on data from the last site-wide monitoring event completed in June 2017.

A more detailed discussion of the results of the investigative efforts conducted at the Site to date is included in the RI Report (AECOM, 2018).

1.3 Feasibility Study Work Plan

The RI Report for the Site was submitted to the SCDHEC in November 2018 and subseqeuntly approved on February 4, 2019. Following approval of the RI Report, SCDHEC requested that Signify develop an FS Work Plan for the Site. The purpose of the FS Work Plan was to outline the proposed information that would be included in the Site FS. The cover letter for the FS Work Plan also proposed that a BSTS and subsequent pilot study should be completed prior to development of the FS. The FS Work Plan was submitted to SCDHEC on May 15, 2019 (AECOM, 2019). SCDHEC approved the FS Work Plan on June 4, 2019.

In their June 4, 2019 approval letter, SCDHEC requested that Signify submit a BSTS Work Plan by July 31, 2019. The BSTS Work Plan was approved by SCDHEC on August 23, 2019. The BSTS was subseqently implemented in September 2019.

1.4 Bench Scale Treatability Study

In order to develop a more definitive remediation plan for Site groundwater and prior to developing the FS for the Site, two potential in-situ remediation technologies for groundwater including in-situ chemical oxidation (ISCO) and enhanced reductive dechlorination (ERD) were evaluated in the BSTS as possible treatment options for the Site-related CVOCs (AECOM, 2020). ERD is an active groundwater remedial approach that can combine multiple in situ technologies to degrade CVOCs via reductive biological and/or abiotic chemical processes. In this case, ERD via in-situ bioremediation (ISB), via in situ chemical reduction (ISCR), and via a combination of both were evaluated by the BSTS.

On September 19, 2019, soil was collected from an area between monitoring wells MW-10 and MW-10I, and groundwater was collected from MW-10 and MW-10I. This area and the two monitoring wells are located just north of the Facility property on the Dickert property (**Figures 1-5 and 1-6**). Soil and groundwater samples were shipped to Redox-Tech, LLC (Redox Tech) in Cary, North Carolina for ISCO total oxidant demand (TOD) testing. Soil and groundwater samples were also submitted to SiREM Laboratories (SiREM) in Ontario, Canada for evaluation of the various ERD treatments.

The TOD evaluation was conducted to determine if native Site groundwater and saturated aquifer material would be amenable to ISCO treatment. Aquifer materials targeted for ISCO treatment that contain high natural organic carbon, high naturally reduced inorganic minerals such as iron, and elevated CVOC concentrations require higher concentrations of oxidant to effectively treat the targeted contaminants. TOD values determined in the four microcosms used for ISCO testing indicated a limited oxidant demand exerted by Site groundwater and saturated soil. TOD values for the microcosms ranged from less than 0.3 grams per kilogram (g/kg) to 2.8 g/kg, which falls within the typical range for saprolitic soils found in the Piedmont region of South Carolina. Based on these results and a subsequent discussion with Redox Tech, a TOD value of 1 to 2 g/kg was considered adequate for ISCO design purposes. Because the Site TOD value is low, these results indicated that ISCO may be a suitable remedial option to treat CVOC-impacted Site groundwater.

The BSTS for ERD evaluated the effectiveness of multiple treatment amendments for CVOC-impacted Site media including EDS-ER™ (an emulsified vegetable oil [EVO]), which promotes ISB via reductive dechlorination, MicroEVO™ (a sulfidated zero valent iron [ZVI]), which promotes abiotic ISCR, and KB- 1® Plus (a chlorinated solvent bioaugmentation microbial culture). One of the EDS-ER™ amended treatment microcosms and one of the MicroEVO™ ISCR amended treatment microcosms were also buffered using sodium bicarbonate to maintain the pH within the optimal range (i.e., 6 to 8 standard units) for reductive dechlorination to occur.

Based on the results of the BSTS, it was determined that the microcosm with buffered EVO that was amended approximately 40 days after initiation of testing with KB- 1® Plus was able to completely degrade the TCE in Site groundwater. The microcosms containing sulfidated ZVI saw an immediate decrease in TCE to approximately half of its initial concentration; however, bioaugmentation was required to promote further reduction in the concentration of TCE. VC remained in this sulfidated ZVI microcosm at the conclusion of the BSTS in January

2020. It was subsequently surmised that sulfidation of the ZVI likely interfered with the complete reduction of TCE to ethene and that non-sulfidated ZVI would likely be more effective.

Based on the results of the BSTS, both ISCO and ERD using a combination of ISB and ISCR were determined to be potentially applicable remediation technologies that could be used to address CVOC contamination in Site groundwater. A field-based pilot study was recommended as the next logical step in order to evaluate effectiveness, implementability, and cost associated with full-scale implementation of one or both technologies.

In their June 15, 2020 approval letter, SCDHEC reviewed and concurred with the BSTS results and recommendation for the completion of a pilot study at the Site. SCDHEC requested that Signify submit a PSWP by August 15, 2020. Signify subsequently requested an extension to complete the PSWP. A due date extension to October 2, 2020 was approved by SCDHEC on August 24, 2020.

Section 2. Pilot Study Location, Design, and Implementation

The following subsections describe the proposed pilot study location, design, and implementation procedures.

2.1 Pilot Study Location

Because both ISCO and ERD (using ISB and ISCR) are potentially applicable treatments for CVOCs in Site groundwater, the proposed pilot study will consist of separate pilot study areas. Based on the 2017 CVOC concentrations detected in shallow and intermediate zone groundwater, two areas were identified for the pilot study. One pilot study area is located within the eastern end of the Main Building near monitoring well TMW-31 and will be used to conduct the ISCO pilot study. The objective of the proposed ISCO pilot study is to decrease the TCE concentration in the shallow groundwater zone within this area using a strong chemical oxidant. **Section 2.2** describes the injection design and the amendment to be used to achieve the ISCO pilot study objective. The amendment will be injected through temporary points using direct-push technology (DPT) to treat the targeted shallow groundwater. Flow direction in shallow zone groundwater near TMW-31 is to the west-northwest (**Figure 1-3**). Site monitoring well construction details are provided in **Table 2-1**.

Figure 2-1 shows the ISCO pilot study area and the proposed DPT injection locations. It should be noted that a source area located in the western end of the Main Building was initially identified for the ISCO pilot study, however, this location is in the middle of a production area with high traffic and limited access. Another potential location near MW-8 located outside of the western end of the Main Building was also identified; however, without treatment of the source area within the vicinity of TMW-21 and TMW-22, ongoing impact from the upgradient source to downgradient groundwater at MW-8 would likely occur, and the effectiveness of the pilot study would be difficult to accurately evaluate. As a result, the area near TMW-31 was selected for the ISCO portion of the pilot study.

The ERD pilot study area is proposed to be conducted north of the Pole Winder Building across the railroad tracks on the Dickert Property. The objective of the proposed ERD pilot study is to decrease the concentration TCE in the shallow and intermediate groundwater zones within the vicinity of monitoring wells MW-10 and MW-10I. The ERD pilot study will include the concurrent injection of an organic carbon substrate and ZVI into the targeted shallow and intermediate zone groundwater to create strongly anaerobic and reducing conditions suitable for enhanced ISB and ISCR of the Site-related CVOCs in groundwater. Additional amendments including a pH buffer, additional nutrients, and a bioaugmentation culture will be used to enhance the ISB component of ERD. The ERD substrate and amendments will be delivered to the subsurface via DPT injection.