51377

Westinghouse

CD Scanned
PM Copy

Westinghouse Electric Company
Nuclear Fuel
Columbia Fuel Fabrication Facility
5801 Bluff Road
Hopkins, South Carolina 29061
USA

RECEIVED
JUN 18 2019
SITE ASSESSMENT, REMEDIATION & REVITALIZATION

SCDHEC, BLWM
Kim Kuhn
2600 Bull Street
Columbia, SC 29201

Direct tel: 803.647.1920
Direct fax: 803.695.3964
e-mail: joynerdp@westinghouse.com

Your ref:
Our ref: LTR-RAC-19-44

June 18, 2019

Subject: FINAL Remedial Investigation Work Plan Submission

Mrs. Kuhn:

Please find attached the FINAL Remedial Investigation (RI) Work Plan submitted to comply with Item 1 of Consent Agreement 19-02-HW. The FINAL work plan addresses the comments provided by the Department in its May 24, 2019 response letter to the draft submission by Westinghouse on April 26, 2019. The table below provides a cross-reference for the Department's comments and the associated section in the FINAL work plan where the comment was addressed.

Final RI Work Plan Section	Final RI Work Plan Page #	Revision Purpose	DHEC Comment #
Cover page and header	Entire document	Added "Final" to the document title.	Not applicable
3.5.6	10	Revised designation of monitoring well W-19 to W-19 B to correspond with the figures.	Not applicable
3.5.6	11	Added a paragraph about the additional lithologic borings.	5
3.5.7	11	Revised the Tc-99 soil sampling depths and specified the analytical method.	1, 2
3.5.8	12	Clarification about which departments within DHEC will receive copies of the sediment characterization plan for the East Lagoon.	7
3.5.12	13	Added a paragraph about additional future sediment and surface water sampling.	4
3.5.13	13	Added a paragraph about staff gauges.	3

102

3.5.15	14	Added a sentence and table of the analysis parameters should water supply wells be sampled.	6
4 and 4.1	15	Revised the number of lithologic borings and TC-99 soil samples to be collected.	Not applicable
4.3.1	15	Revised the introductory paragraph to be clearer about the soil borings.	Not applicable
4.3.1.1	16	Added subsection 4.3.1.1 to explain the Tc-99 hand augered soil borings versus the other types of borings in the Work Plan.	Not applicable
4.3.1.2	16	Provided clarification about soft clearing necessary for safety reasons. Also, revised the number of lithologic borings.	Not applicable
4.10	20	Added soil to the list of media being analyzed.	Not applicable

Respectfully,

Diana P. Joyner
Principal Environmental Engineer
Westinghouse Electric Company, CFFF
803.497.7062 (m)

Cc: N. Parr, Environmental Manager
E. Wills, EH&S Manager
J. Pricener, Counsel for Environmental Health & Safety
J. Grant, AECOM Project Manager
ENOVIA Records

Enc.: "FINAL Remedial InvestigationWork Plan, Westinghouse Columbia Fuel Fabrication Facility", AECOM, June 18, 2019.
Hard copy and electronic media

S1377

AECOM Imagine it. Delivered.

RECEIVED

JUN 18 2019

SITE ASSESSMENT, REMEDIATION & REVITALIZATION

CD Scanned PM Copy

Final Remedial Investigation Work Plan Westinghouse Columbia Fuel Fabrication Facility

Consent Agreement #19-02-HW
5801 Bluff Road
Hopkins, South Carolina 29061

June 2019

102

Quality information

Prepared by	Prepared by	Reviewed by
Jeremy Grant, P.G. Sr. Project Manager	Chuck Suddeth, P.G. Sr. Project Manager	Scott Ross, P.G. Sr. Project Manager

Prepared by:

AECOM
101 Research Drive
Columbia, SC 29203
aecom.com

Table of Contents

Tables

Figures

Appendices

List of Acronyms

AECOM	AECOM Technical Services, Inc.
AOC	Area of Concern
ASTM	ASTM International
BLS	below land surface
BRA	Baseline Risk Assessment
CA	Consent Agreement
CaF_2	calcium fluoride
CD	compact disk
CFFF	Columbia Fuel Fabrication Facility
COC	chain of custody
COPC	constituent(s) of potential concern
COPEC	constituent of potential ecological concern
CSM	Conceptual Site Model
CWW	Contaminated Wastewater
DHEC	South Carolina Department of Health and Environmental Control
DI	deionized
DNR	South Carolina Department of Natural Resources
DO	dissolved oxygen
DOE	United States Department of Energy
DOT	Department of Transportation
DPT	direct push technology
EPA	United States Environmental Protection Agency
EML HASL	Environmental Measurements Laboratory Health and Safety Laboratory
ERA	Ecological Risk Assessment
FBQSTP	Field Branches Quality System and Technical Procedures
FSP	field sampling plan
GEL Labs	GEL Laboratories, LLC
GPS	Global Positioning System
GW	Groundwater
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
HF	hydrofluoric acid
HHRA	Human Health Risk Assessment
HSA	hollow stem auger
ID	identification
IDW	investigation derived waste
MCL	maximum contaminant level
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
NAD-83	North American Datum of 1983
NAVD	North American Vertical Datum
NPDES	National Pollution Discharge Elimination System
NPL	National Priority List
NRC	Nuclear Regulatory Commission
NTUs	Nephelometric Turbidity Units
ORP	oxidation-reduction potential
OU	Operational Unit
OVA PID	organic vapor analyzer photoionization device
PBRA	Preliminary Baseline Risk Assessment
PCE	tetrachloroethene
pCi/L	picocuries per liter
PPE	personal protective equipment
PPM	parts per million

PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RI	remedial investigation
RSL	Regional Screening Level
Rust	Rust Environment and Infrastructure
S&ME	Soil and Material Engineers
SC	South Carolina
SCRDI	SCRDI Bluff Road
SED	sediment
SESD	EPA Region IV Science and Ecosystems Support Division
Shealy	Shealy Environmental Services, Inc.
SOLX	solvent extraction
SU	Standard Unit
SW	surface water
TMS	Tax Map Series
Tc-99	Technetium-99
TCE	trichloroethene
TCL	target compound list
U	uranium
UF_6	uranium hexafluoride
UN	uranyl nitrate
USCS	Unified Soil Classification System
VOCs	volatile organic compounds
Westinghouse	Westinghouse Electric Company, LLC
WWTP	wastewater treatment plant

1. Introduction

The South Carolina Department of Health and Environmental Control (DHEC) and Westinghouse Electric Company, LLC (Westinghouse) Columbia Fuel Fabrication Facility (CFFF) entered into Consent Agreement (CA) 19-02-HW on February 26, 2019 for CFFF located at 5801 Bluff Road (property) in Hopkins, South Carolina (SC; **Figure 1**). CFFF manufactures and assembles fuel assemblies and components for the commercial nuclear power industry.

As a result of historical operations and the need to further assess potential environmental impacts, DHEC and CFFF entered into the CA. The CA requires further assessment and potential remediation of constituents of potential concern (COPC).

Condition 1 of the CA specifies that CFFF prepare a Remedial Investigation (RI) Work Plan that presents a comprehensive approach for the evaluation of property groundwater, surface water, sediment, and soil quality; sufficient to assess the full nature and extent of COPC. The CA also specifies that the RI Work Plan include a Conceptual Site Model (CSM) reflecting CFFF's current understanding of site hydrogeology, known COPC sources, potential migration pathways, along with a summary of potential risks to human health and the environment. The CSM is presented in **Section 3**.

This RI Work Plan has been developed by a technical team consisting of personnel from Westinghouse, AECOM Technical Services, Inc. (AECOM), GEL Engineering LLC, and Leidos. The planned assessment activities presented in this RI Work Plan will evaluate the environmental condition of soil, groundwater, surface water, and sediment as part of a phased approach to fulfill the requirements of the CA.

CFFF will initiate this comprehensive evaluation upon DHEC's approval of the RI Work Plan as documented in **Section 7**. As specified in the CA, the results of the RI investigation will be evaluated to assess the need for further assessment and/or remedial activities. Should the analytical results from this scope of work or future remedial design efforts indicate that source area assessment is required; an additional work plan proposing source area soil sampling will be submitted to DHEC.

1.1 Site Location and Physical Setting

The CFFF property is located on Bluff Road (SC Highway 48) approximately 15 miles southeast of Columbia, SC and includes approximately 1,200 acres as identified by Richland County Tax Map Series (TMS) numbers 18600-01-01 and 18601-01-02. The property is surrounded by rural forested and agricultural property. **Figures 1 through 3** illustrate the site features discussed below.

The primary plant building is located approximately 2,700 feet southwest of Bluff Road on the northern portion of the property. The wastewater treatment plant (WWTP) is located near the southwest corner of the plant building. Treated wastewater is piped to the Congaree River where it is discharged under National Pollution Discharge Elimination System (NPDES) permit SC0001848 from a diffuser located along the bottom of the river at a location approximately three miles south of the developed portion of the property.

The SCRDI Bluff Road (formerly known as South Carolina Recycling and Disposal, Inc.) site is located across Bluff Road from the northern property boundary. According to information on the internet (Justia US Law – law.justia.com), hazardous waste storage began on this property in late-1973 or early-1974 and operations ceased in 1982. This property was placed on the United States Environmental Protection Agency's (EPA) Superfund program's National Priority List (NPL) in 1983. Releases at SCRDI are not known to have impacted CFFF but the potential for impacts related to this facility will be further evaluated as part of this assessment.

Based on topographic data depicted on **Figure 1** and on-site survey data, the elevation of the developed area of the property is approximately 130-140 feet above mean sea level (MSL). Elevations drop to approximately 110 feet above MSL immediately south of the plant/WWTP area, on the Congaree River floodplain and Mill Creek, a tributary of the Congaree River. The change in elevation occurs abruptly along a bluff that defines the northeastern edge of the floodplain.

A manmade pond (Gator Pond) that pre-exists CFFF is located approximately 500 feet southwest of the WWTP within a step down area of the bluff. The pond is fed by a spring and does not have a constructed spillway. Water discharges from the pond through groundwater seepage or overland flow during periods of high precipitation.

Upper and Lower Sunset Lakes are located west and south of the pond and approximately 900 feet southwest of the WWTP. Sunset Lakes are located within a natural oxbow of Mill Creek. A manmade dam approximately 1,700 feet south of the WWTP backs up water in Mill Creek, creating Lower Sunset Lake. A second manmade dam cuts across Mill Creek approximately 1,000 feet southwest of the WWTP, creating Upper Sunset Lake.

The southern portion of the property, including the pond, Mill Creek, and Sunset Lakes are located within the floodplain of Mill Creek and the Congaree River. Surface drainage at the site flows toward several drainage ditches across the property and surrounding areas. These ditches flow into upstream areas of Mill Creek (approximately 3,000 feet west of the plant) and Upper Sunset Lake (approximately 1,500 feet west of the plant).

1.2 Site Operational Background

The CFFF was constructed in 1969. Prior to construction the property consisted of farmland and woodlands. The main manufacturing activity is the fabrication of low-enriched uranium (U) fuel assemblies and components for the nuclear power industry. The manufacturing process generates multiple wastewater streams which are treated by various physical/chemical/biological processes and in WWTP lagoons prior to discharge to the Congaree River under a NPDES permit issued by DHEC.

Releases of COPC have occurred from the wastewater treatment system, manufacturing operations and past activities performed since 1969. CFFF has assessed known releases and installed an extensive groundwater monitoring system beginning in the early 1980s. Assessment activities conducted to date have determined that releases have impacted soil and groundwater in locations largely confined to the immediate plant area. Various remediation efforts have been undertaken in response to the identified releases. Based upon historical and current groundwater and surface water analytical results, no off-site impacts are known or believed to have occurred. **Appendix A** includes a summary of previous assessment and remediation activities.

1.3 Remedial Investigation Objectives

One objective of this RI is to assess the vertical and horizontal extent of COPC in groundwater, and the occurrence of COPC, if any, in surface water, sediment and soil. A second objective is to establish that there are no ongoing releases of COPC. The RI Report will summarize the investigative efforts and discuss the results for each media evaluated during the process. The RI Report will also include a summary of the human health and ecological risks as assessed by the Baseline Risk Assessment (BRA) performed at the completion of the RI. The BRA will be included as an appendix to the RI Report. The RI and risk evaluation information will be used to determine the need for further focused assessment activities as well as consider an appropriate remedy as part of a future Feasibility Study.

1.4 Remedial Investigation Work Plan Organization

This RI Work Plan is organized in the following sections:

- Section 2 – Facility Operating Units
- Section 3 – Conceptual Site Model and Data Needs
- Section 4 – Assessment Activities
- Section 5 – Key Project Personnel
- Section 6 – Reporting
- Section 7 – Project Schedule

2. Facility Operational Units

Based upon current and historical operations, the facility has been divided into eight operational units (OUs). These OUs are: the Northern Storage Area, the Mechanical Area of the plant building, the Chemical Area of the plant building, West Lagoons Area, Primary Wastewater Treatment Area, Sanitary Lagoon Area, Southern Storage Area, and Western Storage Area. One area of concern (AOC), entitled the “Western Groundwater AOC”, has also been identified. These OUs and AOC are described further below and are displayed on **Figures 4 through Figure 7**. Additional information such as bulk chemicals stored in each OU is displayed in **Table 1**.

2.1 Northern Storage Area Operational Unit

Storage located in the Northern Storage Area OU includes final product shipping containers, radioactive waste intermodal containers awaiting shipment, and drums of lubricants and flammable liquids in the Oil House. Operations include refurbishment of shipping containers. COPC in this area are volatile organic compounds (VOCs) and U.

2.2 Mechanical Area Operational Unit

Manufacturing operations conducted in the Mechanical Area of the plant building include fuel rod inspection and storage, final assembly and storage, packaging, tube preparations, machining and tooling operations, grid fabrication, skeleton assembly, non-fuel component fabrication, and shipping and receiving. There is a small nickel plating operation within the Mechanical Area for coating grid straps for certain fuel designs. Containerization and off-site shipment of plating waste materials began in May of 2012 after the sump in the plating process area was refurbished. Maintenance operations within the Mechanical Area OU use fuel oil, mineral spirits, and cutting oil. COPC within the Mechanical Area include nickel, nitrate, and VOCs.

2.3 Chemical Area Operational Unit

Manufacturing operations conducted in the Chemical Area of the plant building include U conversion, powder blending, pellet manufacturing, including nuclear absorber addition, fuel rod loading, analytical services laboratory, and Uranium Recovery and Recycle Services (URRS). URRS operations include cylinder washing, incineration, U dissolution and purification through solvent extraction, and waste disposal preparations. There are two different feed materials used in the plant building for the uranium conversion process. One feed material, uranium hexafluoride (UF_6), is contained in cylinders and is heated from a solid to a gaseous state. The other feed material, liquid uranyl nitrate (UN), is “spiked” with hydrofluoric acid (HF) in a batch operation. Above ground and underground piping in the Chemical Area OU conveys wastewater to the Wastewater Treatment Area OU.

Bulk chemical storage tanks containing UN and HF, small chemical drum storage containing tetrachloroethene (PCE) and kerosene used in the solvent extraction process, deionized water (DI) processing, and other miscellaneous operations are located outside of the plant building within the Chemical Area OU. CFFF records describe historic releases in this OU, including the most recent HF spiking station leak, Contaminated Waste Water line leaks and uranyl nitrate spills. COPC within the Chemical Area include VOCs, U, Tc-99, nitrate, ammonia, and fluoride.

2.4 Wastewater Treatment Area Operational Unit

Two lined settling ponds (North and South Lagoons), one process wastewater pond (East Lagoon), a sodium silicate (Waterglass) wastewater treatment process to treat U-contaminated, ammoniated wastewater from the conversion process, and several storage tanks exist in the Wastewater Treatment Area OU. The North and South Lagoons were relined from January through February 2012 with 80-mil High Density Polyethylene (HDPE). The East Lagoon was last relined in the 1980’s when the Waterglass process was installed. The liner is constructed of 36-mil Hypalon®. There is a significant quantity of U-contaminated sediment that has settled in the East Lagoon.

The North and South Lagoons receive treated wastewater from the West I and West II Lagoons. Operations in the West Lagoons Area OU are described in **Section 2.4**. Treated liquid process waste from the North or South lagoon is mixed with treated sanitary wastewater in an underground pipe prior to transfer into the facility lift station. The combined waste is then passed through a final aerator, followed by dechlorination and pH adjustment as required and subsequently pumped to the Congaree River via a 6-inch pipeline. The discharge location of this pipeline is shown on **Figure 1**.

The Waterglass wastewater treatment process includes removal of residual U from ammoniated wastewater originating in the Chemical Area OU through flocculation and filtration. The filtered wastewater contains less than 0.2 parts per million (PPM) U. Following U removal, lime is added and the wastewater is processed through a distillation column to remove and recover ammonia and fluoride.

The East Lagoon currently receives non-SNM liquid inputs such as effluent from the Deionized Water Building and rainwater from containment areas such as the chemical tank farm. The East Lagoon is monitored for pH and liquid level and is sampled for fluoride, ammonia and Total Suspended Solids (TSS). Once full, the East Lagoon is pumped to either the North or South Lagoon. Before the North or South Lagoon is discharged, a four corner sample is taken and analyzed for pH, TSS, ammonia, fluoride and activity. The East Lagoon also provides extra capacity for overflow from other lagoons or for containment in the event of a spill or emergency. Past practices associated with East Lagoon operations included the introduction of materials containing low level, radiological contamination. Because of these past practices, sediment in the East Lagoon is contaminated with U. Characterization of the East Lagoon sediment is included in this initial work plan.

Storage vessels in the Wastewater Treatment Area include tanks of nitric acid, sodium silicate, calcium oxide and calcium hydroxide, totes of sulfuric acid and nitric acid, tanks of contaminated ammoniated wastewater, and drums of Waterglass solids, containing ammonia and U.

COPC within the Wastewater Treatment Area include U, Tc-99, fluoride, nitrate, and ammonia.

2.5 West Lagoons Area Operational Unit

Two lined settling ponds exist within the West Lagoons area. These lagoons were relined from December 2008 through February 2009 with 80-mil HDPE. West II Lagoon receives treated wastewater from the Waterglass and solvent extraction (SOLX), U removal processes and still bottoms from ammonia distillation. The effluent from West II Lagoon flows to West I Lagoon. In both lagoons, calcium fluoride (CaF_2) solids settle out from the treated wastewater. Periodically, the settled CaF_2 solids are removed through a dredging and dewatering campaign. Removed CaF_2 is stored on a concrete pad adjacent to West II Lagoon prior to shipping off-site for recycling into cement or use in brick manufacturing operations. Runoff from the CaF_2 pad is collected in a drainage system and returned to West II Lagoon. COPC within the West Lagoons Area include VOCs, U, Tc-99, nitrate, ammonia, and fluoride.

2.6 Sanitary Lagoon Area Operational Unit

Site sanitary sewage, including potentially contaminated sanitary wastewater from showering and handwashing in the Chemical Area OU is treated in an extended aeration package plant prior to discharge to a polishing lagoon. U is captured in biosolids within the sanitary lagoon and shipped offsite for burial. The Sanitary Lagoon was installed in 1968 and is not lined. The discharged effluent is chlorinated and mixed with treated liquid process waste in the Wastewater Treatment Area. COPC within the Sanitary Lagoon Area OU are U and Tc-99.

2.7 Southern Storage Area Operational Unit

Miscellaneous activities exist within the Southern Storage Area such as onsite emergency response operations; storage buildings containing new, spare and surplus process equipment; Sea Land containers with inventory stored for U recovery and with excess equipment; UF_6 cylinder recertification; and UF_6 cylinders that are empty or contain only heel quantities of material. Past operations included a storage pad where low-level radioactive material was stored for off-site disposal. This OU currently stores fuel oil, gasoline and used oil tanks and drums of coolant and paint. COPC within the Southern Storage Area OU include VOCs, fluoride, U and Tc-99.

2.8 Western Storage Area Operational Unit

Bulk chemical storage (e.g., ammonium hydroxide, fuel oil #2, and sodium hydroxide), UF_6 cylinder storage, hazardous waste storage and respirator cleaning operations exist in the Western Storage Area OU. In addition, a former oil house was located in this area. COPC within the Western Storage Area OU include fluoride, U, Tc-99, nickel, nitrate, ammonia and VOCs.

2.9 Western Groundwater Area of Concern

The Western Groundwater AOC is defined as the area around monitoring well W-19. Groundwater from monitoring well W-19 contains concentrations of PCE above its maximum contaminant level (MCL). There are currently no known facility operations in this area, hence this area being referred to as an AOC. Monitoring well W-19 is approximately 1,100 feet west northwest of West II Lagoon.

3. Conceptual Site Model and Data Needs

3.1 Conceptual Site Model Setup

A CSM has been developed by AECOM for the CFFF that includes the current understanding of site hydrogeology, known contamination sources and potential pathways of contaminant releases. The CSM uses existing data as well as other readily available information such as topographic data, underground utility locations and depth, and information regarding leaks and spills that have occurred at the site. The purpose of the CSM is to graphically illustrate site surface and subsurface conditions, including but not limited to subsurface utilities and geology, in a manner that facilitates understanding of COPC origin (source(s)), fate, and transport. The CSM also facilitates identification of data needs. As these data needs are filled, the CSM will be updated, thereby serving as a living document.

A detailed description of the CSM setup and selected outputs of the current CSM, known as Rev 0, is contained in **Appendix B**. **Table 2** illustrates the CSM input categories, their associated phases, and corresponding sources. Data gathered during this assessment will be used to update the CSM for inclusion in the RI Report.

3.2 Geology

The CFFF is located in the Upper Coastal Plain physiographic province. The Upper Coastal Plain of SC is bounded to the southeast by the Orangeburg Scarp and by the crystalline rocks of the Piedmont province to the northwest. The sedimentary units of the Coastal Plain form a wedge of accumulation that thickens from the fall line to the coast. These units directly overlie crystalline basement (bedrock) composed of metamorphic and igneous rock.

The Congaree River floodplain has completely eroded away the surficial aquifer at the site and sediments deposited within the flood plain are younger (Holocene) than those above the bluff (Pleistocene). Due to the thickness and depth below land surface of the Black Mingo confining clay, the Congaree River did not erode through this clay layer (South Carolina Department of Natural Resources [DNR], 2011).

Beneath the surficial aquifer and Congaree River deposited sediment is a confining bed composed of dry silt/clay and brittle shale of the upper Black Mingo Formation. Beneath the clay confining unit is an artesian sand aquifer within the lower Black Mingo Formation known as the Black Mingo aquifer. There are currently three monitoring wells (W-3A, W-49, and W-50) screened within the Black Mingo aquifer. Previous geologic cross sections (AECOM, 2013) indicate that the Black Mingo confining bed ranges in thickness from 39 feet at monitoring well W-3A to 83 feet at monitoring well W-50. Geologic cross sections are in **Appendix B**.

The Middendorf Formation occurs below the Black Mingo Formation, overlies bedrock and also contains artesian sand aquifers. Sediments of the Middendorf Formation generally consist of multi-colored clay interbedded with fine to coarse grained sand. Previous subsurface investigations have not extended into the Middendorf aquifer. Bedrock occurs at a depth of approximately 500 feet in the area of the CFFF (Colquhoun et al., 1983).

3.3 Hydrogeology

The sediments occurring beneath the site can be divided into four hydrogeologic units: surficial aquifer, floodplain sediment aquifer, Black Mingo aquifer, and Middendorf aquifer. The uppermost hydrogeologic unit is sediments of the Okefenokee Formation (Colquhoun, 1965) referred to as the surficial aquifer at the site. According to the DNR Geologic Survey Fort Jackson South Geologic Quadrangle map, surficial aquifer sediments are Pleistocene age terrace material consisting of mixtures of alluvial clay and poorly sorted silty fine to coarse sand with subrounded granules and gravel. This Okefenokee Formation may contain remnants of preserved channel morphology and other fluvial landform scars (DNR, 2011). It is likely that there is a hydraulic connection between the Okefenokee Formation and the Congaree River floodplain sediments and/or surface water in Sunset Lakes.

Surficial aquifer sediments generally occur to a depth of 20 to 40 feet at the plant site, depending on topography, and can be differentiated into an upper firm clayey, silty sand unit (10 to 20 feet thick) and a lower loose sand and silty sand unit (also 10 to 20 feet thick). Groundwater in the surficial aquifer occurs under unconfined (water table) conditions where the water table generally is a subdued replica of the topography. Thus, groundwater in the surficial aquifer generally flows from areas of higher topography in the vicinity of the plant building towards areas of lower topography in the floodplain of the Congaree River and its local tributary, Mill Creek.

For the purpose of discussion about existing groundwater monitoring wells within the surficial aquifer above the bluff, there are two categories of screened intervals: upper surficial aquifer and lower surficial aquifer. Lower surficial aquifer monitoring wells are screened at depths within five feet of the top of the Black Mingo confining clay. All other monitoring wells within the surficial aquifer are upper surficial aquifer monitoring wells.

Based upon data collected during previous investigations, groundwater in the upper surficial aquifer can be inferred to flow toward the southwest in western areas of the site, including the vicinity of the WWTP lagoons. The upper surficial groundwater flow direction shifts toward the south with components of flow to the southeast in areas south of the plant building.

Groundwater flow in the lower surficial aquifer varies in direction from northwest to west to southwest. Groundwater within the lower surficial aquifer flows toward the southwest in areas west and south of the sanitary lagoon, similar to groundwater flow in the upper surficial aquifer. However, groundwater flow within the lower surficial aquifer diverges from flow direction of the upper surficial aquifer to a western and slightly northwestern direction in areas near and west of West II Lagoon.

Groundwater flow in the Black Mingo aquifer is inferred to be to the southwest based upon groundwater elevations from the three monitoring wells that are screened within this aquifer. Recent historical potentiometric surface maps for the upper surficial aquifer, lower surficial aquifer, and Black Mingo aquifer are contained in **Appendix C**.

Based upon previous hydraulic characterization, the average linear flow velocity in the surficial aquifer was estimated to be 0.42 feet per day or 153 feet per year. The potential for flow between the surficial aquifer and the Black Mingo aquifer was assessed to be downward at vertical hydraulic gradients ranging between 0.04 and 0.1 feet per feet respectively for the 1995 and 2013 water level data (Rust Environment and Infrastructure [Rust], 1995 and AECOM, 2013). However, low moisture content and low vertical hydraulic conductivities (less than 10^{-7} centimeters per second; Soil and Material Engineers [S&ME], 1982) throughout the 39 to 83 foot thickness of the Black Mingo confining clay preclude significant transfer of fluid between the surficial aquifer and the Black Mingo aquifer.

There is a dynamic relationship between surface water in the ditches that transect the site and groundwater in the surficial aquifer. The bottom of the northern portions of the ditches is often above the water table and thus the ditches at these locations are dry, as demonstrated during previous surface water and sediment sampling (Rust, 1995). Runoff from precipitation that enters the dry portions of the ditches may infiltrate to the water table, temporarily recharging the surficial aquifer. The bottom of the southern portions of the ditches is below the water table and continually receives discharge of groundwater from the surficial aquifer. Middle portions of the ditches may recharge the shallow aquifer during low water table conditions and may receive groundwater discharge during high water table conditions.

Currently there are only two monitoring wells installed within the floodplain of Congaree River; therefore additional data will be collected to better understand subsurface stratigraphy and hydrogeology in the floodplain.

3.4 Summary of the Preliminary Baseline Risk Assessment

3.4.1 2014 Preliminary Baseline Risk Assessment

A Preliminary Baseline Risk Assessment (PBRA) was prepared by AECOM (AECOM, 2014). The PBRA included the initial steps of the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (ERA). The preliminary steps included evaluation of the exposure setting, development of a preliminary conceptual site model, and conservative screenings of recent data collected at the site.

Data used for the HHRA evaluation included groundwater, surface water, and sediment to assess potential complete exposure pathways for current and future land use (assumed to remain industrial). A complete pathway includes: (1) a chemical source and release mechanism, (2) a transport or retention medium, (3) an exposure point where human contact with the impacted medium occurs, and (4) a route of intake for the COPC into the body at the exposure point.

The following potentially complete exposure pathways were identified by the HHRA:

- Exposure to groundwater COPC via vapor intrusion for current or future workers in a building located above or near (within approximately 100 feet horizontally or vertically) where VOCs have been detected in shallow groundwater (i.e., the uppermost saturated zone).
- Exposure to site-related COPC in surface water and sediment for current or future maintenance workers while maintaining the drainage ditches through the western side of the facility. Potential exposure routes for both media include incidental ingestion and dermal absorption.

Detected analytes that were evaluated by the HHRA process include VOCs, gross alpha, gross beta, ammonia, fluoride, and nitrate. Three VOCs (cis-1,2-dichloroethene, PCE, and trichloroethene [TCE]) and gross alpha in groundwater were identified as warranting designation as COPC. No human health COPC were designated in surface water or sediment of the ditches, streams, and ponds.

For the ERA, ecological receptors were considered to be aquatic organisms with the greatest potential for contact with surface water and sediment (i.e., fish and benthic invertebrates, respectively). Preliminary chemicals of potential ecological concern (COPEC) initially identified by conservative screening of surface water and sediment from water bodies on the property were 2-butanone, acetone, methyl acetate, and nitrate in surface water and ammonia, fluoride, and gross alpha in sediment. These were further evaluated using readily available lines of evidence. This evaluation determined that the preliminary COPECs initially identified do not have the potential to pose significant risk to ecological receptors. Therefore, none of the chemicals in surface water or sediment warranted designation as COPECs, and further evaluation of ecological risk was deemed to not be needed.

3.4.2 2019 Preliminary Human Health Risk Assessment

AECOM prepared an updated HHRA for CFFF (AECOM, 2019). The chemicals that were the focus of the 2019 analysis were identified as COPC during previous investigations. It should be noted that in 2018 the CFFF revised its environmental monitoring program to require analysis of groundwater for U and Tc-99 in addition to alpha and beta indicator parameters (gross alpha and gross beta). U is the alpha emitter from site, and Tc-99 is the beta emitter.

The following data was evaluated in the 2019 HHRA:

- Groundwater data from the October/November 2018 and December 2018 sampling campaigns from 38 shallow wells. Constituents analyzed included VOCs (cis-1,2-dichloroethene [cis-1,2-DCE], PCE, TCE, chloroform, 1,1-biphenyl, carbazole, naphthalene, phenanthrene, and carbon disulfide); inorganics (fluoride, ammonia, and nitrate); and radionuclides (gross alpha, gross beta, U, and Tc-99). Groundwater location W-24 was considered a background location not affected by site activities.
- Surface water samples collected monthly from six locations on the CFFF property (entrance, roadway, causeway, pond, spillway, and exit). These samples were analyzed for gross alpha and gross beta. Surface water samples were collected for analysis of fluoride from five of these locations monthly (entrance, roadway, causeway, spillway, and exit; **Figure 2**) and from three of these locations weekly (roadway, causeway, and spillway; **Figure 2**). In addition, surface water samples were collected monthly from four locations on the Congaree River (at the Blossom Street Bridge, above the facility's NPDES discharge (**Figure 1**), below the discharge, and where Mill Creek joins the river) and analyzed for gross alpha and gross beta. Monthly data for the year 2018 were evaluated.
- Soil and vegetation samples collected twice annually at four locations around the perimeter of the CFFF property. These samples were analyzed for total U, gross alpha, and gross beta. None of these sample locations are considered background. Data from the two most recent samples (2018) were evaluated.
- Sediment and fish tissue samples collected once annually at or near the location of the NPDES permitted effluent discharge from the CFFF into the Congaree River. These samples were analyzed for isotopic U, gross alpha, and gross beta. Data from the two most recent samples (2017 and 2018) were evaluated.

Based upon the 2019 evaluation, the following results were indicated:

- No preliminary COPC were designated in surface water.
- U was not identified as a preliminary COPC in surface soil because its maximum detected activity, when converted to a concentration, did not exceed its screening value, which was a residential soil regional screening level (RSL) based on a hazard quotient of 0.1.

- In the absence of a screening value for U in vegetation, the residential soil RSL also was used for vegetation and was not exceeded. Therefore, U was not identified as a preliminary COPC in vegetation.
- U was not identified as a COPC in river sediment because its maximum detected activity, when converted to a concentration, did not exceed its screening value.
- U was not identified as a COPC in fish tissue from the Congaree River because its maximum detected activity, when converted to a concentration, did not exceed its screening value.
- The radionuclides U, Tc-99, gross alpha, and gross beta were identified as COPC in groundwater because their maximum detected concentrations (U) or activities (Tc-99, gross alpha, and gross beta) exceeded their screening values. Because site groundwater is not used for regular long-term use of water for drinking and bathing purposes under current conditions and is unlikely to be used for such purposes in the future, this screening is very conservative.
- The USEPA Vapor Intrusion Screening Level Calculator was used to identify vapor intrusion COPC in groundwater. Chloroform, PCE, TCE, 1,1-biphenyl, and ammonia were identified as vapor intrusion preliminary COPC in groundwater for a hypothetical residential exposure scenario.

3.5 Additional Data Needs

Based on the CSM, the following data needs for the CFFF have been identified:

- Background groundwater quality;
- Horizontal and vertical extent of uranium in groundwater;
- Chemical Area OU perimeter groundwater quality;
- Groundwater flow direction east of the plant building;
- Upgradient extent of VOCs;
- Extent of VOCs in the Western Groundwater AOC;
- Source and extent of Technetium-99;
- Characterization of East Lagoon sediment;
- Congaree River floodplain geology;
- Hydraulic characteristics of floodplain sediments;
- Downgradient extent of the COPC plumes;
- Sediment and surface water quality within the ditches, pond, and lakes;
- Bathymetry of the on-site pond and Upper/Lower Sunset Lakes;
- Depth to the confining clay near West II Lagoon;
- Updated Human Health and Ecological Risk Assessment.

To fulfill the additional data needs, multi-media sampling will be conducted to include collection of groundwater, surface water, sediment, and soil samples. Lithologic borings will also be installed to assess the subsurface geology and update the CSM. Environmental samples will not be obtained from the lithologic borings. Specific information about how these additional data needs will be addressed is discussed in **Sections 3.5.1 through 3.5.14**.

A summary of the groundwater monitoring wells proposed to be installed, the target aquifer for each monitoring well, the approximate depth and screen length of each monitoring well, the list of groundwater analytes, and the rationale for each monitoring well are in **Table 3**. A summary of the proposed sediment and surface water sample locations, the list of surface water and sediment analytes and the rationale for each sample location are in **Table 4**. Multi-media sampling and lithologic boring locations are displayed in **Figures 8 through 13**. The most recent historical plume maps for PCE, TCE, fluoride and nitrate are in **Appendix D**.

3.5.1 Background Groundwater Quality

To better document background groundwater quality, a three well cluster (W-69 through W-71; **Figures 8 through 13**) including one upper surficial aquifer well, one lower surficial aquifer well, and one Black Mingo aquifer well will be installed approximately 1,330 feet northeast of and upgradient of the plant building. Data from this well cluster will provide background groundwater quality data prior to the groundwater reaching the manufacturing area where impacts to groundwater by COPC can alter groundwater's geochemistry. Background groundwater quality data is important for use in fate and transport modeling and potential remedial design evaluation.

3.5.2 Horizontal and Vertical Extent of Uranium in Groundwater

During assessment of groundwater quality in the vicinity of the Contaminated Wastewater (CWW) Line (western side of the plant), nine groundwater monitoring wells (W-50 through W-59; **Figure 3**) were installed. Two of these wells (W-55 and W-56; **Figure 3**) contained concentrations of U above the MCL of 30 picocuries per liter (pCi/L). To further assess the extent of the U plume, CFFF proposes to install four monitoring wells (W-72 through W-75; **Figure 12**) in this area.

3.5.3 Chemical Area Operating Unit Perimeter Groundwater Quality

Historic operations of the facility are known to have impacted subsurface soil and groundwater quality beneath limited portions of the site during the nearly 50 years of operations. Historic and current manufacturing processes within the Chemical Area OU have the potential to impact soil and groundwater. For reasons of safety and disruption to facility operations, it is impractical to assess soil and groundwater quality beneath the Chemical Area OU while manufacturing is ongoing.

As part of CFFF's Decommissioning Funding Plan (Westinghouse, 2016) for the United States Nuclear Regulatory Commission (NRC), funding is set aside to remove potentially impacted soil beneath the plant building's footprint. This plan is updated every three years. Decommissioning is the safe removal of a facility from service and reduction of residual radioactivity to a level that permits either unrestricted or restricted property release at the end of the license period.

In order to detect potential groundwater impacts that may be emanating from beneath the plant building, a monitoring well network will be completed around the downgradient perimeter of the Chemical Area OU. Perimeter monitoring wells already exist along the western side of the Chemical Area OU. CFFF proposes to install nine groundwater monitoring wells (W-76 though W-84; **Figures 8 through 13**) around the remaining downgradient perimeter of the Chemical Area OU.

3.5.4 Groundwater Flow Direction East of the Plant Building

Previous investigations have focused on the western side of the plant building where waste treatment operations are located, thereby providing adequate data on groundwater flow in that area. However, one monitoring well, W-23R, is located east of the plant building. Along with installation of the monitoring wells to assess background groundwater quality as described in **Section 3.5.1**, a monitoring well pair (W-85 and W-86; **Figures 8 through 13**) consisting of upper and lower surficial aquifer wells will be installed east of the plant building to better assess groundwater flow direction(s) in this area.

3.5.5 Upgradient Extent of the Volatile Organic Compounds

The extent of the PCE and TCE plumes has not been defined in the lower surficial aquifer upgradient of monitoring well W-65. Therefore, one additional lower surficial aquifer monitoring well (W-87; **Figures 8 through 13**) is proposed to be installed near the northwestern corner of the plant building.

3.5.6 Extent of Volatile Organic Compounds in the Western Groundwater Area of Concern

Site-wide groundwater sampling in the 4th quarter of 2018 identified concentrations of PCE above its MCL in monitoring well W-19B (lower surficial aquifer). To better define the Western Groundwater AOC plume described in **Section 2.8**, CFFF proposes to install two well pairs (one upper surficial aquifer and one lower surficial aquifer, W-88 through W-91; **Figures 8 through 13**) north and west of W-19B.

Currently, there is not a known source for PCE in groundwater in the vicinity of monitoring well W-19B. To better understand the subsurface and potential groundwater migration pathways between PCE source areas and monitoring well W-19B, five lithologic borings (L-12 through L-16, **Figures 8 through 13**) will be installed west of West II Lagoon. Geologic data gathered from these borings will be incorporated into the CSM.

3.5.7 Source and Extent of Technetium-99

Site-wide groundwater sampling in the 4th quarter of 2018 identified that groundwater from two monitoring wells (W-6 and W-11; **Figure 3**) contained concentrations of Tc-99 above its MCL of 900 pCi/L. Monitoring wells W-6 and W-11 are lower surficial aquifer wells and are paired with upper surficial aquifer wells. Groundwater within the upper surficial wells does not contain Tc-99 at concentrations above the MCL.

Potential sources/source areas of Tc-99 are the UN bulk storage area, the CaF_2 dredged from the West Lagoons, sediment in both the East and Sanitary Lagoons, materials stored in sea-land containers in the Southern Storage Area OU, the UN cylinder off-loading area and processes that occur in the UF_6 cylinder recertification building. UN is also used within the Conversion and URRS manufacturing operations within the Chemical Area OU, but the existing well network shows the building is not a current source of Tc-99 in the existing monitored areas.

To further assess the potential source areas for Tc-99, CFFF proposes collecting soil samples from 14 soil borings (SS-1 through SS-13 and boring from monitoring well W-78 (SS-14); **Figure 13**), four sediment samples (SED-25 through SED-28; **Figure 13**), and two dredged material samples. Composite soil samples will be collected at depths of 0-1 feet below land surface (BLS), 1-3 feet BLS, 3-5 feet BLS and 5-7 feet BLS in the 14 soil borings unless hand auger refusal is encountered.. Seven feet BLS is the approximate depth of the seasonal high water table where the borings are located. The soil samples will be analyzed for Tc-99 using analytical method DOE EML HASL-300 (Tc-02-RC Modified). The specific soil sample locations are described below.

Two soil borings (SS-1 and SS-2; **Figure 13)** will be installed adjacent to the CaF_2 storage pad. Two grab samples of dredged CaF_2 will also be collected. One of the CaF_2 samples will be collected from the most recent dredged CaF_2 and the second sample will be collected from a CaF_2 stockpile that is known to have exceeded the “free releasable” limit of 11 PPM of U. Free releasable CaF_2 can be used without restrictions on its usage (ANSI/HSP, 2013).

Four soil borings (SS-3 through SS-6; **Figure 13**) will be installed along the edges of the concrete in the Southern Storage Area OU near the sea-land containers that store materials that may contain Tc-99. Stormwater runoff from this concrete pad may contain Tc-99.

Four soil borings (SS-7 through SS-10; **Figure 13**) will be installed in the vicinity of the UF_6 cylinder recertification building where releases of hydrostatic testing fluids have been documented.

Three soil borings (SS-11 through SS-13; **Figure 13**) will be installed in the vicinity of the UN bulk storage dike outer wall. Soil borings will not be installed within the diked area to protect the integrity of this storage area.

During the installation of Chemical Area OU perimeter monitoring well W-78 (**Figure 13**), soil samples (SS-14) will be collected because of its proximity to the UN offloading area. Monitoring well W-78 is located adjacent to the southern end UN offloading area and soil sample SS-9 (**Figure 13)** is located adjacent to the northern end of UN offloading area and the UN bulk storage tanks.

Two sediment samples will be collected from both the Sanitary Lagoon (SED-25 and SED-26, **Figure 13**) and the East Lagoon (SED-27 and SED-28, **Figure 13**). Concentrations of U have been detected in the biosolids dredged from the Sanitary Lagoon that are shipped offsite for burial. Biosolids have not previously been analyzed for Tc-99. Operations and processes since 1980 may have impacted sediment within the East Lagoon with Tc-99.

To further assess the extent of the Tc-99 plume, CFFF proposes installing two groundwater monitoring wells (W-92 and W-93; **Figure 13**). Monitoring well W-92 will be installed adjacent to the gator pond, downgradient (south southwest) of monitoring well W-11, and paired with existing upper surficial monitoring well W-27. Monitoring well W-93 will be installed in close proximity to the UN bulk storage area (paired with Chemical Area OU perimeter monitoring well W-77) and upgradient (north northeast) of monitoring well W-6.

3.5.8 East Lagoon Sediment Characterization

CFFF intends to remove the sediment from this lagoon and either reline the lagoon or remove this lagoon from service. A comprehensive sampling plan is being developed by CFFF based on EPA Guidance on Choosing a Sampling Design for Environmental Data Collection (EPA, 2002) and will be submitted to DHEC's Bureau of Land and Waste Management and Bureau of Water for approval by June 30, 2019. The plan will outline the characterization of the sediment accumulated in the lagoon. A Sediment Characterization Report will be submitted to DHEC under separate cover following completion of the characterization. CFFF will request a meeting with DHEC to discuss the results and proposed additional actions related to installing a new liner or removing the lagoon from service.

3.5.9 Congaree River Floodplain Geology

There are two existing monitoring wells (W-20 and W-25; **Figure 3**) located within the Congaree River floodplain. Monitoring wells W-20 and W-25 are located approximately 550 feet and 2,200 feet southwest, respectively, from the dike separating Upper and Lower Sunset Lake and provide the only lithologic data for this portion of the property.

Within fluvial (river system) environments such as the Congaree River floodplain, sand bar and river channel deposits are typically the most conductive units. Channel deposits are at the base of the main flow channel whereas sandbars are deposited perpendicular to a stream's meanders. Mill Creek is currently eroding sediments deposited by the Congaree River. River channel and sand bar deposits of the Congaree River may not have a surficial expression as overbank deposits (flooding events) may have filled in these expressions leaving a relatively flat topography within the floodplain.

To better understand the floodplain stratigraphy, CFFF proposes to install ten lithologic borings (L-1 through L-10; **Figures 8 through 13**) within the Congaree River floodplain south of the developed portion of the property to be logged continuously for detailed lithology. The lithologic borings will be terminated at the top of the Black Mingo formation. The borings are focused along and across Mill Creek, including three boring across the dike separating Upper and Lower Sunset Lakes. This data will help identify potential migration pathways and the transition from the Okefenokee Formation sediments to the floodplain sediments.

This lithologic data will be added to the CSM to assist CFFF in assessing where permanent wells within the floodplain should be located. The location and number of wells to be installed during this phase of work will be based on where the CSM indicates data gaps exist. As discussed in **Section 3.5.10** four monitoring wells are presently proposed within the Congaree River floodplain. If the CSM indicates that these locations should be adjusted or that fewer wells are necessary to fill data gaps within the floodplain, CFFF will discuss these adjustments with DHEC.

3.5.10 Downgradient Extent of Constituents of Potential Concern

COPC in groundwater plumes have primarily been defined to the edge of the bluff during previous investigations. CFFF proposes to install four additional wells (W-94 through W-97; **Figures 8 through 13**) in the Congaree River floodplain. The proposed floodplain monitoring well locations and screened intervals may be altered after the CSM has been updated with the lithologic boring data discussed in **Section 3.5.9**. If the proposed locations are altered, the well locations will be mutually agreed upon by CFFF and DHEC.

3.5.11 Hydraulic Characteristics of the Floodplain

Hydraulic conductivity of the sediments in the floodplain will be obtained from slug tests conducted in the four proposed floodplain monitoring wells (W-93 though W-96; **Figures 8 through 13**) since no hydraulic conductivity data previously has been collected from this area. This data will provide a better understanding of groundwater flow velocity within the floodplain.

3.5.12 Sediment and Surface Water Quality in the Ditches, Pond, and Lakes

To better understand the relationship between groundwater and surface water, CFFF proposes to collect sediment and surface water samples in the ditches above the bluff, the Gator Pond, Upper Sunset Lake and Lower Sunset Lake. There are three on-site ditches that are referred to as the east ditch, the middle ditch, and the west ditch. The locations of the ditches, their flow directions and sediment/surface water sample locations are shown on **Figures 8 through 13**. As the on-site ditches extend to the south, they become increasingly incised and intersect the water table creating groundwater discharge areas. Discharge points may also occur along the face of the bluff as elevations abruptly decrease. The on-site pond is fed by a spring and Upper and Lower Sunset Lakes (Mill Creek) also serve as groundwater discharge points. Thus all of these surface water features receive groundwater discharges except during times of higher surface water flow when surface water may recharge groundwater.

Surface water and sediment samples are designated with SW and SED, respectively. The sample locations will be paired (i.e. SW-1 and SED-1) with the exception of the on-site pond where two sediment samples (SED-23 and SED-24; **Figures 8 through 13**) and one surface water sample (SW-23) will be obtained.

The eastern ditch has two branches that receive flow from the SCRDI Bluff Road site (Superfund site) via culverts beneath Bluff Road. The branches of the eastern ditch intersect north of the manufacturing area and flow through the southern portion of the developed area of the property until it discharges into Upper Sunset Lake. The middle ditch has a point of origin that is approximately 200 feet north of the plant building, turns south before moving through the developed area of the plant and intersects the east ditch approximately 100 feet west of the Sanitary Lagoon. The west ditch originates approximately 100 feet south of the Dominion Energy Substation (which began operation in 2007) and flows to the southwest where it intersects a natural drainage swale/unnamed tributary of Mill Creek that empties into Upper Sunset Lake.

The east ditch has six sample locations along its length and the middle ditch has two sample locations along its length. CFFF is concerned that stormwater runoff from the SCRDI Bluff Road site may be discharging onto the CFFF property via culverts beneath Bluff Road; therefore, two of the paired locations (SW/SED-1 and SW/SED-2; **Figures 8 through 13**) are located near the northern property boundary. The western ditch does not flow through areas of the property where historic or current manufacturing processes occur; therefore, no sample locations are proposed for the western ditch. Upper Sunset Lake and Lower Sunset Lake both have two paired sample locations. Rationale for the surface water and sediment sample locations is summarized in **Table 4**.

Based upon data collected during this phase of work, additional surface water and sediment sampling will be conducted during future scopes of work to better understand the groundwater and surface water interaction. Additional sampling includes, but is not limited to, transects across Upper and Lower Sunset Lakes.

3.5.13 Bathymetry Surveys

Bathymetric (depth profile) surveys will be conducted by AECOM SC registered land surveyors in the Gator Pond, Upper Sunset Lake, and Lower Sunset Lake. This data will define the profiles of each water body and facilitate a better understanding of the interaction of groundwater with surface water along the bluff. The CSM will be updated with the bathymetric data.

To further facilitate the understanding of the interaction between groundwater and surface water, staff gauges will be installed in the Gator Pond, Upper Sunset Lake and Lower Sunset Lake. Staff gauges will allow CFFF to monitor the elevation of the surface water in these bodies. The staff gauges will be surveyed during the bathymetric survey.

3.5.14 Depth to the Confining Clay near West II Lagoon

During the installation of monitoring well W-39 (located near the southern end of West II Lagoon; **Figure 3**), a clay layer was encountered at a much shallower depth than nearby monitoring wells and interpreted to be the Black Mingo Formation. Additionally, during subsequent investigations lower permeability layers (clay and/or silt) have been encountered in the vicinity of monitoring well W-39 above and distinct from the Black Mingo confining clay. To better understand the subsurface geology and to confirm the depth to the Black Mingo confining clay near monitoring well W-39, a lithologic boring (L-11) will be installed adjacent to monitoring well W-39.

3.5.15 Updated Human Health and Ecological Risk Assessment

Execution of the RI Work Plan will generate additional data and will be used to update the CSM. The data in the updated CSM will be combined with data collected since preparation of the PBRA (AECOM, 2014) and will be used to prepare an updated HHRA and ERA to evaluate potential pathways for human health and ecological exposures.

A formal survey of private water supply wells has not previously been conducted during previous scopes of work and is needed to understand whether or not there is a complete pathway for exposure to COPC in groundwater. During the Remedial Investigation, CFFF and AECOM personnel will conduct a water well survey within one mile of the property boundary. Should a water supply well(s) be located either in a sidegradient or downgradient direction from the site and a decision is made to collect groundwater samples from this well(s), personnel from CFFF, AECOM, and DHEC will coordinate the scheduling of the well sampling. The one mile radius from the property boundary is displayed on **Figure 1.**

Should water supply wells be sampled during the Remedial Investigation, the following is a list of parameters and associated analytical methods for these samples:

Volatile Organic Compounds (VOCs)	EPA Method 524.2
Semi-VOCs	EPA Method 525.2
Metals	EPA Method 6020B
Nitrates	EPA Method 300.0/353.2
Ammonia	EPA Method 350.1
Fluoride	EPA Method 300.0
Isotopic uranium	EPA Method 200.8 DOE-AL
Technetium-99	DOE EML HASL-300, Tc-02-RC Modified

The updated risk assessment will be included in the RI Report.

4. Assessment Activities

Execution of the RI work plan to fulfill the data needs identified in **Section 3.5** includes installation of monitoring wells and lithologic borings, sampling of various environmental media, and other supporting tasks as follows:

- Installation of 29 permanent monitoring wells;
- Completion of 16 lithologic soil borings;
- Collection of 56 soil samples;
- Collection of two CaF stockpile samples,
- Collection of 13 surface water samples;
- Collection of 18 sediment samples;
- Site-wide groundwater sampling;
- Surveying; and
- Private water supply well survey.

Procedures detailed in the EPA Region 4 Science and Ecosystem Support Division (SESD) Field Branches Quality System and Technical Procedures (FBQSTP) will be used to complete the RI field efforts. Copies of the referenced procedures are included in **Appendix E**.

A site-specific Health and Safety Plan (HASP) will also be prepared by AECOM for this project and will be submitted under separate cover.

4.1 Site Reconnaissance

As discussed in **Section 3.5**, a total of 29 monitoring wells, 16 lithologic borings, 56 soil samples, 13 surface water samples, and 18 sediment samples will be installed/collected during the implementation of this RI Work Plan. Each location will be evaluated for accessibility and adjusted as necessary prior to mobilization of the field crews. Sample locations will be recorded with survey-grade global positioning system (GPS) equipment and marked with paint and/or stakes with flagging tape attached.

Monitoring well locations within the plant area (W-72 through W-84 and W-87; **Figures 8 through 13**) may be adjusted based on the proximity of underground utilities. Locations of proposed monitoring wells and lithologic borings may be adjusted up to 50 feet to facilitate safe accessibility without DHEC approval. Proposed surface water/sediment sample locations will not be adjusted without DHEC approval. Monitoring well, lithologic boring, and surface water/sediment relocations, regardless of their magnitude, will be documented in daily field reports including the reason for the change.

4.2 Subsurface Utility Locating

Prior to drilling, the potential presence of subsurface utilities will be assessed using three steps at each proposed monitoring well and lithologic boring location. First, CFFF personnel will review drawings and other information for the potential presence of underground utilities. Second, a private utility locator will be contracted to check each location and nearby vicinity and mark potential subsurface utilities in the vicinity. Third, a hand auger, air knifing, daylighting, or vacuum truck service will advance each boring to at least five feet BLS to verify the absence of utilities.

4.3 Soil Boring and Monitoring Well Installation Procedures

4.3.1 Soil Borings

Soil borings will be completed for the data needs described in **Section 3.5**. These borings include hand augers borings to assess potential source areas of Tc-99, lithologic borings, surficial aquifer monitoring wells, and a Black Mingo aquifer monitoring well.

4.3.1.1 Hand Auger Borings

These borings will be advanced using a stainless steel hand auger to hand auger refusal or the depth BLS described in **Section 3.5.7**, whichever is less. Soil from the sampling interval will be emptied onto a 3 foot by 3 foot 4-mil polyethylene plastic mixing square dedicated to the specified interval and homogenized. Composite soil samples will be collected in general accordance with EPA Region 4 SESDPROC-300-R3 Soil Sampling (EPA, 2014a). Homogenized soil samples will be placed in pre-cleaned, laboratory-provided sample bottles and analyzed for Tc-99. The hand auger will be decontaminated between each borehole as described in **Section 4.8**.

4.3.1.2 Surficial Aquifer Monitoring Wells and Lithologic Borings

Soil borings for surficial aquifer monitoring wells and lithologic borings will be advanced using dual-tube or discrete-interval direct push technology (DPT)/Geoprobe™, rotosonic, or hollow stem auger (HSA) methods. The borings will be advanced to the general depths specified herein. The depths of the boring may be adjusted by the on-site AECOM hydrogeologist based on conditions observed during the field effort. Soil cores/samples will be collected continuously for geologic characterization and soil classification, with the exception of the top five feet of soil where hand augers are not used.

As described in Section 4.2, a soft clearing technique(s) will be used to verify that there are not underground utilities within the proposed borehole location prior to drilling for safety reasons. Areas around the plant building have been compacted prior to construction resulting in frequent hand auger refusal in this area. Due to frequent hand auger refusal in this area, boreholes for monitoring wells in the perimeter well network (including monitoring well W-93) will not be cleared using a hand auger.

Depending on the drilling technology used, coring/sampling methods may include rotosonic coring tools, dual-tube or discrete-interval Geoprobe™ soil core barrels with acetate liners, or split-spoons. Borings completed for surficial aquifer monitoring wells with DPT/Geoprobe™ methods will be over-drilled using hollow stem augers for monitoring well installation described in **Section 4.3.2**. Borings completed using rotosonic or HSA methods will be sufficient in diameter to allow for construction of 2-inch diameter monitoring wells.

Soils collected during drilling will be visually classified and described on boring logs using the Unified Soil Classification System (USCS) as described in ASTM International (ASTM) Standard ASTM D2487-17 (ASTM, 2017). Soil cores will be field screened for VOCs at five foot intervals using an organic vapor analyzer photoionization detector (OVA PID). Lithologic information and OVA PID readings obtained during installation of each well will be documented on boring logs. Copies of the boring logs will be included in the RI Report.

Lithologic soil borings L-1 through L-16 will be abandoned in accordance with the SC Well Standards (R.61-71(H)(2)(e)). Borehole abandonment will include backfilling the borehole with a bentonite-cement (up to 5% bentonite) grout via tremie pipe from the bottom up.

4.3.1.3 Black Mingo Aquifer Monitoring Well

The Black Mingo Aquifer monitoring well (W-71) will be completed as a double-cased well. The upper portion of the boring will be advanced to the top of the Black Mingo confining unit using the drilling and soil coring methods described in **Section 4.3.1.1**. The boring will then be over-drilled with large diameter rotosonic, HSA, or mud-rotary methods approximately three to five feet into the Black Mingo confining clay. A 6-inch or 8-inch diameter Schedule 40 polyvinyl chloride (PVC) surface casing will be installed in the boring and grouted in place using bentonite-cement (up to 5% bentonite) to prevent shrinkage. The grout will be allowed to cure for a minimum of 24 hours before continuing drilling.

The lower portion of the boring for monitoring well W-71 will be drilled through the surface casing using either rotosonic or mud rotary methods. The boring will be advanced through the Black Mingo confining unit and into the Black Mingo aquifer to a depth determined appropriate by the AECOM field hydrogeologist. Soil cores/samples will be collected continuously for geologic characterization and soil classification using rotosonic or wire-line coring tools. If necessary, the boring will be over-drilled using mud rotary or rotosonic methods to facilitate monitoring well installation described in **Section 4.3.2**.

Soils collected during drilling will be visually classified and described on boring logs using the methods and procedures described in **Section 4.3.1.1**. Soil cores will be field screened at five foot intervals for VOCs using an OVA PID. A copy of the boring logs will also be included in the RI Report.

4.3.2 Monitoring Well Installation

Monitoring wells will be constructed at previously specified locations in accordance with EPA Region 4 SESDGUID-101-R1 Design and Installation of Monitoring Wells protocol (EPA, 2013a) and SC Well Standards R.61-71 (DHEC, 2016) following the completion of the lithologic borings described in **Section 4.3.1**.

Monitoring well depths and screen intervals will be to the approximate depths specified herein, and will be adjusted based on the depth to the water table, and/or confining unit depths. Upper surficial aquifer monitoring wells will be installed to depths based on the depth of the water table at each location and will consist of 10 feet of well screen bracketing the water table with approximately seven feet of screen below the water table. Lower surficial aquifer monitoring wells will be installed to the top of the Black Mingo confining unit and will consist of 5 feet of well screen. Black Mingo aquifer monitoring well W-71 will be installed into the first water-bearing sands beneath the bottom of the confining unit and will consist of 10 feet of well screen.

Each monitoring well will be constructed using two-inch diameter, flush threaded, Schedule 40 PVC casing, and 10 feet of 0.010-inch slotted screen installed through the rotosonic casing, HSA annulus, or within a mud rotary borehole. Filter sand will be placed in the annular space surrounding the well screen to a depth of approximately two feet above the top of the well screen. A bentonite clay seal with a minimum thickness of two feet will be placed above the filter pack and hydrated. As the filter sand and bentonite clay are added, the rotosonic casing or HSA will be pulled from the borehole to ensure the annulus is completely filled. Depths to sand and bentonite will be monitored with a weighted tape measure as the installation progresses. The monitoring wells will be grouted using bentonite-cement (up to 5% bentonite) or high solids bentonite (minimum 20% solids). The grout will be pumped from above the bentonite seal to land surface via a tremie pipe as the rotosonic casing or HSA core barrel is pulled.

Surface completions for the monitoring wells will be either above-grade steel protective casings or finished at grade within a vault, depending on the normal activities and vehicular traffic at each location (i.e., building perimeter wells vs. outlying areas) and determined by CFFF before monitoring well installations begin. Above-grade surface completions will consist of a 4-inch square above-grade protective casing with a lockable lid, constructed of either steel or aluminum set approximately 2.5 feet above land surface. Surface completions at grade will consist of an 8-inch diameter cast-iron vault with a bolt down lid. Each protective casing/vault will be set into a 2-foot by 2-foot square by 6-inch thick concrete pad. Typical construction details for standard monitoring wells and double cased monitoring wells are in the monitoring well permit application in **Appendix F**.

Per SC Well Standards R.61-71 (DHEC, 2016), monitoring wells will be properly labeled with an identification plate immediately upon well completion. The identification plate will be constructed of a durable, weatherproof, rustproof, material. The identification plate will be permanently secured to the well casing or enclosure floor around the casing where it is readily visible. The identification plate will be permanently marked to show:

(1) Company name and certification number of the driller who installed the well;
(2) Date that the well was completed;
(3) Total depth (feet) of the well;
(4) Casing depth (feet);
(5) Screened interval; and
(6) Designator and/or identification number.

The monitoring wells will be developed by AECOM personnel to remove sediment generated during well installation and to allow the sand filter packs to settle and compact around the screens. Well development will be conducted no sooner than 24 hours after grouting has been completed. The monitoring wells will be developed by alternatively surging and then pumping with an electric submersible pump. Groundwater indicator parameters (e.g., pH, temperature, specific conductivity, dissolved oxygen [DO], oxidation reduction potential [ORP], and turbidity) will be measured periodically during development using a water quality meter and recorded on Monitoring Well Development Logs. Development of monitoring wells will continue until parameters have stabilized to within approximately 10% (0.2 standard units [SU] for pH) and the turbidity is reduced to <10 nephelometric turbidity units (NTUs) unless a higher NTU is specifically approved by the Project Manager on a well by well basis. Total well depth will also be measured and recorded during development.

4.4 Groundwater Sampling Procedures

The new monitoring wells will be sampled no sooner than 24 hours following development. The new monitoring wells will be sampled along with the existing monitoring well network during planned semiannual groundwater sampling.

Prior to sampling, water levels will be measured in the site monitoring wells using an electric water level indicator and recorded on a Water Level Data Summary Form. The water levels will be measured as quickly as practical in one event. The data will be used to determine groundwater elevations and flow direction.

The wells will be purged and sampled by low-flow, low-volume procedures using either a peristaltic pump or a variable speed submersible pump and dedicated polyethylene or Teflon™ tubing. Low-flow purging will be completed with the tubing or pump intake installed at the approximate monitoring well screen-interval midpoint in accordance with EPA Region 4 SESDPROC-301-R4 Groundwater Sampling (EPA, 2017). Water quality parameters will be measured approximately every five minutes using a water quality meter equipped with a flow-through cell. The water quality parameters will include temperature, pH, specific conductivity, DO, ORP, and turbidity. Field water quality meters will be calibrated prior to delivery to the site and at the beginning of each day using fresh standards, each in accordance with the manufacturers' recommendations. Additional calibrations will be performed as warranted (i.e., if the instrument is behaving erratically). Calibration details will be recorded on calibration log forms.

Purging will proceed until pH is within 0.2 SU, specific conductivity and temperature is within 3%, and the turbidity is <10 NTUs or stable within 10% if greater than 10 NTUs and only if specifically approved by the Project Manager (**Section 5**) on a well by well basis.. Groundwater samples will be collected in accordance with procedures described in the previously referenced EPA Standard Operating Procedure using the disposable polyethylene or Teflon™ tubing.

Groundwater samples from water supply wells be obtained in accordance with EPA Region 4 SESDPROC-305-R3 Potable Water Supply Sampling (EPA, 2013b) using the following procedure:

- Locate spigot or discharge pipe closest to well head. If well head has a pressure regulating tank, select spigot or discharge point prior to systems connection with the pressure tank;
- Open spigot allowing evacuation/purging of well for 10 to 15 minutes;
- Monitor and document flow/discharge rate from the spigot;
- Periodically measure and document water quality parameters (pH, temperature, specific conductivity, dissolved oxygen, oxidation reduction potential, and turbidity). This would include measurement of parameters during initial discharge and typically every five minutes; and
- Upon completion of purge, reduce flow rate if possible, and collect samples in designated bottles.

The groundwater samples, including water supply samples (if necessary), will be analyzed as referenced in **Section 4.10** and **Table 3**.

4.5 Surface Water/Sediment Sampling Procedures

As indicated in **Section 3.5.10**, paired surface water and sediment samples will be collected from 13 locations (**Figures 8 through 13)** at the property, with the exception of sediment sample SED-24 which is a second sediment sample location within the on-site pond. At each surface water body, surface water/sediment sampling will be conducted in order from the most down-stream location to the most up-stream location to preclude disturbing sediments that could then become suspended and wash downstream potentially biasing the other samples. At each location, the surface water sample will be collected prior to the sediment sample.

4.5.1 Surface Water Sampling

Surface water samples will be collected in accordance with procedures described in the EPA Region 4 SESDPROC-201-R3 Surface Water Sampling procedure (EPA, 2013c). Samples will be collected by submerging bottles directly into the water column where the water column is sufficiently deep to prevent disturbing sediments. For bottles containing preservative, the bottle will be submerged enough to allow surface water to slowly fill the bottle while preventing the preservative from washing out of the sample container. For bottles that do not contain preservative, the sample bottle will be lowered into the water column with the cap in-place and facing upstream. Once the mouth of the bottle is at the desired sampling depth, the cap will be removed allowing water to fill the container. If the surface water depth is not sufficient to fill sample bottles directly, a stainless steel or Teflon™ dipper will be used to collect the water sample and transfer it to the sample bottles.

Following sample collection, field water quality indicator parameters of pH, specific conductivity, temperature, DO, OPR, and turbidity will be measured in-situ by submerging the water quality instrument probe into surface water. Field measurements and visual observations including color and a description of the general conditions at each surface water sampling location will be recorded on surface water sampling logs.

The surface water samples will be analyzed as referenced in **Section 4.10** and **Table 3**.

4.5.2 Sediment Sampling

Sediment samples will be collected in accordance with procedures described in the EPA Region 4 SESDPROC-200-R3 Sediment Sampling procedure (EPA, 2014b). The sediment samples will be collected at least six inches into the sediment at each location. If possible, the sediment samples will be collected using a stainless steel hand auger. Other sampling devices may include stainless steel spoons, scoops, shovels, trowels, or rigid tubing.

The sediment samples will be analyzed as referenced in **Section 4.10** and **Table 4**.

4.6 Field Quality Control Sampling

To provide quantitative data on the precision and accuracy of the sampling and analysis program, quality assurance (QA) and quality control (QC) samples consisting of duplicate, matrix spike (MS)/matrix spike duplicate (MSD), equipment blank, and trip blank samples will be collected during environmental sampling. Field QA/QC samples will be collected, handled, preserved, documented, packaged, and shipped using the same procedures as for other samples of the same media. In summary, the QA/QC samples will be collected as specified below for each environment medium sampled:

- Duplicate – one duplicate sample per 20 samples
- MS/MSD – one MS and one MSD sample per 20 samples
- Equipment Blank – one equipment blank from sampling equipment requiring field decontamination for each 20 samples
- Trip Blank – one trip blank for each cooler containing samples that require VOC analysis

4.7 Sample Identification

Each environmental sample, including field samples and QA/QC samples will be assigned a unique identification based on the sample media/type. This naming convention will facilitate proper linking of sample data (field and laboratory) to the electronic database and to map locations. Sample nomenclature is listed below:

- Groundwater samples from permanent monitoring wells will be identified as the well identification (i.e. W-70).
- Surface water samples will be identified with “SW” and a two digit sequential code (i.e. SW-11).
- Sediment samples will be identified with “SED” and a two digit sequential code (i.e. SED-11).
- Water supply wells, if obtained, will be identified with “WSW” and a two digit sequential code (i.e. WSW-01).
- Duplicate and MS/MSD samples will be identified with the sample identification (ID) followed by the codes “DUP”, “MS”, or “MSD” (i.e.W-70-DUP, SW-11-MS, SED-11-MSD).
- Equipment blanks and trip blanks will be identified with “EB” or “TB”-{sequence number}-{date} (i.e. EB-01-070419, TB-01-070419).

4.8 Field Equipment Decontamination

Drilling equipment and reusable equipment will be cleaned between borings/samples. Equipment cleaning will be performed in accordance with the EPA Region 4 SESDPROC-205-R3 Field Equipment Cleaning and Decontamination (EPA, 2015a). Drilling equipment will be decontaminated with a pressure washer using potable water between each boring. For groundwater sampling, single-use, factory-cleaned sampling equipment will generally be used when possible. Hand auger buckets and water level meters will be washed with a detergent (e.g., Liqui-Nox®) solution and rinsed with de-ionized (DI) water between boreholes and monitoring wells, respectively. Probes used for field measurements will be rinsed with DI water between each sample location. Flow-thru cells will be rinsed with DI water between sampling locations and washed with the detergent solution and DI water at the end of the day.

4.9 Disposal of Investigation Derived Waste

Investigation derived waste (IDW) generated during the field program will be managed in accordance with CFFF procedures and the EPA Region 4 SESDPROC-202-R3 Management of Investigation Derived Waste (EPA, 2014c). Materials which may become IDW include: personal protective equipment (PPE), disposable equipment, soil cuttings from drilling or hand auguring, drilling fluids, sediments, groundwater obtained through well development or well purging, and cleaning/decontamination fluids.

IDW will be containerized in Department of Transportation (DOT) approved 55-gallon drums and temporarily staged at a central location pending results of laboratory analyses and selection of final disposal method(s). Each drum will contain IDW from one monitoring well/boring. IDW from multiple locations will not be mixed in drums. A composite sample will be collected from each drum containing soil IDW and analyzed as referenced in **Section 4.10**. IDW composite soil samples will be collected in general accordance with EPA Region 4 SESDPROC-300-R3 Soil Sampling (EPA, 2014a).

Drums containing drilling fluids, decontamination water, and well development/purge water will be characterized using groundwater analytical results from the monitoring wells, referenced in **Section 4.10** and **Table 3**.

Following receipt of IDW characterization and monitoring well groundwater sampling data, CFFF personnel will coordinate the profiling and disposal of the IDW materials.

4.10 Environmental Laboratory Analysis

Groundwater, soil for the Tc-99 source area investigation, surface water, sediment, and IDW soil samples will be analyzed by Shealy Environmental Services, Inc. (Shealy) and GEL Laboratories, LLC (GEL Labs), as appropriate. Laboratory analyses and methods are listed on **Tables 3 and 4** and summarized below:

- Target compound list (TCL) VOCs by EPA Method 8260B;
- TCL semi-VOCs by EPA Method 8270D;
- Target analyte list (TAL) metals by EPA Method 6010D/6020B;
- Nitrates by EPA Method 353.2;
- Ammonia by EPA Method 350.1;
- Fluoride by EPA Method 9056A;
- Isotopic U by United States Department of Energy (DOE) Environmental Measurements Laboratory Health and Safety Laboratory (EML HASL)-300 (U-02-RC Modified);
- Isotopic U by EPA Method 200.8/200.2; and
- Tc-99 via DOE EML HASL-300 (Tc-02-RC Modified)

4.11 Sample and Data Management

Data management ensures that the data are readily accessible and accurately maintained. Validation of laboratory analytical data will be conducted to ensure that the data quality is appropriate for subsequent risk assessment and evaluation of remedial options. The following sections described the sample and data management procedures for the project.

4.11.1 Sample Custody

From the time of collection through transportation and delivery to the laboratory, sample handling will follow proper chain-of-custody (COC) procedures. Sample containers will be surrounded by bubble wrap or equivalent packing material and placed in coolers with ice upon collection. Once samples are collected and placed on ice, a COC form(s) will be filled out completely, including information specific to the project and each sample. Each COC will be cooler-specific. Personnel packing the cooler will verify the samples listed on the COC match the samples in the cooler, then sign and date the completed COC. A copy of the COC will be retained in the files, and the original completed COC will be enclosed in a sealable plastic bag and placed inside the cooler for shipment.

4.11.2 Sample Handling and Shipment

Sample handling, packaging, and shipping activities will follow the procedures outlined in the EPA Region 4 SESDPROC-209-R3 Packing, Marking, Labeling, and Shipping of Environmental and Waste Samples (EPA, 2015b). For samples to be analyzed at Shealy in Columbia, project personnel will deliver the samples to Shealy, where a Shealy representative will sign the COC, take custody of the samples, and provide a copy of the COC to the project personnel. For samples to be shipped to GEL Labs by commercial overnight carrier, the coolers will be packed in accordance with the above-mentioned reference, sealed with shipping tape and custody seals, and delivered to the carrier. Project personnel will retain a copy of the COC included in each cooler shipped. The laboratory will be notified of the number, type, and approximate collection dates for the samples being shipped each day and communicate any delays in sample shipment. The laboratory will be alerted when shipments are scheduled for weekend delivery, to ensure that personnel are available to receive the samples.

4.11.3 Data Management and Validation

Data will be collected and recorded in a variety of ways including standardized field forms, electronically-recorded field measurements, and laboratory-generated data. Information about locations, field measurements, samples, laboratory tests, and data results will be maintained in the project database. Access will be restricted to project personnel, and the ability to view and/or add or change data will be granted to only those individuals identified to perform those tasks. Original data documents and electronic files will be archived in the appropriate hardcopy and computerized project filing system.

Numerical analyses, instrument readings and recordings, measurements, and tests will be documented and subjected to internal review. Field records will be legible and sufficiently complete to permit reconstruction of data gathering activities by a qualified individual other than the originator when data are reduced. The method of data reduction will be identified and recorded. Field generated data sheets and other field documents will be collected and reviewed daily for accuracy and completeness by the Field Project Manager or his designee. Additional information about data assessment and validation is in **Appendix G**.

4.12 RI Screening Criteria

Data from the multi-media samples will be compared to published regulatory screening levels for detected compounds. Groundwater analytical results will be compared to the primary MCLs in the SC Primary Drinking Water Regulations, R.61-58 (DHEC, 2008) or, if not specified in R.61-58, to the current EPA RSLs for tapwater. Surface water analytical results will be compared against SC Water Classification and Standards R. 61-68 (DHEC, 2014) based on consumption of either "water and organism" or "organism only" as applicable for the water body. Sediment analytical results will be compared to EPA Region 4 Sediment Screening Values for Hazardous Waste Sites for Non-Narcotic Modes of Action (EPA, 2018).

4.13 Surveying

Surveying will be performed by an AECOM South Carolina Registered Land Surveyor(s) for two separate tasks:

- Monitoring well locations and elevations; and
- Bathymetric surveys of the Pond, Upper Sunset Lake, and Lower Sunset Lake.

Horizontal locations will be reported in South Carolina State Plane Coordinates referenced to the North American Datum of 1983 (NAD-83) to the nearest 0.01 foot. Ground surface elevations and well top of casing measuring point elevations will be referenced to the North American Vertical Datum of 1988 (NAVD-88) to the nearest 0.01 foot.

4.13.1 Monitoring Well Surveying

Following completion of the monitoring wells, the horizontal locations and top of casing and land surface elevations will be surveyed. The survey information will be used to accurately plot monitoring well locations, update summary tables, convert water level depths to elevations, and produce water table surface/potentiometric maps.

4.13.2 Bathymetric Surveys of the Gator Pond, Upper Sunset Lake, and Lower Sunset Lake

The bathymetric surveys will be performed on the Gator pond, Upper Sunset Lake, and Lower Sunset Lake by completing at least three transects running roughly northeast to southwest (perpendicular to the shoreline) across each surface water body. Due to the amount of trees blocking line of sight in Upper Sunset Lake, at least one transect will be conducted within the power line right of way and the other transects may be done with offsets as new lines of sight are established.

Surveyors will collect elevation data of the bottom of the water body and water surface along with horizontal locations of each survey point at regular intervals along each transect. Data points within Upper and Lower Sunset Lakes will be approximately every 50 feet. Data points at the Gator Pond will be collected on a closer spaced interval, such as 25 feet, due to the smaller size of this water body.

4.14 Water Supply Well Survey

As discussed in **Section 3.5.15**, a water supply well survey will be performed for areas within the 1-mile radius of the property boundary (**Figure 1**) by reviewing records at DHEC and the DNR, contacting hunt club property owners to the east, south, and west of the CFFF property, performing a reconnaissance of residences, and talking with residents where possible north and east of the property along Bluff Road and other roads within the 1-mile radius. AECOM will obtain copies of documents such as well locations and construction information, if available.

CFFF will contact the hunt clubs within the 1-mile radius to inquire about the presence of domestic or irrigation wells on these properties, their locations, use, and construction details. If wells are identified, CFFF will ask permission for AECOM, DHEC, and CFFF personnel to inspect the wells, obtain GPS locations, and collect groundwater samples from the wells. Collection of GPS locations during the water well survey will be conducted in accordance with the procedures outlined in the EPA Region 4 SESDPROC-110-R4 Global Positioning System (EPA, 2015c).

AECOM will perform a reconnaissance of residences within the 1-mile radius, not associated with the hunt clubs. Based on **Figure 1** and current aerial photos, individual residences are present north and east of the property along Bluff Road and other connecting roads within the 1-mile radius. AECOM will look for the presence of water meters (or lack thereof), well houses, and other indications of whether a private supply or irrigation well may exist at each residence. The AECOM field crew will attempt to talk with the owners/residents if they assess that it is safe to do so.

The water well survey results will include a description of the findings, a map denoting the water well locations, a table of the water well owner/construction information, and sample results, if available. The survey findings will be included in the RI Report.

5. Key Project Personnel

Project personnel associated with and responsible for implementation of this remedial investigation include:

- Ms. Diana P. Joyner will serve as the Project Coordinator. Ms. Joyner is responsible for overall project coordination and communications with DHEC and contractors implementing the remedial investigation.

  Diana P. Joyner
  CFFF
  Principal Environmental Engineer
  Westinghouse Electric Company, LLC
  Columbia Fuel Fabrication Facility
  5801 Bluff Road
  Hopkins, SC 29061
  joynerdp@westinghouse.com
  803-647-1920 (office)
  803-497-7062 (mobile)

- Mr. Jeremy Grant, P.G. will serve as the Project Manager. Mr. Grant is responsible for implementation of the RI and communications with CFFF.

  Jeremy Grant, P.G.
  AECOM
  101 Research Drive
  Columbia, SC 29201
  jeremy.grant@aecom.com
  803-400-0090 (office)
  803-422-2910 (mobile)

- Ms. Doria Cullom, will serve as the QA/QC Officer for this project. Ms. Cullom will provide technical support to project staff and be responsible for assuring deliverables meet QA/QC requirements and project objectives.

  Doria Cullom
  AECOM
  10 Patewood Drive
  Building 6, Suite 500
  Greenville, SC 29615
  doria.cullom@aecom.com
  864-234-8929 (office)
  864-314-5364 (mobile)

- Mr. Chuck Suddeth will assist with project implementation, oversight and support of field activities, and communicating project findings to the Project Manager and QA/QC Officer. Other field personnel will be used as needed to meet project objectives.

  Chuck Suddeth
  AECOM
  101 Research Drive
  Columbia, SC 29201
  charles.suddeth@aecom.com
  803-254-4400 (office)
  803-530-2931 (mobile)

Environmental media sampling activities will be performed by AECOM. Analytical laboratory services will be provided by Shealy and GEL Labs, both of which possess the applicable certifications defined in 25A South Carolina Environmental Laboratory Certification Program, R.61-81 (DHEC, 1980) for the test methods specified in this RI Work Plan (South Carolina Certification Numbers 32010 and 10120001):

Grant R. Wilton
Shealy Environmental Services
106 Vantage Point Drive
West Columbia, SC 29172
gwilton@shealylab.com
803-791-9700 (main)
803-227-3150 (direct)

Hope Taylor
GEL Laboratories
2040 Savage Road
Charleston, SC 29407
hope.taylor@gel.com
843-556-8171 (main)
843-852-5814 (direct)

Should any of the key team members change during the course of the RI, DHEC will be informed in writing of the change(s).

6. Reporting

In accordance with the CA, CFFF will submit monthly progress reports to DHEC unless another schedule is agreed to by both parties. The progress reports will provide the information specified in the CA and may include requests for conducting additional sampling based on the results of the sampling specified herein. Upon completion of the RI, CFFF will prepare and submit to DHEC an RI Report describing the findings of the investigation and any proposed corrective measures or remedial actions.

Upon completion of the tasks summarized in this RI Work Plan, CFFF will evaluate what additional assessment, if any, needs to be conducted to comply with the CA. CCCF and its technical team anticipates meeting with DHEC personnel following receipt of the laboratory and field data to discuss the current and historical assessment results. If additional assessment (i.e., previously unidentified source area) is determined appropriate, the additional data collection will be outlined in a supplement to this RI Work Plan for DHEC's review and approval.

If no additional assessment is determined necessary by CFFF and DHEC, CFFF will prepare the RI Report. The report will discuss the results of groundwater, sediment, and surface water samples collected during the assessment. The RI Report will include figures depicting sample locations and COPC distribution, data summary tables, data validation details, trend analysis for groundwater from select wells mutually agreed upon by CFFF and DHEC, conclusions regarding the information collected to date, and recommendations for future efforts. Appendices will contain updated output from the CSM, lithologic logs, individual monitoring well construction details, well development logs, groundwater sampling logs, and laboratory reports and laboratory validation notes (original data sheets in adobe acrobat [pdf format] and a compact disc [CD] in hard copy).

An anticipated general outline for the RI Report is as follows:

- Introduction – This section will discuss site history and the purpose of the report.
- Investigation Procedures – This section will summarize the investigative history and briefly describe the investigative activities and procedures utilized during the assessment.
- Physical Characteristics of the Site – This section will discuss the site setting, geology, and hydrogeology of the site and surrounding area. This CSM will be used to illustrate the site characteristics.
- Nature and Extent of Media Impacts – This section will summarize COPC detected and their distribution and will be supported by the CSM.
- Risk Assessment – This section will discuss the data from groundwater, sediment, and surface water samples. These data will include identified COPC to be carried through the risk assessment process. The Risk Assessment will consist of two components: a Human Health Risk Assessment and an Ecological Risk Assessment; and
- Conclusions – This section will summarize the pertinent information from each section and present general conclusions regarding a path forward for the property in conformance with the CA.

7. Project Schedule

CFFF proposes the following schedule (after approval of the work plan):

- Week 0 – Week 2: Pre-field work preparations – Site reconnaissance (includes stakeout of monitoring well and lithologic borehole locations) and utility location
- Week 2 – Week 14: Field work – Installation of lithologic borings, installation of monitoring wells, surface water and sediment sampling, bathymetric surveys, and water well survey
- Week 15 – Week 16: Well development and survey
- Week 17 – Week 19: Groundwater sampling
- Week 21 – Week 22: Data validation
- Week 23 – Week 25: Data table generation, plume map generation, internal meeting(s)
- Week 25 – Week 26: Meeting with DHEC to discuss investigation results to assess the next step(s)

Please note that this schedule may be adjusted so that groundwater sampling can be scheduled to coincide with the semi-annual groundwater program conducted on the existing monitoring well network.

8. References

AECOM, 2013. Remedial Investigation Report, Westinghouse Electric Company, Columbia Fuel Fabrication Facility, Richland County, South Carolina, December 31.

AECOM, 2014. Preliminary Baseline Risk Assessment, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, February 7, 2014.

ANSI/HPS N13.12: Surface and Volume Radioactivity Standards for Clearance, 2013.

ASTM International, 2017. ASTM D2487-17 Standard Practice For Classification Of Soils For Engineering Purposes (Unified Soil Classification System)

Colquhoun, Donald J., 1965. Terrace Sediment Complexes in Central South Carolina, Atlantic Coastal Plain Geological Association Field conference 1965 Guidebook.

Colquhoun, Donald J., et. al. 1983. Surface and Subsurface Stratigraphy, Structure and Aquifers of the South Carolina Coastal Plain. Department of Geology, University of South Carolina

DHEC, 1980. Regulation 61-81 State Environmental Laboratory Certification Program. May 1980.

DHEC, 2008. Regulation 61-58 State Primary Drinking Water Regulations. June 2008.

DHEC, 2016. Regulation 61-68 Water Classifications and Standards. June 2014.

DHEC, 2016. Regulation 61-71 Well Standards. May 2016.

DNR Geologic Survey, 2011. Geologic Map of the Fort Jackson South Geologic Quadrangle, Calhoun and Richland Counties, South Carolina, GQM-52, Kimberly M. Meitzen 2011.

EPA, 2013a. Design and Installation of Monitoring Wells (SESDGUID-101-R1). Region IV. Science and Ecosystem Support Division, Athens, GA. January 29, 2013.

EPA, 2013b. Potable Water Supply Sampling (SESDPROC-305-R3). Region 4. Science and Ecosystem Support Division, Athens, GA. May 29, 2013.

EPA, 2013c. Surface Water Sampling (SESDPROC-201-R3). Region 4. Science and Ecosystem Support Division, Athens, GA. February 28, 2013.

EPA, 2014a. Soil Sampling (SESDPROC-300-R3). Region 4. Science and Ecosystem Support Division, Athens, GA. August 21, 2014.

EPA, 2014b. Sediment Sampling (SESDPROC-200-R3). Region 4. Science and Ecosystem Support Division, Athens, GA. August 21, 2014

EPA, 2014c. Management of Investigation Derived Waste (SESDPROC-202-R3). Region 4 Science and Ecosystem Support Division, Athens, GA. July 3, 2014.

EPA, 2015a. Field Equipment Cleaning and Decontamination Operating Procedure (SESDPROC-205-R3). Region 4. Science and Ecosystem Support Division, Athens, GA. December 18, 2015.

EPA, 2015b. Packing, Marking, Labeling and Shipping of Environmental and Waste Samples (SESDPROC-209-R3). Region 4. Science and Ecosystem Support Division, Athens, GA. February 4, 2015.

EPA, 2015c. Global Positioning System (SESDPROC-110-R4). Region 4. Science and Ecosystem Support Division, Athens, GA. June 18, 2015.

EPA, 2017. Groundwater Sampling (SESDPROC-301-R4). Region 4. Science and Ecosystem Support Division, Athens, GA. April 26, 2017.

EPA, 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. Region 4. Scientific Support Division, Superfund Section. March 2018.

JUSTIA US Law website (USA/SCDHEC vs SCRDI et al. lawsuit), http://law.justia.com/cases/federal/district-courts/FSupp/653/984/2400694/, reviewed by Mr. Jeremy Grant of AECOM on September 24, 2017.

Rust, 1995. Conceptual Design Report, Westinghouse Commercial Fuel Division, Columbia, South Carolina, September 8, 1995.

S&ME, 1982. Ground-Water Hydrology of the Westinghouse Electric Corporation Plant, Richland County, South Carolina, March 1, 1982.

Westinghouse, 2016. Decommissioning Funding Plan, May 12, 2016.

Tables

Table 1
Westinghouse Columbia Fuel Fabrication Facility
RI Work Plan
Operational Units Information

Operational Unit (OU)	Existing Monitoring Wells Within the OU	Chemicals Stored	Potential Associated COPCs
Northern Storage Area OU	Upper Surficial: W-36	oils, lubricants, mineral spirits, acetone, isopropanol (oil house) uranium (radioactive waste storage)	VOCs and U
Mechanical Area OU	Upper Surficial: W-45	#2 Fuel oil, mineral spirits, cutting oil, acetone, hydrochloric acid, nickel compounds, sulfuric acid, and nitric acid	Nickel, VOCs, and nitrate
Chemical Area OU	Upper Surficial: W-38, W-39 W-51, W-52, W-53, W-54, W-55, W-56, W-57, W-58, W-59	Sulfuric acid, heat transfer fluids , ammonium hydroxide, ammonium fluoride, uranyl nitrate, hydrofluoric acid, nitric acid, perchloroethene, kerosene, tributylphosphate, and used oil	VOCs, uranium (U), technitium-99 (Tc-99), nitrate, ammonia, and fluoride
Wastewater Treatment Area OU	Upper Surficial: W-18R, W-22, W-28, W-29, W-30 Lower Surficial: W-6	Nitric acid, sulfuric acid, uranium,Tc-99, calcium oxide, calcium hydroxide, sodium silicate, and ammonia	U, Tc-99, nitrate, ammonia, and fluoride
West Lagoons Area OU	Upper Surficial: W-39, W-43, W-66 Lower Surficial: W-65	Ammonium hydroxide, nitrate, and calcium fluoride	VOCs, U, Tc-99, nitrate, ammonia, and fluoride
Sanitary Lagoon Area OU	Lower Surficial: W-17	Biosolids	U
Southern Storage OU	Upper Surficial: W-7A, W-10, W-13R, W-32 Lower Surficial: W-11	#2 fuel oil, unleaded gasoline, used oil , paint, coolant, and uranium hexafluoride, uranium & Tc-99 contaminated equipment	VOCs, U, Tc-99, and fluoride
Western Storage OU	Upper Surficial: W-35, W-40 Black Mingo: W-50	Ammonium hydroxide, fuel oil #2, sodium hydroxide, and uranium hexafluoride cylinders	Ammonia, VOCs, fluoride, U, nickel, nitrate, and Tc-99

Table 2
Westinghouse Columbia Fuel Fabrication Facility
RI Work Plan
CSM Inputs

CSM INPUTS	Color Code				CSM IMPLEMENTATION STATUS/DATE				SOURCES OF INFORMATION
	P	I	R	PR	Preliminary	Investigation	Remedy	Post-Remedy	
SITE HISTORY AND LAND USE									
Operational History	■	■	■						
Location of Operational Activities			■		Complete 11/2018	Complete 1/2019			CAD Files: 600F02CV01,01,r39.dwg; OutsideUrrsSurfaceModel_Robbi.dwg; West lagoon_Robbi.dwg provided by Justin Cox of CFFF on 11/6/18 and 1/11/19. Spill Locations provided by Nancy Parr of CFFF on 10/29/2018 on Spills Location DWG.pdf and CFFF Spill Tracking Sheet 11.20.18.xlsx, and markup provided by Ed Byrd of CFFF in person on 1/23/19.
List of COCs	■	■	■		Complete 11/2018	Complete 1/2019			Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Volume/Frequency of COCs	■	■	■						
Accessibility to Source Areas	■	■	■		Complete 11/2018	Complete 1/2019			Site maps provided by Justin Cox of CFFF
Proximity to Receptors	■	■	■	■					
Known Environmental Release Events	■	■	■		Complete 11/2018	Complete 1/2019			Spill Locations provided by Nancy Parr of CFFF on 10/29/2018 on Spills Location DWG.pdf and CFFF Spill Tracking Sheet 11.20.18.xlsx, and markup provided by Ed Byrd of CFFF in person on 1/23/19. Drawing 647F01CV01 - C1 - Environmental Risk Map (Exterior) and (Interior) of Plant & Grounds
Third-Parties	■	■	■	■					
Adjacent Land Owners	■	■	■	■					
Other Potentially Responsible Parties	■	■	■	■					
CONTAMINANT CHARACTERISTICS									
Physical Properties	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Volatile, Semi-Volatile, NAPL, Metals, Inorganic	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Density, Viscosity, Solubility	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Horizontal and Vertical Extent	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Proximity to active operations (Vapor Issues)	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Proximity to receptors (on-site and off-site)	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Relationship to subsurface features	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Distribution in different geologic units	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Fate and Transport	■	■	■	■	Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Advection/dilution/dispersion	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Adsorption	■	■	■		Complete 11/2018				Final RI Report WCFFF Sep 2015 - provided by Jeremy Grant of AECOM
Multiphase flow	■	■	■						
Biodegradation									
Concentration in Environmental Media	■	■	■	■		Complete 12/2018			Groundwater: Used Nancy Parr of CFFF email table from 12/13/18 "WCFFF All Data_Historical Compilation_2018-OctNov_dpj_12-13-18.xls" For non-detects, one half of the lowest result was used (normally use 1/2 MDL, but not provided).
PCE	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
TCE	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Cis-1,2-DCE	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Vinyl Chloride	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Fluoride	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Nitrate	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Tc-99	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Uranium	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
SUBSURFACE CONDITIONS									
Geology	■	■	■			Complete 1/2019	Complete 2/2019		Used Geotable prepared by Chuck Suddeth of AECOM provided on 1/15/2019 "WCFFF_Geo Cross-Section Data_cks.xlsx" Used Montoring Well details table prepared by Chuck Suddeth of AECOM on 1/6/2019 "WCFF_MW-GW_ElevData.xlsx" Building Seismic Evaluation Report - NSA-TR-COL-13-01, October 2013 - provided by Nancy Parr of CFFF.
Bedrock	■	■	■			Complete 2/2019			Bedrock Geology Map - Fort jackson South Geologic Quadrangle, Kimberly Meitzen, 2011
Hydrostratigraphy	■	■	■						
Geochemistry/Microbiology	■	■	■	■					
pH/Oxidation Reduction Potential	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Hydrogeology	■	■	■	■		Complete 12/2018			October - November 2018 Groundwater Sampling
Hydraulic Conductivity/Transmissivity	■	■	■			Complete 1/2019			Used Geotable prepared by Chuck Suddeth of AECOM provided on 1/15/2019 "WCFFF_Geo Cross-Section Data_cks.xlsx" Building Seismic Evaluation Report - NSA-TR-COL-13-01, October 2013 - provided by Nancy Parr of CFFF.
Flow Direction/Gradient	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Depth to Water	■	■	■			Complete 12/2018			October - November 2018 Groundwater Sampling
Utilities	■	■	■	■					

Table 2
Westinghouse Columbia Fuel Fabrication Facility
RI Work Plan
CSM Inputs

CSM INPUTS	Color Code					CSM IMPLEMENTATION STATUS/DATE				SOURCES OF INFORMATION
	P	I	R	PR		Preliminary	Investigation	Remedy	Post-Remedy	
PATHWAYS AND RECEPTORS										
Surface Water	■	■	■							
Vapor Intrusion	■	■	■							
Direct Contact	■	■	■							
Ecological	■	■	■							
REGULATORY										
Existing Environmental Permits	■	■	■	■						
Surface Water Discharge	■	■	■	■						
Industrial User Permit	■	■	■	■						
Applicable Regulatory Program/Jurisdiction	■	■	■	■						
Remediation Endpoint Pathway	■	■	■	■						
Relationship with Regulator/Agency	■	■	■	■						

Table 3
Westinghouse Columbia Fuel Fabrication Facility
RI Work Plan
Proposed Monitoring Well Details

Monitoring Well Number	Target Aquifer Unit	Approximate Depth (feet)	Screen Length (feet)	Analytical Testing	Rationale
W-69	Upper Surficial	20	10	TCL VOCs by EPA Method 8260B, TCL SVOCs by EPA Method 8270D, TAL Metals by EPA Method 6010D/6020B, nitrates via EPA Method 353.2, ammonia via EPA Method 350.1, fluoride via EPA Method 9056A, isotopic uranium via DOE EML HASL-300 (U-02-RC Modified), isotopic uranium via EPA Method 200.8/200.2, and technetium 99 via DOE EML HASL-300 (Tc-02-RC Modified). Field Parameters[1]	Background groundwater quality
W-70	Lower Surficial	35	5		Background groundwater quality
W-71	Black Mingo	135	10		Background groundwater quality
W-72	Upper Surficial	15	10		Further define extent of uranium in the groundwater
W-73	Upper Surficial	15	10		Further define extent of uranium in the groundwater
W-74	Lower Surficial	35	5		Further define extent of uranium in the groundwater
W-75	Upper Surficial	20	10		Further define extent of uranium in the groundwater
W-76	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-77	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-78	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-79	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-80	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-81	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-82	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-83	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-84	Upper Surficial	20	10		Perimeter well around the Chemical Area OU
W-85	Lower Surficial	35	5		Assess groundwater quality and flow direction east of the Chemical Area OU
W-86	Upper Surficial	20	10		Assess groundwater quality and flow direction east of the Chemical Area OU
W-87	Lower Surficial	35	5		Assess the upgradient extent of VOCs
W-88	Lower Surficial	40	5		Assess the extent of VOCs in the Western GW AOC
W-89	Upper Surficial	30	10		Assess the extent of VOCs in the Western GW AOC
W-90	Lower Surficial	40	5		Assess the extent of VOCs in the Western GW AOC
W-91	Upper Surficial	30	10		Assess the extent of VOCs in the Western GW AOC
W-92	Lower Surficial	45	5		Assess the down gradient extent of Technitium 99
W-93	Lower Surficial	35	5		Assess the upgradient extent of Technitium 99
W-94	Floodplain	20	10		Assess groundwater quality within the Congaree River floodplain
W-95	Floodplain	20	10		Assess groundwater quality within the Congaree River floodplain
W-96	Floodplain	20	10		Assess groundwater quality within the Congaree River floodplain
W-97	Floodplain	20	10		Assess groundwater quality within the Congaree River floodplain

Notes:
TCL - Target Compound List
EPA - United States Environmental Protection Agency
VOCs - volatile organic compounds
SVOCs - semi-volatile organic compounds
TAL - Target Analyte List
DOE EML HASL - United States Department of Energy Environmental Measurements Laboratory Health and Safety Laborator
[1] - pH, specific conductivity, temperature, turbidity, dissolved oxygen, and oxidation-reduction potential.

Table 4
Westinghouse Columbia Fuel Fabrication Facility
RI Work Plan
Proposed Surface Water and Sediment Sampling Details

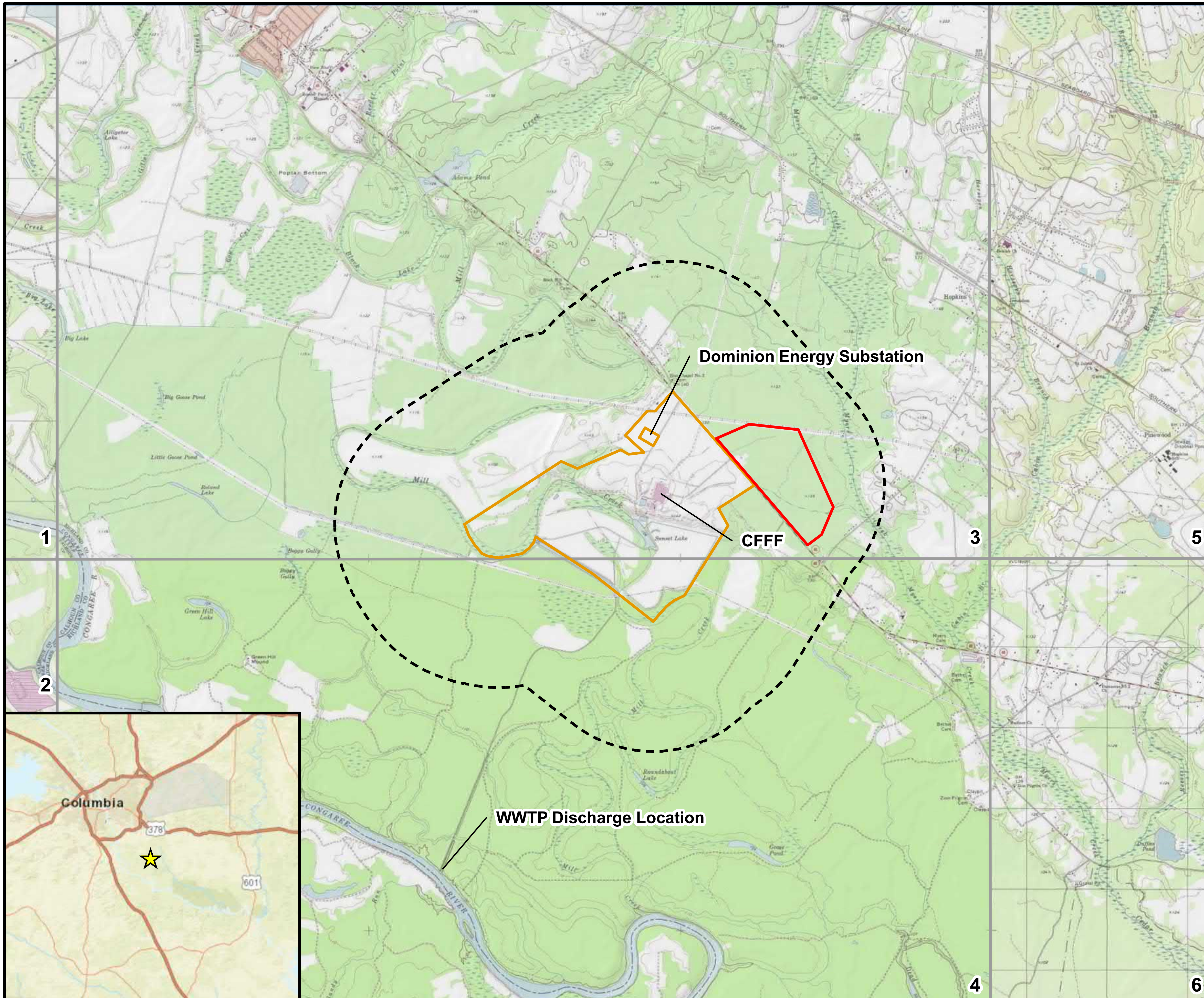
Sample Location	Analytical Testing	Rationale
SW-11	TCL VOCs by EPA Method 8260B, TCL SVOCs by EPA Method 8270D, TAL Metals by EPA Method 6010D/6020B, nitrates via EPA Method 353.2, ammonia via EPA Method 350.1, fluoride via EPA Method 9056A, isotopic uranium via DOE EML HASL-300 (U-02-RC Modified), isotopic uranium via EPA Method 200.8/200.2, and technetium 99 via DOE EML HASL-300 (Tc-02-RC Modified).	Assess if COPCs may be coming from SCDRI Bluff Road site or Bluff Road
SED-11		Assess if COPCs may be coming from SCDRI Bluff Road site or Bluff Road
SW-12		Assess if COPCs may be coming from SCDRI Bluff Road site or Bluff Road
SED-12		Assess if COPCs may be coming from SCDRI Bluff Road site or Bluff Road
SW-13		Upstream of the manufacturing operations
SED-13		Upstream of the manufacturing operations
SW-14		Upstream of the connection with the middle ditch
SED-14		Upstream of the connection with the middle ditch
SW-15		Background, upstream area of the middle ditch
SED-15		Background, upstream area of the middle ditch
SW-16		Downstream middle ditch after manufacturing area prior to connection to the eastern ditch
SED-16		Downstream middle ditch after manufacturing area prior to connection to the eastern ditch
SW-17		Intersection of the PCE plume and the eastern ditch
SED-17		Intersection of the PCE plume and the eastern ditch
SW-18		Intersection of the eastern ditch and the Congaree River floodplain
SED-18		Intersection of the eastern ditch and the Congaree River floodplain
SW-19		Upper Sunset Lake upstream of the discharge point of the eastern ditch
SED-19		Upper Sunset Lake upstream of the discharge point of the eastern ditch
SW-20		Where a lobe of the PCE plume may be encountering Upper Sunset Lake
SED-20		Where a lobe of the PCE plume may be encountering Upper Sunset Lake

Table 4
Westinghouse Columbia Fuel Fabrication Facility
RI Work Plan
Proposed Surface Water and Sediment Sampling Details

Sample Location	Analytical Testing	Rationale
SW-21	TCL VOCs by EPA Method 8260B, TCL SVOCs by EPA Method 8270D, TAL Metals by EPA Method 6010D/6020B, nitrates via EPA Method 353.2, ammonia via EPA Method 350.1, fluoride via EPA Method 9056A, isotopic uranium via DOE EML HASL-300 (U-02-RC Modified), isotopic uranium via EPA Method 200.8/200.2, and technetium 99 via DOE EML HASL-300 (Tc-02-RC Modified).	Lower Sunset Lake sample location
SED-21		Lower Sunset Lake sample location
SW-22		Lower Sunset Lake sample location
SED-22		Lower Sunset Lake sample location
SW-23		Gator pond sample location
SED-23		Gator pond sample location
SED-24		Gator pond sample location
SED-25	Same analytes as above with the exception of VOCs	Sanitary Lagoon location
SED-26		Sanitary Lagoon location
SED-27		East Lagoon location
SED-28		East Lagoon location

Notes:
SW - surface water sample location
SED - sediment sample location
COPC - Consituent of Potential Concern
TCL - Target Compound List
EPA - United States Environmental Protection Agency
VOCs - volatile organic compounds
SVOCs - semi-volatile organic compounds
TAL - Target Analyte List
DOE EML HASL - United States Department of Energy Environmental Measurements Laboratory Health and Safety Laboratory

Figures



Legend

1 Mile Buffer of Facility Property Boundary

Locations

Property Line

SCRDI Bluff Road (Superfund Site)

Topographic Quadrangle Boundary

ID	Topographic Quadrangle Name
1	Southwest Columbia
2	Gaston
3	Fort Jackson South
4	Saylors Lake
5	Congaree
6	Gadsden

0 2,000 4,000 Feet

1:48,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

Data Source: Esri/USGS

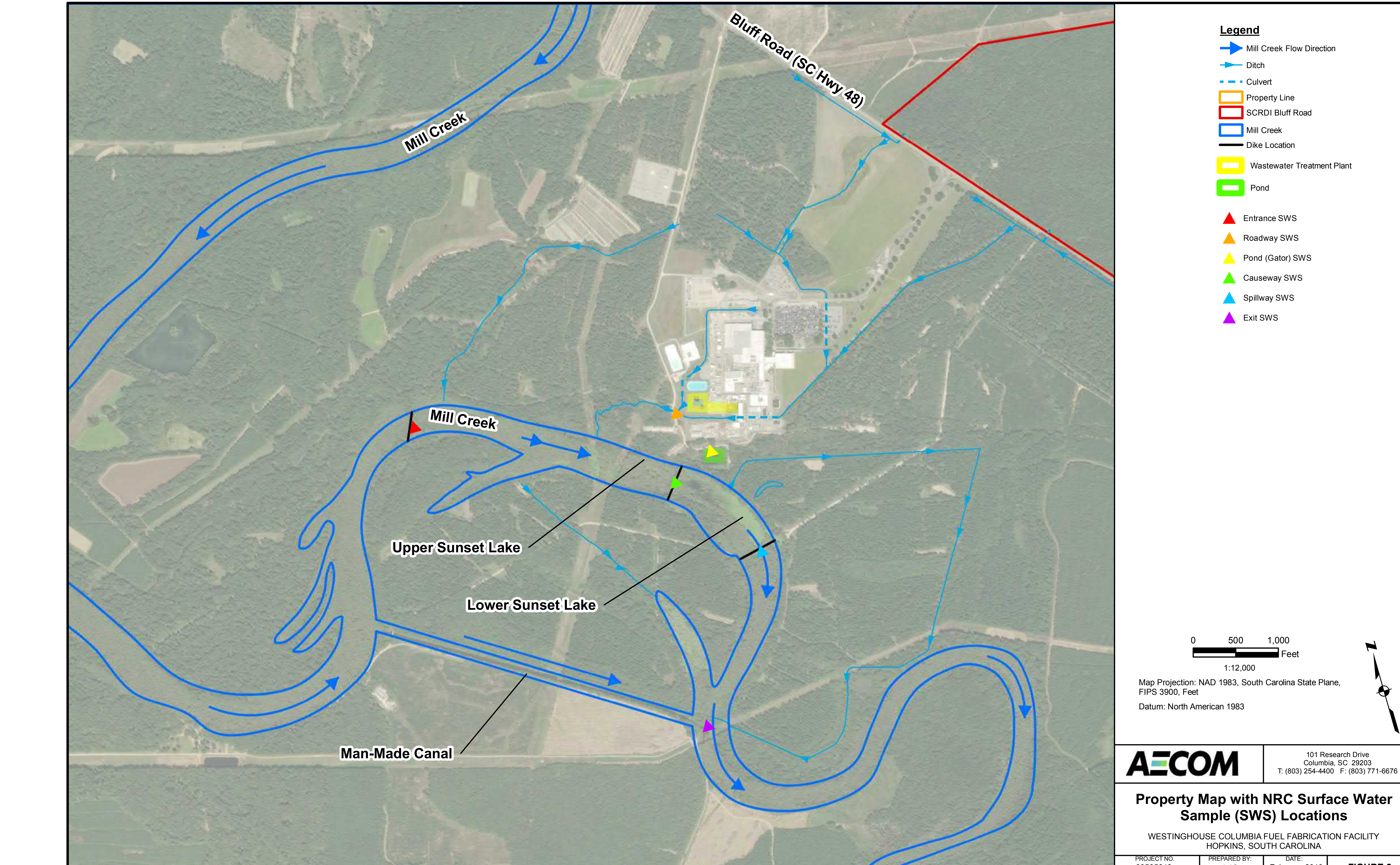
AECOM
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Site Location Map

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	February 2019	FIGURE 1

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\sitelocationmap.mxd



Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

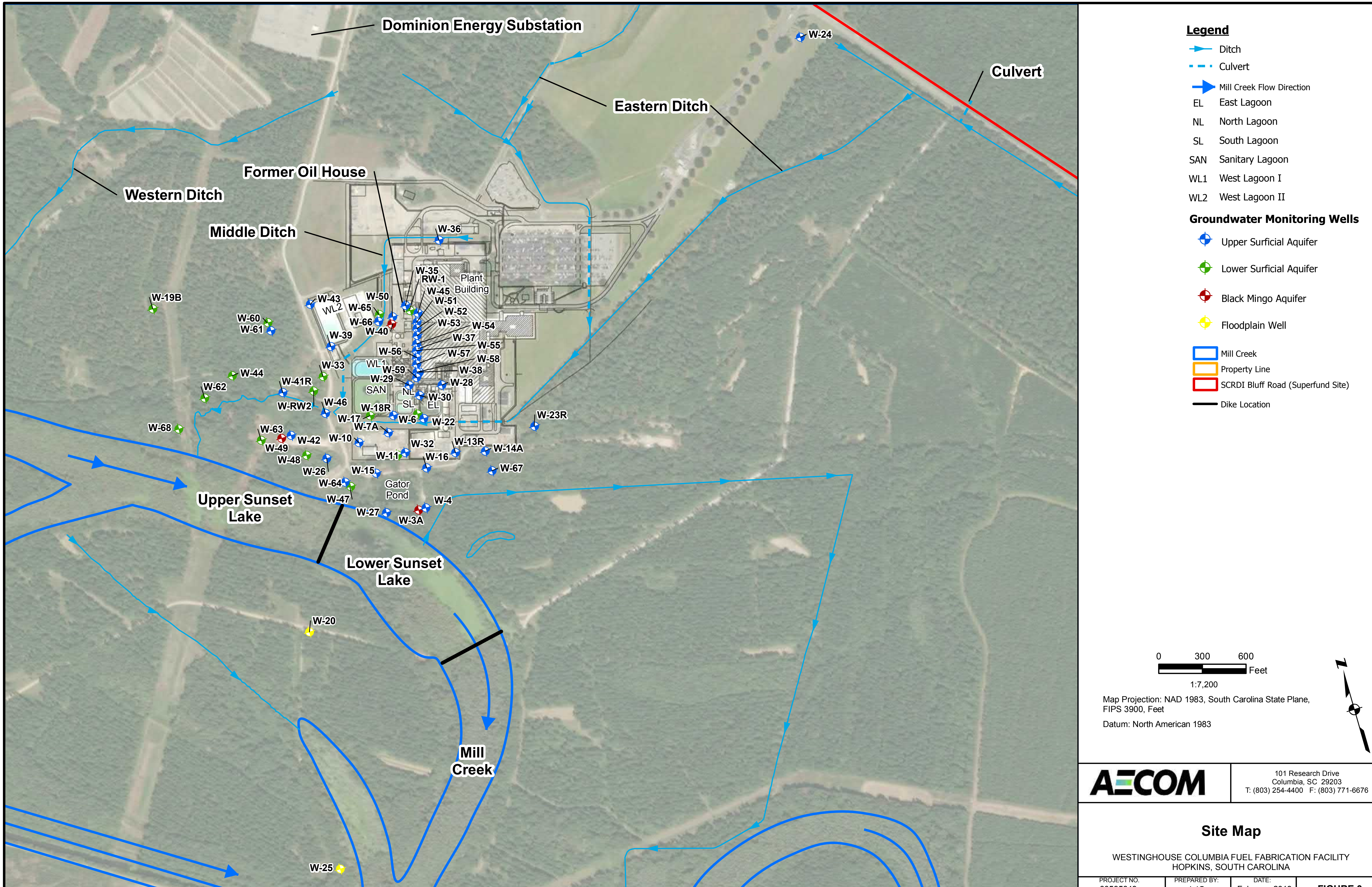
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Property Map with NRC Surface Water Sample (SWS) Locations

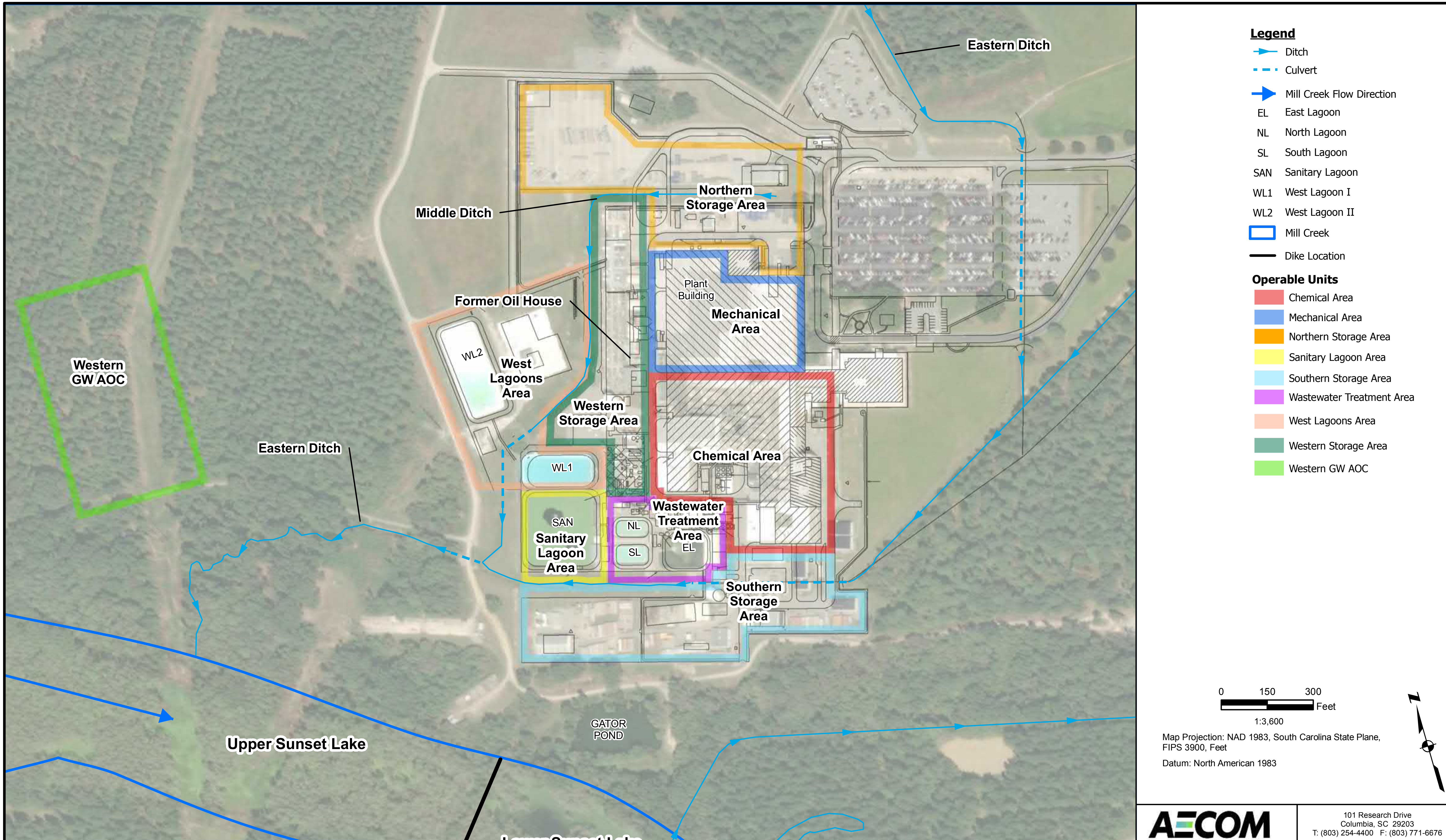
WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	February 2019	FIGURE 2

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\Not Used in Final Report\PropertyMapWithSurfaceSample.mxd



Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\SiteMap.mxd

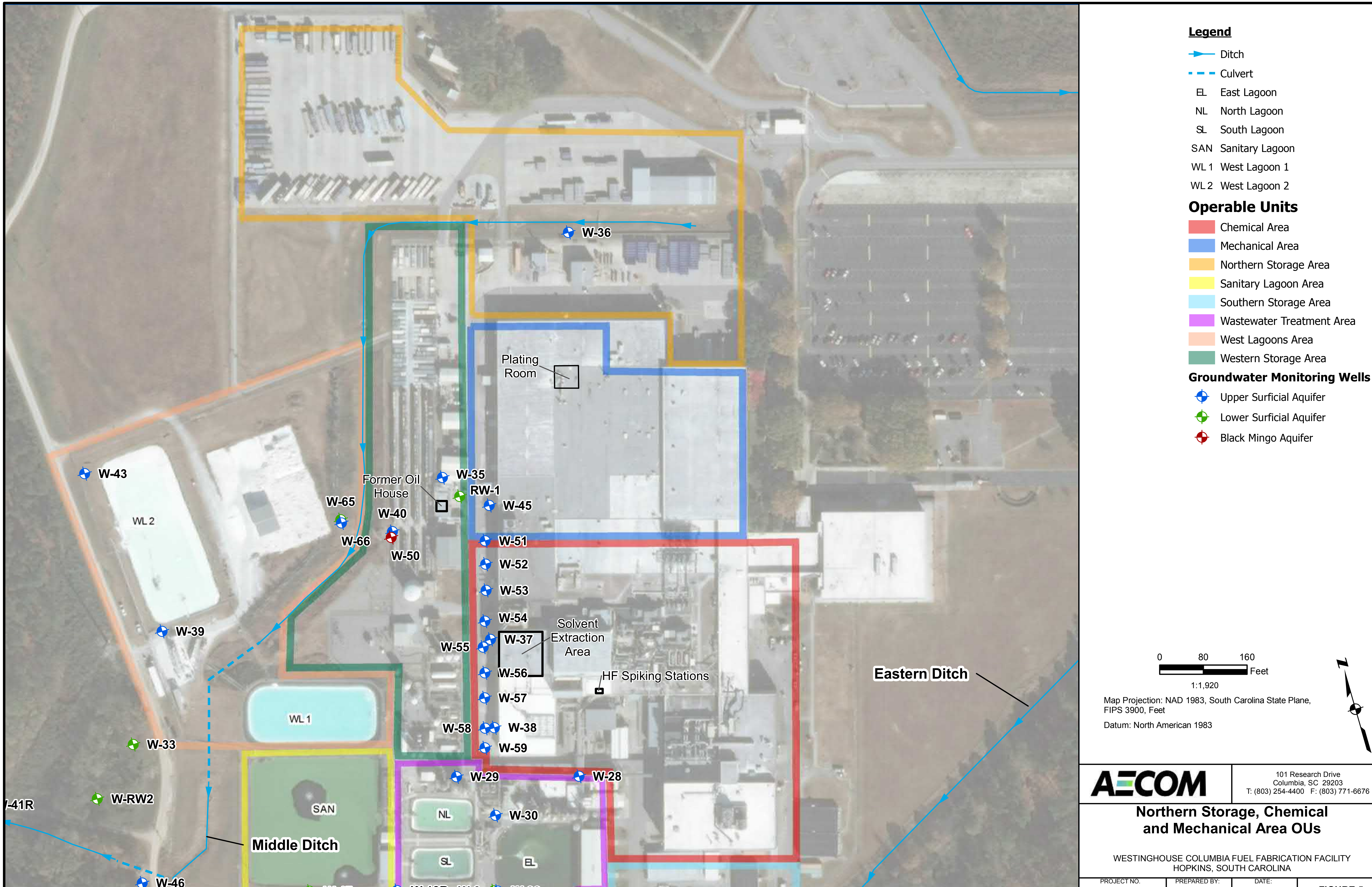


Operational Units Map

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	February 2019	FIGURE 4

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\OperationUnitsMap.mxd



AECOM
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Northern Storage, Chemical and Mechanical Area OUs

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	CCS	March 2019	FIGURE 5

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\DDP.mxd

Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL 1 West Lagoon 1
- WL 2 West Lagoon 2
- Mill Creek

Operable Units

- Chemical Area
- Mechanical Area
- Northern Storage Area
- Sanitary Lagoon Area
- Southern Storage Area
- Wastewater Treatment Area
- West Lagoons Area
- Western GW AOC
- Western Storage Area

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer

0 100 200 Feet

1:2,400

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

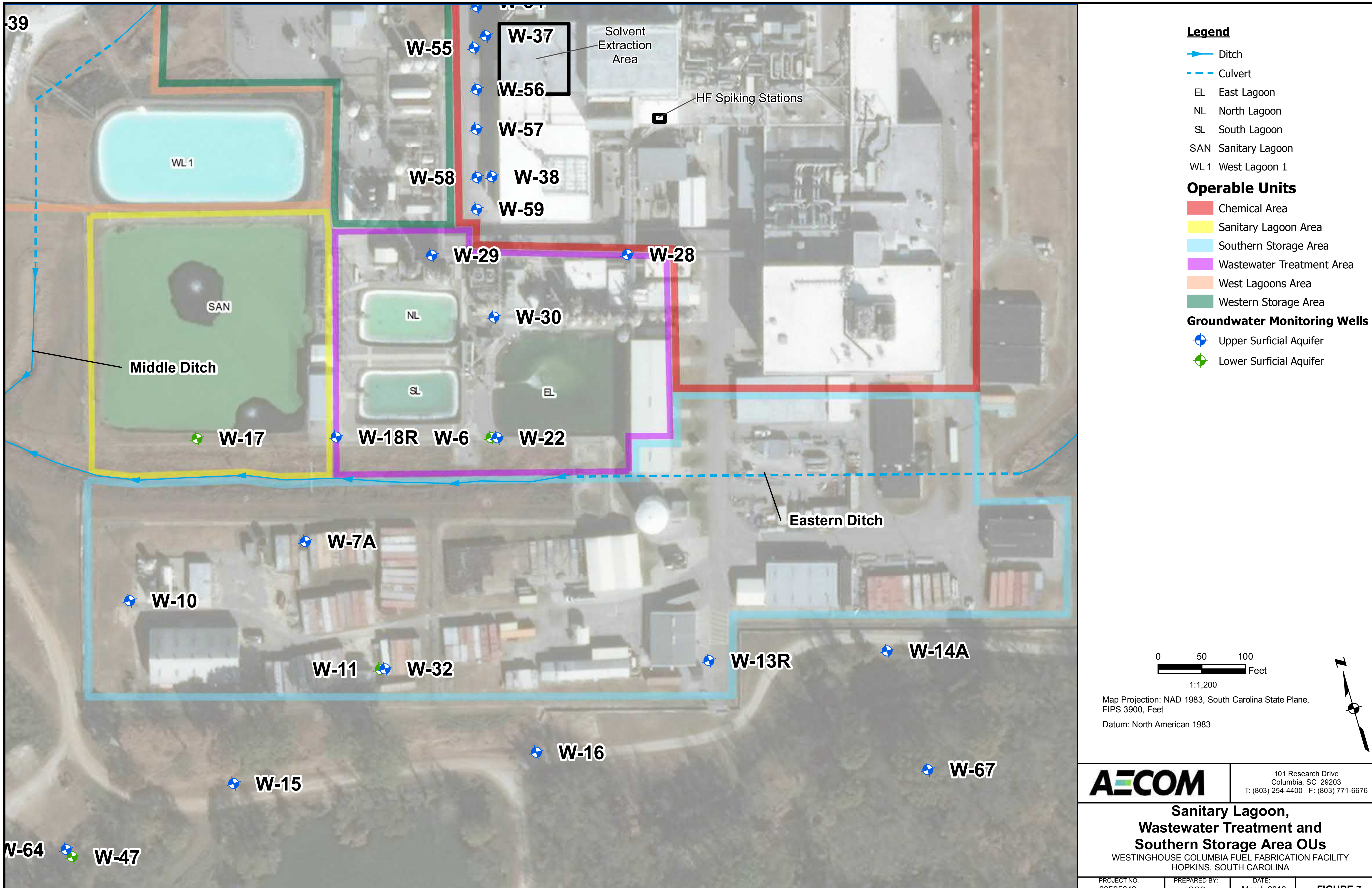
AECOM
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Western GW AOC, West Lagoons and Western Storage Area OUs

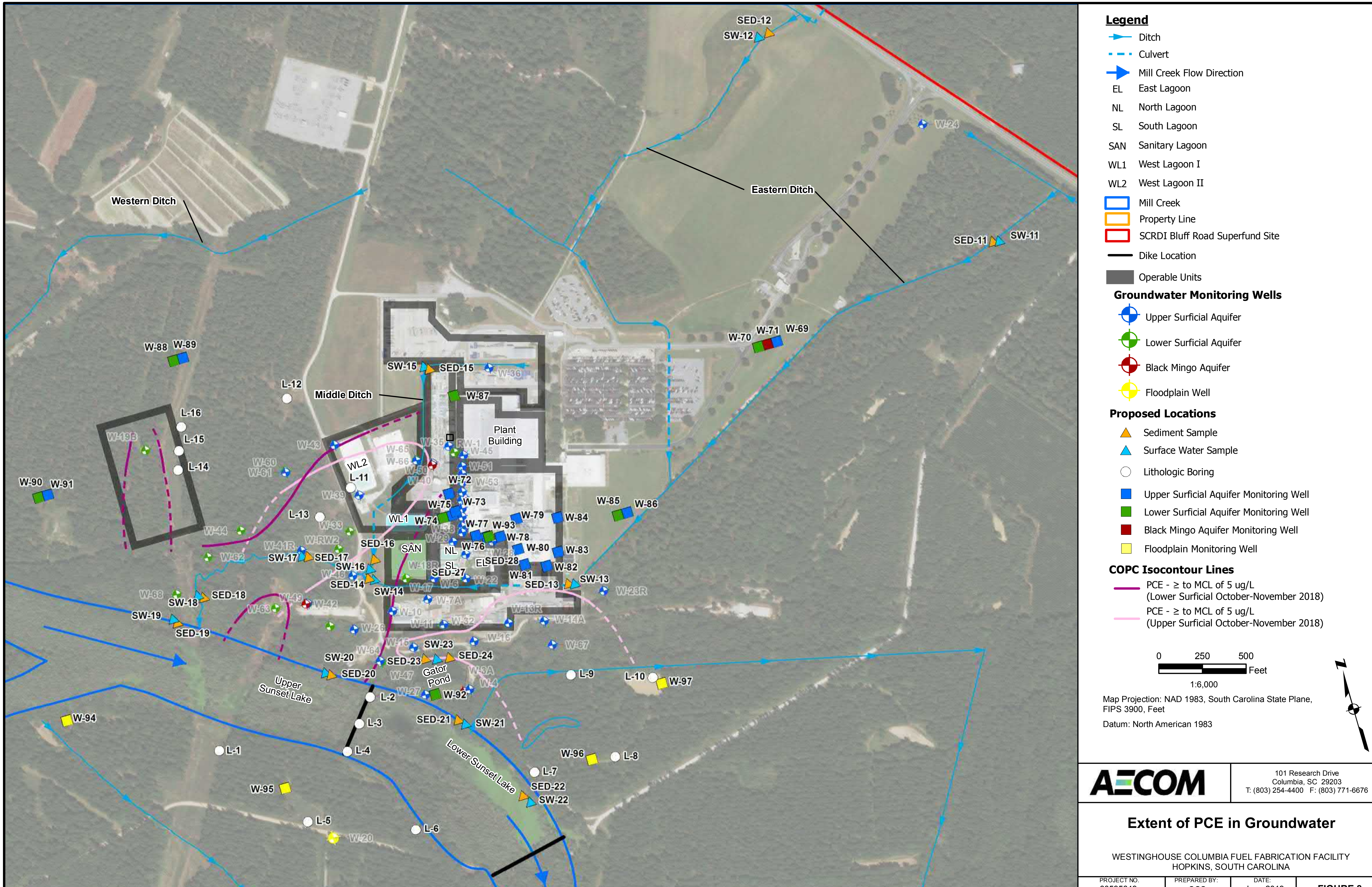
WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	CCS	March 2019	FIGURE 6

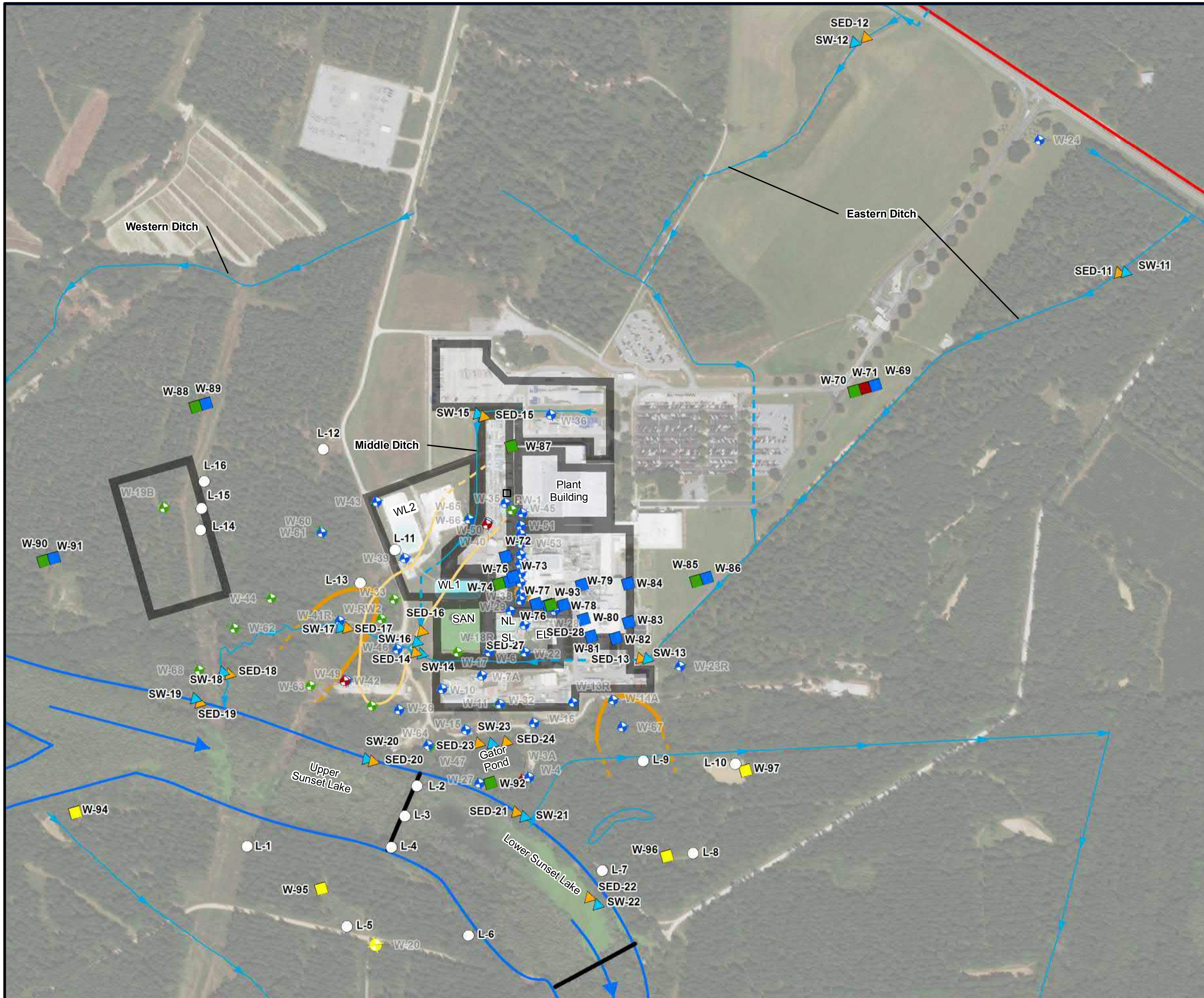
Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\DDP.mxd



Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\DDP.mxd



Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\ExtentOfPCEInGW.mxd



Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon I
- WL2 West Lagoon II
- Mill Creek
- Property Line
- SCRDI Bluff Road Superfund Site
- Dike Location
- Operable Units

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer
- Floodplain Well

Proposed Locations

- Sediment Sample
- Surface Water Sample
- Lithologic Boring
- Upper Surficial Aquifer Monitoring Well
- Lower Surficial Aquifer Monitoring Well
- Black Mingo Aquifer Monitoring Well
- Floodplain Monitoring Well

COPC Isocontour Lines

- TCE - ≥ to MCL of 5 ug/L (Lower Surficial October-November 2018)
- TCE - ≥ to MCL of 5 ug/L (Upper Surficial October-November 2018)

0 250 500 Feet

1:6,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

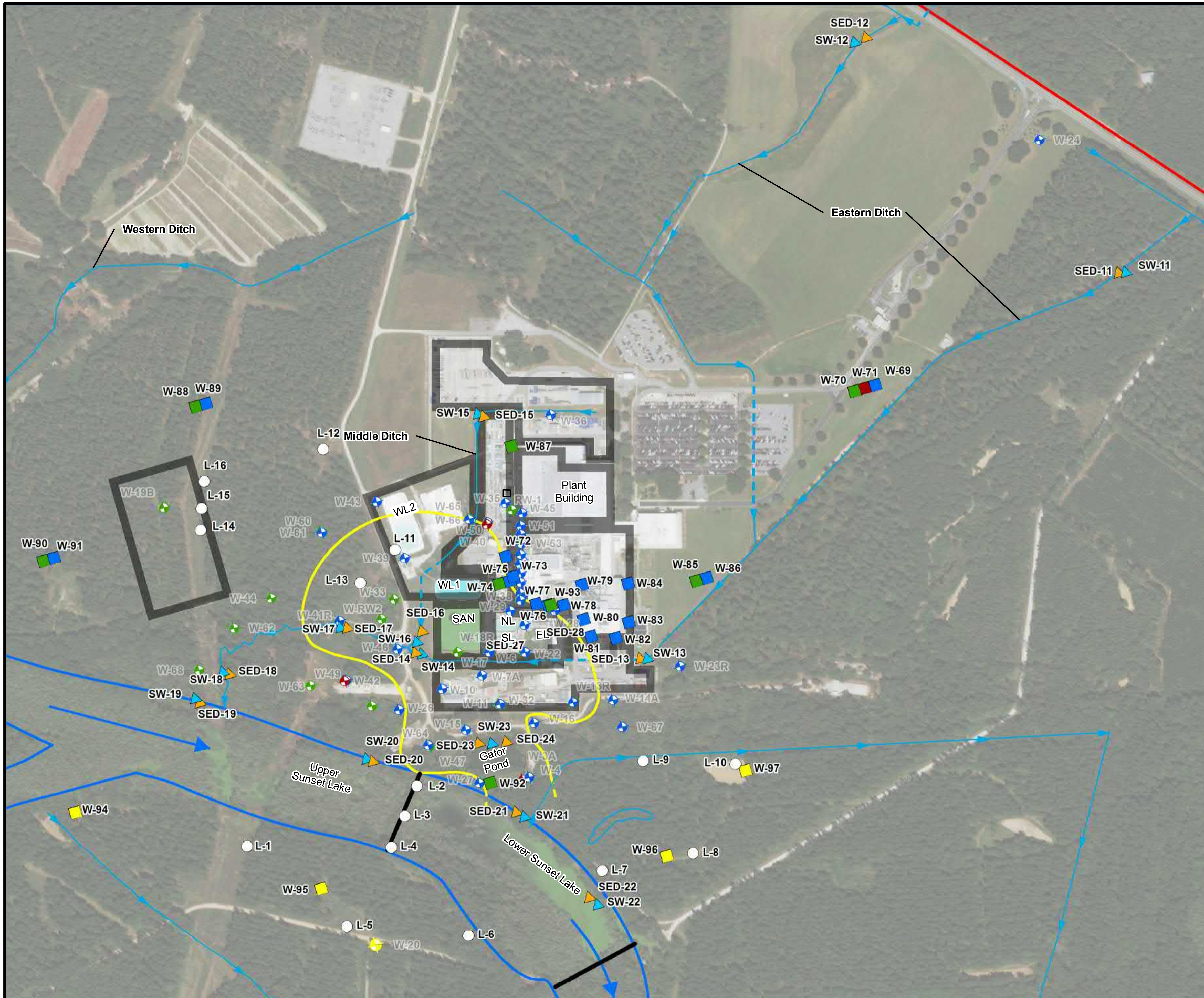
AECOM
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Extent of TCE in Groundwater

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	CCS	June 2019	FIGURE 9

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\ExtentOfTCEInGWv3.mxd



Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon I
- WL2 West Lagoon II
- Mill Creek
- Property Line
- SCRDI Bluff Road (Superfund Site)
- Dike Location
- Operable Units

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer
- Floodplain Well

Proposed Locations

- Sediment Sample
- Surface Water Sample
- Lithologic Boring
- Upper Surficial Aquifer Monitoring Well
- Lower Surficial Aquifer Monitoring Well
- Black Mingo Aquifer Monitoring Well
- Floodplain Monitoring Well

COPC Isocontour Lines

- Nitrate - ≥ to MCL of 10 ug/L (October-November 2018)

0 250 500 Feet

1:6,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

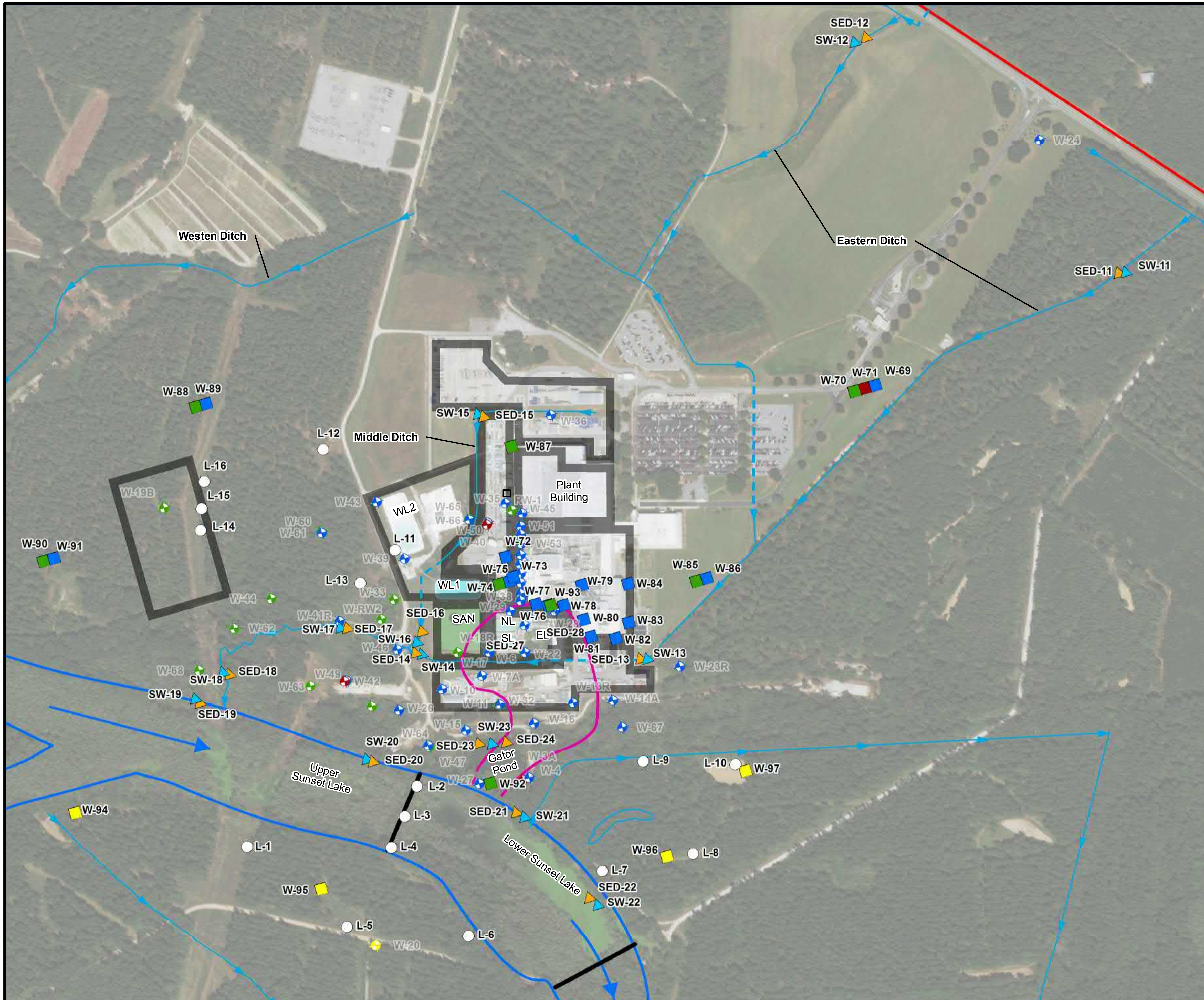
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Extent of Nitrate in Groundwater

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	June 2019	FIGURE 10

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\ExtentOfNitrateInGWv2.mxd



Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon I
- WL2 West Lagoon II
- Mill Creek
- Property Line
- SCRDI Bluff Road (Superfund Site)
- Dike Location
- Operable Units

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer
- Floodplain Aquifer

Proposed Locations

- Sediment Sample
- Surface Water Sample
- Lithologic Boring
- Upper Surficial Aquifer Monitoring Well
- Lower Surficial Aquifer Monitoring Well
- Black Mingo Aquifer Monitoring Well
- Floodplain Monitoring Well

COPC Isocontour Lines

- Flouride - ≥ to MCL of 4 ug/L (October-November 2018)

0 250 500 Feet

1:6,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

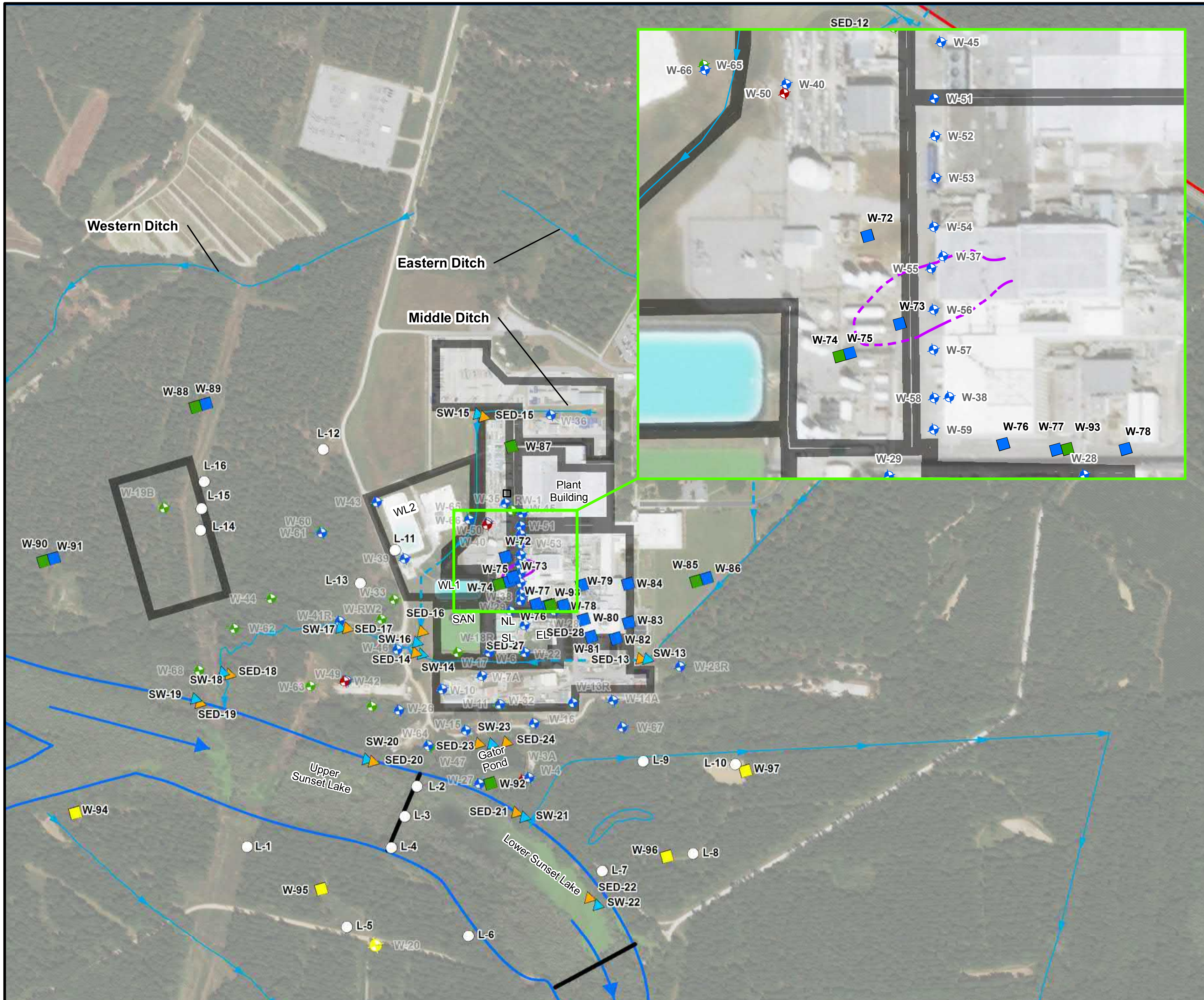
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Extent of Flouride in Groundwater

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	June 2019	FIGURE 11

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\ExtentOfFlourideInGWv2.mxd



Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon I
- WL2 West Lagoon II
- Mill Creek
- Property Line
- SCRDI Bluff Road Superfund Site
- Dike Location
- Operable Units

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer
- Floodplain Well

Proposed Locations

- Sediment Sample
- Surface Water Sample
- Lithologic Boring
- Upper Surficial Aquifer Monitoring Well
- Lower Surficial Aquifer Monitoring Well
- Black Mingo Aquifer Monitoring Well
- Floodplain Monitoring Well

COPC Isocontour Lines

- Uranium - ≥ to MCL of 30 pCi/L (October - November 2018)

0 250 500 Feet

1:6,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

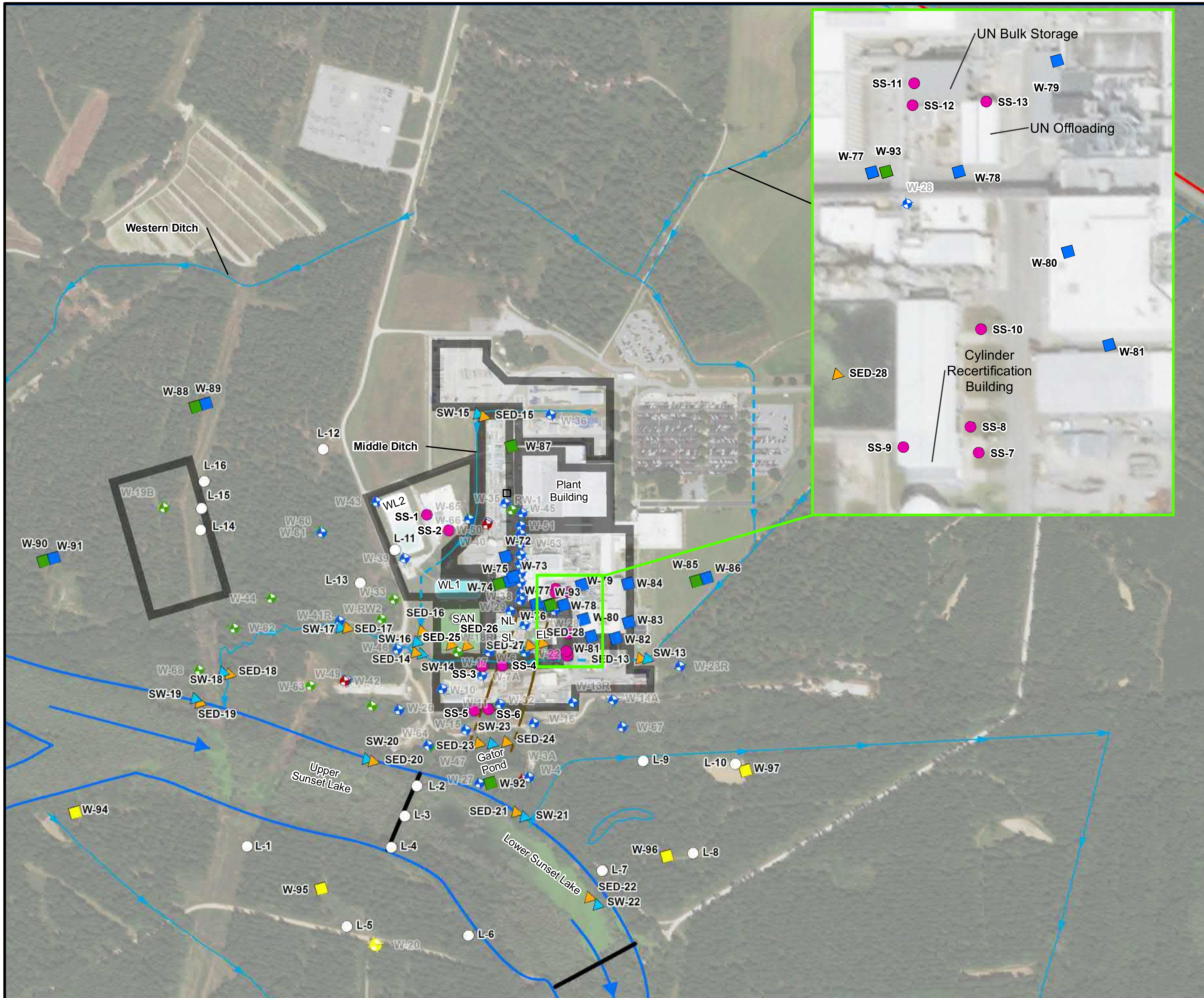
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Extent of Uranium in Groundwater

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	June 2019	FIGURE 12

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\ExtentOfUraniumInGWv2.mxd



Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon I
- WL2 West Lagoon II
- Mill Creek
- Property Line
- SCRDI Bluff Road Superfund Site
- Dike Location
- Operable Units

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer
- Floodplain Well

Proposed Locations

- Sediment Sample
- Surface Water Sample
- Soil Sample
- Lithologic Boring
- Upper Surficial Aquifer Monitoring Well
- Lower Surficial Aquifer Monitoring Well
- Black Mingo Aquifer Monitoring Well
- Floodplain Monitoring Well

COPC Isocontour Lines

- Technetium-99 - ≥ to MCL of 900 pCi/L (October - November 2018)

0 250 500 Feet

1:6,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Extent of Technetium-99 in Groundwater

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	June 2019	**FIGURE 13**

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\ExtentOfTechnetiumInGWv3.mxd

Appendix A
Summary of Previous Assessment and Remediation

<u>Summary of Previous Assessments</u>

1980 Groundwater Investigation

Davis and Floyd, Inc. (Davis and Floyd) performed a groundwater investigation in 1980 including the installation of 28 monitoring wells between the wastewater treatment plant (WWTP) and the on-site pond as the result of a fish kill in the pond. The results are presented in the *Report on Groundwater Investigations* (Davis and Floyd, 1980). Davis and Floyd identified fluoride and ammonia nitrogen in groundwater and surface water and concluded that likely sources were the concentrated waste treatment tanks, the ammonia storage tank area, and/or the waste treatment lagoons.

1982 Groundwater Hydrology Study

In 1982 Soil and Material Engineers (S&ME) was contracted by Davis and Floyd to review its report and make recommendations as to whether additional hydrogeologic investigations were warranted. As a result of this review, S&ME performed borehole geophysical logging and completed one deep stratigraphic boring. The *Groundwater Hydrology Study* (S&ME, 1982) identifies the hydrogeologic units beneath the Columbia Fuel Fabrication Facility (CFFF) and groundwater flow direction.

Studies in 1984 and 1985

Monitoring wells currently designated as W-40 and W-45 were installed in the shallow aquifer in 1984 and well W-3A was installed in the Black Mingo Aquifer in 1985 by Law Engineering Testing Company (Rust, 1995). Records pertaining to the basis for installing wells currently designated at W-40 and W-45 are not available. Well W-3A was installed to allow groundwater monitoring from a deeper water bearing zone (Law, 1985).

Groundwater Mixing Zone Request

A report entitled *Ground-Water Mixing Zone Request* (S&ME, 1988) was submitted to South Carolina Department of Health and Environmental Control (DHEC) in response to the Department's suggestion that criteria for the establishment of a mixing zone possibly could be met. Ultimately the request was not granted pending collection of additional data.

USEPA Screening Site Inspection

The United States Environmental Protection Agency (EPA) performed a Screening Site Inspection (SSI) in 1989. The SSI involved the collection and analyses of groundwater, surface water, soil, and sediment samples for organic and inorganic constituents. The *Screening Site Inspection Report* (EPA, 1989) indicates that a variety of organic and inorganic compounds were detected in groundwater samples collected at the facility. During follow up meetings, CFFF, DHEC and the EPA agreed that additional investigation was warranted to verify the presence or absence of organic compounds.

Solvent Extraction Area Investigations

In 1991, Westinghouse Environmental and Geotechnical Services, Inc. (WEGS) collected soil samples from below the concrete floor in the solvent extraction area of the plant building, due to cracks observed in the floor. The soil sampling methods and soil boring records are presented in the *Report of Soil*

Sampling (WEGS, 1992), and the laboratory analytical results were provided by the CFFF to the U.S. Nuclear Regulatory Commission (NRC).

Soil and groundwater samples were collected by SEC Donohue Environment & Infrastructure (SEC Donohue) outside of the solvent extraction area during a second investigation in 1992 and analyzed for nitrate and radioactivity. The results of the second investigation are presented in *the Report of Soil and Groundwater Sampling* (SEC Donohue, 1992) and identify gross alpha concentrations in two soil samples, nitrate concentrations in soil, and gross alpha concentrations in groundwater.

Confirmatory Groundwater Investigation

A confirmatory groundwater investigation was performed by SEC Donohue in 1992 based upon meetings that followed submission of the SSI report. The groundwater analytical results of this investigation are presented in the *Confirmatory Ground-Water Investigation Report* (SEC Donohue, 1992). This investigation identified concentrations of fluoride and nitrate above their respective MCLs in groundwater samples from wells near the WWTP and tetrachloroethene (PCE) and/or trichloroethene (TCE) above their respective MCLs in groundwater samples from monitoring wells W-33, W-35, and W-36. The *Confirmatory Groundwater Investigation Report* recommended that the establishment of a groundwater mixing zone in the vicinity of the WWTP should proceed for the fluoride-ammonia-nitrate plume. The report also noted that further investigation may be necessary for PCE and TCE.

Chlorinated Solvent Assessment

Based on the results of the confirmatory groundwater investigation, a chlorinated solvent assessment was performed by Rust Environment and Infrastructure (Rust) in late 1993 and early 1994. The assessment included collecting depth-discrete groundwater samples using a Hydropunch™ sampler, installation and sampling of new monitoring wells, sampling existing monitoring wells, and on-site ditch surface water sampling. The results are presented in the *Chlorinated Solvent Assessment Report* (Rust, 1994). The results identified concentrations of PCE and/or TCE above their MCLs in groundwater in the vicinity of and downgradient from the Oil House.

Remedial Design Investigation/Conceptual Design Report

Based on the results of the chlorinated solvent assessment, Rust performed a remedial design investigation in 1995. The investigation included monitoring well abandonments (W-3, W-19A and two unidentified wells), direct push technology (DPT) soil and groundwater sampling, monitoring well and recovery well installations (RW-1 and RW-2), groundwater sampling, on-site ditch surface water sampling, and hydraulic testing. The results are presented in the *Conceptual Design Report* (Rust, 1995). The report includes refined interpretations of site hydrogeology, source area soil and groundwater results, DPT and monitoring well groundwater results, surface water results, and aquifer hydraulic testing results.

Pilot Test for AS and SVE

Rust conducted a pilot test in 1996 to determine the effectiveness of an air sparge/soil vapor extraction (AS/SVE) groundwater remediation system for VOCs at the site. One AS test well, three AS piezometers, one SVE test well, and three SVE piezometers were constructed in the vicinity of monitoring well W-26.

The test results indicated that the site was a candidate for application of both technologies. The pilot test results are presented in the *Pilot Test Report* (Rust, 1996). Installation and operation of the full scale system and related remediation activities are discussed in **Appendix B**.

Source Investigation

On behalf of the CFFF, AECOM Technical Services, Inc. (AECOM) performed a source investigation in the wastewater lagoon area in 2011. The source investigation included DPT borings and groundwater sampling, wastewater sampling from five lagoons, and analysis of groundwater and wastewater samples for fluoride and nitrate. The *Source Investigation Report* (AECOM, 2011) identifies fluoride and nitrate concentrations above their respective MCLs in groundwater in the vicinity of the North, South and East Lagoons, and surrounding facilities.

Remedial Investigation and Preliminary Baseline Risk Assessment 2013-2014

On March 13, 2013, DHEC issued a letter stating that reports from 2010 through 2012 had been reviewed and that future assessments and remedial actions would be evaluated in accordance with the EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*. DHEC requested submittal of a Remedial Investigation (RI) Report for the CFFF consistent with the EPA guidance. The letter also requested preparation of a Baseline Risk Assessment (BRA) and indicated that following approval of the RI and BRA, DHEC would require a Feasibility Study (FS) to evaluate potential remedial alternatives.

The results of the RI are presented in the *Remedial Investigation Report* (AECOM, 2013), which primarily summarizes over 30 years of environmental investigations. However, as part of the RI, CFFF also collected 10 sediment samples from facility drainage ditches. Analysis of the sediment samples identified acetone, 2-butanone, 1,2-dichlorobenzene, fluoride, gross alpha, gross beta, nitrate, methyl acetate, PCE, and toluene at one location near the PCE groundwater plume.

The BRA included screening human health and ecological risk in accordance with EPA guidance documents. The results of the risk assessment are presented in the *Preliminary Baseline Risk Assessment* ([PBRA] AECOM, 2014). Additional information about the PBRA is contained in **Section 3.4** of this Work Plan.

Post RI Report Regulatory Changes and Voluntary Cleanup Contract 2015-2016

Following its review of the *RI Report*, DHEC issued a letter on September 15, 2015 stating that regulatory oversight of the VOC groundwater impact will be managed by the Bureau of Land and Waste Management (BLWM) and that groundwater monitoring and reporting for the WWTP area will be managed by the Bureau of Water. The letter requests preparation of a work plan for new monitoring wells in specific areas of the VOC plume and a second work plan for long-term groundwater monitoring.

In a letter dated September 30, 2015, the BLWM recommends that groundwater field screening be performed prior to installing new monitoring wells. After the September 30, 2015 letter, DHEC notified CFFF that sites managed under the BLWM would be required to enter a Voluntary Cleanup Contract (VCC). CFFF entered into a Voluntary Cleanup Contract, VCC-16-4948-RP with SCDHEC on August 23,

2016. As part of the VCC terms, CFFF submitted a work plan in October of 2016 developed by AECOM to delineate tasks associated with continued VOC investigation.

CVOC Field Screening Investigations 2016-2017

During this investigation groundwater was screened for VOCs using the AQR Color-Tec® method and a low-level membrane interface probe (LLMIP). Groundwater samples from select intervals based upon the screening results were submitted for laboratory confirmation analysis. The field screening and laboratory analytical data from the 2016 and 2017 investigations were submitted to DHEC in the *CVOC Field Screening Report* dated December 14, 2017 (AECOM, 2017). The report includes recommendations for the installation of 10 permanent monitoring wells with five to be installed in the upper portion of the surficial aquifer and five in the lower portion of the surficial aquifer.

HF Spiking Station #2 Assessment 2018

CFFF uses two spiking stations where hydrofluoric acid (HF) is mixed with uranyl nitrate as part of the Conversion Process. In June 2018 a system leak was discovered in Spiking Station #2. Subsurface soil samples were collected from 16 hand auger borings in HF Spiking Station #2 in August and September 2018. The results indicated that some of the soil below the concrete floor within the HF Spiking Station #2 area is impacted with fluoride, nitrate and uranium, and has localized areas of low pH (<5 standard units). The results of the soil sample collection data is documented in the *HF Spiking Station #2 Assessment Report* (AECOM, 2018a).

Contaminated Wastewater Line Assessment 2018

Breaches in the Contaminated Waste Water (CWW) line were discovered by CFFF personnel in 2008 and 2011. AECOM performed an investigation of subsurface soil and groundwater in the vicinity of the CWW line during July – September 2018. The investigation consisted of the installation of groundwater screening borings, monitoring wells, and hand auger borings.

The results of the CWW line investigation are documented in the *Contaminated Wastewater Line Assessment Report* (AECOM, 2018b). The subsurface soil sampling results identify uranium at concentrations above the free releasable limit in soil samples from two borings. Free releasable soils are soils that can be used as clean fill dirt without restrictions on its usage (ANSI/HSP, 2013). Uranium concentrations exceeding the MCL were detected in groundwater samples from monitoring wells W-55 and W-56, formerly known as CWW-TMW-05 and CWW-TMW-06 (AECOM, 2018b).

CVOC Assessment 2018

Nine monitoring wells (W-60 through W-68) were installed and the site-wide monitoring well network was sampled during October – December 2018. One proposed monitoring well was not installed because the surficial aquifer was not thick enough in that location to install a well pair. The results of the monitoring well installations and sampling were submitted are included in the *CVOC Assessment Report* (AECOM, 2019). The report identifies PCE and TCE groundwater plumes in the upper and lower portions of the surficial aquifer west of the plant building and in the upper portion of the surficial aquifer south of the plant building. The report recommends continued periodic groundwater monitoring events and additional plume characterization to assess the horizontal and vertical extent of PCE and TCE in the upper and lower portions of the surficial aquifer in the western and southern plumes.

References

AECOM, 2011, Source Investigation Report, Westinghouse Electric Company, Columbia Fuel Fabrication Facility, Richland County, South Carolina, SCDHEC Site ID #00456, June 15, 2011.

AECOM, 2013. Remedial Investigation Report, Westinghouse Electric Company, Columbia Fuel Fabrication Facility, Richland County, South Carolina, December 31.

AECOM, 2014, Preliminary Baseline Risk Assessment, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, February 7, 2014.

AECOM, 2017, CVOC Field Screening Report, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, December 14, 2017.

AECOM, 2018a, HF Spiking Station #2 Assessment Report, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, November 30, 2018.

AECOM, 2018b, Contaminated Wastewater Line Assessment Report, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, November 30, 2018.

AECOM, 2019, CVOC Assessment Report, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, January 11, 2019.

ANSI/HPS N13.12: Surface and Volume Radioactivity Standards for Clearance, 2013.

Davis and Floyd, 1980, Report on Groundwater Investigations, Westinghouse Electric Corporation,

Nuclear Fuel Division, Columbia, South Carolina: Job Number 3067-1, November 1980.

Environmental Protection Agency (EPA), 1989, Westinghouse Screening Site Inspection Final Report, July 25, 1989.

Law Engineering Testing Company, 1985, Report of Monitoring Well Installation.

Westinghouse Electric Corporation, Nuclear Fuel Division, Columbia, South Carolina, June 24, 1985.

Rust, 1994, Chlorinated Solvent Assessment Report, Westinghouse Commercial Fuel Division, Columbia, South Carolina, May 17, 1994.

Rust, 1995, Conceptual Design Report, Westinghouse Commercial Fuel Division, Columbia, South Carolina, September 8, 1995.

Rust, 1996, Pilot Test Report, Westinghouse Electric Corporation, Commercial Fuel Division, Columbia, South Carolina, October 1996.

S&ME, Inc., 1988, Groundwater Mixing Zone Request, Westinghouse Columbia Plant, Richland County, South Carolina, June 2, 1988.

SEC Donohue, 1992a, Report of Soil and Ground-Water Sampling Outside of the Solvent Extraction Area, Westinghouse Electric Corporation, Commercial Nuclear Fuel Division, Columbia, South Carolina, April 29, 1992.

SEC Donohue, 1992b, Confirmatory Ground-Water Investigation Report, Westinghouse Electric Corporation, Commercial Nuclear Fuel Division, Columbia, South Carolina, October 15, 1992.

Soil & Material Engineers, Inc., 1982, Ground-Water Hydrology of the Westinghouse Electric Corporation Plant, Richland County, South Carolina, March 1, 1982.

WEGS, 1992, Report of Soil Sampling, Solvent Extraction Area, Westinghouse Electric Corporation, Commercial Nuclear Fuel Division, Columbia, South Carolina, January 20, 1992.

Summary of Previous Remediation Activities

AS/SVE System

As reported in the Pilot Test Report (RUST, 1996), an air sparge (AS)/soil vapor extraction (SVE) pilot study was conducted in 1996 that indicated AS/SVE technology was effective for removing volatile organic compounds (VOCs) from the surficial aquifer and vadose zone. In 1997 a full-scale AS/SVE system was constructed downgradient of the VOC plume. The system consisted of a southern area of five AS wells and four SVE wells and a northern area of six AS wells and five SVE wells. *The Operation and Maintenance Manual* (Rust, 1998) included as-built drawings of the AS/SVE system. The AS/SVE system operated from 1997 until 2011.

System operation resulted in decreasing VOC concentrations in monitoring wells W-15, W-16, W-26, W-48, and W-41R. The estimated total VOC mass was reduced approximately 76% in the areas influenced by the AS/SVE system. Apparent mass reduction in the areas influenced by the AS/SVE system was 97% in the southern AS/SVE area and 44% in the northern AS/SVE area. The system was turned off in 2011 when VOC concentrations appeared to have reached an asymptotic state. Relevant documents pertaining to the AS/SVE system and related remediation issues are discussed below.

Response to SCDHEC Comments and Five-Year AS/SVE Performance Monitoring Evaluation

The South Carolina Department of Health and Environmental Control (DHEC) provided comments about the AS/SVE system in its letter dated July 11, 2007, following a file review including O&M documents and review of the most recent groundwater monitoring report. In the letter, DHEC requested isoconcentration maps and historical groundwater data tables in future monitoring reports, a five-year performance review of the AS/SVE system, and proposed remedial alternatives for fluoride, ammonia, and nitrate.

Earth Tech Inc. (Earth Tech) responded on October 25, 2007, in the *Response to July 11, 2007, DHEC comments and Five-Year AS/SVE Performance Monitoring Evaluation* (Earth Tech, 2007). In its submittal, Earth Tech provides data spreadsheets, isoconcentration maps and a five-year performance monitoring evaluation.

The evaluation indicated that the extent of the PCE and TCE plumes had stabilized but noted that PCE and TCE concentrations had gradually increased at two monitoring wells located near the AS/SVE system. The operation of the system had controlled the migration of PCE and TCE; however, the overall performance was less evident and less effective on PCE and TCE compared to dehalogenation daughter products 1,2-dichloroethene (DCE) and vinyl chloride (VC). The evaluation report recommended shutting down the system and developing a monitored natural attenuation (MNA) demonstration plan to evaluate VOC concentration trends. The evaluation report concluded that the groundwater mixing zone approach is favorable for the fluoride-nitrate-ammonia plumes.

Remediation Performance Evaluation and Application for Groundwater Mixing Zone

In a meeting on August 28, 2008, DHEC, Columbia Fuel Fabrication Facility (CFFF), and AECOM discussed that CFFF would sample various wells and surface water locations for analysis of VOCs, gross alpha, gross beta, ammonia, fluoride, and nitrate. Isoconcentration maps for these parameters would be created and a groundwater mixing zone application would be prepared using the latest data. In addition, a performance evaluation of the existing AS/SVE remediation system would be prepared to include calculations of mass removal and evaluations of remediation methods.

The meeting discussions are summarized in the *Remediation Performance Evaluation and Application for Groundwater Mixing Zone* (AECOM, 2009). The evaluation indicated that the system performance appeared to have reached an asymptotic state with reduced efficiency and decreased ability to reduce VOC concentrations. Evaluations of VOCs, radiological, and inorganic data were included. AECOM recommended shutting down the system and developing a Monitored Natural Attenuation strategy within the framework of a groundwater mixing zone. The evaluation concluded that requirements for hydrogeologic control for a groundwater mixing zone had been satisfied.

Response to August 30, 2010 Letter

A DHEC letter dated August 30, 2010, reviewed the *Remediation Performance Evaluation and Application for Groundwater Mixing Zone* dated April 24, 2009. In December 2010, on behalf of the CFFF, AECOM submitted the *Response to August 30, 2010 Letter* (AECOM, 2010) and stated that the CFFF would cease operation of the AS/SVE system in 2011 and perform quarterly groundwater monitoring for VOCs for one year.

DHEC also stated in its letter that the gross alpha MCL was exceeded in two surface water samples, the gross beta "MCL" (Note: There is no gross beta MCL. An action limit of 50pCi/l was incorrectly referenced as an MCL.) was exceeded in five monitoring wells, and that radiological data tended to fluctuate with no clear trends. AECOM's response stated that gross beta activity did not exceed the dose equivalent value of 4 millirems per year (mrem/yr) as demonstrated in the *Remediation Performance Evaluation and Application for Groundwater Mixing Zone* (AECOM, 2009). Speciation results of gross alpha and gross beta activity were provided to DHEC.

Based on fluoride and nitrate concentrations in groundwater in the WWTP area, the CFFF agreed to perform a source investigation in the vicinity of the WWTP consisting of DPT borings and groundwater sampling for analysis of fluoride and nitrate. The investigation would also include collection of water samples from nearby wastewater impoundments and discharge pipes, and review of past integrity testing of pipes and liners in an attempt to identify potential sources of leakage and potential release(s). The August 30, 2010, letter indicated that plans to inhibit fluoride plume migration to surface water at Sunset Lake would begin with source remediation in the WWTP. If fluoride concentrations in groundwater in the vicinity of Sunset Lake did not decline, the response stated that other remedial actions may be considered.

Liner Replacement in Wastewater Lagoons

CFFF replaced the liners in four of the six WWTP lagoons since 2008 to reduce the potential of wastewater being released from the lagoons into the surficial aquifer. The new liners consist of 80 mil high density polyethylene (HDPE). The liners in the West II and West I Lagoons were replaced in December 2008 and February 2009, respectively. The liners in the South and North Lagoons were replaced in January 2012 and February 2012.

HF Spiking Station #2

Following identification of a leak in the HF Spiking Station #2 (HFSS2) operation in June 2018 and associated assessment work (AECOM, 2018) to assess subsurface impacts, CFFF removed approximately 75.70 tons of impacted soil underneath a concrete secondary containment system to eliminate risk to the CFFF employees and risk of potential future migration to the groundwater. CFFF elected to remediate soils to practical excavation depths between 9 and 12 feet below concrete floor surface, which is between 5 and 8 feet below ground surface because the plant building floor is 4 feet above ground surface. Soil removal activities were initiated in October 2018 and were completed in

March 2019. Soil samples from the bottom of the excavation confirmed completion of the remedial activities and documented any remaining residual radioactivity.

References

AECOM, 2009, Remediation Performance Evaluation and Application for Groundwater Mixing Zone, Westinghouse Electric Company, Columbia Nuclear Fuel Plant April 25, 2009.

AECOM, 2010, Response to August 30, 2010 Letter, Westinghouse Electric Company, Columbia Fuel Fabrication Facility, Richland County, South Carolina, SCDHEC Site ID #00456, December 15, 2010.

AECOM, 2018, HF Spiking Station #2 Assessment Report, Westinghouse Columbia Fuel Fabrication Facility, 5801 Bluff Road, Hopkins, South Carolina, November 30, 2018.

Earth Tech, 2007, Response to July 11, 2007, DHEC comments and Five-Year AS/SVE Performance Monitoring Evaluation, Westinghouse Electric Nuclear Fuel – Columbia Site, October 25, 2007.

Rust, 1996, Pilot Test Report, Westinghouse Electric Corporation, Commercial Fuel Division, Columbia, South Carolina, October 1996.

SCDHEC, 2019 Voluntary Cleanup Contract VCC-16-4948-RP, August 23, 2016.

Appendix B
Conceptual Site Model

Conceptual Site Model

United States Environmental Protection Agency (USEPA), the Interstate Technology and Regulatory Commission (ITRC), American Petroleum Institute (API), and several state environmental regulatory platforms have adopted and recommended the practice of developing a conceptual site model (CSM) at sites with environmental contamination. ASTM International has developed two standards in wide use within the industry, including ASTM E2531-06 (CSM and Remediation Strategies at LNAPL Sites) and ASTM E-1689-2014 (CSMs at Contaminated Sites).

CSMs are completed for two general reasons: (1) they effectively capture a snapshot of site conditions, and provide a basis for justifying transition to a site remedy or other remedial endpoints, and (2) some regulatory agencies require CSMs.

A key word in the above sentence is “snapshot”. CSMs evolve through site investigation and remediation life cycles. At different stages in the investigation and remedy analysis CSMs serve different purposes. Through the process, identification of data needs is critical in steering the development and refinement and re-iteration of CSMs through the following four general stages:

1. Preliminary CSM. Occurs at the project inception stage where limited site information and investigative data are available. The preliminary CSM is qualitative in nature and is often used for planning purposes and scoping of steps needed for the investigative stage. Inherited legacy sites and new contaminant release sites often fit under this category.

2. Investigation CSM. Used for conceptualizing what risks are present. As a site is being characterized, incoming data are used to formulate a conceptual understanding of site conditions and risks to receptors. Site investigation can occur over several phases and the CSM evolves as data needs are identified, prompting subsequent investigations. The purpose of the investigation CSM is to support the decision process, leading to interim remedial action, remedial investigation, feasibility analysis, and selection of site remedy.

3. Remedy CSM. After a remedy is selected, pre-design investigation may provide additional data such as refinement of contaminant mass and distribution, better understanding of biogeochemical processes, or attainment of higher resolution data needed to develop three-dimensional visualizations of where targeted remedial actions will be needed. Remedy CSMs can be fairly elaborate 2-D or 3-D renders which precisely depict site conditions. CSMs of this nature are also used for demonstrative, communication and education purposes, especially with sites with varied stakeholder involvement.

4. Post-Remedy CSM. As a site remedy is implemented and on-going performance monitoring metrics are collected, post-remedy CSMs are developed to better enhance remedial system effectiveness. Post-remedy CSMs serve as optimization tools. CSMs of this nature are also used for demonstrative, communication and education purposes, especially with sites with varied stakeholder involvement or demonstration to regulator remedial system effectiveness.

Site history and land use is important to gain a preliminary understanding of site characteristics. Suspected source locations and the estimated time/s of releases are examples of key information. This initial data is used to develop reasonable expectations for environmental release areas, identify data needs and focus subsequent CSM data collection activities. Both historic and current land use data were compiled from existing environmental reports, historic and current maps, aerial photographs and interviews with on-site personnel to create the CFFF CSM.

Information concerning the characteristics of the contaminants at a particular site can be classified into either A) intrinsic contaminant properties or B) their subsurface presence, distribution and behavior. The intrinsic contaminant properties were determined from readily available information, such as the Safety Data Sheets (SDS). Intrinsic chemical properties are parameters that are necessary to develop an understanding of the environmental fate and proper investigation technique for released chemicals. The subsurface characteristics include the extent and level of released chemicals in soil, groundwater, soil gas, surface water and sediment. This information was derived from site investigation activities (Investigation stage). These data were used to compare to regulatory criteria and thus determine which impacted media require remediation.

The data associated with subsurface conditions typically encompass the largest data need for a CSM. To develop a comprehensive understanding of subsurface conditions, both regional and site-specific geologic and hydrogeologic information were integrated. Regional information is important to develop a broad understanding of the geologic setting, topography, and surface water features. This information was obtained from the Richland County GIS department. Site-specific information concerning subsurface conditions was obtained from site investigations. These data are used to predict subsurface fate and transport and select targeted areas for active remediation.

The primary objective of environmental remediation is to protect human health and the environment. Developing an understanding of the primary chemical exposure pathways and final receptors, must be gained to fulfill this objective. An analysis of pathways and receptors must be a site-specific analysis and will typically utilize data gathered from other input data categories (e.g., subsurface conditions). An example of a very common exposure pathway is contaminant inflow into existing subsurface stormwater infrastructure. Addressing the Pathways and Receptor input category is typically addressed through the completion of a risk assessment.

The applicable regulations governing a site are very important and must be identified during the Preliminary CSM stage. The applicable regulatory agencies (federal, state, local) and presiding regulatory was defined prior to initiation of site specific CSM development stages. Information concerning the regulatory setting is utilized to develop an overall strategy to achieve a remedial endpoint (i.e., site closure).

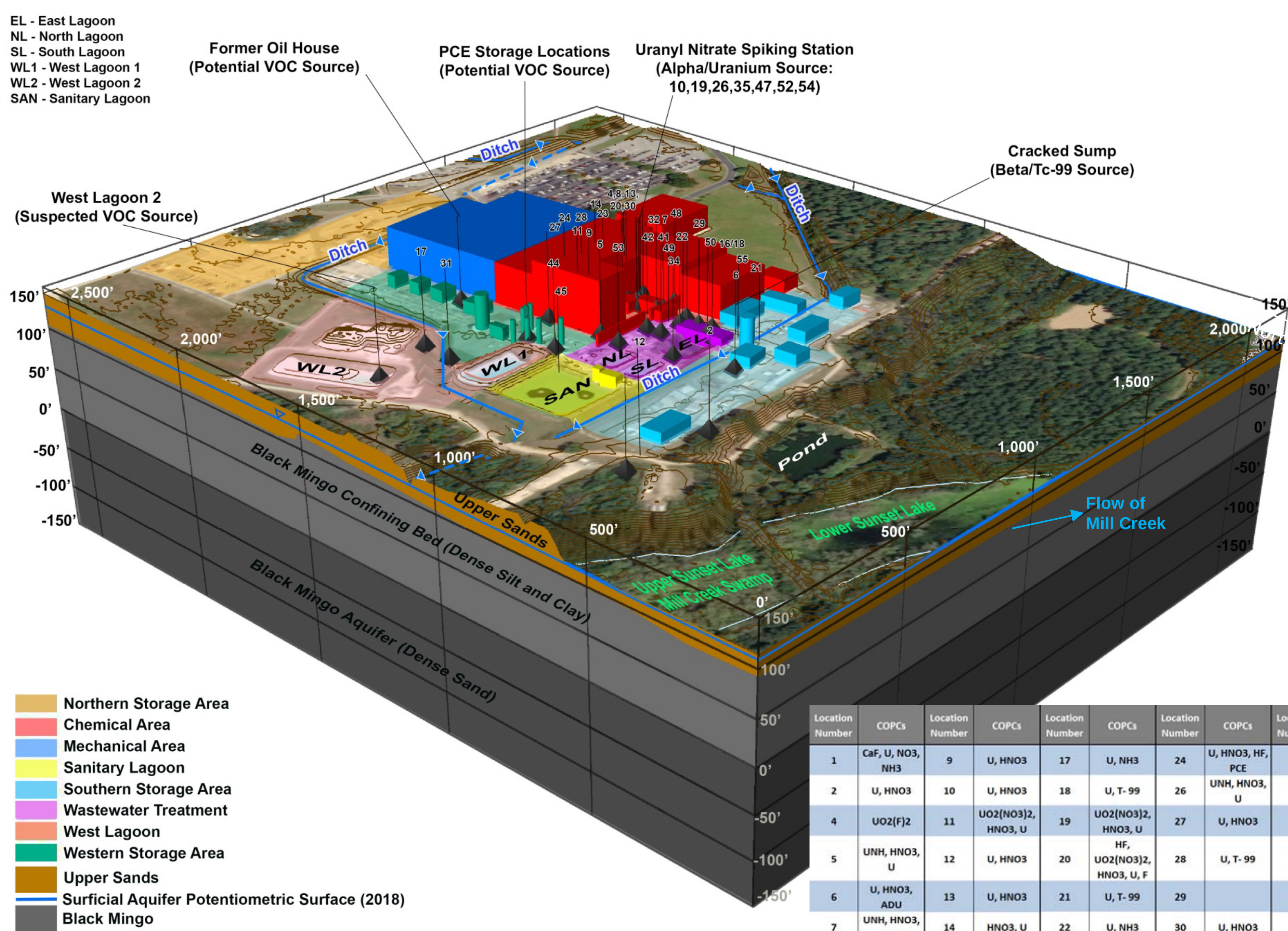
Within each phase different input categories are evaluated and added as inputs into the model to help support the investigation, plan for the remedy and evaluate the site during post-remedy. The input sources were documented and then organized spatially in a geodatabase using ArcGIS. When possible, geodesic coordinates were attached to quantitative and qualitative data in order to identify spatial and temporal patterns.

Conceptual Site Model
Rev. 0

Westinghouse Columbia

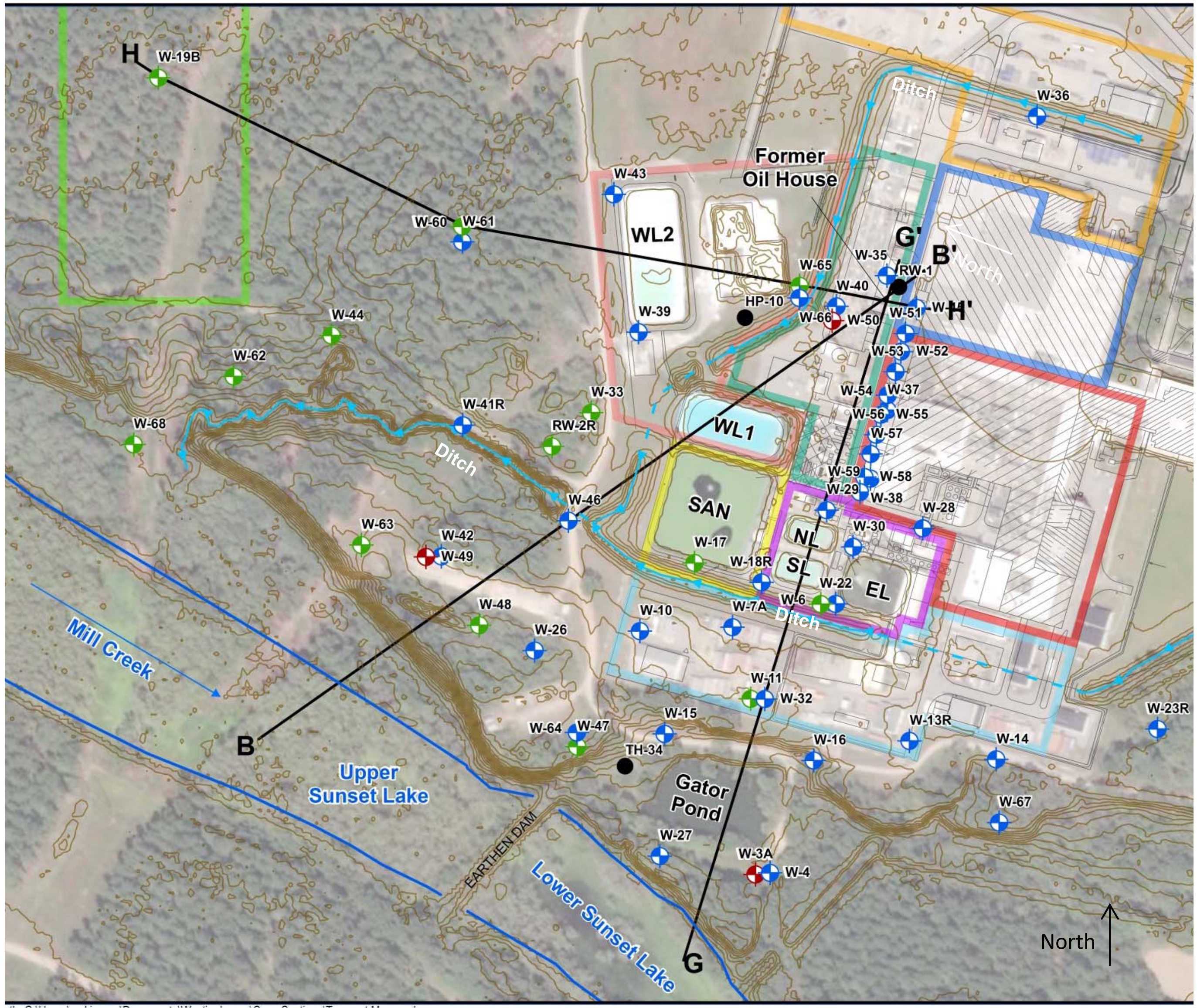
Site CSM Block Diagram – Known Spills

2.5X Vertical Exaggeration



Location Number	COPCs	Location Number	COPCs	Location Number	COPCs	Location Number	COPCs	Location Number	COPCs	Location Number	COPCs
1	CaF, U, NO3, NH3	9	U, HNO3	17	U, NH3	24	U, HNO3, HF, PCE	32	U, HF	48	HF, U,
2	U, HNO3	10	U, HNO3	18	U, T- 99	26	UNH, HNO3, U	34	U	49	U
4	UO2(F)2	11	UO2(NO3)2, HNO3, U	19	UO2(NO3)2, HNO3, U	27	U, HNO3	35	UNH, HNO3	50	U
5	UNH, HNO3, U	12	U, HNO3	20	HF, UO2(NO3)2, HNO3, U, F	28	U, T- 99	41	U, HNO3	52c 18c&46c	UNH, HNO3, U
6	U, HNO3, ADU	13	U, HNO3	21	U, T- 99	29		42	U	53	U
7	UNH, HNO3, U	14	HNO3, U	22	U, NH3	30	U, HNO3	44	Gasoline, U, Fuel Oil	54	UNH, HNO3, U
8	U, HNO3, HF	16	U, T- 99	23	U	31	U	47	UO2(NO3)2, HNO3, U	55	U, Tc-99

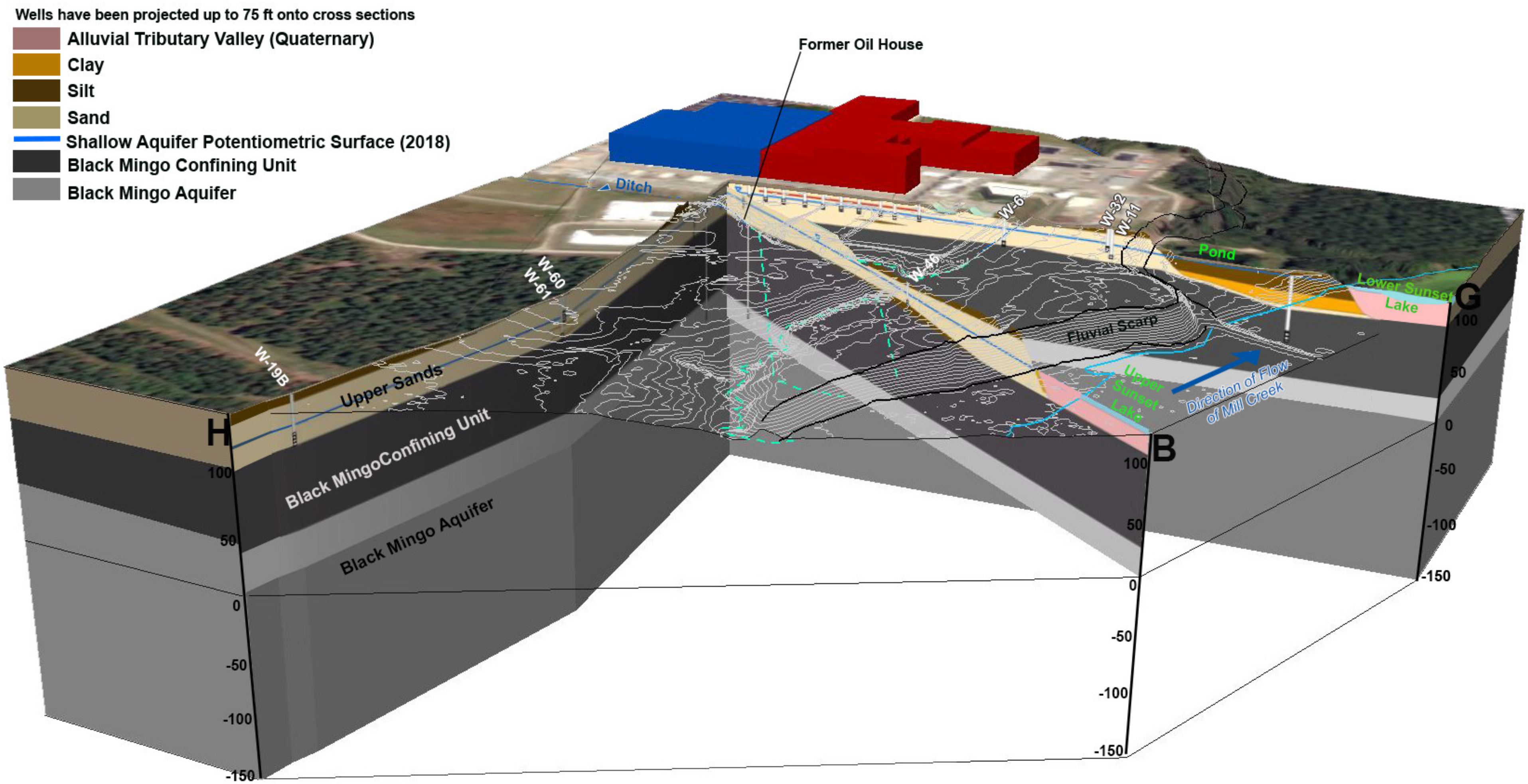
Site CSM Block Diagram – Transect Reference



EL - East Lagoon
NL - North Lagoon
SL - South Lagoon
WL1 - West Lagoon 1
WL2 - West Lagoon 2
SAN - Sanitary Lagoon

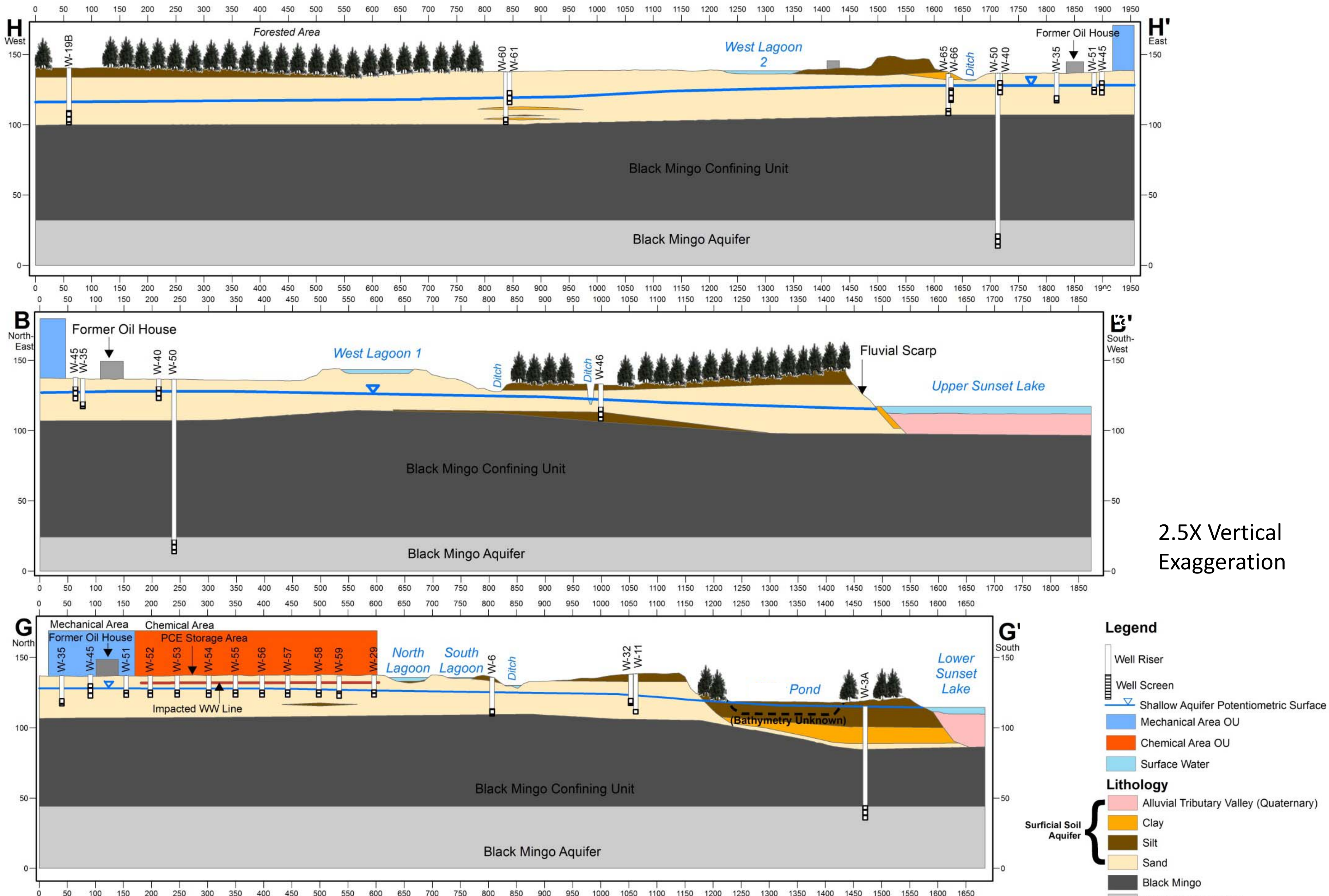
- Northern Storage Area
- Chemical Area
- Mechanical Area
- Sanitary Lagoon
- Southern Storage Area
- Wastewater Treatment
- West Lagoon
- Western Storage Area
- Upper Sands
- Surficial Aquifer Potentiometric Surface (2018)
- Black Mingo

Site CSM Block Diagram – Geology



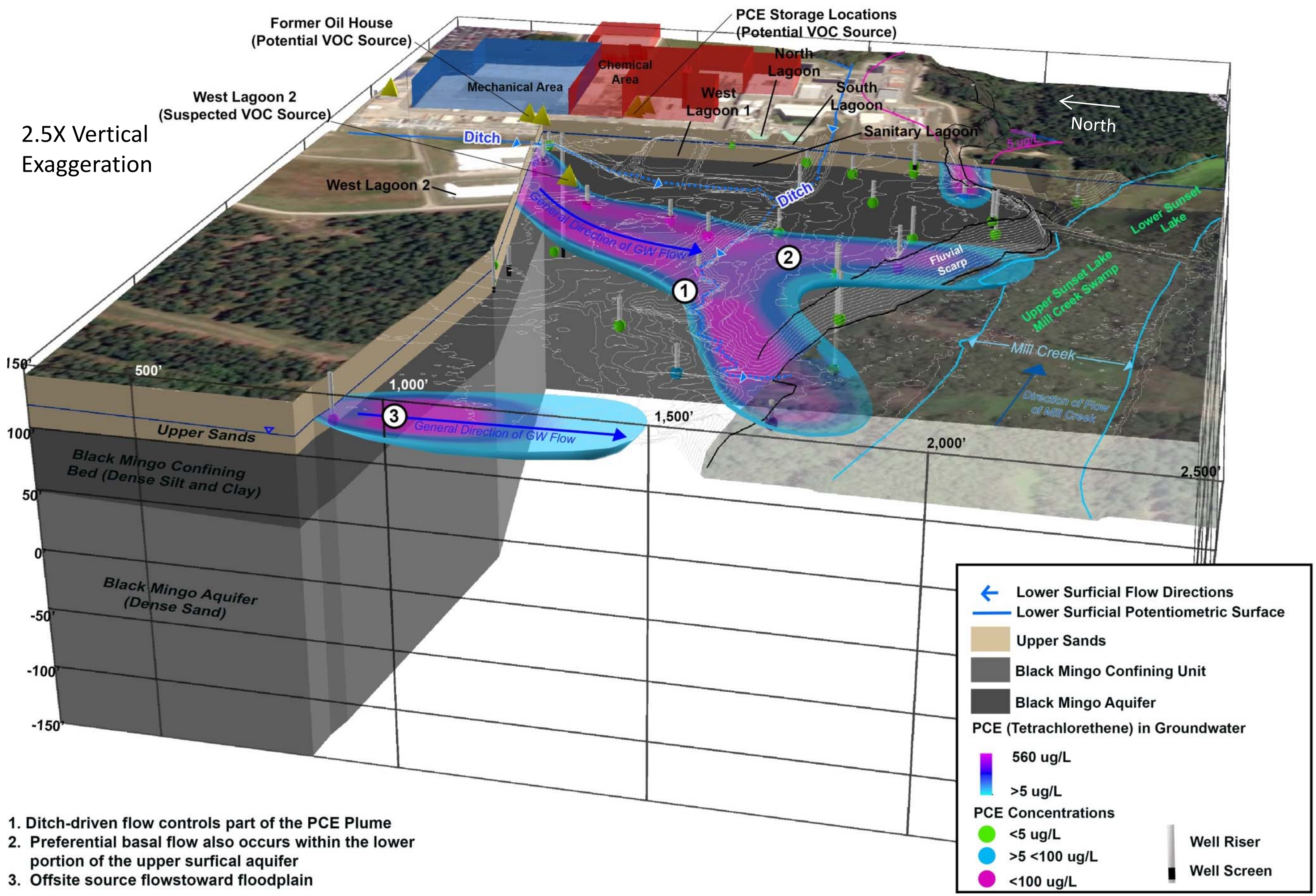
2.5X Vertical
Exaggeration

Site CSM Cross Sections



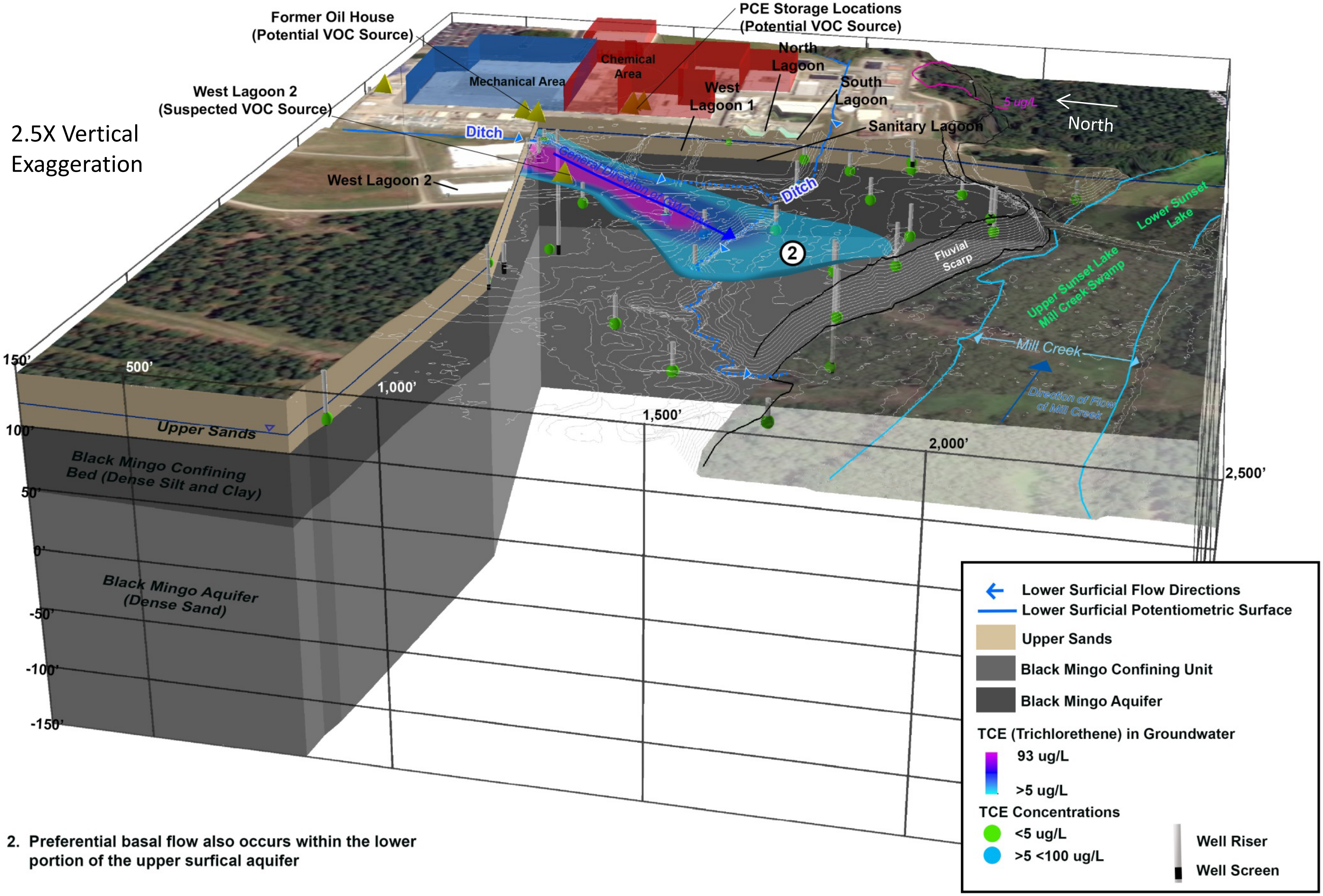
2.5X Vertical Exaggeration

Site CSM Block – PCE



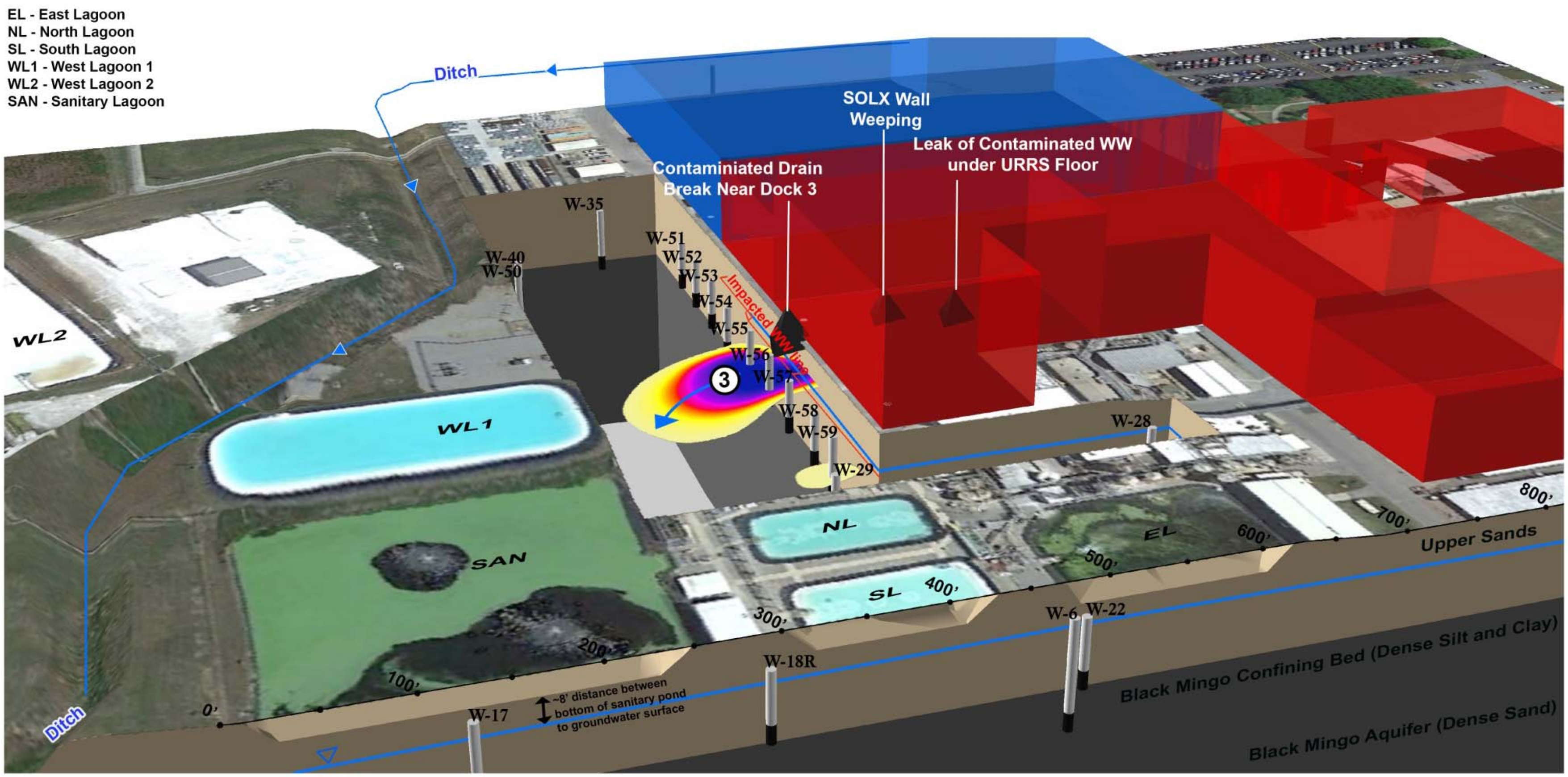
1. Ditch-driven flow controls part of the PCE Plume
2. Preferential basal flow also occurs within the lower portion of the upper surfical aquifer
3. Offsite source flowstoward floodplain

Site CSM Block – TCE



2. Preferential basal flow also occurs within the lower portion of the upper surfical aquifer

Site CSM Block –Uranium Sources



Uranium Concentrations
- 180 ug/L in Groundwater
- >30 ug/L in Groundwater

Well Riser
Well Screen
Green indicates concentrations below 30 ug/L

Upper Sands
Black Mingo
Surficial Aquifer Potentiometric Surface
Surficial Aquifer Potentiometric Surface

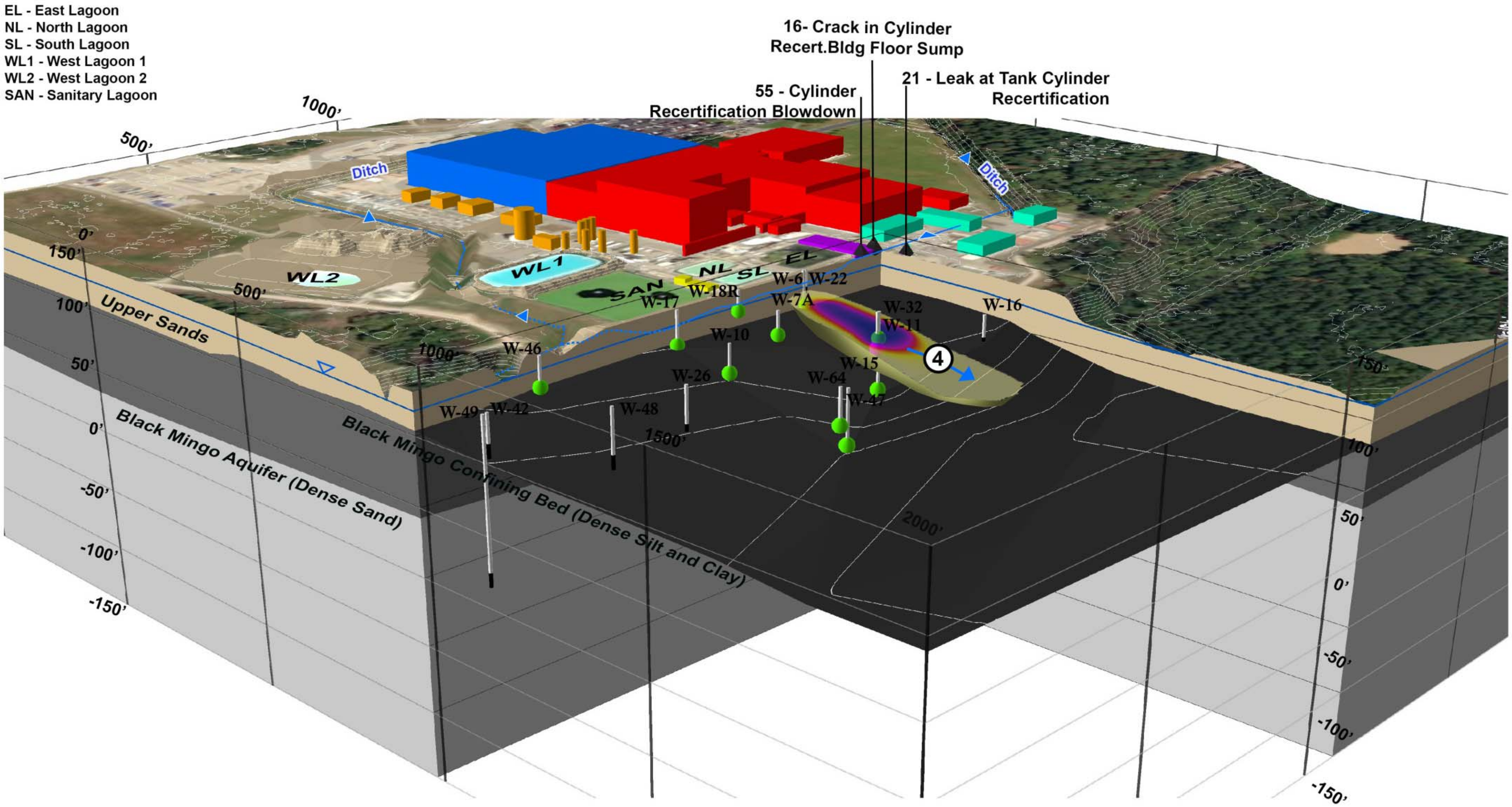
Potential Radioactive Release Sources

3. Flow from source areas into uppermost surficial aquifer only and low rate of advection and dispersion

Note: Most recent groundwater result used from 2018 through and including October and November 2018 monitoring wells results.

2.5X Vertical Exaggeration

Site CSM Block –Tc-99 Sources



Technetium-99 Concentrations
- >3000 ug/L in Groundwater
- >86ug/L in Groundwater
- ▲ Potential Tc-99 Release Sources

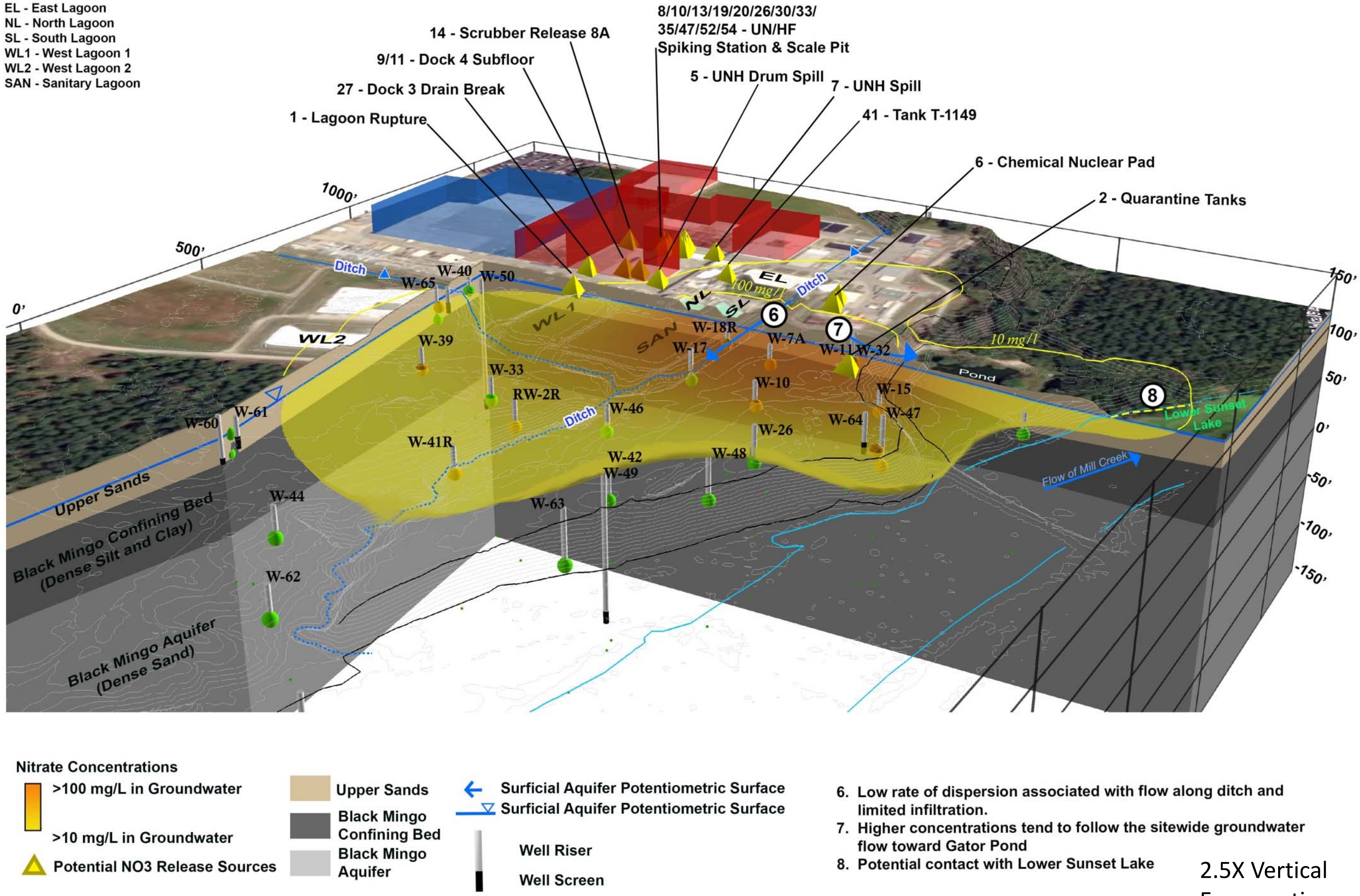
- Upper Sands
- Black Mingo Confining Bed
- Black Mingo Aquifer

- Surficial Aquifer Potentiometric Surface
- Surficial Aquifer Potentiometric Surface
- Well Riser
- Well Screen

4. Higher concentrations tend to follow the sitewide groundwater flow toward Gator Pond

2.5X Vertical Exaggeration

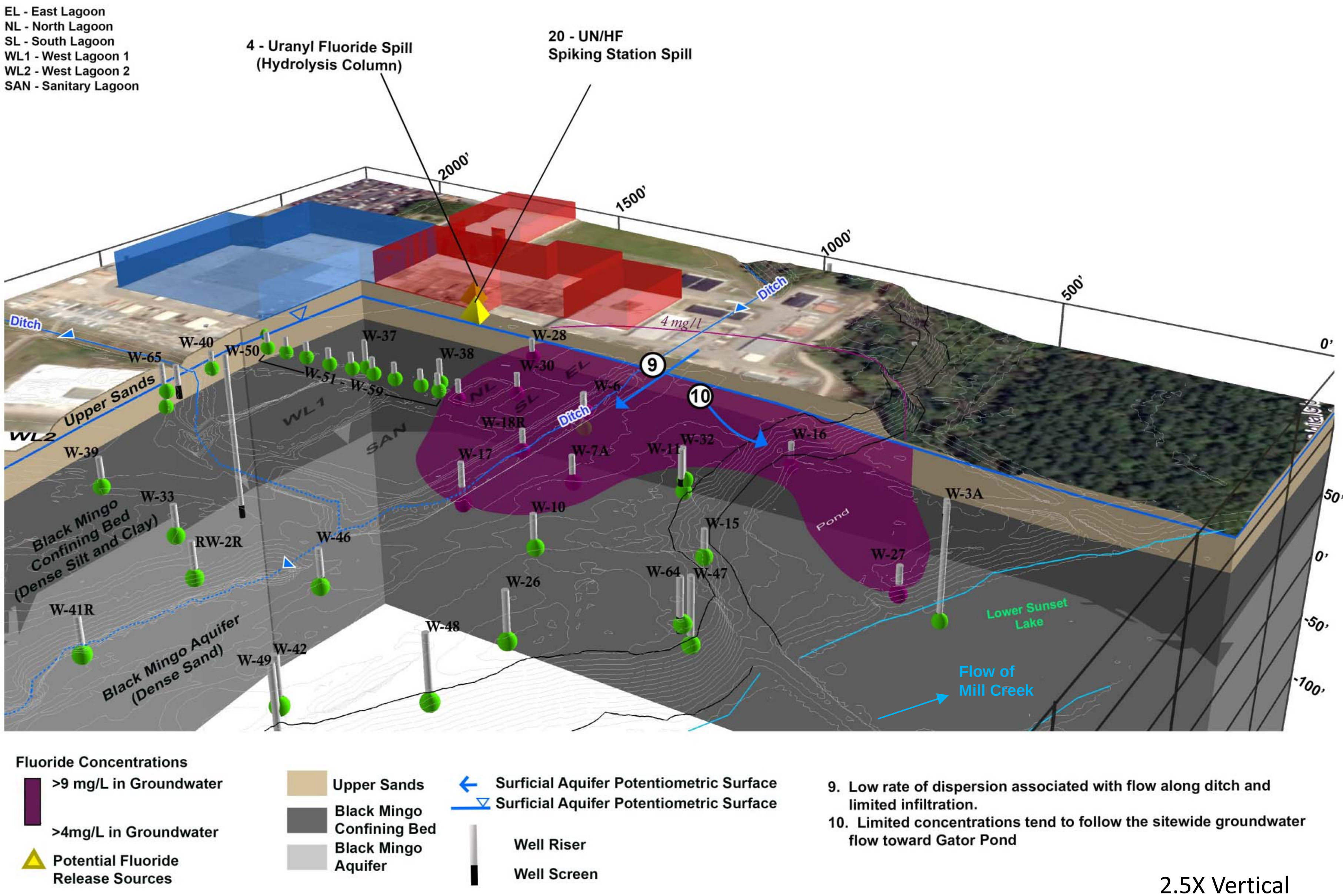
Site CSM Block –NO3 Sources



6. Low rate of dispersion associated with flow along ditch and limited infiltration.
7. Higher concentrations tend to follow the sitewide groundwater flow toward Gator Pond
8. Potential contact with Lower Sunset Lake

2.5X Vertical Exaggeration

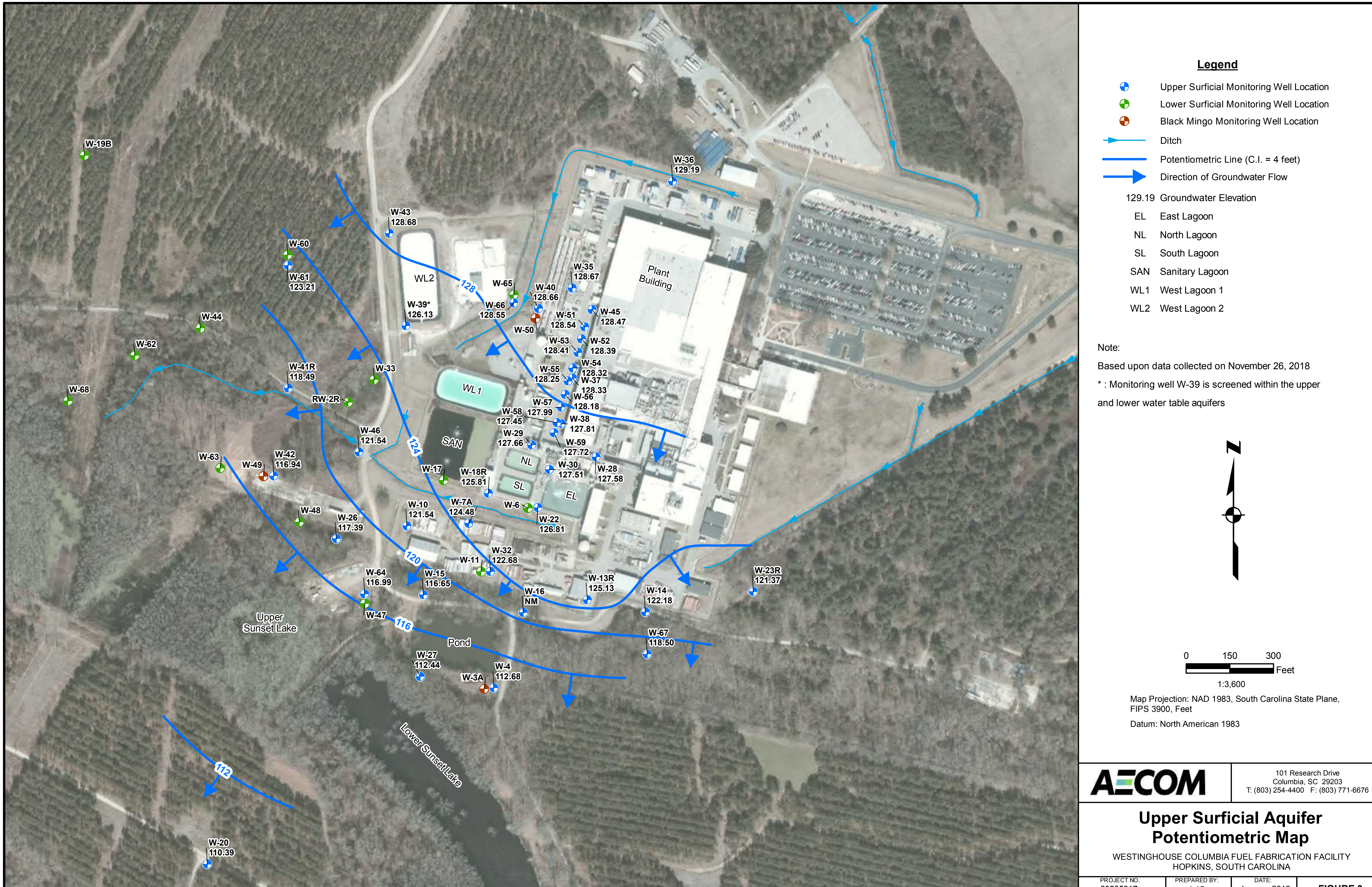
Site CSM Block –Fluoride Sources



9. Low rate of dispersion associated with flow along ditch and limited infiltration.
10. Limited concentrations tend to follow the sitewide groundwater flow toward Gator Pond

2.5X Vertical Exaggeration

Appendix C
Historical Potentiometric Maps



Path: M:\EnvDataViz\Westinghouse\mxd\January2019\figure3_upperWT_GWpot.mxd

Source: CVOC Assessment Report (AECOM, 2019)

Legend

Upper Surficial Monitoring Well Location

Lower Surficial Monitoring Well Location

Black Mingo Monitoring Well Location

Ditch

Potentiometric Line (C.I. = 4 feet)

Direction of Groundwater Flow

128.36 Groundwater Elevation

EL East Lagoon

NL North Lagoon

SL South Lagoon

SAN Sanitary Lagoon

WL1 West Lagoon 1

WL2 West Lagoon 2

Note:

Based upon data collected on November 26, 2018

* : Monitoring well W-39 is screened within the upper and lower water table aquifers

N

0 150 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Lower Surficial Aquifer Potentiometric Map

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60585917	LJG	January 2019	**FIGURE 4**

Path: M:\EnvDataViz\Westinghouse\mxd\January2019\figure4_lowerWT_GWpot.mxd

Source: CVOC Assessment Report (AECOM, 2019)

Legend

Upper Surficial Monitoring Well Location

Lower Surficial Monitoring Well Location

Black Mingo Monitoring Well Location

Floodplain Aquifer Monitoring Well Location

Ditch

Potentiometric Line (C.I. = 4 feet)

Direction of Groundwater Flow

118.23	Groundwater Elevation
EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

Note:

* : Monitoring well W-39 is screened within the upper and lower surficial aquifer

N

0 150 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

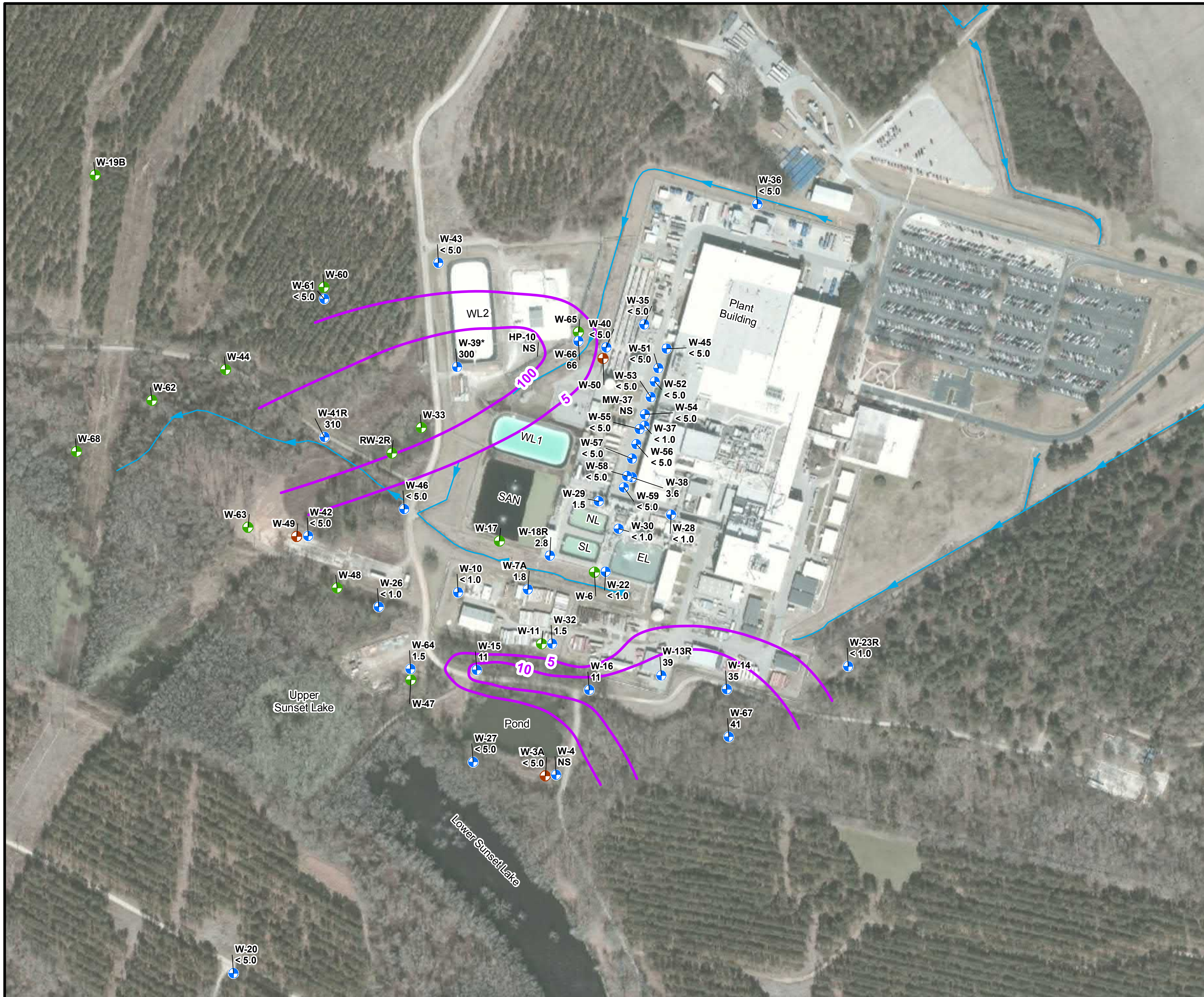
Black Mingo Aquifer Potentiometric Map

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	CCS	March 2019	FIGURE X

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\BlackMingoAquiferPotMap.mxd

Appendix D
Historical Groundwater Plume Maps



Legend

- Upper Surficial Monitoring Well Location
- Lower Surficial Monitoring Well Location
- Black Mingo Monitoring Well Location
- Ditch
- PCE Isoconcentration Contours (µg/L)

300	PCE Concentration in µg/L
EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

Note:

Based upon data collected on November 26, 2018

* : Monitoring well W-39 is screened within the upper and lower water table aquifers

N

0 150 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

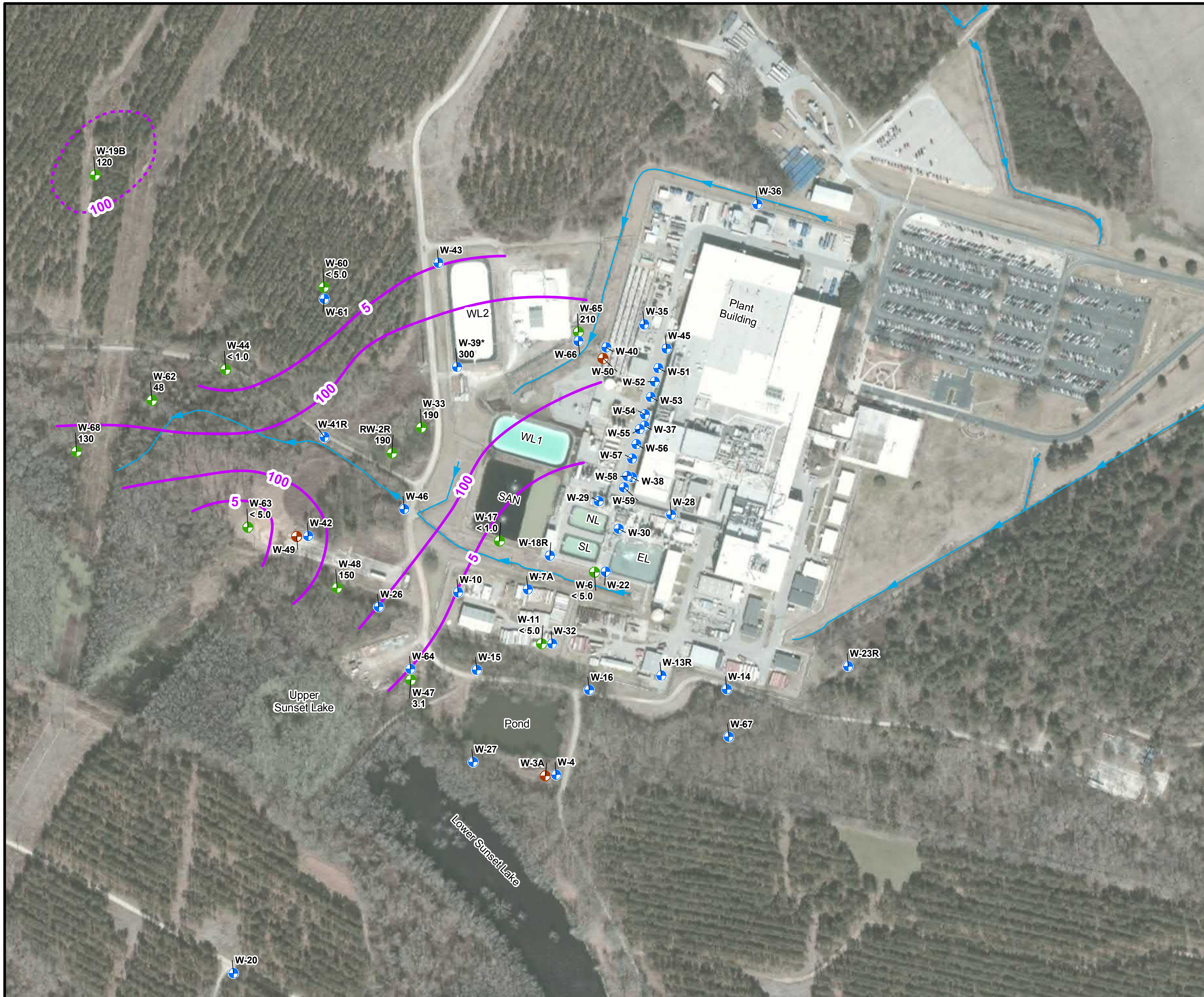
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

PCE Plume
Upper Surficial Aquifer

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60585917	LJG	January 2019	FIGURE 5

Path: M:\EnvDataViz\Westinghouse\mxd\January2019\figure5_pce_upperWT.mxd



Legend

- Upper Surficial Monitoring Well Location
- Lower Surficial Monitoring Well Location
- Black Mingo Monitoring Well Location
- Ditch
- PCE Isoconcentration Contours (µg/L) (Dashed where inferred)

210	PCE Concentration in µg/L
EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

Note:

Based upon data collected on November 26, 2018

* : Monitoring well W-39 is screened within the upper and lower water table aquifers

N

0 150 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

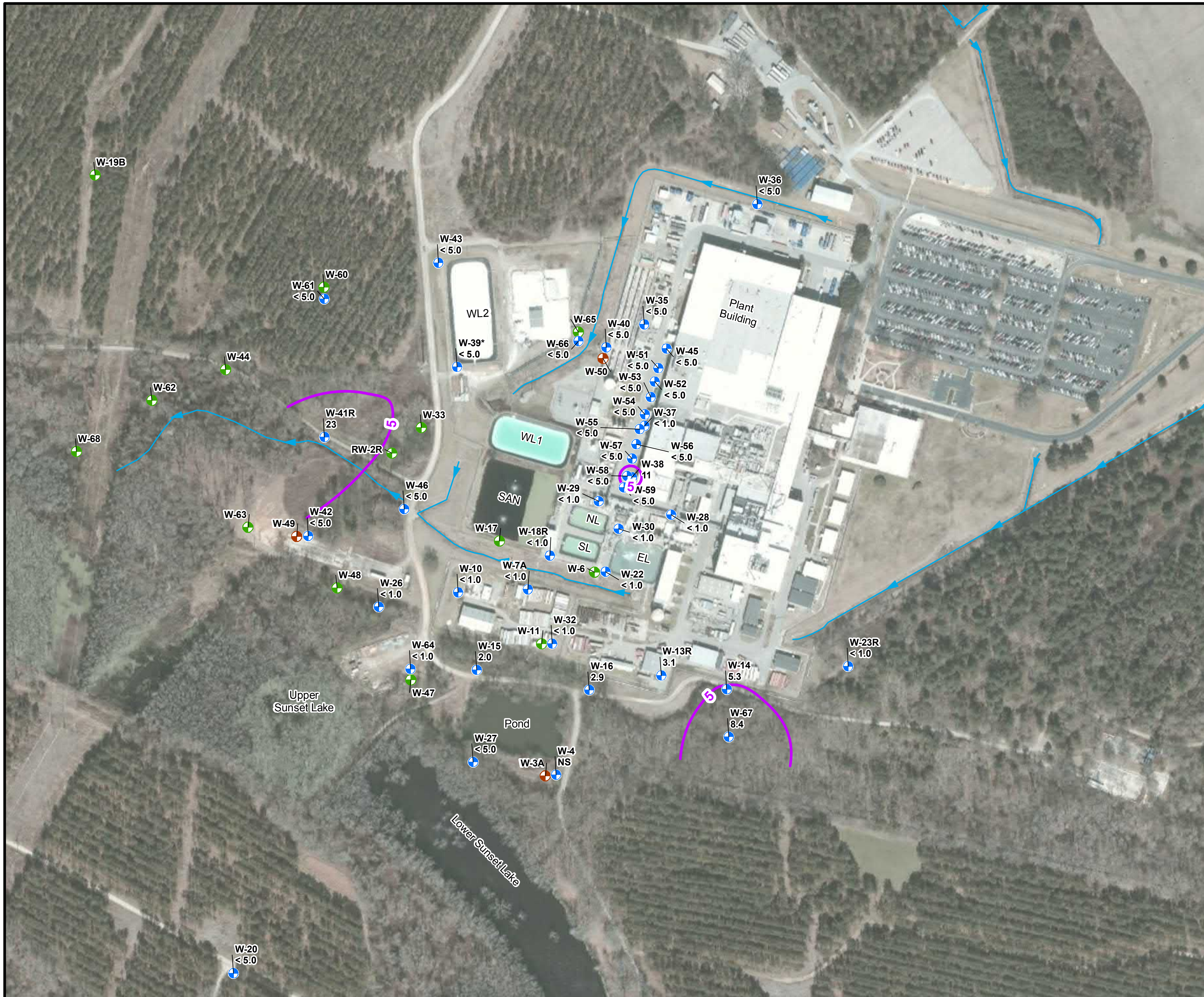
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

PCE Plume
Lower Surficial Aquifer

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60585917	LJG	January 2019	FIGURE 6

Path: M:\EnvDataViz\Westinghouse\mxd\January2019\figure6_pce_lowerWT.mxd



Legend

- Upper Surficial Monitoring Well Location
- Lower Surficial Monitoring Well Location
- Black Mingo Monitoring Well Location
- Ditch
- TCE Isoconcentration Contours (µg/L)

5.3	TCE Concentration in µg/L
EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

Note:

Based upon data collected on November 26, 2018

* : Monitoring well W-39 is screened within the upper and lower water table aquifers

N

0 150 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

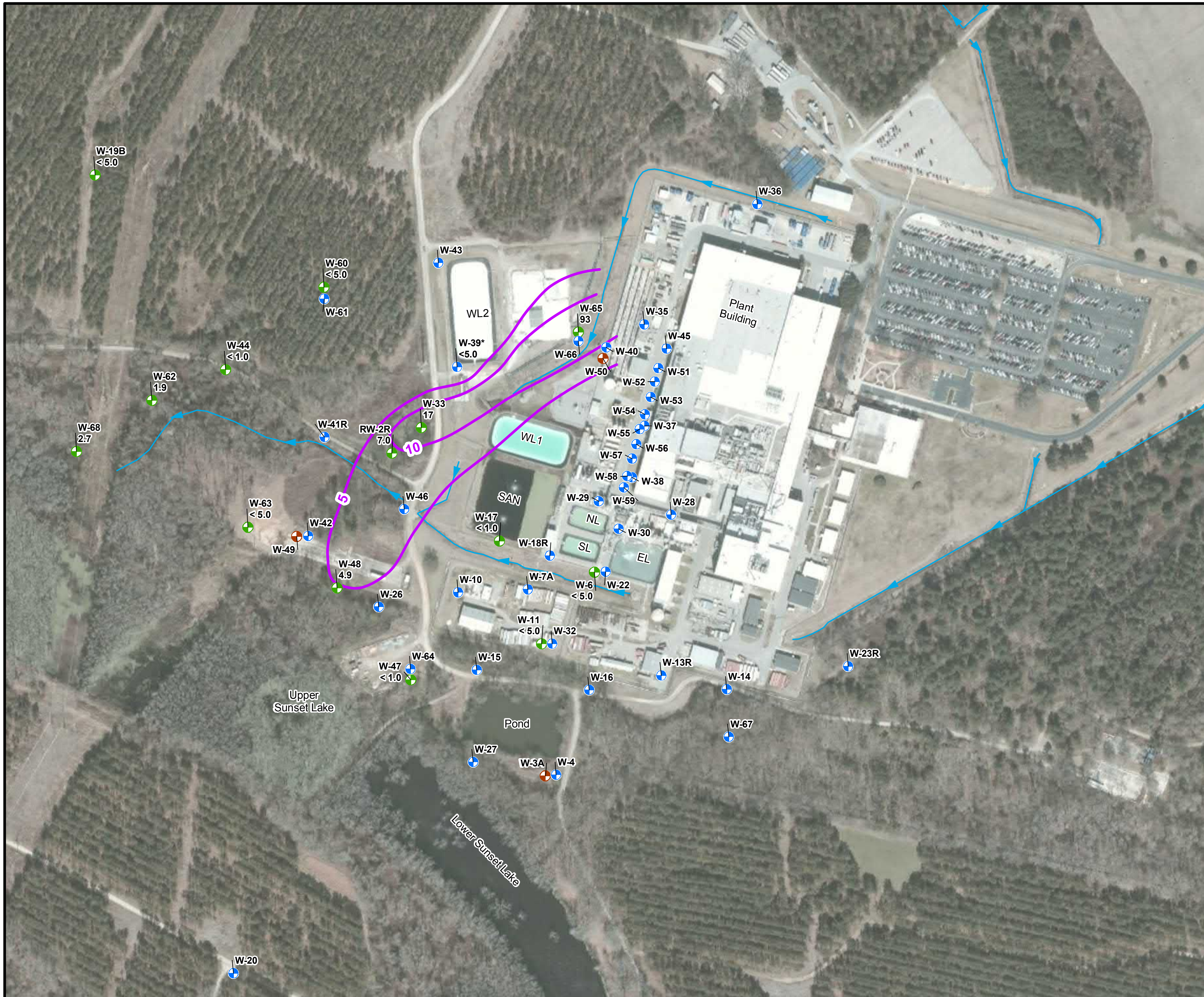
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

TCE Plume
Upper Surficial Aquifer

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60585917	LJG	January 2019	FIGURE 7

Path: M:\EnvDataViz\Westinghouse\mxd\January2019\figure7_tce_upperWT.mxd



Legend

- Upper Surficial Monitoring Well Location
- Lower Surficial Monitoring Well Location
- Black Mingo Monitoring Well Location
- Ditch
- TCE Isoconcentration Contours (µg/L)

93	TCE Concentration in µg/L
EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

Note:

Based upon data collected on November 26, 2018

* : Monitoring well W-39 is screened within the upper and lower water table aquifers

N

0 150 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

TCE Plume
Lower Surficial Aquifer

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60585917	LJG	January 2019	FIGURE 8

Path: M:\EnvDataViz\Westinghouse\mxd\January2019\figure8_tce_lowerWT.mxd

N

Legend

- Shallow Aquifer Monitoring Well Location
- Black Mingo Aquifer Monitoring Well Location
- Surface Water/Sediment Sampling Locations
- Ditch
- 840 Nitrate Concentration (mg/L)
- Nitrate Isoconcentration Contour (mg/L)

EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

300 150 0 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

NITRATE IN GROUNDWATER
JULY 2018

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60528361	CCS	September 2018	FIGURE I2

Path: M:\EnvDataViz\Westinghouse\mxd\NitrateInGroundwater_2018_07.mxd

N

Legend

- Shallow Aquifer Monitoring Well Location
- Black Mingo Aquifer Monitoring Well Location
- Surface Water/Sediment Sampling Locations
- Ditch
- 8.82 Floride Concentration (mg/L)
- Floride Isoconcentration Contour (mg/L)

EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

300 150 0 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

FLUORIDE IN GROUNDWATER
JULY 2018

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60528361	CCS	September 2018	FIGURE I1

Path: M:\EnvDataViz\Westinghouse\mxd\FluorideInGroundwater_2018_07.mxd

Legend

- Shallow Aquifer Monitoring Well Location
- Black Mingo Aquifer Monitoring Well Location
- Surface Water/Sediment Sampling Locations
- Ditch
- 35.0 Gross Alpha Concentration (pCi/L)
- Gross Alpha Isoconcentration Contour (pCi/L)

EL	East Lagoon
NL	North Lagoon
SL	South Lagoon
SAN	Sanitary Lagoon
WL1	West Lagoon 1
WL2	West Lagoon 2

300 150 0 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

GROSS ALPHA IN GROUNDWATER
JULY 2018

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60528361	CCS	September 2018	FIGURE I3

Path: M:\EnvDataViz\Westinghouse\mxd\GrossAlphaInGroundwater_2018_07.mxd

Legend

- Shallow Aquifer Monitoring Well Location
- Black Mingo Aquifer Monitoring Well Location
- Surface Water/Sediment Sampling Locations
- Ditch
- 199 Gross Beta Concentration (pCi/L)
- Gross Beta Isoconcentration Contour (pCi/L)
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon 1
- WL2 West Lagoon 2

300 150 0 300 Feet

1:3,600

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM
101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

GROSS BETA IN GROUNDWATER
JULY 2018

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60528361	CCS	September 2018	FIGURE I4

Path: M:\EnvDataViz\Westinghouse\mxd\GrossBetaInGroundwater_2018_07.mxd

Appendix E
Standard Operating Procedures

COPY

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia	
OPERATING PROCEDURE	
Title: **Soil Sampling**	
Effective Date: August 21, 2014	**Number:** SESDPROC-300-R3
Authors	
Name: Kevin Simmons Title: Environmental Scientist, Regional Expert Signature: [signature] Date: 8/18/2014	
Approvals	
Name: John Deatrick Title: Acting Chief, Enforcement and Investigations Branch Signature: [signature] Date: 8/18/14	
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature: [signature] for Bobby Lewis Date: 8/20/14	

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-300-R3, *Soil Sampling*, replaces SESDPROC-300-R2. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Updated the author from Fred Sloan to Kevin Simmons. Updated the Enforcement and Investigations Branch Chief from Archie Lee to Acting Chief, John Deatrick. Section 1.5.1: Added "The reader should" to last sentence of the paragraph. Section 1.5.2: Omitted "When sampling in landscaped areas," from first sentence of eighth bullet. Section 3.2.4: In the first paragraph, first sentence, added "(rapidly form bubbles)." Omitted "(rapidly form bubbles)" from second paragraph, second sentence. Any reference to "Percent Moisture and Preservation Compatibility (MOICA)" or "Percent Moisture" was changed to "Percent Solids", both in the text and in Table 1.	August 21, 2014
SESDPROC-300-R2, *Soil Sampling*, replaces SESDPROC-300-R1.	December 20, 2011
SESDPROC-300-R1, *Soil Sampling*, replaces SESDPROC-300-R0.	November 1, 2007
SESDPROC-300-R0, Soil Sampling, Original Issue	February 05, 2007

COPY

TABLE OF CONTENTS

TABLES

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting soil samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling soil samples in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a soil sample, the variant procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN, and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field X-Ray Fluorescence (XRF) Measurement, SESDPROC-107, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

US EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Most Recent Version (Method 5035)

US EPA. Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting soil samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting soil samples:

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association

(IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader in the project files.
- Sampling in landscaped areas: Cuttings should be placed on plastic sheeting and returned to the borehole upon completion of the sample collection. Any 'turf plug' generated during the sampling process should be returned to the borehole.
- Sampling in non-landscaped areas: Return any unused sample material back to the auger, drill or push hole from which the sample was collected.

2 Special Sampling Considerations

2.1 Special Precautions for Trace Contaminant Soil Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different sample is collected and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers with samples suspected of containing high concentrations of contaminants shall be handled and stored separately.
- All background samples shall be segregated from obvious high-concentration or waste samples. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly-contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other member(s) collect the samples.
- Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), for collection of samples for trace metals or organic compound analyses.

2.2 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.

2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.

3. All soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
- Two quarters should then be mixed to form halves.
- The two halves should be mixed to form a homogenous matrix.

  This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

4. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

2.3 Dressing Soil Surfaces

Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.

2.4 Quality Control

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same soil type. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools. SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) contains other procedures that may be applicable to soil sampling investigations.

2.5 Records

Field notes, recorded in a bound field logbook, as well as chain-of-custody documentation will be generated as described in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005).

3 Method 5035

The procedures outlined here are summarized from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Method 5035.*

3.1 Soil Samples for Volatile Organic Compounds (VOC) Analysis

If samples are to be analyzed for VOCs, they should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with an auger bucket, the sample for VOC analysis should be collected directly from the auger bucket (preferred) or from minimally disturbed material immediately after an auger bucket is emptied into the pan. The sample shall be containerized by filling an En Core® Sampler or other Method 5035 compatible container. ***Samples for VOC analysis are not homogenized.*** Preservatives may be required for some samples with certain variations of Method 5035. Consult the method or the principal analytical chemist to determine if preservatives are necessary.

3.2 Soil Sampling (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of VOCs in soils at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

3.2.1 Equipment

Soil for VOC analyses may be retrieved using any of the SESD soil sampling methods described in Sections 4 through 8 of this procedure. Once the soil has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2-oz. soil VOC container, or pre-prepared 40 mL vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

3.2.2 Sampling Methodology - Low Concentrations (<200 µg/kg)

When the total VOC concentration in the soil is expected to be less than 200 µg/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 mL pre-prepared vial) immediately to reduce volatilization losses. The 40 mL vials should contain 10 mL of organic-free water for an un-preserved sample or approximately

10 mL of organic-free water and a preservative. It is recommended that the 40 mL vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A soil sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 mL pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. soil jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 mL pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil samples may be prepared for shipping and analysis as follows:

En Core® Sampler - the sample shall be capped, locked, and secured in the original foil bag. All foil bags containing En Core® samplers are then placed in a plastic bag and sealed with custody tape, if required.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40-mL pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 mL containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

3.2.3 Sampling Methodology - High Concentrations (>200 µg/kg)

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils\sediments containing high total VOC concentrations may also be collected as described in Section 3.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 mL methanol.

3.2.4 Special Techniques and Considerations for Method 5035

Effervescence

If low concentration samples effervesce (rapidly form bubbles) from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved, as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note: the amount of organic free water placed into the vials will have to be accurately measured.

Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size and the lack of sample mixing, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

Holding Times

Sample holding times are specified in the Analytical Support Branch *Laboratory Operations and Quality Assurance Manual* (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample on ice is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

Percent Solids

Samplers must ensure that the laboratory has sufficient material to determine percent solids in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent solids determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent solids determination will be required. The sample collected for percent solids may also be used by the laboratory to check for preservative compatibility.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities.

The summary table on the following page lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. SESD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

Table 1: Method 5035 Summary

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect two 40 mL vials with ≈ 5 grams of sample, and one 2 oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	Screening conducted by lab.	Presently a 48-hour holding time for unpreserved samples. Sample containers must be tared.
2	Collect three En Core® samplers, and one 2 oz. glass jar w/septum lid for screening, % solids.	Lab conducts all preservation/preparation procedures.	Presently a 48- hour holding time for preparation of samples.
3	Collect two 40 mL vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and one 2-oz. glass jar w/septum lid for screening, % solids .	High level VOC samples may be composited. Longer holding time.	Hazardous materials used in the field. Sample containers must be tared.
4	Collect one 2-oz. glass jar w/septum lid for analysis, % solids (high level VOC only).	Lab conducts all preservation/preparation procedures.	May have significant VOC loss.

4 Manual Soil Sampling Methods

4.1 General

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual collection methods becomes impractical.

If a thick, matted root zone, gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials.

When compositing, make sure that each composite location (aliquot) consist of equal volumes, i.e., same number of equal spoonfuls.

4.2 Spoons

Stainless steel spoons may be used for surface soil sampling to depths of approximately 6 inches below ground surface where conditions are generally soft and non-indurated, and there is no problematic vegetative layer to penetrate.

4.2.1 Special Considerations When Using Spoons

- When using stainless steel spoons, consideration must be given to the procedure used to collect the volatile organic compound sample. If the soil being sampled is cohesive and holds its in situ texture in the spoon, the En Core® Sampler or syringe used to collect the sub-sample for Method 5035 should be plugged directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to plugging the sample for Method 5035 directly from the ground surface at a depth appropriate for the investigation Data Quality Objectives.

4.3 Hand Augers

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Typically, 4-inch stainless steel auger buckets with cutting heads are used. The bucket is advanced by simultaneously pushing and turning using an attached handle with extensions (if needed).

4.3.1 Surface Soil Sampling

When conducting surface soil sampling with hand augers, the auger buckets may be used with a handle alone or with a handle and extensions. The bucket is advanced to the appropriate depth and the contents are transferred to the homogenization container for processing. Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

4.3.2 Subsurface Soil Sampling

Hand augers are the most common equipment used to collect shallow subsurface soil samples. Auger holes are advanced one bucket at a time until the sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and removed.

The practical depth of investigation using a hand auger depends upon the soil properties and depth of investigation. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. Hand augers may also be of limited use in tight clays or cemented sands. In these soil types, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torqueing of the hand auger extensions. At some point these problems become so severe that power equipment must be used.

4.3.3 Special Considerations for Soil Sampling with the Hand Auger

- Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- Observe precautions for volatile organic compound (VOC) sample collection found in Section 3, Method 5035. Collect the VOC sample directly from the auger bucket, if possible.
- Power augers, such as the Little Beaver® and drill rigs may be used to advance boreholes to depths for subsurface soil sampling with the hand auger. They may not be used for sample collection. When power augers are used to advance a borehole to depth for sampling, care must be taken that exhaust fumes, gasoline and/or oil do not contaminate the borehole or area in the immediate vicinity of sampling.
- When moving to a new sampling location, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

5 Direct Push Soil Sampling Methods

5.1 General

These methods are used primarily to collect shallow and deep subsurface soil samples. Three samplers are available for use within the Division's direct push tooling inventory. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe each of the specific sampling methods that can be accomplished using direct push techniques, along with details specific to each method. While SESD currently uses the sample tooling described, tooling of similar design and materials is acceptable.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

5.2 Large Bore® Soil Sampler

The Large Bore® (LB) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of depth-discrete subsurface soil samples. The sample barrel is approximately 30-inches (762 mm) long and has a 1.5-inch (38 mm) outside diameter. The LB® sampler is capable of recovering a discrete sample core 22 inches x 1.0 inch (559 mm x 25 mm) contained inside a removable liner. The resultant sample volume is a maximum of 283 mL.

After the LB® sample barrel is equipped with the cutting shoe and liner, the piston-rod point assembly is inserted, along with the drive head and piston stop assembly. The assembled sampler is driven to the desired sampling depth, at which time the piston stop pin is removed, freeing the push point. The LB® sampler is then pushed into the soil a distance equal to the length of the LB® sample barrel. The probe rod string, with the LB® sampler attached, is then removed from the subsurface. After retrieval, the LB® sampler is then removed from the probe rod string. The drive head is then removed to allow removal of the liner and soil sample.

5.3 Macro-Core® Soil Sampler

The Macro-Core® (MC) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration. Although the MC® sampler can be used as an open-barrel sampler, in SESD usage, the piston point is always used to prevent the collection of slough from the borehole sides.

5.4 Dual Tube Soil Sampling System

The Dual Tube 21 soil sampling system is a direct push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of continuous core inside a cased hole, minimizing or preventing cross-contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual tube assembly and core to its initial sample depth.

5.5 Special Considerations When Using Direct Push Sampling Methods

- *Liner Use and Material Selection* – Direct Push Soil Samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terepthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most SESD investigations, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.

- *Sample Orientation* – When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

- *Core Catchers* – Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.

- *Decontamination* – The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESDPROC-205, most recent version. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes using the procedures specified for downhole drilling equipment in Field Equipment and Decontamination – SESDPROC-205, most recent version.

- *Decommissioning* – Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet deep that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.

- *VOC Sample Collection* – Observe precautions for volatile organic compound sample collection found in Section 3 of this procedure.

6 Split Spoon/Drill Rig Methods

6.1 General

Split spoon sampling methods are used primarily to collect shallow and deep subsurface soil samples. All split spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the sub used to attach the spoon to the string of drill rod. Two basic methods are available for use, including the smaller diameter standard split spoon, driven with the drill rig safety hammer, and the larger diameter continuous split spoon, advanced inside and slightly ahead of the lead auger during hollow stem auger drilling. The following sections describe each of the specific sampling methods, along with details specific to each method.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

6.2 Standard Split Spoon

A drill rig is used to advance a borehole to the target depth. The drill string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0-inches OD (1.5-inches ID) and 18-inches to 24-inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition.

6.3 Continuous Split Spoon

The continuous split spoon is a large diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and either 5 feet or 10 feet in length, although the 5-foot long samplers are most common. After the auger string has been advanced into the soil column a distance equal to the length of the sampler being used it is returned to the surface. The sampler is removed from inside the hollow stem auger and the threaded collars are removed. The split spoon is then opened for sampling.

6.4 Special Considerations When Using Split Spoon Sampling Methods

- Always discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during inserting the split spoon.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

7 Shelby Tube/Thin-Walled Sampling Methods

7.1 General

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

7.2 Shelby Tube Sampling Method

A typical Shelby tube is 30 inches in length and has a 3.0-inch OD (2.875-inch ID) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball-check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable.

To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force. After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

7.3 Special Considerations When Using Split Spoon Sampling Methods

Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

8 Backhoe Sampling Method

8.1 General

Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. If possible, the sample should be collected without entering the trench. Samples may be obtained from the trench wall or they may be obtained directly from the bucket at the surface. The following sections describe various techniques for safely collecting representative soil samples with the aid of a backhoe.

The depth measurement for the sample begins at the top of the soil horizon.

8.2 Scoop-and-Bracket Method

If a sample interval is targeted from the surface, it can be sampled using a stainless steel scoop and bracket. First a scoop and bracket are affixed to a length of conduit and is lowered into the backhoe pit. The first step is to take the scoop and scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless steel scoop is removed and a clean stainless steel scoop is placed on the bracket. The clean scoop can then be used to remove sufficient volume of soil from the excavation wall to make up the required sample volume.

8.3 Direct-from-Bucket Method

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample.

8.4 Special Considerations When Sampling with a Backhoe

- Do not physically enter backhoe excavations to collect a sample. Use either procedure 8.2, Scoop-and-Bracket Method, or procedure 8.3, Direct-from-Bucket Method to obtain soil for sampling.
- Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled (see Section 2.3), to mitigate problems with smearing.

- Paint, grease and rust must be removed and the bucket decontaminated prior to sample collection.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

COPY

Region 4 **U.S. Environmental Protection Agency** **Science and Ecosystem Support Division** **Athens, Georgia**
GUIDANCE
Title: **Design and Installation of Monitoring Wells**
Effective Date: January 29, 2013   **Number:** SESDGUID-101-R1
Authors
Name: Brian Striggow Title: Environmental Engineer Signature: [signature] Date: 1-22-13
Approvals
Name: Danny France Title: Chief, Enforcement and Investigations Branch Signature: [signature] Date: 1-22-13
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature: [signature] Date: 1/22/13

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDGUID-101-R1, *Design and Installation of Monitoring Wells*, replaces SESDPROC-101-R0. **General:** Corrected any typographical, grammatical and/or editorial errors. **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Antonio Quinones to Danny France. The FQM was changed from Laura Ackerman to Bobby Lewis. **Section 1.2:** Added the following statement: Mention of trade names or commercial products does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted the reference to the H: drive of the LAN. **Section 1.4:** Replaced the "SESD Operating Procedure for Field Records and Documentation, SESDPROC-204-Most Recent Version" with its updated version, the "SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version. **Section 1.5.1:** Updated the SHEMP Manual reference to reflect that the most recent version of the Manual will be used. **Section 1.5.2:** On the second bullet, replaced the reference with the "SESD Operating Procedure for Logbooks (SESDPROC-010)."	January 29, 2013
SESDGUID-101-R0, *Design and Installation of Monitoring Wells*, Original Issue	February 18, 2008

COPY

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when designing and installing permanent and temporary groundwater monitoring wells to be used for collection of groundwater samples.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when designing, constructing and installing groundwater monitoring wells. On the occasion that SESD field personnel determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for any aspect of the design, construction and/or installation of a groundwater monitoring well, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

USEPA Region 4 Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), November 2001

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Science and Ecosystem Support Division, Region 4, Athens, GA, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Groundwater Sampling, SESDPROC-301, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

EPA/540/S-95/503, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation*

ASTM standard D5092, *Design and Installation of Ground Water Monitoring Wells in Aquifers*

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when constructing and installing groundwater monitoring wells. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Section 2.6, Safety Procedures for Drilling Activities, contains detailed and specific safety guidelines that must be followed by Branch personnel when conducting activities related to monitoring well construction and installation.

1.5.2 Procedural Precautions

The following precautions should be considered when constructing and installing groundwater monitoring wells.

- Special care must be taken to minimize or prevent inadvertent cross-contamination between borehole locations. Equipment, tools and well materials must be cleaned and/or decontaminated according to procedures found in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).
- All field activities are documented in a bound logbook according to the procedures found in SESD Operating Procedure for Logbooks (SESDPROC-010).

2 Permanent Monitoring Well Design Considerations

2.1 General

The design and installation of permanent monitoring wells involves drilling into various types of geologic formations that exhibit varying subsurface conditions. Designing and installing permanent monitoring wells in these geologic environments may require several different drilling methods and installation procedures. The selection of drilling methods and installation procedures should be based on field data collected during a hydrogeologic site investigation and/or a search of existing data. Each permanent monitoring well should be designed and installed to function properly throughout the duration of the monitoring program. When designing monitoring wells, the following should be considered:

- Short-and long-term objectives;
- Purpose of the well(s);
- Probable duration of the monitoring program;
- Contaminants likely to be monitored;
- Surface and subsurface geologic conditions;
- Properties of the aquifer(s) to be monitored;
- Well screen placement;
- General site conditions; and
- Potential site health and safety hazards.

In designing permanent monitoring wells, the most reliable, obtainable data should be utilized. Once the data have been assembled and the well design(s) completed, a drilling method(s) must be selected. The preferred drilling methods for installing monitoring wells are those that temporarily case the borehole during drilling and the construction of the well, e.g. hollow-stem augers and sonic methods. However, site conditions or project criteria may not allow using these methods. When this occurs, alternate methods should be selected that will achieve the project objectives. The following discussion of methods and procedures for designing and installing monitoring wells will cover the different aspects of selecting materials and methods, drilling boreholes, and installing monitoring devices.

2.2 Drilling Methods

The following drilling methods may be used to install environmental monitoring wells or collect samples under various subsurface conditions. In all cases the preferred methods are those that case the hole during drilling, i.e. Hollow Stem Augers (HSA) and sonic methods using an override system. Other methods may be used where specific subsurface or project criteria dictate.

2.2.1 Hollow Stem Auger (HSA)

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be used at the bottom of the augers to keep out most of the soils and/or water that have a tendency to enter the bottom of the augers during drilling. Potable water (analyzed for contaminants of concern) may be poured into the augers during drilling to equalize pressure so that the inflow of formation materials will be held to a minimum. Water-tight center bits are not acceptable because they create suction when extracted from the augers. This suction forces or pulls cuttings and formation materials into the augers, defeating the purpose of the center plug. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by drilling and washing out the plug using a rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. Bottom plugs can be used where no soil sampling is conducted during the drilling process. The bottom plug is wedged into the bottom of the auger bit and is knocked out at depth with drill pipe or the weight of the casing and screen assembly. The plug material should be compatible with the screen and casing materials. The use of wood bottom plugs is not acceptable. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Boreholes can be augered to depths of 150 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

2.2.2 Solid Stem Auger

This type of auger consists of a sealed hollow or solid stem or shaft with a continuous spiraled steel flight welded on the outside of the stem. An auger bit connected to the bottom disturbs soil material when rotated and the helical flights transport cuttings to the surface. At the desired depth the entire auger string is removed to gain access to the bottom of the borehole. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed. Boreholes can be augered to depths of 200 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

Both of the previously discussed auger methods can be used in unconsolidated soils and semi-consolidated (weathered rock) soils, but not in competent rock.

Each method can be employed without introducing foreign materials into the borehole such as water and drilling fluids, minimizing the potential for cross contamination. Minimizing the risk of cross contamination is one of the most important factors to consider when selecting the appropriate drilling method(s) for a project.

2.2.3 Sonic Methods

These methods generally alternately advance concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string is removed with a core of drill cuttings while the outer 'override' string remains to hold the borehole open. The cuttings can be removed nearly intact from the inner casing for examination of the stratigraphy prior to sampling or disposal. Because there are no auger flights to increase the borehole diameter, the quantity of cuttings removed from the hole is minimized as compared to hollow stem augering. With moderate rotation, smearing of the formation materials on the borehole walls is reduced as well. This drilling method is useful in a variety of materials, from flowing sands to heavily consolidated or indurated formations.

In flowing sands, the drill casings can be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string. The same QA/QC requirements for sampling of material introduced to the borehole apply as in other drilling methods. Because the amount of water introduced into the borehole can be significant, an approximation of the water used in the drilling process should be logged for use in estimating appropriate well development withdrawal.

Sonic drilling allows a larger diameter temporary casing to be set into a confining layer while drilling proceeds into deeper aquifers. This temporary casing is then removed during the grouting operation. In many cases this will be acceptable technique. However, the level of contamination in the upper aquifer, the importance of the lower aquifers for drinking water uses, the permeability and continuity of the confining layer, and state regulations should be taken into account when specifying this practice as opposed to permanent outer casing placed into the confining unit. Note that when using the temporary casing practice, it is critical that grout be mixed and placed properly as specified elsewhere in this section.

Because the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, particular care should be taken that the well casing is placed in the center of the drill stem while placing the filter pack. Centralizers should be used in most cases to facilitate centering, particularly in the case of deep wells with PVC casing.

2.2.4 Rotary Methods

These methods consist of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids which generally consist of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill pipe, (or within a concentric drill stem in reverse rotary). Except in the case of air rotary, the drilling fluid provides a hydrostatic pressure that reduces or prevents borehole collapse. When considering this method, it is important to evaluate the potential for contamination when fluids and/or air are introduced into the borehole.

Due to the introduction of the various circulating fluids, the use of rotary methods requires that the potential for contamination by these fluids be evaluated. Water and mud rotary methods present the possibility of trace contamination of halogenated compounds when municipal water supplies are used as a potable water source. Air rotary drilling can introduce contamination through the use of lubricants or entrained material in the air stream. Unless contaminated formations are cased off, the circulation of drilling fluids presents a danger of cross contamination between formations. In any of the rotary (or sonic) methods, care must be exercised in the selection and use of compounds to prevent galling of drill stem threads.

2.2.4.1 Water Rotary

When using water rotary, potable water (that has been analyzed for contaminants of concern) should be used. If potable water (or a higher-quality water) is not available on-site, then potable water will have to be transported to the site or an alternative drilling method will have to be selected. Water does not clog the formation materials, but the suspended drilling fines can be carried into the formation, resulting in a very difficult to develop well. This method is most appropriate for setting isolation casing.

2.2.4.2 Air Rotary

Air rotary drilling uses air as a drilling fluid to entrain cuttings and carry them to the surface. High air velocities, and consequently large air volumes and compressor horsepower are required. "Down-the-hole" (DTH) percussion hammers driven by the air stream can be used with this method to rapidly penetrate bedrock materials. Where a casing through unconsolidated material is required to prevent borehole collapse, it can be driven in conjunction with advancement of the drill stem.

When using air rotary drilling in any zone of potential contamination, the cuttings exiting the borehole must be controlled. This can be done using the dual-tube reverse circulation method where cuttings are carried to the surface inside dual-wall drill pipe and separated with a cyclone separator. An air diverter with hose or pipe carrying cuttings to a waste container is also an acceptable alternative. Allowing cuttings to blow uncontrolled from the borehole is not acceptable.

When using air rotary, the issue of contaminants being introduced into the borehole by the air stream must be addressed. Screw compressor systems should have a coalescing filter system in good working order to capture excess entrained compressor oils. The lubricant to be used with DTH hammers as well as thread lubricants to be used on drill stem should be evaluated for their potential impact on analytical samples.

2.2.4.3 Mud Rotary

Mud rotary is an undesirable drilling method because contamination can be introduced into the borehole from the constituents in the drilling mud, cross contamination can occur along the borehole column, and it is difficult to remove the drilling mud from the borehole after drilling and during well development. The drilling mud can also carry contaminates from a contaminated zone to an uncontaminated zone thereby cross-contaminating the borehole. If mud rotary is selected, only potable water and pure (no additives) bentonite drilling muds should be used. All materials used should have adequate documentation as to manufacturer's recommendations and product constituents. QA/QC samples of drilling muds and potable water should be sampled at a point of discharge from the circulation system to assure that pumps and piping systems are not contributing cross-contamination from previous use.

2.2.5 Other Methods

Other methods such as the cable-tool method, jetting method, and boring (bucket auger) method are available. If these and/or other methods are selected for monitoring well installations, they should be approved by a senior field geologist before field work is initiated.

2.3 Borehole Construction

2.3.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter so that well construction can proceed without major difficulties. For open boreholes, the annular space should be approximately 2" to allow the uniform deposition of well materials around the screen and riser, and to allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. For example, a 2" nominal diameter (nom.) casing would require a 6" inside diameter (ID) borehole.

In hollow stem augers and sonic method drill casing, the ID should be of sufficient size to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the auger or casing. In general, 4-1/4" ID should be the minimum size used for placement of 2" nom. casing and 8-1/4" ID for 4" nom. casing. Larger augers should be used where installation difficulties due to geologic conditions or greater depths are anticipated, e.g. larger augers might be required to place a bentonite pellet seal through a long water column.

2.3.2 Over-drilling the Borehole

Sometimes it is necessary to over-drill the borehole in anticipation of material entering the augers during center bit removal or knocking out of the bottom plug. Normally, 3 to 5 feet is sufficient for over-drilling. The borehole can also be over-drilled to allow for an extra space or a "sump" area below the well screen. This "sump" area provides a space to attach a 5 or 10 foot section of well casing to the bottom of the well screen. The extra space or "sump" below the well screen serves as a catch basin or storage area for sediment that flows into the well and drops out of suspension. These "sumps" are added to the well screens when the wells are screened in aquifers that are naturally turbid and will not yield clear formation water (free of visible sediment) even after extensive development. The sediment can then be periodically pumped out of the "sump" preventing the well screen from clogging or "silting up". If the borehole is inadvertently drilled deeper than desired, it can be backfilled to the design depth with bentonite pellets, chips, or the filter sand that is to be used for the filter pack.

2.3.3 Filter Pack Placement

When placing the filter pack into the borehole, a minimum of 6-inches of the filter pack material should be placed under the bottom of the well screen to provide a firm base. Also, the filter pack should extend a minimum of 2-feet above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. In open boreholes, the filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by pouring the sand into an open drill stem is acceptable with the use hollow stem augers, and other methods where the borehole is temporarily cased down to the filter pack.

2.3.4 Filter Pack Seal – Bentonite Pellet Seal (Plug)

Bentonite pellets consist of ground, dried bentonite compacted into pellets available in several sizes. Bentonite pellets are compressed to a bulk density of 70-80 lbs/ft^3 and hydrate to a 30% min. solids material. Where neat cement grouts are to be used, the placement of a bentonite pellet seal above the filter pack is mandatory to prevent the possibility of grout infiltration into the screened interval prior to setting. Bentonite chips or other sealing products should not be substituted in this application. Where bentonite grouts are to be used, the placement of a bentonite pellet seal is optional, but desirable.

Since bentonite pellets begin hydrating rapidly, they can be very difficult to place properly. They are generally placed by pouring slowly into open boreholes, hollow stem augers or sonic drill pipe. In some cases, pellets are placed by tremie pipe and flushed into place with potable water. A tamper can be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

Pellet seals should be designed for a two-foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Where neat cement grouts are to be used, the pellets should be hydrated for eight hours, or the manufacturer's recommended hydration time, whichever is greater. Where the water table is temporarily below the pellet seal, potable (or higher quality) water should be added repeatedly to hydrate the pellets prior to grouting.

2.3.5 Grouting the Annular Space

The annular space between the casing and the borehole wall should be filled with either a 30% solids bentonite grout, a neat cement grout, or a cement/bentonite grout. Each type of grout selected should be evaluated as to its intended use and integrity. Bentonite grouts are preferred unless the application dictates the use of another material.

Bentonite grout shall be a 30% solids pure bentonite grout. Drilling muds are not acceptable for grouting. The grout should be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is the greater depth. The bentonite pellet seal or filter pack should not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal or filter pack. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. The preferred method of achieving proper solids content is by measurement of ingredients per the manufacturer's specifications during mixing with a final check by grout balance after mixing. Bentonite grouts should have a minimum density of 10 lbs/gal to ensure proper gelling and low permeability. The density of the first batch of grout should be measured while mixing to verify proper measurement of ingredients. In addition, the grouting operation should not cease until the bentonite grout flowing out of the borehole has a minimum density of 10 lbs/gal. Estimating the grout density is not acceptable.

Cement grouts are generally dictated where a high level of dissolved solids or a particular dissolved constituent would prevent proper gelling of a bentonite grout. Neat cement grouts (cement without additives) should be mixed using 6 gallons of water per 94-lb bag of Type 1 Portland cement to a density of 15lbs/gal. The addition of bentonite (5 to 10 percent) to the cement grout can be used to delay the "setting" time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed should be evaluated on a case by case basis by a senior field geologist.

2.3.6 Above Ground Riser Pipe and Outer Casing

The well casing, when installed and grouted, should extend above the ground surface a minimum of 2.5 feet. A vent hole should be drilled into the top of the well casing cap to permit pressure equalization, if applicable. An outer protective casing should be installed into the borehole after the annular grout has cured for at least 24 hours. The outer protective casing should be of steel construction with a hinged, locking cap. Generally, outer protective casings used over 2-inch well casings are 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings are 6 inches square and 5 feet long. Other types of protective casing including those constructed of pipe are also acceptable. All protective casings should have sufficient clearance around the inner well casings, so that the outer protective casings will not come into contact with the inner well casings after installation. The protective casings should have a weep hole to allow drainage of accumulated rain or spilled purge water. The weep hole should be approximately 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pad to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas.

Prior to installing the protective casing, the bentonite grout in the borehole annulus is excavated to a depth of approximately two feet. The protective casing is installed by pouring concrete into the borehole on top of the grout. The protective casing is then pushed into the wet concrete and borehole a minimum of 2 feet. Extra concrete may be needed to fill the inside of the protective casing so that the level of the concrete inside of the protective casing is at or above the level of the surface pad. In areas where frost heave of the surface pad is possible, the protective casing should first be pressed into the top surface of the bentonite grout seal and concrete poured around the protective casing. A granular material such as sand or gravel can then be used to fill the space between the riser and protective casing. The use of granular material instead of concrete between the protective casing and riser will also facilitate the future conversion of the well to a flush-mount finish, if required. The protective casing should extend above the ground surface to a height so that the top of the inner well casing is exposed when the protective casing is opened. At each site, all locks on the outer protective casings should be keyed alike.

2.3.7 Concrete Surface Pad

A concrete surface pad should be installed around each well at the same time as the outer protective casing is being installed. The surface pad should be formed around the well casing. Concrete should be placed into the pad forms and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the concrete surface pad is dependent on the well casing size. If the well casing is 2 inches in diameter, the pad should be 3 feet x 3 feet x 4 inches. If the well casing is 4 inches in diameter, the pad should be 4 feet x 4 feet x 6 inches. Round concrete surface pads are also acceptable. The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.

2.3.8 Surface Protection – Bumper Guards

If the monitoring wells are located in a high traffic area, a minimum of three bumper guards consisting of steel pipes 3 to 4 inches in diameter and a minimum 5-foot length should be installed. These bumper guards should be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. Substantial steel rails and/or other steel materials can be used in place of steel pipe. Welding bars between the bumper posts can provide additional strength and protection in high traffic areas, but the protective bumpers should not be connected to the protective casing.

2.4 Construction Techniques

2.4.1 Well Installation

The borehole should be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level. Deviation from plumb should be within 1° per 50ft of depth. Slanted boreholes are undesirable and should be noted in the boring logs and final construction logs. The depth and volume of the borehole, including the over-drilling if applicable, should have been calculated and the appropriate materials procured prior to drilling activities.

The well casings should be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers and/or a plumb bob and level. Another method of placing the well screen and casings into the borehole and plumbing them at the same time is to suspend the string of well screen and casings in the borehole by means of a hoist on the drill rig. This wireline method is especially useful if the borehole is deep and a long string of well screen and casings have to be set and plumbed.

No lubricating oils or grease should be used on casing threads. No glue of any type should be used to secure casing joints. Teflon "O" rings can also be used to insure a tight fit and minimize leakage; however, "O" rings made of other materials are not acceptable if the well is going to be sampled for organic compound analyses.

Before the well screen and casings are placed on the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing. The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. Monitoring wells less than 50 feet deep generally do not need centralizers. If centralizers are used they should be placed below the well screen and above the bentonite pellet seal. The specific placement intervals should be decided based on site conditions.

When installing the well screen and casings through hollow-stem augers, the augers should be slowly extracted as the filter pack, bentonite pellet seal, and grout are tremied and/or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials (sand, pellets, etc.) will accumulate at the bottom of the augers causing potential bridging problems.

After the string of well screen and casing is plumb, the filter pack material should then be placed around the well screen to the designated depth. With cased drilling methods, the sand should be poured into the casing or augers until the lower portion is filled. The casing or augers are then withdrawn, allowing the sand to flow into the evacuated space. With hollow stem augers, sand should always fill the augers 6-12 inches, maintained by pouring the sand while checking the level with a weighted tag line. The filter pack sand in open boreholes should be installed by tremie methods, using water to wash the sand through the pipe to the point of placement.

After the filter pack has been installed, the bentonite pellet seal (if used) should be placed directly on top of the filter pack to an unhydrated thickness of two feet. When installing the seal for use with cement grouts, the bentonite pellet seal should be allowed to hydrate a minimum of eight hours or the manufacturer's recommended hydration time, whichever is longer.

After the pellet seal has hydrated for the specified time, the grout should then be pumped by the tremie method into the annular space around the casings. The grout should be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed.

After the surface pad and protective casing are installed, bumper guards should be installed (if needed). The bumper guards should be placed around the concrete surface pad in a configuration that provides maximum protection to the well. Each piece of steel pipe or approved material should be installed into an 8-to 10-inch diameter hole, to a minimum depth of 2 feet below ground surface, and filled with concrete. As previously stated, the bumper guard should extend above the ground surface a minimum of 3 feet. The total length of each bumper guard should be a minimum of 5 feet.

After the wells have been installed, the outer protective casing should be painted with a highly visible paint. The wells should be permanently marked with the well number, date installed, site name, elevation, etc., either on the cover or an appropriate place that will not be easily damaged and/or vandalized.

If the monitoring wells are installed in a high traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush mounted traffic and/or man-hole covers. Flush mounted traffic and man-hole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush mounted covers should be installed slightly above grade to minimize standing water and promote runoff. Permanent identification markings should be placed on the covers or in the concrete plug around the cover. Expansive sealing plugs should be used to cap the well riser to prevent infiltration of any water that might enter the flush cover.

2.4.2 Double-Cased Wells

Double-cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross-contamination or when flowing sands make it impossible to install a monitoring well using conventional methods. A highly contaminated surface soil zone may also be cased off so that drilling may continue below the casing with reduced danger of cross contamination. A pilot borehole should be bored through the overburden and/or the contaminated zone into the clay confining layer or bedrock. An outer casing (sometimes called surface or pilot casings) should then be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two feet and into competent bedrock a minimum of 1 foot. The total depths into the clay or bedrock will vary, depending on the plasticity of the clay and the extent of weathering and\or fracturing of the bedrock. The final depths should be approved by a senior field geologist. The size of the outer casing should be of sufficient inside diameter to contain the inner casing, and the 2-inch minimum annular space. In addition, the borehole should be of sufficient size to contain the outer casing and the 2-inch minimum outer annular space, if applicable.

The outer casing should be grouted by the tremie, displacement, grout shoe, or Halliburton method from the bottom to the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be either a neat cement, cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type I portland cement/bentonite or cement/sand mixture. The use of a pure bentonite grout for a bottom plug or seal is not acceptable, because the bentonite grout cures to a gel-like material, and is not rigid enough to withstand the stresses of drilling. When drilling through the seal, care should be taken to avoid cracking, shattering, or washing out the seal. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing should be driven into place and a grout seal placed in the bottom of the casing.

2.4.2.1 Bedrock Wells

The installation of monitoring wells into bedrock can be accomplished in two ways:

1. The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is then installed into the borehole by setting it into the bedrock, and grouting it into place as described in the previous section. After the grout has set, the borehole can then be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking and/or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and "down" pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. A visual test can also be made by examining the cement/concrete core that is collected when the seal is cored with a diamond coring bit. If the seal leaks (detected by pressure testing) and/ or the core is cracked or shattered, or if no core is recovered because of washing, excessive down pressure, etc., the seal is not acceptable. The concern over the structural integrity of the grout seal applies to all double cased wells. Any proposed method of double casing and/or seal testing will be evaluated on its own merits, and will have to be approved by a senior field geologist before and during drilling activities, if

applicable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. There is no inner casing, and the outer surface casing, installed down into bedrock, extends above the ground surface, and also serves as the outer protective casing. If the protective casing becomes cracked or is sheared off at the ground surface, the well is open to direct contamination from the ground surface and will have to be repaired immediately or abandoned. Another limitation to the open rock well is that the entire bedrock interval serves as the monitoring zone. In this situation, it is very difficult or even impossible to monitor a specific zone, because the contaminants being monitored could be diluted to the extent of being non-detectable. The installation of open bedrock wells is generally not acceptable in the Superfund and RCRA programs, because of the uncontrolled monitoring intervals. However, some site conditions might exist, especially in cavernous limestone areas (karst topography) or in areas of highly fractured bedrock, where the installation of the filter pack and its structural integrity are questionable. Under these conditions the design of an open bedrock well may be warranted.

2. The second method of installing a monitoring well into bedrock is to install the outer surface casing and drill the borehole (by an approved method) into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (steeply dipping shales, etc.) where the bedrock has a tendency to shift or move when disturbed. Omitting the filter pack around the well screen is a general practice in some open rock borehole installations, especially in drinking water and irrigation wells. However, without the filter pack to protect the screened interval, sediment particles from the well installation and/or from the monitoring zone could clog the well screen and/or fill the screened portion of the well rendering it inoperable. Also, the filter pack serves as a barrier between the bentonite seal and the screened interval. Rubber inflatable packers have been used to place the bentonite seal when the filter pack is omitted, but the packers have to remain in the well permanently and, over a period of time, will decompose and possibly contribute contaminants to the monitoring zone.

2.5 Well Construction Materials

2.5.1 Introduction

Well construction materials are chosen based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site(s). In this section, the different types of available materials will be discussed.

2.5.2 Well Screen and Casing Materials

When selecting the materials for well construction, the prime concern should be to select materials that will not contribute foreign constituents, or remove contaminants of concern from the ground water. If the monitoring program is designed to analyze for organic compounds, stainless steel materials are the preferred choice. If the monitoring program calls for the analyses of only inorganic compounds or the contaminants or formation are highly corrosive, then rigid PVC materials meeting National Sanitary Foundation (NSF) Standard 14 type WC (Well Casing) are acceptable. PVC materials may be acceptable for monitoring identified organic compounds in a soluble aqueous phase where incompatibilities are known to not exist. EPA document EPA/540/S-95/503, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation* (http://www.epa.gov/ada/-download/issue/napl.pdf) should be used for guidance in this area and in the use of PVC with non-aqueous phase liquids (NAPLs). Another concern is to select materials that will be rugged enough to endure the entire monitoring period. Site conditions will generally dictate the type of materials that can be used. A preliminary field investigation should be conducted to determine the geologic conditions, so that the most suitable materials can be selected. The best grade or highest quality material for that particular application should be selected. Each manufacturer can supply the qualitative data for each grade of material that is being considered. All materials selected for monitoring well installation should be evaluated and approved by a senior field geologist prior to field activities.

Well screen and casing materials generally used in monitoring well construction on RCRA and Superfund sites are listed in order of preference:

1. Stainless Steel (304 or 316)
2. Rigid PVC meeting NSF Standard 14 (type WC)
3. Other (where applicable)

There are other materials used for well screens and casings such as black iron, carbon steel, galvanized steel, and fiberglass, but these materials are not recommended for use in long term monitoring programs at hazardous waste sites, because of their low resistance to chemical attack and potential constituent contribution to the ground water. In cases where a driven casing is used, or a high strength outer casing is needed, carbon steel may be acceptable in non-corrosive aquifers. This outer casing should have threaded connections. Welding casing is not an acceptable practice unless all relevant safety issues have been adequately addressed.

The minimum nominal casing size for most permanent monitoring wells will be 2". Where a complete program of installation, monitoring, and abandonment is being designed, smaller wells may be installed if suitable purging and sampling equipment for the smaller diameter wells can be specified and obtained. The length of well screens in permanent monitoring wells should be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long term monitoring purposes should normally not be less than 5 feet in length. Well screens less than 5 feet long are generally only used in temporary monitoring wells where ground water samples are collected for screening purposes.

2.5.3 Filter Pack Materials

The filter pack materials should consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain-size distribution or particle sizes of the filter pack materials should be selected based upon a sieve analysis conducted on the soil samples collected from the aquifer materials and/or the formation(s) to be monitored. Filter pack materials should not be accepted unless proper documentation can be furnished as to the composition, grain-size distribution, cleaning procedure, and chemical analysis. If a data search reveals that there is enough existing data to adequately design the well screen and filter pack, then it may not be necessary to conduct a sieve analysis on the formation materials to be monitored. However, all data and design proposals will be evaluated and approved by a senior staff geologist before field activities begin.

2.5.4 Filter Pack and Well Screen Design

The majority of monitoring wells are installed in shallow ground water aquifers that consist of silts, clays, and sands in various combinations. These shallow aquifers are not generally characteristic of aquifers used for drinking water. Therefore, modifications to the procedures used for the design of water well filter packs may be required. In cases where insufficient experience exists with local or similar materials, the filter pack and well screen design should be based on the results of a sieve analysis conducted on soil samples collected from the aquifer or the formation(s) that will be monitored.

In formations consisting primarily of fines (silts and clays), the procedures for water well screen design may result in requirements for filter packs and screen slot sizes that are not available. In those cases the selection of 0.010" screen slots with a 20-40 sand filter pack, or 0.005" screen slots with 100 sand filter pack for very fine formations, will be acceptable practice. Table 6.6.1 provides size specifications for the selection of sand packs for fine formation materials. ASTM standard D5092, *Design and Installation of Ground Water Monitoring Wells in*

Aquifers, may be consulted for further guidance on specifications for sand appropriate for these applications.

Table 6.6.1
Sand Pack Specifications

Screen Opening (in)	Sand Pack Mesh Name	1% Passing Size (d-1) (in)	10% Passing Size (d-10) (in)	30% Passing Size (d-30) (in)	Derived 60% Passing Size (d-60) (in)	Range for Uniformity Coefficient
0.005-0.006	100	.0035 - .0047	.0055 - .0067	.0067 - .0083	.0085 - .0134	1.3 - 2.0
0.010"	20-40	.0098 - .0138	.0157 - .0197	.0197 -.0236	.020 - .0315	1.1 - 1.6

The following procedure should be used in coarser grained formations:

The data from the sieve analysis are plotted on a grain-size distribution graph, and a grain-size distribution curve is generated. From this grain-size distribution curve, the uniformity coefficient (Cu) of the aquifer material is determined. The Cu is the ratio of the 60 percent finer material (d60) to the 10 percent finer material (d10)

$$Cu = (d60/d10)$$

The Cu ratio is a way of grading or rating the uniformity of grain size. For example, a Cu of unity means that the individual grain sizes of the material are nearly all the same, while a Cu with a large number indicates a large range of particle sizes. As a general rule, a Cu of 2.5 or less should be used in designing the filter pack and well screen.

Before designing the filter pack and well screen, the following factors should be considered:

1. Select the well screen slot openings that will retain 90 percent of the filter pack material.

2. The filter pack material should be of the size that minimizes head losses through the pack and also prevents excessive sediment (sand, silt, clay) movement into the well.

3. A filter material of varying grain sizes is not acceptable because the smaller particles fill the spaces between the larger particles thereby reducing the void spaces and increasing resistance to flow. Therefore, filter material of the same grain size and well rounded is preferred.

4. The filter pack design is based on the gradation of the finest aquifer materials being analyzed.

Steps to design a filter pack in aquifers:

1. Construct a grain-size distribution curve, on a grain-size distribution graph, from the sieve analysis of the aquifer materials. The filter pack design (as stated above) is based on the gradation of the finest aquifer materials.

2. Multiply the d30 size from the grain-size distribution graph by a factor of four to nine (Pack-Aquifer ratio). A factor of four is used if the formation is fine-grained and uniform (Cu is less than 3), six if it is coarse-grained and non-uniform, and up to nine if it is highly non-uniform and contains silt. Head losses through filter packs increase as the Pack-Aquifer (P-A) ratios decrease. In order to design a fairly stable filter pack with a minimum head loss, the d30 size should be multiplied by a factor of four.

3. Plot the point from step 2 on the d30 abscissa of a grain-size distribution graph and draw a smooth curve with a uniformity coefficient of approximately 2.5.

4. A curve for the permissible limits of the filter pack is drawn plus or minus 8 per cent of the desired curve with the Cu of 2.5.

5. Select the slot openings for the well screen that will retain 90 per cent or more of the filter pack material.

The specific steps and procedures for sieve analysis and filter pack design can be found in soil mechanics, ground water, and water well design books. The staff geologists and/or engineers should be responsible for the correct design of the monitoring wells and should be able to perform the design procedures.

2.6 Safety Procedures for Drilling Activities

A site health and safety plan should be developed and approved by the Branch Safety Officer or designee prior to any drilling activities, and should be followed during all drilling activities. The driller or designated safety person should be responsible for the safety of the drilling team performing the drilling activities. All personnel conducting drilling activities should be qualified in proper drilling and safety procedures. Before any drilling activity is initiated, utilities should be marked or cleared by the appropriate state or municipal utility protection organization. In developed areas, additional measures should be taken to locate utilities not covered by the utility protection program. Before operating the drill rig, a pilot hole should be dug (with hand equipment) to a depth of three feet to check for undetected utilities or buried objects. Proceed with caution until a safe depth is reached where utilities normally would not be buried. The following safety requirements should be adhered to while performing drilling activities:

1. All drilling personnel should wear safety hats, safety glasses, and steel toed boots. Ear plugs are required and will be provided by the safety officer or driller.

2. Work gloves (cotton, leather, etc.) should be worn when working around or while handling drilling equipment.

3. All personnel directly involved with the drilling rig(s) should know where the kill switch(s) is located in case of emergencies.

4. All personnel should stay clear of the drill rods or augers while in motion, and should not grab or attempt to attach a tool to the drill rods or augers until they have completely stopped rotating. Rod wipers, rather than gloves or bare hands should be used to remove mud, or other material, from drill stem as it is withdrawn from the borehole.

5. Do not hold drill rods or any part of the safety hammer assembly while taking standard penetration tests or while the hammer is being operated.

6. Do not lean against the drill rig or place hands on or near moving parts at the rear of the rig while it is operating.

7. Keep the drilling area clear of any excess debris, tools, or drilling equipment.

8. The driller will direct all drilling activities. No work on the rig or work on the drill site will be conducted outside of the driller's direction. Overall drill site activities will be in consultation with the site geologist or engineer, if present.

9. Each drill rig will have a first-aid kit and a fire extinguisher located on the rig in a location quickly accessible for emergencies. All drilling personnel will be familiarized with their location.

10. Work clothes will be firm fitting, but comfortable and free of straps, loose ends, strings etc., that might catch on some moving part of the drill rig.

11. Rings, watches, or other jewelry will not be worn while working around the drill rig.

12. The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

2.7 Well Development

A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before development procedures are initiated. The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed, and to try to re-establish the natural hydraulic flow conditions of the formations which may have been disturbed by well construction, around the immediate vicinity of each well. A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases the above requirements can be satisfied; however, in some cases the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case the well may still contain well construction materials, such as drilling mud in the form of a mud cake and/or formation soils that have not been washed out of the borehole. Excessive or thick drilling mud cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped to dryness or near dryness, the water table should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Caution should be taken when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack. The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field log book.

The following development procedures, listed in approximate increasing order of the energy applied to the formation materials, are generally used to develop wells:

1. Bailing
2. Pumping/overpumping
3. Surging
4. Backwashing ("rawhiding")
5. Jetting
6. Compressed air (with appropriate filtering): airlift pumping and air surging

These development procedures can be used, individually or in combination, in order to achieve the most effective well development. In most cases, over-pumping and surging will adequately develop the well without imparting undue forces on the formation or well materials. Except when compressed air is being used for well development, sampling can be initiated as soon as the ground water has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new monitoring well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and re-stabilize to pre-well construction conditions. Because of the danger of introducing contaminants with the airstream, the possibility of entraining air in the aquifer, and the violent forces imparted to the formation, air surging is the least desired method of development and should only be used where there is a specific need for the procedure. Air-lift pumping is permissible where an eductor pipe is used and several well volumes of water are removed from the well by other by pumping means after air-lift pumping. The selected development method(s) should be approved by a senior field geologist before any well installation activities are initiated.

2.8 Well Decommisioning (Abandonment)

When a decision is made to decommission (abandon) a monitoring well, the borehole should be sealed in such a manner that the well cannot act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly decommission a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. In order to comply with state well decommissioning requirements, the appropriate state agency should be notified (if applicable) of monitoring well decommissioning. However, some state requirements are not explicit, so a technically sound well abandonment method should be designed based on the site geology, well casing materials, and general condition of the well(s).

2.8.1 Decommissioning Procedures

As previously stated the preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig. The clean borehole can then be backfilled with the appropriate grout material. The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). This abandonment method can be accomplished on small diameter (1-inch to 4-inch) wells without too much difficulty. With wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole. Wells with little or no grouted annular space and/or sound well casings can be removed in this manner. However, old wells with badly corroded casings and/or thickly grouted annular space have a tendency to twist and/or break-off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present.

A PVC well casing may be more difficult to remove from the borehole than a metal casing, because of its brittleness. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by water or drilling mud. Another method is to use a solid-stem auger with a carbide tooth pilot bit to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials.

Where state regulations and conditions permit, it may be permissible to grout the casing in place. This decision should be based on confidence in the original well construction practice, protection of drinking water aquifers, and anticipated future property uses. The pad should be demolished and the area around the casing excavated. The casing should be sawn off at a depth of three feet below ground surface. The screen and riser should be tremie grouted with a 30% solids bentonite grout in the saturated zone. The remaining riser may be grouted with a cement grout for long term resistance to desiccation.

3 Temporary Monitoring Well Installation

3.1 Introduction

Five types of temporary monitoring well installation techniques have been demonstrated as acceptable. The type selected for a particular site is dependent upon site conditions. The project leader and site geologist should be prepared to test temporary well installations on site and select the best solution. Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of ground water quality.

Temporary monitoring well locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used, but typically there is no bentonite seal, grout, surface completion, or extensive development (as it normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed, and backfilled in a matter of hours.

Due to the nature of construction, turbidity levels may initially be high. However, these levels may be reduced by low flow purging and sampling techniques as described in Section 7.2.4.

Temporary wells may be left overnight, for sampling the following day, but the well must be secured, both against tampering and against the fall hazard of the open annulus. If the well is not sampled immediately after construction, the well should be purged prior to sampling as specified in SESD Operating Procedure for Groundwater Sampling, SESDPROC-301.

3.2 Data Limitation

Temporary wells described in this section are best used for delineation of contaminant plumes at a point in time, and for some site screening purposes. They are not intended to replace permanent monitoring wells. Temporary wells can be used in conjunction with a mobile laboratory, where quick analytical results can be used to delineate contaminant plumes.

3.3 Temporary Well Materials

Materials used in construction of temporary monitoring wells are the same standard materials used in the construction of permanent monitoring wells. Sand used for the filter pack (if any) should be as specified in Section 2.5.3, Filter Pack Materials. The well screen and casing should be stainless steel for ruggedness and suitability for steam cleaning and solvent rinsing. Other materials may be acceptable, on a case by case basis. Some commercially available temporary well materials, pre-packed riser, screen and filter pack assemblies are available commercially; however, these pre-assembled materials cannot be cleaned. Appropriate QA/QC must be performed to assure there will be no introduction of contamination.

3.4 Temporary Monitoring Well Borehole Construction

Borehole construction for temporary wells is as specified in Section 2.3, using a drill rig. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen (or removed completely) prior to sampling. When hand augers are used, the borehole is advanced to the desired depth (or to the point where borehole collapse occurs). In situations where borehole collapse occurs, the auger bucket is typically left in the hole at the point of collapse while the temporary well is assembled. When the well is completely assembled, a final auger bucket of material is quickly removed and the well is immediately inserted into the borehole, pushing, as needed, to achieve maximum penetration into the saturated materials.

3.5 Temporary Monitoring Well Types

Five types of monitoring wells which have been shown to be acceptable are presented in the order of increasing difficulty to install and increasing cost:

3.5.1 No Filter Pack

This is the most common temporary well and is very effective in many situations. After the borehole is completed, the casing and screen are simply inserted. This is the least expensive and fastest well to install. This type of well is extremely sensitive to turbidity fluctuations because there is no filter pack. Care should be taken to not disturb the casing during purging and sampling.

3.5.2 Inner Filter Pack

This type differs from the "No Filter Pack" well in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter pack. For this type well to function properly, the static water level must be at least 6-12 inches above the filter pack. The screen slots may plug in some clayey environments with this construction method and others that use sand only inside the well screen.

3.5.3 Traditional Filter Pack

For this type of well, the screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. Occasionally, it may be difficult to effectively place a filter pack around shallow open boreholes, due to collapse. This method requires more sand than the "inner filter pack" well, increasing material costs. As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity.

3.5.4 Double Filter Pack

The borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the top of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction can be effective in aquifers where fine silts or clays predominate. This construction technique takes longer to implement and uses more filter pack material than others previously discussed.

3.5.5 Well-in-a-Well

The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser, and centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, to approximately 6 inches above the screen. The well is then inserted into the borehole.

This system requires twice as much well screen and riser, with attendant increases in assembly and installation time. The increased amount of well construction materials results in a corresponding increase in decontamination time and costs. The use of pre-packed well screens in this application will require rinse blanks of each batch of screens. Pre-pack Screen assemblies cannot be decontaminated for reuse.

3.6 Decommissioning

Temporary well boreholes must be decommissioned after sampling and removal of the screen and riser. Backfilling the holes with cuttings may be acceptable practice for shallow holes in uniform materials with expected low contamination levels. Use of cuttings would not be an acceptable practice if waste materials were encountered or a confining layer was breached. Likewise, where the borehole is adjacent to, or downgradient of contaminated areas, the loose backfilled material could create a highly permeable conduit for contaminant migration. If the borehole will not be backfilled with the soil cuttings for this or other reasons, then SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, should be referenced regarding disposal of the cuttings as IDW.

4 Temporary Monitoring Well Installation Using the Geoprobe® Screen Point 15/16 Groundwater Sampler

4.1 Introduction

The Geoprobe® Screen Point 15/16 Groundwater Sampler is a discrete interval ground water sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials. Once the target depth has been reached, the screen is opened and groundwater can be sampled as a temporary monitoring well, which yields a representative, uncompromised sample from that depth. Using knock-out plugs, this method also allows for grouting of the push hole during sample tool retrieval.

The Screen Point® 15 sampler consist of four parts (drive point, screen, sampler sheath and drive head), with an assembled length of 52 inches (1321 mm) and a maximum OD of 1.5 inches (38 mm). When opened, it has an exposed screen length of 41 inches (1041 mm). It is typically pushed using 1.25-inch probe rod. The Screen Point® 16 consists of the same parts and works in the same fashion, the only differences being larger diameter and its use with 1.5" rods.

4.1.1 Assembly of Screen Point® 15/16 Groundwater Sampler

1. Install O-ring on expendable point and firmly seat in the angled end of the sampler sheath.

2. Place a grout plug in the lower end of the screen section. Grout plug material should be chosen with consideration for site specific Data Quality Objectives (DQOs).

3. When using stainless steel screen, place another O-ring* in the groove on the upper end of the screen and slide it into the sampler sheath.

4. Place an O-ring* on the bottom of the drive head and thread into the top of the sampler sheath.

5. The Screen Point® 15/16 Groundwater Sampler is now assembled and ready to push for sample collection.

   * It should be noted that O-ring use in steps 3 and 4 are optional.

4.1.2 Installation of Screen Point® 15/16 Groundwater Sampler

1. Attach drive cap to top of sampler and slowly drive it into the ground. Raise the hammer assembly, remove the drive cap and place an O-ring* in the top groove of the drive head. Add a probe rod and continue to push the rod string.

2. Continue to add probe rods until the desired sampling depth is reached.

3. When the desired sampling depth is reached, re-position the probe derrick and position either the casing puller assembly or the rod grip puller over the top of the top probe rod.

4. Thread a screen push adapter on an extension rod and attach sufficient additional extension rods to reach the top of the Screen Point® 15/16 sampler. Add an extension handle to the top of the string of extension rods and run this into the probe rod, resting the screen push adapter on top of the sampler.

5. To expose the screened portion of the sampler, exert downward pressure on the sampler, using the extension rod and push adapter, while pulling the probe rod upward. To expose the entire open portion of the screen, pull the probe rod upward approximately 41 inches.

6. At this point, the Screen Point® 15/16 Groundwater Sampler has been installed as a temporary well and may be sampled using appropriate ground water sampling methodology. If waters levels are less than approximately 25 feet, EIB personnel typically use a peristaltic pump, utilizing low-flow methods, to collect ground water samples from these installations. If water levels are greater than 25 feet, a manual bladder pump, a micro bailer, or other method may have to be utilized to collect the sample (SESD Operating Procedure for Groundwater Sampling, SESDPROC-301-R0) provides detailed descriptions of these techniques and methods).

4.1.3 Special Considerations for Screen Point® 15/16 Installations

<u>Decommissioning (Abandonment)</u>

In many applications, it may be appropriate to grout the abandoned probe hole where a Screen Point® 15/16 sampler was installed. This probe hole decommissioning can be accomplished through two methods which are determined by location and contamination risk. In certain non-critical areas, boreholes may be decommissioned by filling the saturated zone with bentonite pellets and grouting the vadose zone with neat cement poured from the surface or Bentonite pellets properly hydrated in place. Probe holes in areas where poor borehole sealing could present a risk of contaminant migration should be decommissioned by pressure grouting through the probe rod during sampler retrieval. To accomplish this, the grout plug is knocked out of the bottom of the screen using a grout plug push adapter and a grout nozzle is fed through the probe rod, extending just below the bottom of the screen. As the probe rod and sampler are pulled, grout is injected in the open hole below the screen at a rate that just fills the open hole created by the pull. Alternatively, the screen can generally be pulled and the hole re-probed with a tool string to be used for through-the-rod grouting.

Screen Material Selection

Screen selection is also a consideration in sampling with the Screen Point® 15/16 sampler. The screens are available in two materials, stainless steel and PVC. Because of stainless steel's durability, ability to be cleaned and re-used, and overall inertness and compatibility with most contaminants, it is the material typically used during EIB investigations.

COPY

Region 4 **U.S. Environmental Protection Agency** **Science and Ecosystem Support Division** **Athens, Georgia**
OPERATING PROCEDURE
Title: **Groundwater Sampling**

Effective Date: April 26, 2017	**Number:** SESDPROC-301-R4

Authors

Name: Brian Striggow
Title: Environmental Engineer

Signature: [signature] Date: 4-20-17

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch

Signature: John Deatrick Date: 4/24/17

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division

Signature: [signature] Date: 4/20/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-301-R4, Groundwater Sampling, replaces SESDPROC-301-R3. **General:** Corrected any typographical, grammatical, and/or editorial errors. **General:** An extensive rewrite and reorganization of material. Stronger support of low-flow methods while maintaining cautious view of minimal/no purge methods.	April 26, 2017
SESDPROC-301-R3, Groundwater Sampling, replaces SESDPROC-301-R2.	**March 6, 2013**
SESDPROC-301-R2, Groundwater Sampling, replaces SESDPROC-301-R1.	**October 28, 2011**
SESDPROC-301-R1, Groundwater Sampling, replaces SESDPROC-301-R0.	**November 1, 2007**
SESDPROC-301-R0, Groundwater Sampling, Original Issue	**February 05, 2007**

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting groundwater samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that SESD field personnel determine that any of the procedures described are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

Interstate Technology & Regulatory Council, Technology Overview of Passive Sampler Technologies, Prepared by The Interstate Technology & Regulatory Council Diffusion Sampler Team, March 2006.

Nielsen, David. *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring*. 2nd ed. Boca Raton, FL: Taylor&Francis, 2006. Print.

Puls, Robert W., and Michael J. Barcelona. 1989. Filtration of Ground Water Samples for Metals Analysis. Hazardous Waste and Hazardous Materials 6(4), pp.385-393.

Puls, Robert W., Don A. Clark, and Bert Bledsoe. 1992. Metals in Ground Water: Sampling Artifacts and Reproducibility. Hazardous Waste and Hazardous Materials 9(2), pp. 149-162.

SESD Guidance Document, Design and Installation of Monitoring Wells, SESDGUID-001, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Groundwater Level and Well Depth Measurement, SESDPROC-105, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDROC-202, Most Recent Version

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Potable Water Supply Sampling, SESDPROC-305, Most Recent Version

United States Environmental Protection Agency (US EPA). 1975. Handbook for Evaluating Water Bacteriological Laboratories. Office of Research and Development (ORD), Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1977. Sampling for Organic Chemicals and Microorganisms in the Subsurface. EPA-600/2-77/176.

US EPA. 1978. Microbiological Methods for Monitoring the Environment, Water and Wastes. ORD, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 1995. Ground Water Sampling - A Workshop Summary. Proceedings from the Dallas, Texas November 30 – December 2, 1993 Workshop. ORD, Robert S. Kerr Environmental Research Laboratory. EPA/600/R-94/205, January 1995.

US EPA 1996. Ground Water Issue. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. ORD, Robert W. Puls and Micael Barcelona. EPA/540/S-95/504, April 1996

US EPA. Analytical Services Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

Varljen, M., Barcelona, M., Obereiner, J., & Kaminski, D. (2006). Numerical simulations to assess the monitoring zone achieved during low-flow purging and sampling. *Ground Water Monitoring and Remediation*, 26(1), 44-52.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done legibly, completely, and neatly in a bound logbook.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either pre-preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles and rendering the sample unacceptable. In this case, unpreserved vials should be used and arrangements confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm or knuckle to check if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. While the 8260 method allows for bubbles up to 6 mm at the time of analysis, dissolved or entrained gases can coalesce during shipment. Collecting VOC vials absent of bubbles is generally feasible and is a reasonable precaution.

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- Sampling equipment must be constructed of Teflon® or stainless steel materials. Bailers and pumps should be of Teflon® and stainless steel construction throughout.
- New Teflon® tubing should be used at each well, although tubing dedicated to a particular well may be reused, either after decontamination or storage in the well between sampling events. Caution is appropriate in reusing tubing where early sampling events report high concentrations of contaminants.
- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if purging and sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same cooler as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.

2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.

3. Place the sample into appropriate, labeled containers. Samples collected for VOC, and alkalinity analysis must be collected without headspace. All other sample containers must be filled with an allowance for ullage.

4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If pre-preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by Analytical Services Branch (ASB) personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), most recent version.

5. Sample containers should be placed in an ice-filled cooler as soon as possible after filling. Ice in coolers should be in bags with minimal pooled water and the cooler should be periodically checked and replenished to maintain sample storage temperature.

2.4 Quality Control

Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers, tubing, or other sampling equipment.

Where appropriate, a background sample upgradient of all known influences or a control sample upgradient of site influences may be indicated. Background and control samples should be collected as close to the sampled area as possible and from the same water-bearing formation as the site samples.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3 Groundwater Purging and Sampling

3.1 Overview of Purging and Sampling Strategies

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of aquifer conditions. Sampling is the process of obtaining, containerizing, and preserving (when required) a ground water sample after the purging process is complete. There are several approaches to well purging and sampling that may be appropriate in various circumstances or for various combinations of available equipment. They are briefly summarized below and in *Table 1, Purge and Sample Strategies with Equipment Considerations.*

The M**ultiple-Volume Purge** method involves removing a minimum of three well volumes of water from the top of the water column and then sampling when the well has achieved stability of water quality parameters and adequately low turbidity. This is a traditional method and consistent results are generally obtained with samplers of varying skill. A drawback is that large volumes of purge water may be produced for large diameter or deep wells.

The **Low-Flow** method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multiple-Volume Purge and generates less purge water. The method requires more skill and judgment on the part of the samplers.

The **Multiple-Volume Purge** method and the **Low-Flow** method can be considered equivalent for conventionally screened and filter-packed wells in that they both sample a flow-weighted average of water entering the well during pumping. However, other variables can result in differences between results with the two methods. In repeat sampling events, the sampling design should not change from one method to the other without appropriate cause. The transition should be noted in the report.

Minimum-Purge and **No-Purge** methods are based on the assumption that water within the screened interval of the well is at equilibrium with the water in the surrounding aquifer. This assumption should be carefully considered in the use of these methods and various cautions are discussed in sections below. The minimal-purge and no-purge methods are most useful for long-term monitoring and are generally inappropriate for the early stages of investigation. In some cases the methods might be used to gather screening-level data from wells that are too large to practically purge or have other sampling complications.

The **Minimum-Purge** and **No-Purge** methods collect water in the vicinity of the device under near-static conditions and are not equivalent to the multiple-volume purge and Low-Flow methods. Stratification of horizontal flow or vertical flow conditions within the well can result in non-intuitive and deceptive results. A comparison study should be conducted before transitioning a sampling program to the minimal-purge or no-purge methods.

3.2 Purging

Wells are purged to eliminate stagnant water residing in the casing and/or screen that has undergone geochemical changes or loss of VOCs. At the conclusion of purging, the desired flow-weighted average of water entering the well under pumping conditions will be available for sampling. Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls. As many contaminants (metals and many organics) will sorb to the formation particles, a sample including these particles will not represent the dissolved concentrations of the contaminants. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will represent the dissolved concentration of contaminants.

In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed and the volume of water removed during purging. The measurements should be recorded in a purge table in the field logbook that includes the start time of purging, the parameter measurements at intervals during purging, estimated pumped volumes, depths to water for Low-Flow sampling, and any notes of unusual conditions. A typical purge table used for Low-Flow sampling is reproduced below.

Continuation of sample GW65-0713

INITIAL 23.33 ft

TIME	pH (S.U.s)	Spec. Cond. (us/cm)	Temp. (Deg. C)	D.O. (mg/L)	D.O. (% sat.)	ORP (mV)	Turbidity (NTUs)	Water Level (Ft.)	Purge Vol. (gallons)
0930								Pump On	
0935	5.71	1065	19.6	0.77	8.7	43.9	210	24.83	1/4
1004	5.64	988	20.0	0.36	3.9	222.5	17.8	25.24	2
1026	5.63	959	20.5	0.25	2.7	98	9.95	25.18	3 1/2
1038	5.62	950	20.5	0.21	2.4	75	9.85	25.18	4
1046	5.61	946	20.8	0.21	2.4	73	6.07	25.18	4 1/2
1047								Sample Collection Time	

3.3 Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Secondary Drinking Water Standard of 5 NTUs).

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than 5 percent. Other parameters, such as dissolved oxygen (DO) or oxidation-reduction potential (ORP), may also be used as a purge adequacy parameter. Normal stability goals for DO are 0.2 mg/L or 10% change in saturation, whichever is greater. DO and ORP measurements must be conducted using either a flow-through cell or an over-topping cell to minimize oxygenation of the sample during measurement. A reasonable ORP stability goal is a range of 20 mV, although ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter. Determining the frequency of measurements has generally been left to 'Best Professional Judgement'. Care is in order, as measurements recorded at frequent intervals with low flow rates can falsely indicate stability of parameters. Several measurements should be made early in the well purge to establish the direction and magnitude of trends, which can then inform the stability decision. Stability parameters should either be not trending, or approaching an asymptote, when a stability determination is made. As a matter of practice, parameter measurements are generally made at 5-10 minute intervals.

Because the measured groundwater temperature during purging is subject to changes related to surface ambient conditions and pumping rates, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from SESD's list of parameters used for stability determination. Even though temperature is not used to determine stability, it is still advisable to record the temperature of purge water as it is often used in the interpretation of other parameters.

Information on conducting the stability parameter measurements is available in the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113).

COPY

Table 1, Purge and Sample Strategies with Equipment Considerations

Purging Strategy	Purge Eqpt	Sample Eqpt	Comments
Multi-Volume Purge	------------------------	------------------------	Overall Method Comments- Advantages: Consistent results can be achieved with minimal skill level required. Common, simple equipment can be used. Disadvantages: Can result in large volumes of purge water. Can take extended periods of time with large diameter wells or long water columns.
In this traditional method, 3-5 well volumes of water are removed from the top of the water column while verifying the stability of water quality parameters. Following the well purge, the well is sampled from the top of the water column.	Bailer	Bailer	Bailers are rarely used for purging due to the effort required, the difficulty of lowering turbidity adequately, and the possibility of aerating the upper water column.
	Electric Submersible Pump	Bailer	Common multiple-volume setup when depth to water exceeds 25 feet. Abbreviated pump decontamination procedure can be used between wells.
	Electric Submersible Pump	Electric Submersible Pump	Requires full pump decontamination and new tubing at each well. In most cases the pump would be deployed to the screened interval instead to perform Low-Flow sampling.
	Peristaltic Pump	Peristaltic Pump	Common, multi-volume setup when depth to water is less than 25 feet. Special sampling techniques are required for the collection of SVOCs and VOCs.
Low-Flow methods	------------------------	------------------------	Overall Method Comments- Advantages: Lower volumes of purge water. May be faster, especially with longer water columns. Disadvantages: Requires greater skill for consistent results. Higher tubing costs than multi-volume method.
The pump or tubing inlet is placed within the screened interval and the well is purged to stable water quality parameters while maintaining stable drawdown of the water level.	Electric Submersible Pump	Electric Submersible Pump	Commonly used when depth to water exceeds 25 feet. Pump is cleaned to sample equipment standards prior to sampling each well and new or dedicated tubing used for each well. Concerns have been raised concerning VOC loss from agitation in the turbine section or from sample heating.
	Peristaltic Pump	Peristaltic Pump	Commonly used where depth to water is less than 25 feet. Special sampling techniques required for the collection of SVOCs and VOCs. Concerns have been raised concerning VOC loss from vacuum created in sample tubing.
	Bladder Pump	Bladder Pump	Least danger of VOC loss as entire sample train is under positive pressure and little sample heating occurs. Difficult to remove large volumes of water in reasonable time. Mild surging effect may keep turbidity elevated in sensitive wells.
Minimum-Purge, No-Purge Methods	------------------------	------------------------	Overall Method Comments- Advantages: Very little or no waste water. Well suited to repeat sampling events. Likely faster with lower costs. Disadvantages: Not directly equivalent to other methods. Vertical stratification or vertical flow conditions in the screened interval can result in deceptive or non-intuitive analytical results.
Predicated on the assumption that aquifer flow through the well maintains the water in the screened interval in a state equivalent to that in the aquifer. This assumption should be proven or the data qualified. Sampling is conducted with little or no purge, or by equilibrating a sampler in screened interval.	Pumps, various	Pumps, various	In the minimum-purge method, the internal volume of the sample tubing and pump is calculated. One volume of the pump and tubing is purged to flush the equipment and the well is then sampled.
	na	Passive Diffusion Bags	In most common form, a sealed water-filled polyethylene bag is allowed to equilibrate in the water column. Suitable primarily for VOCs. Generally require 2 week minimum in-situ residence time.
	na	Hydrasleeves	Collect a fixed volume of water from a specific interval. Requires duplicate samplers or redeployment for larger volumes. Sorbtion issues may bias results.
	na	Snap sampler	Deploys a sample container in the sampling interval where it is allowed to equilibrate (commonly for two weeks) before being sealed insitu by the sampler mechanism and retrieved. Limited to specific containers.

3.4 Multiple-Volume Purge

In the traditional Multiple-Volume Purge method, water is removed from the top of the water column, causing water to enter the screen and flush stagnant casing water upward to be subsequently removed. In recognition of the mixing of fresh and stagnant water in the casing section, a minimum of three well volumes is removed, at which time purging can be terminated upon parameter stabilization. Wells can be assumed to be adequately purged when five well volumes have been removed, although further purging may be conducted to meet specific goals, such as further reduction of turbidity.

3.4.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined The diameter of the well is determined and the water level and total depth of the well measured and recorded prior to inserting a pump or tubing into the well. The water level is subtracted from the total depth, providing the length of the water column. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. The well volume can be calculated using the equation:

$$V = 0.041\ d^2h$$

Where:
h = length of water column in feet
d = diameter of well in inches
V = one well volume in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, such as *Table 2 Well Casing Diameter Volume Factors*. The water column length is multiplied by the appropriate factor in the Table 2 to determine the single well volume, three well volumes, or five well volumes for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

COPY

TABLE 2, WELL CASING DIAMETER VOLUME FACTORS

Well Casing Diameter (in)	Reference 1 Well Volume (gallons/ft)	Minimum purge 3 Well Volumes (gallons/ft)	Maximum purge* 5 Well Volumes (gallons/ft)
0.5	0.01	0.03	0.05
0.75	0.02	0.07	0.11
1	0.04	0.12	0.20
2	0.16	0.49	0.82
3	0.37	1.1	1.8
4	0.65	2.0	3.3
5	1.0	3.1	5.1
6	1.5	4.4	7.3
7	2.0	6.0	10.0
8	2.6	7.8	13.1
9	3.3	9.9	16.5
10	4.1	12.2	20.4
11	4.9	14.8	24.7
12	5.9	17.6	29.4
13	6.9	20.7	34.5
14	8.0	24.0	40.0
15	9.2	27.5	45.9
16	10.4	31.3	52.2
18	13.2	39.7	66.1
24	23.5	70.5	118
36	52.9	159	264
48	94.0	282	470

*** See text for discussion on terminating purge at five well volumes**

An adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as an initial purge volume goal.

3.4.2 Pumping Conditions

The pump or tubing inlet should be located at the top of the water column. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is as close as possible to the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump or tubing will have to be lowered to accommodate the drawdown.

3.4.3 Stability of Chemical Parameters

In the multiple-volume purge method, a stability determination may be made after three well volumes have been removed. If the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to a total of five well volumes) should be removed. If the parameters have not stabilized after the removal of five well volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible.

3.4.4 Sample Collection

There are several means by which sampling can proceed after adequate volume has been purged and water quality parameters have stabilized. If a submersible pump and tubing are of suitable material and cleanliness for sample collection, sampling can proceed immediately by directly filling bottles from the tubing outlet. Commonly with the multiple-volume purge method, the pump is set up and cleaned in a manner suitable only for purging. In these cases, the pump is stopped and removed from the well and sampling proceeds with a bailer per the procedure described in Section 3.6.3. The pump should have a check valve to prevent water in the pump tubing from discharging back into the well when the pump is stopped. If a peristaltic pump is used, sampling can proceed as described in Section 3.6.1.

3.5 Low-Flow Method

This method involves placing the pump or tubing inlet within the screened interval of the well and purging at a low enough rate to achieve stable drawdown and minimal depression of the water level. The well is sampled without interruption after field parameters are stable and low turbidity is achieved. In general, only water in the screened interval of the well is pumped and the stagnant water in the well casing above the screen is not removed. Wells can generally be sampled in less time with less purge volume than with the multi-volume purge method. More attention is required in the assessment of stability criteria than the multi-volume method.

3.5.1 Nomenclature

A variety of terminology has been used to describe this method by SESD and others, including: 'low flow', 'low-flow/low-volume', 'tubing-in-screen method', 'low flow/ minimal drawdown', and 'micropurge'. The current preferred SESD terminology for this method is 'Low-Flow'. As the term 'micropurge' is sometimes used to refer to minimal-purge methods and has been trademarked by a vendor, the use of 'micropurge' to describe the Low-Flow method generally introduces ambiguity and confusion and thus the use of the term is discouraged.

3.5.2 Placement of Pump Tubing or Intake

The inlet of the pump tubing or intake of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. While it is often thought that particular aquifer zones can be targeted by specific pump or intake placement, for conventionally constructed screened and filter-packed monitoring wells the zone monitored is only weakly dependent on the intake placement (Varljen, Barcelona, Obereiner & Kaminski, 2006).

The pump or tubing can be placed by carefully lowering them to the bottom of the well and then withdrawing half of the screen length, plus the length of any sump sections at the bottom of the well. A drawback of this approach is that it may stir up sediment at the well bottom. An alternate approach is to lower the pump or tubing a measured distance to place it at mid-screen without touching the bottom of the well. In the case of pumps, special care should be used in lowering them slowly, especially in the screened interval, to prevent elevating turbidity needlessly by the surging action of the pump.

3.5.3 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well to measure the water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. In some cases, it will be necessary for the well to drawdown a considerable distance (10 ft or more in extreme cases) to maintain a minimal usable pumping rate for sampling (100-200 ml/min). Excessive pump rates and drawdown can result in increased turbidity, or aeration of the sample if the screen is exposed. Stable drawdown is an essential condition of the Low-Flow method. If the stable drawdown condition cannot be met, then one of the other methods should be employed.

3.5.4 Stability of Chemical Parameters

As with the Multiple-Volume Purging method described, it is important that all chemical parameters be stable prior to sampling. It is common for wells to require the removal of one of more screened-interval volumes (~2 gal for a 10 ft screen in a 2" dia. well) to achieve stability. Although it is possible for wells to achieve stability with lower purge volumes, the sampler should exercise caution in making an early stability determination.

3.5.5 Sample Collection

Low-Flow sampling is implemented using a pump and tubing suitable for sampling. After making the determination of parameter stability with stable drawdown, sampling can proceed immediately. Where submersible or bladder pumps are used, sampling can proceed by directly filling bottles from the tubing outlet. Where peristaltic pumps are used, sampling can proceed per the procedure described in Section 3.6.3.

3.6 Minimum-Purge and No-Purge Sampling

The Minimum-Purge and No-Purge sampling methods are employed when it is necessary to keep purge volumes to an absolute minimum, where it is desirable to reduce long-term monitoring costs, or where large wells or other limitations prevent well purging. The underlying assumption when employing these methods is that the water within the well screen is equilibrated with the groundwater in the associated formation. This assumption should be demonstrated prior to use of these methods or the results suitably qualified. These methods are generally impractical for SESD to implement because of the common lack of hydrogeological information in early investigative phases and the necessity with some methods that the samplers be pre-deployed to allow equilibration.

Vertical flow conditions and stratification of the water column have also been known to result in deceptive and non-intuitive analytical results. The use of these methods in the early phases of investigation can easily result in misinterpretation of site conditions and plume boundaries.

Particular caution is in order in the use of these methods when any of the following conditions exist:

- Low hydraulic conductivity ($K<10^{-5}$ cm/sec)
- Low groundwater surface gradients
- Fractured bedrock
- Wells with long screened intervals
- Wells screened in materials of varying hydraulic conductivities

If it is desired to transition a long-term monitoring program to Minimum-Purge or No-Purge sampling, a pilot study should be conducted where the Minimum-Purge or No-Purge sample results are compared to the conventional methods in use. Multiple samplers may be deployed in the screened interval to help establish appropriate monitoring intervals.

These methods are in common use and for the purposes of the SESD quality system they can be considered standard, but unaccredited, procedures. Several Minimum-Purge or No-Purge procedures that might be employed are shown below. It is not the intention to recommend particular equipment or vendors, and other equipment that can accomplish the same goals may be suitable.

3.6.1 Minimum Purge Sampling

The pump or tubing inlet is deployed in the screened interval. A volume of water equal to the internal pump and tubing volume is pumped to flush the equipment. Sampling then proceeds immediately. While superficially similar to Low-Flow sampling, the results obtained in this method will be sensitive to the vertical pump or tubing inlet placement and are subject to the limitations described above.

3.6.2 Passive Diffusion Bags

The no-purge Passive Diffusion Bag (PDB) typically consists of a sealed low-density polyethylene (LDPE) bag containing deionized water. They are deployed in the screened interval of a well and allowed to equilibrate, commonly for two weeks, prior to retrieval and decanting of the water into sample containers. Many volatile organic compounds will reach equilibrium across the LDPE material, including BTEX compounds and many chlorinated solvents. Compounds showing poor equilibration across LDPE include acetone, MTBE, MIBK, and styrene. PDBs have been constructed of other materials for sampling other analytes, but the vast majority of PDB samplers are of the LDPE material. Various vendors and the Interstate Technology and Regulatory Council (ITRC) can provide additional information on these devices.

3.6.3 HydraSleevesTM

HydraSleeeves™ are no-purge grab sampling devices consisting of a closed-bottom sleeve of low-density polyethylene with a reed valve at the top. They are deployed in a collapsed state to the desired interval and fill themselves through the reed valve when pulled upward through the sampling interval. The following is a summary of their operation:

Sampler placement – A reusable weight is attached to the bottom of the sampler or the sampler is clipped to a weighted line. The HydraSleeve™ is lowered on the weighted line and placed with the top of the sampler at the bottom of the desired sampling interval. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. The well is allowed to return to equilibrium.

Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level and only minimal agitation during collection.

Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field parameter measurements.

Because the HydraSleeve™ is retrieved before equilibration can occur and they are constructed of non-Teflon® materials, there may be issues with sorbtion of contaminants in the use of this sampler.

3.6.4 Snap Samplers

The Snap Sampler is a patented no-purge groundwater sampling device that employs a double-end-opening bottle with "Snap" sealing end caps. The dedicated, device is deployed at the desired position in the screened interval with up to six Snap Samplers and six individual sampling bottles. The device is allowed to equilibrate in the screened interval and retrieved between 3 and 14 days after deployment. Longer deployments are possible to accommodate sampling schedules.

To operate, Snap Samplers are loaded with Snap Sampler bottles and the "Snap" caps are set into an open position. Samplers are deployed downhole with an attachment/trigger line and left to equilibrate downhole. To collect samples, the Snap Sampler bottles seal under the water surface by pulling a mechanical trigger line, or using an electric or pneumatic trigger system. The trigger releases Teflon® "Snap Caps" that seal the double-ended bottles. The end caps are designed to seal the water sample within the bottles with no headspace vapor. After the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal.

The manufacturer of the Snap Sampler provides considerable additional information on the validation and use of the device.

3.7 Equipment Considerations

Equipment choices are dictated by the purging and sampling method used, the depth to water, the quantity of water to be pumped, and quality considerations. The advantages and disadvantages of various commonly used pumps are discussed in the sections below and summarized in *Table 1, Purge and Sample Strategies with Equipment Considerations.* Additional information on the use of individual pumps is available in SESD Operating Procedure for Pump Operation, SESDPROC-203.

3.7.1 Use of Peristaltic Pumps

Peristaltic pumps are simple, inexpensive, and reliable equipment for purging and sampling where the limit of suction is not exceeded (approximately 25-30 vertical feet from the groundwater surface to the pump). When used for sampling, they should be equipped with new Teflon® tubing for each well. The flexible peristaltic pump-head tubing should also be changed between wells.

Samples for organic analyses cannot be exposed to the flexible peristaltic pump-head tubing, both due to the risk that the tubing would sorb contaminants and the propensity of this tubing to contribute organic compounds to the sample. Samples can be collected without contact with the pump-head tubing by the use of vacuum transfer caps for analyses requiring 1 liter glass containers and the use of the 'soda-straw' method for the filling of VOC vials.

The sample containers for the more turbidity-sensitive analyses are filled first, as filling the VOC vials (and to a lesser extent the glass bottles) may disturb the well and increase turbidity. The most appropriate order of sampling with a peristaltic pump is generally to fill poly containers for metals and classical analyses, followed by glass bottles for SVOCs and associated analyses, and finally to fill 40 ml VOC vials.

The following step-by-step procedure assumes that the pump has been set up per SESD Operating Procedure for Pump Operation (SESDPROC-203) and that containers for a typical full suite of analyses will be filled. The procedure is suitable for use with either multi-volume Purge and Low-Flow methods with minor differences in the collection of VOCs:

1. Deploy the lower end of the tubing to the desired point in the well. This would be the top-of-water for the multi-volume purge method or to the mid-screen for the Low-Flow method. Connect the well tubing to the flexible pump-head tubing and connect a short piece of tubing from the pump-head tubing to a measuring bucket.

2. Turn on the pump and establish a suitable pumping rate. For the multi-volume purge method, the rate will generally be a relatively fast rate that the well will sustain without elevating turbidity. For the low-flow method the pump rate is established at a slower rate to maintain a minimal and stable drawdown level.

3. Proceed with the measurement of water quality parameters and adjust the pump rate as needed to achieve low turbidity and stable drawdown.

4. When the well purge has been determined to be sufficient, fill containers for metals and classical analyses directly from the pump outlet. There is no need to interrupt pumping. The tubing should be held at the opening of the container and should not touch the container during filling. Protect caps from dust and debris during filling.

5. After filling the containers for metals and classical analyses stop the pump. Make sure that the tubing leading into the well is secured against movement during the following operations.

6. Create a crimp in the well tubing approximately one foot from the pump and grasp the crimped tubing in one hand. It is generally most effective to create a double 'Z' crimp.

7. Cut the sample tubing between the crimp and the pump. The tightly-held crimped tubing should keep water from running back into the well. In lieu of

cutting the tubing, the well tubing can be disconnected from the pump and a short piece of tubing connected in its place.

8. Insert both free ends of the tubing into the ferrule-nut fittings of a pre-cleaned Teflon® transfer cap assembly and tighten the nuts. Attach the transfer cap assembly to the first glass container for semi-volatile analysis and securely tighten the threaded ring.

9. Turn the pump on. Very slowly release the 'Z' crimp in the sample tubing. As vacuum builds up in the sample container, water should begin to move up the sample tubing instead of back into the well. If after several minutes water has not begun moving up the tubing, check the tightness of fittings and the attachment of the cap to the bottle. Allowing water to rush back down the tubing from the 'Z' crimp can surge the well and elevate turbidity.

10. Fill the container to about halfway between the shoulder and the neck. Crimp the well tubing. Move the transfer cap to any additional bottles and repeat the filling process.

11. When finished filling bottles with the transfer cap, again crimp the tubing. Remove the well tubing from the transfer cap and reattach it to the pump. Slowly run the pump and release the crimp until water is approaching the flexible peristaltic tubing.

12. Make a kink or otherwise mark the tubing at the top of the casing in case the tubing needs to be reinserted for additional sample volume. Slowly remove the tubing from the well and coil it in one hand in loose coils. With the top end of the tubing blocked, water is retained in the tubing as it is withdrawn, much as in a capped soda straw, hence the name for this method.

13. Remove the top from a 40 ml VOC vial and position the end of the sample tubing near the top of the vial. Reverse the pump direction and turn the speed knob to its slowest position. Turn on the pump and slowly increase speed until water slowly fills the vial. Fill the vial with a slow laminar flow that does not agitate the water in the vial or entrain bubbles. Continue to fill the vial until a convex meniscus forms on the top of the vial and turn off the pump.

14. Carefully screw the septum-lid to the vial and fasten firmly. Invert the vial and tap on your knuckles to check for bubbles. Carefully add additional volume to the vial if necessary. Small bubbles are undesirable but may be unavoidable with some media, especially when using pre-preserved vials.

15. Repeat the filling process for additional vials. Avoid partially filling vials as the available water in the tubing is used. If more volume is required than that contained in the tubing, purge the remaining water from the tubing and reinsert

the tubing in the well to the level marked previously. Run the pump to refill the tubing. If performing Low-Flow sampling, run additional volume through the pump to purge any water that may have been collected from the stagnant water column.

16. Fill additional vials as needed. Be sure that any water that has contacted the flexible peristaltic tubing is not pumped into a vial.

3.7.2 Use of Submersible Centrifugal Pumps

Submersible centrifugal pumps are used in wells of 2" diameter and larger. They are especially useful where large volumes of water are to be removed or when the groundwater surface is a large distance below ground surface. Commonly used pumps are the Grundfos® Redi-Flo2, the Geotech GeoSub, and the various 'Monsoon' style pumps. Other pumps are acceptable if constructed of suitable materials.

When used with the Multiple-Volume Purge method, the pump is generally used only to purge, with sampling performed with a bailer. In this use, the pump can be used with polyethylene or other tubing or hose that will not contribute contaminants to the well. The pump and tubing is decontaminated between wells per the relevant provisions of SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205). When used in this application the pump should be equipped with a check valve to prevent water in the discharge tubing or hose from running back down into the well.

When used for Low-Flow purging and sampling the pump must be constructed of stainless steel and Teflon®. Pump cleaning at each well follows the more stringent procedures described in SESD Operating Procedure for Field Equipment Cleaning and Decontamination SESDPROC-205) for this application. The sample tubing should be either new Teflon® tubing, or tubing dedicated to each well. Dedicated tubing would ideally be cleaned between uses, but tubing stored in the well casing between uses is acceptable, although caution should be exercised where very high concentrations of contaminants have been sampled in a well.

3.7.3 Use of Bailers

Bailers are a common means of sampling when the Multiple-Volume Purge method is used. They are occasionally used for purging when other equipment is not available or has failed. As bailers surge the well on each withdrawal, it is very difficult to lower turbidity adequately during a well purge, and when used for sampling they can elevate turbidity in a well before all sample volume is collected. If not lowered carefully into the top of the water column, the agitation may strip volatile compounds. Due to the difficulties and limitations inherent in their use, other sampling or purging means should generally be given preference.

Bailers should be closed-top Teflon® bailers with Teflon® coated stainless steel leaders used with new nylon haul rope. They are lowered gently into the top of the water column, allowed to fill, and removed slowly. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging and during sampling, to minimize turbidity and loss of volatile organic constituents.

If the well has previously been purged with a pump, there is likely stagnant water at the top of the well that was above the pump or tubing inlet. Several bailers of water should be retrieved and discarded to assure the upper stagnant water has been removed.

When sampling, containers are filled directly by pouring from the outlet at the top of the bailer. Containers for metals analysis should be filled first in case the bailing process increases well turbidity. VOC vials should be filled carefully and slowly with a laminar flow to reduce agitation and the stripping of VOCs.

3.7.4 Use of Bladder Pumps

Bladder pumps use a source of compressed gas to compress and release a bladder straddled by check valves within the pump body. As the bladder is compressed, water is expelled out the upper check valve to the surface. When gas pressure is released, the bladder refills as well water enters the lower pump inlet. A control unit is used to control the pressure and timing of the bladder inflation gas flow.

Bladder pumps are capable of pumping from moderate depths to water, but are not capable of high flow rates. As they operate cyclically, the well is surged slightly on each cycle and it may be difficult to lower turbidity in sensitive or poorly developed wells. As the entire sample train is under positive pressure and the pumps develop little heat, they are ideal for sampling VOCs.

Prior to sampling and between each well the pumps are cleaned internally and externally per the provisions of SESD Operating Procedure for Field Decontamination (SESDPROC-205) and a new Teflon® bladder installed. New (or dedicated) Teflon® sample tubing is used at each well, although polyethylene tubing can be used for the compressed gas drive line and cleaned between each well.

3.7.5 Use of Inertial Pumps

Inertial pumps consist of a check valve which is affixed to the lower end of semi-rigid tubing. The tubing and valve are cycled up and down, allowing water to alternately be drawn into the check valve inlet and then pulled up towards the surface. Two commonly used inertial pumps are the Waterrra® pump for wells 1arger than 1" and the Geoprobe® Tubing Check Valve for small diameter wells. The primary use of these pumps is in well development where their near-immunity to silt is an advantage. Inertial pumps should not be used for the final well purge or for sampling as there is a low likelihood of reducing turbidity to appropriate levels and they have the potential to strip volatiles from the water column through agitation.

To set up the pump, the check valve is screwed onto the discharge tubing where it will cut its own threads. In the case of the Waterra® pump, a surge block can also be pressed onto the check valve. The pump is lowered into the well to the screened interval and rapidly cycled up and down a distance of 3” -12”. The stroke length and speed are adjusted for pumping effect. Electric actuators can be used to reduce the effort involved. The pump should be moved to different levels in the screen to surge the entire screen. The pump can occasionally be lowered to the bottom of the well to vacuum out silt. Any silt that clogs the valve is usually quickly rinsed out by the pump cycling and if the clog remains the pump is easily retrieved and redeployed.

The surging activity is usually continued until turbidity is lowered to a measurable range and cannot easily be lowered further. Further development or purging is then conducted with other pumps.

3.8 Wells With In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, and in other applications. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps.

A permanent monitoring well with an in-place pump may be treated as other monitoring wells without pumps. Since the in-place pump is generally “hard” mounted at a pre-selected depth, it cannot be moved up or down during purging and sampling. If the pump inlet is above the screened interval, the well should be sampled using the Multiple-Volume Purge method. If the pump intake is located within the screened interval, the well can be sampled using Low-Flow procedures. Known details of pump type and construction, tubing types, pump setting depths, and any other available information about the system should be recorded in the field logbook.

In the case of the other types of wells, e.g., municipal, industrial and residential supply wells, there is typically not enough known about the construction aspects of the wells to apply the same criteria as used for monitoring wells. The volume to be purged in these situations therefore depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

3.8.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be found located between the pump and the storage tank. If no valve is present, locate and use the valve closest to the tank. Measurements of field parameters are recorded immediately prior to the time of sampling.

3.8.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Often under these conditions, 15 to 30 minutes of purging will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling should be considered the measurements of record for the event.

3.9 Temporary Monitoring Wells

3.9.1 General Considerations

As temporary wells are installed for immediate sample acquisition, the procedures used to purge temporary ground water monitoring wells may differ from those for permanent wells. Temporary wells include standard well screen and riser placed in boreholes created by hand augering or drilling, or they may consist of a drive rod and screen such as a direct-push Geoprobe® Screen Point that is driven into place at the desired sampling interval. As aquifer water enters the sampler immediately upon deployment, the requirement to remove several volumes of water to replace stagnant water does not necessarily apply. In practice, developing and purging the well to usable turbidity levels will remove many times the water that would be removed in a Multiple-Volume Purge with calculated well volumes. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply standard permanent monitoring well purging criteria to achieve representative aquifer conditions in the sample.

3.9.2 Development of Temporary Wells

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, causing extreme turbidity. The goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.

The following procedure has been found to be effective in developing and sampling small diameter temporary wells where a peristaltic pump can be used. Turbidity can generally be lowered to 50 NTU at the time of sampling and turbidity less than 10 NTU is often achieved.

1. Cut peristaltic tubing to reach to the bottom of the well. Connect to a peristaltic pump and begin pumping at a high rate.

2. Use the tubing to vacuum out sediment at the bottom of the well.

3. Aggressively surge the end of the tubing in the screened interval by cycling the tubing rapidly up and down. Periodically repeat vacuuming of the well bottom.

4. When a visible 'break' to a lower turbidity is observed, cease surging the well and begin lowering the pumping rate.

5. When the water clears (turbidity < 100-200 NTU) begin raising the end of the tubing to the top of the water column.

6. Continue purging from the top of the water column, lowering the pump speed as required to lower turbidity. When adequately low turbidity and stable water quality parameters have been achieved, sampling can proceed.

Where the water level is below the limit of suction in a small diameter temporary well, a Geoprobe® mechanical bladder pump can be used for purging and sampling. The well should first be developed with an inertial pump to remove the bulk of silt and suspended particles that could clog the check valves of the bladder pump. The inertial pump is used to vacuum out the bottom of the well and surged in the screened interval until a 'break' to lower turbidity is observed prior to deployment of the bladder pump. Since the mechanical bladder pump requires cumbersome redeployment to change its pumping level, it should be deployed low enough in the water column that the water level will not be lowered below the pump during purging and sampling. The mechanical bladder pump is generally deployed above the screened interval to facilitate the settling of particles, but below the top of the water column to alleviate the need to reset the pump. Detailed instructions on the deployment of the pump can be found in SESDPROC203, Pump Operation.

3.9.3 Decommissioning of Temporary Wells

After temporary wells have fulfilled their purpose, they should be properly decommissioned similar to permanent wells. In general, the casings and screens can be easily removed and the borehole should then be pressure grouted from the bottom of the original borehole to prevent surface contamination of the aquifer, cross-connection of aquifers, and to remove a potential vapor pathway.

Direct-push screen-point wells may be decommissioned by one of two methods.

1. A disposable screen is used. The sampling sheath is pulled off of the screen and a 30% solids bentonite grout is pumped down the tool string as the rods are withdrawn.

Grout volumes are measured during pumping to assure that the hole is completely filled. The disposable screen is left behind at the bottom of the borehole.

2. The screen is removed with the sampler sheath and tool string. The hole is immediately re-entered with an empty sample sheath with disposable point. Upon reaching the original total depth of the temporary well, 30% solids bentonite grout is pumped down the tool string with the pumped volume monitored during tool string withdrawal to assure that the hole is completely filled.

A system is available to insert a small diameter grouting tube down through the screen-point screen. Grout is pumped through the grouting tube while the tools are withdrawn. SESD does not use this system as grout denser than 20% solids cannot reliably be installed with this system.

Additional guidance on decommissioning may be found in SESDGUID-101, Design and Installation of Monitoring Wells.

3.9.4 Other Considerations for Direct-Push Groundwater Sampling

With certain direct push sampling techniques, such as the Hydropunch™ and other discrete samplers used with cone-penetrometer rigs, purging is either not practical or not possible. The sampling device is simply pushed or driven to the desired depth and opened, whereupon the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the sampler may collect a turbid sample inappropriate for metals analyses or the sample may have inadequate volume to achieve desired reporting levels.

3.10 Wells Purged to Dryness

In some situations, even with slow purge rates, a well may be purged dry in the Multiple-Volume Purge method or stable drawdown cannot be maintained in the Low-Flow method. In these cases, the well should be purged to dryness (evacuated) and sampled upon recovery of adequate volume for sampling. Sampling should occur as soon as adequate volume has recovered. The field parameters should be measured and recorded at the time of sample collection as the measurements of record for the sampling event.

Sampling under these conditions is not ideal and suitable qualifications of the data should be included in the report. Water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, No-Purge methods may prove useful for these wells.

4 Additional Purging and Sampling Considerations

4.1 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible centrifugal or bladder pumps to purge wells which are excessively contaminated with oily compounds as it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative equipment, such as bailers or peristaltic pumps, should be considered.

4.2 Investigation Derived Waste

Purging and field cleaning of equipment generates liquid investigation derived waste (IDW), the disposition of which must be considered. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

4.3 Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult the Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM) for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

4.4 Special Sample Collection Procedures

4.4.1 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which contacts the water in the well must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-

206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Rinse blank samples should be collected to verify the adequacy of cleaning when using a sampling pump other than a peristaltic pump.

4.4.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, sufficiently low turbidity is difficult to achieve and maintain. Removal and insertion of equipment after the purge or during sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to fill sample containers for metals analysis first. The preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds, and finally volatile organic compounds.

4.5 Filtering

As many contaminants are known to sorb to soil particles, the normal goal of sampling is to reduce the presence of these particles (measured by turbidity) in order that the dissolved concentration of contaminants can be obtained. However, transport of sorbed contamination on colloidal particles can be a means of contaminant transport on some sites. For this reason, the SESD approach is to reduce turbidity through the careful purging of wells, rather than through filtering of samples, in order that the colloidal particles would be included in the sample.

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not acceptable to correct for improperly designed or constructed monitoring wells, inadequate well development, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the SESD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).

2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the redevelopment or re-installation of permanent ground water monitoring wells or the implementation of carefully conducted low flow rate sampling techniques.

If filtration is necessary for purposes of geochemical modeling or other **pre-approved** cases, the following procedures are suggested:

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.

2. When using pumps for sampling, the filter can generally be attached directly to the pump outlet. When sampling with a bailer or when otherwise required, an initial unfiltered sample with extra volume will be collected, and a peristaltic pump with filter used to decant and filter the sample to the final sample container.

3. Use a 0.45 µm pore-size filter to remove most non-dissolved particles. A 5 µm or 10 µm pore-size filter should be used for the purpose of determining colloidal constituent concentrations.

4. Fill the filter and rinse with approximately one additional filter volume prior to filling sample bottles

Potential differences can result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 1.4, References, for complete citation for these documents.

4.6 Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in the Subsurface; 2) Handbook for Evaluating Water Bacteriological Laboratories; and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes. See Section 1.4, References, for complete citation for these documents.

4.7 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). Malfunctioning equipment should be labeled in the field and repaired, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

4.8 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations, pumping rates during purging, and, driller or boring logs. This information should be documented in the field records.

4.9 Well Development

Wells may be encountered that are difficult to sample effectively due to inadequate initial development or the need for redevelopment due to scaling, sedimentation, corrosion, or biofouling. These wells may produce water only at low flow rates or water with chronically elevated turbidity. Redevelopment of these wells should be considered as the process can improve sample quality and speed field operations. Well development procedures are described in Design and Installation of Monitoring Wells (SESDGUID-101).

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Potable Water Supply Sampling**	
Effective Date: May 30, 2013	**Number:** SESDPROC-305-R3
Authors	
Name: Mike Neill Title: Environmental Scientist, Regional Expert Signature: Mike Neill	Date: 5-28-13
Approvals	
Name: Danny France Title: Chief, Enforcement and Investigations Branch Signature: Danny France	Date: 5/29/13
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature:	Date: 5/28/13

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-305-R3, *Potable Water Sampling*, replaces SESDPROC-305-R2 **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Changed author from Maria Labrador to Mike Neill. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. Section 1.4: Omitted references that were no longer applicable. **Section 2.3**: Reorganized section by adding four subsections: Sample Handling, Sample Preservation, Sample Dechlorination and Other Sample Preservation/Stabilization. Section 2.3.1: Omitted "procedures" and "used" and added "used" in the first sentence. Omitted "labeled" from first sentence of Item 3. Item 4 was added to address samples requiring reduced temperature storage. Section 2.3.2: This section was revised to reflect current preservation practices. Section 2.3.3: The following language was added to create Section 2.3.3: "Potable water samples that have been treated with chlorine require the addition of sodium thiosulfate to dechlorinate the sample." Section 2.3.4: The following language was added to create Section 2.3.4: "If other preservation or stabilization requirements are needed, refer to the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version." Section 3.1: The requirements for obtaining the resident's information were moved to the top of this section. In the first sentence of the next to last paragraph the following language was added: "or the container is pre-preserved." Section 4: Section was renamed from "Potable Water Supply Sampling Methods – Purging" to "Potable Water Supply Purging." Section 4.1 and Section 4.1.1: Section 4.1.1 was moved to Section 4.1. Section was renamed from "Purging and Purge Adequacy" to "Potable Wells – Purging and Purge Adequacy." Language from former Section 4.2 concerning potable water purging from residential wells was relocated to the	May 30, 2013

COPY

first and last paragraph of this section. Section 4.2: Previous language was omitted and replaced with language concerning water supply plants and large industrial supplies. Section was renamed to reflect the new subject. Section 4.2: Section was omitted. Section 5.2: Section was renamed from "Collecting Samples from Wells with In Place Plumbing" to "Collecting Samples from Residential Wells." Section 5.3: Section was renamed from "Sample Preservation" to "Collecting Samples from Water Supply Plants." The entire section was revised to reflect current practices. Section 5.4: Content from Section 5.4.1 was incorporated into Section 5.4. Sections 5.4.1 and 5.4.2 were omitted. Section 5.5: This section was omitted. Section 5.6: This section was omitted.	
SESDPROC-305-R2, *Potable Water Sampling*, replaces SESDPROC-305-R1	January 29, 2013
SESDPROC-305-R1, *Potable Water Sampling*, replaces SESDPROC-305-R0	November 1, 2007
SESDPROC-305-R0, Potable Water Supply Sampling, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting potable water supply samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling potable water supply samples in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a potable water supply sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

Puls, Robert W., and Michael J. Barcelona. Filtration of Ground Water Samples for Metals Analysis. *Hazardous Waste and Hazardous Materials* 6(4): 385-393 (1989).

Puls, Robert W., Don A. Clark, and Bert Bledsoe. Metals in Ground Water: Sampling Artifacts and Reproducibility. *Hazardous Waste and Hazardous Materials* 9(2): 149-162 (1992).

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples, SESDPROC-209, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version.

US EPA. April 13, 1981. Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples. Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273)

US EPA. 1995. Ground Water Sampling - A Workshop Summary. Proceedings from the Dallas, Texas November 30 - December 2, 1993 Workshop. Office of Research and Development Robert S. Kerr Environmental Research Laboratory. EPA/600/R-94/205.

US EPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4, SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting potable water supply samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting potable water supply samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal

Regulations (49 CFR Parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and stored in a secure place.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Potable water supply samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vials may be either preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the great majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the potable water supply has a high amount of dissolved limestone, i.e., is highly calcareous, there will most likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

2.2 Special Precautions for Potable Water Supply Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.
- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, etc., while the other members collect the samples.

- Samplers must use new, verified and certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), or the SESD Operating Procedure for Field Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

2.3.1 Sample Handling

The following should be used when collecting samples from potable water supplies:

- Potable water supply samples will typically be collected from a tap or spigot located at or near the well head or pump house and before the water supply is introduced into any storage tanks or treatment units. Efforts should be made to reduce the flow from either the tap or spigot during sample collection to minimize sample agitation.
- During sample collection, make sure that the tap or spigot does not contact the sample container.
- Place the sample into appropriate containers. Samples collected for VOC analysis must not have any headspace (see Section 2.1, Volatile Organic Compounds Analysis). All other sample containers must be filled with an allowance for ullage.
- Samples requiring reduced temperature storage should be placed on ice immediately.

2.3.2 Sample Preservation

All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by Analytical Support Branch (ASB) personnel prior to departure for the field investigation. ASB personnel will also provide sodium hydroxide tablets to preserve water samples that are being analyzed for cyanide. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. Additional preservative should be added to achieve adequate preservation.

2.3.3 Sample Dechlorination

Potable water samples that have been treated with chlorine require the addition of sodium thiosulfate to dechlorinate the sample.

2.3.4 Other Sample Preservation/Stabilization

If other preservation or stabilization requirements are needed, refer to the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version.

2.4 Quality Control

Equipment rinsate blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by any sampling equipment.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in the SESD Operating Procedure for Control of Records (SESDPROC-002). Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with the SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005) and the SESD Operating Procedure for Logbooks (SESDPROC-010).

3 Potable Water Supply Sampling – Sample Site Selection

3.1 General

Obtain or confirm the following information:

- the name(s) of the resident(s) or water supply owner/operator
- the exact physical address
- the exact mailing address (if different from the physical address)
- the resident's/operator's home, work and mobile telephone numbers (when available)

The information is required so that the residents or water supply owner/operators can be informed of the results of the sampling program.

The following should be considered when choosing the location to collect a potable water sample:

- Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest.

- Whenever possible, choose the tap closest to the water source, and prior to the water lines entering the residence, office, building, etc., and also prior to any holding or pressurization tanks.

- The sampling tap must be protected from exterior contamination associated with being too close to a sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collection procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. If the tap is too close to the ground for direct collection into the appropriate container, it is acceptable to use a smaller container to transfer sample to a larger container. The smaller container should be made of glass or stainless steel, and should be decontaminated to the same standards as the larger container.

- Leaking taps that allow water to discharge from around the valve stem handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations.

- Disconnect any hoses, filters, or aerators attached to the tap before sampling. These devices can harbor a bacterial population if they are not routinely cleaned or replaced when worn or cracked.

- Taps where the water flow is not constant should be avoided because temporary fluctuation in line pressure may cause clumps of microbial growth that are lodged in a pipe section or faucet connection to break loose. A smooth flowing water stream at moderate pressure without splashing should be used. The sample should be collected without changing the water flow. It may be appropriate to reduce the flow for the volatile organic compounds aliquot to minimize sample agitation.

Occasionally, samples are collected to determine the contribution of system-related variables (e.g., transmission pipes, water coolers, water heaters, holding tanks, pressurization tanks, etc.) to the quality of potable water supplies. In these cases, it may be necessary to ensure that the water source has not been used for a specific time interval (e.g., over a weekend or a three- or four-day holiday period). Sample collection may consist of collecting a sample of the initial flush, collecting a sample after several minutes, and collecting another sample after the system being investigated has been completely purged.

When sampling for bacterial content or the container is pre-preserved, the sample container should not be rinsed before use due to possible contamination of the sample container or removal of the thiosulfate dechlorinating agent (if used). When filling any sample container, care should be taken that splashing drops of water from the ground or sink do not enter into either the bottle or cap.

When sampling at a water treatment plant, samples are often collected from the raw water supply and the treated water after chlorination.

4 Potable Water Supply– Purging

4.1 Potable Wells - Purging and Purge Adequacy

Wells with in-place plumbing are commonly found at residences. The objective of purging wells with in-place pumps is the same as with monitoring wells without in-place pumps, i.e., to ultimately collect a water sample representative of aquifer conditions.

Purging is the process of removing stagnant water immediately prior to sampling. In order to determine when an adequate purge has occurred, field investigators should monitor the pH, specific conductance and turbidity of the water removed during purging. For potable water supply sampling, it is recommended to purge the system for at least 15 minutes when possible.

An adequate purge is achieved when the pH and specific conductance of the potable water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Although 10 NTUs is normally considered the minimum goal for most water sampling objectives, lower turbidity has been shown to be easily achievable in most situations and reasonable attempts should be made to achieve these lower levels. Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and the specific conductance varies no more than approximately 10 percent. There are no set criteria establishing how many total sets of measurements are adequate to document stability of parameters.

If, after 15 minutes, the in situ chemical parameters have not stabilized according to the above criteria, additional water can be removed. If the parameters have not stabilized after 15 minutes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging.

A well with an intermittently run pump should, in all respects, be treated like a well without a pump. In these cases, parameters are measured and the well is sampled from the pump discharge after parameter conditions have been met. Generally, under these conditions, 15 to 30 minutes will be adequate.

4.2 Water Supply Plants

Municipality water supply plants and large industrial supplies that operate continuously, require no purge other than opening a valve and allowing it to flush for a few minutes. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance and turbidity are recorded at the time of sampling when water quality parameters are required.

4.3 Investigation Derived Waste

Purging generates quantities of purge water or investigation derived waste (IDW), the disposition of which must be considered. See the SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

5 Potable Water Supply Sampling Methods – Sampling

5.1 General

Sampling is the process of obtaining, containerizing, and preserving (if required) a potable water supply water sample after the purging process is complete. It is recognized that there are situations, such as industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected. Discretion should always be used in obtaining a sample.

5.2 Collecting Samples from Residential Wells

Samples should be collected following purging from a valve or cold water tap as near to the well as possible, preferably prior to any storage/pressure tanks or physical/chemical treatment system that might be present. Remove any hose that may be present before sample collection and reduce the flow to a low level to minimize sample disturbance, particularly with respect to volatile organic constituents. Samples should be collected directly into the appropriate containers (see the ASBLOQAM for a list of containers). It may be necessary to use a secondary container, such as a clean 8 oz. or similar size sample jar or a stainless steel scoop, to obtain and transfer samples from spigots with low ground clearance. All measurements for pH, specific conductance and turbidity should be recorded at the time of sample collection.

1. Ideally, the sample should be collected from a tap or spigot located at or near the well head or pump house and before the water supply is introduced into any storage tanks or treatment units. If the sample must be collected at a point in the water line beyond pressurization or holding tank, a sufficient volume of water should be purged to provide a complete exchange of fresh water into the tank and at the location where the sample is collected. If the sample is collected from a tap or spigot located just before a storage tank, spigots located inside the building or structure should be turned on to prevent any backflow from the storage tank to the sample tap or spigot. It is generally advisable to open several taps during the purge to ensure a rapid and complete exchange of water in the tanks.

2. Purge the system for at least 15 minutes when possible. During the purge period, obtain at least three sets of readings as follows: after purging for several minutes, measure the pH, specific conductivity and turbidity of the water. Continue to measure these parameters to assess for stabilization.

3. After three sets of readings have been obtained, samples may be collected. If stabilization has not occurred after the 15-minute purge period, it is at the discretion of the project leader to collect the sample or continue purging and

monitoring the parameters. This would depend on the condition of the system and the specific objectives of the investigation.

5.3 Collecting Samples from Water Supply Plants

Municipality water supply plants and wells that continuously operate, require no purge other than opening a valve and allowing it to flush for a few minutes. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance and turbidity are recorded at the time of sampling when water quality parameters are required.

5.4 Special Sample Collection Procedures

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment which comes into contact with the water must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination, (SESDPROC-205) or the SESD Operating Procedure for Field Cleaning and Decontamination at the FEC (SESDPROC-206), as applicable.

COPY

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia	
OPERATING PROCEDURE	
Title: **Surface Water Sampling**	
Effective Date: February 28, 2013	**Number:** SESDPROC-201-R3
Authors	
Name: Chris Decker Title: Biologist Signature:	Date: 2/19/13
Name: Kevin Simmons Title: Environmental Scientist Signature:	Date: 2/19/13
Approvals	
Name: Danny France Title: Chief, Enforcement and Investigations Branch Signature:	Date: 2/20/13
Name: John Deatrick Title: Chief, Ecological Assessment Branch Signature:	Date: 2/20/13
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature:	Date: 2/19/13

COPY

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-201-R3, *Surface Water Sampling*, replaces SESDPROC-201-R2. **General:** Corrected any typographical, grammatical and/or editorial errors. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2.3**: Item 4 was revised to reflect practice of using individual single-use preservative vials instead of preservatives prepared by ASB.	**February 28, 2013**
SESDPROC-201-R2, *Surface Water Sampling*, replaces SESDPROC-201-R1.	**January 16, 2013**
SESDPROC-201-R1, *Surface Water Sampling*, replaces SESDPROC-201-R0.	**November 1, 2007**
SESDPROC-201-R0, *Surface Water Sampling*, Original Issue	**February 05, 2007**

COPY

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting surface water samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling surface water samples in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a surface water sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples, SESDPROC-209, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

United States Environmental Protection Agency (US EPA). 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting surface water samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting surface water samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and stored in a secure place.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Surface water samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas, unpreserved samples have only a seven-day holding time. In the great majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the surface water sample contains a high concentration of dissolved calcium carbonate, there may be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a reverse or convex meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

Samples for VOC analysis must be collected using either stainless steel or Teflon® equipment.

2.2 Special Precautions for Surface Water Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.
- All background or control samples shall be collected and placed in separate ice chests or shipping containers. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly contaminated media must not be

placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.

- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Samplers must use new, verified and certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, or SESD Operating Procedure for Field Cleaning and Decontamination at the FEC, SESDPROC-206, for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

1. Surface water samples will typically be collected either by directly filling the container from the surface water body being sampled or by decanting the water from a collection device such as a stainless steel scoop or other device.
2. During sample collection, if transferring the sample from a collection device, make sure that the device does not come in contact with the sample containers.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC analysis must not have any headspace (see Section 2.1, Volatile Organic Compounds (VOC) Analysis). All other sample containers must be filled with an allowance for ullage.
4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by ASB personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples, except for the samples collected for VOC analysis. If it is determined that a sample is not adequately preserved, additional preservative should be added to achieve adequate preservation. Preservation requirements for surface water samples are found in the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM).
5. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

2.4 Quality Control

If possible, a control sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples. In streams or other bodies of moving water, the control sample should be collected upstream of the sampled area. For impounded bodies of water, particularly small lakes or ponds, it may be difficult or inappropriate to obtain an unbiased control from the same body of water from which the samples are collected. In these cases, it may be appropriate to collect a background sample from a similar impoundment located near the sampled body of water if there is a reasonable certainty that the background location has not been impacted. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers or other sampling equipment.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005.

3 General Considerations

3.1 General

The surface water sampling techniques and equipment described in the following sections of this procedure are designed to minimize effects on the chemical and physical integrity of the sample. If the procedures in these sections are followed, a representative sample of the surface water should be obtained.

3.2 Equipment Selection Considerations

The physical location of the investigator when collecting a sample may dictate the equipment to be used. If surface water samples are required, direct dipping of the sample container into the stream is desirable. Collecting samples in this manner is possible when sampling from accessible locations such as stream banks or by wading or from low platforms, such as small boats or piers. Wading or streamside sampling from banks, however, may cause the re-suspension of bottom deposits and bias the sample. Wading is acceptable if the stream has a noticeable current (is not impounded), and the samples are collected while facing upstream. If the stream is too deep to wade, or if the sample must be collected from more than one water depth, or if the sample must be collected from an elevated platform (bridge, pier, etc.), supplemental sampling equipment must be used.

To collect a surface water sample from a water body or other surface water conveyance, a variety of methods can be used:

- Dipping Using Sample Container
- Scoops
- Peristaltic Pumps
- Discrete Depth Samplers
- Bailers
- Buckets
- Submersible Pumps
- Automatic Samplers

Regardless of the method used, precautions should be taken to ensure that the sample collected is representative of the water body or conveyance. These methods are discussed in the following sections.

4 Dipping Using Sample Container

A sample may be collected directly into the sample container when the surface water source is accessible by wading or other means. The sampler should face upstream if there is a current and collect the sample without disturbing the bottom sediment. The surface water sample should always be collected prior to the collection of a sediment sample at the same location. The sampler should be careful not to displace the preservative from a pre-preserved sample container, such as the 40-ml VOC vial.

5 Scoops

Stainless steel scoops provide a means of collecting surface water samples from surface water bodies that are too deep to access by wading. They have a limited reach of about eight feet and, if samples from distances too far to access using this method are needed, a mobile platform, such as a boat, may be required.

Stainless steel scoops are useful for reaching out into a body of water to collect a surface water sample. The scoop may be used directly to collect and transfer a surface water sample to the sample container, or it may be attached to an extension in order to access the selected sampling location.

6 Peristaltic Pumps

Another device that can be effectively used to sample a water column, such as a shallow pond or stream, is the peristaltic pump/vacuum jug system. The peristaltic pump can be used to collect a water sample from any depth if the pump is located at or near the surface water elevation. There is no suction limit for these applications. The use of a metal conduit to which the tubing is attached, allows for the collection of a vertical sample (to about a 25-foot depth) which is representative of the water column. The tubing intake is positioned in the water column at the desired depth by means of the conduit. Using this method, discrete samples may be collected by positioning the tubing intake at one depth or a vertical composite may be collected by moving the tubing intake at a constant rate vertically up and down the water column over the interval to be composited.

Samples for VOC analysis cannot be collected directly from the peristaltic pump discharge or from the vacuum jug. If a peristaltic pump is used for sample collection and VOC analysis is required, the VOC sample must be collected using one of the "soda straw" variations. Ideally, the tubing intake will be placed at the depth from which the sample is to be collected and the pump will be run for several minutes to fill the tubing with water representative of that interval. After several minutes, the pump is turned off and the tubing string is retrieved. The pump speed is then reduced to a slow pumping rate and the pump direction is reversed. After turning the pump back on, the sample stream is collected into the VOC vials as it is pushed from the tubing by the pump. Care must be taken to prevent any water that was in contact with the silastic pump head tubing from being incorporated into the sample.

7 Discrete Depth Samplers

When discrete samples are desired from a specific depth, and the parameters to be measured do not require a Teflon®-coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position, thus allowing free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample containers. With a rubber tube attached to the valve, dissolved oxygen sample bottles can be properly filled by allowing an overflow of the water being collected. With multiple depth samples, care should be taken not to disturb the bottom sediment, thus biasing the sample.

When metals and organic compounds parameters are of concern, then a double-check valve, stainless steel bailer or Kemmerer sampler should be used to collect the sample.

8 Bailers

Teflon® bailers may also be used for surface water sampling if the study objectives do not necessitate a sample from a discrete interval in the water column. A closed-top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found.

9 Buckets

A plastic bucket can be used to collect samples for measurement of water quality parameters such as pH, temperature, and conductivity. Samples collected for analysis of classical water quality parameters including but not limited to ammonia, nitrate-nitrite, phosphorus, and total organic carbon may also be collected with a bucket. Typically, a bucket is used to collect a sample when the water depth is too great for wading, it is not possible to deploy a boat, or access is not possible (excessive vegetation or steep embankments) and the water column is well mixed. The water body is usually accessed from a bridge. The bucket is normally lowered by rope over the side of the bridge. Upon retrieval, the water is poured into the appropriate sample containers

Caution should be exercised whenever working from a bridge. Appropriate measures should be taken to insure the safety of sampling personnel from traffic hazards.

10 Submersible Pumps

Submersible pumps can be used to collect surface water samples directly into a sample container. The constituents of interest should be taken into consideration when choosing the type of submersible pump and tubing to be used. If trace contaminant sampling of extractable organic compounds and/or inorganic analytes will be conducted, the submersible pump and all of its components should be constructed of inert materials such as stainless steel and Teflon®. The tubing should also be constructed of Teflon®. If re-using the same pump between sample locations, the pump should be decontaminated using SESD Operating Procedure for Field Equipment Cleaning and Decontamination, (SESDPROC-205). New tubing should be used at each sample location.

If the samples will be analyzed for classical parameters such as ammonia, nitrate-nitrite, phosphorus, or total organic carbon, the pump and tubing may be constructed of components other than stainless steel and Teflon®. The same pump and tubing may be re-used at each sampling station after rinsing with deionized water and then purging several volumes of sample water through the pump and tubing prior to filling the sample containers.

Either a grab or composite sample can be collected using a submersible pump. A composite sample can be collected by raising and lowering the pump throughout the water column. If a composite sample is collected, it may be necessary to pump the sample into a compositing vessel for mixing prior to dispensing into the sample containers. If a compositing vessel is required, it should be constructed of materials compatible with the constituents of concern and decontaminated between sample stations according to appropriate procedures, again depending on the constituents of concern.

11 Automatic Samplers

Where unattended sampling is required (e.g., storm-event sampling, time-of-travel studies) an automatic sampler may be used. The automatic sampling device may be used to collect grab samples based on time, in-stream flow or water level or used to collect composite samples as dictated by the study data needs. The automatic sampling device should be calibrated prior to deployment to insure the proper volume is collected. The manufacturer's instruction manual should be consulted for automatic sampler operation.

12 Trace-Level Mercury Sampling

In order to prevent contamination during sample collection, Region 4 has developed this sampling procedure for trace-level mercury analysis (< 1 part per trillion). This procedure is based on EPA Method 1669.

A vacuum chamber assembly is utilized to collect surface water samples for trace-level mercury analyses. The vacuum chamber assembly consists of the following: 1) an airtight acrylic, cylindrical chamber with an o-ring sealed lid to hold the sample bottle, 2) a Teflon® sample tubing that connects to a centered Teflon® compression fitting on top of the chamber. The other end of the tubing passes through a rigid Teflon® pole for stability and has a modified magnetic screen holder at the intake, and a hand vacuum pump. The chamber is designed to hold a 2-liter sample bottle; however, smaller sample containers may be utilized with a spacer inserted into the chamber. A two inch square of 100 µm Nitex® screen is used on the magnetic screen holder at the intake to prevent large pieces of debris from entering the sample. The screen does not prevent the passage of particulate organic matter which is often prevalent in surface water. The vacuum chamber has a second off-center compression fitting with a 4 inch piece of Teflon® tubing inserted in the fitting. A piece of clear Tygon® tubing approximately 18-24 inches long is placed over the small piece of Teflon®. The Teflon® adds stability to the tubing and keeps it from crimping. The Tygon® is attached to the hand pump and the chamber with electrical tape. The Nitex® screen intake is inserted into the water to be sampled and a vacuum is pulled on the chamber by means of the hand vacuum pump, thus drawing a water sample into a sample container placed directly beneath the intake tubing within the chamber.

Teflon® bottles or 300-Series glass bottles with single use Teflon®-lined caps may be used for sample collection. All sample containers used for collection of trace-level mercury water samples must be pre-cleaned in a laboratory as described in EPA Method 1631. Teflon® containers should also be etched on the outside of the bottle with a unique identification number for QA purposes. All bottles for trace-level sampling must be double bagged in re-sealable bags. Water samples collected for total, inorganic, methyl or ethyl mercury analyses are pumped into appropriately cleaned bottles. Preservation should be done in a clean room laboratory that has been specifically prepared for the preparation of trace level samples (positive pressure ventilation, sticky floor mats, etc.). Preservation must occur within 48 hours of sample collection, sooner if possible. Region 4 utilizes laboratory preservation of trace-level mercury samples in order to minimize the potential for contamination, and if split samples are required, they must be split in a trace-level clean room laboratory.

The following quality assurance/quality control (QA/QC) samples are collected in conjunction with low-level mercury samples:

- bottle blanks
- equipment blanks

- air deposition blanks
- trip blanks
- duplicates and
- splits

A bottle blank is prepared in the lab with reagent-grade water to ensure the cleanliness of the bottles prior to use in the field. After decontamination of the Teflon® tubing by pumping and discarding several sample container volumes of reagent-grade water through the tubing, (using the same amount of water used for sample collection in the field) an equipment blank sample is collected into an appropriately pre-cleaned sample container. Equipment blanks are collected at the beginning of each field trip and at the end of each day. The bottle blank and the equipment blank do not go out into the field and are preserved at the end of the day with the regular field samples.

Air deposition blanks are collected to determine if airborne mercury is present at the time of sample collection. The air deposition blanks consist of a pre-cleaned mercury sample container, filled with reagent-grade water by the laboratory that prepared the containers, and is shipped with the containers to the field. The air deposition blank is uncapped using “clean hands”/ “dirty hands” procedures (see below) and set near the sampling location throughout the duration of the mercury sample collection for that particular station. Once the mercury sample is collected, the air deposition blank is recapped and handled and processed with the other mercury samples. One air deposition blank is collected each day by each field crew unless atmospheric conditions or site conditions warrant additional blanks.

Trip blanks are utilized to determine if any contaminants of interest to the study are potentially introduced to the samples during storage and transport to the laboratory. Trip blanks are prepared by the laboratory which supplies the mercury sample containers. The trip blanks consist of cleaned bottles which are filled with reagent-grade water by the laboratory and shipped with the other clean sample containers. A dark plastic bag is placed in each cooler that will hold the trace-level water samples. One trip blank is placed in each trace-level cooler of samples and returned to the laboratory with the ambient trace-level water samples. All trace-level samples should be kept in the dark until they are preserved. The trip blanks are never opened in the field. Trip blanks are preserved in the clean room.

Duplicate samples are discrete samples collected at the same site and time to measure variability of collected samples and to assess sample collection consistency. Sample splits are aliquots of a minimum 500 ml poured from a single ambient sample. They must be split in a trace-level clean room laboratory.

In order to prevent cross contamination in samples analyzed for trace-level mercury in ambient surface waters, clean sampling protocols must be employed throughout the sampling effort. For each sampling event, one sampling team member is designated as “clean hands” and one as “dirty hands” (see below). All operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle are handled by the individual designated as “clean hands.” “Dirty hands” is responsible for preparation of the sampling device (except the sample container) and for all other activities that do not involve direct contact with the sample.

Prior to sample collection with the vacuum chamber assembly, the Teflon® line is cleaned at each station by rinsing with ambient water as follows: A 2-liter poly bottle is placed into the chamber and filled half full with ambient water. The bottle is swirled to rinse it and the water is discarded downstream of sampling area. The same 2-liter poly bottle can be used at each station. Additional cleaning measures are not recommended as long as the chamber assembly is only used to collect ambient surface water samples. Detergent washes and acid rinses are not conducted due to potential mercury contamination from these solutions. If applicable, samples for other analyses can be collected in a poly bottle with the vacuum chamber assembly but should be collected before the trace-level sample as an additional means of flushing the sampling line prior to collection of the trace-level samples. It is not necessary to implement the “clean hands”/ “dirty hands” method for collection of non-mercury samples, but latex or vinyl gloves should be worn when any samples are collected.

Following are procedures for cleaning the vacuum chamber tubing and collection of ancillary water quality samples, if applicable:

1. Carefully approach the sampling station from downstream and downwind if possible.

2. While wearing latex or vinyl gloves, place an uncapped 2-liter poly bottle into the chamber and secure the chamber lid by attaching the spring-loaded clamps.

3. Place a new square of 100 µm Nitex® screen in the magnetic screen holder. Place the intake beneath the surface of the water (mid-depth or six inches, whichever is less) and hold firmly in place. Care should be taken not to disturb sediment particles in very shallow waters (< 4 inches deep).

4. Squeeze the hand pump until liquid starts to fill the bottle in the chamber. When the bottle is approximately half full, release the vacuum on the chamber, remove the bottle, swirl the contents and discard the water downstream. Repeat this rinse. If ancillary water quality samples are to be collected, return the 2-liter poly bottle to the chamber and pump the required volume of water to fill the appropriate ancillary sample containers. Remove the 2-liter bottle from the chamber and cap. Fill the ancillary sample bottles upon completion of the mercury sample collection.

Water samples for trace level mercury analyses should be collected immediately after the ancillary water samples have been collected according to the following procedures:

1. "Clean hands" should put on a pair of latex or vinyl gloves, then a pair of shoulder length polyethylene gloves.

2. "Dirty hands" should put on a pair of latex or vinyl gloves, retrieve the double bagged trace level sample bottle from the cooler, and open the outer bag. "Clean hands" should open the inner bag and remove the pre-cleaned Teflon® or glass bottle.

3. "Dirty hands" should open the lid on the chamber. "Clean hands" should place the sample bottle in the chamber, remove the bottle top and place it inside the chamber with the bottle.

4. "Dirty hands" should close and secure the chamber lid and using the hand pump, fill the container. The sample container should be filled to overflowing. "Dirty hands" should then release the vacuum and open the lid on the chamber.

5. "Clean hands" should place the top on the sample bottle, remove it from the chamber and place it in the inner bag and seal the bag. "Dirty hands" should seal the outer bag and place the sample in the black bag in the dark cooler. Only coolers dedicated to storage and transport of trace-level mercury samples should be used.

COPY

Region 4 **U.S. Environmental Protection Agency** **Science and Ecosystem Support Division** **Athens, Georgia**
OPERATING PROCEDURE

Title: **Sediment Sampling**	
Effective Date: August 21, 2014	**Number:** SESDPROC-200-R3
Authors	
Name: Kevin Simmons Title: Environmental Scientist, Regional Expert Signature: [signature]	Date: 8/18/2014
Approvals	
Name: John Deatrick Title: Acting Chief, Enforcement and Investigations Branch Signature: [signature]	Date: 8/18/14
Name: Laura Ackerman Title: Acting Chief, Ecological Assessment Branch Signature: [signature]	Date: 08/18/14
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature: [signature] for Bobby Lewis	Date: 8/20/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-200-R3, *Sediment Sampling*, replaces SESDPROC-200-R2. **General:** Corrected any typographical, grammatical, and/or editorial errors. Throughout the document mention of quality system or SESD quality system was replaced with Field Branches Quality System or FBQS. **Cover Page:** Changed the Enforcement and Investigations Branch Chief from Archie Lee to Acting Chief, John Deatrick. Changed the Ecological Assessment Branch Chief from Bill Cosgrove to Acting Chief, Laura Ackerman. Changed the FQM from Liza Montalvo to Bobby Lewis. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. Throughout the document: any reference to “Percent Moisture” was changed to “Percent Solids.”	August 21, 2014
SESDPROC-200-R2, *Sediment Sampling*, replaces SESDPROC-200-R1.	September 8, 2010
SESDPROC-200-R1, *Sediment Sampling*, replaces SESDPROC-200-R0.	November 1, 2007
SESDPROC-200-R0, *Sediment Sampling*, Original Issue	February 05, 2007

TABLE OF CONTENTS

TABLES

COPY

Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting sediment samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators when collecting and handling sediment samples in the field. On the occasion that SESD field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a sediment sample, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-004, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-104, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples, SESDPROC-209, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

United States Office of Occupational Health and Safety (US OSHA). 1981. Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples (PM-273), Memo from David Weitzman, Work Group Chairman, US EPA. April 13, 1981.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting sediment samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting sediment samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and stored in a secure place.

.

2 Special Sampling Considerations

2.1 Sediment Samples for Volatile Organic Compounds Analysis

If samples are to be analyzed for volatile organic compounds (VOCs), they should be collected in a manner that minimizes disturbance of the sample. The sample for VOC analysis should be collected directly from the sample device, if possible, before it is emptied into the pan. It may not be possible to do this with certain types of sediment sampling equipment, such as the Ponar dredge. In cases such as these, the VOC aliquots should be collected from the dredge contents immediately after they have been deposited in the pan and prior to any mixing. The sample shall be placed in the appropriate container (En Core® Sampler or other Method 5035 compatible container) with no headspace. ***Samples for VOC analysis are not homogenized***. Preservatives may be required for some samples with certain variations of Method 5035. Consult the method description below in Section 2.2, Sediment Sampling (Method 5035) or the principal analytical chemist to determine if preservatives are necessary.

In some cases, the sediment may be soft and not lend itself to collection by plunging En Core® Samplers or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sample device, i.e., the En Core® Sampler barrel or syringe, prior to sample collection, and to carefully place the sediment in the device, filling it fully with the required volume of sample.

2.2 Sediment Sampling (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of VOCs in sediments at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

2.2.1 Equipment

Sediment for VOC analyses may be retrieved using any of the SESD sediment sampling methods described in Sections 3 through 6 of this procedure. Once the sediment has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2-oz. sediment VOC container, or pre-prepared 40 ml vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

2.2.2 Sampling Methodology - Low Concentrations

When the total VOC concentration in the sediment is expected to be less than 200 µg/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 ml pre-prepared vial) immediately to reduce volatilization losses. The 40 ml vials should contain 10 ml of organic-free water for an un-preserved sample or approximately 10 ml of organic-free water and a preservative. It is recommended that the 40 ml vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A sediment sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 ml pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. sediment jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 ml pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Sediment samples may be prepared for shipping and analysis as follows:

En Core® Sampler - the sample shall be capped, locked, and secured in a plastic bag.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40-ml pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 ml containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

2.2.3 Sampling Methodology - High Concentrations

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Sediments containing high total VOC concentrations may also be collected as described in Section 2.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 ml methanol.

2.2.4 Special Techniques and Considerations for Method 5035

Effervescence

If low concentration samples effervesce from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence (rapid formation of bubbles) then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic-free water. An appropriate amount of organic-free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note that the amount of organic free water placed into the vials will have to be accurately measured.

Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

Holding Times

Sample holding times are specified in the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC sediment sample is 48 hours. Arrangements should be made to ship the sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

Percent Solids

Samplers must ensure that the laboratory has sufficient material to determine percent solids in the VOC sediment sample to correct the analytical results to dry weight. If other analyses requiring percent solids determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent solids determination will be required.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities. A summary of the requirements for shipping samples follows. Refer to the code for a complete review of the requirements.

1. The maximum volume of methanol or sodium bisulfate in a sample container is

limited to thirty (30) ml.

2. The sample container must not be full of methanol.

3. The sample container must be stored upright and have the lid held securely in place. Note that the mechanism used to hold the cap in place must be able to be completely removed so weight is not added to the sample container, as specified in Method 5035.

4. Sample containers must be packed in an absorbent material capable of absorbing spills from leaks or breakage of the sample containers.

5. The maximum sample shuttle weight must not exceed 64 pounds.

6 The maximum volume of methanol or sodium bisulfate per shipping container is 500 ml.

7 The shipper must mark the sample shuttle in accordance with shipping dangerous goods in acceptable quantities.

8. The package must not be opened or altered until no longer in commerce.

The following summary table lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. SESD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

Table 1: Method 5035 Summary

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect 2 – 40 ml vials with ~5 grams of sample and 1 – 2 oz. glass w/septum lid for screening and % solids	Screening conducted by lab	Presently a 48 hour holding time for unpreserved samples
2	Collect 3 EnCore® Samplers and 1 – 2oz. glass w/septum lid for screening and % solids	Lab conducts all preservation/preparation procedures	Presently a 48 hour holding time for preparation of samples
3	Collect 2 – 40 ml vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and 1 – 2 oz. glass w/septum lid for screening and % solids	High level VOC samples may be composited Longer holding time	Hazardous materials used in field
4	Collect 1 – 2 oz. glass w/septum lid for analysis and % solids	Lab conducts all preservation/preparation procedures	May have significant VOC loss

2.3 Special Precautions for Trace Contaminant Sediment Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers with samples suspected of containing high concentrations of contaminants shall be stored separately. All background samples shall be collected and placed in separate ice chests or shipping containers. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.

- Samplers must use new, verified and certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, or SESD Operating Procedure for Field Cleaning and Decontamination at the FEC, SESDPROC-206, for collection of samples for trace metals or organic compound analyses.

2.4 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 5

2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same volume.

3. All sediment samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

    - The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
    - Two quarters should then be mixed to form halves.
    - The two halves should be mixed to form a homogenous matrix.

    This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

4. Place the sample into an appropriate, labeled container(s) using the alternate shoveling method and secure the cap(s) tightly. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

5. Return any unused sample material back to the location from which the sample was collected.

2.5 Quality Control

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. The control sample should be collected at an upstream location in the same stream or conveyance from which the primary samples area collected. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools.

2.6 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-004. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3 General Considerations

3.1 General

The sediment sampling techniques and equipment described in the following Sections 4, 5 and 6 of this procedure document are designed to minimize effects on the chemical and physical integrity of the sample. If the procedures in this section are followed, a representative sample of the sediment should be obtained.

3.2 Equipment Selection Considerations

The physical location of the investigator when collecting a sample may dictate the equipment to be used. Wading is the preferred method for reaching the sampling location, particularly if the stream has a noticeable current (is not impounded). However, wading may disrupt bottom sediments causing biased results; therefore, the samples should be collected facing upstream. If the stream is too deep to wade, the sediment sample may be collected from a platform such as a boat or a bridge.

To collect a sediment sample from a water body or other surface water conveyance, a variety of methods can be used:

- Scoops and spoons
- Dredges (Ponar, Young)
- Coring Devices (tubes, Shelby tubes, Ogeechee Sand Pounders®, and augers)
- Vibracore® (Electronic Vibratory Core Tube Driver)

Regardless of the method used, precautions should be taken to insure that the sample collected is representative of the water body or conveyance. These methods are discussed in the following paragraphs.

4 Stainless Steel Scoops and Spoons

4.1 Wading

If the conveyance is dry or is a wadeable surface water body, the easiest way to collect a sediment sample is by using a stainless steel scoop or spoon. If the conveyance is dry, the sediment is accessed directly and is collected using either the stainless steel scoop or spoon. If the conveyance is a wadeable stream or other water body, the method is accomplished by wading into the surface water body and while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed/drained from the scoop or spoon. However, this may result in the loss of some fine-grained particle size material associated with the substrate being sampled. Care should be taken to minimize the loss of this fine-grained material. Aliquots of the sample thus collected are then placed in a glass pan and homogenized according to the quartering method described in Section 2.4.

4.2 Bank/Platform Sampling

In surface water bodies that are too deep to wade, but less than eight feet deep, a stainless steel scoop or spoon attached to a piece of conduit can be used either from the banks, if the surface water body is narrow, or from a boat. Again, care should be taken to minimize the loss of the fine particle sizes. The sediment is placed into a glass pan and mixed according to the quartering method described in Section 2.4.

5 Dredges

5.1 General Considerations

Dredges provide a means of collecting sediment from surface water bodies that are too deep to access with a scoop and conduit. They are most useful when collecting softer, finer-grained substrates comprised of silts and clays but can also be used to collect sediments comprised of sands and gravel, although sample recovery in these materials may be less than complete.

Free, vertical clearance is required to use any of the dredges. Dredges, attached to ropes, are lowered vertically from the sampling platform (boat, bridge, etc.) to the substrate being sampled beneath the deployment point.

5.2 Ponar Dredge

The Ponar dredge has side plates and a screen on the top of the sample compartment and samples a 0.05 m^2 surface area. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing turbulence around the dredge. The Ponar dredge is easily operated by one person and is one of the most effective samplers for general use on most types of substrates.

The Ponar dredge is deployed in its open configuration. It is lowered gently from the sampling platform to the substrate below the platform. After the dredge lands on the substrate, the rope is tugged upward, closing the dredge and capturing the sample. The dredge is then hauled to the surface, where it is opened to acquire the sample.

5.3 Mini-Ponar Dredge

The Mini-Ponar dredge is a smaller, much lighter version of the Ponar dredge and samples a 0.023 m^2 surface area. It is used to collect smaller sample volumes when working in industrial tanks, lagoons, ponds, and shallow water bodies. It is a good device to use when collecting sludge and sediment containing hazardous constituents because the size of the dredge makes it more amenable to field cleaning. Its use and operation are the same as described in Section 5.2, Ponar Dredge, above.

5.4 Young Grab

The Young grab sampler is a stainless steel clamshell-type grab sampler similar to a Ponar dredge**.** It is a clamshell-type sampler with a scissors closing action typically used for marine and estuarine sediment sampling. The Young grab sampler is one of the most consistently performing grab sampling devices for sediment sampling in both offshore marine sediments, as well as estuarine sediments. The Young sampler comes in two sizes, 0.1 m^2 and 0.04 m^2. The 0.1 m^2 is typically used when a larger volume of sediment is needed for chemistry and particle size. The 0.04 m^2 is typically used for marine benthic macroinvertebrate sampling and has become the standard grab sampler used by NOAA, USGS and USEPA.

The Young sampler is lowered to the substrate to be sampled with a cable or rope that has a catch that is released when tension is taken off the cable or rope. When the sample device is pulled up, the scissors action of the arms close the clamshell and grabs the sample.

The major difference in the Young grab sampler and other grab samplers is a square or rectangular frame attached to the device which prevents it from penetrating too deeply into soft sediments. In harder substrates, weights may be added to the frame in order to hold the grab in place to prevent collection of a “shallow” sample. A tripod frame can also be attached to the frame surrounding the Young grab sampler. The wire or rope that the grab is raised and lowered with passes through an opening in the top of the tripod and prevents the device from landing sideways or at an angle when there are strong currents or there is lateral movement of the sampling vessel during grab sampling operations.

The draw back to the Young grab sampler is that due to the weight and size of the frame, a ship with an “A” frame or a boat with a davit is required in order to raise and lower the sampler.

6 Sediment Coring Devices

6.1 General

Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical picture of sediment deposition is desired since they preserve the sequential layering of the deposit. They are also particularly useful when it is desirable to minimize the loss of material at the sediment-water interface. Many types of coring devices have been developed, depending on the depth of water from which the sample is to be obtained, the nature of the bottom material and the length of core to be collected. They vary from hand-driven push tubes to electronic vibrational core tube drivers. These methods are described below in the following sections.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed; the sample is withdrawn intact, permitting the removal of only those layers of interest; core liners manufactured of glass or Teflon® can be purchased, thus reducing possible sample interferences; and the samples are easily delivered to the lab for analysis in the tube in which they were collected.

The disadvantage of coring devices is that a relatively small surface area and sample size is obtained, often necessitating repetitive sampling in order to obtain the required amount of material for analysis. Because it is believed that this disadvantage is offset by the advantages, coring devices are recommended in sampling sediments for trace organic compounds or metals analyses.

6.2 Manually Deployed Push Tubes

In shallow, wadeable waters, or for diver-collected samples, the direct use of a core liner or tube manufactured of Teflon®, plastic, or glass is recommended for the collection of sediment samples. Plastic tubes are principally used for collection of samples for physical parameters such as particle size analysis and, in some instances, are acceptable when inorganic constituents are the only parameter of concern. Their use can also be extended to deep waters when SCUBA diving equipment is utilized. Teflon® or plastic is preferred to glass since they are unbreakable, reducing the possibility of sample loss or personal injury. Stainless steel push tubes are also acceptable and provide a better cutting edge and higher strength than Teflon®. The use of glass or Teflon® tubes eliminates any possible interference due to metals contamination from core barrels, cutting heads, and retainers. The tube should be approximately 12-inches in length if only recently deposited sediments (8 inches or less) are to be sampled. Longer tubes should be used when the depth of the substrate exceeds 8 inches. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. Because coarse or unconsolidated sediments, such as sands and gravel, tend to fall out of the tube, a smaller diameter push tube is normally required to obtain a sample. In extreme cases, where sample retention in the tube is problematic, core-catchers or end caps made of Teflon® should be employed. A tube about two-inches in diameter is usually the best size. The wall thickness of the tube should be about 1/3-inch for Teflon® plastic, or glass. The inside wall may be filed down at the bottom of the tube to provide a cutting edge to facilitate entry of the liner into the substrate.

Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water (always work facing upstream and working from downstream up). The core tube is pushed into the substrate until four inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction. The top of the tube is then capped to provide suction and reduce the chance of losing the sample. A Teflon® plug or end cap, or a sheet of Teflon® held in place by a rubber stopper or cork may be used. After capping, the tube is slowly extracted with the suction and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the tube and core above the water surface, it too should be capped. An alternative to the coring device is the Shelby tube. The Shelby tube has a gravity check valve at the top of the tube where an auger handle attaches. This check valve allows air and water to escape as the tube is advanced. Once the tube is to the desired depth, the check valve will close automatically forming suction on the tube; thus, holding the sample inside.

When extensive core sampling is required, such as a cross-sectional examination of a streambed with the objective of profiling both the physical and chemical contents of the sediment, complete cores are desirable. A strong coring tube such as one made from aluminum, steel or stainless steel is needed to penetrate the sediment and underlying clay or sands. To facilitate complete core collection and retention, it is recommended that the corer (like a Shelby tube) have a check valve built into the driving head which allows water and air to escape from the cutting core, thus creating a partial vacuum, helping to hold the sediment core in the tube. The corer is attached to a standard auger extension and handle, allowing it to be corkscrewed into the sediment from a boat or while wading. The coring tube is easily detached and the intact sediment core is removed with an extraction device.

Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by simply turning the core tube to its side, and gently pouring the liquid out until fine sediment particles appear in the waste liquid. The loss of some of the fine sediments usually occurs with this technique.

6.3 Ogeechee Sand Pounders® and Gravity Cores

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or a boat using different coring devices such as Ogeechee Sand Pounders®, gravity cores and vibrating coring devices. All three devices utilize a core barrel with a core liner tube system. The core liner can be removed from the core barrel and replaced with a clean core liner, as needed, after each sample. Liners are made of stainless steel, Teflon® or plastic. The type of core liner and its composition should be based on the contaminants to be evaluated.

Ogeechee Sand Pounders® and gravity cores are hand-held devices that use a standard size 2-inch diameter core barrel. The core tube and liner are interchangeable between the two units. The Ogeechee® uses a slide-hammer mechanism attached to the core head that allows the sampler to pound the core tube into the sediment. The Ogeechee® is good for sandy, more consolidated sediments. The gravity core uses a guiding fin mechanism with a built-in gravity-type check valve. The gravity core is placed in the water and released at the surface to free fall to the bottom. The fin mechanism keeps the core tube upright and free from spinning in the water column as it descends. The core tube stabs the bottom, forcing the sediment into the tube. Both coring devices are equipped with removable nose pieces on the core barrel and disposable core catchers for the liner tubes. The core catchers are designed to cap the liner tube to avoid loss of the core when retrieved from the bottom. The gravity core can be modified to attach a slide hammer mechanism, similar to the Ogeechee®, to further pound the core into the sediment further if deemed necessary.

Sediment cores collected from most hand operated coring devices can suffer from either spreading or compaction when driven into the sediment, depending on the softness of the sediment. Spreading occurs when the sediment is pushed or moved to the side during the advancement of the core tube. Compaction occurs when the sediment is being pushed downward as the core tube is advanced. Both phenomena can affect the physical integrity of the core sample. For instance, the core tube may be advanced through the sediment to a depth of 36 inches, but upon examination of the recovered core, there is only 24 inches of sediment in the core tube.

6.4 Vibratory Core Tube Drivers (Vibracore®)

Vibratory Core Tube Drivers (Vibracore®) facilitate sampling of soft or loosely consolidated, saturated sediments, with minimal compaction or spreading, using lined or unlined core tubes. It is designed for use with core tubes having nominal diameters ranging from 2-inches to 4-inches OD. The Vibracore® uses an electric motor to create vibration ranges from approximately 6,000 RPM to 8,000 RPM (100 Hz to 133 Hz) depending on the resistance afforded by the sediment; the greater the resistance, the higher the frequency. The actual vibrational displacement of the Vibracore® is on the order of a few tens of thousandths of an inch, so essentially no mixing of the sediment within the tube occurs. The vibrational energy tends to re-orient the sediment particles at the lower end of the core tube, causing them to move out of the way of the advancing wall of the core tube and into a more efficient (i.e. denser) packing. This action advances the core tube with minimal compaction of the sediment.

7 Diving

7.1 General

Sediment samples can also be obtained from large streams and open water bodies such as ponds, lakes, estuarine bodies and open ocean environments by divers. Using a variety of the above mentioned methods, divers can directly access the substrate and collect sediment samples. Depending upon the sampling methods used and the required analyses, the samples may be collected directly into the containers from the substrate or they may be returned, in bulk, to the bank or other sampling platform for processing and sample container allocation.

COPY

Region 4 **U.S. Environmental Protection Agency** **Science and Ecosystem Support Division** **Athens, Georgia**
OPERATING PROCEDURE
Title: **Field Equipment Cleaning and Decontamination**
Effective Date: December 18, 2015 — **Number:** SESDPROC-205-R3
Authors
Name: Brian Striggow Title: Environmental Engineer Signature: [signature] Date: 12-18-15
Approvals
Name: John Deatrick Title: Chief, Field Services Branch Signature: [signature] Date: 12/18/15
Name: Hunter Johnson Title: Field Quality Manager, Science and Ecosystem Support Division Signature: [signature] Date: 12/18/15

COPY

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-205-R3, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R2. **Cover Page:** The author was changed to Brian Striggow. SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **General:** Corrected any typographical, grammatical and/or editorial errors. **Section 1.4:** Differentiate between Liquinox® and Luminox® detergents. **Section 3.4:** Restore solvent rinse as alternative cleaning method. **Section 3.7:** Added section on cleaning of 12 Volt electric submersible pumps. **Section 3.8:** Added section on cleaning of bladder pumps. **Section 3.9:** Added language on cleaning and transport of SP15/16 screens **Section 3.10:** Added section on cleaning of rental pumps	December 18, 2015
SESDPROC-205-R2, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R1.	December 20, 2011
SESDPROC-205-R1, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R0.	November 1, 2007
SESDPROC-205-R0, *Field Equipment Cleaning and Decontamination*, Original Issue	February 05, 2007

COPY

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

- Decontamination: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.

- Deionized water: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.

- Detergent shall be a standard brand of phosphate-free laboratory detergent such as Liquinox® or Luminox®. Liquinox® is a traditional anionic laboratory detergent and is used for general cleaning and where there is concern for the stability of the cleaned items in harsher cleaners. Luminox® is a specialized detergent with the capability of removing oils and organic contamination. It is used in lieu of a solvent rinse step in cleaning of equipment for trace contaminant sampling. Where not specified in these procedures, either detergent is acceptable.

- Drilling Equipment: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.

- Field Cleaning: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Tap water: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

1.5 References

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.6 General Precautions

1.6.1 Safety

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.

- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.6.2 Procedural Precaution

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

2 Introduction to Field Equipment Cleaning and Decontamination

2.1 General

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

2.2 Handling Practices and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- Detergent must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.

- Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- Deionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

- Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

2.3 Disposal of Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

2.4 Sample Collection Equipment Contaminated with Concentrated Materials

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

1. Leave with facility for proper disposal;

2. If possible, containerize, seal, and secure the equipment and leave on-site for later disposal;

3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.5 Sample Collection Equipment Contaminated with Environmental Media

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

1. Wipe the equipment clean;

2. Water-rinse the equipment;

3. Wash the equipment in detergent and water followed by a tap water rinse.

4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.6 Handling of Decontaminated Equipment

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

3 Field Equipment Decontamination Procedures

3.1 General

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

3.2 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.
- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

3.4.1 Standard SESD Method

1. An optional Liquinox® detergent wash step may be useful to remove gross dirt and soil.

2. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films.

3. Rinse thoroughly with tap water.
4. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to air-dry.
5. Wrap the dry equipment with aluminum foil or bag in clean plastic. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

3.4.2 Alternative Solvent Rinse Method

The historical solvent rinse method of cleaning equipment for trace contaminant sampling remains an acceptable method.

1. Clean with tap water and Liquinox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Liquinox® detergent and high pressure hot water) as an alternative to

brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. . Rinse thoroughly with tap water.

3. Rinse thoroughly with deionized water.

4. Rinse with an appropriate solvent (generally isopropanol).

5. Rinse with organic-free water and place on a clean foil-wrapped surface to air-dry.

4. Wrap the dry equipment with aluminum foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused.

3.5 Well Sounders or Tapes

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

1. Wash with Liquinox® detergent and tap water.
2. Rinse with tap water.
3. Rinse with deionized water.

3.6 Redi-Flo2® Pump

CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with Liquinox® detergent and water solution.

2. Rinse with tap water.

3. Final rinse with deionized water.

4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

3.6.2 Purge And Sample

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC,* should be implemented in the field where a high risk of cross-contamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice, provided that sampling proceeds from least to most contaminated areas.

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.

2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution. Luminox® is commonly used. An additional pre-wash container of Liquinox® may be used; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution. An array of 2' long 2" PVC pipes with bottom caps is a common arrangement. The solutions should be changed at least daily.

3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.

4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.

5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.

7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.

8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.

9. Place the pump and reel in a clean plastic bag.

3.6.3 Redi-Flo2® Ball Check Valve

1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.

2. Using a brush, scrub all components with detergent and tap water.

3. Rinse with deionized water.

4. Rethread the ball check valve to the Redi-Flo2® pump head.

3.7 Mega-Monsoon® and GeoSub® Electric Submersible Pump

As these pumps have lower velocities in the turbine section and are easier to disassemble in the field than Grundfos pumps, the outer pump housing should be removed to expose the impeller for cleaning prior to use and between each use when used as a sampling pump for trace contaminant sampling.

1. Remove check valves and adapter fittings and clean separately.
2. Remove the outer motor housing by holding the top of the pump head and unscrewing the outer housing from its O-ring sealed seat.
3. Clean all pump components per the provisions of section 3.4. Use a small bottle brush for the pump head passages
4. Wet the O-ring(s) on the pump head with organic-free water. Reassemble the outer pump housing to the pump head.
5. Clean cable and reel per Section 3.4.
6. Conduct final rinse of pump with organic-free water over pump and through pump turbine.

3.8 Bladder Pumps

Bladder pumps are presumed to be intended for use as purge-and-sample pumps. The Geotech® bladder pump and Geoprobe Systems® mechanical bladder pump can be cleaned similarly.

1. Discard any tubing returned with the pump.
2. Completely disassemble the pump, being careful to note the initial position of and retain any springs and loose ball checks.
3. Discard pump bladder.
4. Clean all parts as per the standard cleaning procedure in Section 3.4.
5. Install a new Teflon® bladder and reassemble pump.

3.9 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

3.9.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam, with a detergent compartment, should be obtained.

3.9.2 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed prior to arrival on site, or well away from the decontamination pad and areas to be sampled.

- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.

- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.

- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

3.9.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

3.9.4 Field Decontamination Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does not apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill

rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.

3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3.9.5 Field Decontamination Procedure for Direct Push Technology (DPT) Equipment

1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:

2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.

3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4, Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.

4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of Section *3.7.4, Field Decontamination Procedure for Drilling Equipment* of this procedure.

5. Stainless steel SP15/16 well screens require special care as the narrow slots are difficult to clean under even controlled circumstances and galvanic corrosion can release chrome from the screen surface. As soon as possible after retrieval, the screen slots should be sprayed from the outside to break loose as much material as possible before it can dry in place. To prevent galvanic corrosion, the screens must be segregated from the sampler sheaths, drive rods, and other carbon steel during return transport from the field.

3.10 Rental Pumps

Completing a groundwater sampling project may require the use of rental pumps. Rental pumps are acceptable where they are of suitable stainless steel and Teflon® construction. These pumps should be cleaned prior to use using the procedures specified herein and a rinse-blank collected prior to use.

COPY

Region 4 **U.S. Environmental Protection Agency** **Science and Ecosystem Support Division** **Athens, Georgia**
OPERATING PROCEDURE
Title: **Management of Investigation Derived Waste**
Effective Date: July 3, 2014 — **Number:** SESDPROC-202-R3
Authors
Name: Art Masters Title: Environmental Scientist, Regional Expert Signature: [signature] Date: 7/2/14
Approvals
Name: John Deatrick Title: Acting Chief, Enforcement and Investigations Branch Signature: [signature] Date: 7/2/14
Name: Mike Bowden Title: Acting Chief, Ecological Assessment Branch Signature: [signature] Date: 7/2/14
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature: [signature] Date: 7/2/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-202-R3, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R2. **General:** Corrected typographical, grammatical and/or editorial errors. **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Archie Lee to Acting Chief John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Mike Bowden. The FQM was changed from Liza Montalvo to Bobby Lewis. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history.	July 3, 2014
SESDPROC-202-R2, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R1.	October 15, 2010
SESDPROC-202-R1, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R0.	November 1, 2007
SESDPROC-202-R0, Management of Investigation Derived Waste, Original Issue	February 05, 2007

TABLE OF CONTENTS

TABLES

COPY

Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 Scope/Application

The procedures and management options for the different categories of IDW described in this document are to be used by SESD field personnel to manage IDW generated during site investigations. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when managing IDW. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when managing IDW:

- Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
- During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

2 Types of Investigation Derived Waste

Materials which may become IDW include, but are not limited to:

- Personal protective equipment (PPE) - This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.

- Disposable equipment and items - This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.

- Soil cuttings from drilling or hand augering.

- Drilling mud or water used for mud or water rotary drilling.

- Groundwater obtained through well development or well purging.

- Cleaning fluids such as spent solvents and wash water.

- Packing and shipping materials.

Table 1, found at the end of this procedure, lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis. This determination and subsequent management is the responsibility of the program site manager.

3 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW should be addressed in the study plan or QAPP for the investigation. To reduce the volume of any IDW transported back to the Field Equipment Center (FEC), it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard into the facility's dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site.

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved study plan or QAPP. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facility's treatment system. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions permit. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected and returned to the FEC for disposition.
- The collection, handling and proposed disposal method must be specified in the approved study plan or QAPP.

4 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan or QAPP for the study or investigation. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed in the source area from which they originated if doing so does not endanger human health or the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve Division resources. Most routine studies should not produce any hazardous IDW, with the possible exception of spent solvents and, possibly, purged groundwater. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination (see SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205). If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be left on-site with the permission of site operator and proper disposal arranged.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

Table 1: Disposal of IDW

TYPE	HAZARDOUS	NON - HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per SESDPROC-205, and return to FEC.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator and arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. If unfeasible, return to FEC for disposal in dumpster.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

** **These materials may be placed on the ground if doing so does not endanger human health or the environment or violate federal or state regulations.**

COPY

Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Athens, Georgia	
OPERATING PROCEDURE	
Title: **Packing, Marking, Labeling and Shipping of Environmental and Waste Samples**	
Effective Date: February 4, 2015	**Number:** SESDPROC-209-R3
Authors	
Name: Art Masters Title: Environmental Scientist, Regional Expert Signature: [signature] Date: 2/4/2015	
Approvals	
Name: John Deatrick Title: Chief, Field Services Branch Signature: [signature] Date: 2/2/15	
Name: Hunter Johnson Title: Field Quality Manager, Science and Ecosystem Support Division Signature: [signature] Date: 2/4/2015	

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-209-R3, *Packing, Marking, Labeling and Shipping of Environmental and Waste Samples*, replaces SESDPROC-209-R2. **Cover Page:** Changes made to reflect reorganization of SESD from two field branches to one: John Deatrick listed as the Chief, Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history.	February 4, 2015
SESDPROC-209-R2, *Packing, Marking, Labeling and Shipping of Environmental and Waste Samples*, replaces SESDPROC-209-R1.	April 20, 2011
SESDPROC-209-R1, *Packing, Marking, Labeling and Shipping of Environmental and Waste Samples*, replaces SESDPROC-209-R0.	November 1, 2007
SESDPROC-209-R0, Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, Original Issue	February 05, 2007

COPY

TABLE OF CONTENTS

1 General Information

1.1 Purpose

Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by Department of Transportation under 49 CFR, Subchapter C, Hazardous Materials Regulations, and the International Air Transport Authority (IATA), which is equivalent to United Nations International Civil Aviation Organization (UN/ICAO). Transportation of hazardous materials (dangerous goods) by EPA personnel is covered by EPA Order 1000. This document describes general and specific procedures, methods and considerations to be used and observed by SESD field investigators when packing, marking, labeling and shipping environmental and waste samples to ensure that all shipments are in compliance with the above regulations and guidance.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when packing, marking, labeling, and shipping environmental samples and dangerous goods by air transport. Samples collected during field investigations or in response to a hazardous materials incident must be classified prior to shipment, as either environmental or hazardous materials (dangerous goods) samples.

In general, environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with high levels of hazardous materials. Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods.

Government employees transporting samples or hazardous materials (i.e., preservatives or waste samples) in government vehicles are not subject to the requirements of this section in accordance with 49 CFR 171.1(d)(5). EPA contractors, however, are not covered by this exemption and may not transport these materials without full compliance with 49 CFR.

Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version.

Title 40 Code of Federal Regulations (CFR), Pt. 136.3, Identification of Test Procedures, July 1, 2001. See Table II, Footnote 3.

Title 49 CFR, Pt. 171.1(d)(5), Applicability of Hazardous Materials Regulations (HMR) to Persons and Functions.

United States Department of Transportation (US DOT). 2003. Letter from Edward T. Mazzullo, Director, Office of Hazardous Materials Standards, to Henry L. Longest II, Acting Assistant Administrator, USEPA, Ref No. 02-0093, February 13, 2003.

US Environmental Protection Agency (US EPA) Order 1000.18, February 16, 1979.

US EPA. 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA.

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version.

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when packing, marking, labeling, and shipping environmental or waste samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional.

2 Shipment of Dangerous Goods

The project leader is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Shipment of nitric acid is strictly regulated. Consult the IATA Dangerous Goods Regulations for guidance. ***Dangerous goods must not be offered for air transport by any personnel except SESD's dangerous goods shipment designee or other personnel trained and certified by IATA in dangerous goods shipment.***

3 Shipment of Environmental Samples

Guidance for the shipment of environmental laboratory samples by personnel is provided in a memorandum dated March 6, 1981, subject "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples". By this memorandum, the shipment of the following unpreserved samples is not regulated:

- Drinking water
- Treated effluent
- Biological specimens
- Sediment
- Water treatment plant sludge
- POTW sludge

In addition, the shipment of the following preserved samples is not regulated, provided the amount of preservative used does not exceed the amounts found in 40 CFR 136.3 or the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version. This provision is also discussed in correspondence between DOT and EPA (Department of Transportation, Letter from Edward T. Mazzullo, Director, Office of Hazardous Materials Standards, to Henry L. Longest II, Acting Assistant Administrator, USEPA, Ref No.: 02-0093, February 13, 2003). It is the shippers' (individual signing the air waybill) responsibility to ensure that proper amounts of preservative are used:

- Drinking water
- Ambient water
- Treated effluent
- Biological specimens
- Sediment
- Wastewater treatment plant sludge
- Water treatment plant sludge

Samples determined by the project leader to be in these categories are to be shipped using the following protocol, developed jointly between USEPA, OSHA, and DOT. This procedure is documented in the "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Untreated wastewater and sludge from Publicly Owned Treatment Works (POTWs) are considered to be "diagnostic specimens" (not environmental laboratory samples). However, because they are not considered to be etiologic agents (infectious) they are not restricted and may be shipped using the procedures outlined below.

COPY

Environmental samples should be packed prior to shipment by air using the following procedures:

1. Allow sufficient headspace (ullage) in all bottles (except VOA containers with a septum seal) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

2. Ensure that the lids on all bottles are tight (will not leak).

3. Place bottles in separate and appropriately sized polyethylene bags and seal the bags. If available, the use of Whirl-Pak bags is preferable, if unavailable seal regular bags with tape (plastic electrical tape).

4. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape inside and outside. Line the cooler with a large heavy duty plastic bag.

5. Place cushioning/absorbent material in the bottom of the cooler and then place the containers in the cooler with sufficient space to allow for the addition of cushioning between the containers.

6. Put "blue ice" (or ice that has been "double bagged" in heavy duty polyethylene bags and properly sealed) on top of and/or between the containers. Fill all remaining space between the containers with absorbent material.

7. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).

8. Place the Chain-of-Custody Record or the CLP Traffic Report Form (if applicable) into a plastic bag, and tape the bag to the inner side of the cooler lid.

9. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

COPY

Region 4 **U.S. Environmental Protection Agency** **Science and Ecosystem Support Division** **Athens, Georgia**
OPERATING PROCEDURE

Title: **Global Positioning System**	
Effective Date: June 23, 2015	**Number:** SESDPROC-110-R4
Authors	
Name: Jonathan Vail Title: Environmental Scientist, Regional Expert Signature:	Date: 6/18/2015
Name: Mel Parsons Title: Life Scientist Signature:	Date: 6/18/15
Name: Brian Striggow Title: Environmental Engineer Signature:	Date: 6/18/15
Approvals	
Name: John Deatrick Title: Chief, Field Services Branch Signature:	Date: 6/18/15
Name: Hunter Johnson Title: Field Quality Manager, Science and Ecosystem Support Division Signature:	Date: 6/18/15

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-110-R4, *Global Positioning System*, replaces SESDPROC-110-R3 **Cover Page:** SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2.1.1**: Changes were added to elaborate on the description and purpose of GPS systems. **Section 2.1.3**: Changes made to reflect the abilities of different differential GPS systems. Sentence added to reflect the preferences to certain differential GPS systems. **Section 2.2.1**: Added to explain that the GPS measurement estimate will be based on a certain number of standard deviations. **Section 2.2.2**: Changes were made to reflect a name change. **Section 2.4.1**: Changes were made to reflect the current procedures. **Section 2.4.2**: Changes were added to reflect the changes in current procedure practices. Conversion process removed and revised in a later section. **Section 4.X**: Conversion procedure updated and revised to reflect the current practices. Paragraph added to reflect the standard format for navigational purposes. **Section 2.5**: Removed the DOP where it includes accuracy requirements for what the output should include to reflect the changes in the operating procedures	June 23, 2015

SESDPROC-110-R3, *Global Positioning System*, replaces SESDPROC-110-R2	April 20, 2011
SESDPROC-110-R2, *Global Positioning System*, replaces SESDPROC-110-R01	November 1, 2007
SESDPROC-110-R1, *Global Positioning System*, replaces SESDPROC-110-R0	October 1, 2007
SESDPROC-110-R0, Global Positioning System, Original Issue	March 22, 2007

TABLE OF CONTENTS

Contents

1 General Information

1.1 Purpose

This document describes the Global Positioning System (GPS) and procedures, methods and considerations to be used and observed when using GPS to record location data in the field. Guidance is provided on accuracy requirements for various uses of location data and potential means to obtain the requisite accuracy. This document contains direction developed solely to provide internal guidance to SESD employees.

1.2 Scope/Application

The procedures contained in this document are to be used by SESD field investigators when using the Global Positioning System to obtain the geographical coordinates of sampling locations and/or measurements during field investigations. In SESD investigations, GPS is the preferred means of collecting horizontal location information. In most cases the accuracy of GPS is unsuitable for collection of elevation data.

On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain the required coordinate information and alternate procedures are employed, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. GPS users must be currently qualified as proficient in the operation of the specific GPS equipment to be used. The manufacturer's operation manuals should be used for detailed information on the use of specific GPS equipment. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Rand Corporation, The Global Positioning System, Assessing National Policies, Appendix B, GPS History, Chronology, and Budgets, 1995.

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version.

Trimble® Navigation Limited, Mapping Systems General Reference, Revision B, 1996.

USEPA, Global Position Systems – Technical Implementation Guidance, Office of Environmental Information (EPA/250/R-03/001), 2003.

USEPA, GIS Technical Memorandum 3. Global Positioning Systems – Technology and It's Application in Environmental Programs, Research and Development (PM-225). EPA/600/R-92/036, 1992.

USEPA, Locational Data Policy, Office of Information Resources Management, IRM Policy Manual 2100 Chapter 13, 1991.

2 Methodology

2.1 General

2.1.1 GPS Description

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations. System testing using a limited number of satellites began in 1978 with the system being declared fully operational in 1995. The system was declared available for civilian uses in the 1980s and has seen burgeoning civilian application for navigation and mapping. GPS is the U.S. implementation of a Global Navigation Satellite System (GNSS). Increasingly, GPS receivers have the capability to utilize signals from other GNSS such as the Russian GLONASS or European Galileo systems. SESD has no limitations on the use of signals from other GNSS.

The GPS system consists of three basic elements: the space segment, control segment, and user segment. The space segment consists of the constellation of up to 24 active NAVSTAR satellites in six orbital tracks. The satellites are not in geo-synchronous orbit and are in constant motion relative to a ground user. The control segment consists of several ground stations that serve as uplinks to the satellites and that make adjustments to satellite orbits and clocks when necessary. The user segment consists of the GPS receiver which will typically consist of an antenna, multi-channel receiver, and processing unit.

For the purposes of this document, the user segment GPS receivers may be loosely grouped into Recreational and Navigational receivers (henceforth referred to as General-Use receivers), Mapping Grade receivers, and Survey Grade receivers.

- Most General-Use grade receivers are available on the retail market to consumers for a variety of applications including boating, hiking, and automotive navigation. They display an instantaneous reading of position and are generally not optimized for data collection. Waypoints containing instantaneous position fixes can often be stored and downloaded. The accuracy of these receivers is adequate for many environmental applications.

- Mapping Grade receivers are used for applications such as resource management and Geographical Information System (GIS) feature collection. The receivers are capable of averaging multiple position fixes for greater accuracy and then data-logging the results with sufficient information to post-correct the positions as described below. The accuracy that can be achieved may be better than one meter.

- Survey Grade receivers can provide accuracy at the centimeter level by using long occupation times and special techniques for receiver use and data processing. Survey Grade receivers are not currently used by SESD in field investigations.

GPS receivers derive positions by simultaneously measuring the distance (range) to several satellites in precisely known orbits, and using trilateration of the ranges to calculate a unique position for the receiver. The range to each satellite is determined by precisely measuring the transit time of radio signals broadcast from the satellites.

2.1.2 GPS Accuracy Factors

The accuracy of the basic GPS system is approximately 15m. GPS accuracy can be affected by a number of factors including the Selective Availability feature, atmospheric delays, satellite clock and orbit errors, multipath signals, signal strength, and satellite geometry relative to the user.

In the early GPS implementation, the DOD used a feature known as Selective Availability (SA) to degrade the quality and subsequent accuracy of the GPS signals to non-DOD users. With Selective Availability enabled, accuracy of position fixes could be as poor as 100m without the use of differential correction techniques described below. Currently there is no SA limitation in accuracy in place with a stated Executive Branch intention to not return to the use of the SA signal degradation.

As satellites move in their orbits and some signals are blocked by obstructions, the geometry of the available satellite signals relative to the user will constantly change. When the satellites with available signals are clustered closely together in the sky, small errors in range will result in large errors in reported position. Conversely, when the satellites are distributed more broadly across the sky, the resultant position errors will be at their minimum. The general measure of this phenomenon is Dilution of Precision (DOP), which may be represented as Position Dilution of Precision (PDOP), or more specifically for geographical coordinate collection, Horizontal Dilution of Precision (HDOP). Mapping and Survey Grade receivers generally can calculate and display DOP and allow the user to limit logging to times when the higher potential accuracy conditions of low DOP prevail. General-Use receivers may display DOP and use DOP with other factors to estimate a general accuracy figure. DOP may range from approximately 2 to 50, with high quality work usually requiring a HDOP of less than 4-6.

Signal strength and multipath signals relate to the strength and quality of the signal reaching the receiver antenna. Signal attenuation by the atmosphere, buildings, and tree cover limit the accuracy of the ranges obtained. The measure of signal strength is Signal to Noise Ratio (SNR), generally measured in decibels (db). Most receivers of any grade will display the SNR of the satellite signals in a bar graph or table. Mapping Grade

Receivers generally allow the user to specify a minimum signal strength for the use of a satellite signal (commonly 2-15db). Poor signal strength can be resolved by waiting for satellite locations to change or moving the receiver location. Multipath signals result from portions of the satellite signal bouncing off terrain, structures, or atmospheric disturbances, resulting in a degraded total signal. Higher quality Mapping Grade receivers may be capable of rejecting the stray multipath signals, such as Trimble® receivers using Everest™ technology.

2.1.3 Differential GPS

Selective Availability, clock errors, and orbital errors affect all GPS users, and atmospheric delays affect all users over a relatively wide region. A second GPS receiver in the same general area as the user will experience the same errors from these sources as the user's receiver. Consequently, correction factors from a remote station at a known location can be applied to the user's receiver in a process known as Differential GPS (DGPS). DGPS can be applied in real-time using additional radio signals, or after the collection event by a method called post-correction.

Real-time DGPS uses established networks of base stations at precisely surveyed locations. The US Coast Guard operates a system of 80 base stations which became fully operational in 1999. The range corrections are broadcast on marine radiobeacon frequencies, with redundant coverage of most of the US coastline and the Mississippi River. There is near complete single beacon coverage of most of the internal US, but there are known gaps in coverage in both EPA Region 4 and the US as a whole. The system is sometimes referred to using the more general term DGPS or in nomenclature referring to the beacon-based nature of the system. Beacon-based DGPS is implemented primarily in Navigational and Mapping Grade receivers. Use of beacon based DGPS at SESD has become increasingly rare in favor of use of the Wide Area Augmentation System
Real-time DGPS can also be implemented with a Space Based Augmentation System (SBAS). The most common SBAS used in the United States is the Wide Area Augmentation System (WAAS), developed by the Federal Aviation Administration to meet the additional demands on GPS for aircraft navigation. The WAAS network of base stations collects information on satellite clock errors, orbital errors, and atmospheric conditions. The error information is transferred to satellites in geo-synchronous orbits and subsequently broadcast to suitably equipped GPS receivers on frequencies compatible with the GPS range signals. While the beacon-based DGPS passes specific satellite range corrections to the receivers, WAAS communicates a model for the errors which is usable over large areas. Current Mapping Grade receivers will likely use WAAS with or without the option of beacon-based DGPS. Modern General-Use receivers are generally equipped with WAAS differential correction capability.

Post-Corrected DGPS is accomplished by downloading the receiver survey files to a desktop or laptop computer and then retrieving correction files for the same time period (generally via the internet) from an established base station in the area of the survey. Post-processed accuracy improves with proximity of the base station to the surveyed locations and base station data should be used from a station within 300km of the site surveyed. The survey positions are processed by application software and a new set of positions is generated using the correction data. The capability for post-processed differential correction is limited to Mapping Grade and Survey Grade receivers.

Various factors limit GPS accuracy in the vertical plane to approximately half of that obtainable in the horizontal plane, i.e., if a location fix is accurate to 3 m in the horizontal plane, it may only be accurate to 6 m in the vertical plane. Since relatively high accuracy is usually required for the uses of elevation data, GPS is rarely used to obtain and report elevations.

2.2 Requirements for Locational Information

2.2.1 Data Uses

Locational information can serve many purposes in an environmental investigation, a few of which are listed below:

1. Providing an unambiguous means to identify facilities or sampling plats.
2. Providing locational information to key analytical data in a GIS based data archiving system to the original sampling locations.
3. Differentiating watersheds.
4. Providing information to calculate extents and volumes of contamination.
5. Providing a means to relocate the media represented by samples for removal or treatment.
6. Providing information to prepare presentation graphics of sampling locations.

Depending on the specific uses for the data and the type of work being performed, there will be different needs for the accuracy of the locational data. Studies where a sample represents a large area of relatively homogeneous material would not require the same accuracy as the location of a permanent monitoring well. Below are broad guidelines for the accuracy that might be required for different applications.

Desired Accuracy	Application
100 m	Open ocean work where sample is presumed to be representative of a large area
20 m	Open water work (lakes or estuaries) where sample is presumed to be representative of a large area
10 m	Stream and river work where samples are presumed to be broadly representative of a reach
5-3 m	Stream work where samples are representative of a specific narrowly defined section
10 m	Air Monitoring Stations
10 - 3 m	Microscale air monitoring
3 - 1 m	Permanent monitoring wells
1 m	Locations of 'Hot Spots' destined for removal of limited areal extent
3 - 1 m	Locations of Temporary groundwater wells in plumes requiring narrow delineation
3 m	Locations of Temporary groundwater wells in broad plumes
3 m	Locations of environmental samples with sample spacing >20 m
5 m	Locations of environmental samples with sample spacing >60 m
200 - 20 m	Coordinates describing a facility where mobile waste units are sampled
30 - 3 m	Locations of industrial process areas or NPDES permitted facilities where the sampling locations are described in field notes relative to the process or site features

Specific demands of a study may drive increased or decreased requirements for accuracy. The preferred means of locational data collection for most studies will be GPS, although alternate means are permissible if they meet accuracy requirements. The following table indicates the accuracy that may be expected from various means of establishing coordinates.

Accuracy	Description
200 - 50 m	Map Derived, coarse work
40 - 20 m	Map Derived, fine work or using GIS with digital imagery
15 m	General-UseGeneral-Use Grade GPS, w/o WAAS
5 m	General-Use Grade GPS, w/ WAAS or beacon corrections
10 m	Mapping Grade GPS, no corrections, averaged readings,
3 m	Mapping Grade GPS w/ differential correction, averaged readings
1 m	Mapping Grade GPS w/ differential correction, controlled DOP and SNR, averaged readings
<10 cm	Surveying Grade GPS or optical surveying (dependent on baseline length)

Accuracy is a term used to describe the degree of conformity of a measurement. In GPS, accuracy is usually specified as an estimate of the radius from the measured coordinates that is likely to include the actual coordinates. The estimate will be based on a percentage likelihood or a certain number of standard deviations that the accuracy estimate is met. As such, it is recognized that some measurements will fall outside of the specified accuracy. For the purposes of SESD GPS work, the nominal accuracy figures derived from manufacturer's literature for specific operating conditions, displayed by the receiver at the time of feature collection, or output from processing software will be taken at face value.

2.2.2 Datums and Data formats

In general, a datum is a reference from which other measurements are taken. In the development of surveying systems by civil entities, different datums were used as base references that will result in differing coordinates for the same location. A GPS receiver will generally display coordinates in a number of different user-selected datums. **Unless there are specific requirements on a project, all SESD work should be conducted using the WGS84 datum. A**lternatively, the nearly equivalent NAD83 datum may be used if WGS84 is unavailable as a receiver option. If an alternate coordinate system is used where coordinates are obtained and recorded in field logbooks, the use of the alternate coordinate system should also be noted in the logbook.

The Region 4 Equis database requires that coordinates for sample locations be entered in the WGS84 datum and dd.dddddd format. Unless specific project requirements dictate otherwise, all coordinates explicitly stated in reports will be in WGS84 format and in all cases the datum used will be specified.

There is no SESD policy on significant digits for GPS information, and accuracy should not be implied from the presence of significant digits in reported coordinates. However, good scientific practice should be followed in the presentation of locational information in order that useful information not be truncated or a higher degree of accuracy implied. The following table shows the incremental distance in latitude represented by the least significant digit for various coordinate formats:

dd.dddddd°	Approximately 4" or 10 cm
dd.ddddd°	Approximately 44" or 1.1 m
dd.dddd°	Approximately 36' or 11 m
dd°mm'ss"	Approximately 100' or 30 m
dd°mm'ss.x"	Approximately 10' or 3 m
dd°mm'ss.xx"	Approximately 1' or 30 cm
dd°mm.xxxx'	Approximately 7" or 18 cm
dd°mm.xxx'	Approximately 6' or 1.8 m
dd°mm.xx'	Approximately 60' or 18 m

2.3 Quality Control Procedures

By nature of its origin in the DOD and recent application to aircraft navigation, the GPS is designed for high reliability. GPS failures resulting in an incorrect reading beyond the bounds of known errors are so rare that the possibility can be ignored for most SESD studies. If a study requires the verification of receiver function, this can be accomplished by verifying that a receiver displays the correct position while occupying a known benchmark.

2.4 Special Considerations

The data quality objectives for the application, availability of receivers, and other factors will dictate the type of receiver used. There are several specific considerations for the use of the various GPS receivers available at SESD.

2.4.1 Special considerations for the use of Trimble® Geo7X Mapping Grade Receivers

Several important settings can be adjusted or checked under the 'Setup' toolbar.

Suggested settingsfor Trimble® Geo7X receivers are:

1. Settings>Coordinate System:

   System = Latitude/Longituude

   Datum = WGS 1984

   Altitude Reference = MSL

   Altitude Units – Feet

These settings would rarely need to be changed, but should be checked prior to collecting data.

2. Settings>Real-time Settings
   Set to:

   Choice 1 = Integrated SBAS

   Choice 2 = Wait for Real-time

   When ‘Choice 2’ is set to ‘Wait for Real-time’, the receiver will not log positions if a WAAS signal cannot be received. When this occurs, ‘Choice 2’ may need to be changed temporarily to ‘Use uncorrected GNSS’. The location would then be logged with the reduced accuracy of uncorrected GPS, which should be noted in field logbooks. The accuracy of the position can be improved later by post-processing.

3. Settings>Logging Settings

   At the top of the logging settings dialog is the ‘Accuracy Settings’ label. Tap the ‘wrench’ box to the right of the first field to open the Accuracy Settings dialog box.

   Set the first box under ‘Accuracy Value for Display/Logging’ to ‘Horizontal’

   The box below the Horizontal/Vertical selection chooses whether positions will be corrected in real time or by post-processing. Choose ‘In the field’ if Real-time WAAS corrections will be used, or ‘Postprocessed’ if positions will be post-corrected. This selection will affect the accuracy estimates displayed. If Real-time correction is used when this setting is set to ‘Postprocessed’, the estimated error reported will be erroneously low.

Select 'Yes' or 'No' for accuracy based logging. Selecting 'Yes' will prevent the receiver from logging until the desired accuracy can be achieved. This setting is recommended when a specific accuracy for locational data is required. Selecting 'Yes' enables the following choices:

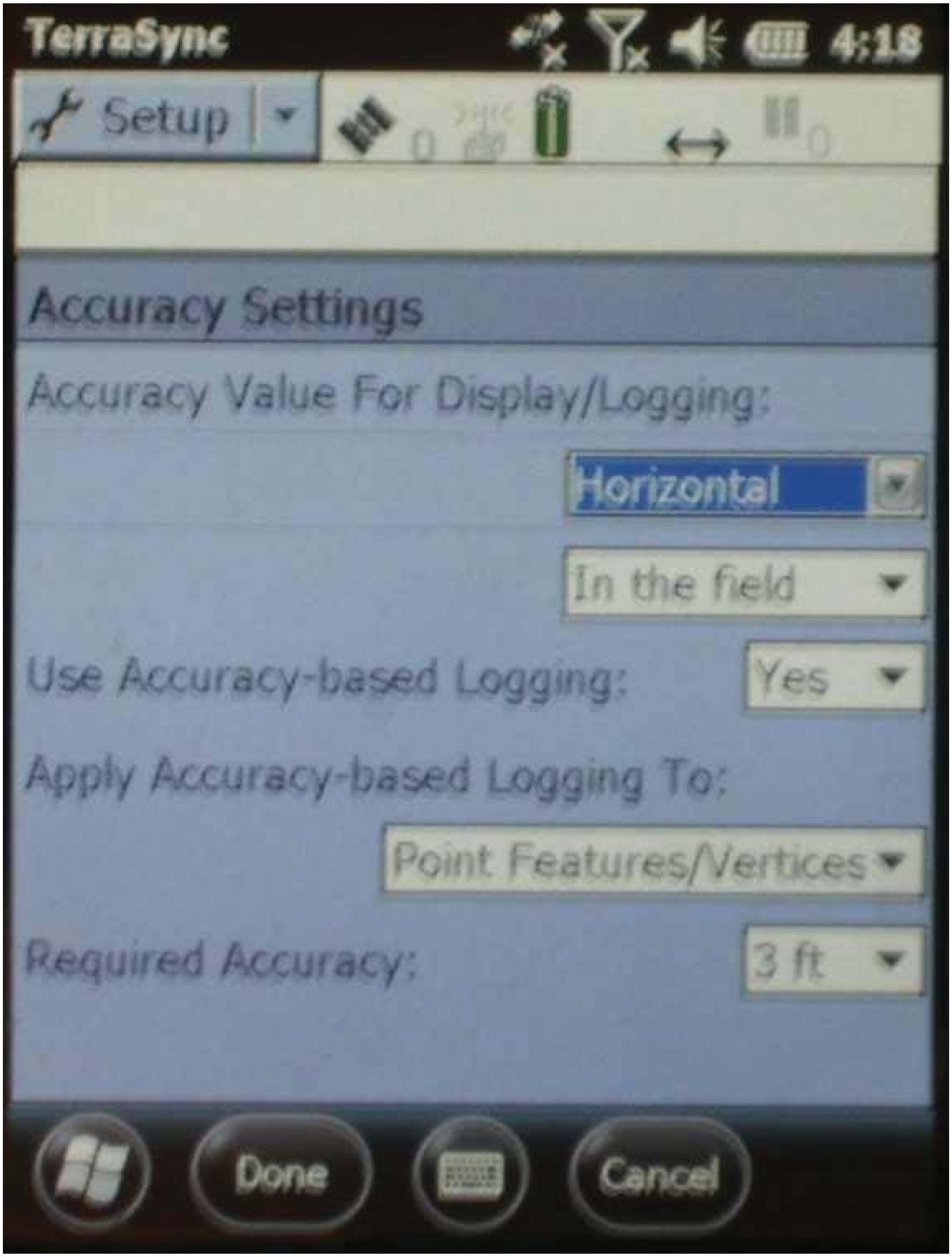
The next box, 'Apply Accuracy-based Logging to:' can be set to point features or 'All Features'. Set appropriately.

The 'Required Accuracy' field selects the accuracy threshold that will allow logging. If a position cannot be logged because the threshold cannot be met, several options are available:

1. Set the accuracy threshold to a higher but still acceptable value.
2. Plan to post-correct the coordinates and change the settings in this dialogs accordingly. Post-correction will generally allow more accurate correction than WAAS.
3. Return to the point at a later time when propagation or satellite geometry is more suitable.
4. Use the 'Offset' feature (see below) to log the positions from a more suitable location (e.g. less tree cover).

The screen shot below shows the Accuracy Settings Dialog Box:

COPY


TerraSync
4:18
Setup
Accuracy Settings
Accuracy Value For Display/Logging:
Horizontal
In the field
Use Accuracy-based Logging:
Yes
Apply Accuracy-based Logging To:
Point Features/Vertices
Required Accuracy:
3 ft
Done
Cancel

If the point to be logged cannot be occupied, or signals cannot be received at the location, the ‘Offset’ feature of the receiver can be used. The SESD Geo7X receivers can employ a laser rangefinder and internal compass to calculate the offsets. To use the ‘Offset’ feature:

1. Begin logging from the offset location.
2. Pull down the ‘Options’ menu and select ‘Offset’, then ‘Distance – Bearing’
3. The Offset dialog will open where distances and bearings could be manually entered.
4. To use the laser rangefinder and compass to populate the dialog fields, press the physical ‘⌖□ button located on the receiver below the screen.
5. The laser rangefinder application will start and a red sighting laser will turn on. Point the laser at the desired point to survey and sight the object in the crosshairs on the screen. When sighted on the survey object, tap on the ‘⌖' icon on the screen to lock in the distance and bearing at the bottom of the screen. Press the ‘⌖' icon again to update the readings, or press the ‘✓□ icon to transfer the bearing and distance to the Offset dialog box.
6. If the numbers transferred to the Offset dialog box are appropriate, tap ‘Done’ to return to the feature logging screen.

There is no quality system calibration performed on the electronic compass and rangefinder. It is the responsibility of the user to assure that the bearings and ranges returned by the laser rangefinder system will result in accuracy consistent with the overall GPS work. A quick check for reasonableness can be performed by comparing the logged position on the Map screen with the current position shown.

Photos can also be taken with the unit and associated with the logged features. The user is referred to vendor documentation for instruction in the use of this feature.

Trimble® receivers at SESD contain a data dictionary that can facilitate the management of GIS data. If the COC_GIS dictionary is selected at the time of file creation, SESD standard media codes can be assigned to features at the time of logging that will accompany the data through the download process. The use of the COC_GIS data dictionary can simplify the management of the data when processed in a GIS system or when submitted to the Equis data archiving system.

The logging interval of the Trimble® Geo 7X receivers can be set to a 1 or 5 second interval as an option during feature collection. The setting may be set to 1 second to expedite feature collection. A point feature should have a minimum of 36 positions logged to obtain the additional accuracy afforded by the averaging of positions. After a minimum of 36 positions are logged and the feature is closed, the averaged coordinates for the location can be obtained by selecting the feature on the 'Map' screen. The averaged position should always be the one entered into field notebooks.

2.4.2 Special considerations for the use of Garmin® and other General-Use Grade Receivers

Several types of General-Use grade of receivers are in use at SESD, most from the Garmin® product line. Most of the Garmin® receivers operate with a similar interface to facilitate use of the various devices. The nautical receivers/depth sounders are suitable for recording location data within the limitations described for the General-Use grade receivers.

Some receivers will allow averaging of positions to improve accuracy. Use of this feature is recommended when possible.

Anecdotal experience at SESD suggests that GPS designed primarily for automobile navigation is unsuitable for obtaining locational data.

The older Garmin receivers would display on the status screen whether differential correction was in use by displaying small 'D' characters at the base of the signal strength bars. Newer receivers do not display this information directly and correction status can only be ascertained by the accuracy estimates or monitoring the status screen for acquisition of signals from the WAAS satellites.

2.4.3 Coordinate Conversion

Coordinates may be displayed in different formats on the various receivers, or coordinates obtained from outside SESD may be presented in a format other than that required. If the coordinates are in the correct datum, but recorded in the dd°mm'ss.sss" format they can be arithmetically converted to dd.dddddd format. Convert to decimal degrees as follows:

Converting to decimal degrees (dd.dddddd) from degrees°minutes'seconds" (dd°mm'ss.sss"):

dd.dddddd = dd + (mm/60) + (ss.sss/3600)

Example: Convert 33°28'45.241" to decimal degrees

33 + (28/60) + (45.241/3600) = 33.479236

The reverse conversion is accomplished as follows:

Converting to degrees°minutes'seconds" from decimal degrees

Starting with dd.dddddd

Multiply .dddddd by 60 to obtain mm.mmmm

Multiply .mmmm by 60 to obtain ss.sss

Then dd°mm'ss.sss" = dd & mm & ss.sss

Example: Convert 33.479236 to dd°mm'ss.sss" format

Multiply .479236 by 60 to obtain 28.7540 (mm.mmmm)

Multiply .7540 by 60 to obtain 45.241 (ss.sss)

Dd°mm'ss.sss" = 33° & 28' & 45.241" = 33°28'45.241"

The standard format for navigational purposes is decimal minutes (dd°mm.mmm'). This format is utilized due to the fact that nautical navigation charts are set up in this format. However, location information must be converted to a decimal degree (dd.ddddd°) format in order for GIS software to properly interpret the information and for submission to the Region 4 Equis database. Assuming the coordinates have been recorded in the proper datum, the conversion can be accomplished by dividing the minutes portion of the coordinates by 60.

<u>Converting to decimal degrees from decimal minutes:</u>

dd.ddddd° = dd + (mm.mmm/60)

Example: Convert 81°49.386' to decimal degrees

81 + (49.386/60) = 81.8231 degrees

<u>The reverse conversion is accomplished as follows:</u>

dd°mm.mmm' = dd & (.ddddd*60)

Example: Convert 81.8231 degrees to decimal minutes (dd°mm.mmm')

Multiply .8231 by 60 to obtain 49.386 (mm.mmm)

81° & 49.386' = 81°49.386'

GPS users need to familiarize themselves with the differences between the formats, as they can appear similar. Spreadsheets can automate the conversion process.

2.5 Records

The GPS coordinates and the SESD equipment identification number of the GPS receiver should be recorded in field logbooks at the time of GPS coordinate collection. The data logging capability of receivers may be used in lieu of the requirement to record the coordinates in logbooks when the following conditions can be met:

1. The location can easily be found later if it needs to be resurveyed prior to demobilization. A permanent monitoring well can easily be resurveyed, while most open-water work would not afford this opportunity.

2. The data is downloaded and ascertained to meet the accuracy requirements for the project prior to demobilization from the site.

3. The data is stored in at least two separate locations for transport, such as a laptop hard drive and a flash drive or compact disc.

In all cases where positions are electronically recorded, the provisions of the Electronic Records section of the SESD Operating Procedure for Control of Records (SESDPROC-002) should be followed.

Where locational data is collected and processed electronically, but not reported explicitly in the final report, a copy of the coordinates in text format should be output and entered into the project file in paper or electronic form. The output should include:

1. Latitude, generally in dd.dddddd format.

2. Longitude, generally in dd.dddddd format.

3. Date of collection.

4. A note on the differential correction process used where it supports the accuracy requirements.

5. The datum used for the export.

Trimble® Pathfinder Office can create files with this information when exporting coordinates to a text file. The information will be contained in the .pos and .inf files.

Appendix F
Monitoring Well Permit Application

Monitoring Well Application

1. Proposed Location of Monitoring Well(s):

Street Address: **5801 Bluff Road**

City (including Zip): **Hopkins, 29061**

County: **Richland**

Please attach Scaled Map or Plat Figure E-1

2. Well Owner's Information:

Name (Last then First):

Company: **Westinghouse CFFF**

Complete Address: **5801 Bluff Road**
Hopkins, SC 29061

Telephone Number: **(803) 647-3338**

3. Property Owner's Information:

☑ Check if same as Well Owner

Name (Last then First):

Company:

Address:

Telephone Number:

4. Proposed Drilling Date: **05/15/2019**

5. Intended Purpose of Well(s):

Pre-Purchase ☐

Investigation ☑

NOTE: If this request is for an existing DHEC project, please enter the Program area and ID number below.

Program Area: **Land and Waste Management**
Project or Site ID #: **File #51377**

6. Proposed number of monitoring wells: **41**

7. Proposed parameters to be analyzed (check all that apply), please specify analytical method beside check box:

Parameter	Check	Method
VOCs	☑	TCL VOCs Method 8260B
BTEX	☐	
MtBE	☐	
Naphthalene	☐	
PAHs	☑	TCL SVOCs Method 8270D
Metals	☑	TAL M. Md. 6010D/6020B
Nitrates	☑	Method 353.2
Base, Neutral & Acid Ex.	☐	
Pesticides/Herbicides	☐	
Phenols	☐	
Radionuclides	☑	Isotopic Uranium and Technetium HASL-300, and EPA 200.8, Technetium 99 HASL-300, Alpha/Beta EPA 900.0
PCBs	☐	
Other (specify below)	☑	

Ammonia Method 350.1 and Fluoride Method 9056A Note: Analyses will be performed on the 30 monitoring wells only

8. Proposed construction details (complete and attach proposed monitoring well schematics):

See Figures E-2 through E-5
Note: 11 of the proposed wells are temporary lithologic borings

South Carolina Department of Health and Environmental Control (SCDHEC) summary of standards for monitoring well construction (per South Carolina Well Standards and Regulations R. 61-71)

Approval and License Requirements

Prior Department approval is required for the installation or abandonment of all monitoring wells including direct push, geoprobe or other temporary type monitoring wells. The attached monitoring well approval document should be completed, submitted and approved prior to construction of any monitoring well. A monitoring well is any well used to obtain water samples for water quality analyses or to measure groundwater levels. There are no fees for approvals. All monitoring wells must be drilled by a driller that is registered in South Carolina with the Board of Certification of the Environmental Systems Operators. If any of the information on the application including the proposed drilling date, well construction details or well placement changes, the Department (i.e. project manager issuing the well approval) must be notified 24 hours prior to well construction.

Location

Due to the nature and purpose of a monitoring well, the depth and location requirements in respect to surface water bodies, potential contamination sources, etc., are variable, and shall be approved on a case by case basis by the Department.

Construction and Material

Casing should be of sufficient strength to withstand normal forces encountered during and after well installation and be composed of material so as to minimally affect water quality analyses. Casing should have a sufficient diameter to allow for efficient sample collection (i.e., to provide access for sampling equipment). The diameter of the drilled hole needs to be large enough on all sides (1.5 inches of annular space) to allow forced injection of grout through a tremie pipe. All monitoring wells should have a cement pad or aggregate reinforced concrete at the ground surface which extends at least six inches beyond the bore hole diameter and six inches below ground surface to prevent infiltration between the surface casing and the bore hole. All monitoring wells should be grouted from the top of the bentonite seal to the surface with a neat cement, high solids bentonite or neat cement, bentonite mixture approved by the Department. A hydrated bentonite seal with a minimum thickness of 12 inches is to be placed above the filter pack to prevent infiltration of grout if the well has a filter pack. The monitoring well intake or screen design should minimize the amount of formational materials entering the well. The gravel pack should be utilized opposite the well screen as appropriate so that parameters analyses will be minimally affected. All monitoring wells should have a locking cap or other security device to prevent damage and/or vandalism. Any monitoring well which is destroyed, rendered unusable or is abandoned should be reported to the Department and be properly abandoned, revitalized or replaced as appropriate or required by permit or regulation.

Development

Monitoring wells shall be properly developed. Development shall include the removal of formation cuttings and drilling fluids from the well bore hole. Development shall be complete when the well produces water typical of the aquifer being monitored.

Reporting Requirements

A monitor well record form (1903) or equivalent to include the following should be completed and submitted to the Department within 30 days after completion of the monitoring wells:

Name and address of facility/owner;
Surveyed or global positioning system location of monitor well(s) on a scaled map or plat;
Driller and certification number;
Date drilled;
Driller's or Geologist's log;
Total depth;
Screened interval;
Diameter and construction details;
Depth to water table with date and time measured;
Surveyed elevation of measuring point with respect to established benchmark;
Monitoring well approval number issued by the Department.

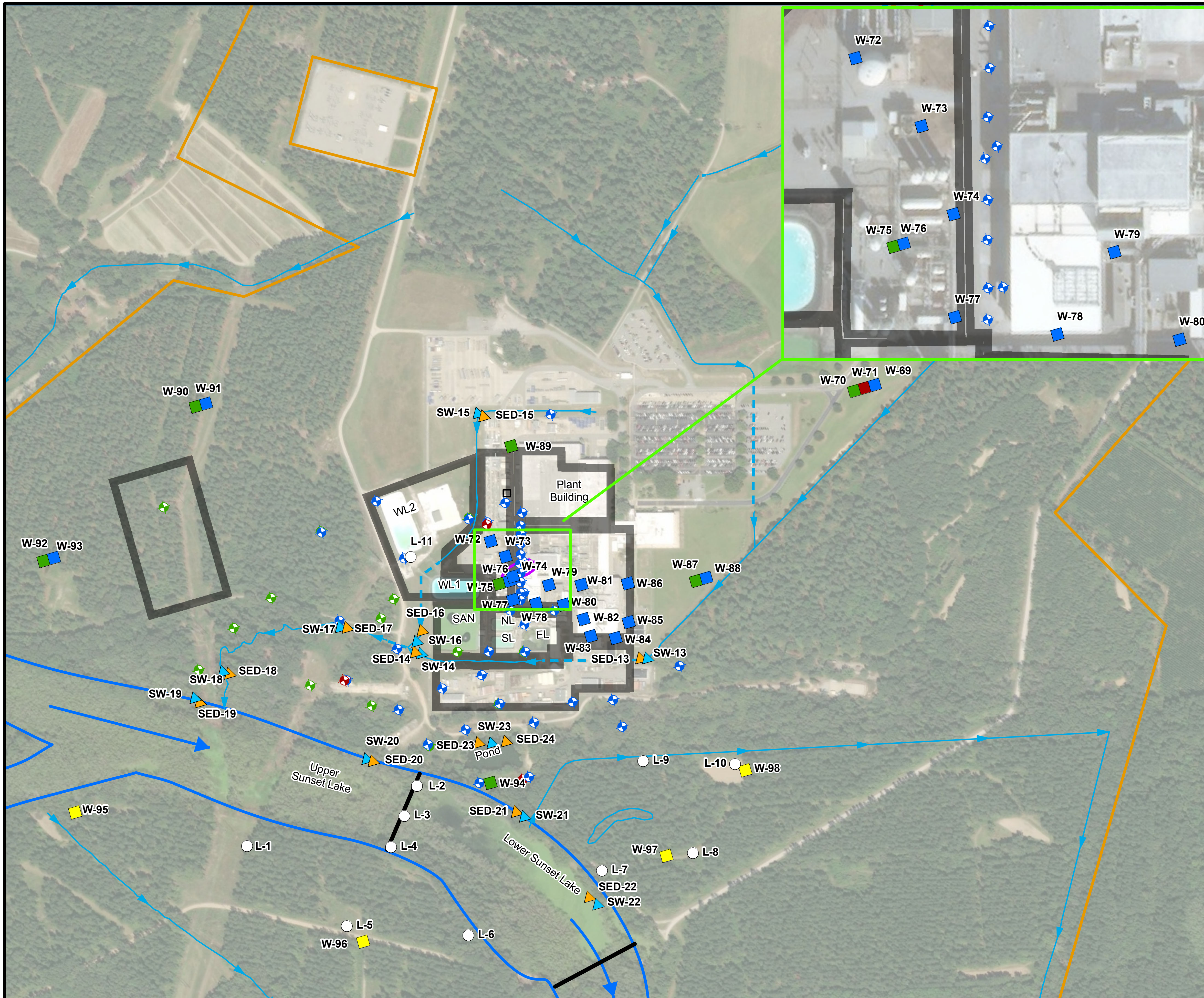
Additionally, the groundwater and soil (if taken) analytical results should be submitted to the Department within 30 days of receipt from the laboratory.

Abandonment

All monitoring wells shall be properly abandoned, when deemed appropriate by the Department. Any well that acts as a source of contamination shall be repaired or permanently abandoned immediately after receipt of notice from the Department. Abandonment shall be by forced injection of grout or pouring through a tremie pipe starting at the bottom of the well and proceeding to the surface in one continuous operation. The well shall be filled with either neat cement, bentonite-cement, or 20% high solids sodium bentonite grout, from the bottom of the well to the land surface.

* This summary of standards for monitoring well construction may not include a listing of all information necessary to obtain an approval to install monitoring wells. Final approval of monitoring well installation will be dependant upon the regulatory requirements for the Department program area for which the monitoring wells are to be installed.

* Some areas of the Department may require a detailed justification of the placement of monitoring wells and the depth of monitoring well screened zones prior to granting installation approval.



Legend

- Ditch
- Culvert
- Mill Creek Flow Direction
- EL East Lagoon
- NL North Lagoon
- SL South Lagoon
- SAN Sanitary Lagoon
- WL1 West Lagoon 1
- WL2 West Lagoon 2
- Mill Creek
- Property Line
- SCRDI Bluff Road
- Dike Location
- Operable Units

Groundwater Monitoring Wells

- Upper Surficial Aquifer
- Lower Surficial Aquifer
- Black Mingo Aquifer

Proposed Locations

- Sediment Sample
- Surface Water Sample
- Lithologic Boring
- Upper Surficial Aquifer Monitoring Well
- Lower Surficial Aquifer Monitoring Well
- Black Mingo Aquifer Monitoring Well
- Floodplain Monitoring Well

0 250 500 Feet

1:6,000

Map Projection: NAD 1983, South Carolina State Plane, FIPS 3900, Feet

Datum: North American 1983

AECOM

101 Research Drive
Columbia, SC 29203
T: (803) 254-4400 F: (803) 771-6676

Proposed Monitoring Wells and Soil Borings

WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY
HOPKINS, SOUTH CAROLINA

PROJECT NO.	PREPARED BY:	DATE:	
60595649	LJG	February 2019	FIGURE E-1

Path: M:\EnvDataViz\Westinghouse\mxd\2019_WCFFF_RI_Work_Plan\Proposed_MW&SB.mxd

FIGURE E-2

TYPICAL SURFICIAL AQUIFER MONITORING WELL DETAIL - ABOVE GRADE

Project Name: Columbia Fuel Fabrication Facility
Drilling Co: ____________
Well Number: ____________

Location: Hopkins, SC
Driller: ____________
Job Number: ____________

Client: Westinghouse Columbia Fuel Fabrication Facility
Drilling Method: Sonic or HSA
Date Completed: ____________

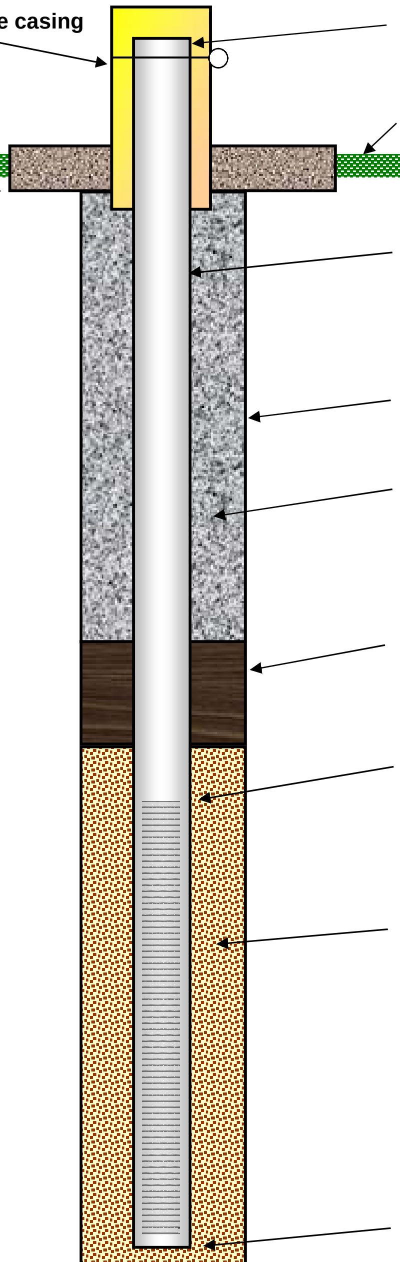
Geologist: ____________
Static Water Level: ____________ **betook**
Survey Datum: ____________

4-inch square locking protective casing

Grass, Asphalt/Concrete

Concrete Surface Pad
(2 ft x 2 ft x 6 in)

COMMENTS



Top Of Casing Elevation ________ ft ________ ft Stickup

Land Surface Elevation ________ ft

Well Casing From ________ ft to ________ ft
Casing Type: **SCH-40 PVC**
Inside Diameter: **2-in.**

Diameter of Borehole (nominal)
6 to 8 in

Bentonite/Cement Grout
From ________ ft to ________ ft

Bentonite Pellet Seal
Type: ____________
From ________ ft to ________ ft

Top of Screen Depth ________ ft
Screen Type: **SCH-40 PVC**
Screen Slot Size: **0.010-in** ID **2** in
Screen Length: **10** ft

Filter Sand for Screen
Sand Type: ____________
From ________ ft to ________ ft

Bottom of Well Depth ________ ft

Bottom of Boring (estimated) Depth ________ ft

Total Depth of Well, b. Top of Casing Depth ________ ft

Note:
Drawing Not to Scale
All Depths are Referenced to Ground Surface

AECOM

FIGURE E-3

TYPICAL SURFICIAL AQUIFER MONITORING WELL DETAIL - BELOW GRADE

Project Name: Columbia Fuel Fabrication Facility
Drilling Co: ______
Well Number: ______

Location: Hopkins, SC
Driller: ______
Job Number: ______

Client: Westinghouse Columbia Fuel Fabrication Facility
Drilling Method: Sonic or HSA
Date Completed: ______

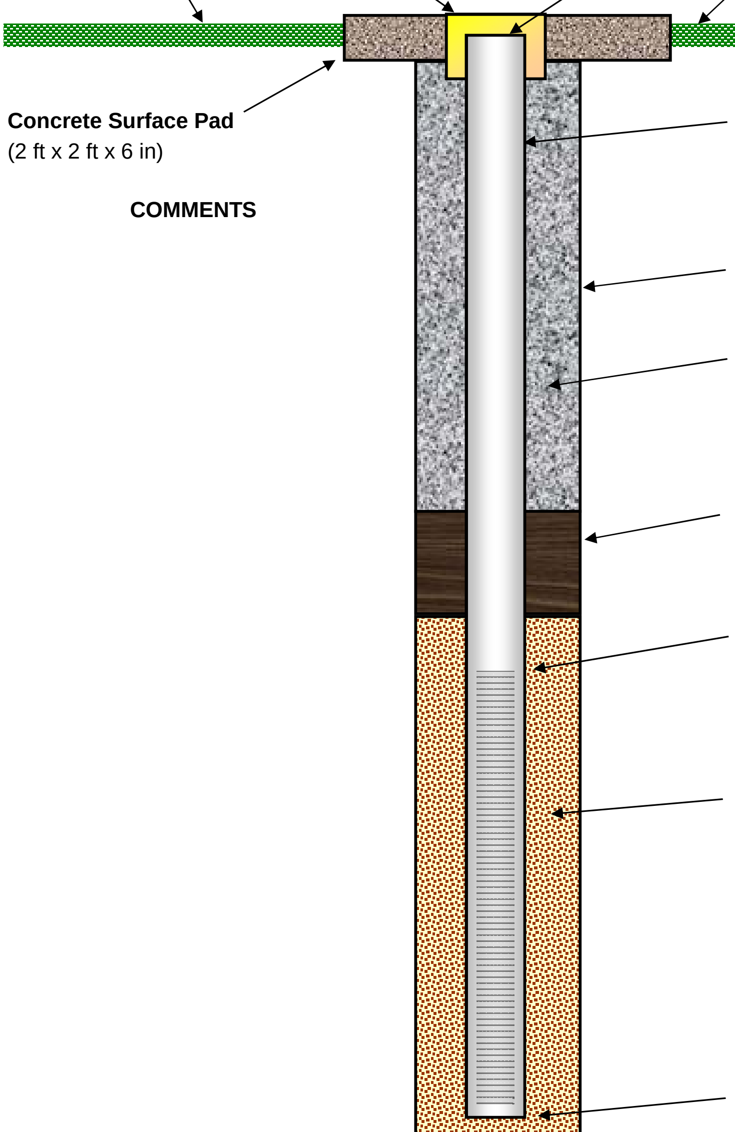
Geologist: ______
Static Water Level: ______ **betook**
Survey Datum: ______

8-inch diameter steel vault

Grass, Asphalt/Concrete

Concrete Surface Pad
(2 ft x 2 ft x 6 in)

COMMENTS



Top Of Casing Elevation ______ ft ______ ft Stickup

Land Surface Elevation ______ ft

Well Casing From ______ ft to ______ ft

Casing Type: **SCH-40 PVC**
Inside Diameter: **2-in.**

Diameter of Borehole (nominal)
6 to 8 in

Bentonite/Cement Grout
From ______ ft to ______ ft

Bentonite Pellet Seal
Type: ______
From ______ ft to ______ ft

Top of Screen Depth ______ ft
Screen Type: **SCH-40 PVC**
Screen Slot Size: **0.010-in** ID **2** in
Screen Length: **10** ft

Filter Sand for Screen
Sand Type: ______
From ______ ft to ______ ft

Bottom of Well Depth ______ ft

Bottom of Boring (estimated) Depth ______ ft

Total Depth of Well, b. Top of Casing Depth ______ ft

Note:
Drawing Not to Scale
All Depths are Referenced to Ground Surface

Figure E-4

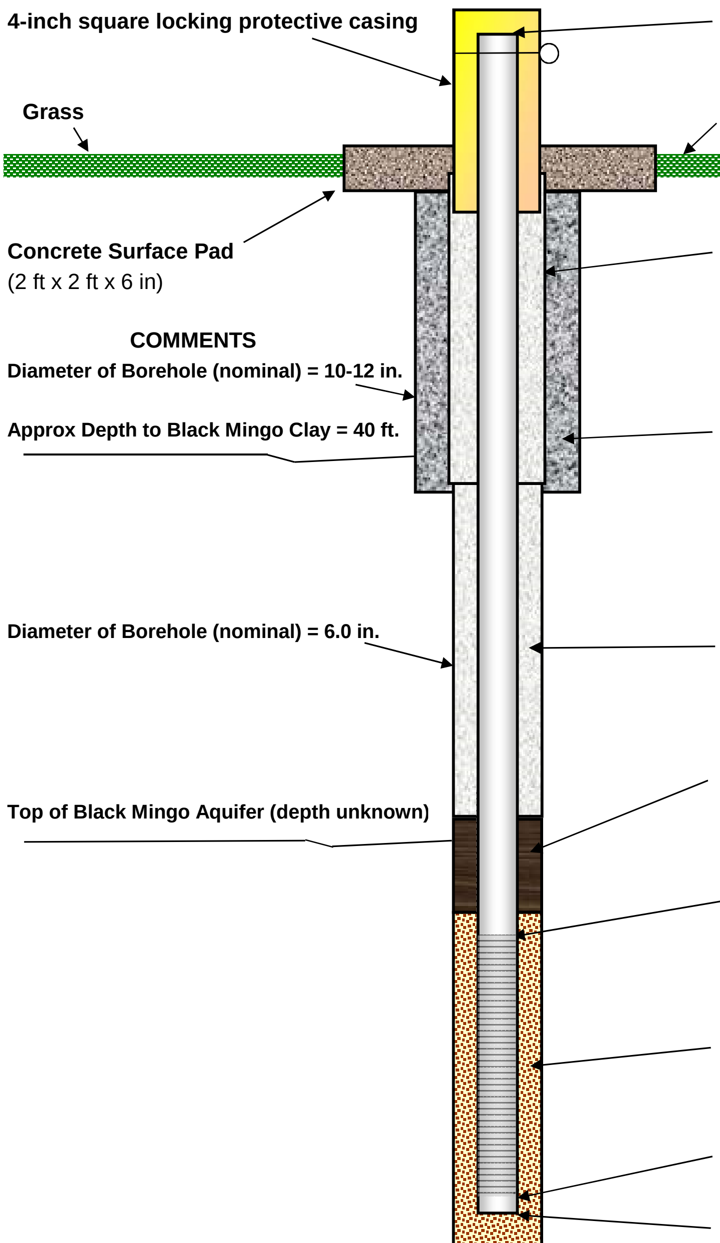
TYPICAL DOUBLE-CASED MONITORING WELL DETAIL

Project Name: Columbia Fuel Fabrication Facility
Drilling Co: ______
Well Number: ______

Location: Hopkins, SC
Driller: ______
Job Number: ______

Client: Westinghouse Columbia Fuel Fabrication Facility
Drilling Method: Sonic
Date Completed: ______

Geologist: ______
Static Water Level ______ **b.TOC**
Survey Datum: ______



Top Of Casing Elevation ______ ft ______ ft Stickup

Land Surface Elevation ______ ft

Surface Casing From ______ ft to ______ ft

Casing Type: **SCH-40 PVC**
Inside Diameter: **6 to 8-in.**

Bentonite/Cement Grout from Bottom of Surface Casing to Land Surface

Bentonite/Cement Grout from Top of Bentonite Seal to Land Surface

Bentonite Seal
Type: ______
From ______ ft to ______ ft

Top of Screen
Screen Type: **SCH 40 PVC** Depth ______ ft
Screen Slot Size: **0.010 in**
Screen Length: **10.0** ft ID **2.0** in

Filter Sand for Screen
Sand Type: ______
From ______ ft to ______ ft

Top of Sediment Sump/Bottom Screen Depth ______ ft
Type: ______

Bottom of Well Depth ______ ft

Bottom of Boring (estimated) Depth **80-100** ft

Note:
Drawing Not to Scale
All Depths are Referenced to Ground

FIGURE E-5

TYPICAL LITHOLOGIC BORING

Project Name: Columbia Fuel Fabrication Facility
Drilling Co: ______
Well Number: ______

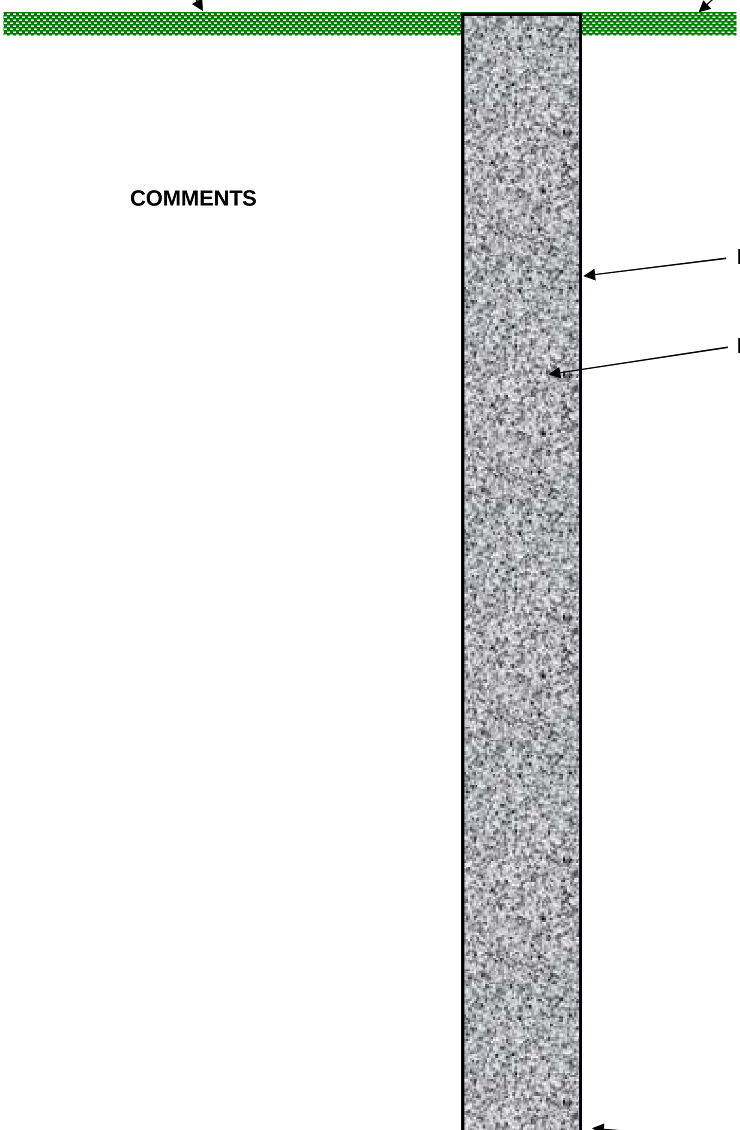
Location: Hopkins, SC
Driller: ______
Job Number: ______

Client: Westinghouse Columbia Fuel Fabrication Facility
Drilling Method: Sonic or Geoprobe Direct Push
Date Completed: ______

Geologist: ______
Static Water Level: ______ **betook**
Survey Datum: ______

Grass, Asphalt/Concrete

Land Surface Elevation ______ ft



COMMENTS

Diameter of Borehole (nominal)
2 to 6 in

Bentonite/Cement Grout
From total depth to land surface

Bottom of Boring

Note:
Drawing Not to Scale
All Depths are Referenced to Ground Surface

Appendix G
Data Assessment and Validation Information

Data Assessment and Validation Information

Assessment and validation of laboratory analytical data will be conducted to ensure that the data quality is appropriate for subsequent risk assessment and evaluation of remedial options. Data assessment is a systematic process for reviewing a body of data against a predefined set of criteria to provide assurance that the data meet project analytical Data Quality Objective (DQO) requirements. The purpose of the data assessment process is to determine if and how the usability of the analytical data is affected by the overall analytical processes and sample collection and handling procedures. If specific analytical DQOs are not met, the data are qualified (i.e., data flags are assigned to sample results) in accordance with guidelines established by the USEPA. Data assessment allows the data user to adequately determine if the data can be used for its intended purpose. The data acceptance criteria are established according to Standard Operating Procedures (SOPs) and Statements of Work (SOWs) provided to the contracted analytical laboratory. The assessment of data quality and usability involves five components, as described below.

1) **Field Sampling Check** is a process to ensure that all samples were collected and the laboratory analyses were performed as stipulated in the applicable site-specific Work Plan or Field Sampling Plan (FSP). Inspection of sample preservation procedures, sample handling, analysis requested, sample description and identification (ID), cooler receipt forms, holding time evaluation, and Chain of Custody procedures are all evaluated to ensure that the evidentiary nature of the samples and the resulting analytical data have not been compromised.

2) **Data Verification** is a process for determining the completeness, correctness, consistency, and compliance of a data package in accordance with requirements contained in the applicable SOW and/or contract-specific requirements. This is a review of the data package, electronic data deliverable (EDD), and invoice received from the contract laboratory to ensure that the contract required information is present and complete prior to data validation.

3) **Data Review** is a process of reviewing the primary quality control (QC) data provided by the laboratory and the results of any internal quality assurance (QA)/QC samples, such as field blanks, trip blanks, equipment blanks or ambient blanks, field split samples, and duplicate samples, to ascertain any effect the laboratory's procedures or the sample collection process has on the data.

4) **Data Evaluation** is a process to determine if the data meet project-specific analytical DQOs and contract requirements. This evaluation may involve a review of field sampling and sample management procedures, laboratory audits, Performance Evaluation (PE) sample results, and any other data quality indicators that are available.

5) **Data Validation** is a process to determine the accuracy and precision of analytical data generated and to identify any anomalies encountered. The validation process is performed in accordance with USEPA regional or national functional guidelines, project-specific guidelines, and compliance with the requirements of each analytical method.

   Two major components of data validation are laboratory performance and matrix interferences. Evaluation of laboratory performance is a check for compliance for each analytical method to determine if the samples were analyzed within the prescribed acceptance criteria of the method. Data not meeting project-specific analytical DQOs or the requirements of the analytical method are qualified with data flags according to referenced guidelines. The purpose of the data validation is to assess and document the performance of the analytical process. A summary of all QC samples and results will be verified for measurement performance criteria and completeness.

Standard level verification will consist of review of signed chains-of-custodies, condition upon receipt forms, case narratives, analytical results, surrogate recoveries, ambient/equipment/trip blank results (as necessary), method blank results, initial and continuing calibration verification, laboratory control sample recoveries/laboratory control samples duplicate relative percent differences, matrix spike recoveries/matrix spike duplicate relative percent differences. Full verification may be performed on the data packages if serious deficiencies are found during the standard level verification process.

Once data validation is complete, a data assessment report (DAR) will be generated for each analytical data package discussing and comparing overall precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity for each matrix, analytical group, and concentration level, as well as describing limitations on the use of project data if criteria for DQOs are not met.

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A Fortune 500 firm, AECOM had revenue of approximately $20.2 billion during fiscal year 2018. See how we deliver what others can only imagine at aecom.com and @AECOM.

AECOM
101 Research Drive
Columbia, SC 29203
aecom.com