S.C. Department of Health and Environmental Control

QUALITY ASSURANCE PROGRAM PLAN FOR THE UNDERGROUND STORAGE TANK MANAGEMENT DIVISION

Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
Columbia, South Carolina

July 2020

SECTION A – PROJECT MANAGEMENT

A1 TITLE AND APPROVALS

Document Title: Quality Assurance Program Plan
Underground Storage Tank (UST) Management Division
Bureau of Land and Waste Management (BLWM)
South Carolina Department of Health and Environmental Control (S.C. DHEC)

Address: 2600 Bull Street
Columbia, SC 29201

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Plan Coverage: This Quality Assurance Plan covers all water and soil quality data collection as well as analysis activities conducted by or regulated by the UST Management Division at SCDHEC.

APPROVAL FOR AGENCIES

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LIST OF ACRONYMS

ACQAP	Annual Contractor Quality Assurance Plan
AFVR	Aggressive Fluid and Vapor Recovery
AST	Aboveground Storage Tank
BFD	Blind Field Duplicate
bgs	Below Ground Surface
BLWM	Bureau of Land and Waste Management
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CAP	Corrective Action Plan
CASE	Corrective Action System Evaluation
CIO	Chief Information Officer
CFM	Cubic Feet per Minute
CNFA	Conditional No Further Action
CoC	Chemical of Concern
CPC	Compliance Point Concentration
CWA	Clean Water Act
DHEC	Department of Health and Environmental Control
DIPE	Di-Isopropyl Ether
DL	Detection Limit
DQI	Data Quality Indicator
DQO	Data Quality Objective
DRO	Diesel Range Organics
EDB	Ethylene Dibromide or 1,2 Dibromoethane
EFIS	Environmental Facility Information System
EtBE	Ethyl tert-Butyl Ether
EA	Environmental Affairs
FPP	Free Phase Product
FST	Field Screening Technique
GAC	Granular Activated Carbon
GRO	Gasoline Range Organics
HPT	Hydraulic Pressure Test
ICAR	Interim Corrective Action Report
IGWA	Initial Groundwater Assessment
LIF	Laser Induced Fluorescence
LNAPL	Light Non-Aqueous Phase Liquid
LOD	Limit of Detection
mg/kg	milligrams per kilogram
MIP	Membrane Interface Probe
MDL	Method Detection Limit
MNA	Monitored Natural Attenuation
MTBE	Methyl tert-butyl Ether
NFA	No Further Action
OFA	Onsite Field Audit
OIP	Optical Image Profiler
ORP	Oxidation Reduction Potential
PAH	Polynuclear Aromatic Hydrocarbons
PE	Professional Engineer

PG	Professional Geologist
PQL	Practical Quantification Limit
QA/QC	Quality Assurance / Quality Control
QAP	Quality Assurance Plan
QAPP	Quality Assurance Program Plan
QAM	Quality Assurance Manager
QL	Quantification Limit
QMP	Quality Management Plan
RL	Reporting Limit
RBCA	Risk Based Corrective Action
RBSL	Risk Based Screening Level
RPD	Relative Percent Difference
SC DHEC	South Carolina Department of Health and Environmental Control
SOP	Standard Operating Procedure
SSWP	Site Specific Work Plan
SSTL	Site Specific Target Level
SUPERB	State Underground Petroleum Environmental Response Bank
TAA	Tert-Amyl Alcohol
TBA	Tert-Butyl Alcohol
TBF	Tert-Butyl Formate
TOC	Total Organic Carbon
µg/L	micrograms per liter
UST	Underground Storage Tank
VOC	Volatile Organic Compound

A3 Distribution List

The SCDHEC Underground Storage Tank Management Division Quality Assurance Program Plan, and subsequent revisions thereof, will be distributed to the following:

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Robert Hodges, PG	Manager	SCDHEC, Site Assessment, Remediation & Revitalization Division, Brownfields Section, Columbia, SC 29201	803-898-0919		hodgesrf@dhec.sc.gov
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SC Certified UST Site Rehabilitation Contractors*		This will be covered in the contractor's ACQAP or addendum to this Programmatic QAPP.			

Table 1. Distribution List

* Copies of the UST QAPP will be provided to all SCDHEC Certified UST Site Rehabilitation Contractors. It will be the responsibility of those contractors to provide the UST QAPP to any analytical laboratories or other subcontractors that they utilize.

The Annual Contractors Quality Assurance Plan (ACQAP) or site-specific QAPP Addendums also include distribution lists of those personnel specific to the project(s) that will be receiving a copy of the UST Programmatic QAPP and the ACQAP or site-specific QAPP Contractor Addendums. Personnel will be required to sign that they have received a copy of the most recent UST Programmatic QAPP and the site-specific QAPP Contractor Addendums or ACQAP.

A4 Organization

To implement this Quality Assurance Program Plan (QAPP), the UST Management Division has established a suitable management structure. Personnel from the Underground Storage Tank (UST) Management Division and Bureau of Land and Waste Management of South Carolina Department of Health and Environmental Control (SCDHEC) will provide technical management and oversight of the Site Rehabilitation work to be performed. The successful implementation of the QAPP involves a large educational component. Management and support personnel involved should be qualified, by training and/or expertise, to assume the necessary responsibilities.

The responsibilities for key positions within the SCDHEC UST Management Division are listed and an Organizational Chart is presented as Figure 1 below:

Quality Assurance Manager - The Quality Assurance Manager (QAM) is responsible for the oversight of all quality assurance activities associated with SCDHEC sampling and analysis standard operating procedures (SOPs). The QAM reports directly to upper management. The QAM will resolve any issues when corrective actions are needed to address data quality issues involving SCDHEC staff and SOPs. The QAM will approve the SCDHEC UST Programmatic QAPP.

UST Management Division QAPP Coordinator - The UST Management Division QAPP Coordinator is responsible for revisions to the UST Programmatic QAPP as necessary. The UST QAPP Coordinator will ensure that copies of the QAPP and all revisions are distributed to all parties listed in the Distribution List. The UST QAPP Coordinator will approve the SCDHEC UST Programmatic QAPP and will provide UST Project Managers with guidance to ensure the content of the site-specific QAPP Contractor Addendums or Site-Specific Work Plans (SSWP) is correct and complete. The UST QAPP Coordinator also reviews and approves contractors ACQAP submittals.

Division Directors - The Division Directors will provide necessary liaison with the QAM and the Regional Office to help ensure that UST QA Program requirements are consistently met within the state.

Section Managers - Section Managers are responsible for oversight of the UST Project Managers. The Section Managers provide input to site-specific decisions in addition to ensuring consistency with policies and procedures of the UST Management Division. Section Managers will address QA matters with the UST Project Managers and the contractors at the site level and will approve site-specific QAPPs.

UST Project Managers - UST Project Managers are responsible for direct oversight of contractors conducting assessment and Site Rehabilitation of releases at UST sites. Project Managers perform day-to-day review of plans and reports related to Site Rehabilitation activities on their assigned sites. These reviews include verification and analysis of data submitted to the UST Management Division by Site Rehabilitation Contractors and analytical laboratories and recommendations for future work. Project Managers are responsible for the review of and approval of site-specific QAPP Contractor Addendums or SSWPs to ensure compliance with the UST Programmatic QAPP. The UST Project Managers are also responsible for validating the Project Data.

Site Rehabilitation Contractor - The Site Rehabilitation Contractor is an independent contractor responsible for managing and coordinating field and office activities needed for assessments or cleanup. Site Rehabilitation Contractors that perform activities involving data analysis and interpretation must be registered with SCDHEC as a Class I Site Rehabilitation Contractor. Site Rehabilitation Contractors that perform activities involving only data collection (e.g., drilling, sampling) must be registered with SCDHEC as a Class II Site Rehabilitation Contractor. All Site Rehabilitation Contractors are responsible for submitting QAPP Addenda with each Site Specific Work Plan (SSWP) or Annual Contractor Quality Assurance Project Plan (ACQAP) that describes all South Carolina UST site work conducted by the contractor, as detailed below in Section A5. The Site Rehabilitation Contractor is also responsible for validating and verifying the Project Data. UST Division Project Managers must be notified of UST site work in South Carolina at least 4 days prior to the initiation of field activities.

Analytical Laboratory - The Analytical Laboratory receives the soil and water samples, performs the requested analyses, and provides analytical reports. Analytical laboratories must be certified by the SCDHEC Office of Environmental Laboratory Certification in accordance with Regulation R.61-81 for the analytical methods performed.

Soil Boring and Monitoring Well Driller - The Driller installs soil borings and monitoring wells. All soil borings and monitoring wells must be installed by a certified South Carolina (SC) well driller in accordance with South Carolina Well Standards and Regulations, R.61-71.

Organizational Chart for SCDHEC UST

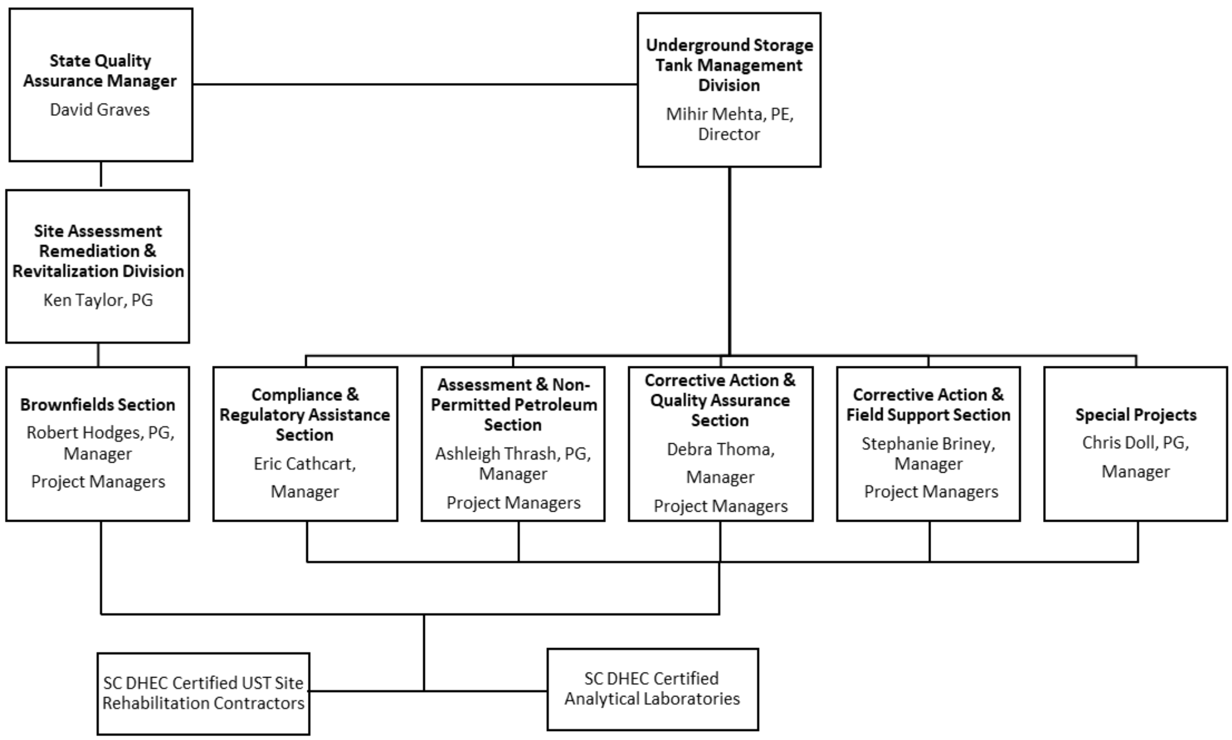


Figure 1. Organizational Chart

A5 Problem Definition/Background

I. Introduction

Over 11,000 releases have been reported from regulated underground storage tanks (USTs) in South Carolina. The SCDHEC UST Management Division addresses the chemicals released from leaking USTs. UST releases are present in virtually every type of South Carolina community, ranging from rural to metropolitan. The petroleum chemicals of concern (CoC) present in the soil and groundwater constitute potential risks to human health and the environment and require investigation so that decisions can be made regarding appropriate site rehabilitation actions or possible closure. Environmental data are critical to decision-making concerning the protection of the public and the environment from the adverse effects of pollutants from leaking underground storage tanks.

II. Quality Assurance Policy

The UST Management Division of the SCDHEC Bureau of Land and Waste Management (BLWM) adopts by reference the following Quality Assurance Practice statement as documented in the Environmental Affairs Quality Management Plan (QMP):

Environmental data are critical to decision making. Making the correct decision based on the data is important in the protection of the public and the environment. The Department's quality assurance practice is that there be sufficient QA activities conducted to demonstrate that all environmental data generated, processed, or used will be scientifically valid, legally defensible, and of known and acceptable precision and accuracy. Data shall be complete, representative, and comparable. The quality of all data generated by and for DHEC shall meet or exceed all Department and EPA requirements. Data of the appropriate type and quality shall be used by the Department in all of its environmental programs and decision-making processes. In addition, all employees are responsible for adhering to this practice and other policies, procedures and guidance of the quality system.

Quality assurance (the documentation of quality control) and quality control practices are needed to ensure that data involving all environmental efforts – e.g., pollution abatement, cleanup, public health protection, and environmental technology - successfully perform their intended role.

All such decisions must be technically defensible and must be protective of human health and the environment. It is the policy of the UST Management Division to investigate all leaking UST sites in a consistent fashion and to ensure that responsible parties act in an expeditious manner to perform the appropriate Site Assessments and, when circumstances dictate, implement an adequate remedial plan. The UST Management Division determines which actions are required at a release site based on the decision-making process outlined in the flow chart in Appendix A.

The policy of the UST Management Division is and will be to collect water and soil quality data that are scientifically valid, defensible, and of known accuracy. The UST Management Division presently uses existing guidance and the procedures outlined in this plan to ensure that investigations are accurately conducted and defensible in an administrative proceeding. Contractors certified by the UST Management Division to perform UST release investigations are required to submit a QA/QC plan with a site-specific QAPP Addendum or an Annual Contractor Quality Assurance Plan (ACQAP) with SSWPs based on USEPA QA/R-4 and this document, the UST Programmatic QAPP, prior to engaging in site activities.

III. Authority

The SCDHEC Underground Storage Tank Management Division Quality Assurance Program Plan is established under authority provided in Section II.A.1 of the South Carolina SUPERB Site Rehabilitation and Fund Access Regulations, R.61-98.

A6 Program Description

The SCDHEC UST Management Division treats each leaking UST site on a case-by-case basis. The UST Project Manager assigned to each site ensures progress on legal and routine actions and decides on the degree of remediation required based on several factors. The primary factor to be considered is whether a direct threat to human health or the environment currently exists. Such cases are prioritized, and direct action is taken to protect the public and environmental receptors. At a minimum, free phase product removal is required, to the extent practicable, wherever it is encountered. It is the goal of the UST Management Division to clean the groundwater to site-specific target levels (SSTLs) based on all current and potential receptors as measured by the sampling of monitoring wells throughout the CoC plume.

Because every site will be treated on a case-by-case basis, the UST QAPP is designed to be appended with specific site information for each release. These appendices are developed by Contractors and reviewed and approved by DHEC UST Project Managers. The UST Project Manager will ensure that all required information from a site is presented in a Site-Specific Work Plan (SSWP) or site-specific QAPP Contractor Addendum. The information will include, at minimum, a site map with the sampling sites indicated, the history of the site, the number of samples to be collected, when the sampling will take place, the Laboratory that will be used along with their DHEC Laboratory Certification Number, and who will collect the samples. The site-specific QAPP Contractor Addendum or SSWP will be submitted to the UST Project Manager for approval at least 15 business days before sampling is to commence. The site-specific QAPP Contractor Addendum (Appendix B) or SSWP (Appendix C) must be approved before site work begins. The UST Management Division has developed a format for these addenda.

For sites where repetitive data-producing activities such as quarterly monitoring are being conducted under an approved Corrective Action Plan (CAP), the Contractor will prepare the site-specific QAPP Contractor Addendum or SSWP one time at the initiation of CAP implementation and will be reviewed annually at a minimum and revised as changes warrant for the duration of activity under the CAP.

The QAPP for the UST Management Division detailed in this document describes the course of action for South Carolina leaking UST site activities. Site activities which generate environmental data include soil and water sample collection and analysis; soil boring and monitoring well installation; decontamination procedures; groundwater, geophysical, and other survey measurements; and data reduction and analyses. Site-specific QAPP Contractor Addenda or SSWPs present information specific to the site including location, topography, work schedules including the start and completion dates, and resource constraints.

All releases are prioritized in accordance with the ranking system outlined in Site Priority Classification detailed in this section. Releases qualified for funding from the SUPERB Account are funded in order of relative risk based upon availability of funds in the SUPERB Account. All other releases are investigated as rapidly as possible, depending upon the tank owner's ability to conduct necessary Site Rehabilitation activities. Each of the releases is unique depending on its components, the type of product stored, the local hydrogeologic conditions and the history of the release.

Initial investigations are conducted using standardized scopes of work (i.e., Initial Groundwater Assessment (IGWA), Tier I Assessment) that provide sufficient data on the extent and severity of contamination and the location of proximate potential receptors to allow preliminary ranking of the risk presented by a release and determination of subsequent scopes of work. Comprehensive investigations of releases that will require Site Rehabilitation are conducted in accordance with the Tier II Assessment work scope. The Tier II work scope provides a systematic approach to obtaining all of the data necessary to fully characterize the extent and severity of a release and determine its potential risk to human health and the environment. The Site Rehabilitation process outlines the data gathering necessary to document the progress and completion of site rehabilitation for petroleum releases. The UST Management Division will utilize a decision-making flow chart (Appendix A) to determine what scope of work is to be conducted at a site. UST Contractors are required to submit an addendum to this QAPP (see Appendix B) or if working under an approved ACQAP, an SSWP (see Appendix C) containing site information. This information includes site selection, work schedules, geographical locations, and time or resource constraints since this information is specific for each UST release project/site.

These and all other pertinent site activities that will generate environmental data will be subject to UST Programmatic QAPP requirements. Potential uses for collected environmental data include but are not limited to the estimation of the magnitude and extent of contamination, characterization of site conditions for development of remedial action procedures, and documentation of effectiveness of remediation.

The primary goal of the quality assurance program outlined in this document is to ensure that all data generated by or for the SCDHEC UST Management Division which relates to UST site activities will be scientifically valid, legally defensible, and of known and acceptable precision and accuracy. Specific objectives of the quality assurance procedures include the following:

1) All data generated for or by the UST Management Division will be of sufficient or greater quality to withstand scientific and legal challenge;
2) The intended use of all data and any limitations on that use will be determined and clearly defined before data collection efforts begin to ensure that the necessary levels of data quality are attainable;
3) All sample collections and analysis are project specific and will be defined in investigation work plan;
4) All data produced for or by the UST Management Division will be of known and acceptable precision, accuracy, representativeness, completeness, and comparability. Data not within specified quality parameters will not be accepted and the sample shall either be re-analyzed, re-extracted or re-digested, or if necessary, the sample re-collected; and
5) All projects will receive adequate supervision by the UST Management Division staff to ensure quality data is collected.

The structure of the Assessment and Corrective action process for identified USTs releases is described below.

I. THE RISK-BASED CORRECTIVE ACTION (RBCA) PROCESS

The Risk-Based Corrective Action (RBCA) process is a stepwise, tiered approach for the assessment and cleanup of UST releases. The steps of the RBCA Process are outlined below with a discussion of the site-specific factors that determine the actions required for a given release. The RBCA process is also illustrated as a flow chart in Appendix A.

a. RBCA Procedures

When a petroleum release from a UST facility is identified, owners/operators of facilities must ensure that initial abatement measures are taken to prevent further releases, control fire and explosion hazards, and remove accessible free phase petroleum product pursuant to SC UST Control Regulations, R.61-92.

Investigation plans, RBCA evaluation reports, Site Rehabilitation Plans, and Engineering Reports must be approved by the UST Management Division, as necessary, and in accordance with applicable guidance and regulations. All Site Rehabilitation activities related to UST releases must be performed by a SCDHEC certified Site Rehabilitation Contractor as required by the SUPERB Fund Access and Site Rehabilitation Regulations, R.61-98.

b. Risk Based Screening Levels

The RBCA process utilizes Risk Based Screening Levels (RBSLs) established to protect human health and the environment from exposures to specific contaminants in environmental media. RBSLs have been derived for the substances associated with petroleum most likely to be encountered in environmental media at a release site and to potentially cause adverse effects to human health and the environment.

The following substances are considered potential CoCs at all UST sites, and RBSLs have been derived to regulate their concentrations in water and soil: Benzene, Toluene, Ethylbenzene, and Xylenes, collectively referred to as (BTEX), Methyl tert-butyl Ether (MTBE), Naphthalene, 1,2-dichloro-ethane (DCA), Ethylene Dibromide or 1,2-dibromoethane (EDB), and lead. Polynuclear Aromatic Hydrocarbons (PAHs) heavier than naphthalene are considered to be potential CoCs at UST sites where kerosene and diesel fuel has been released. Metals, including arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are treated as potential CoCs when waste oil is suspected to have been released at a UST site. Action levels have been developed for several additional oxygenates, which have been added to petroleum, including: Ethyl tert-butyl ether (ETBE), 3,3-dimethyl-1-butanol, tertiary-amyl methyl ether (TAME), diisopropyl ether (DIPE), tert-butyl formate (TBF), tert-butyl alcohol (TBA), tert-amyl alcohol (TAA), and ethanol.

Analytical parameters for ranges of petroleum constituents, such as Gasoline and Diesel Range Organics (GRO and DRO), and Total Petroleum Hydrocarbons (TPH) analysis may be requested by UST project managers to determine the potential sources of petroleum contamination at a release site. Screening levels are not used for comparison to aggregate petroleum parameters because the toxicity of ranges of different compounds cannot be described accurately. The UST division does not employ a "surrogate" approach to the evaluation of toxicity of petroleum ranges, instead, the individual components of petroleum for which toxicity has been demonstrated are selected as individual CoCs.

II. SITE ASSESSMENT

Once a UST release has been identified, the information necessary to determine if emergency action is appropriate and to compare contaminant concentrations to RBSLs must be obtained. Initial Groundwater Assessment (IGWA) and Tier I Assessment activities are carried out to obtain the information necessary for completion of preliminary soil and groundwater quality evaluation and the completion of a Tier 1 Risk

Evaluation. Tier II Assessments are carried out if CoC concentrations in impacted environmental media require additional delineation.

III. SITE IDENTIFICATION AND PRIORITY CLASSIFICATION

An evaluation of potential immediate exposures to danger and environmental hazards is conducted upon the identification of a release. Emergency Action to eliminate immediate exposure is required as soon as such exposures are identified. The UST Management Division should be notified at (803) 898-2544 or, when necessary, an emergency can be reported directly to the Emergency Response Program at 1-888-481-0125 or (803) 253-6488. Appropriate actions must be implemented as soon as possible to eliminate an immediate threat. Typical release scenarios and response actions to eliminate immediate threats are provided in Table 2.

Scenario	Potential Initial Response
Explosive levels or concentrations of vapor are present in a residence or other building	Evacuate occupants; begin abatement measures such as ventilation.
Explosive levels are present in the subsurface utility system	Evacuate immediate vicinity; begin abatement measures such as ventilation.
Free-phase product is present in significant quantities at ground surface, on surface water bodies, or in utilities.	Prevent further free-phase product migration, institute recovery, monitor vapor concentrations.
An active water supply well, water supply line, or public water is impacted or immediately threatened.	Notify users, provide alternate water supply, and treat water point of use.
A sensitive habitat or sensitive resources are impacted.	Minimize extent of impact by containment measures and implement habitat management to minimize exposure.

Table 2. Potential Initial Response Actions to Eliminate Immediate Threats at Typical Release Sites

Releases are classified by SCDHEC into categories based on the current and projected degree of risk to human health and the environment identified during initial release investigation and subsequently upon completion of each tier evaluation. Site classification is an on-going process based on available information. Releases may be reclassified following abatement, further assessment information, and remedial actions.

Release sites are classified according to the following criteria:

Classification 1 - The highest priority classification is for those releases that pose an immediate threat to human health and the environment. Sites are placed in Classification 1 if:

a) An emergency situation exists;
b) A fire or explosion hazard exists;
c) Vapors or free product exists in a structure or utility;
d) Concentrations of CoC have been detected in a potable water supply or surface water supply intake;
e) Free product exists on surface water;
f) CoC exists in surface water.

Classification 2 - The second priority classification is for releases that pose a significant near term (0 to 1 year) threat. This Classification is subdivided into 2a and 2b. Sites are placed in Classification 2 if:

Classification 2a:

1) A significant near term (0 to 1 year) threat to human health, safety, or sensitive environmental receptors exists; or
2) Potable supply wells or surface water supply intakes are located < 1-year ground water travel distance down gradient of the source area.

Classification 2b:

1) Free product exists in a monitoring well at a measured thickness > 1 foot; or
2) Potable supply wells or surface water supply intakes are located < 1,000-feet down gradient of the source area (where ground-water velocity data is not available).

Classification 3 - The third priority classification is for those releases where there is a short-term (1 to 2 years) threat. This Classification is subdivided in to 3a and 3b. Sites are placed in Classification 3 if:

Classification 3a:

1) A short-term (1 to 2 years) threat to human health, safety, or sensitive environmental receptors exists;
2) Potable supply wells or surface water supply intakes are located > 1-year and < 2-years groundwater travel distance down gradient of the source area; or
3) Sensitive habitats or surface water exist < 1-year ground-water travel distance down gradient of the source area and the groundwater discharges to the sensitive habitat or surface water.

Classification 3b:

1) Free product exists in a monitoring well at a measured thickness > 0.01 feet;
2) Concentrations of CoC above the RBSL have been detected in a non-potable water supply well;
3) Hydrocarbon-containing surface soil (< 3-feet below grade) exists in areas that are not paved;
4) Sensitive habitats or surface water used for contact recreation exist < 500-feet down gradient of the source area (where ground-water velocity and discharge location data are not available);
5) The site is located in a sensitive hydrogeologic setting, determined based on the presence of fractured or carbonate bedrock hydraulically connected to the impacted aquifer; or
6) Ground water is encountered <15-feet below grade and the site geology is predominantly sand or gravel.

Classification 4 - The fourth priority classification is for releases where there is a long-term (> 2 years) threat to human health or the environment. This Classification is subdivided into 4a and 4b. Sites are placed in Classification 4 if:

Classification 4a:

1) A long-term (>2 years) threat to human health, safety, or sensitive environmental receptors exists;
2) Potable supply wells or surface water supply intakes are located > 2-years and < 5-years groundwater travel distance down gradient of the source area; or
3) Non-potable supply wells are located < 1-year groundwater travel distance down gradient of the source area.

Classification 4b:

1) Free product exists as sheen in any monitoring wells;

2) Non-potable supply wells are located < 1,000-feet down gradient of the source area (where groundwater velocity data is not available); or
3) The groundwater is encountered < 15 feet and the site geology is predominantly silt or clay.

Classification 5 - The fifth priority classification is for releases where there is no current demonstrable threat to human health or the environment but where data indicate COC concentrations are above the RBSLs and further assessment is needed. Groundwater travel times are calculated from the monitoring well closest to the exposure point that contains concentration of COCs above the RBSLs. Sites are placed in Classification 5 if:

1) There is no demonstrable threat, but additional data are needed to show that there are no unacceptable risks posed by the site;
2) assessment data for the site indicate concentrations of chemicals of concern are above the risk-based screening levels or site-specific target levels, as appropriate, and further assessment is needed; or
3) Assessment data for the site indicate concentrations in sample are below the RBSL or SSTL, as appropriate, but the samples are determined not to be representative, therefore, further assessment is needed.

IV. INITIAL GROUNDWATER ASSESSMENT (IGWA) WORK SCOPE

An IGWA is conducted at sites where a release of petroleum from a regulated underground storage tank (UST) has been confirmed and preliminary information is necessary to categorize the release. The objective of this scope of work is to determine the initial risk classification of the confirmed release by conducting a receptor survey, installing one groundwater monitoring well, and collecting and analyzing one soil and one groundwater sample for petroleum chemicals of concern. The general elements of an IGWA are outlined in the section below. Report requirements are detailed in Section A9, and field investigation requirements in Section B. The following primary components of the IGWA are intended to determine whether a reported release requires additional investigation:

1) A receptor survey including the location of all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the Risk Based Corrective Action (RBCA) Process (i.e., utilities, surface waters, wetlands, basements) within a 1,000-foot radius of the site;
2) Documentation of land use at the site and adjacent land as residential, commercial, agricultural, industrial, etc. Any UST site(s) within a 500-foot radius of the subject site and their UST permit number(s) should be documented in the Report of Findings;
3) Monitoring Well or Boring Installation documentation (Section B1);
4) A description of Soil and Groundwater Sampling and Analyses and a presentation of results in comparison to RBSLs. (Section B2); and
5) Presentation of all results in a Report of Findings Submitted to the owner/operator and UST Management Division.

V. TIER I ASSESSMENT WORK SCOPE

A Tier I Assessment is conducted at sites where a release of petroleum from a regulated UST has been confirmed and additional information is necessary to classify the release in the RBCA process (See

Appendix A for flow chart). The sampling and data collection requirements for a Tier I assessment are presented in Section B. The work scope requirements for Tier I Assessments include:

1) A review of historical records of site activities and past releases;
2) Quantification of the CoCs and biological indicator parameters in soil and groundwater as specified by the UST Project Manager;
3) Location of primary source(s) of CoCs: - USTs, product lines, dispensers, service bays, etc.;
4) Location of secondary source(s) of CoCs: - free-product, soil with concentrations above RBSLs, etc.;
5) Determination of regional or site-specific hydrogeologic conditions (e.g., depth to ground water, flow direction, gradient, ambient groundwater quality, groundwater flow velocity);
6) Location of current and reasonable future potential receptors within 1,000 feet of the site
7) Identification of potential significant transport and exposure pathways. A complete exposure pathway includes:
    i. A source and mechanism for CoC release into the environment;
    ii. A transport medium (e.g., air, soil, groundwater, vapor migration through soil and utilities) for the CoC to move from the source to a receptor;
    iii. A point of potential contact of the receptor with the medium (points of exposure such as drinking water wells, surface water bodies); and
    iv. An exposure route or for the CoC to affect a potential receptor (e.g., ingestion, inhalation, dermal contact).
9) Determination of current and reasonably anticipated future uses of the property, groundwater, surface water, and sensitive habitats for the site and adjacent properties. Use of property shall be determined based on factors such as: zoning laws; comprehensive infrastructure such as transportation and public utilities; existing institutional controls, such as deed restrictions; site location in relation to urban, residential, commercial, industrial, agricultural, and recreational areas; Federal/State land use designation; historical or recent development patterns; and location of wellhead protection areas;
10) Documentation, if available, of changes in CoC concentrations over time (i.e., stable, increasing, decreasing);
11) Documentation, if appropriate, of CoC concentrations measured at point(s) of exposure (e.g., in nearby drinking water wells, CoC vapor concentrations identified in nearby utilities); and
12) Collection of water and/or air samples, as appropriate, from any existing exposure point (well, underground structure, water body) that has a potential of being impacted by virtue of its proximity to the source.

VI. TIER 1 EVALUATION

Data obtained from an IGWA allows comparison of CoC concentrations to the soil and groundwater RBSLs to determine if additional Tier I or Tier II Assessment is required.

Data obtained from a Tier I Assessment are used in three steps to complete the Tier 1 Evaluation:

c. Comparison with RBSLs

For a Tier 1 Risk Evaluation, it is assumed that all exposure points are located in or near the source area. CoC concentrations should be compared with the values provided in the RBSL Tables in Appendix D for the groundwater ingestion, soil leaching to groundwater, vapor inhalation, and soil ingestion pathways. For other chemicals of concern not included in Appendix D, the RBSLs may be calculated based on an estimated increased lifetime cancer risk limit of 10^{-6} and a hazard index of 1. As the toxicity of TPH concentrations is not accurately quantifiable, it is not used in the risk decision-making process. Each CoC is evaluated separately for each exposure route, as SC RBCA does not consider the additive effect of risk from different CoCs and different routes of exposure.

Exposure point concentrations of CoCs in impacted media are determined by the following during Tier I evaluations:

Groundwater - The maximum CoC concentration obtained during the most recent sampling event should be used. Historical sampling events can be used to establish trends.

Soil - The maximum CoC concentration obtained during the last sampling event should be used for the ingestion and dermal contact pathways. For the soil leaching to groundwater pathway, the average of two soil sample results or highest single sample with the highest non-zero concentrations from each source will be compared with RBSLs.

Air - The maximum CoC vapor concentration obtained during the most recent sampling event should be used. Historical sampling events can be used to establish trends.

d. Site Conceptual Exposure Model

A site conceptual exposure model uses information about the following to identify all complete and potential exposure pathways:

1) Release information

Pertinent release information includes but is not limited to: the historical use of the property where the release occurred, the approximate age of the release, and the properties of the CoC (e.g., solubility, volatility) that were released.

2) Site Characteristics

Pertinent site characteristics include, but are not limited to: geology, soil type, depth to bedrock, depth to groundwater, bulk density, porosity, water content, hydraulic gradient, ground-water flow direction, seepage velocity, fractional organic carbon and the physical distribution of each CoC around the source.

3) Proximity of existing potential receptors and their characteristics:

i. The construction specifications (e.g., depth, diameter, and material of construction of a private well or storm sewer) of all existing potential exposure points should be identified;
ii. Location of all aquatic receiving environments (e.g., rivers, lakes, marshes, etc.) within 1,000 feet; and
iii. The current land use should be identified for each property that is impacted, may potentially become impacted, or is adjacent to a potentially impacted property, (e.g., vacant lot, restaurant, school, residence, factory).

4) Applicable zoning or land use ordinances

The local city or county administrative authorities should be contacted for information pertaining to any restrictive zoning and land use ordinances. Zoning ordinances set broad-scale restrictions on property development such as residential, commercial, or industrial. Land use ordinances may establish smaller scale restrictions such as disallowing the installation of drinking water or irrigation wells. A photocopy of the applicable sections of the ordinances should be provided. If a copy cannot be obtained, the ordinance number and the name, phone number, and business address of the appropriate city or county authorities should be provided with the relevant information.

5) Potential Exposure Pathways

Based on the estimated age of the release, known distribution of the CoCs, and the potential for migration, all complete and potential exposure pathways should be identified and summarized for land use (current and future conditions). For example, drinking water wells may not currently exist but ground water may reasonably become a source of irrigation or drinking water. The following potential exposure pathways should be considered for evaluation:

Environmental Medium	Potential Exposure Pathways
1. Air	- Vapor Inhalation - Explosive hazard
2. Surface Water	- Ingestion - Dermal contact - Inhalation of Volatiles (enclosed space and outdoor)
3. Groundwater	- Ingestion - Dermal contact - Inhalation of Volatiles (enclosed space and outdoor)
4. Surficial Soil	- Ingestion - Dermal contact - Inhalation of Particulates
5. Subsurface Soil	- Ingestion (during excavation) - Dermal contact (during excavation) - Inhalation of Particulates - Leaching to groundwater

Table 3. Potential Exposure Pathways

Exposure routes and pathway summarization for the site conceptual model are shown in Appendix E.

e. Identify Additional Data Requirements

For each complete or potential exposure pathway identified in the site conceptual model, identify the data necessary to evaluate potential risk associated the pathway and to quantify the potential impact. For example, if the accumulation of vapor phase contaminants in a utility is a concern, additional data may be necessary to characterize the transport of the CoC from the source to the utilities via ground water, the extent of volatilization from the ground water, the transport of vapors from the ground water to the utility, and the construction specifications (material of construction and types of seals) of the utility. These data requirements would then become an integral part of a Tier II assessment. The site conceptual model format for various media of exposure should be summarized in the tables given in Appendix E and included in the final report as required in Section A9 of this document.

VII. TIER 1 EVALUATION OUTCOMES

Once the Tier 1 Evaluation is completed, three decision options are available for consideration based on CoC concentrations and site characteristics:

a. No Further Action

If the exposure point concentrations (see Tier 1 Evaluation for an explanation of the representative concentrations) of the CoCs are below the RBSLs, further assessment and/or cleanup is not necessary (see No Further Action Decisions).

b. Emergency Action

Typical release scenarios and response actions to eliminate any immediate threat are provided in Table 2. Emergency Action to eliminate immediate exposure is required. The Underground Storage Tank Management Division should be notified at (803) 898-2544, or when necessary, an emergency can be reported directly to the Emergency Response Program at 1-888-481-0125 or (803) 253-6488. Appropriate actions must be implemented as soon as possible to eliminate an immediate threat.

c. Concentration above RBSLs

If the concentrations of the CoCs are above the RBSLs, a Tier II Assessment is warranted under the following conditions:

1) If CoC concentrations exceeds the RBSL but it is predicted that the use of site-specific data will allow substantially different Site-Specific Target Levels (SSTLs) to be determined;
2) If the cost of remedial action to reach RBSL will likely be greater than Tier II Evaluation (data collection, analysis, review, etc.) and subsequent remedial action;
3) Free phase product is present; or
4) The approach or assumptions used to derive the Tier I goals are not appropriate for conditions at the site.

VIII. TIER II ASSESSMENT

Additional Site Assessment may be required to fully evaluate the current and future exposure pathways identified in the Tier 1 Evaluation. The Tier II Implementation section outlines a comprehensive Site Assessment approach for obtaining the additional information necessary for a Tier 2 Evaluation. The Tier II Assessment is used for sites with petroleum releases from regulated underground storage tanks (USTs) where additional investigation of site-specific conditions is warranted based on existing data from previous investigations. Tier II Assessment defines site geology and the extent of the contamination horizontally and vertically. The number and placement of wells and borings are not specified in this QAPP.

Tier II Assessments include:

1) Determination of geology;
2) Description of the site-specific hydrologic conditions;
3) Delineation of the extent of free-phase product;
4) Determination of horizontal and vertical extent of each CoC above its RBSL, as appropriate;
5) Determination of changes in concentrations of each CoC over time (i.e., increasing, stable, or decreasing with time);
6) Determination of concentrations of each CoC measured at exposure points (e.g., in a nearby drinking water well, vapor concentration of nearby utilities); and
7) Evaluation of fate and transport of each CoC.

This section describes the minimum elements necessary for a Tier II Assessment while allowing technical flexibility so that the work may be completed in an effective manner. The purpose of the Tier II Assessment is to define the site geology and the extent of all petroleum CoCs (to include RCRA metals for waste oil USTs) as well as identify all current and potential receptors that could be impacted by the release from a regulated UST system. The results of the Tier II Assessment are to be used to establish appropriate site-specific target levels and recommendations for future actions as outlined in the Risk Based Corrective Action (RBCA) Process Section.

a. Tier II Assessment Report Requirements and Responsibilities

All Site Rehabilitation activities related to a release from a regulated UST system require technical approval by the UST Management Division in accordance with applicable state regulations. All Site Rehabilitation activities must be conducted by a SCDHEC Class I certified Site Rehabilitation Contractor as required by the SUPERB Site Rehabilitation and Fund Access Regulations, R.61-98, whether reimbursement will be from the SUPERB Account or other financial mechanism. A qualified professional from the company or firm must sign and seal the Tier II Assessment Report and any other submittals that are based upon interpretation of data (e.g., monitoring well location plans) and their South Carolina P.E. or P.G. license number and SCDHEC certified Class I Site Rehabilitation Contractor number must be on the signature page of the report/submittal. All temporary and other monitoring wells must be drilled by a licensed class A, B, or C South Carolina Certified Well Driller. All laboratory analysis must be performed by a South Carolina Certified Laboratory for the specified parameters. All investigative derived waste must be handled within 90 days of generation in accordance with applicable state and federal regulations.

For off-site access, the Contractor and/or UST owner/operator must obtain all off-site access agreements and/or encroachment permits necessary for investigation and well installation. The UST Management Division will assist in acquiring access if all efforts to gain access fail, and the tank owner/operator requests assistance from the UST Management Division in writing. When off-site access assistance is requested, the following items must be provided to the UST Project Manager:

1) The property identification to include the tax map number of the property, (e.g., 00020-304-10-01A), and 911 street address, (e.g., 201 South Main);
2) The property owner's complete name, address, and telephone number;
3) A map with the locations of all proposed temporary screening points or monitoring well locations for each parcel or property. To ensure the exact parcel is identified, the map should clearly show include the distance from properly identified state or county road intersections; and
4) Copies of all previous correspondence to and from the property owner(s).

b. Tier II Assessment Plan

A concise Site-Specific Work Plan and, if applicable, QAPP Contractor Addendum and Tier II Assessment Plan shall be submitted to the UST Management Division by the tank owner/operator or on their behalf by their Site Rehabilitation Contractor for approval prior to implementation. To assist with preparation of the Tier II Assessment Plan, the Freedom of Information Office may be contacted at (803) 898-3882 to obtain the technical file of the release being investigated if previous site data is not available from the tank owner/operator or if information concerning adjacent UST or Aboveground Storage Tank (AST) facilities is required. The Tier II Assessment Plan included as part of the site-specific QAPP Contractor Addendum or Site-Specific Work Plan shall include as a minimum:

Site information – A summary of all general information including Facility Name, Address, Phone Number, and UST Permit number; the name, address, phone number of the UST owner/operator responsible for investigating the release(s); the current property owner; the Site Rehabilitation Contractor; and the well driller. If the tank owner/operator responsible for Site Rehabilitation is different from the current tank owner, include the name, address, and phone number for the current tank owner.

Figures - This section must include a copy of the relevant portion of a USGS 7.5 min topographic map showing the site location, and a scaled site map. The site map shall conform to industry standards and must include as a minimum: a north arrow, a legend, a bar scale, and the date of data collection. Identify the site by the facility name, complete street address, and UST permit number. The map should indicate the location and identity of all on-site and adjacent structures, existing and/or former UST(s), AST(s) and associated underground piping; identify all streets and/or highways; locate property lines, paved areas, and existing monitoring and other wells (e.g. vapor monitoring wells). All water supply wells (potable, municipal, irrigation) will be accurately located on the topographic and/or site map.

Field Screening Methodology - The use of field screening methods to optimize the number and location of permanent monitoring wells is highly recommended. The selection of field screening methodologies is at the sole discretion of the contractor. The specific field screening methodologies shall be discussed, and the proposed location, number and depth of screening points shall be indicated. It is the responsibility of the contractor to ensure the horizontal and vertical extent of CoCs are defined prior to installation of monitoring wells.

Monitoring Wells - The maximum number and depth of monitoring wells, to include soil borings and temporary wells used for screening, estimated to be necessary to define the concentrations and extent of free-phase product and groundwater CoC shall be included in the site-specific QAPP Contractor Addendum or Site-Specific Work Plan. If the Contractor later determines this number to be insufficient, approval of additional monitoring wells or additional footage may be requested from the UST Project Manager. Additional wells require the UST Management Division's technical approval as well as financial pre-approval if costs are to be reimbursed from the SUPERB Account or will be applied toward a SUPERB deductible. To provide a record of the request by the Contractor and approval by The UST Management Division, it is recommended that any additions be requested by e-mail to the appropriate UST Project Manager.

Implementation Schedule – The Contractor shall propose a schedule indicating the time frame required for submittal of the Tier II report after notification to proceed from the UST Management Division. The due date of the report will typically be 90 to 120 days from the approval date of the site-specific QAPP Contractor Addendum, or Site-Specific Work Plan and Tier II Assessment Plan, unless otherwise designated by the UST Management Division. If the work cannot be completed as specified, the UST Project Manager must be notified immediately. A change in the report due date may be issued for work to continue if adequate justification is provided. To provide a record of the request by the Contractor and approval by the UST Management Division, it is recommended that the appropriate UST Project Manager be notified by e-mail.

In some cases, the UST Management Division may predetermine a defined scope of work to meet a specific goal(s) (e.g., installation of a compliance well, resample the existing monitoring well network, free product recovery wells, free product recovery test) and plan preparation by the Contractor will not be necessary. In these instances, the UST Management Division will notify the tank owner/operator and his designated Site Rehabilitation Contractor to proceed with the required work and a due date will be assigned.

c. Tier II Implementation

Objectives - The objectives and performance standards of the Tier II Implementation are:

1) To delineate the horizontal and vertical extent of CoCs in the soil and groundwater;
2) To identify and evaluate all exposure pathways based on a current survey of existing and potential receptors;
3) To characterize the nature of the CoCs present;
4) To define the site geology and hydrogeology; and
5) To use fate and transport analysis to predict the actual or potential impacts of CoCs on receptors if requested by the UST Management Division. The UST Management Division shall allow some flexibility in meeting this objective, provided that the contractor meets the first four performance standards.

d. Potential Receptor Survey

Utilities Survey / Site Survey- To successfully complete the existing receptor and utility surveys the contractor shall:

1) Locate all private and public water supply wells within 1000 foot radius of the site and sample, when necessary, as detailed below in Section B2;
2) Record the current use (residential, commercial, agricultural, industrial) of the site and adjacent land including all properties having a monitoring well associated with this facility. All adjacent

properties with tanks (underground, above ground, or heating oil) that are active or closed will be identified. If the tanks are permitted, the applicable permit number(s) will be provided. Information pertaining to any applicable zoning and land use ordinances shall be obtained from local city or county administrative authorities. Zoning ordinances set broad-scale restrictions on property development such as residential, commercial, or industrial. Land use ordinances may establish smaller scale restrictions such as disallowing the installation of a drinking water or irrigation well. A copy of the applicable sections or a summary of the ordinances shall be provided. Additionally, the name, phone number, and business address of the appropriate local authorities shall be provided with a summary of the relevant information. A photocopy of local regulations or ordinances is not required;

3) If not previously submitted, provide a copy of the applicable portion of the county tax map. This map shall depict the location of the facility, all impacted properties, all properties located adjacent to the impacted properties, and any property on which a monitoring well (to include temporary wells) was installed as part of the investigation. Provide a table listing the names and addresses of the owners of each of these properties and the name of all wells (monitoring, irrigation, potable, etc.) on that property or parcel;
4) Locate and report all underground utilities (electrical, natural gas, telephone, fiber optic, water, cable TV, storm drain, and sewer lines) within a 500 foot radius of the site, or 500 feet from the edge of the plume, whichever is greater, on a one inch equals 50 foot map unless another scale is approved by the UST Project Manager. Depict all identified underground utilities, both on and adjacent to the property, on a scaled site map to within one foot. The depth (within 2 feet) also shall be reported; and
5) The Contractor must provide a comprehensive facility survey if not already completed. A South Carolina Licensed Land Surveyor must perform the survey. The surveyed map should meet the requirements detailed below in Section A9. Only one comprehensive survey will be required per Tier II Assessment for surveyed areas. If the area was previously surveyed, only a subsequent survey to locate new soil borings, or monitoring wells on the original survey plat will be required.

e. Subsurface Investigation

Described below in: Section B1 - Sampling Process Design/Experimental Design).

IX. TIER 2 EVALUATION

The Tier 2 Risk Evaluation consists of three sub-steps: establishing exposure point(s), establishing the site-specific points of compliance, and calculating the corresponding SSTL for each CoC for identified points of compliance and verification.

a. Establish the exposure point(s)

An exposure point is the point at which it is assumed that a receptor (either actual or potential) can currently or in the future come into contact with the CoC. Exposure points may include, but are not limited to:

1) Private and public water supply wells;
2) Irrigation wells;
3) Surface water bodies (e.g., lakes, streams, rivers);
4) Sensitive habitats (e.g., wetlands, fisheries, shellfish areas); and
5) Underground utilities, building basements, etc.

Note: All current and future exposure pathways should be considered for each CoC.

An exposure pathway is the course that the CoC takes from the source to a human or environmental receptor. To determine if the pathway is complete, the Tier 2 Risk Evaluation must provide sufficient information to identify the source and the transport mechanisms to the exposure point. For example, if a CoC reaches an underground utility, the construction material (e.g., PVC, ductile iron, etc.) of the underground utility and the types of seals (e.g., glue, neoprene, etc.) at the pipe couplings should be identified and used to determine if a potential exists for the CoC to enter those lines resulting in an exposure to the receptor. However, if utilities are at three feet below land surface and groundwater is at 35 feet, a complete exposure pathway probably does not exist. For a given medium and exposure route, if a risk does not exist for a selected pathway then the exposure point should not be evaluated further.

For the groundwater ingestion pathway, the exposure point must be established based on current and reasonably anticipated future use of the groundwater. Table 4 and Figure 2 give examples of exposure points for various possible situations. Please refer to the Site Conceptual Exposure Model for details on how to identify if the adjacent property is a possible exposure point.

b. Establish Point(s) of Compliance

A point of compliance is a location selected between the source area (area of maximum concentrations) and the exposure point where the concentration of each CoC must be at or below the Compliance Point Concentration (CPC). Typically, the CPC is between the SSTL at the source area and RBSL applied at the exposure point. Points of compliance should be established down gradient of the source area but hydraulically up gradient of an exposure point. At least one point of compliance must be located between the source area and the exposure point for each completed pathway, with a minimum of one-year travel time for the CoC from the point of compliance to the exposure point. Additional point(s) of compliance are necessary where complex hydrogeological conditions exist that may control CoC migration.

When establishing point(s) of compliance the following factors must be considered:

1) Locations of current receptors;
2) Locations of potential receptor(s);

3) Current and projected land and resource usage; and
4) Velocity of the CoC in soil, groundwater or air.

Site Status	Down gradient offsite property status	Compliance Point should be located	Figure
Actual or potential source of water	Source of water or not	At source area	2a
Within the radius of influence of a pumping well	Source of water or not	At the edge of the well's radius of influence	2b
No Exposure Point on the property	Off-site aquifer is a source of water	Closest off-site property boundary	2c
No Exposure Point on the property	Off-site aquifer is not a source of water	Hydraulically up gradient of a potential receptor	2d

Table 4. Choice of Compliance Points

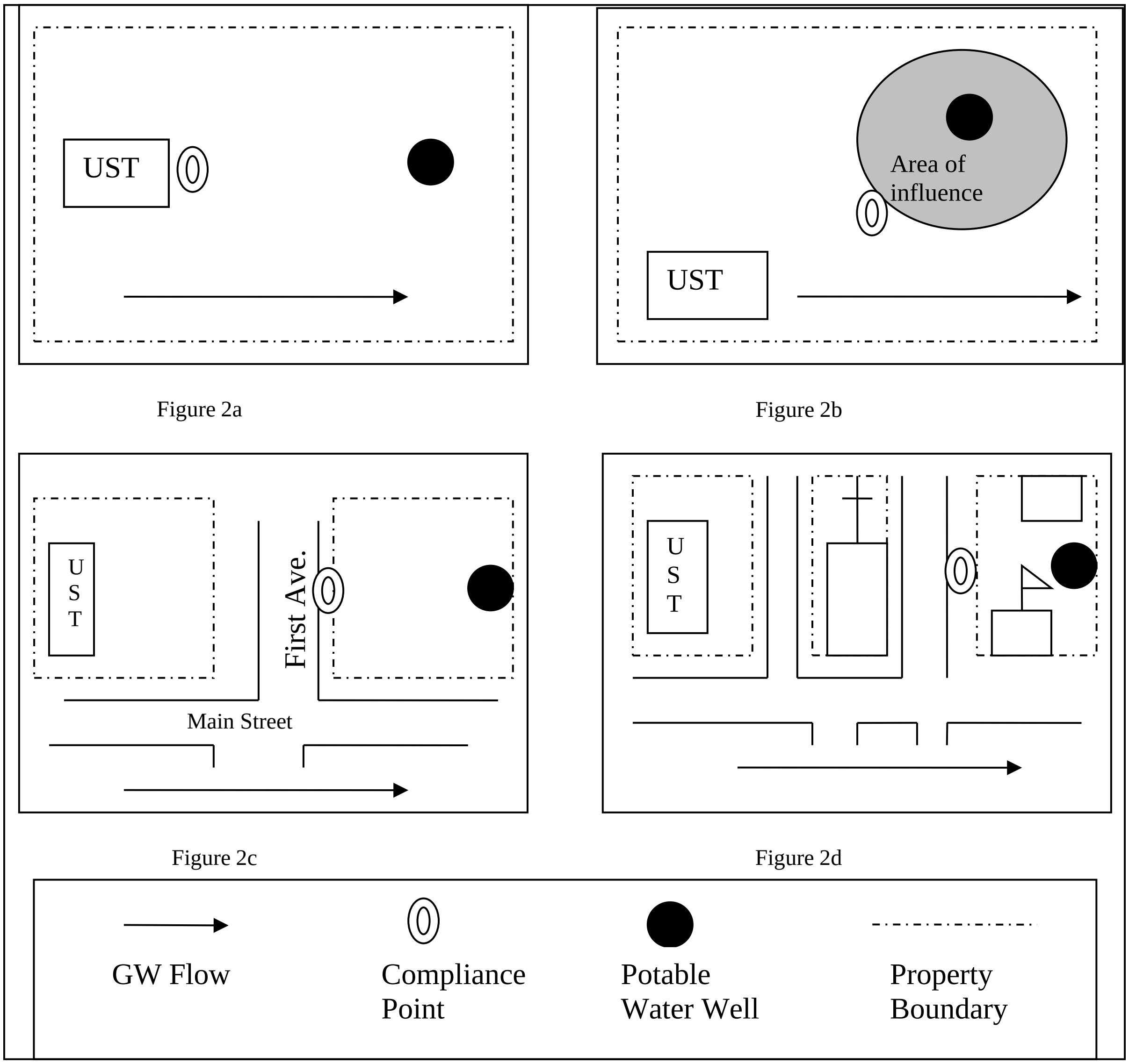


Figure 2. Figures of Compliance Points

c. Establish Site Specific Target Levels

Site-specific target levels (SSTLs) should be established for each CoC and each exposure pathway identified in the site conceptual model based on the spatial and temporal (both measured and predicted) attenuation of the concentration of each CoC above the RBSL. All possible scenarios must be evaluated during this process utilizing simple fate and transport models. Input data can be limited to site-specific data attainable through standard industry practices. All assumptions must be listed and fully explained.

The following steps should be followed to complete the Tier 2 Evaluation:

1) For the soil leaching to groundwater pathway, the SSTL for soil can be calculated using the leachability model provided in Appendix H. Following the method described below, it may be

appropriate to first calculate the SSTL for the groundwater pathway before using the leachability model. The soil SSTL must be protective of the estimated SSTL for groundwater;

2) For the groundwater ingestion pathway, there are two methods that can be used to estimate the reduction of CoC in the saturated zone:
   i. Using empirical data; or
   ii. Models implemented with site-specific data.
3) In a case where the CoC plume is shown to be stable or shrinking (by monitoring data), empirical data can be used to approximate the Concentration Reduction Factor (CRF) of the CoC in the relevant medium from the source to the compliance point. For example, if the concentration of benzene in a source area is 100 micrograms per liter (µg/L) and the actual measured non-zero concentration in the most down gradient monitoring well is 10 micrograms per liter (µg/L), and then benzene has been documented to be reduced by a factor of 10 (i.e., the CRF is 10). The SSTL = RBSL X CRF. Since the groundwater RBSL for benzene is 5 µg/L to be applied at the exposure point, the SSTL for groundwater to be met at the source area is (5 µg/L * 10) =50 µg/L;
4) Fate and transport models can also be used to calculate the SSTLs. SSTLs are typically calculated by calibrating the model using actual measured site-specific data and then, increasing or decreasing the concentration in the source area until the concentration at the exposure point will not exceed the RBSL. For sites with site-specific conditions that may warrant a more complex analysis, it may be appropriate to utilize computer models such as Bioscreen, Solute, AT123D, Bioplume II, and other applicable models to calculate the SSTLs. All assumptions made must be valid and the input parameters, along with explanation for their choice, must be provided with the modeling results; and
5) SSTLs for the dermal contact, soil and groundwater ingestion and vapor inhalation pathways shall be based on an increased lifetime cancer risk limit of 10^{-6} and a hazard index of 1 for non-carcinogenic effects to be applied at the exposure point. Each chemical is evaluated separately for each exposure route, as the S.C. RBCA process does not consider the additive effect of risk from different chemicals and different routes of exposure. The state toxicologist will be consulted as necessary to provide recommended exposure limits.

X. TIER 2 EVALUATION OUTCOMES

Once the Tier 2 Evaluation is completed, three decision options are available for consideration based on the CoC concentrations:

a. Monitored Natural Attenuation Action (MNA)

If the representative concentrations of the CoCs are below the SSTLs, and further CoC delineation is not necessary, a Corrective Action Plan (CAP) proposing a short-term (e.g., 18 months or less) monitoring program to verify natural attenuation should be submitted. The Site Rehabilitation work scope describes the details of demonstrating natural attenuation.

b. Active Corrective Action

If the concentrations of the CoCs are above the SSTLs and Tier III Assessment is not considered to be necessary, Site Rehabilitation to achieve Tier II SSTLs should be recommended. Free-phase product must be removed to the extent practicable pursuant to R.61-92, Section 280.64.

If the concentrations of CoCs are above the SSTLs, Tier 3 Evaluation is warranted under the following conditions:

1) If the SSTLs developed under Tier 3 Evaluation are anticipated to be significantly different than the Tier II SSTLs (i.e., concentrations of CoC exceed the SSTLs but it is predicted that the use of site-specific biodegradation data will allow different site-specific cleanup goals to be determined);
2) If the cost of remedial action to Tier II SSTL will likely be greater than Tier 3 Evaluation (data collection, analysis, review, etc.) and subsequent remedial action; and
3) The approach used to derive the Tier II goals is not appropriate for conditions at the site.

c. Tier III Assessment

Tier III Assessments are described in the following section.

XI. TIER III ASSESSMENT

In a Tier III Assessment, SSTLs for the source area and the point(s) of compliance are developed on the basis of more sophisticated statistical and CoC fate and transport analyses using site-specific input parameters for appropriate exposure scenarios. Any additional information required for site-specific modeling efforts should be proposed in a Tier III Assessment Plan.

XII. TIER 3 EVALUATION

The Tier 3 Evaluation involves the use of more sophisticated mathematical models than those used in Tier II (e.g., computer analytical models) or numerical groundwater modeling codes that predict time dependent dissolved CoC transport under conditions of spatially varying permeability fields to predict exposure point(s) concentrations and to re-calculate SSTLs based on more site-specific data. Monte Carlo models, which allow a range of fate and transport scenarios to be calculated, may also be appropriate. Less conservative site-specific exposure factors can be used in calculations for commercial and industrial sites if pre-approved by the UST Management Division. All assumptions, methods and models must be submitted for pre-approval.

XIII. TIER 3 EVALUATION OUTCOMES

Once the Tier 3 Evaluation is completed, two decision options are available for consideration based on the CoC concentrations:

a. Monitored Natural Attenuation (MNA)

If the concentrations of the CoCs are below the Tier 3 SSTLs, further CoC delineation is not necessary. A CAP proposing a short-term monitoring program to verify natural attenuation should be submitted. The Site Rehabilitation section describes the details of demonstrating natural attenuation.

b. Active Corrective Action

If the concentrations of the CoCs are above the Tier 3 SSTLs, an active cleanup to achieve Tier 3 SSTLs should be recommended.

The following table gives a comparison of the three Tier Evaluations:

Item		Tier 1 Evaluation	Tier 2 Evaluation	Tier 3 Evaluation
Screening Levels		RBSLs	RBSLs/SSTLs	RBSLs/SSTLs
Representative Concentrations – Air		Maximum CoC Concentrations	Maximum CoC Concentrations	Maximum CoC Concentrations
Representative Concentrations - Soil	Ingestions, Inhalation & Dermal Contact	Maximum CoC Concentrations	Maximum CoC Concentrations	Maximum CoC Concentrations
	Leachate	Maximum Concentration or average of samples	Maximum Concentration or average of samples	Maximum Concentration or average of samples
Representative Concentrations – Water		Maximum CoC Concentrations	Maximum CoC Concentrations	Maximum CoC Concentrations
Target Increased Cancer Risk Limit		1×10^{-6}	1×10^{-6}	1×10^{-6} or as approved
Non-Cancer Hazard Index		1	1	1 or as approved
Exposure Factors		Not Applicable	Not Applicable	Default or Site-specific
Fate & Transport		Not Applicable	Domenico or equivalent	Numerical Models
Leachate		Not Applicable	Leachability Model	Leachability or other
Air		Not Applicable	Vapor Models or Data	Vapor Models or Data
Main Steps		Compare RBSLs, Site Conceptual Exposure Model, Receptors, Data requirements	Establish: Exposure Points, Points of Compliance and SSTLs	Further refine SSTLs based on additional data & modeling
Locations where RBSLs are applied		Source Area(s)	Exposure Point(s), Compliance Point(s)	Exposure Point(s)
Data Collection		Source Area Characterization	Complete Plume Delineation	Detailed site-specific biodegradation study
Outcome of Evaluation		NFA, Tier 2 Evaluation, Emergency Action	NFA, CNFA, Corrective Action, Tier 3 Evaluation	CNFA, NFA, Corrective Action

Table 5. Assessment Tier Comparison

XIV. SITE REHABILITATION (ACTIVE OR MNA)

The selected active Site Rehabilitation methodology must be designed to achieve SSTLs for each CoC. An appropriate monitoring program will be required to ensure that the target goals continue to be met and the receptor(s) are protected. Once the SSTL for every CoC is achieved, a verification-monitoring program to demonstrate natural attenuation should be implemented. DHEC approvals and/or permits are required for all Corrective Action Plans (CAPs), air and water discharges, underground injection, etc. Quarterly Corrective Action System Evaluation (CASE) reports are required for Sites in active corrective action. Detailed design specifications must be developed for installation and operation of above ground remediation systems. All planned Site Rehabilitations, whether active or MNA, will be placed on public notice as required by the South Carolina UST Control Regulations (R.61-92, 280.67) to allow potentially affected parties to participate in the Site Rehabilitation decision making process.

Based on the concentration of each CoC and its potential risk to receptors, there are two processes of Site Rehabilitation:

a. Active Site Rehabilitation

This term, synonymous with remediation, refers to physical actions taken to reduce the concentrations of CoC. Active Site Rehabilitation is applicable where:

1) The concentration of any CoC exceeds the SSTL and must be reduced to prevent an impact to an actual or potential receptor;
2) Free phase product is present with a thickness greater than 0.01 feet or 1/8 inch; or
3) The plume continues to increase in size, CoCs continue to migrate away from the source, or the concentration of any individual CoC is increasing at a compliance point.

b. Intrinsic Remediation or Natural Attenuation

These terms refer to the naturally occurring microbial and fate and transport processes that result in a reduction of the total mass of hydrocarbons. Intrinsic remediation is applicable where:

1) The concentration of any CoC exceeds the RBSL but is less than the SSTL;
2) Measurable free product is not present;
3) The CoC plume is at or approaching equilibrium (i.e., the advancement of the plume is slowing down), and the concentration of a CoC is not increasing at any point;
4) Predicted exposure point concentrations do not exceed the RBSL at any time (i.e., no predicted risk to human health or the environment); and
5) All conditions for intrinsic remediation can be verified in 18 months or less.

An intrinsic approach may need to be upgraded to Active Site Rehabilitation if the above conditions cannot be demonstrated; a new or potential receptor is identified, or if there is a change in land use or zoning ordinances.

XV. VERIFICATION MONITORING FOR MONITORED NATURAL ATTENUATION

During or following a Site Rehabilitation, a compliance monitoring program may be required to ensure that the target goals continue to be met and the assumptions and predictions used in Tier II and III assessments are verified. In order to reach these goals, appropriate monitoring parameters (organic and inorganic, as necessary), frequency of monitoring, and monitoring methods will be established based on site-specific requirements. Once monitoring data support the conclusion that the contaminant plume has reached equilibrium or is not moving at a significant rate; that concentrations of CoCs are not increasing; that no unacceptable to risk to human health, safety, or the environment exists; and that the CoCs will naturally attenuate over time, no further action under S.C. RBCA is necessary.

XVI. NO FURTHER ACTION DECISIONS

No Further Action (NFA) decisions will be issued by the UST Management Division for underground storage tank releases where additional Site Rehabilitation actions are not required. An NFA is issued for release sites where each CoC for soil, vapor and groundwater has decreased to the RBSL. A Conditional No Further Action (CNFA) may be issued upon the UST Management Division's concurrence that the petroleum CoC concentrations are less than SSTLs but still greater than RBSLs. Such decisions can be reached only when verification monitoring documents that natural attenuation is taking place, and that no risk to human health or environment will result. For example, if concentrations of CoCs are present but below SSTLs in the groundwater in areas where human consumption is prevented by local ordinances, then no further actions are necessary and a CNFA may be issued. Again, this decision is based on the demonstration that the release does not pose a risk to human health or the environment. The UST Management Division's CNFA decision will be issued in writing to the owner/operator and all assumptions and conditions will be outlined (e.g., groundwater on the property should not be used for consumption).

A registry of releases is maintained in the SCDHEC Freedom of Information Office and on the Bureau of Land and Waste Management Website to assist the public and document the status of release(s). This registry identifies the location of the UST release, the affected property (or properties), and the assumptions and conditions of the CNFA. If the Owner/Operator provides information to support that the concentrations associated with the release are at levels below RBSLs for all the CoCs at a facility where a CNFA has been issued, then an NFA will be issued for the release.

XVII. OTHER UST WORK TO BE IMPLEMENTED

a. AFVR Events

Aggressive Fluid Vapor Recovery events may be utilized to remove free-phase product from the subsurface as an abatement measure prior to, in lieu of, or as part of the implementation of a corrective action plan. Specifications for AFVR events and reports are presented in Sections B1 and A9, respectively.

b. Water Supply Well Sampling

UST Management Division staff may collect samples from public or private water supply wells in response to a complaint, as part of a receptor survey at a site, or as a confirmation sampling to determine current concentrations. Water supply well sampling requirements are described in Section B2.

c. Monitoring Well / Surface Water Sampling

UST Management Division staff may collect samples from monitoring wells or surface water bodies to establish or verify current site conditions. The UST Management Division may direct the responsible party and their contractor to conduct a sampling event; or may direct the state lead contractor to conduct a sampling event. Monitoring well and surface water sampling requirements are presented in Section B2. Reporting requirements are described in Section A9.

d. Additional Monitoring Well Installation and Development

The UST Management Division may direct the responsible party and their contractor to install monitoring wells or may direct the state lead contractor to install monitoring wells. UST project managers may also direct responsible parties or contractors to redevelop wells that have become fouled or contain water that is excessively turbid. Baseline requirements for monitoring well installation and development are presented in Section B1.

e. Installation and Maintenance of Granulated Activated Carbon (GAC) Units

The UST Management Division may direct the responsible party and their contractor to install granulated activated carbon units on private supply wells to filter out chemicals of concern until a permanent source of non-impacted drinking water can be obtained; or may direct the state lead contractor to install granulated activated carbon units on private supply wells to remove chemicals of concern until a permanent source of non-impacted drinking water can be obtained. Baseline requirements for GAC unit installation are described in Section B1.

f. Repair and Abandonment of Monitoring Wells

The UST Management Division may direct the responsible party and their contractor or the state lead contractor to repair or abandon monitoring wells that are no longer needed or damaged. Baseline requirements for Monitoring Well abandonment are described in Section B1.

g. Remedial Injection and In-Situ Remediation

Remedial injections are used to alter subsurface conditions to effect LNAPL and CoC breakdown or removal as part of Corrective Action Plans or Abatement Measures. A wide variety of remedial additives are employed at UST release sites in South Carolina. Baseline requirements for injection activities are presented in Section B1.

h. Remedial Excavations

Some UST petroleum releases are remediated using excavation and off-Site disposal. The UST Management Division will approve remedial excavations at release Sites where it is considered to be the most appropriate remedial option. General guidelines for remedial excavation are presented below in Section B1.

A7 Data Quality Objectives and Data Quality Indicators

UST Project Managers and Class I certified contractors are tasked with the evaluation of all data for accuracy, precision, validity, and defensibility within the context of the overall investigation. Hydrogeology, surface topography, the physical location of the site, and the presence of possible receptors are taken into account when evaluating data. The site-specific QAPP Contractor Addendum or Site-Specific Work Plan will include a map showing property boundaries, the location of the USTs, and possible receptors (both on the property and off). Where appropriate, data verification is employed. Repeat measurements, check samples and duplicate samples are all measures that are employed in addition to routine review of laboratory QA/QC to ensure that the data being evaluated are acceptably accurate and precise.

The evaluation of site data is always performed relative to the history or the future of the particular release, whether preliminary (part of a Site Assessment or subsurface investigation) or the evaluation of Site Rehabilitation system effectiveness. Data are evaluated, along with previous data, to ascertain the present condition of a site and to project future actions necessary to mitigate the health and environmental impacts of the release. Environmental data are generally a "snapshot in time" of a release. Groundwater is usually a slow-moving medium, and long-term monitoring is generally required before definite fate and transport characteristics of a release can be defined. However, employing professional judgment in the evaluation of preliminary data can reduce the investigation period substantially.

The quality of all environmental data generated and processed will be assessed for accuracy, precision, completeness, representativeness and comparability, which are described in more detail in Section C1.

The data user should ensure that the quality of the data to be used meets the minimum requirements stated in the study design.

I. Data Quality Objectives (DQO) Process

1) State the Problem - The UST Management Division evaluates the extent and severity of all UST releases, and determine the actions needed according to regulation;

2) Identify the Decision - As the release progresses through the RBCA process, each successive action is determined by the SUPERB Regulation (R61-98);

3) Identify inputs to the Decision - Inputs to the decision include the concentrations in environmental media within a plume, the contaminants of concern present, risk-based screening levels, regulatory requirements, and site-specific target levels;

4) Define the Study Boundaries - The spatial and temporal boundaries of investigative activities are laid out in each Site-Specific Work Plan and QAPP Contractor Addendum submitted for a release by certified contractors;

5) Develop an analytical approach and a Decision Rule - If contamination above RBSL is identified at a release Site, then the RBCA process outlined in Appendix A is implemented, including the stipulated analytical approaches;

6) Specify Limits on Decision Error - Error is inherent in every sampling and analytical procedure, and may be introduced through sampling design errors, sampling errors, or analytical errors. Sampling error is minimized through proper field sampling technique and handling training as outlined in each Certified Contractor's SOPs. Analytical error is limited using SCDHEC certified laboratories. Laboratory SOPs are examined by the SCDHEC Office of Environmental Laboratory Certification. Sample results are comparable due to adherence to the permitted analytical methodology specified in Appendix F;

The UST program requires that 90% of all data produced during each environmental investigation be valid. The protocols in Section B1 and requirements set forth in Section B2 of this QAPP provide guidance to minimize or eliminate any discrepancies that could adversely affect data quality; and

7) Optimize the Design for Obtaining Data – The sampling protocols outlined in the RBCA process are based on experience characterizing plumes released from USTs and their potential impacts on receptors. These protocols optimize the investigative design for data acquisition, lead to decisions based on accurate information, and obtain outcomes that protect human and environmental health.

II. Data Quality Indicators

Precision: Precision examines the distribution of the reported values about their mean. The distribution of reported values refers to how different the individual reported values are from the average reported value. Precision may be affected by the natural variation of the matrix or contamination within the matrix, as well as by errors made in the field and/or laboratory handling procedures. Comparison of blind field duplicate

(BFD) and matrix spike/matrix spike duplicate sample results provides an indication of precision. Precision will be evaluated by the calculation of the Relative Percent Differences (RPD):

$$RPD (\%) = \text{Absolute value of } ((C_S – C_D)/(C_S + C_D)/2) \times 100$$

Where: C_S = Concentration of the sample
C_D = Concentration of the duplicate sample

RPDs are compared to the limits presented in tables in Appendix F.

Bias: Bias refers to the degree of inaccuracy of a measurement. The sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analytical techniques are all potential sources of bias. Bias may be quantified by using matrix spike, surrogate, and laboratory control samples. Accuracy is evaluated by calculating the percent recoveries (%R) of the matrix spike/matrix spike duplicate samples, the laboratory control samples, and the Volatile Organic Contaminate (VOC) surrogates. The %R for the matrix spike samples is calculated using the following equation:

$$\%R = ((C_M – C_S)/T) \times 100$$

Where: C_M = Concentration of matrix spike sample
C_S = Concentration of sample
T = amount spiked

The %R for the laboratory control samples and the surrogates will be calculated using the following equation:

$$\%R = (C/T) \times 100$$

Where: C = observed concentration
T = amount spiked

The percent recoveries presented in laboratory analytical data reports are compared to the limits presented in Appendix F.

Representativeness: Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, or an environmental condition. This criterion will be met by assuring that sampling locations are properly selected, that a sufficient number of samples are collected, and that all sampling, handling, and analytical procedures are conducted in accordance with the protocols outlined in this QAPP.

Completeness: The UST program is designed based on principles to define plumes of petroleum contamination and assess the effectiveness of remedial actions. The number of samples collected and data generated are to be reviewed during a UST project. If some samples are found to be invalid due to collection, shipping, or laboratory problems, the samples may be recollected to ensure that enough data are available to make a sound decision. Completeness is important to the entire process and contractors are expected to produce reports with at least 90% valid samples/data.

Comparability: Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through using standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units.

Method Sensitivity: Method sensitivity is parameter dependent and is defined in Appendix F. Sensitivity is assessed primarily through Method Detection Limits and Reporting Limits calculated by analytical laboratories, which are verified by the SCDHEC Laboratory Certification Division.

A8 Training and Certification

I. DHEC Requirements

All DHEC UST Management Division staff involved in the assessment and remediation process working on UST projects must have the following training:

1) 40-hour OSHA HAZWOPER; and
2) OSHA HAZWOPER Annual Refresher

Most personnel with QA responsibilities within the UST Management Division have acquired their QA experience through on-the-job training. Those designated to serve in the program have a technical (scientific, engineering) background that includes previous experience with QA concepts and with evaluation of data generated from environmental measurements. The UST Management Division encourages and supports the acquisition by personnel of quality assurance experience or pertinent experience and information. This is done through:

1) Participation in QA-related USEPA seminars;
2) Attendance at appropriate professional meetings, conferences or workshops; and
3) Completion of appropriate short courses.

It shall be the policy of the UST Management Division to provide resources to allow for personnel involved in leaking UST investigations to receive training relating to groundwater contamination, Site Rehabilitation technologies, and health and safety issues. Records of all the training classes taken by the UST Management Division staff are kept in each staff member's personnel file.

DHEC UST Management Division staff will undergo all necessary training to ensure compliance with the EQC SOP Manual regarding field procedures (acceptable sampling techniques, sample collection, preservation and handling procedures, and field instrument operation and documentation procedures).

II. Contractor Requirements

The information below will be provided by the Contractor as part of their site-specific QAPP Contractor Addenda or ACQAP. The Contractor must specify who will be responsible for detailing how training will be provided, who will be responsible for assuring that personnel participating in the study receive proper training, and where the training is documented.

a. Class I and II Certified Contractors

All Site Rehabilitation activities at UST sites must be conducted by a DHEC certified Site Rehabilitation Contractor as required by the SUPERB Site Rehabilitation and Fund Access Regulations, R.61-98.

In accordance with Section IV.A.4 of the SUPERB Site Rehabilitation and Fund Access Regulations, R.61-98, a **Class I** certified contractor must have at least one full-time permanent employee of that company registered as a Professional Engineer or Geologist in South Carolina and have at least three years applicable experience in performing Site Rehabilitation activities related to releases of regulated substances from underground storage tanks. The certification number must be provided on all reports submitted to the UST Management Division.

A **Class II** certified contractor must have a minimum of three years applicable experience in performing Site Rehabilitation activities related to releases of regulated substances from underground storage tanks; and any necessary South Carolina certifications and/or licenses. The contractor certification number must be provided on all reports submitted to the UST Management Division.

Any required occupational safety and health training (i.e., OSHA) as defined by the laws and regulations of the United States of America, the State of South Carolina, the county, or any municipality is the responsibility of the Contractor.

b. Certified Drillers

Well drillers must be certified in accordance with Title 40, Chapter 23 of the SC Code of Laws. The certification number must be provided on all well forms submitted to the UST Management Division. The certification number must also be provided in the ACQAP or site-specific QAPP Contractor Addendum. Well drillers are required to sign the site-specific QAPP Contractor Addendum or ACQAP stating they have received the most recent version of the UST Programmatic QAPP due to their involvement with Site Rehabilitation activities.

c. Certified Laboratory

Laboratories must be certified in accordance with SCDHEC Office of Environmental Laboratory Certification for the analytical methods performed. The laboratory certification number must be provided on all laboratory data submitted to the UST Management Division. The certification number must also be provided in the site-specific QAPP Contractor Addendum. Laboratory directors are required to sign the site-specific QAPP Contractor Addendum or ACQAP stating they have received the most recent version of the UST Programmatic QAPP.

A9 Documents and Records

The UST Programmatic QAPP will be reviewed and, if necessary, revised at least annually by the UST Management Division QAPP Coordinator. Any required updates to the UST Programmatic QAPP will be distributed in accordance with the distribution list contained in this document. A copy of the UST Programmatic QAPP will be maintained in a common directory on the UST Management Division file server. UST Project Managers will be required to sign a statement indicating that they have received a copy of the UST Programmatic QAPP. A new form must be signed whenever revisions to the UST Programmatic QAPP are made to ensure that all project managers have been provided the most recent version of the document. Contractors will be provided a copy of the UST Programmatic QAPP electronically and will be required to sign a statement indicating receipt of the UST Programmatic QAPP. The statement will be required as part of the yearly certification renewal process. A new form will be required to be submitted when revisions to the UST Programmatic QAPP are made. The site-specific QAPP Contractor Addendum or ACQAP will include a signature page signed by all parties involved in UST site activities, that they have received the most recent version of the UST Programmatic QAPP and the site-specific QAPP Contractor Addendum or ACQAP.

All records and reports submitted to the UST Management Division that contain data interpretation must be signed and sealed by a Professional Engineer or a Professional Geologist registered in the State of South Carolina. All original records and reports submitted to the UST Management Division must be maintained by the contractor for a minimum of 5 years, unless otherwise specified by the UST Management Division. Record archival policies for the UST Management Division are given in Appendix J. This includes electronic as well as hard copy storage.

One paper and one digital copy of all reports must be delivered to the UST Management Division on or prior to the due date specified in the Notice to Proceed for the work. All report text must be in ten (10) point font or greater. Digital copies should include an unsecured .pdf file of the entire document, .xlsx files containing all tables, and .dxf files for all figures.

Each report submitted to the UST Management Division shall include the following elements **as applicable to the scope of work being conducted**:

I. Introduction

Include in all reports:

1) UST Facility Name, Permit Number, Address, and Telephone Number;
2) UST Owner's and Operator's name, Address, and Telephone Number;
3) Property Owner's Name, Address, and Telephone Number;
4) DHEC Certified UST Site Rehabilitation Contractor's Name, Address, Telephone Number, and Certification Number;
5) Name, Address, Telephone Number, and Certification Number of the well driller that installed borings/monitoring wells;
6) Name, Address, Telephone Number, and Certification Number of the certified laboratory performing analytical analyses;
7) Facility history including tank information (number, size, and contents of all current and former USTs and ASTs), date release reported to DHEC, estimated quantity of release, cause of release (if known), and status of any other releases at the facility. If the facility is no longer a petroleum marketing facility, please provide the current facility name and use. If the facility is currently not in use, please list the current use as vacant; and
8) Regional geology and hydrogeology.

II. Receptor Survey & Site Data

Include in all reports:

1) Locate all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements)

within a 1,000 foot radius of the site or within 500 feet of the down gradient edge of the plume, whichever is greater from the source area;

2) The results shall include all known groundwater quality and public and private groundwater usage;
3) Document the current use of the site and adjacent land (residential, commercial, agricultural, industrial, etc.). Identify any UST site(s) within a 1,000 foot radius of the subject site and provide their UST permit number(s) in the report; and
4) Site-specific geology and hydrogeology.

Soil Assessment/Field Screening Information & Methodology (IGWA, Tier I and Tier II Assessment, and additional Assessment Reports):

1) Describe the primary soil types and field screening results;
2) Describe how soil samples were collected (e.g. two encore samplers and one four-ounce jar) and preserved; and
3) Describe how the field screening was conducted.

III. Monitoring Well Information

Include in IGWA, Tier I, and Tier II Assessment, Additional Assessment, Monitoring Well Installation CASE Reports, and additional Assessment Reports as applicable:

1) Provide the monitoring well installation and development date(s);
2) Describe the well development procedure and volume of development water; and
3) Provide justification for monitoring well locations.

IV. Groundwater and Surface Water Data

Include in IGWA, Tier I, and Tier II Assessment, Groundwater Sampling and CASE Reports, as applicable:

1) Describe the groundwater sampling methodology and provide the date sampled;
2) Describe the purging methodology and provide the volume of water purged and groundwater measurements to verify that purging is complete;
3) If free product is present, provide the thickness and a photograph of the product if not provided in previous reports or if physical characteristics of product have changed noticeably; and
4) Provide photographs of all surface water sample locations sampled, including flagging tape or other type of identification locator used.

V. AFVR Information

Include in AFVR and CASE Reports, as applicable:

1) A brief description of the completed work scope and any relevant descriptions pertaining to the data tables;
2) A table summarizing the airflow (in CFM), pre-treatment vapor concentrations (parts per million), post-treatment vapor concentrations (parts per million) and off-gas reduction (%) per

measurement interval. The table shall also list the AFVR extraction wells and stinger depths in feet throughout the event;

3) A table summarizing the vacuum gauge measurements from all extraction wells and adjacent wells;
4) The total volume of water recovered (gallons);
5) The total volume of free phase product (FPP) recovered in gallons (typically measured with a product/water interface device inserted into the top of the tanker and then converted to an approximate volume);
6) The total volume of petroleum removed as vapor in equivalent gallons. This is calculated based on the airflow rate and the pre-treatment vapor concentrations;
7) A table documenting the FPP thickness in each well before and after the AFVR event;
8) A scaled base map depicting the location of the extraction wells and the surrounding wells equipped with vacuum gauges;
9) There can be no spillage or leakage in transport. An original copy of the weight ticket and disposal manifest from the permitted treatment facility that clearly designates the quantity of effluent received, applicable permit numbers, and dates must be included as Appendix H in the final report; and
10) **Note: If a weight ticket cannot be obtained from disposal facility, then documentation (e.g., date stamped photograph) of a measurable device used to ensure an accurate measurement of effluent gallons produced must be provided in the report.**

VI. <u>Granulated Activated Carbon Installation</u>

Include in reports that document GAC installation activities.

1) Description of the unit installed, to include carbon capacity, warranty information, counter information, validation by Water Quality Association, where installed, combination or key information, etc;
2) A schematic diagram of the unit (new or old) with the model number, serial number, site name, UST permit number, inlet and outlet ports will be required. This information must be submitted within one week of installation;
3) The Contractor must provide all calculations for determining CoC breakthrough and the frequency at which the filter material must be changed based on CoC concentration and projected water usage; and
4) All work must be done by a professional plumber certified in the state of South Carolina. Proof of certification must be provided with the site-specific QAPP Contractor Addendum or Site-Specific Work Plan.

VII. <u>Corrective Action Activity Summary</u>

Include the following information in all CASE Reports, along with any additional information specified in the applicable Pay for Performance contract:

1) Description of overall remedial strategy for the site and progress made, discussion of progress in comparison to the proposed corrective action timetable, include a visual representation, such as a Gantt chart. Discuss any deviations from the initial schedule proposed in the CAP.

2) Detailed description of all remedial activities conducted during the current reporting period, including but not limited to any remedial injection, air sparging, AFVR and/or extraction events, water treatment system operation or excavation;
3) Presentation of all monitoring and groundwater sampling result data, including vapor, vacuum, and groundwater level monitoring conducted during AFVR and/or extraction events during that reporting period, as described above in Section V;
4) Interpretation of groundwater sample result data in the context of overall remedial strategy, including CoCs and any secondary parameters analyzed, such as Oxidation-Reduction Potential (ORP), sulfate, nitrate, ferrous iron, magnesium and dissolved oxygen;
5) A description of any remedial excavation conducted during the reporting period, including a summary of the amount of material removed, soil disposal location, and the means used for deterring excavation limits;
6) Include a summary table of all remedial activities conducted during the corrective action contract as Appendix L. The summary table should include rows presenting quantities of remedial additives injected; FPP, vapor phase CoCs, and groundwater removed/treated; and number of hours remedial systems were operated. The table should be divided by reporting periods; and
7) Include laboratory reports for all analytical results received during the reporting period and all attendant sampling logs as Appendix B. Logs for all borings and temporary wells installed should be included as Appendix G, and logs for any monitoring wells installed in Appendix E.

VIII. Results & Discussion

Include applicable sections in all reports.

1) Assessment results – the report shall include a brief discussion of the assessment and results. The discussion shall include all methodology used;
2) Aquifer Evaluation results (if conducted) – the report shall include a brief discussion of the aquifer evaluation and results. All methods and industry standards used shall be referenced in the report;
3) Fate & Transport results (if conducted) – the report shall include a brief description of the fate & transport model(s) used. All assumptions shall be clearly identified. The input parameters are to be given in tabular format. The method of model calibration for each CoC shall be discussed;
4) Data Evaluation – Present a brief narrative description of QA/QC sample results, including RPDs calculated from blind field duplicate results and any data usability issues identified in Appendix A;
5) Tier 1 Risk Evaluation – Site Conceptual Model Tables must be included. (See Appendix E);
6) Tier 2 Risk Evaluation (If requested by the UST Project Manager):

i. Exposure pathway analysis. It is recommended that the Site Rehabilitation contractor fax all screening data, receptor locations, exposure points, and compliance points to the UST Project Manager at (803) 898-2544 prior to the start of exposure modeling. The tier analysis shall be done in accordance with the Risk Based Corrective Action (RBCA) Process;

ii. SSTLs shall be calculated for each CoC and for each potential vapor, soil, and groundwater exposure pathway. Results shall be tabulated; and

7) Recommendations – The report shall include recommendations for further action (Additional Assessment, active remediation, intrinsic remediation, etc.).

IX. Tables

Include in all reports as specified.

1) Current Analytical data for the site shall be given in tabular form as **Table 1**. At sites that are likely to be adjacent to other petroleum or hazardous material release sites, samples should be designated with the 5-digit permit number and the location ID (e.g. 12345-MW1). Water supply should be designated with the well ID (e.g. 12345-WSW1). Surface water sampling locations should be designated with the location ID (e.g. 12345-SW1). Include water parameter measurements (pH, specific conductance, temperature, turbidity and dissolved oxygen). Analytical sample results should be presented in separate sub-tables for each environmental medium and class of analytes, as appropriate, labeled **Table 1a, 1b, 1c etc**. Groundwater analytical data from the previous five sampling events should also be presented on when available;
2) Potentiometric data for the site shall be listed in tabular form for the current and all previous sampling events as **Table 2**. This should include top of casing elevations, screened intervals, depth to water, depth to product, and groundwater elevation for each well; and
3) Site Conceptual Model – identify the data necessary to characterize the migration potential along the pathway and to quantify the potential impact.

X. Figures

Include in all reports as specified.

1) Topographic Map – the report shall include a copy of the relevant portion of a USGS 7.5 min topographic map showing the site location and the locations of all public and private water supply wells and other potential receptors within 1,000 feet of the site or within 500 feet of the down gradient edge of the dissolved CoC plume, whichever is greater. The figure will be captioned with the facility name and address, UST Permit number, date, and bar scale. The map must include a north arrow. Label as **Figure 1.**

2) Site Base Map

Initial Groundwater Assessment: The site base map, labeled as **Figure 2**, shall be accurately scaled, but does not need to be surveyed. The map shall include the following:

i. Location of property lines;
ii. Streets or highways (indicate names and numbers);
iii. Location of buildings;
iv. Paved areas on or adjacent to site;
v. Location of all present and former above ground and underground storage tanks and associated lines, pumps, and dispensers;

vi. Underground and aboveground utilities on or adjacent to site (sewer, water, telephone, gas, electric, etc.);
vii. Location of any potential receptors;
viii. Soil Boring/Monitoring Well location(s);
ix. Previous soil sampling locations;
x. Captioned with the facility name and address, UST Permit number, date and a bar scale; and
xi. A north arrow.

Tier I Assessment – A scaled location map that contains the elements of the IGWA Site Base Map, and any potential receptors within a 500-foot radius of the facility.

Tier II Assessment – a surveyed map (scaled to 1 inch = 50 feet) labeled as **Figure 2** that shows a minimum area of 500 by 500 feet with the UST facility in the center of the map. The figure will be captioned with the facility name and address, UST Permit number, data, and bar scale. The figure must also include:

i. Existing or former USTs;
ii. UST lines;
iii. UST dispensers;
iv. Field screening points;
v. Soil borings;
vi. Wells (monitoring, vapor wells);
vii. A north arrow;
viii. The locations and relative elevations of potential receptors; and
ix. Other above and below-ground structures to include paved areas and utilities.

3) CoC Site Maps – the maps shall show the known and estimated horizontal extent of CoC in the soil and groundwater. Analytical values for the CoC shall be indicated at each sampling point. A separate map shall be used for each medium. Label the Soil CoC map as Figure 3a and the Groundwater CoC map as Figure 3b, when sample results are reported for multiple environmental media.

The analytical data should be adjacent to the relative sampling point and should use the following format (additional parameters such as dissolved oxygen may be required):

Sample ID (MW# or SB#)
Benzene (µg/kg or µg/L)
Toluene (µg/kg or µg/L)
Ethylbenzene (µg/kg or µg/L)
Xylenes (µg/kg or µg/L)
Naphthalene (µg/kg or µg/L)
MtBE (ug/kg or ug/L)
Total Lead (µg/kg or µg/L)
RCRA Metals (µg/kg or µg/L)
Total PAHs (µg/kg or µg/L)
EDB (µg/L)
1,2 DCA (µg/L)
ETBE (µg/L)
3,3-Dimethyl-1-butanol (µg/L)
TAME (µg/L)
DIPE (µg/L)
TBF (µg/L)
TBA (µg/L)
TAA (µg/L)
Ethanol(µg/L)

Note: Not all parameters apply to each Site. If the laboratory analysis indicates all CoCs at or below detection limits, "ND" may be listed on the map beside that boring or monitoring well;

4) Site Potentiometric map – the map shall indicate the water level elevations for each monitoring well and show the direction of groundwater flow for all aquifers evaluated. Include in Tier I, Tier II, Groundwater Sampling Reports. Label as **Figure 4**. Reports for sites where more than one more aquifer has been evaluated should present separate potentiometric figures for each aquifer evaluated as **4a, 4b, 4c**, for shallow, intermediate, and deep aquifers etc.

Note: Great care should be exercised in the use of computer contouring programs (e.g., Surfer®). Any unusual potentiometric features depicted on the map (e.g., sinks, mounds, abnormally steep gradients, etc.) must be explained;

5) Geologic Cross-sections Tier II Assessment Reports include two cross-sections showing the lithology, hydrology and stratigraphy of the site, and the known and estimated vertical extent of CoC in the soil and groundwater. The cross-sections shall intersect at a 90-degree angle if possible. One cross-section shall include the source area and go down gradient through as many wells as practicable with the highest concentrations. If a subsequent assessment is conducted to define the extent of CoC, the cross-sections will be updated to include the additional wells. Label as **Figures 5a, 5b, 5c** etc;

6) CoC Isopleth Maps Tier II Assessment, Groundwater Sampling/Monitoring, Additional Assessment, and CASE Reports should include a map or series of maps showing the predicted migration and attenuation of CoCs through time. Individual CoCs at concentrations greater than Screening levels or SSTLs are preferred for Isopleth Maps at the discretion of the professional reviewer in coordination with UST Division project managers. These maps should be presented as **Figures 6a, 6b**, **6c** etc.;

XI. Appendices

1) Appendix A: (Tier II Assessment Report): Site Survey prepared and certified by a South Carolina Licensed Professional Land Surveyor The surveyed base map should be plotted to an accuracy of 1 foot and include the following:

i. Location of property lines, for the subject site and all affected adjacent properties;
ii. Streets and highways (indicate names);
iii. Location of buildings;
iv. Paved areas on or adjacent to site;
v. Location of present and former above ground and underground storage tanks and associated lines, pumps, and dispensers;
vi. Underground utilities on or adjacent to the site (sewer, water, gas, telephone, electric, etc.);
vii. Location of any potential receptors;
viii. Soil boring locations;
ix. Monitoring well locations;
x. Survey datum location;
xi. Captioned with the facility name and address, UST Permit number, date, and bar scale; and
xii. North arrow.

2) Appendix B:
   i. Analytical Data Summary tables that include all available current and historical data. Separate tables into different environmental media and/or classes of CoCs as Appendix Tables B1, B2, B3 etc., as appropriate;
   ii. Sampling logs; and
   iii. Laboratory data reports and chain-of-custody forms for current samples. The analytical data packages will include the following information: sample results with units, method blank results, laboratory control sample recovery, matrix spike/matrix spike duplicate recoveries and relative percent differences, date and time of sample collection, date and time of sample receipt, date and time of sample extraction/preparation, date and time of sample analysis, dilution factors, pH of water samples, sample temperature at time of receipt, analytical methods used, method detection and quantification limits, problems and corrective action, and applicable certifications. (A laboratory data package may be requested that includes raw data/instrument printouts, calibration data (initial and continuing), method and preparation blanks, field blanks, QA/QC data, digestion/extraction bench sheets, analytical logs, etc.).
3) Appendix C: A copy of the relevant portion of the tax map depicting the location of the facility, all impacted properties, and all properties located adjacent to the impacted properties shall also be included. The property owner names, addresses, and phone numbers as well as a list of monitoring wells installed on each parcel should be included in tabular format. The report shall also include a scaled site vicinity map that indicates site location, surface drainage, structures, roads, receptors, and adjacent property uses. (Maps should not be integrated in the report.) List of adjacent property owner and well owners with their information;
4) Appendix D: Soil Boring/Field Screening logs for Temporary Wells and Screening Points to include DHEC Form 1903 for any abandoned temporary borings or wells;
5) Appendix E: Well completion logs, Water Well Record (DHEC Form 1903) and Well Development Log (DHEC Form 2099) for all wells;
6) Appendix F: Aquifer evaluation summary forms (DHEC Form 3531), data, graphs, equations;
7) Appendix G: Disposal manifests;
8) Appendix H: Local zoning regulations;
9) Appendix I: If requested by the UST Management Division Manager, all fate and transport modeling assumptions, data input to each model, and all generated output data;
10) Appendix J: Copies of any access agreements obtained by the Contractor to complete the required work (e.g., letter, email, phone conversation, etc.). For all access agreements received those individuals should be courtesy copied on the cover letter of the submitted report and receive an abbreviated copy of the report;
11) Appendix K: Data verification checklist; and
12) Appendix L: Corrective Action Summary Tables, as Applicable.

Appendices not included in the report should be listed as omitted in the Table of Contents.

SECTION B – DATA GENERATION AND ACQUISITION

B1 Sampling Process Design/Experimental Design

This section describes the processes used to generate data for the S.C. RBCA program. The assessment and corrective action activities directed by the UST Management Division are described in detail and requirements for subsurface investigations are presented. Requirements for sample collection are described in the following Section.

I. IGWA SAMPLING PROCESS DESIGN

a. Monitoring Well/Boring Installation, Sampling, and Analysis

One permanent monitoring well, constructed of 2-inch diameter PVC casing with a 10-foot length of PVC screen bracketing the water table, shall be installed and constructed in the area showing the highest concentration of CoCs above RBSLs as documented from the previous soil and/or groundwater assessment. Alternatively, the UST Management Division may specify a location. IGWA wells must meet the requirements outlined below in Section B1V.

Soil samples are to be collected for screening at every two (2) or five (5) foot intervals depending on the anticipated depth of the water table, using a split-spoon or other discrete-interval sampler. The lithology of each collected soil sample is to be described and screened for organic vapors. Samples collected from auger cuttings are not acceptable.

The method of field screening to be utilized is at the discretion of the Contractor and shall be included in the site-specific QAPP Contractor Addendum or ACQAP. Any third-party certified technology that accomplishes the IGWA performance standards and meets all regulatory requirements is acceptable.

The soil lithology shall be documented on a geologist/boring log as described in Section B1V. If groundwater is encountered within 25 feet of the surface, a monitoring well shall be installed. Additional footage up to 50 feet is allowed upon approval of the UST Project Manager.

The soil sample with the highest screening values is submitted for lab analysis. If the soil samples are within 10% of each other, the sample from the greatest depth is the one selected for lab analysis.

Soil samples collected during IGWA events should be submitted for the following analyses as appropriate:

1) One sample shall be analyzed for USEPA method 8260D (BTEX and Naphthalene);
2) A soil sample shall be collected from **below the water table** but within the anticipated screen interval of the monitoring well installed and forwarded to a geotechnical engineering laboratory for grain size/hydrometer analysis to determine the sand, silt, and clay fractions at 0.074 mm (#200 screen) and at 0.004 mm, respectively.
3) If field screening indicates the likely presence of CoCs, the soil sample with the highest headspace vapor concentrations collected above the water table should be analyzed for total petroleum hydrocarbons using USEPA method 8270E (TPH-DRO); and
4) If field screening indicates the likely presence of CoCs, one soil sample collected from the below the "A" horizon but above the water at a nearby background location and analyzed for total

organic carbon (TOC). TOC analysis must be performed using a TOC analyzer equipped with a soil sample attachment according to method USEPA 9060A.

If groundwater is not encountered within 50 feet of the surface, the soil sample with the highest field screening value and a sample from the bottom of the boring shall be collected for analysis. Soil samples must be analyzed for the parameters listed in Appendix F, Table F4. Enclose the boring log, Water Well Record (DHEC Form 1903), and Well Development Log (DHEC Form 2099) as attachments to the Report of Findings.

After well installation:

1) Monitoring wells shall be developed according to the requirements described below in Section B1V Boring, Monitoring and Recovery Well Installations.
2) The static water level shall be measured after the well has been developed and allowed to equilibrate for a minimum of 24 hours according to the requirements outlined in Section B2 Groundwater Level Monitoring.
3) Groundwater Samples should only be collected after the well has equilibrated for a minimum of 24 hours after development and the groundwater has returned to the pre-drilling conditions. Monitoring well(s) shall be purged and sampled according to the specifications described in Section B2 Groundwater Sampling.
4) Groundwater samples must be analyzed for the parameters listed in Appendix F, Table F4.

b. Receptor Survey

1) Location of all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements) within a 1000-foot radius of the site;
2) Immediately upon locating any potential receptors screen them for hydrocarbons using a properly calibrated screening device. The site-specific QAPP Contractor Addendum or ACQAP shall state which screening device will be used, along with the information required in Section B concerning calibration, maintenance and inspection;
   i. If field screening indicates the presence of hydrocarbons notify the UST Project Manager at (803) 898-2544 as soon as possible within 48 hours of detection and provide the name, address and a contact telephone number for all affected property owners. All field-screening and laboratory data for these receptors shall be included in the Report of Findings;
3) Obtain water samples for all private water supply wells and surface water bodies within a 250-foot radius of the site. All municipal supply wells within a 1,000-foot radius shall also have a sample collected and analyzed for the appropriate parameters (see Table F4);
   i. Notify the UST Project Manager at (803) 898-2544 or by email as soon as possible if any water samples are collected; and
4) All field-screening and lab data for these receptors shall be included in the IGWA Report.

II. TIER I ASSESSMENT SAMPLING PROCESS DESIGN

a. Soil Boring Installation, Sampling, and Analysis

Install eight soil borings in the locations described below:

1) UST Area – either adjacent to currently operating USTs or in the area formerly occupied by USTs:
   i. Two soil borings are advanced to a depth of 25 feet or to the groundwater table. Borings may be advanced until the vertical extent of impact has been delineated if evidence suggests that CoCs are present in soils below the water table. UST area borings advanced to a depth of more than 25 feet should be approved by the UST Project Manager; and
   ii. Soil samples shall be collected at five-foot intervals to the boring terminus. All soils recovered in sample cores or split spoons should be logged according to the requirements described below in Section B1.
2) Piping and Dispenser Area:
   i. Install five borings to a depth of 10 feet, to the groundwater table in the areas formerly occupied by the lines and product dispensers or adjacent to currently operating lines and dispensers. Borings may be advanced until the vertical extent of impact has been delineated if evidence suggests that CoCs are present in soils below the water table. Borings advanced deeper than 10 feet must be approved by the UST Project Manager; and
   ii. Soil samples shall be collected at two-foot intervals to the boring terminus. All soils recovered in sample cores or split spoons should be logged according to the requirements described below in Section B1.
3) Background Soil Boring:
   i. One soil boring is to be installed at least 30 feet away from any USTs product lines, dispensers, and other potential sources of chemicals of concern. This boring is advanced to a depth of 10 feet or to the groundwater table;
   ii. If the site is too small to allow a 30-foot separation, install this soil boring as far away from all USTs, product lines, dispensers, and other potential sources of contamination as possible; and
   iii. A soil sample is collected from below the "A" horizon, unless precluded by a shallow water table.
4) The lithology of each collected soil sample is described and screened for organic vapors, and each boring is documented in separate logs as described below in Section B1V.
5) The following shall be submitted for analysis to a SCDHEC Certified Laboratory:
   i. One soil sample from each boring around the USTs, piping and dispensers shall be submitted to a SCDHEC certified laboratory for analysis for the parameters listed in Table F4. Refer to Appendix F for collection and preservation methods.
   ii. Two additional soil samples from the soil boring with the sample exhibiting the highest organic vapor measurement will be submitted for the following analyses:
      a) One sample shall be forwarded to a geotechnical engineering laboratory for grain size/hydrometer analysis to determine the sand, silt, and clay fractions at 0.074 mm (#200 screen) and at 0.004 mm, respectively;
      b) One sample shall be analyzed for total petroleum hydrocarbons using USEPA method 8015C (TPH-DRO); and

iii. The soil sample collected from the background soil boring shall be analyzed for total organic carbon (TOC). TOC must be performed using a TOC analyzer equipped with a soil sample attachment.

b. Monitoring Well Installation, Sampling, and Analysis

1) A total of three (3) 2-inch inside diameter (ID) PVC-casing wells, with 10-foot screens bracketing the water table, shall be installed and constructed in the appropriate locations according to the requirements in in Section B1V Boring, Monitoring and Recovery Well Installations.
2) Locations:
   i. The first monitoring well shall be installed in the immediate location of the soil boring that exhibited the highest organic vapor measurement;
   ii. The second monitoring well shall be installed in the immediate location of the background soil boring; and
   iii. The third monitoring well shall be installed in a position on the site so that the direction of groundwater flow can be determined (i.e. in a presumable downgradient direction).
3) Soil Sample Collection:
   i. Soil samples are to be collected for screening at two (2) or five (5) foot intervals, using a split-spoon or other discrete-interval sampler, according to the requirements described in Section B2;
      a) The soil sample exhibiting the highest organic vapor measurement from each borehole shall be submitted for laboratory analysis unless; and
      b) If all screening levels for all the samples are within 10%, then the deepest sample shall be submitted for analysis;
   ii. Soil samples must be analyzed for the parameters listed in Appendix F, Table F4; and
   iii. A soil sample shall be collected from within the saturated portion of the screen interval of the monitoring well installed at the location of the soil boring with the highest organic vapor measurement and forwarded to a geotechnical engineering laboratory for grain size/hydrometer analysis to determine the sand, silt, and clay fractions at 0.074 mm (#200 screen) and at 0.004 mm, respectively.
4) After well installation:
   i. Monitoring wells shall be developed according to the requirements described below in Section B1V Boring, Monitoring and Recovery Well Installations.
   ii. The static water level shall be measured after the well has been developed and allowed to equilibrate for a minimum of 24 hours according to the requirements outlined in Section B2 Groundwater Level Monitoring.
   iii. Groundwater Samples should only be collected after the well has equilibrated for a minimum of 24 hours after development and the groundwater has returned to the pre-drilling conditions. Monitoring well(s) shall be purged and sampled according to the specifications described in Section B2 Groundwater Sampling.
   iv. Groundwater samples must be analyzed for the parameters listed in Appendix F, Table F4.

c. Receptor Survey

1) Locate all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements) within a 1000-foot radius of the site;
2) If receptors are identified that may be impacted, they shall be immediately screened for hydrocarbons using a properly calibrated organic vapor analyzer or other similar screening device. The site-specific QAPP Contractor Addendum or ACQAP shall state what screening device will be used, along with the information required in Section B concerning calibration, maintenance and inspection;
   i. If field screening indicates the presence of hydrocarbons, notify the UST Project Manager as soon as possible within 48 hours of detection at (803) 898-2544 and provide the name, address, and a contact telephone number for all associated property owners;
3) Water samples shall be obtained for all private water supply wells and surface water bodies within a 500-foot radius of the site. All municipal supply wells within a 1,000-foot radius shall also have a sample collected and analyzed for the appropriate parameters (see Table F4);
   i. Notify the UST Project Manager at (803) 898-2544 or by email as soon as possible if any water samples are collected; and
4) All field-screening and lab data for these receptors shall be included in the Tier I Assessment Report.

d. Aquifer Evaluation

Two separate aquifer slug tests shall be completed from a monitoring well located within the source area, unless FPP is present, and a downgradient well to determine aquifer characteristics according to the requirements presented below in Section B1. It is up to the discretion of the Contractor as to which method will be used to conduct the aquifer test.

III. TIER II ASSESSMENT SAMPLING PROCESS DESIGN

Any reference, or lack thereof, to any specific assessment or remedial technology does not constitute an endorsement or recommendation by the UST Management Division. Technologies are discussed for illustrative purposes only. Any technology, which accomplishes the Tier II performance standards and meets all regulatory requirements, is acceptable.

If not previously defined and quantified, the horizontal and vertical extent of impacted vadose zone soil contamination shall be fully delineated according to the following:

a. Soil Boring Installation and Sampling

Advance soil borings as follows:

1) UST Area - the area formerly occupied by the USTs or adjacent to the currently operating USTs.
   i. Advance soil borings to a depth of 25 feet or to the groundwater table, or until the vertical extent of impact has been delineated if evidence suggests that CoCs are present in soil beneath the water table.
   ii. Soil samples shall be collected at the surface and at five (5) foot intervals to the boring terminus. All soils recovered in sample cores or split spoons should be logged according to the requirements described below in Section B1.

2) Piping and Dispenser Area

i. Advance borings to a depth of 10 feet, to the groundwater table in the area formerly occupied by the lines and product dispensers or adjacent to the currently operating product lines and dispensers. Borings should be advanced until the vertical extent of impact has been delineated if evidence suggests that CoCs are present in soils below the water table.

ii. Soil samples shall be collected at the surface and at two (2) foot intervals to the boring terminus. All soils recovered in sample cores or split spoons should be logged according to the requirements described below in Section B1.

3) Background Soil Boring

i. Install one soil boring to a depth of 10 feet or to the groundwater table, whichever is shallower, at least 30 feet away from any USTs, product lines, dispensers, and other potential sources of chemicals of concern.

ii. If the site is too small to allow a separation of 30 feet, install this soil boring as far away from all USTs, product lines, dispensers, and other potential sources of contamination as possible.

iii. Collect a soil sample from below the “A” horizon.

4) If the extent of soil contamination is not defined by the borings described above, continue moving away from the area of contamination and installing borings to a depth of 10 feet, or until the extent of soil contamination is defined. Soil samples shall be collected at the surface and at two (2) foot intervals to the boring terminus. All soils recovered in sample cores or split spoons should be logged according to the requirements described below in Section B1.

b. Soil Sample Lithology and Screening

The lithology of each collected soil sample is described and screened for organic vapors, and each boring is documented in separate logs as described below in Section B1V.

c. Soil Sample Analysis

1) If not previously conducted, the soil sample from each boring around the USTs, piping, dispensers, or other area with the highest organic vapor measurement shall be collected according to the requirements described in Section B2. The sample(s) is submitted to an SCDHEC certified laboratory for analysis of the parameters listed in Appendix F, Table F4. Refer to Appendix G for collection and preservation methods and Appendix F for analytical parameters and other requirements;

2) In addition to the samples described above, if not previously conducted, three additional soil samples shall be collected from the boring that exhibited the highest organic vapor measurement:

i. One sample collected from the vadose zone shall be forwarded to a geotechnical engineering laboratory for a grain size/hydrometer analysis to determine the sand, silt and clay fractions at 0.074 mm (#200 screen) and 0.004 mm respectively;

ii. A second sample shall be collected from above the groundwater table and analyzed for Total Petroleum Hydrocarbons (TPH) using USEPA method 8015C (DRO);

iii. A third sample shall be collected from within the saturated portion of the well screen during monitoring well installation and forwarded to a geotechnical engineering laboratory for a grain size/hydrometer analysis to determine the sand, silt and clay fractions at 0.074 mm (#200 screen) and 0.004 mm respectively;

iv. Additional soil samples above or below the water table may be submitted to a certified laboratory for grain/sieve analysis, GRO, DRO, TPH or total organic carbon (TOC); however, the UST Management Division must pre-approve these samples; and

3) In addition, a soil sample collected from the background soil boring shall be analyzed for total organic carbon TOC. TOC must be performed using a TOC analyzer equipped with a soil sample attachment.

d. Soil Leachability Model

If requested by the UST Management Division and not previously calculated, calculate the site-specific target levels (SSTLs) for each CoC in the soil. The Soil Leachability Model provided in the RBCA Process shall be utilized unless an equivalent method is approved. Model input parameters and results shall be recorded on the appropriate forms found in the RBCA Process. The calculated groundwater SSTLs shall be used to calculate soil SSTL values. If groundwater is less than 5 feet below ground surface (bgs), the Soil Leachability Model is not required.

e. Field Screening

The Contractor shall propose in the Tier II Assessment Plan appropriate sample collection methodology and field screening techniques based on the anticipated CoCs. The method for sample collection and the field screening technique shall be at the discretion of the Contractor. The objective of field screening in Tier II Assessment is to adequately delineate the horizontal and vertical extent of any free phase petroleum and petroleum constituents in soil and groundwater and to use the field screening results to optimally locate the monitoring wells.

f. Borehole Abandonment

All soil borings and screening points shall be properly abandoned by an SC Certified Well Driller in accordance with the requirements described below in Section B1V.

g. Monitoring Well Installation

The number and location of the monitoring wells shall be based on field screening results and with the concurrence of the UST Project Manager. The wells shall be installed in locations that fully delineate the horizontal and vertical extent of the groundwater CoC so that all exposure pathways can be monitored. The monitoring wells shall define the extent of the CoC to the maximum extent possible without the installation of unnecessary monitoring wells.

The well screen length shall be ten feet for shallow wells and five feet for deep wells. The well screen for shallow wells should be installed so that the water table is bracketed. However, if the Contractor is aware of significant groundwater level fluctuations, a longer screen length may be necessary and shall be specified in the site-specific QAPP Contractor Addendum or Site-Specific Work Plan. A shallow well will typically be installed adjacent to a surface water body that might be impacted. A shallow and deep monitoring well will typically be installed between the release source and all supply wells that could be impacted as a future compliance point.

1) Monitoring wells must be installed and constructed by a SC Certified Well Driller and in compliance with SC Well Standards and Regulations, R.61-71.
   i. The screen of all shallow monitoring wells shall be 10-foot in length and installed so that the water table is bracketed;
   ii. The wells will require proper filter pack, bentonite seal, grout, well identification plate, locked well cap, well pad constructed at or above ground level, and well cover held in place with bolts or screws; and
   iii. Any monitoring well(s) completed in traffic areas should be flush-mounted. All other wells should be completed with a one-foot minimum stick-up casing.
2) During well installation, soil samples are to be collected for screening at two (2) or five (5) foot intervals, using a split-spoon or other discrete-interval sampler. The lithology of each collected soil sample is described and screened for organic vapors, and each boring is documented in separate logs as described below in Section B1V.
3) A minimum of three vertical assessment wells should be proposed unless the vertical extent of the contamination can be reasonably determined or estimated by another method or if the geology precludes the potential of vertical migration of the CoC. The deep wells are to be paired with water table bracketing wells (preferably the water table well with the highest concentration of CoC, another water table well in the center part of the down gradient portion of the plume, and the first clean down gradient well) to determine vertical extent of the CoC and the vertical hydraulic gradient. If the deeper zone is confined or semi-confined, lateral deep wells may be necessary to accurately characterize flow conditions in the deeper zone. The diameter of the deep well boring must be such that installation of the telescoping monitoring well can easily be accomplished. For example, a 6-inch inside diameter (ID) well casing (following ASTM industry standard) shall be advanced at least 10 feet deeper than the bottom of the adjacent water table bracketing well screen or to the first confining unit, whichever is less. On a case specific basis and pre-approval by the UST Project Manager, a deep well that is proposed outside the contaminated area and does not contain a confining layer, may not need an outer casing if the hydrologic zone is not segregated. The deep well screen length shall be 5-feet unless pre-approved by the UST Project Manager for greater screen length. The well will be installed and constructed in compliance with SC Well Standards and Regulations, R.61-71.
4) Unnecessary monitoring wells shall not be installed (e.g., wells installed a significant distance beyond an existing temporary or permanent well that exhibits no appreciable concentration of CoC or deep wells installed where groundwater analyses indicated minimal concentration of CoC in the shallow monitoring wells).
5) Soil samples collected from the screened intervals of a downgradient shallow, an intermediate, and a deep monitoring well (adjacent to each other), as well as from any other hydrogeologically significant unit, shall be forwarded to a geotechnical engineering laboratory for a grain size/hydrometer analysis to determine the sand, silt and clay fractions at 0.074 mm (#200 screen) and 0.004 mm respectively.
6) After well installation:
   i. Monitoring wells shall be developed according to the requirements described below in Section B1V Boring, Monitoring and Recovery Well Installations.
   ii. The static water level shall be measured after the well has been developed and allowed to equilibrate for a minimum of 24 hours according to the requirements outlined in Section B2 Groundwater Level Monitoring.

Groundwater Samples should only be collected after the well has equilibrated for a minimum of 24 hours after development and the groundwater has returned to the pre-drilling conditions. Monitoring well(s) shall be purged and sampled according to the specifications described in Section B2 Groundwater Sampling.

Groundwater samples must be analyzed for the parameters listed in Appendix F, Table F4.

Note: The elapsed time between the collection date of the groundwater samples from permanent wells and the received date of the report must be no more than 60 days.

h. Receptor Survey

A receptor survey should be conducted as follows during a Tier II Assessment:

1) Locate all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements) within a 1000-foot radius of the site or within 500 feet of the down gradient edge of the plume, whichever is greater from the source area;
2) If receptors are identified that may be impacted, they shall be immediately screened for hydrocarbons using a properly calibrated organic vapor analyzer or other similar screening device. The site-specific QAPP Contractor Addendum or ACQAP shall state what screening device will be used, along with the information required in Section B concerning calibration, maintenance and inspection;
   i. If field screening indicates the presence of hydrocarbons, notify the UST Project Manager as soon as possible within 48 hours of detection at (803) 898-2544 and provide the name, address, and a contact telephone number for all associated property owners;
3) Water samples shall be obtained for all private water supply wells and surface water bodies within a 1,000-foot radius of the site or within 500 feet of the down gradient edge of the plume, whichever is greater from the source area. All municipal supply wells within a 1,000-foot radius shall also have a sample collected and analyzed for the appropriate parameters;
   i. Notify the UST Project Manager at (803) 898-2544 or by email as soon as possible if any water samples are collected; and
4) All field-screening and lab data for these receptors shall be included in the Tier II Assessment Report.

i. Aquifer Evaluation

An aquifer evaluation is carried out in accordance with the requirements presented below in Section B1V. The completion of a pumping test is preferred whenever possible. In cases where a pumping test cannot be conducted because of technical (e.g., well yields are too low) or financial (e.g., wastewater disposal is cost-prohibitive) reasons, aquifer slug tests shall be acceptable. All wastewater generated during aquifer tests shall be properly containerized and disposed of.

1) Slug Tests – Typically at least three separate slug tests shall be conducted in different on-site wells to determine aquifer characteristics unless otherwise specified by the UST Management Division. At least one slug test shall be conducted in a deep well. It is up to the discretion of the Contractor as to which method will be used to conduct the aquifer test;

Note: If water recharge is anticipated to be faster than manual methods allow, then the UST Management Division requires the use of a pressure transducer.

i. Data points (water level measurements) shall be recorded every 5 seconds for the first two (2) minutes for either falling or rising head test. After two minutes, the time increments can gradually increase according to the formations hydraulic conductivity;
ii. Data collected shall be evaluated and analyzed in accordance with industry standards (Hvorslev, Bouwer and Rice, etc.). The slug test shall be reported on the Slug Test Summary Form (DHEC Form 3531). The completed form(s) and all applicable data shall be attached to the report in the appropriate appendix (See Section A9; and
iii. The hydraulic head from the shallow aquifer should not be assumed to apply to deeper aquifers. The shallow aquifer slug test and deep aquifer slug test shall be completed and reported separately.

2) Pumping Test - To ensure that the pumping test data is representative, the test shall be conducted using a sufficient pumping rate and duration to stress the aquifer. Therefore, the pumping test shall have duration of at least 6 hours to a maximum of 24 hours based on site-specific data. Data shall be reported and analyzed in accordance with industry standards. Generation of more than 5,000 gallons of wastewater during a pumping test will require a general discharge permit from the Bureau of Water.

j. Free Product Recovery Test

If 0.2 foot (2.4 inches) or more of free product is encountered in a permanent monitoring well, then a recovery test or bail down test shall be conducted using current industry standards to determine free product recovery rates and true thickness. This data shall be submitted on a graph as an appendix to the report.

k. CoC Fate and Transport

If not previously calculated or upon request by the UST Management Division, calculate the SSTLs for each CoC for groundwater and for vapors. The Contractor shall specify in the site-specific QAPP Contractor Addendum or Site-Specific Work Plan, the model or method proposed if fate and transport modeling is requested by the UST Project Manager. The completion of a relatively simple mathematical and/or algebraic or semi-analytical expression shall be preferred initially. Where a completed pathway may exist, a more complex computer model shall be used.

1) Mathematical and/or algebraic or semi-analytical expressions. For groundwater, the Contractor shall utilize Domenico's Fate and Transport Model provided in Appendix H or an equivalent model. RBSL values should not be recalculated, if values are listed in Appendix D; and

Computer fate and transport modeling. For groundwater, the Contractor may utilize SOLUTE, AT123D, BIOPLUME-II, or an equivalent model. For vapor phase CoCs the contractor shall utilize Farmer, Thibodeaux-Hwang, SeSoil, Jury, Box, or an equivalent model.

l. Tier 2 Risk Evaluation

Use the historical data and the information obtained during this scope of work to perform a Tier 2 Risk Evaluation. This evaluation includes, but is not limited to, the establishment of exposure points (current and future/potential receptors), site-specific target levels, and points of compliance and recommendations for future actions. This evaluation shall be performed in accordance with the RBCA Process. The UST Project Manager must approve the receptor(s) prior to modeling and the model(s) to be used. Only one Tier evaluation will be required for a facility unless new receptor(s) are identified.

m. Final Survey

A final survey to tie-in field screening points, permanent monitoring well locations, elevations to a common elevation datum shall be performed and included in the Tier II Assessment Report as Appendix A. After reviewing the data, the UST PM will determine which type of survey (comprehensive or subsequent) will best fit the needs of the site.

IV. SITE REHABILITATION

This section outlines the criteria for Site Rehabilitation of petroleum releases from regulated underground storage tanks (UST) and is designed to meet the applicable requirements of the South Carolina Underground Storage Tank Control Regulations, R.61-92 Part 280, and the SUPERB Site Rehabilitation and Fund Access Regulations, R.61-98. Confirmed releases of petroleum or petroleum products where concentrations of Chemicals of Concern (CoC) are documented to be in excess of risk-based screening levels (RBSLs) require Site Rehabilitation. The SSTL is the maximum concentration of each CoC that can be present at a specific location to ensure that all current or potential receptors are not adversely affected. Based on the concentration of each CoC and its potential risk to receptors, two processes of Site Rehabilitation are possible:

a. Active Site Rehabilitation

This term is synonymous with active remediation and refers to physical actions taken to reduce the concentrations of CoC. Active Site Rehabilitation is applicable where:

1) The concentration of any CoC exceeds its SSTL and must be reduced to prevent an impact to an actual or potential receptor;
2) Free phase product is present with a thickness greater than 0.01 feet or 1/8 inch; or
3) The plume continues to increase in size, CoC continue to migrate away from the source, or the concentration of any individual CoC is increasing.

b. Active Site Rehabilitation Procedures

Once the extent and severity of contamination is identified and a cleanup goal or SSTL is established, the SSTL mass of petroleum to be removed is established.

1) Data collection - Prior to implementation of Site Rehabilitation, the horizontal and vertical extent of CoC in the soil and groundwater, aquifer characteristics, and SSTLs are determined. This data is typically collected during Tier I, Tier II, and Tier III Assessments as described in this document.

2) Corrective Action Plan and Permit Preparation – The Contractor should submit a Site Rehabilitation Plan and any necessary permit applications to the UST Management Division in

accordance with the schedule outlined by the UST Management Division. The Site Rehabilitation Plan should include, at a minimum:

i. A brief description of how the proposed technology(ies) will reduce the concentrations of CoC at each compliance well to the established Site-Specific Target Level (SSTL). Scientific models, computations, and/or data from other case studies should be included which establish a predicted radius of influence and justify the proposed locations of recovery or injection wells, trenches, and other features;
ii. Proposed construction details for all temporary and permanent wells, trenches, or other features that will be needed to implement the Site Rehabilitation. Their locations should be depicted on a site map in addition to other pre-existing features such as monitoring wells, and aboveground structures. Please note that the locations of proposed construction should be discussed with the property owner with minimal disruption to any existing commercial or residential uses;
iii. A copy of the relevant portion of the tax map shall be included with a list of the property owner's names, tax map numbers, and mailing addresses for each property that:
    a) Is currently impacted by petroleum;
    b) May become impacted by petroleum;
    c) Has monitoring wells associated with the subject release on it; or
    d) Adjoins a property that fits in categories a, b, or c.

iv. A brief description of how any waste materials (wastewater, impacted soil, air) that may be generated will be handled;
v. A brief description of any potential exposure that the Contractor or other citizens may face during the cleanup process and how these potential exposures will be managed to prevent any risk to human health;
vi. A detailed monitoring proposal that complies with requirements in the corrective action specifications package;
vii. A detailed description of the methods that will be used for deactivating and removing any wells and equipment added as a part of Site Rehabilitation;
viii. An implementation schedule should be provided that outlines when the Contractor will:
    a) Initiate and complete construction;
    b) Submit the baseline monitoring report;
    c) Initiate Site Rehabilitation(s);
    d) Submit quarterly Site Rehabilitation system evaluation reports;
    e) Reach SSTLs;
    f) Complete the post-remediation verification monitoring; and
    g) Remove all equipment and abandon all wells as required by the corrective action specification package.
    h) It is recognized that items e, f, and g are estimates.

ix. A completed Bureau of Air Quality Modeling Form should be submitted with the CAP if air emissions will be generated; and
x. An Underground Injection Control Permit Application is required if injection of any solid, liquid, or gas (including ambient air) is proposed. If the injectate includes nutrients, microorganisms, or chemicals, a review of its safety by the state toxicologist is necessary

unless previously conducted. If it has already been reviewed for another site, please provide a copy of the review memorandum.

3) In-Situ Remediation and Injection Guidelines – To evaluate the safety of a proposed injectate, the following information, at a minimum, is required:
   i. Manufacturer's name, address, telephone number, and authorized representative for data disclosure;
   ii. SCDHEC UST Project Manager and telephone number;
   iii. Site contact person, address, and telephone number;
   iv. Contractor applying product, contact person, address, and telephone number;
   v. A map depicting the site and the locations of all local private and public water supply wells;
   vi. Analytical results from a certified laboratory quantifying the CoC present in the soil;
   vii. A description of secondary parameters, such as nitrate, Oxidation Reduction Potential (ORP), sulfate, ferrous iron, dissolved oxygen, etc. to be used to evaluate the suitability of the product and its effectiveness;
   viii. Genus/species/strain of microorganism(s) and/or chemicals present in the product (if requested, this will be maintained as confidential information);
   ix. Identity of specific nutrients and other additives contained in the product (if requested, this will be maintained as confidential information);
   x. Documentation of evidence from authoritative technical references (e.g., Bergey's, etc.) that all microorganisms and chemicals used are not pathogenic to animals or humans;
   xi. Documentation that microorganisms are naturally occurring in the immediate or similar environment;
   xii. Documentation of specific degradation products expected;
   xiii. Documentation of migratory potential of contaminants and degradation products in soil groundwater, and air;
   xiv. Complete description of the bioremediation or injection processes at the site (e.g., application of the product to soil and/or groundwater, aeration of the soil, procedures needed to maintain microbial growth and chemical degradation) and proposed injection pressures;
   xv. Complete description of all potential exposure avenues to humans, animals, and the environment to contaminants and contaminated materials; and
   xvi. Means for preventing spills of injectate and cleanup procedures for any spills that occur; and
   xvii. Disposal procedures for all contaminated materials resulting from the injection or bioremediation process.

4) Remedial Excavation Guidelines – Contractors should submit the following information to the UST Management Division project manager prior to the initiation of remedial excavation activities:
   i. A site plan with the approximate excavation limits;
   ii. Rationale for the proposed excavation limits, and estimated volume/tonnage of material to be removed;
   iii. Name and location of the permitted disposal facility;
   iv. Means for determining the extent of impacted soil and minimizing the amount of excavated material removed from the Site;
   v. Type and source of backfill material, means of compaction; and

vi. Type and quantities of any remedial additives to be mixed with backfill.

5) Public Notice - Pursuant to the South Carolina Underground Storage Tank Control Regulations, R.61-92, Section 280.67, the UST Management Division provides notice to the public of pending Site Rehabilitations. The method of notification is tailored in each situation to reach those members of the public directly and indirectly affected by the planned Site Rehabilitation. Notices may be posted at or in the vicinity of the site. Notices may also be provided to the owner or operator of the underground storage tanks that are suspected to be the source, and owners of local property that:
   i. Is currently impacted by petroleum;
   ii. May become impacted by petroleum;
   iii. Has monitoring wells on it; or
   iv. Adjoins to property that fits in categories i, ii, or iii.

The duration of the public notice should be long enough to give the public a chance to provide their comments (usually 14 to 30 days). If the comments and questions received cannot be adequately answered on an individual basis or if a large number of people have questions, a meeting may be scheduled in their local area at a time suitable to encourage participation. The UST owner or operator and/or the Site Rehabilitation Contractor may be invited to the meeting to further discuss the rehabilitation actions proposed in the Site Rehabilitation Plan.

6) Notice to Proceed – Once the public notice process and all permits have been issued, the UST Management Division will issue a notice to proceed with Site Rehabilitation. This notice does not imply any endorsement that the proposed method will work or that it will achieve the standards (SSTLs) in the most efficient manner possible. The Contractor is responsible for ensuring that the system achieves the required results and for any necessary additions or modifications to the system to achieve the required results. The UST Project Manager must be notified at least 4 days prior to the initiation of field activities. The UST Project Manager should receive prior notification of any proposed changes (other than changing pumping, injection, or air pressure rates). A comprehensive round of groundwater samples will be required prior to initiation of the treatment process outlined in the Site Rehabilitation Plan. Analytical parameters will be specified in the corrective action specification package.

7) Corrective Action System Evaluations (CASE) – Quarterly CASE and monitoring reports documenting progress must be submitted for all Sites in active remediation, as specified in Section A9. The reporting schedule will be outlined in the bid specification. Each CASE should include the following, at a minimum:
   i. Brief description of any construction or treatment system adjustments completed by the Site Rehabilitation Contractor since the previous report. Well completion logs and treatment system construction schematics may be included in the appropriate appendix;
   ii. A table summarizing the measurement of any observed free product and groundwater potentiometric data. In addition, a brief description and a map depicting the most current groundwater flow direction and gradient and any observed historical trends should be included;

iii. A table summarizing the historical and current analytical results from all monitoring wells, which are required to be sampled pursuant to the bid specification. Cleanup goals or SSTLs should also be noted. The total mass exceeding SSTLs should be calculated in accordance with the formula and example in Table 6, below. Negative values should not be used;
iv. Interpretation of groundwater sample result data in the context of overall remedial strategy, including CoCs and any secondary parameters analyzed, such as sulfate, nitrate, ferrous iron, magnesium, ORP, and dissolved oxygen;
v. A brief discussion should be included which describes the Contractor's on-going efforts to maximize the time efficiency of the treatment process;
vi. A summary table of all remedial activities conducted during the corrective action contract;
vii. A revised implementation schedule should be included which more accurately estimates when the cleanup process will be complete; and
viii. Site maps, analytical results, well purging records, and any applicable soil or water disposal manifests should be included in the appendix.

8) <u>Calculation of % Mass Removed</u> – The following formula will be used to calculate the percent total mass reduction: total mass above the cleanup goal or SSTLs from initial sampling less total mass above cleanup goal or SSTLs from subsequent sample results, collected during the most recent sampling event, divided by total mass above cleanup goal or SSTLs from initial sampling.

The following is an example to demonstrate the CoC Mass Reduction Calculation:

Well		Benzene	Toluene	Ethylbenzene	Xylene	MTBE	Naphthalene	Mass>SSTL
MW-1	Initial [A]	7,500	4,000	2,000	15,000	3,000	1,000	A
	SSTL [B]	10	2,000	1,400	10,000	80	50	B
	Initial > SSTL [C]	7,490	2,000	600	5,000	2,920	950	18,860 [C]
	Subsequent [D]	3,000	1,000	900	13,000	2,000	5	D
	SSTL [E]	10	2,000	1,400	10,000	80	50	E
	Subsequent > SSTL [F]	2,990	0	0	3,000	1,920	0	7,910 [F]
MW-4	Initial [G]	150	400	50	250	300	25	G
	SSTL [H]	5	400	50	250	40	25	H
	Initial > SSTL [I]	145	0	0	0	260	0	405 [I]
	Subsequent [J]	100	100	1	1	100	1	J
	SSTL [K]	5	400	50	250	40	25	K
	Subsequent > SSTL [L]	95	0	0	0	60	0	155 [L]
Totals	Initial > SSTL [M]	(sum of initial mass above SSTL for all wells) (C+I)						19,365 [M]
	Subsequent > SSTL [N]	(sum of subsequent mass above SSTL for all wells) (F+L)						8,065 [N]

<u>Table 6. CoC Mass Reduction Calculation Example</u>

i. If subsequent sample results indicate a CoC concentration value at or below the cleanup goal or SSTL and/or a CoC concentration below laboratory detection level but reporting level less than cleanup goal or SSTL for any constituent, the value for the mass reduction will be 0 (negative numbers are not entered in the mass reduction table);
ii. If subsequent sample results indicate that a CoC concentration is below the laboratory detection level but the reporting limit is greater than cleanup goal or SSTL the value for any constituent will be the analytical reporting limit,;
iii. The reporting limit value is entered for subsequent sample results that are below the reporting limit but greater than the Method Detection Limit, which are usually flagged with a "J" in analytical reports; and

iv. Mass Reduction Calculation:
CoC Mass Reduction = (M-N)/(M)*100 = (19,365-8,065)/19,365 = 0.5835 *100 = 58.35% CoC Reduction
(Definitions of variables in this equation can be found in the example table above).

9) Completion of Active Site Rehabilitation – Once analytical results indicate that the concentration of each CoC at each monitoring point is below the cleanup goal or SSTL and the conditions in the Site Rehabilitation specification have been met, the contractor may request authorization from the UST Management Division to stop the treatment system. Once granted, the contractor will begin the post-remediation monitoring and verification cycle. The UST Management Division may require the installation of verification borings and wells. The number of verification points, analytical parameters, and the duration of the post-remediation verification process are specified in the Site Rehabilitation specification. Once the verification process is complete and all concentrations of CoCs are confirmed to remain less than the cleanup goal or SSTL, the UST Management Division will issue approval for the contractor to remove their Site Rehabilitation equipment, abandon pipe runs, and abandon monitoring wells.

c. Intrinsic Remediation or Natural Attenuation

These terms refer to the naturally occurring microbial and fate and transport processes that result in a reduction of the total mass of hydrocarbons. Intrinsic remediation is applicable where:

1) The concentration of any CoC exceeds the RBSL but is less than the SSTL;
2) Measurable free product is not present;
3) The CoC plume is at or approaching equilibrium (i.e., the advancement of the plume is slowing down), and the concentration of a CoC is not increasing at any point;
4) The predicted impact on actual or potential receptors does not exceed the RBSL at any time (i.e., no predicted risk to human health or the environment); and
5) All conditions for intrinsic remediation can be verified in 18 months or less.

An intrinsic approach may need to be upgraded to active Site Rehabilitation if the above conditions cannot be demonstrated; a new or potential receptor is identified, or if there is a change in land use or zoning ordinances.

d. Intrinsic Site Rehabilitation Procedures

1) Data collection - Prior to implementation of Site Rehabilitation, the horizontal and vertical extent of CoCs in the soil and groundwater, aquifer characteristics, and SSTLs are determined. This data is typically collected during Tier I, Tier II and Tier III Assessments as described in this document.
2) Basics of Intrinsic Remediation – Intrinsic remediation refers to the naturally occurring microbial and fate and transport processes that result in a reduction of the total mass of hydrocarbons. A monitoring program is implemented to gather the necessary data to support that intrinsic remediation is reducing the concentrations of CoCs. Once the evidence documents that site conditions are suitable and that intrinsic remediation is taking place, an Intrinsic Corrective Action Report (ICAR) is then prepared to justify the issuance of a “Conditional No Further Action” and the discontinuation of monitoring.

3) Monitoring - The primary evidence for intrinsic remediation shall be the observed reduction in the concentration of each CoC in each well and a corresponding reduction in the overall size and geometry of the plume.
4) Secondary evidence for intrinsic remediation includes further computer modeling of solute and transport rates or estimates of assimilative capacity, and the collection of geochemical parameters that support the depletion of nutrients or the generation of by-products as a result of biological or chemical processes.
5) A monitoring well located hydraulically down gradient of the source is always needed to verify that the plume is not continuing to migrate. Initially, all monitoring wells should be sampled for all CoCs, which have concentrations exceeding the RBSL, and for secondary geochemical parameters. Accepted analytical methodologies are outlined in Appendix F. The data from the first sampling event should be evaluated for evidence of CoC reductions, plume migration, and biological or geochemical evidence of intrinsic remediation such as oxidation, de-nitrification, or methanogenesis. Sampling parameters for future events should be tailored to address those biological and geochemical parameters that provide the strongest evidence of intrinsic remediation.
6) Typically, quarterly sampling during the first year is needed to establish seasonal variability. The frequency after the fourth quarter should be established based on a review of all historical water table fluctuations and CoC variations.
7) Intrinsic Monitoring or MNA Report **-** Each monitoring report should include the following:
   i. A data table summarizing the measurement of any groundwater potentiometric data. In addition, a brief description and a site map depicting the most current groundwater flow direction and gradient and any observed historical trends should be included;
   ii. A data table summarizing the historical and current analytical results of CoC and geochemical parameters from all monitoring wells, which were sampled;
   iii. A brief description of any observed historical CoC concentration trends and any geochemical evidence supporting intrinsic remediation;
   iv. Topographic and site maps depicting the locations of former or existing underground storage tanks lines and dispensers, monitoring wells, buildings, and other structures; and
   v. Analytical results, well purging records, and any applicable purge water or soil disposal manifests should be included in the appendix.

8. Intrinsic Corrective Action Plan - Once the monitoring program has gathered the needed evidence that supports that site conditions are suitable and that intrinsic remediation is taking place, an Intrinsic Corrective Action Plan (ICAP) is prepared to justify the issuance of a “Conditional No Further Action” decision, and the discontinuation of monitoring. The ICAP contains the elements for the Intrinsic Monitoring Report and the following:
   i. A copy of the relevant portion of the tax map shall be included with a list of the property owner’s names, tax map numbers, and mailing addresses for each property that:
      a) Is currently impacted by petroleum;
      b) May become impacted by petroleum;
      c) Has monitoring wells on it; or
      d) Adjoins to property that fits in categories a, b, or c.
   ii. All available data should be used to estimate how long intrinsic remediation will take to restore the soil and groundwater to risk-based screening levels. These estimates may be

derived by extrapolation of documented decreasing trends, or through calibration of scientific models using historical CoC and geochemical data. All input parameters and assumptions should be clearly identified;

iii. The receptor survey should be verified and the local city or county authorities should be contacted for an update on the current applicable zoning and land use ordinances. A brief discussion of the findings should be included; and

iv. If the data supports that no unacceptable risk will result by leaving the CoC in place to naturally degrade during the estimated clean-up time frame, the report should recommend the termination of monitoring.

e. No Further Action Decision

1) A "No Further Action" decision may be issued by the UST Management Division if the concentration of each CoC is at or below the RBSL. The samples that support the decision should be:

i. Collected from the location(s) deemed most likely to represent the worst case CoC concentrations;

ii. Analyzed for appropriate parameters by a laboratory certified in the state of South Carolina for those parameters; and

iii. Collected in accordance with industry standards for quality assurance and quality control.

2) If a Site Rehabilitation system was used, the "No Further Action" decision will only be issued after completion of a post-remediation monitoring program, which confirms that concentrations of each CoC remain below RBSL.

f. Conditional No Further Action Decision

1) Pursuant to The SUPERB Site Rehabilitation and Fund Access Regulations, R.61-98, a "Conditional No Further Action" decision can be granted once the following has been demonstrated:

i. The SSTL have been met;

ii. The CoCs have reached equilibrium or are not being transported in groundwater at a significant rate;

iii. Concentrations of CoCs are not increasing;

iv. No unacceptable risk to human health, safety, or the environment exists; and

v. Concentrations of CoCs will not exceed RBSL at the exposure point or receptor.

2) Prior to issuance of a "Conditional No Further Action" letter, the UST Management Division provides notice to the public to solicit comments and concerns. The method of notification is tailored in each situation to reach those members of the public directly and indirectly affected by the proposed decision.

3) A "Conditional No Further Action" letter is based on site-specific conditions and the current and reasonably anticipated future use of the site. The letter will outline all land use assumptions and conditions at the time the decision is made. The UST Management Division will be notified by the underground storage tank owner or operator within 30 days of any changes in the listed assumptions or conditions so that the potential risk can be re-evaluated. Examples of

assumptions or conditions that may be attached to a "Conditional No Further Action" letter include, but are not limited to:

i. The property is zoned for commercial use and should remain commercial in the future;
ii. Water wells are not currently installed in the impacted area and should not be installed in that area in the future; and
iii. Local ordinance precludes the installation of potable wells.

Once the UST owner or operator is notified of a "No Further Action" or a "Conditional No Further Action" decision, abandonment of the monitoring wells is suggested to minimize the possibility of leakage of future spills into the groundwater aquifer. The UST owner or operator may also choose to keep these wells for future monitoring purposes. If this option is chosen, the UST owner or operator becomes responsible for the future maintenance and abandonment of the monitoring wells.

The UST Management Division maintains a Registry of Releases for all "Conditional No Further Action" decisions. The longitude and latitude from the Geodetic Information System, local tax map number, and street address of each closed conditional release is available at the UST Management Division's Freedom of Information office (803) 898-3880. If a person is later able to demonstrate all CoC are below the RBSL, then that person may request that the release be removed from the registry of releases and a "No Further Action" decision be issued by the UST Management Division.

g. Aggressive Fluid Vapor Recovery (AFVR)

Aggressive Fluid Vapor Recovery (AFVR) is a technology that is used for rapid recovery of liquid phase hydrocarbons such as gasoline or diesel fuel. AFVR uses a high-pressure vacuum to recover both fluid (groundwater and liquid phase hydrocarbons) and vapor phase hydrocarbons from targeted monitoring or recovery wells. The UST Division directs AFVR events as a means to abate petroleum releases. AFVR is also utilized by contractors as part of Corrective Action Plans.

1) Events must be conducted on target monitoring or recovery wells with a minimum inner diameter of 2-inches;
2) Prior to the initiation of the event, fluid levels and free-phase product (FPP) thickness measurements shall be recorded in the target wells designated by the UST Management Division. Fluid levels should be measured in any adjacent wells used to gauge surrounding pressure prior to the start of the event;
3) The Contractor shall manage all effluent (FPP and groundwater) generated by the AFVR event. Effluent management must not interfere with continuity of the event;
4) OVA (organic vapor analyzer) screening devices used to measure vapor concentrations shall be calibrated every eight (8) hours during the operational time periods per day. A calibration log for the event shall be kept onsite with other field documents;
5) Vacuum gauges must be installed directly on the extraction wells and the range of each vacuum gauge should be selected based on the expected pressure range;
6) Magnehelic gauges must be installed on at least two (2) water table bracketing monitoring wells immediately surrounding the extraction well(s) and remain attached for the duration of the event. The range of each magnehelic gauge should be selected based on the expected pressure range. For example, one would expect perimeter wells to have less pressure than the extraction wells and thus require a smaller graduate interval may be necessary;

7) Water level measurements shall be taken on the adjacent wells at the beginning and 8-hour time intervals throughout its duration.
8) Connect the AFVR unit to a grounded metal object or equipment chassis with a ground lead to ensure that static electricity does not result in an explosion hazard.
9) The AFVR event should be completed by establishing a vacuum on the subsurface through the designated monitoring or recovery wells. The unit must be capable of providing a minimum airflow of 250 cubic feet per minute (CFM) and a minimum vacuum of 25 inches of mercury (inHg) at the vacuum pump intake. An airtight seal must be established on the top of each extraction well. The seal may incorporate a "bleeder" valve that must connect with the annulus of the target well to assist with deep recovery if necessary. The "bleeder" valve may not be connected directly to the stinger. The drop tube or "stinger" with a minimum inside diameter of one (1) inch shall be lowered in each extraction well from the depth of water or top of the well screen (if well screen does not bracket water table) to the terminus depth within the first eight (8) hours of the event. The terminal depth shall be determined by the UST Management Division or shall be the historical, post-release low water table elevation or the base of FPP whichever is lower. Once the terminus depth has been achieved then the stinger shall fluctuate throughout the smear zone while maintaining de-watering of the smear zone. The objective of stinger placement is to expose the maximum amount of the FPP smear zone to vacuum thereby maximizing FPP and/or petroleum vapor recovery.
10) All monitoring and/or recovery wells must remain sealed for the duration of the AFVR event, unless stinger depths are being adjusted or water levels are being monitored.
11) The AFVR event shall be continuous and shall not be terminated early without prior approval from the UST Management Division. The Contractor must have sufficient materials and pressure to simultaneously recover from a minimum of three target wells located within a 50-foot diameter circle. If all wells requiring AFVR are not located within a 50-foot diameter circle, AFVR activities may rotate between areas during the event. Recovery shall concentrate on the target well(s) that demonstrate the highest free product removal rate, unless otherwise directed by the UST Management Division.
12) Stinger depth (feet), airflow rate (cubic feet per minute), vacuum gauge readings (inches of mercury), pre-treatment vapor concentrations (parts per million), and post-treatment vapor concentrations (parts per million) shall be recorded at 30-minute intervals for the first 8 hours of any event. Magnehelic gauge readings (inches of water) on adjacent wells shall be recorded at two-hour intervals for the entire event. For events longer than 8 hours, the aforementioned data shall be recorded at one-hour intervals from 9 hours to 24 hours, and 2-hour intervals from 25 to 96 hours. After the first 8 hours, data recording may be suspended between the hours of midnight and 8 AM.
13) If the air emissions are anticipated to have an adverse impact in the vicinity of the AFVR, the UST Management Division may require off-gas treatment. The off-gas treatment must have a minimum 80% reduction rate per required interval measurement. All AFVR units or when required off-gas treatment units must have a post emissions stack that is a minimum of 10 feet above ground surface.
14) Immediately after the completion of the event, all fluid levels should be measured in extraction wells (anticipating FPP) and adjacent wells used for pressure gauging.
15) A report documenting the recovery event shall be submitted within thirty (30) days from the date of the event. The report shall include the following:

i. A brief description of the completed work scope and any relevant descriptions pertaining to the data tables;
ii. A table summarizing the airflow (in CFM), pre-treatment vapor concentrations (parts per million), and post-treatment vapor concentrations (parts per million). The table shall also list the AFVR extraction wells and stinger depths in feet;
iii. A table summarizing the vacuum gauge measurements from all extraction wells and adjacent wells;
iv. The total volume of water recovered (gallons);
v. The total volume in gallons of FPP recovered (typically measured with a product/water interface device inserted into the top of the recovery tank and then converted to an approximate volume);
vi. The total volume in gallons of petroleum removed as vapor. This is calculated based on the airflow rate and the pre-treatment vapor concentrations;
vii. A table documenting the FPP thickness in each well before and after the AFVR event;
viii. Scaled base map depicting the location of the extraction wells and the surrounding wells equipped with vacuum gauges; and
ix. An original copy of the weight ticket and disposal manifest from the permitted treatment facility that clearly designates the quantity of effluent received, applicable permit numbers, and dates must be included as Appendix G in the final report. If a weight ticket cannot be obtained from a disposal facility, then documentation (e.g., date stamped photograph) of a measurable device used to ensure an accurate measurement of effluent gallons produced must be provided in the report.

Note: These specifications detail the specific tasks required to successfully complete the scope of work for AFVR. These specifications do not include general implied tasks as required by Federal, State or local governments (OSHA 40-hour training, Health and Safety Plans, business licenses, etc.).

h. Granulated Activated Carbon Unit Installation

Granulated Activated Carbon (GAC) Units may be installed on water supply wells to filter out petroleum compounds until a permanent source of potable water is obtained.

1) The unit must remove Volatile Organic Compounds (to include Benzene, Toluene, Ethylbenzene, Xylenes, Methyl Tert-butyl Ether, etc.), and Polynuclear Aromatic Hydrocarbons (PAHs);
2) The unit must have a minimum carbon capacity of two cubic feet or 50 pounds;
3) New units must have a minimum five-year warranty on the control head unit and a lifetime warranty on the tank;
4) The unit must have an automatic counter to keep account of water usage or a counter must be installed in conjunction with the unit;
5) The unit must have a 48-hour capacitor that will reset the equipment for backwashing purposes in the event of electrical failure;
6) The equipment specifications must be validated by the Water Quality Association;
7) The contractor will provide a six-month warranty on all pipe, fittings, etc. used in the installation of all units;
8) The unit will be installed inside the existing well house (space permitting) or inside a locked housing. The housing must be durable and blend with the surroundings. Copies of the key to the

lock must be provided to the owner of the well and to the Underground Storage Tank Management Division;

9) The contractor will install sample taps on the inlet and outlet lines of the unit to allow for sampling. The sample taps must be located inside the locked housing for the unit. The installation will include up to ten (10) feet of pipe (Schedule 40 PVC) and all necessary materials and fittings. When installing a GAC unit close to a house or basement extra measures must be taken to control the runoff from the unit;
10) All electrical wiring will be installed in compliance with applicable codes. The installation will include up to twenty (20) feet of wire and all necessary conduit, fittings, trenching (as required), materials and labor;
11) A schematic diagram of the unit (new or old) with the model number, serial number, site name, UST permit number, and inlet and outlet ports will be required. This information must be submitted within one week of installation;
12) A sign in sheet must be in the housing unit to indicate carbon changes and other service. The information must include the time, date, type of service, and the full name(s) of the personnel conducting the service;
13) The contractor must provide all calculations, using analytical data provided by the UST Management Division, for determining CoC breakthrough and the frequency at which the filter material must be changed;
14) All work must be done by a professional plumber certified in the state of South Carolina. Proof of certification must be provided with the QAPP Contractor Addendum or SSWP; and
15) The final report (one [1] hard copy report and one [1] electronic copy) should be submitted and include the relevant elements as required in **Section A9** of the document.

V. BORING, FIELD SCREENING, AND WELL INSTALLATIONS

Subsurface investigation is an integral component of environmental assessment and remediation. Boreholes are advanced to investigate impacts to soil, geological conditions, or to install wells. Monitoring wells are installed when required for plume delineation or to verify the efficacy of corrective action activities. Recovery wells are installed in the source zone and are designed to assist in the capture of hydrocarbons during extraction events. Most of the environmental media sampled as part of the SUPERB program involve boring and well installation.

a. Soil Boring

Each boring advanced to document soil lithology should be logged by a field geologist using the United Soil Classification System. The following information should be recorded:

1) Soil type of each stratigraphic unit;
2) Color of the soil using standard methods;
3) Rocks or minerals present;
4) Qualitative indication of soil conditions (dry, moist, water saturated and any staining of the soil by petroleum, odor);
5) Continuous geological description of all recovered material including interpretation of formation and/or depositional environment, especially at locations in the coastal plain;
6) Split-spoon or core sample intervals, including percent recovery;
7) Any organic vapor and field measurements;

8) Depth of each sample submitted for analysis;
9) Name and signature of person collecting data;
10) Name of Field Supervisor; and
11) Location, depth and type of each sample submitted for analysis.
12) Enclose the Geologist/boring log, Water Well Record (DHEC Form 1903) and Well Development Log (DHEC Form 2099) in the appropriate appendices of the final report (See Section A9).

Sites located in areas of substantial surficial geologic heterogeneity in the Coastal Plain should be investigated using drilling methods capable of discerning soil strata of higher relative permeability to the maximum relevant depth that include the collection of continuous cores to describe lithology. Traditional environmental drilling methods may not be adequate means to assess soil lithology at depths necessary to determine CoC transport in groundwater at some locations. Appropriate drilling technologies should be used to assess soils in these instances.

All soil borings and screening points shall be properly abandoned by a SC Certified Well Driller in accordance with the SC Well Standards and Regulations, R.61-71.

The upper three (3) inches of each boring/point, or up to six (6) inches in a high traffic area, that is not completed as a monitoring well shall be filled with a material comparable to the surrounding material (e.g., an asphalt plug should be placed in the upper three inches of a boring/point advanced in an asphalt parking lot, and a native soil/grass plug may be used in the upper three inches of a boring/point advanced in a grassy area.).

b. Field Screening

If the location(s) for permanent monitoring wells cannot be determined without field screening, the Contractor will utilize a field sampling technique and analyze each sample in the field with an appropriate screening methodology.

1) The method for sample collection and the field screening technique (FST) shall be included in the required site-specific QAPP Contractor Addendum or ACQAP. Field screening serves as a tool to determine adequate locations for monitoring wells addressing horizontal and/or vertical extent of the petroleum constituents in soil and groundwater during one direct push/drill rig mobilization. The Contractor shall use an appropriate technique for each site.
2) The results of the field screening will be to optimally locate and reduce the number of permanent monitoring wells.
   i. Contractors are allowed per UST Project Manager's request to collect groundwater samples from existing shallow wells, deep wells, and down gradient screening points for laboratory analysis to ensure the entire plume is delineated; and
   ii. Field screening locations, field sampling results, any laboratory analyses, and proposed permanent monitoring well locations are to be faxed or e-mailed to the UST Project Manager for concurrence.
3) Typical methods of screening include one or a combination of the following:
   i. Screening using an on-site semi-quantitative analytical method(s) that is capable of detecting benzene, naphthalene, MtBE and EDB without sending screening samples to a SCDHEC certified laboratory. The method(s) will be capable of providing real-time on-site data; i.e. the data is obtained as borings are advanced or within 30 minutes of sample collection. Typical

instrumentation includes, but is not limited to, Laser Induced Fluorescence (LIF), Optical Imagery Profiling (OIP), Membrane Interface Probes (MIP), Ultra Violet Fluorescence (UVF), and field gas chromatography.The method(s) used and the results will be submitted to the appropriate project manager for concurrence with proposed well locations before monitoring wells are installed and included in the report;

ii. Screening by submitting selected vertical and down gradient groundwater samples to a SCDHEC Certified Laboratory for analysis. In order to be considered defined, the laboratory analysis should provide results at or below the RBSL for each CoC. The screening and laboratory results will be submitted to the appropriate UST Project Manager for concurrence before monitoring wells are installed and included in the report; and

iii. Fractured Rock screening using methods to identify individual fractures or zones containing a series of fractures. Fractures may be identified by use of calipers, gamma logs, temperature sensors, flow sensors, video cameras or other in-bore methods and techniques. The goal will be to locate all fractures 0.01 foot or larger, the orientation of the fracture(s) in an individual boring, and collating fractures over the entire site if multiple wells or borings are logged at the site as well as the reporting of this data. The method(s) used and the results will be submitted to the appropriate project manager to determine screen locations in the core hole or if the core hole should be abandoned.

4) Process –Typically the following steps will be used for groundwater screening:

i. Prior to advancing the first field screening point, the depth to groundwater shall be gauged in existing monitoring well(s);

ii. The initial field screening points should be installed in a radial pattern beginning in the immediate vicinity of the suspected source(s). These field screening points shall not be advanced deeper than five feet below the water table as gauged in existing wells and shall delineate the horizontal extent of free phase product and dissolved CoC at the water table. A series of temporary wells may be appropriate to define the extent of free phase product. If advancement refusal is encountered at multiple points, the UST Management Division Manager should be called to determine if field screening should be continued;

iii. Once the upper horizontal extent of the plume has been identified, a minimum of three deeper field screening points shall be advanced to determine the vertical extent of CoC in the soil and groundwater. These points shall be located along the plume centerline and shall be located at the source, the mid-point of the plume, and at the downgradient boundary of the plume. Water samples shall be screened for petroleum constituents at five (5) foot intervals and at any discernible changes in soil type with a properly calibrated field screening instrument. Changes in soil type can be identified utilizing well logs from existing monitoring wells or based on significant changes in the advancement rate of the field screening points. The deeper field screening points shall be terminated at advancement refusal or upon two consecutive samples below risk-based screening levels, whichever is shallower;

iv. The remaining field screening points for horizontal delineation shall be advanced to the depth that exhibited the highest results in the deeper field screening points. For example, if the highest concentration of petroleum is present in a sand stringer located eight feet below the water table, then additional field screening points shall target that stratigraphic interval;

v. The Contractor shall provide the following QA/QC information in their site-specific QAPP Contractor Addendum or ACQAP:

a) Field Instrument - The brand name, model number, and serial number for each instrument(s) utilized;
b) Field Calibration - Written verification of the calibration of the instrument in the field for each day of reported analysis. This shall include the method of calibration, the concentration(s) and composition of the standard, and the existing conditions at the time of calibration (temperature, humidity, etc.). This calibration shall be performed according to the manufacturer's specifications and using a standard reference gas indicative of the constituents being tested. This allows the method to provide measurements of the actual concentration of the subject constituent; and
c) Field Analytical Method - This shall include protocols for sample collection and handling, as well as a detailed description of the field analysis. This shall also include information pertaining to the basis for the method and how it works.

5) Field screening locations, field sampling results (OVA, and/or laboratory data) and proposed monitoring well locations must be provided to the UST Project Manager via email for concurrence prior to the installation of permanent wells. It is the responsibility of the contractor to ensure the horizontal and vertical extent of petroleum CoC are defined prior to installation of monitoring wells;
6) Shallow screening should concentrate on defining the edges of the plume laterally (including areas up gradient of the source), between the source and receptors (water supply wells, surface waters, and utilities) to determine if a preferential pathway exists, and define strata with high hydraulic conductivity (sand stringers, gravel beds); and
7) The Contractor or their subcontractors shall not access private property, clear roads, nor cut vegetation without the property owner's written consent. A copy of all agreements obtained from adjacent property owners should be included in the final report as the appropriate appendix.

Abandonment of temporary soil borings, field screening points and core holes shall be completed under the supervision of a SC Certified Well Driller in accordance with the SC Well Standards and Regulations, R.61-71.

1) The upper three (3) inches of each boring that is not completed as a monitoring well shall be filled with a material comparable to the surrounding material. For example, a native soil/grass plug may be used in the upper three inches of a boring advanced in a grassy area.
2) If for any reason the property owner requests a variance (i.e., to not grout a borehole) the UST Project Manager will be contacted within 2 business days of the request and the request will be documented in the report of findings.

c. Well Installation

The well(s) must be installed by a SC Certified Well Driller and constructed in compliance with R.61-71.

1) Construct permanent monitoring wells of 2-inch inner diameter PVC casing with a 10-foot PVC screen in the area designated by the UST Project Manager.
   i. The screen of all shallow monitoring wells must be installed so that the water table is bracketed.
2) Recovery wells are constructed of at least 4-inch diameter PVC and are screened in a manner to maximize the extraction of vapor and dissolved phase CoCs.
   i. Recovery wells should not be screened across confining layers; and

ii. Recovery well screens may be installed in the vadose zone in circumstances when the maximization of vapor phase CoC extraction is intended.

3) Telescoping wells, also referred to as double cased or pit cased wells, are installed at locations where there is reason to believe that well construction activities may cause cross contamination or interconnection between discrete aquifers separated by confining units. Telescoping wells are also installed to prevent underlying aquifers from being impacted by contamination in surface soils. The following requirements must be met during the construction of telescoping wells to ensure that preferential pathways are not introduced into aquifers:

i. The diameter of the borings must be such that installation of the telescoping monitoring wells can easily be accomplished with a required minimum 1.5-inch annular spaces between both the outer casing and the borehole wall and the outer and inner casings;

ii. A minimum of six-inch inner diameter well casing should be advanced at least ten feet deeper than the bottom of the nearest adjacent water table bracketing well screen, deep enough into the first confining unit for the casing to be adequately sealed without compromising the integrity of the unit, or as otherwise directed by the UST Division Project Manager;

iii. The grout mixture used to seal the outer annular space should be either a neat cement, cement/bentonite, or a 20% solids bentonite grout. However, a minimum three-foot seal or plug at the bottom of the borehole and outer casing should consist of a Type I Portland cement or a cement/bentonite 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;

iv. The annular space around the casing must be pressure grouted to the surface using a tremie pipe or equivalent method in accordance with the SC Well Standards and Regulations (R.61-71) and allowed to cure for a minimum of twenty-four hours; and

v. Well screen lengths for telescoping wells shall be five feet long unless a variance in the screen length is requested by the registered professional and approved by the UST project manager.

4) Monitoring and Recovery wells require proper filter pack, bentonite seal, grout, well identification plate, locking well cap, well pad constructed at or above ground level, and well cover held in place with bolts or screws.

i. Filter Packs must be adequate to limit of the migration of fines from the soil formation from entering the well pipe; and

ii. Information on the well identification plate will be stamped, etched, or engraved in legible text. Use of ink markers (e.g., "Sharpie®") is not acceptable;

5) Any monitoring well(s) completed in heavily trafficked or mowed areas should be flush-mounted with concrete pads and well vaults. All other wells should be completed with a one-foot minimum stick-up casing. Wells installed in wooded or overgrown areas should be marked with a piece of flagging tape attached at eye level or a brightly colored marker at least three (3) feet high.

6) Wells should be identified according to the following convention:

i. Monitoring wells should be identified with the prefix "MW-";

ii. Recovery wells should be identified with the prefix "RW-";

iii. Injection wells should be identified with the prefix "IW-';

iv. Wells installed in close proximity and screened at different depths and nested wells should be given the same identification number differentiated by the suffix D, indicating the deeper well (e.g. MW-# and MW-#D). Additional deeper wells at the same location should be identified by additional "D"s, such that MW-#DD is installed with a deeper screen than MW-#D;
v. Replacement wells should be identified using the same ID as the original well, with the suffix "R" (e.g.) if MW-# is lost or abandoned, the replacement well should be identified as MW-#R; and
vi. At sites that are likely to be adjacent to other petroleum or hazardous material release sites, samples should be designated with the 5-digit permit number as an additional prefix (e.g. 12345-MW-#).

7) Enclose the Geologist/boring log, Water Well Record (DHEC Form 1903) and Well Development Log (DHEC Form 2099) in the appropriate appendix of the final report (See Section A9).

d. Monitoring Well Development

Monitoring wells shall be developed after filter pack is in place, but prior to installing bentonite/grout seal or after a minimum of 24 hours upon well completion. Any other well development procedure that is consistent with industry standard and meets state regulations can be submitted for review and approval by the UST Management Division.

1) Monitoring wells must be properly developed in compliance with SC Well Standards and Regulations, R.61-71. The development method must be capable of removing enough formation cuttings, drilling fluids and additives to provide relatively sediment-free water samples that are typical of the aquifer.
2) A well development method should be specified on the Well Development Log (DHEC Form 2099) which is to be completed during the development process and submitted in the report (See Section A9).

All soil, development and/or purge water generated during implementation shall be containerized in suitable, leak proof containers and disposed of as appropriate within 90 days of generation. Once laboratory analysis for soil and groundwater is received, the UST Project Manager may be contacted to see if on site disposal is appropriate.

If the derived soil and wastewater is generated from a waste oil investigation, prior approval must be obtained from the Bureau of Land and Waste Management before offsite removal commences. RCRA metals analyses to characterize the waste may be directed if required by the permitted disposal facility.

e. Initial Groundwater Sampling Event

When requested to collect groundwater samples from monitoring wells or water supply wells for analyses do so in accordance with Section B2 of this document.

1) Groundwater samples should be collected after each new groundwater monitoring well has been developed and allowed to equilibrate for a minimum of twenty-four (24) hours;
2) All newly installed monitoring well(s) shall be purged prior to their initial sampling in accordance with Section B2 Groundwater Sampling, with all indicator parameters of the groundwater

monitored and recorded. Field data sheets documenting purging volumes and parameters measured shall be included as an attachment to the report of findings.

3) If the monitoring well contains free product exceeding 0.01 feet (1/8 inch), a sample shall not typically be collected. If free product is encountered, please contact the appropriate UST Project Manager to determine if a product bail down test, collection of a product sample for product aging, or collection of a groundwater sample below the product will be required.

f. Waste Disposal

All soil cuttings and groundwater generated during boring construction and monitoring well development/purging shall be temporarily stored in suitable, leak proof containers. Sample, analyze, transport within 90 days of generation, and dispose of any soil or wastewater generated in accordance with the UST Management Division's guidelines. Once laboratory analysis for soil and groundwater is received, the UST Management Division manager may be contacted to see if on site disposal is appropriate. Sampling and disposal shall be the responsibility of the Contractor. It is the responsibility of the Contractor to acquire signatures for the disposal manifests. Categories of waste disposal include:

1) Wastewater - Water generated from well development, purging and/or sampling, or water generated from aquifer testing;
2) Free Product - any product recovered from the sub-surface;
3) Soil - soil that requires treatment or disposal in concurrence with the UST Management Division; and
4) Drilling Fluids – generated during the drilling process that require treatment in concurrence with the UST Management Division.

g. Aquifer Evaluation

If requested, an aquifer slug test may be completed from specified monitoring well(s) located outside of the UST area to determine aquifer characteristics. It is up to the discretion of the Contractor as to which method will be used to conduct the aquifer test.

Note: If water recharge is anticipated to be faster than manual methods allow, then the UST Management Division requires the use of a pressure transducer.

1) Data points (water level measurements) shall be recorded every 5 seconds for the first two (2) minutes for either falling or rising head test. After two minutes the time increments can gradually increase according to the formations hydraulic conductivity;
2) Data collected shall be evaluated and analyzed in accordance with industry standards (Hvorslev, Bouwer and Rice, etc.). The slug test shall be reported on the Slug Test Summary Form (DHEC Form 3531) in the format as shown at http://www.scdhec.gov/environment/docs/slugtest.pdf. The completed forms and all applicable data shall be attached to the report in the appropriate appendix (See Section A9); and
3) The hydraulic head from the shallow aquifer should not be assumed to apply to deeper aquifers. The shallow aquifer slug test and deep aquifer slug test shall be completed and reported separately.

h. Post Installation Survey

Perform subsequent survey to tie in the location and top of casing elevation of the newly installed monitoring well(s) to a minimum of two pre-existing monitoring wells. The survey should be scaled to reflect the existing site map. The accuracy of the subsequent survey will be of major importance.

Comprehensive Survey (if requested) should be conducted after completion of all field activities (soil boring, field screening and monitoring well installation); a survey of the site shall be performed by a South Carolina Registered Surveyor. The survey should be accurate to 0.01 foot. The survey will cover an area measuring 500 ft by 500 ft and shall include, at a minimum, all of the following:

1) The location of all manmade structures;
2) All above ground and underground utilities;
3) All potential receptors;
4) All existing and/or former USTs and associated piping and dispensers; and
5) All monitoring wells associated with the release (elevation shall be measured to the top of casing of each monitoring well).

i. Well Repair, Maintenance, and Abandonment

Repair damaged or missing items to previously installed monitoring wells as necessary. All repairs must be preapproved by the UST Project Manager. A description of all repairs will be included in the report.

Well repair activity will include replacement of one or more of the following:

1) A cracked or broken well pad;
   i. A high strength well pad replacement shall consist of a steel-reinforced concrete well pad that will be able to support heavy vehicles such as fully loaded semi's or concrete trucks. This type of construction is appropriate at truck stops or sites that have heavy machinery driving over the monitoring wells;
2) The well vault;
3) A missing well tag;
4) The well cover;
5) Bolts;
6) Well caps; and/or
7) Locks.

The UST Management Division may require the abandonment of monitoring wells that are no longer required or that have been damaged.

1) Abandon all monitoring wells at the assigned site by of a Class A, B, or C SC Certified Well Driller in accordance with the SC Well Standards and Regulations, R.61-71. In paved areas, the lid will be removed and the vault will be filled with aggregate reinforced concrete or asphalt. In unpaved areas, the pad, vault, and cover will be removed and the space filled with soil to level with the surrounding land surface.
2) The final report should be submitted and include the relevant elements as required in **Section A9** of the document, including photographs of each decommissioned well.

B2 Sampling Methods

Since all data are potentially critical in nature, any issues arising during with sample collection or access to the sites must be reported to the UST Project Manager to determine what actions should be taken (e.g., re-sampling, etc.). Variability is expected in these samples due to nature of environmental sampling. The UST Project Manager should also to be contacted when anomalies are found in the data or in the site itself.

Deployment of in-situ monitoring (field analysis for pH, conductivity, etc.) is discussed under Groundwater Sampling (See Monitoring Well Purging) and used for monitoring the purging of the wells. Information on the specifics of Quality Control, calibration, etc. is discussed in Section B4 of both this QAPP and the site-specific QAPP Contractor Addendum or ACQAP.

The procedures for the decontamination of sampling equipment are given in Appendix I. The individual Contractors are responsible for the disposal of the waste from such decontamination.

When problems occur in the field the Contractor is responsible for contacting the UST Project Manager within 24 hours. All issues shall be documented in field logs.

I. SOIL SAMPLING

The appropriate equipment and techniques must be used to conduct the investigation. This section discusses the sampling equipment available and collection methods that have been shown to be technically appropriate.

a. Equipment

Soil sampling equipment used for sampling trace contaminants should be constructed of inert materials. Ancillary equipment (e.g., auger flights, post-hole diggers, etc.) may be constructed of other materials since this equipment does not come in contact with the samples. Selection of equipment is usually based on the depth of the samples to be collected, but it is also controlled to a certain extent by the characteristics of the material.

b. Sampling Methodology

This discussion of soil sampling methodology reflects both the equipment used (required/needed) to collect the sample, as well as how the sample is handled and processed after retrieval. Selection of equipment is primarily based on the depth of sampling, but it is also controlled, to a certain extent, by the characteristics of the material. Simple manual techniques and equipment, such as hand augers, are usually selected for surface or shallow subsurface soil sampling. As the depth of the sampling interval increases, some type of powered sampling equipment is usually needed to overcome torque induced by soil resistance and depth. The following is an overview of the various sample collection methods employed over three general depth classifications: surface, shallow subsurface, and deep subsurface. Any of the deep collection methods described may be used to collect samples from the shallower intervals.

Manual Collection Techniques and Equipment

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 12 inches below ground surface. The shallow subsurface interval may be considered to extend from approximately 12 inches to 24 inches below ground surface or to a site-specific depth at which sample collection using manual methods becomes impractical. **The sample must be obtained from an area that is not in contact with metal sampler surface.**

1) Surface Soils

i. Surface soils may be collected with a wide variety of equipment. Spoons, shovels, hand-augers, push tubes, and post-hole diggers (made of the appropriate material) may be used to collect surface soil samples. As discussed in the section on powered equipment, surface soil samples may also be collected in conjunction with the use of heavy equipment.

ii. Surface samples are removed from the ground and placed in pans, where mixing occurs prior to filling of sample containers. The Special Techniques and Considerations section contains specific procedures for handling samples for volatile organic compounds (VOC) analysis. If a thick, matted root zone is encountered at or near the surface, it should be removed before the sample is collected.

2) Subsurface Soils

i. Hand-augering is the most common manual method used to collect subsurface samples. Typically, auger-buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time.

ii. The practical depth of investigation using a hand-auger is related to the material being sampled. In sands, hand augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device.

iii. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torqueing of hand-auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required. Some powered methods, discussed later, are <u>not acceptable</u> for actual sample collection, but are used solely to gain easier access to the required sample depth, where hand-augers or push tubes are generally used to collect the sample.

iv. When a vertical sampling interval has been established, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well as to collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a <u>new bucket</u> must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole.

v. Another piece of soil sampling equipment commonly used to collect shallow subsurface soil samples is the Shelby or "push tube". This is a thin-walled tube, generally of stainless-steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if an undisturbed sample is required. The sampling device is removed from the push-head, and then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly if collected at lower depths.

3) Powered Sampling Devices

Powered sampling devices and sampling aids may be used to acquire samples from different depths but are generally limited to the device's capabilities. Among the common types of powered equipment used to collect or aid in the collection of subsurface soil samples are power augers, split-spoon samplers driven with a drill rig drive-weight assembly or hydraulically pushed using drill rig hydraulics, and backhoes. The use of each of these is described below.

i. Power Augers are commonly used to aid in the collection of subsurface soil samples at depths where hand-augers are impractical. This equipment is a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range. It is used to advance a hole to the required sampling depth, at which point a hand auger is usually used to collect the sample.

ii. Drill Rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 100 feet, though some technologies, including air rotary, rotosonic, and diamond core drill rigs can be used to penetrate bedrock. When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed. If geotechnical data are also required, the number of blows with the hammer for each six-inch interval should be recorded.

iii. Direct Push Rigs allow the collection of continuous cores, which are often removed in from core barrels in single use liners, which prevents the contact of sample material with the tooling. The liners are cut to allow access to the cores for sample collection and for lithology to be logged. Dual tube sampling systems are employed to maintain casing in a borehole while the sampling tooling is removed and replaced.

iv. Backhoes or Excavators are often utilized in shallow subsurface soil sampling programs. Samples may either be collected directly from the backhoe bucket or they may be collected from the test pit or trench wall if proper safety protocols are followed. Test pits and trenches offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface must be dressed with a stainless steel shovel, spatula, knife, or spoon to remove the surface layer of soil that was smeared across the trench wall as the bucket passed. If backhoe buckets are not cleaned according to the procedures described in Appendix I, samples should be collected from material that has not been in contact with the bucket surface.

c. Special Techniques and Considerations

1) Collection of Soil Samples for Volatile Organic Compounds (VOC) Analysis

These samples should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with a hand auger, the sample for VOC analysis may be collected directly from the auger bucket or immediately after an auger bucket is emptied into the pan. Samples for VOC analysis are not mixed/homogenized. Soil samples should be placed directly in the container submitted for laboratory analysis with any required preservative and should not be transferred from plastic bags or other containers used for field screening. Low-level samples must be collected in accordance with USEPA Method 5035 following the certification requirements as issued by the SCDHEC Office of Environmental Laboratory Certification.

2) Dressing Soil Surfaces

Any time a vertical or near vertical surface, such as is achieved when shovels or back-hoes are used for subsurface sampling, is sampled; the surface should be dressed to remove smeared soil. This is necessary to minimize the effects of cross-contamination due to smearing of material from other levels.

3) Sample Homogenization (mixing)

It is extremely important that soil samples, with the exception of soil samples collected for VOC analysis, be mixed as thoroughly as possible to ensure that the sample is representative of the interval sampled. Soil samples should be mixed as follows:

i. Repeat a method several times, to assure the soil sample is adequately mixed (e.g., quartering method, round bowl, etc.).
ii. Place the sample into an appropriate labeled container(s) 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.
iii. After collection, all sample handling should be minimized. Investigators should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, investigators should ensure that melted ice cannot cause the sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock bags or similar plastic bags sealed with tape, should be used when small sample containers (e.g., bacterial samples) are placed in ice chests to prevent cross-contamination.

d. Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect soil samples should be cleaned as outlined in Appendix I and repaired, if necessary, before each use and before being stored at the conclusion of field studies. Equipment cleaning conducted in the field or field repairs should be thoroughly documented in field records.

e. Sample Labeling, Handling, and Shipment

Soil samples should be labeled with the following information, which should correspond with the samples' entry on the chain of custody:

1) The sample location identification, indicated by a prefix, such as "SB-" (soil boring), "BH-" (borehole), "FSP-" (field screening point) etc. Samples should be designated with the 5-digit UST permit number as an additional prefix (e.g. "12345-SB-") at sites that are likely to be adjacent to other petroleum or hazardous material release sites.
2) Depth of sample collection;
3) Date and time of sample location;
4) UST Release Permit Number; and
5) Designated analysis and preservative used.

All samples, duplicates, and blanks for volatiles analysis must be cooled, packed in appropriate containers, and shipped to the laboratory on wet ice, as described in Appendix G.

II. GROUNDWATER LEVEL MEASUREMENT AND SAMPLING

a. Water Level and Free Phase Product Measurements

Water level measurements are collected across a Site to determine groundwater flow direction, hydraulic gradient and create potentiometric surface maps. FPP measurements are critical to delineating the source area at a release Site. Groundwater and FPP levels are also measured prior to purging and sampling to determine purge volume and drawdown and whether a monitoring well screen brackets the groundwater table.

All groundwater, FPP, and total depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. Extreme caution should be exercised during this procedure to prevent cross-contamination of the wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected. The reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum.

Specific Groundwater and FPP Level Measuring Techniques

Measuring the depth to the free groundwater surface can be accomplished by the following methods:

1) Electronic Water Level Indicators and Interface Probes- This instrument consists of a spool of dual conductor wire, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed, and a meter light and/or buzzer attached to the spool will signal the contact. Interface probes operate according to the same principles and indicate the presence of FPP in addition to water. Measurements must be made and recorded to the nearest 0.01 foot.
2) Weighted Tape - This method is similar to the "bell sounder" method, except that any suitable weight, not necessarily one designed to create an audible pop, can be used to suspend the tape. The weight should, ideally, be made of a relatively inert material that can be easily cleaned. Measurements must be made and recorded to the nearest 0.01 foot.
3) Chalked Tape - Chalk rubbed on a weighted steel tape will discolor or be removed when in contact with water. Distance to the water surface can be obtained by subtracting the wet chalked length from the total measured length. The tape should be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. Measurements must be made and recorded to the nearest 0.01 foot. This method is not recommended if samples are to be collected for analyses of organic or inorganic contaminants.
4) Other Methods - There are other types of water level indicators and recorders available. Accuracies for these methods vary and should be evaluated before selection. Any method that is not capable of providing measurements within 0.01 foot should not be used. Bailers may be used to provide a qualitative determination of FPP appearance and approximate thickness. A photograph of FPP present in the bailer should be taken if it has not been previously identified at the Site or is of a different appearance in comparison to FPP previously identified at the Site.

Total Well Depth Measurement Techniques

An electronic water level indicator or weighted tape can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is resting on the bottom of the well. In deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well. Care must be taken in these situations to ensure accurate measurements. All total well depth measurements must be made and recorded to the nearest 0.01 foot.

Specific Quality Control Procedures

Devices used to measure groundwater levels should be calibrated against a NIST traceable Invar steel surveyor's chain. These devices must be calibrated to 0.01 foot per 10 feet length. Before each use, these devices must be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. Equipment must be decontaminated according to the procedures specified in Appendix I between measurements at sites. All calibration and maintenance data must be recorded in a logbook. The ground surface elevation and top of casing elevation at the wells must be determined by standard engineering survey practices.

Water Level Surveys

Water level surveys conducted to develop potentiometric surface maps, groundwater flow directions and hydraulic gradients should be completed at all designated wells within as brief a period as is practicable and prior to any purging or sampling of groundwater at or near the release site. Well caps should be removed a few minutes before water levels are gauged to allow the water column to reach equilibrium. If a release site is near tidal surface waters, the potential for saltwater intrusion to affect groundwater elevations should be considered and accounted for, and the tidal cycle should be recorded. Depth to FPP, depth to water, total well depth, date and time should be recorded for each monitoring well that is gauged.

b. Groundwater Sampling

Groundwater samples are usually obtained from groundwater monitoring wells. They can also be obtained from anywhere groundwater is accessible, such as from a porewater sampler, a pit, or a dug or drilled hole. Groundwater samples are generally collected using bailers, pumps or a variety of no purge grab sample and passive diffusion devices. There is no ideal method or technology for groundwater sampling. Each sampling technique has strengths and weaknesses that vary according to site conditions. Contractors and UST Division project managers are responsible for choosing the most appropriate sampling method for a given sample location.

Groundwater sampling procedures can be divided into two general categories: purge and no purge methods. Monitoring wells are purged based on predetermined well volumes or indicator parameter stability to remove stagnant water. Stagnant water has the potential to interact with well materials and contain CoC concentrations which are biased low due to volatilization through contact with air within the well casing. The removal of stagnant water through purging is intended to allow lateral flow of groundwater through the well screen and provide a representative sample of water in the aquifer. Samples collected following purging may represent groundwater flow from the most permeable soil or bedrock stratum adjacent to the screen but may also bias CoC concentrations due to excessive stress to the aquifer if drawdown is too severe.

No purge sampling methodology can be utilized when the screen of a monitoring well brackets the water table, the continuous lateral flow through the well is usually sufficient to limit the effects of volatilization, and interaction with well materials and provides representative samples without purging stagnant water. In practice, results from samples collected with and without purging generally demonstrate that petroleum CoC concentrations are usually dictated by the permeability of the stratigraphy surrounding the well screen where the groundwater sample is collected.

Wells that are not purged contain relatively unmixed water that represents CoC concentrations in the soil strata adjacent to the screen where the sample is collected, irrespective of differences in soil or bedrock permeability along the length of the well screen. Purging effectively removes any stratified groundwater, which is then replaced by groundwater from the most permeable saturated stratum adjacent to the screen. Care should be taken to not over-purge wells to the extent it is effectively dewatered as this has the potential to bias concentrations of volatile CoCs in recharge water low and therefore result in unrepresentative samples.

When the influence of saltwater intrusion is suspected to be likely at sites near tidal surface water bodies, as indicated by elevated conductivity readings (~10,000 µS/cm), care should be taken to collect samples during periods in the tidal cycle when saltwater intrusion will be minimized so that CoC concentrations in groundwater are not diluted.

Groundwater sampling methods should be selected based on site specific information with consideration of monitoring well construction and soil stratigraphy as decided by the UST Management Division project manager with the advice of the Contractor. It is important for groundwater sampling methods to be as consistent as possible between sampling events at a Site, with the possible exception of the initial sampling event following well installation, when purging is always required.

A more detailed discussion of purging and sampling methods and technologies is presented below.

Groundwater Purging Methods

All wells whose screens do not bracket the water table must be purged prior to groundwater sample collection, while other wells may be purged based on the UST Management Division project manager's discretion. Two general methods are used to purge monitoring wells before sampling: low flow/ low stress purging, where a well is purged at a low flow rate until physical and chemical parameters indicate that purge water is representative of conditions in the aquifer; and well volume purging, where a predetermined volume of water is removed prior to sampling. Purging is intended to stress the aquifer as little as possible, and all purge methods should be carried out in a manner that removes groundwater as gently as is practicable to minimize the aeration of groundwater and the transport of any fine particles in the water during recharge. All purging methods can lead to over-purging, so an awareness of drawdown and recharge rate during purging is important regardless of the technique that is employed.

1) Well Volume Purging

The well volume, or volumetric, purge method is usually carried out with bailers, but pumps can also be used. In order to determine when a well has been adequately purged using the well volume method, field investigators must:

i. Observe and record the volume of water removed; and
ii. Monitor the pH, specific conductance, temperature, turbidity and dissolved oxygen of the groundwater removed before each well volume removed during purging.

Purging and sampling should be conducted from the furthest down gradient well to the most up gradient well or from the least contaminated well to the most contaminated well if previous sample results are available. Prior to handling any purging or sampling equipment, clean disposable powderless nitrile gloves must be worn.

The depth of water, any FPP, and the well should be determined before purging. Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) must be calculated. To do this, the diameter of the well must be determined, and the water level and total depth of the well must be measured and recorded. The water level is subtracted from the total depth, providing the length of the water column. Once this information is obtained, the volume of water to be purged can be determined using one of several methods. One is using the equation:

$$V = 0.04d^2h$$

Where: h = depth of water in feet, d = diameter of well in inches, V = volume of water in gallons

Alternatively, the volume may be determined using a casing volume per foot factor for the appropriate diameter well (see Table 7). The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the factor in Table 7, which corresponds to the appropriate well diameter, providing the amount of water, in gallons, contained in the well.

WELL CASING DIAMETER vs. VOLUME (Gals.)/Feet of Water	
Casing Size In Inches	Gallons of Water/Feet
1	0.047
2	0.163
3	0.367
4	0.653
5	1.02
6	1.469
7	1.999
8	2.611
9	3.305
10	4.08
11	4.934
12	5.875

Table 7. Well Casing Diameter vs. Well Volume

A well is adequately volume-purged when three to five times the volume of standing water in the well has been removed. The field notes must reflect the single well volume calculations, 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 a purge volume goal. Field notes must indicate measured parameters for each well volume, when applicable.

A purge can also be considered adequate when the pH, specific conductance, temperature, and dissolved oxygen of the groundwater have stabilized. Stabilization for volumetric purges occurs when, pH remains constant within 0.1 Standard Unit, specific conductance and temperature vary by no more than five (5) percent and turbidity varies no more than ten (10) percent for at least three consecutive measurements. Dissolved oxygen is considered to be stable when it varies by less than ten (10) percent or 0.2 mg/L, whichever is greater for three consecutive measurements. Consecutive turbidity levels less than 10 NTU, and Dissolved Oxygen values less than 0.5 mg/L may also be considered to be stable.

No specific number of measurements is required for the determination of stability. An initial set of measurements must be taken and then one set for each well volume of water removed, though more measurements can be collected between well volumes purged. A minimum of two (2) sets of parameter measurements shall be recorded if the well is purged dry before achieving one well volume (including the initial measurements). **Note: Multiple measurements of any parameter that exceed the range of the measurement device are NOT indicative of equilibrium.**

If, after five (5) well volumes have been removed, the indicator parameters have not stabilized according to the above criteria, additional well volumes may be removed. It is at the discretion of the Contractor whether to collect a sample or to continue purging. The conditions of sampling must be noted in the field log. Water level measurements must be collected and recording prior to sampling. If drawdown is observed to be less than two feet, samples should be collected immediately after purging the well. If drawdown incurred during purging is greater than two feet, the wells should be allowed to equilibrate before sampling. Wells that are purged dry should be allowed to equilibrate for as long as is practicable prior to sampling.

Over-Purging

Even when purge rates are minimized, a well may be pumped or bailed until it is effectively dewatered or dry. In these situations, dewatering constitutes the effective limit of purging. If a well is over-purged, it may result in the sample being comprised partially of water contained in the sand pack, which is not representative of groundwater in the soil. In addition, as water re-enters the well, it may cascade down the sand pack or the well screen, leading to the removal of volatile organic constituents that may be present. This practice may also introduce soil fines into the water column. It is important to evaluate drawdown during purging to ensure that wells are not dewatered, and the resulting samples compromised.

For wells that are dewatered, it is not necessary that the well be bailed dry additional times before sampling. The well should be allowed to equilibrate for at least three hours or until the water level has reached eighty (80) percent of its level prior to purging before sampling.

The drawdown in a well should be monitored to avoid over-purging and indicator parameters must be measured during sample collection as the measurements of record. Alternatively, a low purge sampling technique may be more appropriate. The UST project manager should be notified when poor recharge in monitoring wells may affect the quality of groundwater data. Approximate recharge rates, final depth to groundwater, and indicator parameters during or immediately following sampling must be recorded.

Low Flow Purging

Low flow purging seeks to create lateral flow in a monitoring well and provide a groundwater sample most representative of the aquifer in which the monitoring well is screened. Low flow/low volume purging is a procedure used to minimize stress to an aquifer and provide a sample of lateral flow through a well screen. The pump intake is placed within the screened interval, preferably more than two feet above the bottom of the well to avoid disturbing any sediment. No specific volume of water is removed, instead emphasis is placed on the stabilization of indicator parameters. Low flow sampling is conducted with pumps set at flow rates low enough to minimize drawdown in the well, almost always less than 500 mL/min.

Stabilization of the groundwater level drawdown must be demonstrated before indicator parameters are measured. Drawdown is monitored by measuring the top of the water column with a water level recorder or similar device while purging. Monitor and record the water level and pumping rate each time indicator parameters are recorded or as appropriate, during purging and immediately before sampling. Any adjustments made to the purge rate should be recorded along with the time of the change.

The flow rate used to achieve a stable pumping level should remain as constant as possible while monitoring the indicator parameters for stabilization and while collecting samples. Indicator parameters should be monitored using a filled flow-through cell with an indicator parameter monitoring probe installed.

Temperature, pH, conductivity, dissolved oxygen and turbidity are monitored at 5 -10 minute intervals (greater than the residence time of water within the flow through cell). A low flow purge can be considered adequate when the pH, specific conductance, temperature and dissolved oxygen of the groundwater have stabilized. Stabilization for volumetric purges occurs when, pH remains constant within 0.1 Standard Unit, specific conductance, and temperature vary by no more than five (5) percent and turbidity varies no more than ten (10) percent for at least three consecutive measurements. Dissolved oxygen is considered to be stable when it varies by less than ten (10) percent or 0.2 mg/L, whichever is greater for three consecutive measurements. Consecutive turbidity levels less than 10 NTU, and Dissolved Oxygen values less than 0.5 mg/L may also be considered to be stable.

The intake tubes for peristaltic pumps are lowered into the well, ideally midway in the saturated portion of the screened interval. When submersible pumps (bladder, turbine, displacement, etc.) are used, the pump itself is lowered into the water column, also roughly halfway down the saturated portion of the screen, if possible. Purging rates using pumps are dependent upon the rate of groundwater recovery in the well and the data quality objectives of the site. If the pump's minimum flow rate exceeds the recovery rate of the well, the flow rate should be reduced.

If greater than two (2) feet of drawdown is observed at the lowest achievable flow rate, and the water level is within the screened interval, purging should be discontinued, and the well should be sampled with the tube or pump intake placed midway down the saturated portion of the screened interval after being allowed to equilibrate for a reasonable period of time, ideally greater than three hours.

Purge Water and Sample Location Management

Regardless of which method is used for purging and sampling wells without in-place plumbing, new plastic sheeting must be placed on the ground surface surrounding the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they need to be placed on the ground during the purging or they accidentally come into contact with the ground surface. Sample bottles, field parameter meter(s), and associated field equipment must be placed on plastic to prevent contact with the ground surface. The sampler must not step on the plastic sheeting. It is preferable that tubing used in purging that comes into contact with the groundwater be kept on a spool wrapped in plastic or contained in plastic or aluminum foil both during transportation and field use.

All purge water containing observable free phase product shall be containerized and disposed of at a permitted facility. Purge water that contains no observable FPP can be discharged in such a way that it infiltrates over the delineated plume and/or within the property boundaries of the site provided that the following conditions are met:

1) The groundwater concentrations shall be less than five (5) times the MCL for all constituents being analyzed;
2) Purge water shall not be allowed to discharge to the storm sewer or surface waters;
3) Purge water is discarded within approximately a five (5) foot radius of the well from which it was purged;
4) There shall be no presence of liquid phase petroleum products, to include sheen, blebs, or emulsion in the purge water being discarded; and
5) Purge water shall not be discarded onto soil during saturated or frozen ground conditions, or onto impervious surface material (e.g., concrete, asphalt, etc.).

If not compliant with all the above requirements or there is no historical data, then purge water must be containerized in suitable, leak proof containers and managed as investigation derived waste. Purge water may be treated on-Site using a GAC filter or equivalent treatment system and discharged according to the criteria listed above. The treated purge water should be sampled and analyzed for all CoCs once during each sampling event, following the treatment of purge water from the well with the highest expected CoC concentrations, to verify that concentrations are less than five (5) times the MCL for each CoC. If a treatment system is utilized at multiple sites in the same day, a single treated purge water sample collected at the most impacted site will be considered sufficient to demonstrate adequate treatment all the sites sampled that day.

No-Purge Sampling

Sample collection methods without purging must be approved by the UST Project Manager. Analytical results from groundwater samples collected using a no-purge method may not be accepted as reliable by the UST Management Division if the method was not approved by the UST Project Manager prior to sample collection. No purge sampling, usually using bailers, can be employed in cases when a well's screen brackets the water table but may result in samples that aren't representative of groundwater in the most permeable soil or bedrock stratum along the screen if the sample isn't collected from that portion of the well screen.

No purge samples may be collected when the following conditions are met:

1) The water level in the well is within the screened interval;
2) The primary CoCs are petroleum constituents; and
3) There is no non-aqueous phase liquid present.

Depth to water, before and after sample collection, depth to bottom, and indicator parameters: pH, conductivity, dissolved oxygen, and turbidity, must be measured and recorded for no purge samples.

The UST Management Division manager should be contacted for additional guidance in cases when the most appropriate sample method is uncertain.

Alternate No Purge Sampling Techniques

Alternate methods for collecting no-purge samples are presented below.

1) Passive Diffusion Bag Samplers - Diffusion sampling is a method of groundwater sampling for certain VOCs. No purging is required for this method of sampling. A water diffusion sampler consists of a diffusible bag, like polyethylene, filled with deionized water and sealed. Commercially available samplers should be used when possible. Proper QA/QC on the quality

of the deionized water needs to be obtained in order to adequately interpret sample results. The sampler must be positioned within the screened interval of the well and allowed to equilibrate for a period of two weeks. The sampler is then removed and the water is emptied into a standard sampling container (e.g., a VOA vial). Diffusion samplers may also be used to collect samples from the groundwater/surface water interface or transition zone. The sampler is placed within the transition zone and allowed to equilibrate for a period of two weeks.

2) SNAP Sampler® - SNAP Samplers® may be used to collect no purge groundwater at discreet depths. SNAP Samplers® are usually dedicated to a specific well. The sampler is deployed at a predetermined depth within the screened interval of the well, and the water within the well is allowed to equilibrate for a minimum of two weeks. The sampler contains an open container which is closed using a trigger from the top of the well. The device and sealed containers are retrieved, and any required preservative is injected into the container prior to being sealed with a screw on cap for transport to the laboratory. A new, decontaminated sample container can then be placed into the sampler, which may be redeployed in the same well. Water quality indicator parameters are either measured by lowering a probe into the well or from a separate designated container included in an additional sampling device.
3) HydraSleeve™ Sampler - Commercially available HydraSleeve™ samplers may be used to collect groundwater at discreet depths. Disposable colorless nylon rope and a decontaminated weight must be attached to the sampler. The sampler must be positioned at the depth of interest and allowed to equilibrate for a sufficient amount of time per manufacturers recommendations. The sampler is removed and the water is emptied into a standard sampling container.

Sampling Equipment and Techniques

Sampling is the process of obtaining, containerizing, and preserving groundwater samples. Samples must be collected immediately after the purging process is completed, unless the well has been purged dry. In general, the order of well sampling should occur from the least to the most contaminated well, if known. It is recommended to store and transport potential receptor samples (e.g., water supply wells, surface waters, etc.) and groundwater samples separately to prevent cross contamination.

Purging and sampling are accomplished by using bailers, portable pumps, or in-place plumbing and dedicated pumps. The equipment may consist of a variety of pumps, including peristaltic, large and small diameter turbine (electric submersible), bladder, centrifugal, gear-driven positive displacement or other appropriate pumps. The choice of pump is usually a function of the depth of the well being sampled, the amount of water that is to be removed during purging, and/or site-specific conditions or chemistry. A peristaltic pump may be used for purging well where difference in depth between the sampling location and the water level is less than the limit of suction, approximately 28 feet, and the volume to be removed is reasonably small.

The CoCs at each site and the sampling objectives will determine the type of materials and equipment that can be used for purging and sample collection. Each site and each well must be considered individually in order to determine the proper equipment for sample collection. Water level measurements should always be recorded prior to sampling.

1) Bailers

Bailers are the most commonly used equipment for well volume purging and sampling and no purge sampling. Bailers tend to disturb any sediment that may be present in a well, increasing sample turbidity. Bailers, if improperly used, may also strip volatile organic compounds from the water being sampled. Bailers are to be utilized in a way that minimizes agitation to the water column and provides a sample representative to that of the surrounding aquifer. Bailers should be lowered into the water as gently as possible using colorless nylon string. Samples should be collected with care so as to obtain representative data.

i. Disposable bailers are bailers that are used in only one well and then discarded after the samples have been collected at that well. These bailers should not be used on more than one well at more than one sampling event, as they are not constructed for multiple uses.
ii. Dedicated bailers are used at a single well at a single site and are:
    a) Marked as to the well to which it is dedicated;
    b) Decontaminated with laboratory-grade, phosphate-free detergent and rinsed with deionized water after each use; and
    c) Wrapped in clean aluminum foil or plastic until the next sampling event.
iii. Dedicated bailers can be left hanging in the well, although it should not be in contact with the water column, and the rope must be changed prior to use at the next sampling event.
iv. Non-dedicated reusable bailers must be decontaminated according to Appendix I from before placing into another well. The use of these types of bailers require the collection of an equipment blank during each sampling event.

2) Purging and Sampling Pumps

Pumps are used for purging and sampling when low flow techniques are required or when wells are too deep or contain volumes of water too great to be effectively sampled with bailers. Tubing placed into the water should be either disposable or standard-cleaned (see Appendix I). Most CoCs associated with UST release sites are VOCs so it is important that contact between air and the water being sampled be minimized to prevent volatilization. Sample tubing should be filled completely, and samples should not be collected if air bubbles are present in tubing under most circumstances.

Immediately following purging, samples must be collected using the techniques which are described below. Samples collected for trace organic compounds must be collected at a rate slow enough to prevent the generation of air bubbles and aeration of the water as it enters the bottle.

i. Peristaltic Pumps - When peristaltic pumps are used, only the intake tubing is placed into the water column. Sample tubing should be lowered until it is midway within the saturated portion of the screened interval of the well, but at least two feet above the bottom of the well to avoid agitating any particulates present at the bottom of the well.

    Peristaltic pumps produce a vacuum in tubing placed into a well. The vacuum induced by a peristaltic pump has the potential to incur the loss of volatile contaminants, especially at depths greater than twenty (20) feet. The straw method can be used in cases where low concentrations of VOCs identified in a sample may be used to make a management decision. When purging is complete, the downhole tubing should be filled and disconnected from the flexible pump tubing. The sampler should place a finger, after donning a new nitrile glove, over the tubing, which is removed from the well. Water is then poured from the tubing into the sample containers with minimal contact with air entrained in the tubing. Samples should never be collected directly from the silicone tubing attached to the pump's rotor.

ii. Submersible Pumps – Several types of submersible pumps are commonly used for groundwater purging and sampling, including bladder pumps, piston pumps and gear driven pumps. After purging has been accomplished with a submersible pump, the sample may be obtained directly from the pump discharge. The discharge rate of the pump must be minimized during sampling to diminish sampling disturbance. This is especially important for the collection of VOC and metals samples.

Submersible pumps must be decontaminated as specified in Appendix I prior to sampling. Equipment Blank Samples should be collected from submersible pumps, following their decontamination, at a rate of one per day of use, as described below in Section B5.

Wells with In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, etc. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps. The objective of purging wells with in-place pumps is the same as with monitoring wells without in-place pumps, i.e., to collect a sample representative of the groundwater.

If the pump is in active use, 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 located between the pump and the storage tank. If not, the valve closest to the tank should be used. If the pump runs intermittently, it is necessary to estimate the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump must then be run continuously until the required volume has been purged. If construction characteristics are not known, best judgment should be used in establishing how long to run the pump prior to collecting the sample. Measurements of indicator parameters may be monitored and recorded at intervals during purging and sampling.

Samples must 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 that might be present. Hoses should be removed prior to sample collection. The flow should be reduced 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 Appendix G).

1) Drinking water well (servicing a resident or building) samples shall be analyzed using EPA drinking water methods, see Appendix F (Table F2).
2) Other water well samples shall be analyzed using EPA SW-846 methods, but at lower detection limits, see Appendix F (Table F1).

Temporary Monitoring Wells

Temporary groundwater monitoring wells are installed in the groundwater for immediate sample acquisition. Wells of this type may include a standard well screen and riser placed in boreholes created by hand auguring, power auguring, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval.

The requirement to purge several volumes of water to replace stagnant water, do not apply in these situations. It is important to note, however, that the longer a temporary well is in place and not sampled, the more appropriate it may be to apply standard permanent monitoring well purging criteria.

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, resulting primarily in increased turbidity. Therefore, the goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity samples in these types of wells may be achieved by the use of low-flow purging and sampling techniques.

Low Flow Sampling of Temporary Monitoring Wells

In purging situations where the elevation of the top of the water column is no greater than approximately 25 feet below the pump head elevation, a peristaltic pump may be used to purge temporary wells. Enough tubing should be deployed to reach the bottom of the temporary well screen. At the onset of purging, the tubing should be slowly lowered to the bottom of the screen to remove any formation material that may have entered the well screen during installation. This is critical to ensure rapid achievement of low turbidity conditions. After the formation material is removed from the bottom of the screen, the tubing should be slowly raised through the water column to near the top of the column. The tubing must remain at this level to determine if the pump is lowering the water level in the well. If there is no drawdown, the tubing must be secured at the surface to maintain this pumping level. If draw down is observed on initiation of pumping and a variable speed peristaltic pump is being used, the pump speed must be reduced to stabilize the draw down in the well, if possible. If the draw down stabilizes, the intake point and the pumping rate should be maintained. Sustained pumping at a low rate will usually result in a relatively clear, low turbidity sample. In situations where the draw down cannot be stabilized, the intake point must be continuously lowered to match the water column.

Direct Push Sampling - Direct push sampling may be used when an investigation centers on constituents that are not affected by sample turbidity. The direct push unit allows a microscreen to be opened at various intervals to the formation of interest. With many of the direct push sampling techniques, no purging is conducted. The sampling device is simply pushed to the desired depth and opened, then the sample is collected and retrieved. Methods of water sample collection using direct push technology employ either a vacuum pump or an inert gas lift system. The inert gas lift system reduces the chance for volatilization of constituents from the sample. Sampling occurs from the chamber within the screen (gas lift) or from tubing attached to the screen (vacuum lift). All direct push well screens must be cleaned in accordance with the decontamination procedures presented in Appendix I between sample locations and before usage. For vacuum pump sampling, new tubing must be used at each sample location.

Groundwater Sample Identification

Groundwater samples should be labeled with the following information, which should correspond with the samples' entry on the chain of custody:

1) The sampled well identification. Samples collected from monitoring wells should contain the prefix "MW", those collected from water supply wells should contain "WSW-", etc. Samples should be designated with the 5-digit UST permit number as an additional prefix (e.g. 12345-MW-#) at sites that are likely to be adjacent to other petroleum or hazardous material release

sites. If previous samples at the location were labeled using a different convention, the prior identification should be used for consistency;
2) Date and time of sample location;
3) UST Release Permit Number; and
4) Designated analysis and preservative used.

Specific Sampling Equipment Quality Assurance Techniques

Field equipment used for field analysis must be calibrated daily prior to analysis of any samples. It is recommended that meters be recalibrated or measured against a midpoint calibration standard midpoint during field activities to ensure meters are reading accurately. All equipment used to collect groundwater samples shall be cleaned as outlined in Appendix I and repaired, if necessary, 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.

Water Sample Preservation

Immediately after collection, all samples requiring preservation must be preserved with the appropriate preservative, unless the laboratory has already placed the preservative in the sample bottles. Consult Appendix G for the correct preservative for the particular analytes of interest. Those samples requiring cooling must be placed on wet ice immediately after collection.

Note: To minimize the potential for cross contamination, groundwater samples and drinking water samples should be placed in separate coolers after sample collection.

Special Sample Collection Procedures

1) Volatile Organic Compounds and Metals

In most cases, samples collected for organic compounds and metals must be collected prior to other samples, with VOC samples being collected first. The VOC samples must be collected so that no headspace or air bubbles remain in the sample container. These samples must be collected by slowly pouring the sample contents into the vial until a convex meniscus is seen on the surface of the vial. A Teflon-lined septum cap must carefully be placed on the vial until finger tight. The sample bottle should then be inverted to verify that no air bubbles have been trapped inside.

If an effervescent reaction occurs between the preservative and water, producing large numbers of fine bubbles (e.g., if the groundwater has a high amount of dissolved limestone, which is highly calcareous), 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.

2) Filtering

As a general rule, groundwater samples should not be filtered. However, filtration may be needed to collect representative samples for metals from chronically turbid wells, when approved by the UST Management Division project manager to determine the potential effects of particulates suspended in a sample on COC concentrations. Filtered samples must not be collected from usable water supply wells. Filtering is also not recommended when the sample turbidity appears to be chemically induced or colloidal. When samples are filtered, such as under conditions of excessive turbidity, both filtered and unfiltered samples must be submitted for analyses. Samples for analysis of organic compounds must not be filtered.

III. SURFACE WATER SAMPLING

Surface water sample collection is directed to determine whether CoCs associated with a release site have impacted the aquatic receiving environment. Contractors are responsible for providing SOPs for sampling, the UST Division requires that the following requirements are met:

1) Surface water samples should be collected in a manner that minimizes the potential for cross contamination caused by contact with sampling equipment or sediment suspended during collection;
2) Surface water sample collection should not allow preservative to be washed out of the sample container;
3) Surface water temperature, pH, dissolved oxygen, and conductivity should be measured and recorded on a field form or log book immediately following the collection of samples;
4) Samples should be collected from the portion of the water body closest to the release site, (i.e) from the adjacent bank, not the center of the channel; and
5) Surface water sample locations should be recorded using GPS coordinates and/or photographs and marked with flagging tape hung at eye level or an equivalent maker to allow the location to be accurately resampled.

Surface water samples should be labeled with the following information, which should correspond with the samples' entry on the chain of custody:

1) The surface water sample location identification, indicated by the prefix "SW-". Samples should be designated with the 5-digit UST permit number as an additional prefix (e.g. 12345-SW-#) at sites that are likely to be adjacent to other petroleum or hazardous material release sites. If previous samples at the location were labeled with a different identification, the prior identification should be used for consistency;
2) Date and time of sample location;
3) UST Release Permit Number; and
4) Designated analysis and preservative used.

B3 Sample Handling & Custody

See Appendix G for Preservation and Holding Times for laboratory analyses. All field analyses must be done within 15 minutes of sample collection.

5) Chain of Custody Form Requirements

In addition to the medium specific requirements outlined above, the following information must be included on Chain of Custody forms accompanying samples:

1) Collection date and time for each sample. If the sample is a composite sample and is collected by an automatic sampler, the starting and ending dates and times of the sampling period must be documented. If the composite sample was collected manually, the date, time, and collector of each portion must be documented also.
2) Printed name and signature of sample collector(s).
3) Unique sample identification number. One sample should be entered on each line or column and a sample should not be split among multiple lines or columns.
4) Sampling location and description (if necessary).
5) Sample type - grab or composite. Although grab and composite samples might be collected from the same location at the same time, they differ in composition and must be listed separately and must have unique identification numbers.

Analyses required, specified for each sample.

6) Preservation method and all preservatives used (H_2SO_4, NaOH, wet ice, etc.) for each sample. This includes any de-chlorination agents or other chemicals added to the bottle prior to sampling.
7) Program area – This must be listed as UST Management Division.
8) Sample matrix – drinking water, groundwater, waste, soil, free product, etc.
9) Physical characteristics – identify in Comments (e.g., strong odor, odor, no odor).
10) Transfer signatures with dates and times for both relinquishment and laboratory receipt (the laboratory should indicate courier, FEDEX, UPS, etc. in the "relinquished to" space if applicable).
11) Receipts maintained when shipped by common carrier (FEDEX, UPS, etc.). These receipts should be attached to the pertinent chain-of-custody records.
12) The number and type of container used.

IV. Sample Collection Preservation

Samples shipped to laboratories must be received below 6°C but above 0°C (unless analytical method requires lower temperature). Temperature blanks may be used. Their purpose is to determine the internal temperature of the shipping container upon arrival at the lab. Blanks should consist of one or more small containers (40-250 ml) of water placed in the ice chest with samples and marked as a "Temperature Blank". Alternative methods for measuring temperature, such as an infrared thermometer, may also be used. The temperature at receipt (arrival) must be documented on the chain of custody form. Temperature blank or cooler environment must be documented; sample container should not be used.

In the site-specific QAPP Contractor Addendum or ACQAP, specific information must be given on how the samples will be shipped to the laboratory, indicating how sample or information handling and custody information should be documented, such as in field notebooks and forms, and identifying the individual responsible for this (See Appendix B).

B4 Analytical Methods

All UST certified Site Rehabilitation Contractors will utilize commercial laboratories of their choice that are certified by SCDHEC Laboratory Certification. For samples collected by UST Management Division staff, the state contracted laboratory will be used to analyze samples. All SCDHEC certified laboratories must maintain a Quality Assurance Manual or a Quality Management Plan and Standard Operating Procedures. Even though these documents for the lab are reviewed during the certification process, the UST Management Division may request submission of some or all SOP's.

Analytical methods and procedures for field measurable physical and chemical characteristics as well as performance criteria are found in Appendix F. Whichever methods the lab will be using shall be identified in the site-specific QAPP Contractor Addendum or SSWP. The maximum turnaround time from receipt of the sample(s) until the sample results are reported is 3 weeks.

The site-specific QAPP Contractor Addendum or ACQAP will include sample disposal information and corrective actions for analytical failures. However, when analytical failures occur, the UST Project Manager must be contacted within 24 hours.

If non-standard methods, such as TO-15, TO-17, Ferrous Iron, or the Kerr method are to be employed, the site-specific QAPP Contractor Addendum or SSWP will include an attached SOP.

B5 Quality Control Requirements

Because of the role laboratory data plays in determining regulatory courses of action and decision-making, a QA/QC program to ensure data reliability and quality data is essential. Sample collection, preservation, handling and storage, as well as each step in the analytical method, are considered as they relate to precision, accuracy and the stated data quality needs for a given project. Please refer to Appendix F for the field and laboratory quality control requirements.

In the case of QC failure, the sample must be reanalyzed. In the event that additional samples are not available or cannot be recollected, the contractor must notify the UST Project Manager within 24 hours.

I. Laboratory QA/QC

Laboratory QA/QC information for all sample sets will be required and reviewed by staff. This should include matrix spikes and duplicates in the analytical batch that are non-DHEC project samples. All laboratories must also meet all quality control procedures outlined in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, Updates I–V. Corrective action procedures used by the laboratories are discussed in each laboratory's QA Plan. Precision and accuracy will vary with the analytical method and laboratory procedures. The analyzing laboratory must make precision and accuracy information available upon request. The analyzing laboratory must prepare a quality assurance report evaluating the quality control measurements listed below:

1) Trip blanks - will be submitted for each sampling event. The blanks are prepared by the analyzing laboratory using distilled or de-ionized water that is analyte-free and which is shipped with the other sample bottles to the field and then returned to the analyzing laboratory with the samples for analysis. The trip blanks are not separated from other samples. They must be packaged with the environmental samples collected during the sampling event. They are collected to check sample contamination from

transport and handling. One trip blank will be included in each sample cooler. A separate trip blank should be included in the sample cooler if analyzing under drinking water methods. The trip blank(s) must be analyzed for VOCs. Trip blanks do not need to be analyzed for metals or EDB.

2) Field blanks - will be collected for each sampling event or each day if the sampling event encompasses multiple days. Field blanks will be an aqueous sample of distilled or de-ionized water that is analyte-free collected during groundwater sampling events to assess potential contamination of samples from the site environment. Field blanks are not required to be submitted during soil sampling events. Field blanks for VOCs and EDB must be collected using the same sample collection procedures. Field blanks shall also be collected if sampling public or private drinking water wells using drinking water analytical methods. These field blanks shall be collected in the vicinity of a drinking water well being sampled.

3) Field duplicates - will be collected over the course of each sampling event. One duplicate will be collected for every batch of twenty samples or less. Field duplicates should be collected from locations where detectable concentrations of CoCs are expected to be present. Field duplicate samples are taken within five minutes of collecting the original samples and include all the sub-samples for all analyses. A new sample is collected from the sampling point for the field duplicate. The samples are shipped back with the other sample bottles for analysis, and should not be labeled in a manner that indicates the sample locations (i.e. location IDs and collection times should not correspond with the original sample. The precision resulting from field duplicates is a function of the variance of sample composition, the variance of the sampling technique, and the variance of laboratory analysis.

4) Matrix spike/Matrix spike duplicate – will be prepared by the analyzing laboratory for methodologies in Table F1 and Table F2 of this QAPP. The purpose of MS/MSD is to determine whether the sample matrix contributes bias to the analytical results. The MSD also serves as a check on analytical precision.MS/MSD samples will be processed at a frequency that is stated in the laboratory Quality Assurance Manual. Not only does the UST Management Division require the data from UST samples used for MS/MSD(s), but also those where other clients' samples have been spiked to serve for batch QC to be reported in the data analytical report.

5) Equipment Blanks - should be collected from submersible pumps, following their decontamination, at a rate of one per day of use. All parts of the pump, including any power cords and reusable tubing that many contact water during sampling, should be placed in a decontaminated container. The container should be filled with clean, potable water to a level that is sufficient for the pump to be activated and covers the pump and power cords. The pump should be activated, and the Equipment Blank Sample collected from the outlet of the pump. The Equipment Blank Sample should be submitted for the analysis of all parameters analyzed in samples collected at the Site using the pump during the day the equipment blank is collected. Equipment blank sample handling, storage, and transport should be consistent with those of all other samples submitted for analysis. The detection of CoCs in the Equipment Blank Sample may invalidate the results of the samples collected using the pump during the day the equipment blank is collected. These results should be flagged and discussed when reported.

An analytical laboratory certified for required parameters through the SCDHEC's Office of Environmental Laboratory Certification program must perform all SC certified analytical methods. The Environmental

Laboratory Certification program does not currently offer certification for some methods included in this QAPP (i.e., Ferrous Iron, RSK-175, TO-15, and TO-17).

Formulas for calculating QC statistics are presented in Section A7. If the Contractor is using other procedures for lab QC, then these must be given in the site-specific QAPP Contractor Addendum or ACQAP.

B6 Instrument/Equipment Testing, Inspection, and Maintenance

Field and laboratory instrumentation must be tested daily prior to use. Specific information about equipment that must be tested, inspected and maintained will be required in any addendum to the QAPP provided by the Contractors. Corrective action information is also required in the site-specific QAPP Contractor Addendum or ACQAP. All equipment shall be routinely inspected and maintained according to the service and instruction manuals. Maintenance documentation for the equipment must be kept on file and made available upon request. All instruments and equipment will be tested, inspected, and maintained according to the manufacturer's guidelines and recommendations. Project staff that has been properly trained in these procedures will operate the instruments.

All disposable sampling equipment is used one time, then properly containerized and disposed of. Reusable sampling and investigative equipment is decontaminated prior to commencement of an investigation or sampling event and is decontaminated between uses and at the end of the event (see Appendix I).

B7 Instrument/Equipment Calibration and Frequency

All field equipment needed for sampling, as well as safety equipment, will be calibrated prior to and during continued use to assure that all measurements are as accurate as possible. Personnel will follow the manufacturer's instructions to determine if the instruments are functioning within their established operation ranges. The field analyst will specify the identification of the field instrument by serial number in the field logbook as well as the field data sheet so that the calibrations are traceable to a specific piece of equipment. The field book entry must also provide identification of the calibration standards used. This must include the vendor name, calibration standard concentrations, lot numbers, expiration dates, etc.

To be acceptable, a field test must be bracketed between acceptable calibration results.

1) The first check may be an initial calibration, but the second check must be a continuing verification check.
2) Each field instrument must be calibrated prior to use.
3) Verify the calibration at the beginning of each work shift, during use, and at the end of the use.
4) All initial calibration and verification checks must meet the acceptance criteria in the table below.
5) If an initial calibration or verification check fails to meet the acceptance criteria, immediately recalibrate the instrument or remove it from service.
6) If a verification check fails to meet the acceptance criteria and it is not possible to reanalyze the samples, the following actions must be taken:
   i. Report all results between the last acceptable verification check and the failed check as 'estimated' (qualified with a "J");
   ii. Include a narrative of the problem; and
   iii. Shorten the time period or frequency between verification checks or repair/replace the instrument.

7) All acceptable field data must be bracketed by acceptable checks or the data must be qualified.

Field Parameter	Acceptance Criteria
Temperature	±1°C against an NIST-traceable thermometer
Specific Conductance	10% of each standard used
pH	±0.1 pH units of stated buffer value
Dissolved Oxygen	±0.2 mg/L from the value on the solubility and calibration table
Turbidity	10% of each standard used

Table 8. Field Parameter Acceptance Criteria

Any sampling equipment or field measurement instrument determined to be malfunctioning in any way must be repaired and recalibrated or removed from service. This corrective action must be documented in the records. Corrective action information is also required in the site-specific QAPP Contractor Addendum or ACQAP.

Laboratory equipment calibration protocols are addressed within SOPs that are reviewed by the Office of Environmental Laboratory Certification. Laboratory equipment will have a calibration logbook for each piece of instrument that will be maintained by the analyst.

B8 Inspection/Acceptance of Supplies and Consumables

Establishing a system to document the inspection and acceptance of all supplies and consumables that may directly or indirectly affect the quality of a project or task is highly recommended. All equipment used for field measurements and sampling shall be handled, stored and transported appropriately, so that limited exposure to any element of contamination or cross-contamination is eliminated therefore does not affect the sample media.

The following applies to UST Management Division staff:

Supplies and consumables are inspected upon receipt for breakage and intact packaging. All supplies are re-inspected prior to usage in the field. To prevent tampering, supplies and consumables are stored in the supply storage room that can be locked when staff is not in attendance. Supplies and consumables are to be transported in such a manner that they are not exposed to sources of contamination and are protected from damage.

The necessary supplies for field sampling include, but are not limited to: polyethylene bailers, nitrile gloves, calibration standards (pH, conductivity, and turbidity), sterile glass or plastic sample containers with labels, insulated containers for transporting samples, ice, water quality sampling forms, and sampling SOPs/checklists. The UST Management Division's Senior Field Technician and Laboratory Contract Manager are responsible for ensuring that necessary field and sampling supplies are available as needed.

The analyzing laboratory shall have written procedures for inspecting and accepting supplies and consumables. The analyzing laboratory will provide documentation of the integrity of the sample containers prior to receipt by the UST Management Division. Bailers shall have written quality assurance certification provided. Acceptability requirements for non-analytical supplies and consumables are provided in Table 9.

The following applies to UST Contractors:

Contractors will provide a list in the site-specific QAPP Contractor Addendum or within the standard operating procedures section of the ACQAP, concerning items for field sampling and the analyzing laboratory shall have written procedures for inspecting and accepting supplies and consumables. The analyzing laboratory will provide documentation of the integrity of the sample containers. Supplies and consumables for field and laboratory analysis are inspected as part of the contractor's standard operating procedures. The Contractor shall maintain documentation of the acceptability of all analytical consumables.

Item	Vendor	Acceptance criteria	Handling/Storage Conditions	Person responsible for inspection and tracking.
Nitrile gloves	All	No holes; must be nitrile NOT latex	1 box of appropriate size per vehicle; also used in lab	UST Staff, Contractor, or laboratory staff
Bailers	All	Polyethylene	1 box of appropriate size per vehicle	UST Staff or Contractor
Calibration standards for pH, conductivity, and turbidity	All	Must be within expiration data and acceptable for the allowable method.	Office prep area- room temperature	UST Staff or Contractor
Insulated containers	All	New or properly decontaminated, used only for sample transportation, in good condition, no damage that would compromise sample integrity	Office prep area- room temperature	UST Staff, Contractor, or laboratory staff

Table 9. List of Consumables and Acceptance Criteria

B9 Non-direct Measurements

The UST Management Division utilizes data from non-measurement sources to populate risk or groundwater fate and transport models when values derived from direct measurement do not exist or cannot be readily obtained. These data are gathered from sources such as USEPA standards and from published scientific papers. These data sources are known to be acceptable and are used throughout the country. As these data are not site-specific, values used are conservative in order to produce results that are protective of human health and the environment. Site-specific values will be used whenever possible.

The data source is required to be listed and a reason provided for use in the site-specific QAPP Contractor Addendum or ACQAP.

B10 Data Management

The Contractor will be responsible for providing the Project Specific data management scheme and the specifics of data archival for both the contractor and the lab that is used.

I. Field Data

All field data and observations will be recorded and maintained by the Contractor. After field data has been reviewed for accuracy, it will be produced in tabular form for inclusion in the final report. All field data must be labeled "For information purposes only." Any problems encountered through direct observation or through review of field data will be identified to the UST Project Manager and documented in the final report. The report shall include documentation of any corrective measures taken and discussion of any potential effect on field data objectives.

II. Laboratory Data

Prior to release of the analytical report, the sample data will be reviewed by the laboratory for accuracy, precision, and holding times. This process shall include a review of the data by the primary analyst and then a final review by the laboratory's Quality Control Officer. The data will be reported on a dry weight basis and take into account any required dilutions. The analytical data packages will include the following information: sample ID, analyst's initials, sample results, method blank results, laboratory control sample recovery, matrix spike/matrix spike duplicate recoveries and relative percent differences, surrogate recoveries, date and time of sample collection, date and time of sample receipt, date and time of sample preparation, date and time of sample analysis, dilution factors, pH of water samples, sample temperature at time of receipt, analytical and preparation methods used, method detection and quantitation limits, problems and corrective action, applicable certifications, and chain of custody. (See also Section A9).

The laboratory's review of the data will be based on the following criteria:

1) All analytical holding times are met;
2) Use of specified analytical procedures;
3) Use of properly calibrated and operating instruments; and
4) Successful analysis of the appropriate QC samples.

Once samples have been collected and analyzed, the project manager will assess the data for completeness and data entry errors. Any discrepancies will be verified with the hard copy, the sampler, and the analytical laboratory. The nature of the data and the subsequent analyses will be consistent to permit the comparison of data in one set to others.

I. National Data

The UST Management Division provides data to USEPA Region 4 on a quarterly basis using the USEPA Region 4 Underground Storage Tank Section Quarterly Activities Report.

c. Data Storage

Copies of field and laboratory data will be stored in accordance with the UST Management Division's Records Retention Schedule (See Appendix J). Worst-case results will be entered into the Environmental Facility Information System (EFIS) database. The UST Management Division is scanning all received documents and storing electronically. The electronic data will be stored for the life of the system.

The Contractor and Laboratories will be required to maintain a copy of all information submitted to the UST Management Division for a minimum of five years, unless otherwise specified.

Currently the UST Management Division is accepting data in hardcopy format from the Contractor. In the near future, the UST Management Division will accept data in electronic format to be submitted for electronic validation.

Refer to Section 9 of the SCDHEC EA Quality Management Plan, 2019 (See Appendix L) for details describing procedures for demonstrating the acceptability of the hardware and software configurations for the UST Management Division. Contractor procedures should be comparable especially in that their procedures must follow Federal and State Mandates. In addition, all software should be demonstrated to be acceptable for UST projects prior to use.

SECTION C – ASSESSMENT AND OVERSIGHT

C1 Assessment and Response Actions

B. **Types of Assessments**

1. On-Site Field Audit (OFA) – A thorough on-site audit during which sampling design, equipment, instrumentation, supplies, personnel, training, sampling procedures, chain of custody, sample handling and tracking, data reporting, data handling and management, data tracking and control, and data review procedures are examined for conformance with the UST Programmatic QAPP. An OFA may be scheduled at the discretion of the UST Project Manager or the Contractor, but in most cases will be conducted unannounced. The results will include the finding of the visit, any discrepancies, corrective action measure taken, and if any follow-up visits are needed. Corrective actions for audit deficiencies must be corrected by the contractor in the field before activities commence again. An OFA report form will be filled out appropriately by the UST Project Manager in the field. The OFA form will be documented and stored with the project file after it has been scanned and stored electronically at the SCDHEC office. If requested, a copy of the OFA form will be sent to the Contractor via email.

2. On-Site Analytical TSA (Lab Certification Audit) – An on-site audit of analytical procedures during which the facility, equipment instrumentation, supplies, personnel, training, analytical methods and procedures, laboratory procedures, sample handling and tracking, data reporting, data handling and management, data tracking and control, and data review procedures are checked for conformance with the UST Programmatic QAPP. This can be performed at any time during the project. The SCDHEC Office of Environmental Laboratory Certification requires at least one on-site analytical TSA every three years for certification purposes. This on-site audit includes a data audit as well. Auditors from SCDHEC Office of Environmental Laboratory Certification are drinking water laboratory certification officers certified by USEPA Cincinnati. The job requirements for an auditor include a science degree and extensive laboratory experience. At the end of the on-site audits, a closeout meeting is held with laboratory personnel and management to list the deficiencies found during the on-site inspection. An audit report is sent to the laboratory and corrective actions for audit deficiencies must be submitted to the Office of Environmental Laboratory Certification.

   Subcontracted Laboratory Record/Data Audit – An off-site audit of a subcontracted lab to determine that said lab is certified by SCDHEC for all analytes to be reported. The Contractor or UST Project Manager can also request training records, analytical records and procedures, laboratory procedures, sample handling and tracking, data reporting, data handling and management, data tracking and control, and data review procedures to be checked for conformance with the UST Programmatic QAPP. The need for this audit is determined by UST Project Manager or the Contractor. This type of audit is performed when the primary lab has subcontracted part of the project work. This can be performed at any time during the project. In addition, the laboratory certification status must be determined prior to any samples being analyzed.

3. Split Sampling and Analysis Audit – A comparison study to assess laboratory precision and accuracy. The sampler collects one field sample and then physically splits it into two representative sample aliquots. For split samples to be truly comparable, the splits must have identical sample handling

and pre-treatment, the laboratory(ies) must use the same analytical methods, and the QC items for the analytical runs must be the same. Split samples quantitatively assess the measurement error introduced by the organization's sample shipment and analysis system and must be accompanied by a PT Sample to establish the acceptance criteria. Split sample comparability criteria must be generated prior to sample collection and documented in the QAPP.

4. Proficiency Test (PT) Sample Tracking and Analysis – Providers of testing materials must be acceptable to the SCDHEC Office of Environmental Laboratory Certification. Successful annual analysis of PTs is required to maintain certification.

QA Assessment External (E) or Internal (I)	Frequency	Organization Responsible	Individual Receives Report & Notification of Deficiencies	Timeframe of Notification	Individual that Implements Corrective Actions?	Corrective Action Effectiveness Documented where?	Individuals Receiving Corrective Action Response
Proficiency Testing (PT) /E	One per year	PT Provider acceptable to SCDHEC Office of Environmental Laboratory Certification	**Field:** Field Manager or Contractor **Lab:** Laboratory QC Officer and/or Lab Director **SCDHEC**: Office of Environmental Laboratory Certification	Approx. 3 weeks after study ends	**Field:** Field Manager or Contractor **Lab:** Laboratory QC Officer	Memo to Lab QA Officer or Contractor	Lab QA Officer or Contractor and possibly the Lab Director
TSA/E – (Lab Cert Audit)	Per SCDHEC Office of Environmental Laboratory Certification's policy.	SCDHEC	Lab QA Officer and Lab Director	Per SCDHEC Office of Environmental Laboratory Certification's policy.	Lab Director	Response to Audit	Director, SCDHEC Office of Environmental Laboratory Certification
Onsite Field Audit	As determined by the UST Project Manager	Contractor	UST Project Manager and Contractor	2 days if scheduled, otherwise unannounced	Contactor	Final report submitted to SCDHEC	UST Management Division personnel
Onsite TSA/I For Analytical Lab	As determined for the specific project by UST Staff.	Lab QA Office if requested	Lab Manager and UST Project Manager	2 weeks	Lab Manager	Response to Audit	UST Project Manager and Lab QA Manager
Subcontract Laboratory Record/Data Audit	As determined for the specific project by UST Staff . For subcontracted Labs to determine compliance to the QAPP and certification status.	Contractor or UST Project Manager	Laboratory Director and SCDHEC UST Project Manager. If initiated by the UST Project Manager, the Contractor will get a copy of the report.	1 week	Lab Director	Email to Contractor or UST Project Manager. If Cert. Status is an issue an updated Lab. Cert. Certificate must be included.	Contractor and SCDHEC UST Project Manager

Split Sampling	As determined for the specific project by the UST Project Manager	Contractor	Lab Director and UST Management Division Project Manager	4 weeks after sample collection (turnaround time for the Labs is 3 weeks)	Contractor with the Lab Director	Email to UST	UST Project Manager

Table 10. Assessment and Response Actions

C2 Reports to Management

The UST Management Division will submit the UST Programmatic QAPP to the USEPA for approval and when changes are made to the QAPP. The SCDHEC UST Program is an approved program by USEPA. As such, specific site reports are not submitted to USEPA.

The contractor must provide the UST Project Manager with a Project Status Report (see Appendix M) on a weekly basis via e-mail. The Project Status Report will include the UST Permit number, facility name, date of update, current status, any issues that have arisen, corrective action measures taken to correct deficiencies, any changes to date final report is to be submitted. Alternatively, the contractor can notify the UST Project Manager via email 4 days prior to initiation of any Site Rehabilitation activity(ies). If there are any changes or conflicts with the date(s) of site activities, the UST Project Manager must be contacted within 24 hours of those changes. Due to the nature of the work conducted by the contractors and the UST Management Division, the contractor will notify the UST Project Manager within 24 hours via phone or e-mail concerning any quality assurance problems. This is important because the UST Project Manager and the contractor will determine appropriate corrective action measures to be taken. The environmental contractors and analytical laboratories shall be responsible for reporting and correcting all sample handling procedures that deviate from the approved Data Quality Objectives and/or other project specific requirements. The UST Project Manager will be informed of these issues via the weekly Project Status Report. The UST Project Manager will be notified within 24 hours via phone or e-mail of any issue that cannot be satisfactorily resolved between the contractor and analytical laboratory to determine the appropriate corrective action measures to be taken. A discussion of the problem(s) encountered, including quality assurance problem, the actions taken, and the results will be included in the final report submitted to the UST Management Division. A compilation of the weekly status reports will be included in the final report submitted to the UST Management Division.

The UST Project Manager has the discretion of conducting on-site visits to assess the performance of the contractor in accordance with the QAPP. The UST Project Manager assesses data submitted by the contractor, in cases where errors compromise the integrity of the project the UST Management Division management is notified.

SECTION D – DATA VALIDATION AND USABILITY

D1 Data Review, Verification and Validation

To ensure that data generated are of appropriate quality, all data will be verified and validated. These are systematic procedures for reviewing a body of data against a set of established criteria to provide a specified level of assurance of its validity prior to its intended use. The techniques used must be applied to the body of the data in a systematic and uniform manner. The process of data validation must be close to the origin of the data, independent of data production, and objective in its approach. All data, as applicable, will be validated in accordance with USEPA Quality System Requirements that data be reviewed, verified and validated and, where necessary reconciled to the project-specific or program-specific DQOs. Any deviations will be documented and provided with the final report.

If verification or validation indicates that samples have been collected and/or analyzed out of compliance with the UST QAPP (for instance deviations from the acceptance criteria for quality control defined in this QAPP and its addendums), re-sampling may be required. The contractor must contact the UST Project Manager in the event that there are any deviations from the UST QAPP and the UST Project Manager will determine if the data is acceptable or if re-sampling is required. If data is accepted that deviates from the QAPP the data will be used for screening purposes only and annotated as such.

If a laboratory is found to have lost certification for any of the performed analysis, the data will be used for informational purposes only and annotated as such.

The contractor's laboratory will provide a list of data qualifier flags and definition for each in the site-specific QAPP Contractor Addendum or in the final analytical report from the lab.

D2 Data Validation and Verification Methods

The objective of this section is to describe how data is reviewed. It has been noted that the Analytical Laboratories have internal review systems in place to verify the data before it leaves the lab.

Verification of the sample data is initially done by the laboratory. Verification of the entire project including the data is performed by the contractor's office. A checklist is used by the contractor (see Appendix K) to ensure that this is a thorough check on not only the completeness of the data but adherence to the UST QAPP. The contractor will include this checklist as part of the final report so that validation can be done. The list will include any anomalies noted in the field notes, the data, or the sample narrative from the laboratory. All deviations from the acceptable criteria and potential impacts affecting the usability of the data shall be reported by the data supplier.

UST Division staff will validate the analytical and project data supplied to ensure compliance with the formal and/or informal Data Quality Objectives stated in all approved work plans, permit provisions, enforcement order provisions, and the applicable federal and/or state guidance documents. Validation of the data by the UST Project Manager shall include a check on:

1) Completeness of the data;
2) Adherence to proper sample preservation, transport, or handling protocols;
3) Proper use of sample collection procedures;

4) Proper use of quality control criteria;
5) Documentation of all data;
6) Ability to reconstruct all field sampling procedures through documentation and records of such procedures;
7) Ability to trace data in the final report to a specific sampling site, date, and time; and
8) Appropriateness of the data as related to specific data quality objectives.

Upon receiving the final report, the UST Project Manager will validate the project data by first reading the report and reviewing the checklist, noting the anomalies listed as well as those seen in the report. Then the UST Project Manager will determine that all the locations listed in the SSWP were sampled or that a reason for not sampling the location was provided. The chain of custody is examined to ensure that it was properly completed and that it documented the condition of samples during their preparation, packing, transportation, and analyses. The environmental contractors and analytical laboratories shall be responsible for reporting and correcting all sample handling procedures that deviate from the approved Data Quality Objectives and/or other project specific requirements. The time the sample was collected until it was received by the laboratory is checked for consistency and for time travel (meaning the sample was received before it was collected or other inconsistencies). The temperature upon receipt is also checked. The validator will also determine if the Lab was certified throughout the study.

The lab reports are examined to make sure that all required analytes are present and were analyzed according to the requirements of the UST Programmatic QAPP. The data is further examined against historical data to note changes and anomalies. If data anomalies become a concern and cannot be explained, SCDHEC may arrange for an independent verification by re-sampling or refer to the Regulatory Section of UST Management Division for an investigation of a potential subsequent release. QC data is examined for completeness and adherence to the requirements of the UST Programmatic QAPP. This examination includes an examination to ensure that necessary corrective actions have been taken when QC does not meet QAPP or method requirements. The contractor is responsible for ensuring that the QC requirements have been met and is not supposed to submit a report until this has been done. This review by the UST Project Manager serves as a second check.

Validation is also done on the well construction and boring logs. The records are reviewed for completeness and anomalies. Certification of the well driller is checked. The field measurements are examined to ensure that the wells were purged in accordance with the UST Programmatic QAPP. Lastly, the disposal manifest is checked to ensure that the contractor has included this in the report.

Any anomalies or items that do not meet the requirements of the UST Programmatic QAPP are noted in a Verification, Validation and Usability Report. This is generated by the Project Manager and is based on his/her findings during the validation, but can include items from the contractors verification process as well as conferences with the contractor concerning problems and the corrective action to those problems. This Report is scanned in and filed with the electronic version of the contractor’s final report.

Item	Activity
Data Deliverables and QAPP	Ensure that all required information on sampling and analysis was provided (including planning documents).
Analytes	Ensure that required lists of analytes were reported as specified.
Chain-of-Custody	Examine the traceability of the data from time of sample collection until reporting of data. Examine chain-of-custody records against contract, method, or procedural requirements.
Holding Times	Identify holding time criteria, and either confirm that they were met or document any deviations. Ensure that samples were analyzed within holding times specified in method, procedure, or contract requirements. If holding times were not met, confirm that deviations were documented, that appropriate notifications were made (consistent with procedural requirements), and that approval to proceed was received prior to analysis.
Sample Handling	Ensure that required sample handling, receipt, and storage procedures were followed, and that any deviations were documented.
Sampling Methods and Procedures	Establish that required sampling methods were used and that any deviations were noted. Ensure that the sampling procedures and field measurements met performance criteria and that any deviations were documented.
Analytical Methods and Procedures	Establish that required analytical methods were used and that any deviations were noted. Ensure that the QC samples met performance criteria and that any deviations were documented.
Data Qualifiers	Determine that the laboratory data qualifiers were defined and applied as specified in methods, procedures, or contracts.
Deviations	Determine the impacts of any deviations from sampling or analytical methods and SOPs. Consider the effectiveness and appropriateness of any corrective action.
Sampling Plan	Determine whether the sampling plan was executed as specified (i.e., the number, location, and type of field samples were collected and analyzed as specified in the QAPP).
Sampling Procedures	Evaluate whether sampling procedures were followed with respect to equipment and proper sampling support (e.g., techniques, equipment, decontamination, volume, temperature, preservatives, etc.).
Co-located Blind Field Duplicates	Compare results of co-located field duplicates with criteria established in the QAPP. Should be submitted to laboratory without information identifying sample location or collection time.
Project Quantitation Limits	Determine that quantitation limits were achieved, as outlined in the QAPP and that the laboratory successfully analyzed a standard at the QL.
Confirmatory Analyses	Evaluate agreement of laboratory results.
Performance Criteria	Evaluate QC data against project-specific performance criteria in the QAPP (i.e., evaluate quality parameters beyond those outlined in the methods).
Data Qualifiers	Determine that the data qualifiers applied were those specified in the QAPP and that any deviations from specifications were justified.
Validation Report	Summarize deviations from methods, procedures, or contracts. Include qualified data and explanation of all data qualifiers.

Table 11. Validation Activities

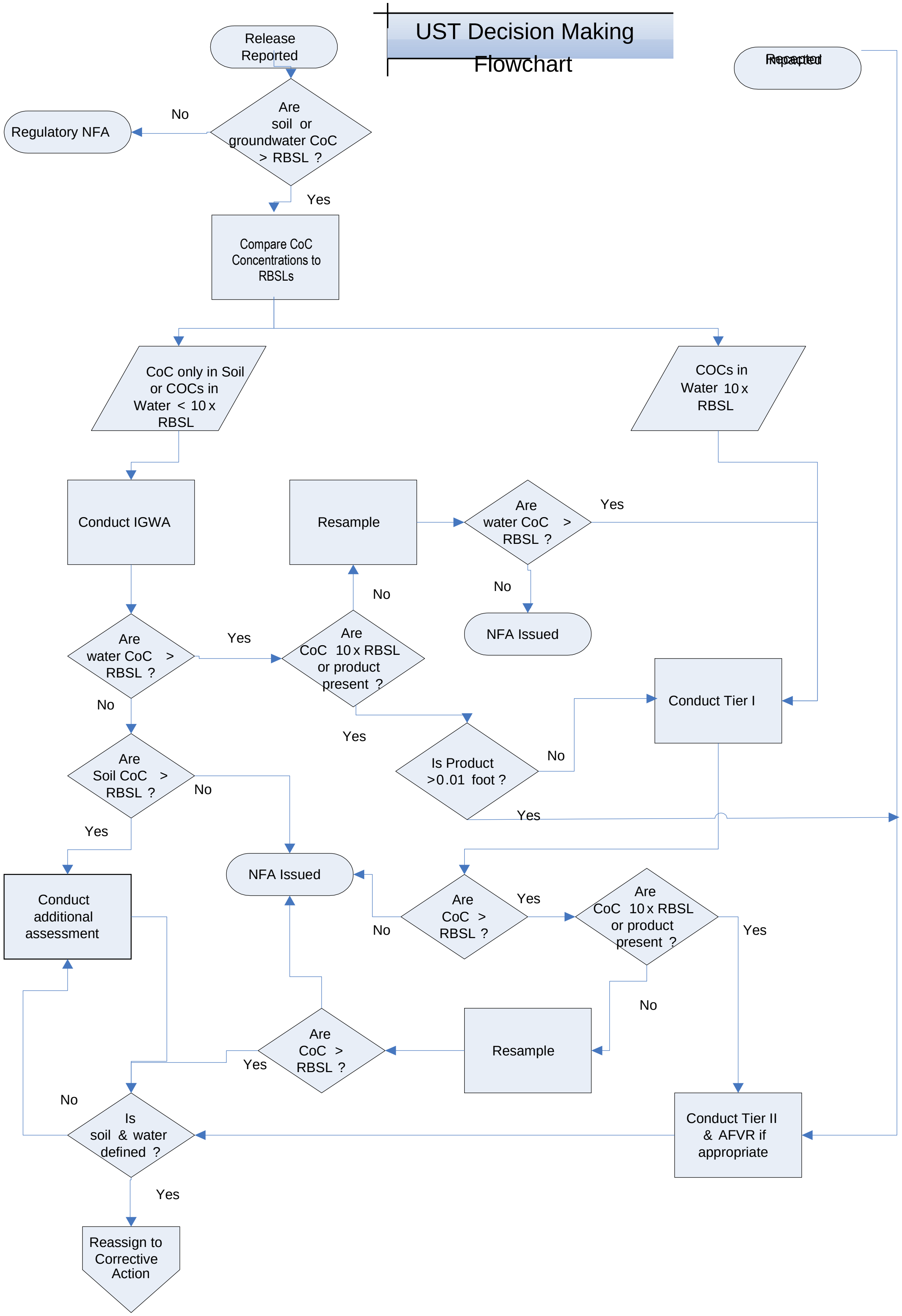
D3 Reconciliation with User Requirements

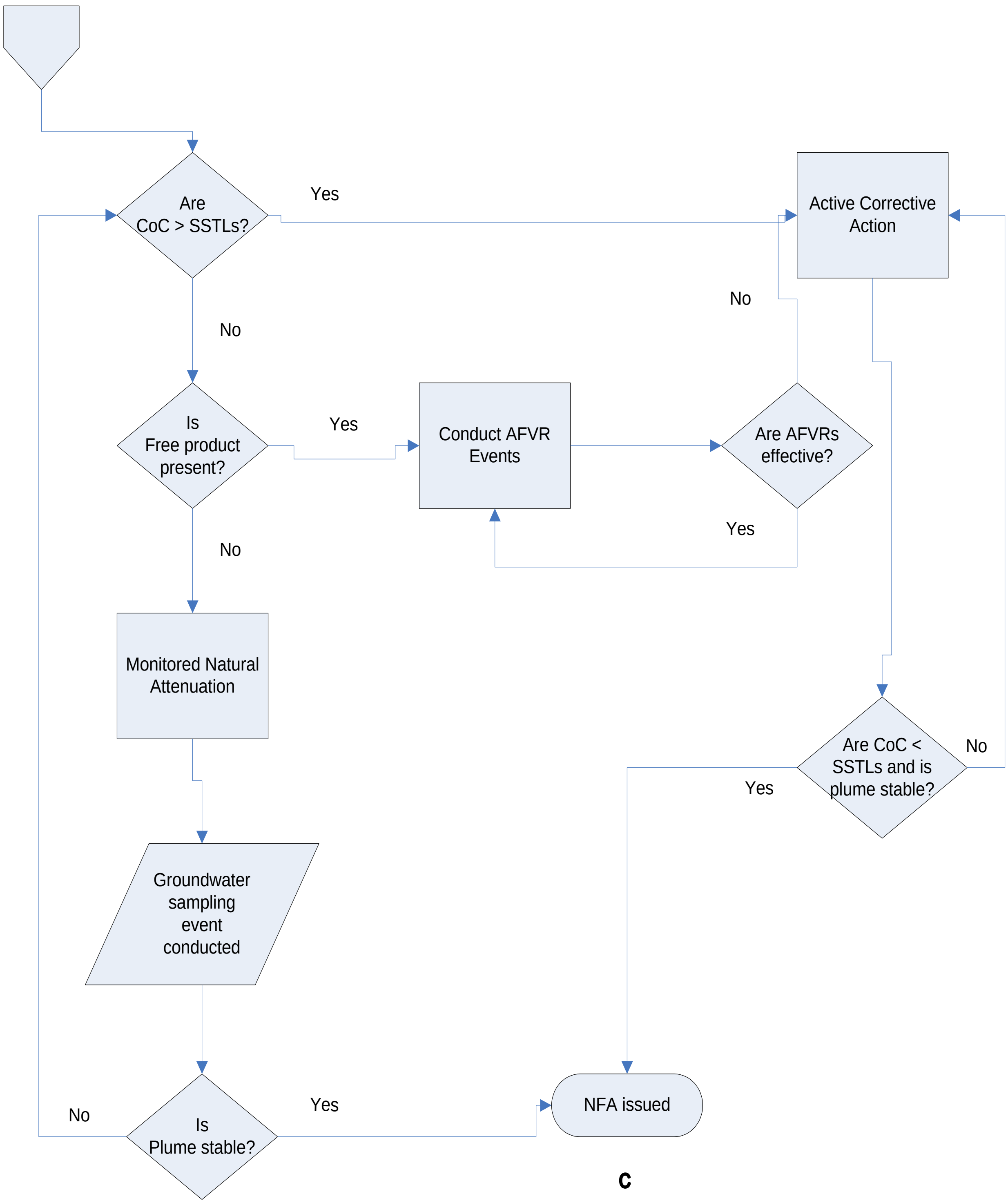
The UST Project Manager shall ensure that the data collected address the needs to evaluate the UST site and meet the specific Data Quality Objectives specified previously. This is done in conjunction with data verification and validation. The Usability Report will be part of the Verification, Validation and Usability report discussed in Section D2. This will document problems and corrective action throughout the project and discuss findings in the data and report that appear to be anomalous, but do not significantly impact the usability of data as a whole. Because data generated with significant deviations from the requirements of the UST Programmatic QAPP will be rejected and because of the nature of the work (biased sampling), all data will have the same expected uncertainties and there will be no limitations on data use.

Item	Assessment Activity
Data Deliverables and QAPP	Ensure that all necessary information was provided, including but not limited to validation results.
Deviations	Determine the impact of deviations on the usability of data.
Sampling Locations, Deviation	Determine if alterations to sample locations continue to satisfy the project objectives.
Chain-of-Custody, Deviation	Establish that any problems with documentation or custody procedures do not prevent the data from being used for the intended purpose.
Holding Times, Deviation	Determine the acceptability of data where holding times were exceeded.
Damaged Samples, Deviation	Determine whether the data from damaged samples are usable. If the data cannot be used, determine whether resampling is necessary.
PT Sample Results, Deviation	Determine the implications of any unacceptable analytes (as identified by the PT sample results) on the usability of the analytical results. Describe any limitations on the data.
SOPs and Methods, Deviation	Evaluate the impact of deviations from SOPs and specified methods on data quality.
QC Samples	Evaluate the implications of unacceptable QC sample results on the data usability for the associated samples. For example, consider the effects of observed blank contamination.
Matrix	Evaluate matrix effects (interference or bias).
Meteorological Data and Site Conditions	Evaluate the possible effects of meteorological (e.g., wind, rain, temperature) and site conditions on sample results. Review field reports to identify whether any unusual conditions were present and how the sampling plan was executed.
Comparability	Ensure that results from different data collection activities achieve an acceptable level of agreement.
Completeness	Evaluate the impact of missing information. Ensure that enough information was obtained for the data to be usable (completeness as defined in PQOs documented in the QAPP).
Background	Determine if background levels have been adequately established (if appropriate).
Critical Samples	Establish that critical samples and critical target analytes/CoCs, as defined in the QAPP, were collected and analyzed. Determine if the results meet criteria specified in the QAPP.
Data Restrictions	Describe the exact process for handling data that do not meet PQOs (i.e., when measurement performance criteria are not met). Depending on how those data will be used, specify the restrictions on use of those data for environmental decision-making.
Usability Decision	Determine if the data can be used to make a specific decision considering the implications of all deviations and corrective actions
Usability Report	Discuss and compare overall precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity for each matrix, analytical group, and concentration level. Describe limitations on the use of project data if criteria for data quality indicators are not met.

Table 12. Considerations for Usability Assessment

Appendix A: UST Management Division RBCA Decision Making Flow Chart


UST Decision Making Flowchart
Release Reported
Are soil or groundwater CoC > RBSL ?
No
Regulatory NFA
Yes
Compare CoC Concentrations to RBSLs
CoC only in Soil or COCs in Water < 10 x RBSL
COCs in Water 10 x RBSL
Conduct IGWA
Resample
Are water CoC > RBSL ?
Yes
No
NFA Issued
Are water CoC > RBSL ?
Yes
No
Are CoC 10 x RBSL or product present ?
No
Yes
Conduct Tier I
Is Product >0.01 foot ?
No
Yes
Are Soil CoC > RBSL ?
No
Yes
Conduct additional assessment
NFA Issued
Are CoC > RBSL ?
Yes
No
Are CoC 10 x RBSL or product present ?
Yes
No
Resample
Are CoC > RBSL ?
Yes
No
Is soil & water defined ?
Yes
Conduct Tier II & AFVR if appropriate
Reassign to Corrective Action


Are
CoC > SSTLs?
Yes
Active Corrective Action
No
No
Is
Free product
present?
Yes
Conduct AFVR Events
Are AFVRs effective?
Yes
No
Monitored Natural Attenuation
Groundwater sampling event conducted
Are CoC <
SSTLs and is
plume stable?
No
Yes
No
Is
Plume stable?
Yes
NFA issued

C

Appendix B: Contractor Addendum

Note to Contractors and those using this Addendum form:

1. **Once the form is completed, DELETE THIS SECTION**
2. Instructions for filling in this Addendum are in red as are suggestions for what needs to go in the document. Tables and other figures that can be used as part of the Addendum---just adjusted for the project will be in black**. Anything in red should be deleted out of the QAPP Contractor Addendum.**
3. In each Section there is generic information or instructions, however, please refer to the SCDHEC QAPP Guide.
4. This is considered an ADDENDUM to the UST Programmatic QAPP. While the UST Programmatic QAPP gives specific direction, this addendum will fill in site specific/lab specific/contractor specific information. Please refer to each section of the UST Programmatic QAPP as this Addendum is prepared. Realize that this Addendum is supposed to be site specific.
5. For help with the parts of the QAPP call the SCDHEC UST QAPP Coordinator at (803) 898-0634 or email at: vincenmm@dhec.sc.gov. For help with specific UST issues please contact your UST Project Manager.
6. Please understand that you are responsible for anything in the UST Programmatic QAPP as well as what is in the Addendum you produce for the project.

Section A: Project Management

A1 Title and Approval Page

Quality Assurance Project Plan
Addendum to the SCDHEC UST Programmatic QAPP
For

Name of Project/Site and UST Permit Number

Site Location (Address, City, State)

Prepared by:________________________________

Affiliation and Contact Information

Date:________________________________

Day/Month/Year

Name of Certified Contractor and Contractor Certification Number

Approvals

Name ________________________________ Date____________
UST Project Manager Signature

Name ________________________________ Date____________
Contractor QA Manager Signature

Name ________________________________ Date____________
Site Rehabilitation Contractor Signature

Name ________________________________ Date____________
Laboratory Director Signature

Other signatures may be required and should be added as directed by UST Project Manager.

Signatures of all parties who may be involved in UST Site Rehabilitation work stating they have received the most recent version of the UST Programmatic QAPP. (Including those on the Approvals page and in the Distribution List)

A2 Table of Contents

A3 Distribution and Project Organization List

The distribution and project organization list is a list of individuals either directly participating in the project or overseeing the project. The UST Programmatic QAPP has specific roles and the responsibilities of each role, however, personnel assigned to these roles must be identified in this QAPP Contractor Addendum. Anyone performing essential functions in this project (not given in the UST Programmatic QAPP) should be listed below and their duties outlined. Those listed below must have access to the UST Programmatic QAPP and receive a copy of the site-specific QAPP Contractor Addendum as well as any updates/revisions. Please notice that some SCDHEC titles are already listed below along with their addresses. The writer of the site-specific QAPP Contractor Addendum is to identify the UST Project Manager who is assigned to this specific project in the table below. Licensed professionals (e.g., PE, PG, well driller, surveyor) listed in the table must provide applicable license information (type, number, expiration date) in the third column. Additional rows are left for other personnel who are essential to this project either from SCDHEC or subcontractors.

Name	Title/Role from UST Master QAPP	License/ Number/ Exp. date	Organization/Address	Telephone Number	Fax Number	Email Address
	UST Technical Project Manager		SCDHEC, UST Management Division, 2600 Bull St., Columbia, SC, 29201	803-898-2544	803-898-0673	
	Contractor Project Manager					
	Contractor Field Manager					
	Contractor Project Verifier					
	Field Staff					
	Well Services/ Driller					
	Laboratory Director					

Table 1A Addendum Distribution and Project Organization List

It is understood that certification records must be produced if requested by SCDHEC.

A4 Problem Definition/Background

Discuss the background (as much as is known) of the site and appropriate historical information, and why this site is being assessed.

Please answer the following: Does this project fall under UST or Brownfields area?

A5 Project/Task Description

1. ***Summarize what is known about the work to be done. This can be a short sentence indicating what the Scope of this project is (see Master QAPP Section A6).***

2. ***The work will begin within ___________________ after cost approval and sampling should be complete by____________________________.***

3. ***Are there any time or resource constraints? Include those factors that may interfere with the tentative schedule.***

A6 Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs)

The Addendum will complete what is given in the Programmatic QAPP Guide on the DOQ Process. Specifically this is Step 4: Defining the Study boundary—which includes a map of the property (Attachment) to show what the extent of the study will cover.

Detail the geographical area that is to be part of the project. Maps should be included to show not only the topography and the geographical area of the State, but also to show more detail of the site itself including property lines.

A7 Certification

The Labs that will be used for this project must be certified by the SCDHEC Office of Environmental Certification for every analysis that they will perform. The information for the Laboratories and their SCDHEC Certificate number must be included in this addendum.

The Following Laboratory(ies) will be used for this Project:
All labs being used (including ones subcontracted) must be included.

<u>Commercial Lab(s)</u>

Please give the information as listed below for each Laboratory that is being used for sample analysis.

Full Name of the Laboratory____
Name of Lab Director____
SCDHEC Certification Number____

Full Name of the Laboratory____
Name of Lab Director____
SCDHEC Certification Number____

(If more than 2 labs are being used, copy the above 3 lines and insert into this document)

Please note: SCDHEC may require that the contractor submit some or all of the Laboratory's SOPs as part of this QAPP.

A8 Documents and Records

Personnel will receive the most current version of the QAPP Contractor Addendum via: (Check all that apply)

____US Mail ____Courier ____Hand delivered

Other (please specify):____

This section requires a list of the records—pertinent to the project- produced during the project by the Contractor, Laboratories, and Subcontractors. Please note that the Programmatic QAPP requires records to be kept at least 5 years.

Record	Produced By	Hardcopy/ Electronic	Storage Location For how long?	Archival

Table 2A Record Identification, Storage, and Disposal

Section B Measurement/Data Acquisition

B1 Sampling Process/Experimental Design

In the table below list the schedule for project activities. This would include drilling the wells, developing the wells, collecting samples and so on.

Task	Start Date	End Date	Comments

Table 3A Sampling Activities

B2 Sampling Methods

Please note: The contractor must follow sampling protocols as given in the UST QAPP.

***Estimate* the number of samples of each matrix that are expected to be collected:**

Soil ___________

Ground Water from monitoring wells ___________

From Drinking/Irrigation water wells ___________

From surface water features ___________

Duplicate samples ___________

Field blanks ___________

Trip blanks ___________

Total number of Water samples ___________

In this next part indicate if the samples will be homogenized and split and describe the way this will be done.

The samples will be (check all that apply): ____ Grab____Homogenized ____Split

If homogenized or split are checked please indicate how will it be done and the equipment needed.

If decontamination procedures differ from Appendix H, please provide details.

Identify any equipment and support facilities needed. This may include such things as Fed-ex® to ship the samples, a Geoprobe®, field analysis done by another contractor (who must be certified), or electricity to run sampling equipment.

Address the actions to be taken when problems occur in the field, and the person responsible for taking corrective action and how the corrective action will be documented.

Failure	Response	Documentation	Individual Responsible

Table 4A Field Corrective Action

B3 Sample Handling and Custody

This section deals with how samples are physically handled. Please answer the following questions and please attach a copy of the Lab's chain of custody. If multiple labs are used along with multiple chains of custodies, all of them must be attached. The chain of custody procedure should describe how the sample's location is accounted from collection to disposal (for each lab). If the laboratory has a SOP for this, it may be attached as long as sampling personnel understand that they must adhere to it. Please note that holding times and preservation for samples must adhere to the requirements in the Master UST QAPP. Preservation and sample handling details must be given in either a case narrative or on the Chain of Custody.

1. ***How will the samples get from the Site to the Lab to ensure holding requirements are met?***

2. ***If sample preservation procedures differ from the UST Programmatic QAPP, please provide details.***

3. ***If chain of custody procedures differ from the UST Programmatic QAPP, please provide details.***

B4 Analytical Methods

This section will give specific information about exactly which methods will be used for analysis. The allowable methods are given in the Programmatic QAPP, but often there are choices so the Contractor's addendum must list the exact methods that will be used. Although the SOPs of the lab are reviewed during their Laboratory Certification Process, UST or the OQA may require submission of some or all SOPs. SOPs may be identified by the full nomenclature from the lab or by abbreviation as long as the abbreviations are explained. **Do not submit laboratory QA plans or SOPs unless they are requested by the UST Management Division Project Manager.**

The tables below may be used for the first requirement.

1. ***Identify the method which the SOP references and the equipment or instrumentation that is needed:***

Parameter	Method Referenced	Comments

Table 5A Analytical SOPs and Referenced Methods

Item 2 may be in an attachment from the Lab from their QA/QC plan or written out below because the Lab has a QA/QC plan that states what is done, but field personnel do not.

2. ***Provide SOPs for the Kerr Method or the Ferrous Iron Method if these are parameters for this study. This can be attached or written here. If attached please note that it is an attachment and where it is located (if applicable).***

B5 Quality Control Requirements:

All QC will follow the requirements laid out in Section B5 of the UST Programmatic QAPP. If procedures for QC differ from the UST Programmatic QAPP, please provide details.

B6 Field Instrument and Equipment Testing, Inspection and Maintenance

1. Identify all field equipment needing periodic maintenance, the schedule for this, and the person responsible.

Instrument	Serial Number	Type of Maintenance	Frequency	Person responsible

Table 6A Instrument and Equipment Maintenance

B7 Instrument Calibration and Frequency

1. Identify equipment, tools, and instruments for field work that should be calibrated and the frequency.
2. Describe how the calibrations should be performed and documented, indicating test criteria and standards or certified equipment.
3. Identify how deficiencies should be resolved and documented. Identify the person responsible for corrective action.

Instrument	Serial Number	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA

Table 7A Instrument Calibration Criteria and Corrective Action

B8 Inspection/Acceptance Requirements for Supplies and Consumables

1. If procedures for storage, handling or transport of supplies/consumables differ from the UST Programmatic QAPP, please provide details.

Consumables are things like disposable bailers, nitrile gloves, sample containers, and so on.

B9 Data Acquisition Requirements (Non-Direct Measurements)

This section discusses data that was not generated by this project. This includes historical data, information Tax Maps, computer data bases, weather data from the National Weather Service, Scientific Literature, and so on. This discussion must include information about why this data is usable for this project.

1. Identify data sources, for example, computer databases or literature files, or models that should be accessed or used.
2. Describe the intended use of this information and the rationale for their selection, i.e.,
3. Provide its relevance to the project.
4. Indicate the justification criteria for use of these data sources and/or models.

Data Source	Used for	Relevance	Justification for use in this project	Comments

Table 8A Non-Direct Measurements

5. Identify key resources/support facilities needed. This will probably be non-applicable for most projects. This would be addressed if the contractor employed someone to provide data modeling, database upkeep, and so on.

B10 Data Management

1. Describe the data management scheme from field to final use and storage.

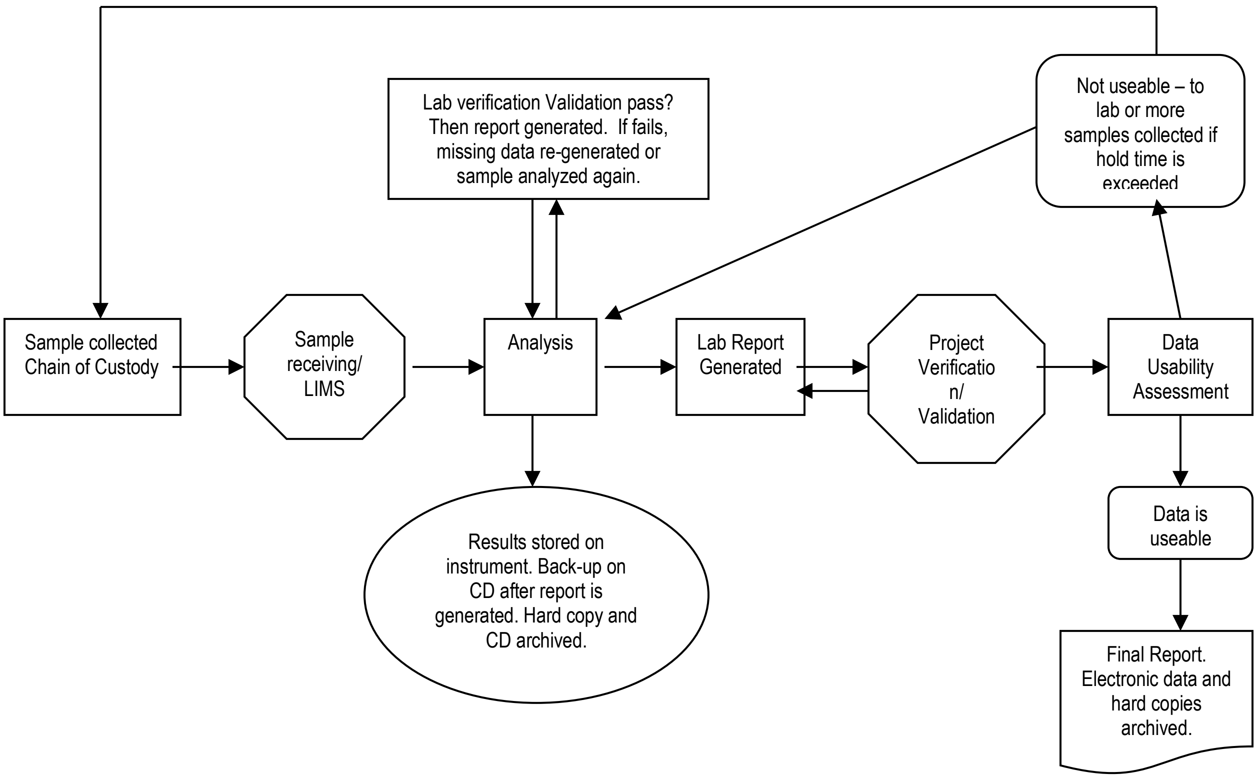


Figure 1 Example of a Data Management Scheme

A diagram, such as the one above, can be used to satisfy Item 1 or a description can be used instead.

2. How does the lab and field staff ensure that no unauthorized changes are made to the chain of custody, sampling notebooks, laboratory notebooks and computer records?
3. How does the lab ensure that there are no errors in samples records including times when sample information is compiled, data calculated and/or transmitted?

Items 2 and 3: This is a discussion of how errors will be avoided. This includes errors in the field paperwork, chain of custody and laboratory processes. Usually this is done by overview of a supervisor who looks over work or rechecks calculations. Software issues also come into play here. Is there a process to keep data from being corrupted or restoring it if the data becomes corrupted? Is there a process to avoid data loss though computer malfunctions? What about security of the data? Is the data protected from tampering? How does the Lab or contractor know that the software/hardware that is used is acceptable? In each process, identify who is responsible for oversight.

4. How will the data be archived once the report is produced? How can it be retrieved? (This applies to both electronic and hard copies).

Section C Assessment and Oversight

C1 Assessment and Response Actions

1. *The Contractor is supposed to observe field personnel daily during sampling activities to ensure samples are collected and handled properly and report problems to DHEC within 24 hours. Please state who is responsible for doing this, what observations will be made, and how those observations will be made. Will this person have the authority to stop work if severe problems are seen?*
2. *The SCDHEC UST QAPP states that the Lab will receive an Offsite Technical System Audit. For this project, what assessments will be done by the Contractor on the Commercial Lab(s) that are being used—other than their certification audit? When or how often are these done? Who will the results be given to and who has the ability to stop work if problems are severe?*

C2 Reports to Management

See the SCDHEC UST Programmatic QAPP.

Section D Data Validation and Usability

See the SCDHEC UST Programmatic QAPP.

Appendix C: Site-Specific Work Plan

dhec

Site-Specific Work Plan for Approved ACQAP
Underground Storage Tank Management Division

To: ______________________________ (SCDHEC Project Manager)
From: ______________________________ (Contractor Project Manager)
Contractor: ______________ UST Contractor Certification Number: ______________

Facility Name: ______________ UST Permit #: ______________
Facility Address: ______________
Responsible Party: ______________ Phone: ______________
RP Address: ______________
Property Owner (if different): ______________
Property Owner Address: ______________
Current Use of Property: ______________

Scope of Work (Please check all that apply)

☐ IGWA ☐ Tier II ☐ Groundwater Sampling ☐ GAC
☐ Tier I ☐ Monitoring Well Installation ☐ Other ______________

Analyses (Please check all that apply)

Groundwater/Surface Water:

☐ BTEXNMDCA (8260B) ☐ Lead ☐ BOD ☐ Methane
☐ Oxygenates (8260B) ☐ 8 RCRA Metals ☐ Nitrate ☐ Ethanol
☐ EDB (8011) ☐ TPH ☐ Sulfate ☐ Dissolved Iron
☐ PAH (8270D) ☐ pH ☐ Other ______________

Drinking Water Supply Wells:

☐ BTEXNMDCA (524.2) ☐ Mecury (200.8 245.1 or 245.2) ☐ EDB (504.1)
☐ Oxygenates & Ethanol (8260B) ☐ RCRA Metals (200.8)

Soil:

☐ BTEXNM ☐ Lead ☐ RCRA Metals ☐ TPH-DRO (3550B/8015B) ☐ Grain Size
☐ PAH ☐ Oil & Grease (9071) ☐ TPH-GRO (5030B/8015B) ☐ TOC

Air:

☐ BTEXN

Sample Collection (Estimate the number of samples of each matrix that are expected to be collected.)

______ Soil ______ Water Supply Wells ______ Air ______ Field Blank
______ Monitoring Wells ______ Surface Water ______ Duplicate ______ Trip Blank

Field Screening Methodology

Estimate number and total completed depth for each point, and include their proposed locations on the attached map.

# of shallow points proposed: ______________ Estimated Footage: ______________ feet per point
# of deep points proposed: ______________ Estimated Footage: ______________ feet per point
Field Screening Methodology: ______________

Permanent Monitoring Wells

Estimate number and total completed depth for each well, and include their proposed locations on the attached map.

# of shallow wells: ______________ Estimated Footage: ______________ feet per point
# of deep wells: ______________ Estimated Footage: ______________ feet per point
# of recovery wells: ______________ Estimated Footage: ______________ feet per point
Comments, if warranted:

____

____

DHEC 0653 (09/2016) SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

UST Permit #: ________________ Facility Name: ________________________________

Implementation Schedule (Number of calendar days from approval)
Field Work Start-Up: ________________ Field Work Completion: ________________
Report Submittal: ________________ # of Copies Provided to Property Owners: ________________

Aquifer Characterization
Pump Test: ☐ Slug Test: ☐ (Check one and provide explanation below for choice)

____
____
____

Investigation Derived Waste Disposal
Soil: ________________ Tons Purge Water: ________________ Gallons
Drilling Fluids: ________________ Gallons Free-Phase Product: ________________ Gallons

Additional Details For This Scope of Work
For example, list wells to be sampled, wells to be abandoned/repaired, well pads/bolts/caps to replace, details of AFVR event, etc.

____
____
____
____
____
____
____

Compliance With Annual Contractor Quality Assurance Plan (ACQAP)
____ Laboratory as indicated in ACQAP? (Yes/No) If no, indicate laboratory information below.
Name of Laboratory: ________________
SCDHEC Certification Number: ________________
Name of Laboratory Director: ________________

____ Well Driller as indicated in ACQAP? (Yes/No) If no, indicate driller information below.
Name of Well Driller: ________________
SCLLR Certification Number: ________________

____ Other variations from ACQAP. Please describe below.

____
____
____
____
____

Attachments
1. Attach a copy of the relevant portion of the USGS topographic map showing the site location.
2. Prepare a site base map. This map must be accurately scaled, but does not need to be surveyed. The map must include the following:
   - North Arrow
   - Location of property lines
   - Location of buildings
   - Previous soil sampling locations
   - Previous monitoring well locations
   - Proposed soil boring locations
   - Proposed monitoring well locations
   - Legend with facility name and address, UST permit number, and bar scale
   - Streets or highways (indicate names and numbers)
   - Location of all present and former ASTs and USTs
   - Location of all potential receptors
3. Assessment Component Cost Agreement, SCDHEC Form D-3664

Appendix D: RBSL Look-Up Tables

Table D1
RBSLs for Groundwater

Chemical of Concern	Concentration (μg/L)
Benzene	5
Toluene	1,000
Ethylbenzene	700
Xylenes	10,000
Total PAHs#	25
MTBE	40
Naphthalene	25
1,2-DCA	5
EDB ▯	0.05
Lead ▯	15
Arsenic **	10
Barium **	2,000
Cadmium **	5
Chromium **	100
Mercury **	2
Selenium **	50
Silver **	5

In calculating SSTLs for individual PAHs (Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, and Dibenz(a,h)anthracene), please use an RBSL of 10 μg/L for each CoC.

▯ UST system was in operation prior to 1991.

** For waste oil UST releases only.

Table D2
Action Levels for Groundwater (Oxygenates)

Chemical of Concern	Concentration (μg/L)
EtBE (Ethyl tert-Butyl Ether)	47
tAME (tert-Amyl Methyl Ether)	128
DIPE (di-Isopropyl Ether)	150
tBA (tert-Butyl Alcohol)	1,400
tAA (tert-Amyl Alcohol)	240
Ethanol	10,000
tBF (tert-Butyl Formate)	None
3,3-Dimethyl-1-Butanol	None

Table D3
RBSLs for Sandy Soil determined based on groundwater RBSLs

Chemical of Concern	RBSL (mg/kg) (for all separation distances)
Benzene	0.007
Toluene	1.45
Ethylbenzene	1.15
Xylenes	14.5
Naphthalene	0.036
Benzo(a)anthracene*	0.066
Benzo(b)fluoranthene*	0.066
Benzo(k)fluoranthene*	0.066
Chrysene*	0.066
Dibenz(a,h)anthracene*	0.066

* **Limits are increased to levels above the calculated values to reasonably attainable laboratory reporting limits.**

Table D4

RBSLs for Clay-rich Soil (mg/kg)

Separation Distance → **↓ Chemical of Concern**	**<10 ft**	**10-15 ft**	**15-20 ft**	**20-25 ft**	**25-30 ft**	**>30 ft**
Benzene	0.003	0.008	0.037	0.187	1.010	5.665
Toluene	0.627	1.167	3.630	12.085	41.885	149.125
Ethylbenzene	1.551	6.168	76.950	1114.5	-	-
Xylenes	13.010	22.495	61.250	176.800	529.000	-
Naphthalene	0.047	0.069	0.139	0.292	0.625	1.350
Benzo(a)anthracene	0.066*	-	-	-	-	-
Benzo(b)fluoranthene	0.066*	7439.0	-	-	-	-
Benzo(k)fluoranthene	0.066*	-	-	-	-	-
Chrysene	0.066*	13.099	59.800	298.550	1573.000	-
Dibenz(a,h)anthracene	0.066*	-	-	-	-	-

Note: Separation Distance is measured from the depth of the worst-case soil sample to the top of the water table.

*** RBSLs are increased to levels above the calculated values to reasonably attainable laboratory reporting limits.**

- Indicates that the values are above saturation levels

Table D5
RBSLs for Inhalation of vapors

Chemical of Concern	RBSL (μg/m^3)
Benzene	0.36
Toluene	5200
Ethylbenzene	1.1
Xylene	100
Methyl Tert-Butyl Ether	11
1,2-DCA	0.11
EDB	0.1*

Note: RBSLs for the PAHs are not of concern because of their low volatility.
* **RBSL is increased to levels above the calculated values to reasonably attainable laboratory reporting limits.**

Table D6

RBSLs for Soil Ingestion and Dermal Contact

Chemical of Concern	Residential (mg/kg)		Industrial (mg/kg)	
	Ingestion	Dermal	Ingestion	Dermal
Benzene	13	None	59	None
Toluene	6,300	None	93,000	None
Ethylbenzene	63	None	300	None
Xylene	16,000	None	230,000	None
Methyl Tert-Butyl Ether	390	None	1,800	None
Naphthalenes	1,600	5,100	23,000	42,000
Benzo(a)anthracene	0.21	0.63	4.5	8.1
Benzo(b)fluoranthene	0.21	0.63	4.5	8.1
Benzo(k)fluoranthene	2.1	6.3	45	81
Chrysene	21	63	450	810
Dibenzo(a,h)anthracene	0.021	0.063	0.45	0.81
1,2-DCA	7.6	None	36	None
EDB	0.35	None	1.6	None

Table D7

Effective Solubility Limits for Gasoline Constituents

Chemical of Concern	Concentration (µg/L)
Benzene	44,390
Toluene	26,540
Ethylbenzene	3,700
Xylenes	21,680
Methyl Tert-Butyl Ether**	173,000
Naphthalenes	6,700
1,2-DCA	3,700
EDB	1,900
ETBE**	5,030,000
3,3-Dimethyl-1-Butanol**	No Limit
TAME**	4,290,000
DIPE**	2,670,000
TBF**	No Limit
TBA**	235,000,000
TAA**	35,900,000
Ethanol**	296,000,000

** Oxygenates

Appendix E: Site Conceptual Models

Site Conceptual Model - CURRENT LAND USE

Exposure Medium	Exposure Route	Pathway Selected for Evaluation? (Yes or No)	Exposure point or Reason for Non-Selection	Data Requirements (IF pathway selected)
Air	Inhalation	Yes No		
	Explosion Hazard	Yes No		
Ground-Water	Ingestion	Yes No		
	Dermal Contact	Yes No		
	Inhalation	Yes No		
Surface Water	Ingestion	Yes No		
	Dermal contact	Yes No		
	Inhalation	Yes No		
Surficial Soil	Ingestion	Yes No		
	Dermal contact	Yes No		
	Inhalation	Yes No		
	Leaching to Ground-Water	Yes No		
Subsurface Soil	Ingestion	Yes No		
	Dermal contact	Yes No		
	Inhalation	Yes No		
	Leaching to Ground-Water	Yes No		

Site Conceptual Model - FUTURE LAND USE

Media (for exposure)	Exposure Route	Pathway Selected for Evaluation? (Yes or No)	Exposure point or Reason for Non-Selection	Data Requirements (IF pathway selected)
Air	Inhalation	Yes No		
	Explosion Hazard	Yes No		
Ground-Water	Ingestion	Yes No		
	Dermal Contact	Yes No		
	Inhalation	Yes No		
Surface Water	Ingestion	Yes No		
	Dermal contact	Yes No		
	Inhalation	Yes No		
Surficial Soil	Ingestion	Yes No		
	Dermal contact	Yes No		
	Inhalation	Yes No		
	Leaching to Ground-Water	Yes No		
Subsurface Soil	Ingestion	Yes No		
	Dermal contact	Yes No		
	Inhalation	Yes No		
	Leaching to Ground-Water	Yes No		

Appendix F: Analytical Parameters and Methods

Table F1

Analytical Precision and Accuracy for Water Samples

Analyte	Analytical Method	Reporting Limit*#		Laboratory Control Sample (LCS) % Recovery	Matrix Spike Samples % Recovery	Precision Relative Percent Difference %RPD
		Groundwater	Receptors Surface Water or Non-Drinking Water Supply Well			
Benzene	5030B with 8260D	5 µg/L	2 µg/L	70 – 130%	70 – 130%	20
Toluene	5030B with 8260D	5 µg/L	2 µg/L	70 – 130%	70 – 130%	20
Ethylbenzene	5030B with 8260D	5 µg/L	2 µg/L	70 – 130%	70 – 130%	20
Total Xylenes	5030B with 8260D	10 µg/L	6 µg/L	70 – 130%	70 – 130%	20
Naphthalene	5030B with 8260D	5 µg/L	2 µg/L	70 – 130%	70 – 130%	20
1,2-Dichloroethane	5030B with 8260D	5 µg/L	2 µg/L	70 – 130%	70 – 130%	20
MTBE	5030B with 8260D	5 µg/L	5 µg/L	70 – 130%	70 – 130%	20
EDB	8011	0.05 µg/L	0.02 µg/L	60 – 140%	60 – 140%	20
ETBE	5030B with 8260D-oxy	100 µg/L	100 µg/L	70 – 130%	70 – 130%	20
3,3-dimethyl-1-butanol	5030B with 8260D-oxy	100 µg/L	100 µg/L	70 – 130%	70 – 130%	20
TAME	5030B with 8260D-oxy	10 µg/L	10 µg/L	70 – 130%	70 – 130%	20
DIPE	5030B with 8260D-oxy	10 µg/L	10 µg/L	70 – 130%	70 – 130%	20
TBF	5030B with 8260D-oxy	100 µg/L	100 µg/L	70 – 130%	70 – 130%	20
TBA	5030B with 8260D-oxy	100 µg/L	100 µg/L	70 – 130%	70 – 130%	20
TAA	5030B with 8260D-oxy	100 µg/L	100 µg/L	70 – 130%	70 – 130%	20
Ethanol	5030B with 8260D-oxy	1,000 µg/L	1,000 µg/L	70 – 130%	70 – 130%	20
1,2,4- and 1,3,5-trimethyl benzene isomers	5030B with 8260D	5 µg/L	5 µg/L	70 – 130%	70 – 130%	20
n-butyl, sec-butyl, and tert-butyl benzene isomers	5030B with 8260D	5 µg/L	5 µg/L	70 – 130%	70 – 130%	20
Isopropyl benzene	5030B with 8260D	5 µg/L	5 µg/L	70 – 130%	70 – 130%	20
n-propyl benzene	5030B with 8260D	5 µg/L	5 µg/L	70 – 130%	70 – 130%	20

Analyte	Analytical Method	Reporting Limit*#		Laboratory Control Sample (LCS)	Matrix Spike Samples	Precision
		Groundwater	Receptors Surface Water or Non-Drinking Water Supply Well	% Recovery	% Recovery	Relative Percent Difference %RPD
Full List 8260D Scan	5030B with 8260D	Analyte specific	Analyte specific	70 – 130%	70 – 130%	20
Benzo(a)anthracene	3510C with 8270E	10 µg/L	10 µg/L	70 – 130%	40 – 150%	20
Benzo(b)fluoranthene	3510C with 8270E	10 µg/L	10 µg/L	70 – 130%	40 – 150%	20
Benzo(k)fluoranthene	3510C with 8270E	10 µg/L	10 µg/L	70 – 130%	40 – 150%	20
Chrysene	3510C with 8270E	10 µg/L	10 µg/L	70 – 130%	40 – 150%	20
Dibenzo(a,h)anthracene	3510C with 8270E or SIM	10 µg/L	10 µg/L	70 – 130%	40 – 150%	20
TPH (Oil & Grease)	9070A	50 mg/L	50 mg/L	78 – 114%	78 – 114%	18
Arsenic	3005A or 3010A with 6020B	5 µg/L	5 µg/L	80 - 120%	75 – 125%	20
Barium	3005A or 3010A, with 6010D or 6020B	50 µg/L	50 µg/L	80 - 120%	75 – 125%	20
Cadmium	3005A or 3010A with 6010D or 6020B	1 µg/L	1 µg/L	80 - 120%	75 – 125%	20
Chromium	3005A or 3010A with 6010D or 6020B	5 µg/L	5 µg/L	80 - 120%	75 – 125%	20
Lead	3005A or 3010A with 6010D or 6020B	5 µg/L	2 µg/L	80 - 120%	75 – 125%	20
Mercury	7470A	0.2 µg/L	0.2 µg/L	80 - 120%	75 – 125%	20
Selenium	3005A or 3010A with 6020B	5 µg/L	5 µg/L	80 - 120%	75 – 125%	20
Silver	3005A or 3010A with 6010D or 6020B	5 µg/L	5 µg/L	80 - 120%	75 – 125%	20
Nitrate	9210A or 9056A	100 µg/L	100 µg/L	80 - 120%	80-120%	20
Sulfate	9056A	1,000 µg/L	1,000 µg/L	80 - 120%	80 - 120%	20

Analyte	Analytical Method	Reporting Limit*#		Laboratory Control Sample (LCS) % Recovery	Matrix Spike Samples % Recovery	Precision Relative Percent Difference %RPD
		Groundwater	Receptors Surface Water or Non-Drinking Water Supply Well			
Methane	Kerr Method RSKSOP-175 rev 2, May 2004	10,000 µg/L	10,000 µg/L	85-115%	NA	NA
Ferrous Iron	SM3500-Fe D	100 µg/L	100 µg/L	90-110%	85-115%	≤ 20%
pH	9040C	NA	NA	NA	NA	NA
Conductivity	9050A	10 µS/cm	10 µS/cm	NA	NA	NA
Turbidity	SM-2130B	1 NTU	1 NTU	NA	NA	NA
Temperature	SM-2550B	NA	NA	NA	NA	NA
Dissolved Oxygen	SM-4500 O G, ASTM D888-09(c), HACH 10360 Rev. 1.2	1,000 µg/L	1,000 µg/L	NA	NA	NA

*A reporting limit standard must be included as part of the calibration curve. Use of non-linear calibration models is not acceptable.
If a lower reporting limit can be achieved for any of the analytes listed above then that lower limit must be reported.

Table F2

Analytical Precision and Accuracy for Drinking Water Samples

Analyte	Analytical Method	Reporting Limit*# Public or Private Drinking Water Supply Well	Laboratory Control Sample (LCS) % Recovery	Matrix Spike Samples % Recovery	Precision Relative Percent Difference %RPD
Benzene	524.2	0.5 µg/L	70 – 130%	N/A	N/A
Toluene	524.2	0.5 µg/L	70 – 130%	N/A	N/A
Ethylbenzene	524.2	0.5 µg/L	70 – 130%	N/A	N/A
Total Xylenes	524.2	0.5 µg/L	70 – 130%	N/A	N/A
Naphthalene	524.2	2 µg/L	70 – 130%	N/A	N/A
1,2-Dichloroethane	524.2	0.5 µg/L	70 – 130%	N/A	N/A
MTBE	524.2	5 µg/L	70 – 130%	N/A	N/A
EDB	504.1	0.02 µg/L	70 – 130%	65 – 135%	N/A
ETBE	5030B with 8260D-oxy	100 µg/L	70 – 130%	70 – 130%	20
3,3-dimethyl-1-butanol	5030B with 8260D-oxy	100 µg/L	70 – 130%	70 – 130%	20
TAME	5030B with 8260D-oxy	10 µg/L	70 – 130%	70 – 130%	20
DIPE	5030B with 8260D-oxy	10 µg/L	70 – 130%	70 – 130%	20
TBF	5030B with 8260D-oxy	100 µg/L	70 – 130%	70 – 130%	20
TBA	5030B with 8260D-oxy	100 µg/L	70 – 130%	70 – 130%	20
TAA	5030B with 8260D-oxy	100 µg/L	70 – 130%	70 – 130%	20
Ethanol	5030B with 8260D-oxy	1,000 µg/L	70 – 130%	70 – 130%	20
1,2,4- and 1,3,5-trimethyl benzene isomers	524.2	5 µg/L	70 – 130%	70 – 130%	N/A
n-butyl, sec-butyl, and tert-butyl benzene isomers	524.2	5 µg/L	70 – 130%	70 – 130%	N/A
Isopropyl benzene	524.2	5 µg/L	70 – 130%	70 – 130%	N/A
n-propyl benzene	524.2	5 µg/L	70 – 130%	70 – 130%	N/A
Arsenic	200.8	1 µg/L	85 - 115%	70 – 130%	N/A
Barium	200.8	50 µg/L	85 - 115%	70 – 130%	N/A
Cadmium	200.8	1 µg/L	85 - 115%	70 – 130%	N/A
Chromium	200.8	5 µg/L	85 - 115%	70 – 130%	N/A
Lead	200.8	2 µg/L	85 - 115%	70 – 130%	N/A

Mercury	245.1, 245.2 or 200.8	0.2 µg/L	85 - 115%	70 – 130%	N/A
Selenium	200.8	5 µg/L	85 - 115%	70 – 130%	N/A
Silver	200.8	5 µg/L	85 - 115%	70 – 130%	N/A

*A reporting limit standard must be included as part of the calibration curve. Use of non-linear calibration models is not acceptable.
If a lower reporting limit can be achieved for any of the analytes listed above then that lower limit must be reported.

Table F3
Analytical Precision and Accuracy for Soil Samples

Analyte	Analytical Method	Reporting Limit*	Laboratory Control Sample (LCS) % Recovery	Matrix Spike Sample % Recovery	Precision Relative Percent Difference %RPD
Benzene[w]	5035 with 8260D	5 µg/kg	70 – 130%	70 – 130%	20
Toluene[w]	5035 with 8260D	5 µg/kg	70 – 130%	70 – 130%	20
Ethylbenzene[w]	5035 with 8260D	5 µg/kg	70 – 130%	70 – 130%	20
Xylenes[w]	5035 with 8260D	10 µg/kg	70 – 130%	70 – 130%	20
Naphthalene[w]	5035 with 8260D	5 µg/kg	70 – 130%	50 – 150%	20
MTBE[w]	5035 with 8260D	5 µg/kg	70 – 130%	50 – 150%	20
Benzo(a)anthracene	3546, 3550C with 8270E	660 µg/kg	70 – 130%	50 – 150%	20
Benzo(b)fluoranthene	3546, 3550C with 8270E	660 µg/kg	70 – 130%	50 – 150%	20
Benzo(k)fluoranthene	3546, 3550C with 8270E	660 µg/kg	70 – 130%	50 – 150%	20
Chrysene	3546, 3550C with 8270E	660 µg/kg	70 – 130%	50 – 150%	20
Dibenz(a,h)anthracene	3546, 3550C with 8270E	660 µg/kg	70 – 130%	50 – 150%	20
TPH (DRO)	3546, 3550C with 8270E	10 mg/kg	70 – 130%	60 – 140%	20
TPH (GRO) [w]	5035 with 8015C	10 mg/kg	70 – 130%	60 – 140%	20
Oil & Grease [w]	9071B	100 mg/kg	70 – 130%	60 – 140%	20
Arsenic	3050B with 6020B	250 µg/kg	80 - 120%	75 – 125%	20

Analyte	Analytical Method	Reporting Limit*	Laboratory Control Sample (LCS) % Recovery	Matrix Spike Sample % Recovery	Precision Relative Percent Difference %RPD
Barium	3050B with 6010D or 6020B	250 µg/kg	80 - 120%	75 – 125%	20
Cadmium	3050B with 6010D or 6020B	250 µg/kg	80 - 120%	75 – 125%	20
Chromium	3050B with 6010D or 6020B	250 µg/kg	80 - 120%	75 – 125%	20
Lead	3050B with 6010D or 6020B	250 µg/kg	80 - 120%	75 – 125%	20
Mercury	7471B	10 µg/kg	80 - 120%	75 – 125%	20
Selenium	3050B with 6020B	250 µg/kg	80 - 120%	75 – 125%	20
Silver	3050B with 6010D or 6020B	250 µg/kg	80 - 120%	75 – 125%	20
TCLP	1311	Applicable Method Limits			
Total Organic Carbon (TOC)**	9060A	0.1 mg/kg	90 - 110%	70 – 130%	20

* A reporting limit standard must be included as part of the calibration curve. Use of non-linear calibration models is not acceptable.

** TOC must be performed using a TOC analyzer equipped with a soil sample attachment.

w Analytical results to be reported as dry weight.

Table F4 Required Sampling Parameters

Groundwater	**Soil**
Benzene Toluene Ethylbenzene Xylenes Naphthalene Methyl tertiary butyl ether (MTBE) Polynuclear Aromatic Hydrocarbons (PAHs) Total lead Ethylene Dibromide (EDB) 1,2-DCA Oxygenates - (Ethanol, 3,3-Dimethyl-1-Butanol, ETBE, TAME, TBA, TAA, TBF and DIPE)	Benzene Toluene Ethylbenzene Xylenes Naphthalene Methyl tertiary butyl ether (MTBE) Polynuclear aromatic hydrocarbons (PAHs) Total lead
Waste Oil Groundwater	**Waste Oil Soil**
Benzene Toluene Ethylbenzene Xylenes Naphthalene Methyl tertiary butyl ether (MTBE) Polynuclear aromatic hydrocarbons (PAHs) Ethylene Dibromide (EDB) 1,2-DCA 8 RCRA Metals, as total metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver)	Benzene Toluene Ethylbenzene Xylenes Naphthalene Methyl tertiary butyl ether (MTBE) Polynuclear aromatic hydrocarbons (PAHs) 8 RCRA Metals, as total metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver)

Appendix G: Preservation and Holding Times

Table G1

Sample Preservation and Holding Times for Groundwater

Analyte	Analytical Method	Container	Preservation	Holding Time[1]
Benzene	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#],		pH<2 using HCl, Cool to <6°C	
Toluene	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
Ethylbenzene	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
Total Xylenes	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
Total Naphthalenes	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
1,2-Dichloroethane	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
MTBE	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
EDB	8011	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with HCl	14 days
	504.1		$Na_2S_2O_3$, Cool to < 6 °C	

Analyte	Analytical Method	Container	Preservation	Holding Time[1]
ETBE	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
3,3-Dimethyl-1-butanol	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
TAME	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
DIPE	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
TBF	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
TBA	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
TAA	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
Ethanol	5030B with 8260D-oxy	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
1,2,4- and 1,3,5-trimethyl benzene isomers	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
n-butyl, sec-butyl, and tert-butyl benzene isomers	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	
Isopropyl benzene	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		pH<2 using HCl, Cool to <6°C	

Analyte	Analytical Method	Container	Preservation	Holding Time[1]
n-propyl benzene	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C and adjust pH to less than 2 with H_2SO_4 or HCl	14 days
	524.2[#]		HCl pH<2, Cool to ≤ 6 °C	
Full List 8260D Scan	5030B with 8260D	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6 °C	7 days
Benzo(a)anthracene	3510C with 8270E	Amber glass container with Teflon-lined lid	Cool to ≤ 6 °C	7 days until extraction 40 days after extraction
Benzo(b)fluoranthene	3510C with 8270E	Amber glass container with Teflon-lined lid	Cool to ≤ 6 °C	7 days until extraction 40 days after extraction
Benzo(k)fluoranthene	3510C with 8270E	Amber glass container with Teflon-lined lid	Cool to ≤ 6 °C	7 days until extraction 40 days after extraction
Chrysene	3510C with 8270E	Amber glass container with Teflon-lined lid	Cool to ≤ 6 °C	7 days until extraction 40 days after extraction
Dibenz(a,h)anthracene	3510C with 8270E	Amber glass container with Teflon-lined lid	Cool to ≤ 6 °C	7 days until extraction 40 days after extraction
TPH (Oil & Grease)	9070A	1 Liter Glass	Cool to ≤ 6 °C pH to less than 2 with H_2SO_4 or HCl	28 days
Arsenic	3005A, 3010A with 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			
Barium	3005A, 3010A with 6010D or 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			
Cadmium	3005A, 3010A with 6010D, 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			

Analyte	Analytical Method	Container	Preservation	Holding Time[1]
Chromium	3005A, 3010A with 6010D, 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			
Lead	3005A, 3010A with 6010D, 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			
Mercury	7470A	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	28 days
	245.1, 245.2 or 200.8			
Selenium	3005A, 3010A with 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			
Silver	3005A, 3010A with 6010D, 6020B	Polyethylene or Glass	HNO_3 to pH <2, Cool to ≤ 6 °C	180 days
	200.8			
Nitrate	9210 or 9056A	Polyethylene or Glass	Cool to ≤ 6° C	48 hours
Sulfate	9056A	Polyethylene or Glass	Cool to ≤ 6° C	28 days
Methane	Kerr Method RSKSOP-175 rev 2, May 2004	2 x 40 ml glass vials with Teflon-lined septum caps	Cool to ≤ 6° C, pH < 2 with 1:1 HCl	14 days
Ferrous Iron	SM3500-Fe B	Glass	None	24-48 hours
pH	9040C	NA	NA	Within 15 minutes
Conductivity	9050A	NA	Cool to ≤ 6° C	28 days
Turbidity	SM-2130B	NA	Cool to ≤ 6° C	48 hours
Temperature	SM-2550B	NA	NA	Within 15 minutes
Dissolved Oxygen	SM-4500 O G, or ASTM D888-09, HACH 10360	NA	NA	Within 15 minutes

[1]This holding time is calculated from the exact time of sample collection. It is recommended that samples be shipped to the lab the same day that they are collected, or as soon as possible thereafter.

[#]If residual chlorine is present, then vials should be pre-preserved with $Na_2S_2O_3$ (sodium thiosulfate), then 2 drops of 1:1 HCl added to each vial after sample collection.

Table G2

Sample Preservation & Holding Times for Soil

Analyte	Analytical Method	Container	Preservation	Holding Time[1]
Benzene	5035 with 8260D	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days
Toluene	5035 with 8260D			
Ethylbenzene	5035 with 8260D			
Xylenes	5035 with 8260D			
Total Naphthalenes	5035 with 8260D			
MTBE	5035 with 8260D			
Benzo(a)anthracene	3540C, 3541, 3545A, 3546, or 3550C with 8270E	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days until extraction 40 days after extraction
Benzo(b)fluoranthene	3540C, 3541, 3545A, 3546 or 3550C with 8270E	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days until extraction 40 days after extraction
Benzo(k)fluoranthene	3540C, 3541, 3545A, 3546 or 3550C with 8270E	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days until extraction 40 days after extraction
Chrysene	3540C, 3541, 3545A, 3546 or 3550C with 8270E	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days until extraction 40 days after extraction
Dibenz(a,h)anthracene	3540C, 3541, 3545A, 3546 or 3550C with 8270E	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days until extraction 40 days after extraction
TPH (DRO)	3540C, 3541, 3545A or 3550C with 8270E	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days until extraction 40 days after extraction
TPH (GRO)	5035 with 8015C	Amber glass with Teflon-lined lid	Cool to ≤ 6° C	14 days
TPH (Oil & Grease)	9071B	Wide-mouth glass container with Teflon-lined lid	Cool to ≤ 6° C	28 days
Arsenic	6020B	Polyethylene or Glass	None	180 days
Barium	6010D or 6020B	Polyethylene or Glass	None	180 days

Analyte	Analytical Method	Container	Preservation	Holding Time[1]
Cadmium	6010D or 6020B	Polyethylene or Glass	None	180 days
Chromium	6010D or 6020B	Polyethylene or Glass	None	180 days
Lead	6010D or 6020B	Polyethylene or Glass	None	180 days
Mercury	7471B	Polyethylene or Glass	None	28 days
Selenium	6020B	Polyethylene or Glass	None	180 days
Silver	6010D or 6020B	Polyethylene or Glass	None	180 days
TCLP	1311	See Method for Requirements		
Total Organic Carbon (TOC)	9060A	Polyethylene or Glass	Cool to ≤ 6° C	28 days

[1]This holding time is calculated from the exact time of sample collection. It is recommended that samples be shipped to the lab the same day that they are collected, or as soon as possible thereafter.

Appendix H: Leachability Model and Domenico Model

Leachability Model for Petroleum Contaminated Soils

The following approach is provided to determine whether leachates from petroleum contaminated soils will migrate to ground water and to determine Site Specific Target Levels (SSTLs) for cleanup of impacted soil. If soil concentrations are above the Risk Based Screening Levels (RBSLs) the soil leachability model can be used to determine if soil remediation is necessary. The model utilizes a series of mathematical equations that quantify contaminant partitioning, transport, degradation, and dilution processes. **Please note that the Leachability Model should be used only when the separation distance is more than 8 feet.**

Data Acquisition

Proper application of this model requires complete delineation of the horizontal and vertical extent of impacted soil and the analysis of representative soil samples. The Tier I Assessment provides guidelines for the number and locations of soil samples to be collected around the tanks, lines, and dispensers at a typical underground storage tank facility. If the horizontal and vertical extent of impacted soil has not been completely delineated during the Tier I assessment, additional samples should be collected during the Tier II Assessment (former Rapid Assessment). A complete soil assessment should include:

A. Installation of soil borings as explained below.

1. Soil borings shall be advanced to the ground water * in the area occupied by the former or existing underground storage tanks, piping, and dispensers.
2. Soil borings shall be advanced to the ground water * adjacent to impacted borings to complete the full delineation.
3. Background Soil Boring: One soil boring shall be installed to a depth of 10 feet or to the ground water table, whichever is shallower, and at least thirty feet away from any USTs, product lines, dispensers, and other potential sources of CoC. If the site is too small to allow a separation of thirty feet, this soil boring shall be installed as far away from all USTs, product lines, dispensers, and other potential sources of CoC as possible. The soil sample must be collected from below the A-horizon unless a shallow water table precludes this.

* If the field screening results indicate that petroleum impact does not extend to the water table, the boring may be terminated after three consecutive clean split-spoon samples at five-foot intervals for the Tier I and Tier II Assessments or a boring to a depth of 50 feet for an Initial Ground Water Assessment. A soil sample shall be collected from the termination depth of that boring to verify the vertical extent of impacted soil. A second sample shall be collected from the depth interval that exhibits the highest concentration of impact. Both samples shall be analyzed by a South Carolina certified laboratory for appropriate CoC.

B. The lithology for each soil sample collected during boring installation shall be appropriately described. Samples shall be screened for organic vapors utilizing properly calibrated instruments. For other less volatile chemicals such as diesel or kerosene, alternative screening methods (e.g., field GC, immunoassay, etc.) can be used.

C. The soil sample from each boring around the USTs, piping, and dispensers shall be submitted to an DHEC certified laboratory for analyses as follows:

1. The sample (from each boring) with the highest organic vapor measurement shall be submitted to the laboratory for analysis. If the organic vapor measurements for all samples in a boring are within ten percent of each other, the sample from the greatest depth above the water table shall be submitted for analysis.
2. The samples (one from each soil boring) submitted to the laboratory shall be analyzed for the appropriate CoC.
3. Soil samples shall be collected from the soil boring with the highest organic vapor measurement will be submitted for analyses in accordance with the Tier I Sampling Process Design.
4. The soil sample collected from the background soil boring shall be analyzed for total organic carbon ($\mathbf{f_{oc}}$). The presence of calcareous soil shall be noted for possible analytical interferences. The presence of stained soil, peat beds, unusually high organic content, or other unusual conditions shall also be noted.

All soil borings must be properly abandoned pursuant to the South Carolina Well Standards and Regulations R.61-71.

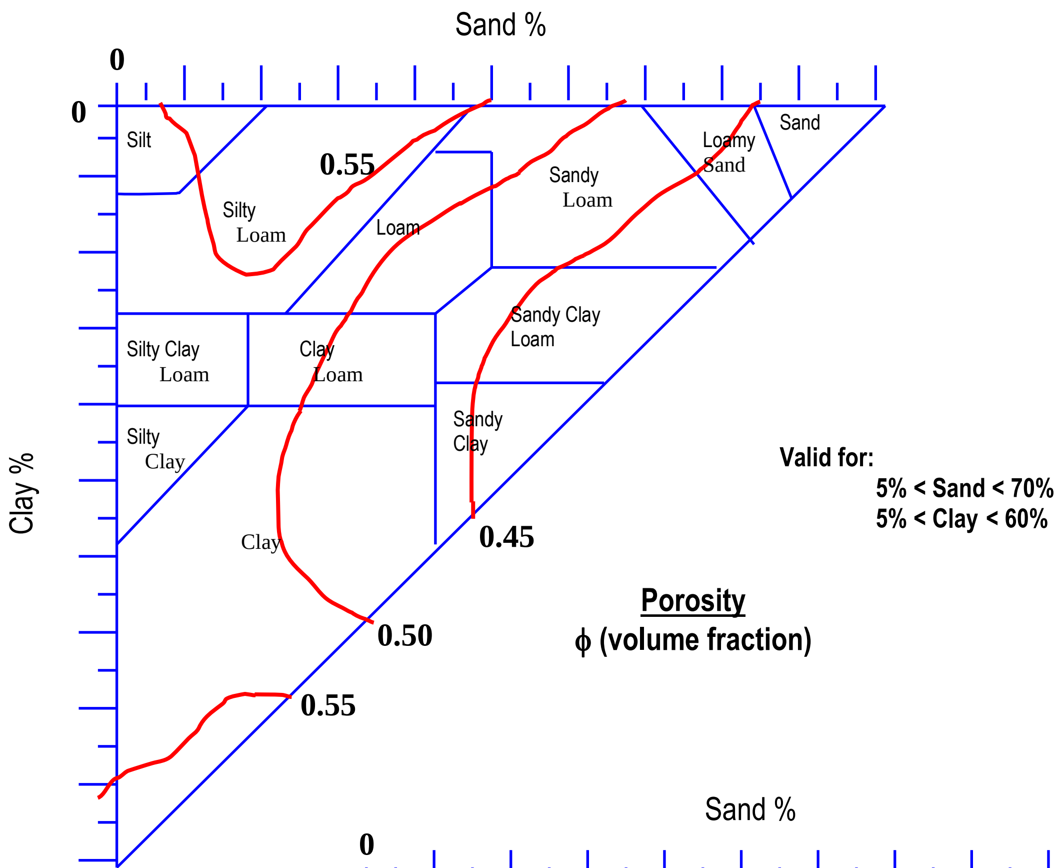


Figure H1

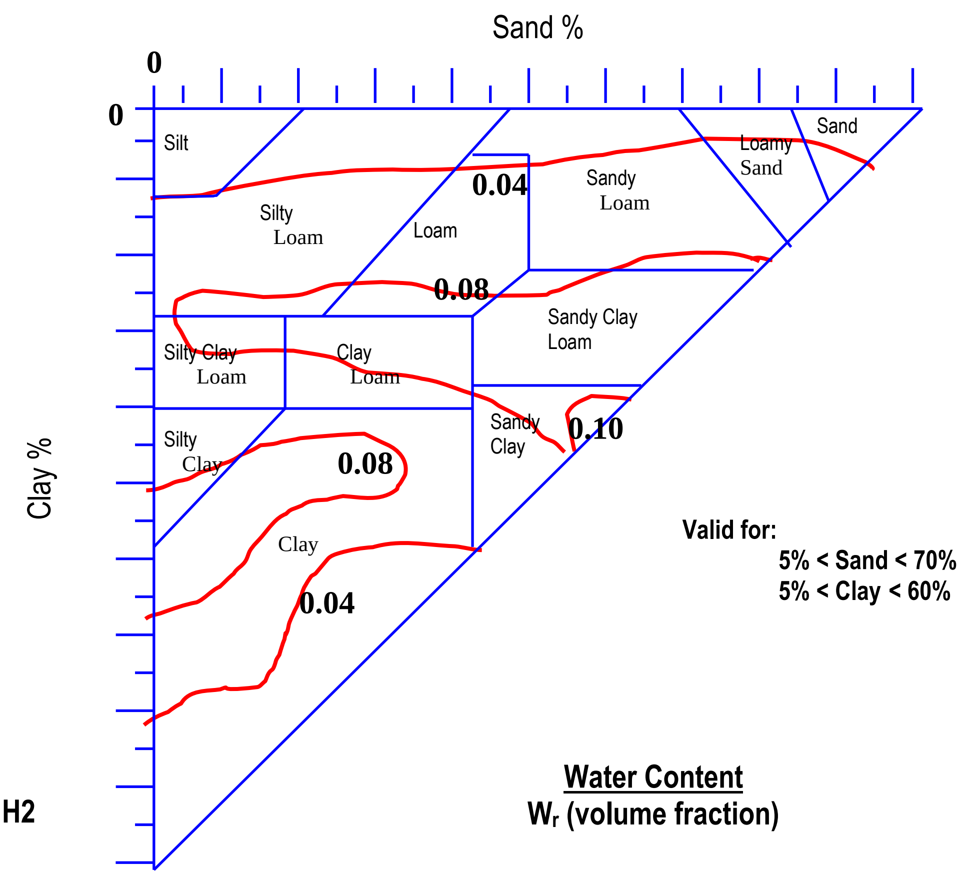


Figure H2

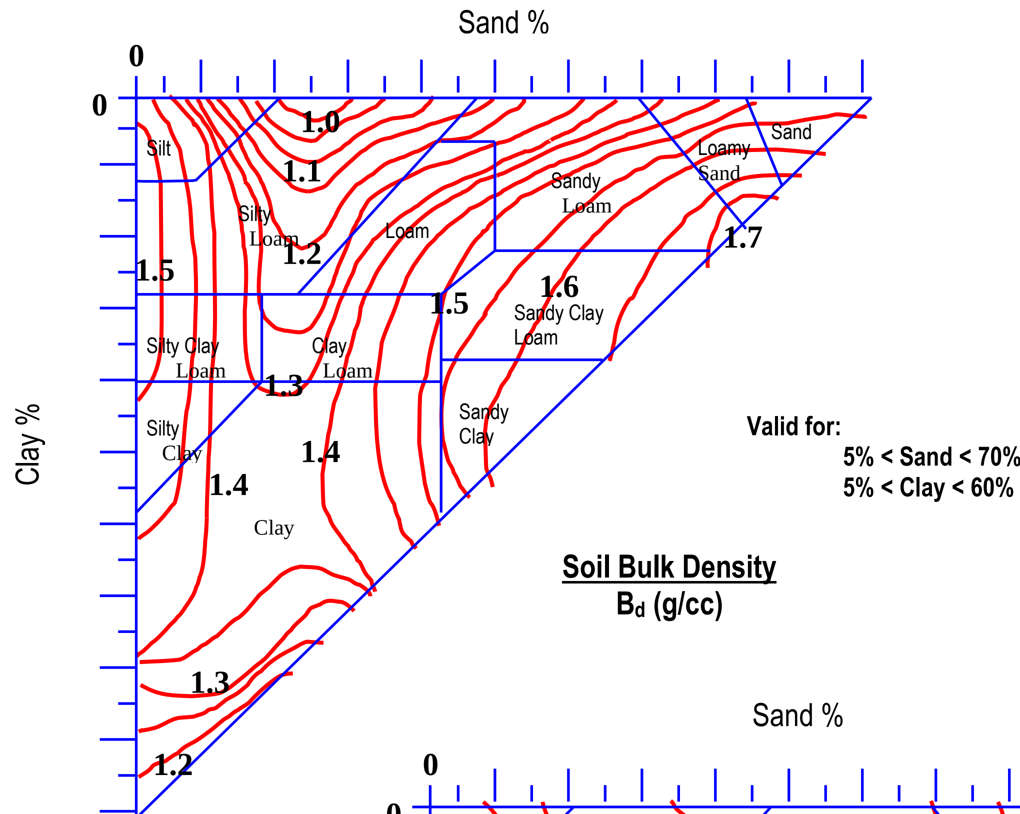


Figure H3

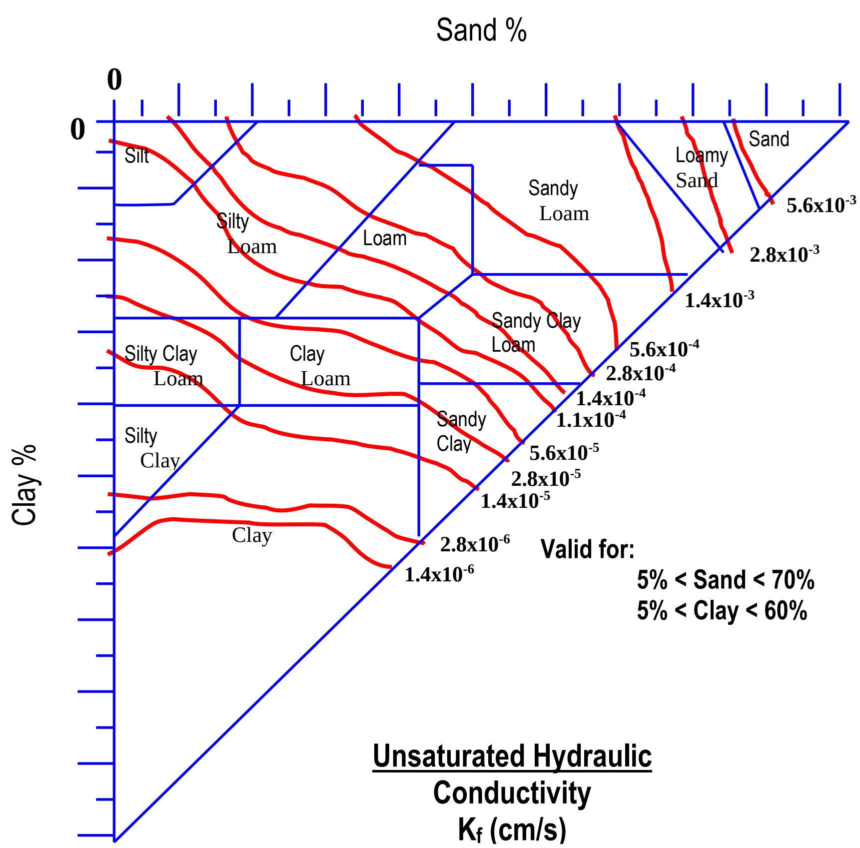


Figure H4

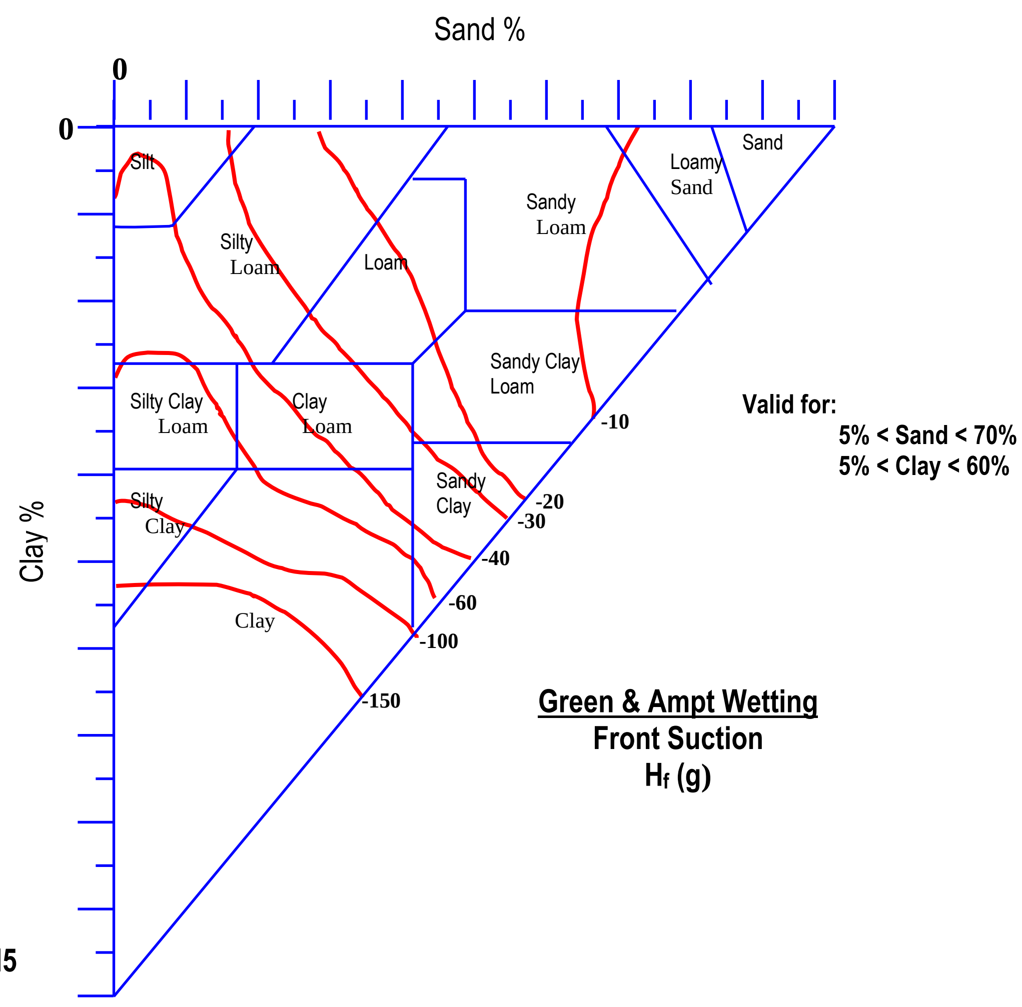

Sand %
0
0
Clay %
Silt
Silty
Loam
Loam
Sandy
Loam
Loamy
Sand
Sand
Sandy Clay
Loam
Silty Clay
Loam
Clay
Loam
Silty
Clay
Sandy
Clay
Clay
-10
-20
-30
-40
-60
-100
-150
Valid for:
5% < Sand < 70%
5% < Clay < 60%
Green & Ampt Wetting
Front Suction
Hf (g)

Figure H5

SOIL LEACHABILITY MODEL INPUT PARAMETERS

The following input parameters are needed to utilize the equations. Forms for site-specific input parameters and calculated results are provided which can be used to summarize the pertinent soil leachability input data, results and conclusions.

The following equations are valid for:

5% < Sand < 70%
5% < Clay < 60%

For sediments that are outside these ranges, the nearest maximum or minimum values should be used.

B_d **Bulk density** is defined as the weight of oven dry soil divided by the total volume of soils (solids +pores). Based on the grain size distribution, B_d can be estimated from Figure H3.

C_{rbsl} **Risk based Screening Level** (mg/L) for CoC in ground water. If appropriate, this can be substituted by the site-specific target level for the CoC in ground water.

C_s **Concentration of CoC** (mg/kg) in soil.

C_{sstl} **Site Specific Target Level** (mg/kg) for chemical of concern in soil.

f_{oc} The **natural organic content** (mg/kg) **of uncontaminated background soil**, typically determined by analysis of total organic carbon (TOC) by USEPA Method 415.1. Naturally occurring TOC values in uncontaminated "B" and "C" horizon soils usually range from 100 to 1,000 mg/kg.

H' The **Henry's Law Constant** (mg/L)/(mg/L) relates the partial pressure of a gas and its corresponding solubility in water at a given temperature. Some averaged values for typical petroleum constituents are provided in Table H1.

H_f The **wetting front suction head** (cm) is the pressure head at the wetting front as it advances downward. Critical pressure head is always negative. Based on the grain size distribution, H_f can be estimated from Figure H5.

H_w **Average annual recharge** (precipitation minus evapotranspiration and runoff). Assume 25 centimeters unless additional information is available.

K_f **Soil hydraulic conductivity** (cm/s). Based on the grain size distribution, the field saturated hydraulic conductivity in the vadose zone can be estimated from Figure H4.

K_{oc} The **soil/water partitioning coefficient** (mL/g) is compound specific and provides an indication of the tendency of CoC to partition between particles containing organic carbon and water. Some averaged values for typical petroleum constituents are provided in Table H2. Please note that the values in Table H1 are most applicable for soils containing an **f_{oc} value $\geq$ 1%**.

L The **separation distance** (cm) between the depth of the soil sample exhibiting the highest concentration of CoC and the measured water table. For example, if the soil sample with the highest concentration of CoC occurred at 10 feet below land surface (bls) and ground water was encountered at 20 feet bls, then L = 10 feet = 304.8 cm.

N **Porosity** (decimal %) is the percentage of the rock or soil that is void of material. Based on the grain size distribution, the porosity can be estimated from Figure H1.

W_r **Residual water content** (decimal %) is the weight of the water remaining in the soil divided by the total weight of the soil sample. Based on the grain size distribution, the residual water content can be estimated from Figure H2.

$t_{½}$ The **biodegradation half-life period** (days) of CoC. This is compound specific. Some conservative values for typical petroleum constituents in vadose zone under anaerobic conditions are provided in Table H1.

Table H1

Chemical Specific Soil Data

CoC	**K_{oc}** * (mL/g)	**H'** (mg/L)/(mg/L)*	**$t_{½}$** ** (days)
Benzene	81	0.226	16
Toluene	133	0.301	22
Ethylbenzene	176	0.280	10
Xylene	639	0.278	28
Naphthalenes	1543	0.002	48
Benzo(a)anthracene	1,380,384	0.0002	679
Benzo(b)fluoranthene	549,541	0.0005	610
Benzo(k)fluoranthene	4,365,158	0.043	2,139
Chrysene	245,471	3.02×0^{-18}	993
Dibenz(a,h)anthracene	1,659,587	3.05×10^{-7}	942

* From Montgomery. J.H. et.al., 1991, Groundwater Chemicals Desk Reference. Lewis Publishers.

** From Howard, P.H. et.al., 1991, Environmental Degradation Rates, Lewis Publishers.

Leachability model calculations consist of the following equation sets. Each set consists of several steps that should be used in calculating the different intermediate parameters.

Equation Set I

Determination of total organic carbon and air-filled porosity

Step 1:

Total organic carbon content (**f_{cs}**) (unitless) of the soil is calculated using the following equation:

$$\mathbf{f_{cs}} = \left(\mathbf{f_{oc}} + \frac{\mathbf{TPH}}{\mathbf{1.724}} \right) \left(\mathbf{1x10^{-6}} \right)$$

where,

f_{oc} is the natural organic carbon content (mg/kg) of uncontaminated soil (see data acquisition section).
TPH is the Total Petroleum Hydrocarbon (mg/kg).
1.724 is the conversion from organic matter to organic carbon fraction.
1×10^{-6} is the conversion from mg/Kg to decimal %.

Step 2:

The air filled porosity (**f**) (decimal %) can be approximated using the following equation:

$$\mathbf{f = \phi - W_r}$$

where,

ϕ is the porosity (decimal %) from Figure H1.
W_r is the residual water content (decimal %) from Figure H2.

Equation Set II

Determination of the velocity of the soil pore water (**V_w**)

Step 1:

The infiltration rate of water through soil under constant head conditions (Green & Ampt equation as discussed in Bouwer, 1978) is determined. The result provides the time (**t**) it should take water to percolate through the vadose zone soil (from the depth of the worst-case soil sample to the water table at the site).

$$\mathbf{t} = \left(\frac{\mathbf{f}}{\mathbf{K_f}} \right) * \left[\mathbf{L} - \left(\{ \mathbf{H_w} - \mathbf{H_f} \} * \left\{ \mathbf{ln} \frac{\mathbf{H_w} + \mathbf{L} - \mathbf{H_f}}{(\mathbf{H_w} - \mathbf{H_f})} \right\} \right) \right]$$

where,

f is the air-filled porosity of soil (decimal %) calculated in Step 2 of Equation Set I.
K_f is the field saturated hydraulic conductivity (cm/s) which can be estimated from Figure H4.
L is the distance (cm) from the depth of the worst-case soil sample to the water table.
H_w is the average annual recharge (cm), default value = 25 cm.
H_f is the Wetting front suction head (cm) which can be estimated from Figure H5.

Step 2:

Taking the above calculated value for time (t) in seconds the velocity of the water (V_w) in feet per year is calculated using the following equation:

$$V_w = \left(\frac{L}{30.48}\right) * \left(\frac{3.15 * 10^7}{t}\right)$$

where,

L is the distance (cm) from the depth of the worst-case soil sample to the water table.
t is the time (s) required for water to travel distance L, calculated in Step 2.

<u>Equation Set III</u>

<u>Determination of the organic retardation effect (V_c) on the contaminant</u>

Step 1:

The soil/water distribution coefficient (K_d) (ml/g) for uncontaminated soil is calculated using the following equation:

$$\mathbf{K_d = K_{oc} * f_{oc} * (1 \times 10^{-6})}$$

where,

$\mathbf{K_{oc}}$ is the soil organic/water partitioning coefficient (ml/g) from Table H1.
$\mathbf{f_{oc}}$ is the natural organic carbon content (mg/Kg) of uncontaminated soil (see data acquisition section).
$\mathbf{1 \times 10^{-6}}$ is the conversion from mg/Kg to decimal %.

Step 2:

The retardation effect of natural soil organic matter on CoC migration is calculated using the following equation:

$$\mathbf{V_c = \frac{V_w}{1 + \left(\frac{Bd * Kd}{\Phi}\right)}}$$

where,

$\mathbf{V_c}$ is the CoC percolation rate (ft/yr)
$\mathbf{V_w}$ is the water percolation rate (ft/yr) from Step 3 of Equation Set II.
$\mathbf{B_d}$ is the bulk density of soil (g/cc) from Figure H3.
$\mathbf{K_d}$ is the soil/water distribution coefficient (ml/g) calculated in Step 1.
ϕ is the porosity (decimal %) from Figure H1.

Equation Set IV

Determination of biodegradation rates and final CoC concentration (**C_p**) in the soil pore water necessary to protect ground water

Step 1:

The following equation is used to calculate the time (days) required for the CoC to reach ground water using

$$T_c = \frac{365 * L}{30.48 * V_c}$$

where,

L is the distance (cm) from the depth of the worst-case soil sample to the water table.
V_c is the CoC percolation rate (ft/yr) as calculated in Step 2 of Equation Set III.

Step 2:

CoC in the vadose zone are subject to several degradation and attenuation processes. This equation considers biodegradation in addition to the parameters of the previous equations. As attenuation processes such as dilution and volatilization are not accounted for in this equation, an estimate of the concentration (C_p) (mg/L) of CoC in the soil pore water necessary to protect ground water is calculated.

$$\log(Cp) = \log(C_{GWsstl}) + \left(\frac{Tc * 0.693}{2.303 * t_{1/2}}\right)$$

where,

C_{GWsstl} is the Site-Specific Target Level (mg/L) for CoC in ground water from groundwater fate and transport model or the Risk-based Screening Level as appropriate.
T_c is the time (days) for contaminant to percolate through the uncontaminated vadose zone soil and reach the ground water as calculated in Step 1 of Equation Set IV.
$t_{1/2}$ is the biodegradation half-life period of CoC (days) from Table H1.

Equation Set V

Determination of the Site-Specific Target Levels for impacted soil

DILUTION/ATTENUATION FACTOR (DAF)

The **Dilution/Attenuation Factor** is a unitless number that expresses the magnitude of dilution and attenuation which occurs after the leachate generated from the soil encounters ground water.

Utilizing a Monte Carlo modeling approach, a range of typical site parameters were evaluated by the UST Management Division to determine appropriate Dilution / Attenuation Factors (DAF). Parameters that were considered include: hydraulic conductivity, hydraulic gradient, ground water recharge rates, dimensions of the impacted soil, and aquifer thickness. The following DAFs should be utilized as default values:

For Sandy Soil (hydraulic conductivity > 10^{-4} cm/sec)	DAF = 8
For Clay Soil (hydraulic conductivity $\leq 10^{-4}$ cm/sec)	DAF = 2

SITE SPECIFIC TARGET LEVEL (SSTL)

Determine the site-specific target level of the CoC in soil. Equilibrium contaminant partitioning between sorbed and aqueous phases can be described by the following equation:

$$C_{sstl} = Cp * DAF * \frac{(Bd * Koc * fcs) + Wr + f * H'}{(Wr * 1g/cc + Bd)}$$

where,

C_{Ssstl} is the Site-Specific Target Level (mg/kg) for the CoC in soil.
C_p is the concentration of the CoC in soil pore water (mg/L) calculated in Step 2 of Equation Set IV.
DAF is the Dilution/Attenuation Factor (unitless).
K_{oc} is the Soil organic/water partitioning coefficient (mL/g) from Table G1.
f_{cs} is the Total organic carbon content in decimal percent of the contaminated soil as calculated in Step 1 of Equation Set I.
f is the air-filled porosity (decimal %) calculated in Step 2 of Equation Set I.
W_r is the residual water content (decimal %) from Figure G2.
1g/cc is the density of water.
B_d is the bulk density of the soil (g/cc) from Figure G3.

Leachability Input Parameters

South Carolina Department of Health and Environmental Control
Bureau of Land and Waste Management – UST Management Division

Site Data

Facility Name: ________________________________ UST Permit # __________

Input Parameters

Percent Sand in soil		________	%	**5% < sand < 70%**	
Percent Clay in soil		________	%	**5% < clay < 60%**	
DAF		________			
Worst	Benzene	________	mg/kg	$\mathbf{C_s}$	
Case	Toluene	________	mg/kg	$\mathbf{C_s}$	
Soil	Ethylbenzene	________	mg/kg	$\mathbf{C_s}$	
Analyses	Xylenes	________	mg/kg	$\mathbf{C_s}$	
	Naphthalene	________	mg/kg	$\mathbf{C_s}$	
	Other CoC	________	mg/kg	$\mathbf{C_s}$	
		________			
		________			
					Figure
Natural organic carbon content			mg/kg	$\mathbf{f_{oc}}$	
TPH			mg/kg	**TPH**	
Porosity			decimal %	ϕ	G1
Residual water content			decimal %	$\mathbf{W_r}$	G2
Bulk density of soil			g/cc	$\mathbf{B_d}$	G3
Soil hydraulic conductivity			cm/sec	$\mathbf{K_f}$	G4
Average annual recharge			cm	$\mathbf{H_w}$	
Wetting front suction (negative number)			cm	$\mathbf{H_f}$	G5
Distance from highest soil contamination to water table			cm	**L**	
Groundwater SSTL (or RBSL if appropriate)			mg/L	$\mathbf{C_{GWsstl}}$	

List possible human exposure pathways from soil:

1 of ___ pages

Leachability Results and Conclusions

South Carolina Department of Health and Environmental Control
Bureau of Land and Waste Management – UST Management Division

Site Data

Facility Name: ________________________________ UST Permit # ___________

Chemical of Concern (Benzene, Naphthalene, etc.) : ________________________________

(Please use a separate form for each Chemical of Concern that exceeds the RBSL in soil.)

Chemical Specific Data

Biodegradation half-life period	days	$t_{1/2}$	Refer to
Soil/water partitioning coefficient	mg/L	K_{oc}	Table
Henry's law constant		H'	G1

Results

			Equation Set	Step
Total organic carbon content	decimal %	f_{cs}	I	1
Air filled porosity	decimal %	f	I	2
Infiltration time	seconds	t	II	1
Velocity of water	ft/yr	V_w	II	2
Soil/water distribution coefficient	mL/g	K_d	III	1
CoC percolation rate	ft/yr	V_c	III	2
Time to reach groundwater	days	T_c	IV	1
Concentration to protect groundwater	mg/L	C_p	IV	2
Site specific target level	mg/kg	C_{Ssstl}	V	

Conclusions

Does concentration of CoC in soil exceed SSTL? Yes __________ No _____________

Risk of human exposure due to contaminated soil Yes __________ No _____________

____ of ___ pages

Domenico's Model

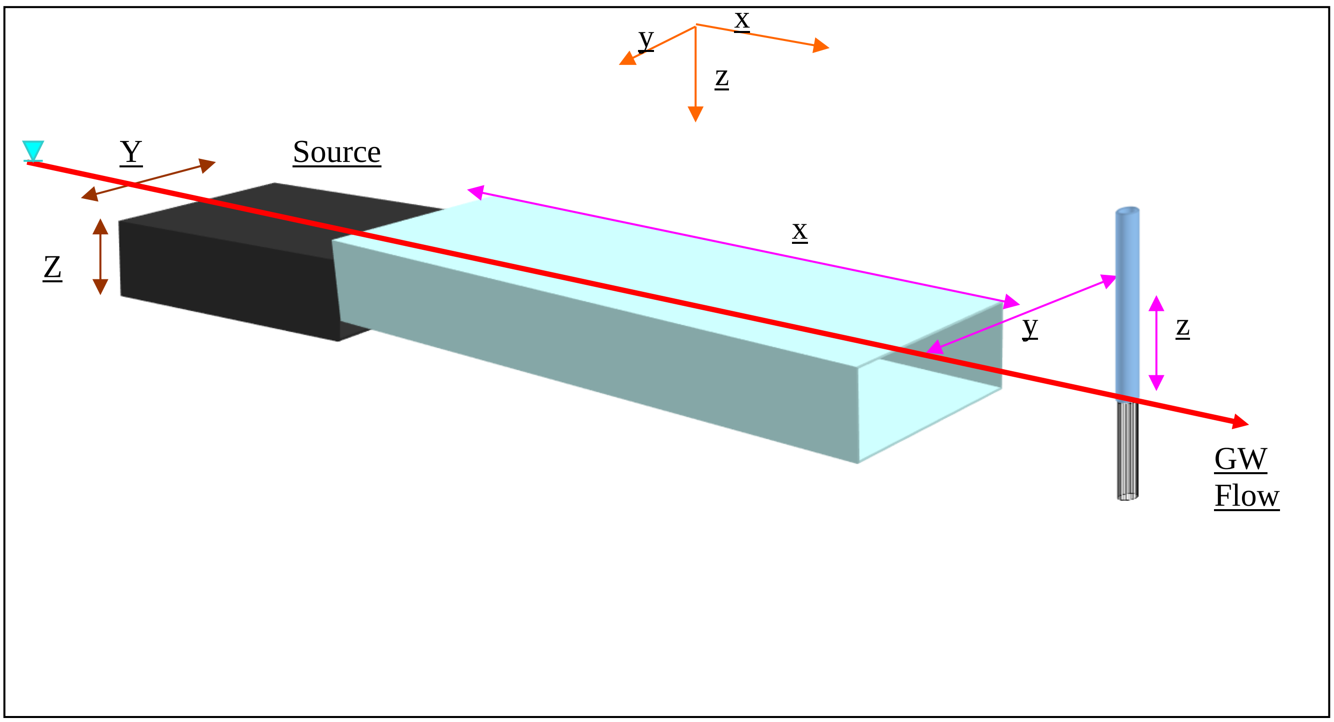
Contaminant transport in the saturated or the unsaturated zone can be estimated using the **Domenico Model**. This analytical model utilizes three-dimensional dispersion, seepage velocity, and biological degradation principles to predict the spatial and temporal decrease in concentration of CoC away from the source.

The Domenico Model (1987) is based on the following assumptions:

1. One dimensional flow and three-dimensional (in two transverse directions and one vertical - downwards direction) dispersion;
2. The medium is isotropic and homogeneous;
3. The source concentration is constant;
4. The areal source is perpendicular to the direction of flow; and
5. Decay of the contaminant in the dissolved and adsorbed phases occurs at the same rate resulting in a first order decay rate.

Figure D1
EQUATION 1

This is the general form of the Domenico's Equation. In this equation, the effects of three-dimensional dispersion,



one-dimensional uniform flow in the x-direction are considered. The source is considered to be a constant concentration (infinite-mass) areal source of dimension Y and Z (as shown in the Figure D1).

$$\mathbf{C}(x,y,z,t) = \left(\frac{\mathbf{C_0}}{\mathbf{8}}\right) * \exp\left[\left(\frac{x}{2\alpha_x}\right)\left(1-\sqrt{1+\frac{4\lambda\alpha_x}{v}}\right)\right] * \mathit{erfc}\left[\frac{x - vt\sqrt{1+\frac{4\lambda\alpha_x}{v}}}{2\sqrt{\alpha_x vt}}\right] *$$

$$\left\{\mathit{erf}\left[\frac{y+\frac{Y}{2}}{2\sqrt{\alpha_y x}}\right] - \mathit{erf}\left[\frac{y-\frac{Y}{2}}{2\sqrt{\alpha_y x}}\right]\right\} * \left\{\mathit{erf}\left[\frac{z+Z}{2\sqrt{\alpha_z x}}\right] - \mathit{erf}\left[\frac{z-Z}{2\sqrt{\alpha_z x}}\right]\right\}$$

where

C_o is the Concentration of CoC at source (mg/L)
Y is the width of source perpendicular to GW flow (m)
Z is the vertical thickness of source (m)
x is the distance from source to receptor (x-coordinate) (m)
y is the y coordinate of the receptor relative to source (m)
z is the z coordinate of the receptor relative to source (m)
α_x is the longitudinal dispersivity (m) (x/10)
α_y is the transverse dispersivity (m) (α_x/3)
α_z is the vertical dispersivity (m) (α_x/20)
v is the contaminant velocity (m/s)*
erf is the error function**
erfc is the complimentary error function**
λ is the first order decay rate (1/sec)***
t is the time during which contaminant transport takes place (sec)

* If the CoC adsorbs, the contaminant velocity (v) is replaced by the retarded velocity (v/R), where R is the

$$\mathbf{R} = \mathbf{1} + \frac{\mathbf{K_{oc} * F_{oc} * B_d * 10^{-6}}}{\Phi}$$

retardation factor in the saturated zone. The Retardation factor can be calculated with the following equation:

where,

K_{oc} is the chemical specific soil/water partitioning coefficient (ml/g) derived from literature.
f_{oc} is the naturally occurring organic carbon (mg/Kg) in soil measured in the saturated zone.
B_d is the Bulk Density (gm/cc).
ϕ is the porosity (decimal %).

** The Error Function and Complimentary Error Function are dimensionless numbers that can be derived from an erf and erfc table. These tables can be found in many hydrogeology textbooks (e.g., Fetter, 1988).

Please note that: erfc(x) = 1- erf (x); erf(-x) = -erf(x); and erfc(-x) = 1 + erf(x).

*** If the first order decay rates have not been determined on a site-specific basis, the decay rate (λ) shall be assumed to be 0. Site-specific values can be evaluated on the basis of temporal and spatial variation of the CoCs.

EQUATION 2

If the receptor is not located along the x-axis centerline, y and z$\neq$0 and λ= 0.

$$\mathbf{C}(x,y,z,t)=\left(\frac{\mathbf{C_0}}{\mathbf{8}}\right)*erfc\left[\frac{(\mathrm{x}-\mathrm{vt})}{2\sqrt{\alpha_x \mathbf{vt}}}\right]*\left\{erf\left[\frac{\mathbf{y}+\frac{\mathbf{Y}}{\mathbf{2}}}{2\sqrt{\alpha_y \mathbf{x}}}\right]-erf\left[\frac{\mathbf{y}-\frac{\mathbf{Y}}{\mathbf{2}}}{2\sqrt{\alpha_y \mathbf{x}}}\right]\right\}*\left\{erf\left[\frac{\mathbf{z}+\mathbf{Z}}{2\sqrt{\alpha_z \mathbf{x}}}\right]-erf\left[\frac{\mathbf{z}-\mathbf{Z}}{2\sqrt{\alpha_z \mathbf{x}}}\right]\right\}$$

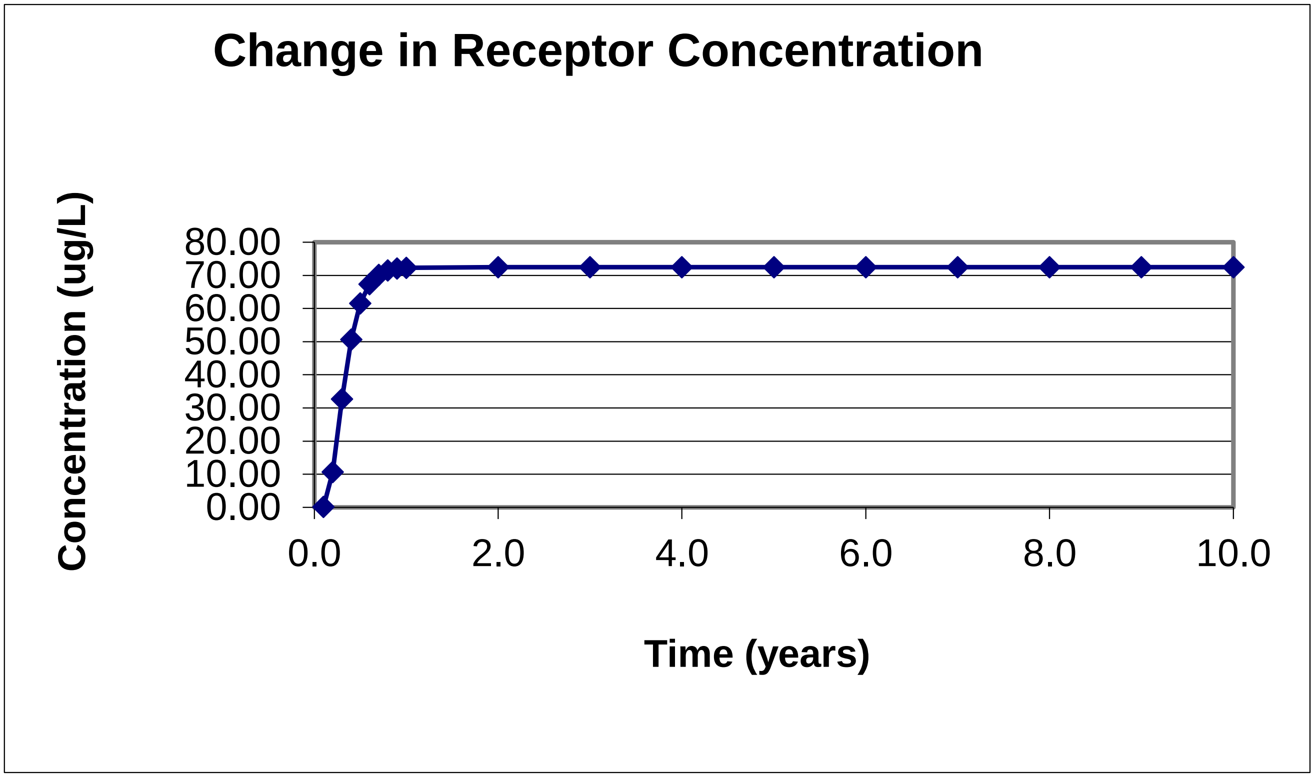
EQUATION 3

Equation 3 should be used if the receptor is located along the centerline (x- axis) and hydraulically down-gradient of the source. In that case, y = z = 0 and λ = 0.

$$\mathbf{C}(x,0,0,t)=\left(\frac{\mathbf{C_0}}{\mathbf{2}}\right)*erfc\left[\frac{(\mathrm{x}-\mathrm{vt})}{2\sqrt{\alpha_x \mathbf{vt}}}\right]*erf\left[\frac{\mathbf{Y}}{4\sqrt{\alpha_y \mathbf{x}}}\right]*erf\left[\frac{\mathbf{Z}}{2\sqrt{\alpha_z \mathbf{x}}}\right]$$

Variation of a CoC with time is according to an exponential relationship. Figure D2 shows the change in the CoC concentrations for a source of C_0=2 mg/L and with dimensions Y=10m, Z=3m, x=100m, and Vs=1E^{-5}m/s; λ =0 /s. The concentrations for the time t=0 to 10 years were calculated and are tabulated as shown. Based on the graph, we see that the CoC concentrations increase as the time increases, becoming asymptotic at a value of 72.48 μg/L. From this graph, it can be seen that the maximum concentration of 72.48 μg/L can be reached at the receptor for the given continuous source and hydrological conditions after five years.
Data calculated to be used in this example are given in the table below.

Figure D2



Time (Year)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
CoC Conc.(μ/L)	0.16	10.7	32.6	50.6	61.6	67.4	70.2	71.5	72.1	72.3	72.4	72.4	72.5	72.5	72.5	72.5	72.5	72.5	72.5

SSTL CALCULATIONS

Using the Domenico's model, one can calculate the SSTLs for a given source and receptor configuration for each CoC. Knowing the RBSL for a given receptor, the inverse of the Domenico's equation can be used to calculate the SSTL.

The following equation can be used.

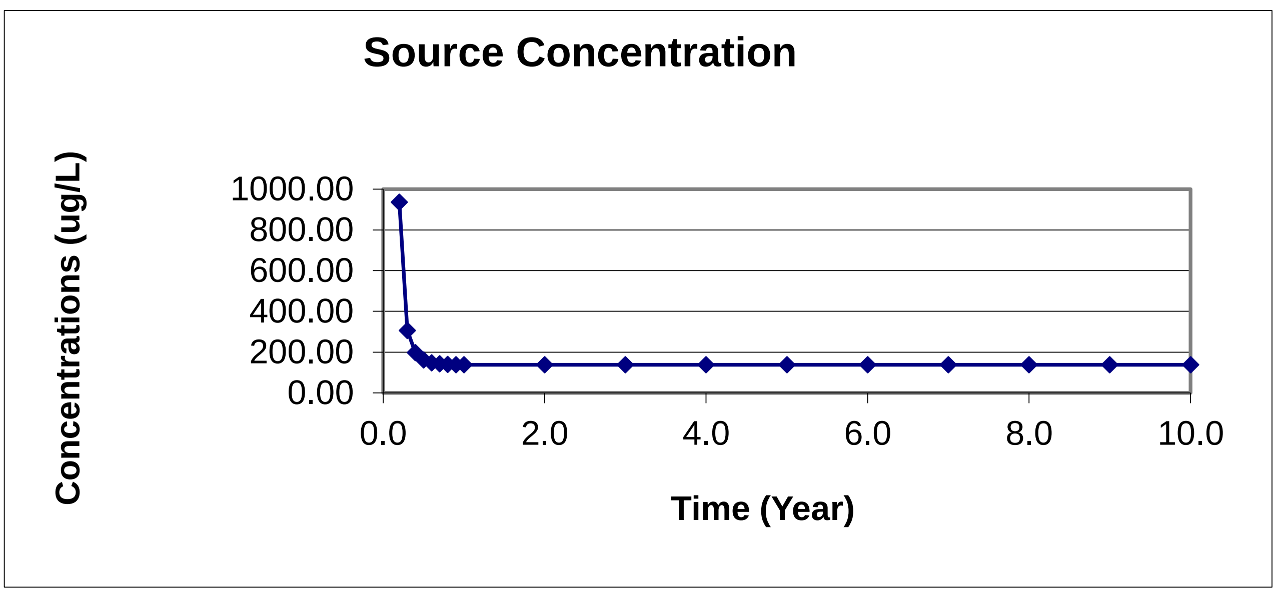
$$\mathrm{Csstl} = \frac{8 * \mathrm{Crbsl}}{\exp\left[\left(\frac{x}{2\alpha_x}\right)\left(1-\sqrt{1+\frac{4\lambda\lambda_x}{v}}\right)\right] * \mathrm{erfc}\left[\frac{x - vt\sqrt{1+\frac{\lambda\alpha_x}{v}}}{2\sqrt{\alpha_x vt}}\right] * \left\{\mathrm{erf}\left[\frac{y+\frac{Y}{2}}{2\sqrt{\alpha_y x}}\right] - \mathrm{erf}\left[\frac{y-\frac{Y}{2}}{2\sqrt{\alpha_y x}}\right]\right\} * \left\{\mathrm{erf}\left[\frac{z+Z}{2\sqrt{\alpha_z x}}\right] - \mathrm{erf}\left[\frac{z-Z}{2\sqrt{\alpha_z x}}\right]\right\}}$$

where

C_{rbsl} is the RBSL concentration for the selected CoC.

Figure D3 shows the change in the CoC concentrations for a source of Y= 10m; Z=3m , x=100m, Vs=1E-5m/s and λ=0 /s. The source concentrations are calculated for a t=0 to 10 years and are plotted as shown. Based on the graph, we can see that the CoC concentrations decrease as the time increases, becoming asymptotic at a value of 137.98 μg/L. From this graph, it can be seen that the minimum SSTL can be established to be at a concentration of 137.98 μg/L after 0.9 year. The data are given in the table below.

Figure D3



Time (year)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
CoC Conc.(μ/L)		936	306	197	162	148	142	139	138	138	138	138	138	138	138	138	138	138	138

Appendix I: Standard Field Cleaning Procedures

STANDARD FIELD CLEANING PROCEDURES

Introduction

Cleaning procedures in this appendix are intended for use by field personnel for cleaning sampling and other equipment in the field. Emergency field sample container cleaning procedures are also included; however, they should not be used unless absolutely necessary. Deviations from these procedures should be documented in the approved study plan, field records, and investigative reports.

These are the materials, methods, and procedures to be used when cleaning sampling and other equipment in the field.

Caution – Exercise care when working with flammable solvents! Avoid any activity that would produce sparks or excess heat. Avoid hazardous atmospheres.

A. Specifications for Cleaning Materials

Specifications for standard cleaning materials referred to in this appendix are as follows:

1. Soap shall be a standard brand of phosphate-free laboratory detergent such as Liquinox. Use of other detergent must be justified and documented in the field logbooks and inspection or investigative reports. The use of Luminox detergent may remove the need to rinse with pesticide-grade isopropanol.
2. Solvent shall be pesticide-grade isopropanol. Use of a solvent other than pesticide-grade isopropanol for equipment cleaning purposes must be justified in the study plan.
3. Tap water may be used from any municipal water treatment system.
4. Analyte free water (deionized water) is tap water that has been treated by passing through a standard deionizing resin column and followed by an activated carbon column.
5. Other solvents may be substituted for a particular purpose if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. After the waste material is removed, the equipment must be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment must be completely dry prior to use.

Solvents, laboratory detergent, and rinse waters used to clean equipment shall not be reused during field decontamination.

B. Handling 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:

1. Soap must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.
2. Solvent must be stored in the unopened original containers until used. They may be applied using a Teflon® squeeze bottles.
3. Tap water may be kept in clean tanks, squeeze bottles, or applied directly from a hose.
4. Analyte free water (deionized water) must be stored in clean glass, stainless steel, or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

C. Disposal of Solvent Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW), including used wash water, rinse water, and spent solvents must be specified in the QAPP Contractor Addendum or the Site Rehabilitation Contractors ACQAP.

D. **Equipment Contaminated with Concentrated Wastes**
Equipment used to collect samples of hazardous materials or toxic wastes or materials from hazardous waste sites, RCRA facilities, or in-process waste streams should be field cleaned before returning from the study. At a minimum, this should consist of washing with soap and rinsing with tap water. More stringent procedures may be required at the discretion of the field investigators.

E. **Safety Procedures for Field Cleaning Operations**
Some of the materials used to implement the cleaning procedures outlined in this appendix can be harmful if used improperly. Caution should be exercised by all field investigators and all applicable safety procedures should be followed. At a minimum, the following precautions should be taken in the field during these cleaning operations:

1. Safety glasses with splash shields or goggles, and nitrile gloves should be worn during all cleaning operations.
2. Solvent rinsing operations will be conducted in the open (never in a closed room).
3. No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

F. **Handling of Cleaned Equipment**
After field cleaning, 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 cleaning area to prevent recontamination. 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.

G. **Field Equipment Cleaning Procedures**
Sufficient clean equipment should be transported to the field so that an entire study can be conducted without the need for field cleaning. However, this is not possible for some items such as portable power augers (Little Beaver®), well drilling rigs, soil coring rigs, and other large pieces of field equipment. In addition, particularly during large scale studies, it is not practical or possible to transport all the pre-cleaned field equipment required into the field. In these instances, sufficient pre-cleaned equipment should be transported to the field to perform at least one day’s work. The following procedures are to be utilized when equipment must be cleaned in the field.

1. <u>Specifications for Decontamination Pads</u>
   Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

   a. The pad should be constructed in an area known or believed to be free of surface contamination.
   b. The pad should not leak.
   c. 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.

d. Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
e. Water should be removed from the decontamination pad frequently.
f. 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. No solvent rinsates will be placed in the pit. Solvent rinsates should be collected in separate containers for proper disposal. If the decontamination pad has leaked excessively, soil sampling may be required.

2. "Classic Parameter" Sampling Equipment

"Classic Parameters" are analyses such as oxygen demand, nutrients, certain inorganics, sulfide, flow measurements, etc. For routine operations involving classic parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample or analyte-free water between sampling locations. A brush may be used to remove deposits of material or sediment, if necessary. If analyte-free water is used samplers should be flushed at the next sampling location with the substance (water) to be sampled, but before the sample is collected.

Flow measuring equipment such as weirs, staff gauges, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

NOTE: The previously described procedures 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. Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

The following procedures are to be used for all sampling equipment used to collect routine samples undergoing trace organic or inorganic constituent analyses:

a. Clean with tap water and soap using a brush if necessary to remove particulate matter and surface films. Equipment may be steam cleaned (soap and high-pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or sawhorses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.
b. Rinse thoroughly with tap water.
c. Rinse thoroughly with analyte free water.
d. Rinse thoroughly with solvent. Do not solvent rinse PVC or plastic items.
e. Remove the equipment from the decontamination area and cover with plastic. Equipment stored overnight should be wrapped in aluminum foil and covered with clean, unused plastic., or hermetically seal in an appropriately sized polyethylene bag.

4. Well Sounders or Tapes

a. Wash with soap and tap water.
b. Rinse with tap water.
c. Rinse with analyte free water. (Do not solvent rinse PVC or plastic items)

5. Submersible Pump Cleaning Procedure
CAUTION - During cleaning always disconnect the pump from the generator or power source
The submersible pump should be cleaned prior to use and between each monitoring well. The following procedure is required:

   a. Pump a sufficient amount of soapy water through the hose to flush out any residual purge water;
   b. Using a brush, scrub the exterior of the electrical cord, contaminated hose and pump with soapy water. Rinse the soap from the outside of the hose with tap water. Rinse the hose with analyte-free water and recoil onto the spool; (Do not wet the electrical plug)
   c. Pump a sufficient amount of tap water through the hose to flush out all the soapy water (approximately one gallon);
   d. Pump a sufficient amount of analyte-free water through the hose to flush out the tap water, then purge with the pump in the reverse mode;
   e. Rinse the outside of the pump housing and hose with analyte-free water (approximately 1/4 gal.); and
   f. Place pump and reel in clean plastic bag.

For Grundfos pumps or similar, to clean the pump ball check valve:

   a. Completely dismantle ball check valve. Check for wear and/or corrosion, and replace as needed;
   b. Using a brush, scrub all components with soap and tap water;
   c. Rinse with analyte free water; and
   d. Reassemble and re-attach the ball check valve to the pump head.

6. Peristaltic Pump Cleaning Procedure:
CAUTION - During cleaning always disconnect the pump from the generator or power source.
The peristaltic pump should be cleaned prior to use and as necessary between each use.
The following procedure is required:

   a. Using a brush, scrub the exterior of the contaminated hose and pump with soap and tap water;
   b. Rinse the soap from the outside of the pump and hose with tap water;
   c. Rinse the tap water residue from the outside of pump and hose with analyte-free water; and
   d. Allow the pump to dry prior to use.

7. Automatic Sampler Tubing
The Silastic and Tygon tubing previously used in the automatic samplers may not be reused. All tubing must be replaced with new tubing.

H. **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.

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 G.1 of this Appendix.

Tap water (potable) brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank of sufficient size so that drilling activities can proceed without having to stop and obtain additional water. 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 (200°F plus), with a soap compartment, should be obtained.

2. Preliminary Cleaning and Inspection
The drill rig should be clean of any contaminants that may have been transported from another hazardous waste site, to minimize the potential for cross-contamination. Further, the drill rig itself should not serve as a source of contaminants. In addition, associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

   a. 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 (soap 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.
   b. 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 (soap and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other hazardous waste sites before being brought on site.
   c. Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sandpaper can be used to remove the printing and/or writing. Most well material suppliers can supply materials without the printing and/or writing if specified when ordered.
   d. The drill rig and other equipment associated with the drilling and sampling activities should be inspected to ensure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.
   e. PVC or plastic materials such as tremie tubes should be inspected. Items that cannot be cleaned are not acceptable and should be discarded.

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 or cleaned with soap and high pressure water between boreholes.

4. Field Cleaning 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 cleaned as outlined in Section G.3 of this Appendix.

   a. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning or cleaning with high pressure water with soap 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 sawhorses above the ground. 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.

b. Rinse thoroughly with tap water; and
c. 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.

When there is concern for low-level contaminants it may be necessary to clean this equipment between borehole drilling and/or monitoring well installation using the procedure outlined in the Section G.3 of this Appendix.

I. **Emergency Disposable Sample Container Cleaning**

New one-pint or one-quart glass mason jars may be used to collect samples for analyses of organic compounds and metals in waste and soil samples during an emergency. In the case of chemicals that adhere to glass, PPE or HDPE mason jars may be used to collect samples. These containers would also be acceptable on an emergency basis for the collection of water samples for extractable organic compounds, pesticides, and metals analyses. These jars cannot be used for the collection of water samples for volatile organic compound analyses.

The rubber sealing ring should not be in contact with the jar and aluminum foil should be used, if possible, between the jar and the sealing ring. If possible, the jar and aluminum foil should be rinsed with pesticide-grade isopropanol and allowed to air dry before use. Several empty bottles and lids should be submitted to the laboratory as blanks for quality control purposes.

Appendix J: UST Management Division Retention Schedule

DEPARTMENT OF HEALTH
AND ENVIRONMENTAL CONTROL

Record Group Number: 169

ENVIRONMENTAL QUALITY CONTROL

BUREAU OF LAND AND WASTE MANAGEMENT

UNDERGROUND STORAGE TANK

13300 REHABILITATION INFORMATION

<u>Description</u>

Used to document the clean up process for releases that have occurred at sites with regulated underground storage tanks. Information includes assessment, monitoring reports, corrective action plans, reports, no further action letters or case closure letters, and correspondence.

<u>Retention</u>

All official records: 9 years after no further action letter or a case closure letter is issued, destroy.

(REVISED)

Approval Date: 27 March 2008

Appendix K: Contractor Verification Checklist

Contractor Checklist

For each report submitted to the UST Management Division, the contractor will be required to verify that all data elements for the required scope of work have been provided. For items not required for the scope of work, the N/A box should be checked. For items required and not completed or provided, the "No" box should be checked and a thorough description of the reason must be provided.

Item #	Item	Yes	No	N/A
1	Is Facility Name, Permit #, and address provided?			
2	Is UST Owner/Operator name, address, & phone number provided?			
3	Is name, address, & phone number of current property owner provided?			
4	Is the SCDHEC Certified UST Site Rehabilitation Contractor's Name, Address, telephone number, and certification number provided?			
5	Is the name, address, telephone number, and certification number of the well driller that installed borings/monitoring wells provided?			
6	Is the name, address, telephone number, and certification number of the certified laboratory(ies) performing analytical analyses provided?			
7	Has the facility history been summarized?			
8	Has the regional geology and hydrogeology been described?			
9	Are the receptor survey results provided as required?			
10	Has current use of the site and adjacent land been described?			
11	Has the site-specific geology and hydrogeology been described?			
12	Has the primary soil type been described?			
13	Have field screening results been described?			
14	Has a description of the soil sample collection and preservation been detailed?			
15	Has the field screening methodology and procedure been detailed?			
16	Has the monitoring well installation and development dates been provided?			
17	Has the method of well development been detailed?			
18	Has justification been provided for the locations of the monitoring wells?			
19	Have the monitoring wells been labeled in accordance with the UST QAPP guidelines?			
20	Has the groundwater sampling methodology been detailed?			
21	Have the groundwater sampling dates and groundwater measurements been provided?			
22	Has the purging methodology been detailed?			
23	Has the volume of water purged from each well been provided along with measurements to verify that purging is complete?			
24	If free-product is present, has the thickness been provided?			
25	Does the report include a brief discussion of the assessment done and the results?			
26	Does the report include a brief discussion of the aquifer evaluation and results?			
27	Does the report include a brief discussion of the fate & transport models used?			

Item #	Item	Yes	No	N/A
28	Are the site-conceptual model tables included? (Tier 1 Risk Evaluation)			
29	Have the exposure pathways been analyzed? (Tier 2 Risk Evaluation)			
30	Have the SSTLs for each compound and pathway been calculated? (Tier 2 Risk Evaluation)			
31	Have recommendations for further action been provided and explained?			
32	Has the soil analytical data for the site been provided in tabular format? (Table 1)			
33	Has the potentiometric data for the site been provided in tabular format? (Table 2)			
34	Has the current and historical laboratory data been provided in tabular format?			
35	Have the aquifer characteristics been provided and summarized on the appropriate form?			
36	Have the Site conceptual model tables been included? (Tier 1 Risk Evaluation)			
37	Has the topographic map been provided with all required elements? (Figure 1)			
38	Has the site base map been provided with all required elements? (Figure 2)			
39	Have the CoC site maps been provided? (Figure 3 & Figure 4)			
40	Has the site potentiometric map been provided? (Figure 5)			
41	Have the geologic cross-sections been provided? (Figure 6)			
42	Have maps showing the predicted migration of the CoCs through time been provided? (Tier 2 Risk Evaluation)			
43	Has the site survey been provided and include all necessary elements? (Appendix A)			
44	Have the sampling logs, chain of custody forms, and the analytical data package been included with all required elements? (Appendix B)			
45	Is the laboratory performing the analyses properly certified?			
46	Has the tax map been included with all necessary elements? (Appendix C)			
47	Have the soil boring/field screening logs been provided? (Appendix D)			
48	Have the well completion logs, DHEC Form 2099, and DHEC Form 1903 been provided? (Appendix E)			
49	Have the aquifer evaluation forms, data, graphs, equations, etc. been provided? (Appendix F)			
50	Have the disposal manifests been provided? (Appendix G)			
51	Has a copy of the local zoning regulations been provided? (Appendix H)			
52	Has all fate and transport modeling been provided? (Appendix I)			
53	Have copies of all access agreements obtained by the contractor been provided? (Appendix J)			
54	Has a copy of this form been attached to the final report and are explanations for any missing or incomplete data been provided?			

Explanation for missing and incomplete information?

Project Verifier (signature)

(print name)

Date

Appendix L: SCDHEC EQC and OCRM Quality Management Plan

From the SCDHEC Quality Management Plan

9.0 COMPUTER HARDWARE AND SOFTWARE

The SCDHEC is committed to following Federal/State mandates regarding protection of data, and software/hardware requirements.

The SCDHEC Chief Information Officer (CIO) manages the process of identifying Management Information Technology (IT) needs and developing a cost-effective Management Information System to satisfy those needs. A core group of technical representatives known as the IRCJV – Information Resource Consultant Joint Venture Committee, assists the CIO in this effort. Members are from each Deputy area within the SCDHEC. The CIO and the IRCJV Committee are responsible for providing standard operating procedures and for identifying and prioritizing IT needs. Together they also evaluate proposed changes that may have the potential for cross-program impact.

The CIO and the Core Group or the appropriate Deputy Managers will identify and prioritize the SCDHEC's needs. The SCDHEC Bureau of Business Management is involved in all aspects of procurement dealing with any and all IT projects. Depending on the cost of the project, the State's CIO office within the Budget and Control Board may be involved in the process as well. This process is completed via a work plan that specifies the requirements, responsibilities, and the schedule(s) of deliverables.

All hardware and software solutions are evaluated prior to purchase using industry best practices, experience from other states and demonstrated performance. DHEC adheres to all mandatory State procurement guidance to ensure the best price via appropriate market competition for the selected product or service.

A Data Quality Team has been established to ensure the effectiveness and quality assurance of the information produced from or collected by our Environmental Facilities Information System (EFIS) is uniform. The group's long-term goal is to maximize the use of the SCDHEC Enterprise Wide Information Management System. EQC also works closely with USEPA to ensure complete and accurate data is submitted through the Exchange Network Node System. The workgroup is currently improving cross program access to data, improving data extraction results and implementing improved public access to information.

In each Bureau, IT (Information Technology) Staff are assigned to be responsible for maintaining the integrity of the computer databases and information systems within that Bureau. They ensure that the records are backed up routinely and that transfers from one area to another of electronic records are done accurately. This Section also ensures that virus protection is kept up to date on each computer in the Bureau.

Prior to data being input to computer databases, it is checked by the analyst and their supervisor. This review includes a check on the calculations and raw data. A percentage of data is checked by a third data verifier. Once the data is transferred to the Program Areas (the Bureau of Water-for example), that Program area is responsible for the data integrity.

The EQC Monitoring Workgroup is currently leading the effort to enable DHEC to receive electronic data deliverables (EDDs) from external laboratories as well as developing a method of producing EDDs from the EQC Laboratories LIMs (Laboratory Information Management System). Our goal is to be able to generate a SEDD Level 2A deliverable within two years. We will begin this effort by implementation on a small project.

The Data Quality Team and the USEPA will be consulted during this process. The goal of this (ADR) is to further certify that the data quality is sufficient to make sound environmental decisions.

Appendix M: Project Status Update Form

UST Permit #

(Facility Name)

Date	Current Status	Deficiency	Corrective Action Taken	Date Deficiency resolved

Comments:____

Appendix N: Glossary of Terms

- **Abatement** - Actions taken to mitigate fire and safety hazards and to prevent further migration of hydrocarbons in their vapor, dissolved, or liquid phase.

- **Accuracy** - A measure of the closeness of an individual measurement or the average of a number of measurements to the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; the USEPA recommends using the terms "precision" and "bias", rather than "accuracy," to convey the information usually associated with accuracy. Refer to Appendix F, Data Quality Indicators for a more detailed definition.

- **Active Remediation** - Physical actions taken to reduce the concentration of CoCs to acceptable levels.

- **Assessment** - The evaluation process used to measure the performance or effectiveness of a system and its elements. As used here, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation (PE), management systems review (MSR), peer review, inspection, or surveillance

- **Attenuation** - The reduction in concentration of CoCs in the environment with distance and time due to processes that include, but are not limited to, biodegradation, diffusion, dispersion, and absorption.

- **Audit (quality)** - A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

- **Bias** – The systematic or persistent distortion of a measurement process, which causes errors in one direction (e.g., the sample measurement is different from the sample's true value-in one direction- high or low).

- **Blank** – A sample subjected to the usual analytical or measurement process to establish a zero baseline or background value.

- **Calibration** – A comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments.

- **Certification** – The process of testing and evaluation against specifications designed to document, verify, and recognize the competence of a person, organization, or other entity to perform a function or service, usually for a specified time.

- **Chain of Custody (COC)** – An unbroken trail of accountability that ensures the physical security of the samples, data, and records.

- **Chemical of Concern (CoC)** - A specific constituent that is identified for evaluation in the RBCA process.

- **Compliance Point (CP)** – see Point(s) of Compliance below.

- **Compliance Point Concentration (CPC)** - The maximum concentration allowable at the point of compliance in order to protect an exposure point.

- **Corrective Action** - any measures taken to rectify conditions adverse to quality, and where possible, to preclude their recurrence (e.g., in remaking standards in the case of a bad calibration).

- **Corrective Action Plan (CAP)** - A document outlining proposed Site Rehabilitation actions.

- **Data Quality Assessment (DQA)** - The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. The five steps of the DQA Process include: 1) reviewing the DQOs and sampling design, 2) conducting a preliminary data review, 3) selecting the statistical test, 4) verifying the assumptions of the statistical test, and 5) drawing conclusions from the data.

- **Data Quality Indicators (DQIs)** - The quantitative statistics and qualitative descriptors that are used to interpret the degree of acceptability or utility of data to the user. The principal data quality indicators are bias, precision, accuracy (bias and precision are), comparability, completeness, and representativeness.

- **Data Quality Objectives (DQOs)** - The qualitative and quantitative statements derived from the DQO Process that clarify a study's technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

- **Data Quality Objectives Process** - A systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use. DQOs are the qualitative and quantitative outputs from the DQO Process.

- **Data usability** – The process of ensuring or determining whether the quality of the data produced meets the intended use of the data.

- **Detection Limit (DL)** - The lowest concentration or amount of the target analyte that can be determined to be different from zero by a single measurement at a stated level of probability. DLs are analyte- and matrix-specific and may be laboratory-dependent.

- **Direct Exposure Pathway** - An exposure pathway where the point of exposure is at the source without a release to any other medium (e.g., inhalation of vapors or dermal contact with free product).

- **Direct supervision** - means supervision provided by a licensee who must:

    1. Be on-site or immediately available to supervise persons by means of telephone, radio or other electronic means; and
    2. Maintain continued involvement in appropriate aspects of each professional activity of the supervisee.

- **Engineering Controls** – Permanent or temporary manmade modifications to a site to reduce or eliminate the potential for exposure to a CoC, such as capping or installing a water treatment system on a well.

- **Engineering Report (ER)** - A document outlining the design and specifications of a Site Rehabilitation system.

- **Exposure** - Contact of a receptor(s) with CoC(s). Exposure is quantified as the amount of CoC available at the exchange boundaries, such as skin or lungs, and available for absorption by the human body.

- **Exposure Assessment** - The determination or estimation, qualitative or quantitative, of the magnitude, frequency, duration, and route of exposure.

- **Exposure Pathway** - The course CoCs travel from the source area(s) to a receptor. A complete exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., groundwater) is included.

- **Exposure Point** - The point at which it is assumed that a receptor, either potential or actual, can come into contact either now or in the future with the CoCs. Maximum contaminant levels or other existing water quality standards must be met at the exposure point.

- **Exposure Route** - The manner in which CoCs come in contact with an organism (e.g., ingestion, inhalation or dermal contact).

- **Field blank** — a blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport. A clean sample, carried to the sampling site, exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample.

- **Flag** — a notation to indicate that the data point associated must be qualified—that a deficiency or deviation exists that is associated with that sample. Flags often appear to resemble footnotes. The notation as to what the flag means is given further on in the document.

- **Gas Chromatograph (GC)** - An instrument used to determine the levels of CoCs in a vapor, soil or ground water sample.

- **Holding time** — the period of time a sample may be stored prior to its required analysis. While exceeding the holding time does not necessarily negate the veracity of analytical results, it causes the qualifying or "flagging" of any data not meeting all of the specified acceptance criteria. With regard to holding time, a day is defined as a period of 24 hours commencing at the time of sample collection and ending at the same time on the following calendar day.

- **Initial Ground Water Assessment (IGWA)** – An assessment to determine the presence of soil and ground water CoCs by the installation of one monitoring well.

- **Indicator (Field) Parameters** – include pH, specific conductance, temperature, turbidity and dissolved oxygen.

- **Indirect Exposure Pathways** - An exposure pathway with at least one intermediate release to any media between the source and the point of exposure (e.g., leaching of CoCs from soil to groundwater).
- **Institutional Controls** - The restriction on use or access (e.g., existing deed restrictions, restrictive zoning and conditions listed in the registry of releases) to a site or facility to eliminate or minimize potential exposure to CoCs.

- **In-Situ Monitoring** - Analysis or observations taken immediately at the site (e.g., pH analysis that must take place within 15 minutes of sample collection).

- **Laboratory Fortified Blank (LFB)** — a sample prepared by adding a known mass of a target analyte to a specified amount of analyte-free deionized (DI) water. Spiked samples are used, to determine the recoveries for samples taken through the procedure and are part of the quality control for the procedure.

- **Laboratory Matrix spike (MS)** — a sample prepared by adding a known mass of a target analyte to a specified amount of a sample for which an independent estimate of the target analyte concentration is available. Spiked samples are used, for example, to determine the effect of the matrix on a method's recovery efficiency

- **Limit of Quantification** — the minimum concentration of an analyte or Class of analytes in a specific matrix that can be identified and quantified above the detection limit and within specified limits of precision and bias during routine analytical operating conditions.

- **Maximum Contaminant Level (MCL)** - a standard for drinking water established by the USEPA under the Safe Drinking Water Act. The MCL is the maximum permissible level of CoC in water that is used as a drinking water supply.

- **Monitored Natural Attenuation (MNA)** - the verifiable reduction of CoC through naturally occurring microbial activity or attenuation mechanisms.

- **Must** — when used in a sentence, a term denoting a requirement that has to be met.

- **Operator** – An entity as defined in Section 44-2-20(10) of the State Underground Petroleum Environmental Response Bank Act.

- **Organic Vapor Analyzer (OVA)** - a field instrument used to measure the organic vapors present in a sample of soil or ground water (e.g., Photoionization Detector (PID)).

- **Owner** – An entity as defined in Section 44-2-20(12) of the State Underground Petroleum Response Bank Act.

- **Point(s) of Compliance** - a location(s) selected between the source area and the exposure point(s) where CoCs must be at or below the determined target levels (CPC) in the specified media (e.g., soil, groundwater or air).

- **Point(s) of Verification** - a location(s) selected for monitoring to verify a decrease in a CoC as a result of corrective action.

- **Precision** — a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions expressed generally in terms of the standard deviation. Refer to Appendix F, Data Quality Indicators, for a more detailed definition.

- **Project Verifier** - reports to the Quality Assurance Manager. The verifier reviews and confirms the acceptability of data generated from work performed and verifies that the work performed fulfills the specified requirements set forth in the QAPP. The verifier identifies and explains any non-compliance issues and documents the corrective action measures taken.

- **Quality** — the totality of features and characteristics of a product or service that bears on its ability to meet the stated or implied needs and expectations of the user.

- **Quality Assurance (QA)** — An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

- **Quality Assurance Manager (QAM)** - the person that is independent of data production which is responsible for ensuring that the finished product meets the performance standards set forth in the QAPP and that the data fulfills the particular requirements for its intended use. The Quality Assurance Manager conducts audits as necessary and is responsible for reviewing SOPs for completeness and consistency.

- **Quality Assurance Program Description/Plan** — See quality management plan.

- **Quality Assurance Project Plan (QAPP)** — a formal document describing in comprehensive detail the necessary quality assurance (QA), quality control (QC), and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria. The QAPP components are divided into four classes: 1) Project Management, 2) Measurement/Data Acquisition, 3) Assessment/Oversight, and 4) Data Validation and Usability. Requirements for preparing QAPPs can be found in USEPA QA/R-4.

- **Quality Control (QC)** — the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality. The system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring the results are of acceptable quality.

- **Quality Control (QC) sample** — an uncontaminated sample matrix spiked with known amounts of analytes from a source independent of the calibration standards. Generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

- **Quality Management Plan (QMP)** — a formal document that describes the quality system in terms of the organization's structure, the functional responsibilities of management and staff, the lines of authority, and the required interfaces for those planning, implementing, and assessing all activities conducted.

- **Quality System** — A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance (QA) and quality control (QC).

- **Readiness Review** — A systematic, documented review of the readiness for the start-up or continued use of a facility, process, or activity. Readiness reviews are typically conducted before proceeding beyond project milestones and prior to initiation of a major phase of work.

- **Reasonably Anticipated Future Use** - Future land use that can be predicted given current use, local government planning, and zoning.· Receptors - Persons, structures, utilities, surface water bodies, sensitive habitats, water supply wells, or any living organisms that are, or may be, affected by a release.

- **Record (quality)** — a document that furnishes objective evidence of the quality of items or activities and that has been verified and authenticated as technically complete and correct. Records may include photographs, drawings, magnetic tape, and other data recording media.

- **Recovery** — the act of determining whether or not the methodology measures all of the analyte contained in a sample. Refer to Appendix E, Data Quality Indicators, for a more detailed definition.

- **Remediation** — the process of reducing the concentration of a contaminant (or contaminants) in air, water, or soil media to a level that poses an acceptable risk to human health.

- **Representative Concentration**:

  1. In Air - The maximum CoC concentration obtained during the most recent sampling event.
  2. In Groundwater - The maximum CoC concentration obtained during the most recent sampling event.
  3. In Soil - The maximum CoC concentration obtained during the most recent sampling event for the ingestion and dermal contact pathways. For the soil reaching groundwater pathway, the average of up to two soil samples with the highest non-zero concentrations from each source area will be used to compare with the screening levels.

- **Repeatability** - the degree of agreement between independent test results produced by the same analyst, using the same test method and equipment on random aliquots of the same sample within a short time period.

- **Reporting limit** - the lowest concentration or amount of the target analyte required to be reported from a data collection project. Reporting limits are generally greater than detection limits and are usually not associated with a probability level.

- **Representativeness** — a measure of the degree to which data accurately and precisely represents a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition. See also Appendix E, Data Quality Indicators.

- **Reproducibility** - the precision, usually expressed as variance that measures the variability among the results of measurements of the same sample at different laboratories.

- **Risk Assessment** - An analysis of the potential risk for adverse health effects caused by CoC to determine the need for Site Rehabilitation or used to develop target levels or cleanup goals if Site Rehabilitation is required.

- **Risk Reduction** - the lowering or elimination of the level of risk posed to human health or the environment through initial response actions, Site Rehabilitation, or institutional or engineering controls.

- **Risk-Based Screening Level (RBSL)** - Risk based action level for a CoC. RBSLs are not site-specific.

- **Separation Distance** – the vertical distance between the depth of worst-case soil contamination and the depth to the top of the water table.

- **Shall** - a term denoting a requirement that is mandatory whenever the criterion for conformance with the specification permits no deviation. This term does not prohibit the use of alternative approaches or methods for implementing the specification so long as the requirement is fulfilled.

- **Site Assessment** - the collection of data on ground-water quality and potential receptors, subsurface geology, hydrology, and site characteristics to determine the extent of the migration of the CoCs and action levels of the CoCs to support remedial action decisions.

- **Site Classification** - a qualitative risk evaluation of a site based on known or readily available information. Associated with site classifications are initial response actions that are to be implemented simultaneously with the RBCA process. Sites are re-classified as actions are taken to resolve concerns or as additional information become available.

- **Site Rehabilitation** - a subset of activities conducted to protect human health, safety, and the environment. These activities include recovery of free-product, evaluating risks, evaluating and implementing monitored natural attenuation, making no further action decisions, implementing institutional controls, active remediation, designing and operating cleanup systems and equipment, and monitoring of progress.

- **Sensitive Habitat** - Fresh and salt-water fisheries, fish habitats including shellfish areas, coastal and inland wetlands, and habitats of threatened or endangered species.

- **Site-Specific Target Level (SSTL)** - Risk-based corrective action target level for a CoC developed for a particular site under the Tier 2 and Tier 3 evaluations.

- **Source Area** - Either the location of free-phase hydrocarbons or the location of the highest concentration of the CoC in soil, vapor, or groundwater.

- **Spike** — a substance that is added to an environmental sample to increase the concentration of target analytes by known amounts; used to assess measurement accuracy (spike recovery). Spike duplicates are used to assess measurement precision.

- **Standard Operating Procedure (SOP)** - a written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps and that is officially approved as the method for performing certain routine or repetitive tasks.

- **Surrogate Spike** - a pure substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them to establish that the analytical method has been performed properly.

- **Tier I Assessment** – Previously known as a Standard Limited Assessment (SLA). A defined scope of work, consisting of three monitoring wells and eight soil borings, to determine soil and groundwater chemicals of concern, hydraulic properties and risk.

- **Tier 1 Evaluation** - a risk-based analysis where non-site-specific values based on conservative exposure factors (RBSL), potential exposure pathways, and land use are evaluated to determine appropriate actions. An Initial Ground-Water Assessment, Tier I Assessment, or Tier II Assessment may include a Tier 1 Evaluation for soil and groundwater, if not previously completed.

- **Tier II Assessment** – Previously known as a Rapid Assessment (RA). A scope of work proposed by a certified Site Rehabilitation Contractor, consisting of established tasks/components in order to provide a comprehensive risk-based assessment of soil and groundwater chemicals of concern, hydraulic properties and risk.

- **Tier 2 Evaluation** - a risk-based analysis applying the RBSL at the exposure point, development of SSTLs for potential indirect exposure pathways based on site-specific conditions, and establishment of point(s) of compliance. A Tier I Assessment or Tier II Assessment may include a Tier 2 Evaluation for vapor, soil, and ground water, if not previously completed.

- **Tier III Assessment** – a scope of work proposed by a certified Site Rehabilitation Contractor, consisting of established tasks/components in order to further refine the site-specific target levels for potential and indirect exposure pathways established from a previously completed Tier II Assessment. A Tier III Assessment would typically incorporate a more sophisticated fate and transport model. Additional monitoring point(s) to further define the geological conditions or collect additional data may also be needed to refine other naturally occurring conditions at the facility or receptor(s). As the UST Management Division typically performs modeling, Tier III Assessments are not commonly performed.

- **Tier 3 Evaluation** - a risk-based analysis to develop values for potential direct and indirect exposure pathways at the exposure point based on site-specific conditions. A Tier II Assessment may include a Tier 3 Evaluation for vapor, soil, and ground water.

- **Trip Blank** - a clean sample of a matrix that is taken to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures.

- **Valid Data** – Data obtained from samples that were collected, preserved, handled, and analyzed according to the requirements of the UST Programmatic QAPP. To determine if data is valid, it will undergo and pass scrutiny via verification by the laboratory and contractor and validation by the UST Management Division.

- **Validation** — Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled. In design and development, validation concerns the process of examining a product or result to determine conformance to user needs. See also Section D.

- **Variance (statistical)** — a measure or dispersion of a sample or population distribution.

- **Verification** — Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. In design and development, verification concerns the process of examining a result of a given activity to determine conformance to the stated requirements for that activity. See also Section D.

Appendix O: Document Review and Revision Record

Attached as Appendix O
Note: Actions older than 5 years may be removed from this record

Approval Date	Rev. No.	Section	Record of Activity
9/11/15	3	Whole Doc	Format change
	3	Whole Doc	Added text 'site-specific' to QAPP Contractor Addendum
	3	Whole Doc	Added text 'Annual Contractor Quality Assurance Plan or ACQAP'
	3	Whole Doc	Added text 'site-specific work plan or SSWP'
	3	Whole Doc	Changed 'Quality Assurance Project Plan' to 'Quality Assurance Program Plan'
	3	Whole Doc	Deleted Appendix I 'Pump Operations'
	3	Whole Doc	Added Appendix N 'Glossary of Terms'
	3	Whole Doc	Deleted text 'Master' from UST QAPP
	3	Whole Doc	Added text 'Programmatic' to UST QAPP
	3	Whole Doc	Changed 'SCDHEC Technical' to 'UST'
	3	Whole Doc	Added 'UST' to Project Manager(s)
	3	A1	Changed 'Christopher Doll PG' to 'Ryan D. Ariail' as QAPP Coordinator, p.24
	3	A1	Changed 'Danny France' to 'Bobbi Carter' as Quality Assurance Manager for EPA Region 4, p.24
	3	A1	Changed title for Nydia Burdick from 'QA Officer' to 'QA Officer Designee', p.24
	3	A1	Added 'Sandra Flemming' as QA Officer, p.24
	3	A1	Removed 'List of Terms p.10' and moved to 'Appendix N: Glossary of Terms p.202'
	3	A3	Changed 'Harbhajan Singh' to 'Ben Singh', p.25
	3	A3	Changed 'Danny France' to 'Bobbi Carter' as Quality Assurance Manager for EPA Region 4 in Table 1 Distribution List, p. 25
	3	A3	Added 'Sandra Flemming' to Table 1 Distribution List, p.26
	3	A3	Changed 'Table 2 Distribution List' to 'Table 1 Distribution List", p.25-26
	3	A4	Changed 'EQC Quality Assurance Management Officer' to 'State Quality Assurance Management Officer', p.27
	3	A4	Updated link 'http://www.schdec.gov/administration/regs/docs/61-81.pdf' to 'http://www.scdhec.gov/Agency/docs/61-81.pdf', p.28
	3	A4	Updated link 'http://www.schdec.gov/evironment/water/regs/r61-71.pdf' to 'http://www.scdhec.gov/Agency/docs/water-regs/r61-71.pdf', p.28
	3	A4	Changed 'EQC Office of Quality Assurance' to 'State Quality Assurance Management Officer'; Added 'Sandra Flemming' to Figure 1 Organizational Chart, p.29
	3	A5	Changed text 'Approximately' to 'Over', p.30
	3	A6	Changed text 'SCDHEC' to 'UST Management Division', p.31
	3	A6	Changed text 'will be rejected, and if necessary, reproduced.' to 'will not be accepted and the sample shall either be re-analyzed, re-extracted or re-digested, or if necessary, the sample re-collected.' p.32
	3	A6	Moved Initial Groundwater Assessment Work Scope from p.41 to p.36
	3	A6	Changed title 'Work to be done for Tier I Assessment:' to 'Tier I Assessment Work Scope' and moved from p.42 to p.37
	3	A6	Changed title 'Work to be done for Tier II Assessment' to 'Tier II Assessment Work Scope' and moved from p.45 to p.42
		A6 Section II.B.a.	Deleted "will be investigated if tanks were in operation prior to 1991.', p.33

Approval Date	Rev. No.	Section	Record of Activity
	3	A6 Section II.H.	Added text 'or the edge of the plume whichever is the furthest from the source', p.33
	3	A6 Section III.E.	Changed 'Table 3 Potential Initial Response Actions to Eliminate Immediate Threat for Typical Release Scenarios' to 'Table 2 Potential Initial Response Actions to Eliminate Immediate Threat for Typical Release Scenarios', p.36
	3	A6 Section IV	Added text 'The IGWA shall be conducted at sites where a release of petroleum from a regulated underground storage tank (UST) has been confirmed and preliminary information is necessary to categorize the release. The objective of this scope of work is to determine the initial risk classification of the confirmed release by conducting a receptor survey, installing one groundwater monitoring well, and collecting and analyzing one soil and one groundwater sample for petroleum chemicals of concern (CoC).', p.36
	3	A6 Section IV.A.1.	Deleted text 'The map should be', p.36
	3	A6 Section IV.E.	Changed text '55 gallon drums or a similar container' to 'suitable, leak proof containers', p.37
	3	A6 Section V.	Deleted 'Tier I Assessment - evaluates the actual and/or potential impact to receptors. Based on the data gathered from the fieldwork, a Tier 1 Risk Evaluation shall be completed. More detailed information may be found in the Risk Based Corrective Action (RBCA) Procedures Section. 1. Compare the data with Risk Based Screening Levels (RBSL) - For a Tier 1 Risk Evaluation it is assumed that all exposure points are located in the source area. CoC concentrations shall be compared with the values provided in the Appendix D of this document, as appropriate. The following measurements of representative concentrations of CoC are to be utilized in this comparison: a. Air - The maximum CoC vapor concentration obtained during the last sampling event shall be used. Historical sampling events can be used to establish trends. b. Groundwater - The maximum CoC concentration obtained during the last sampling event shall be used. Historical sampling events can be used to establish trends. c. Soil - The maximum CoC concentration obtained during the last sampling event shall be used for the ingestion and dermal contact pathways. For the soil leaching to groundwater pathway, the average of the two soil sample results with the highest concentrations from each source area shall be used. 2. Site Conceptual Exposure Model - The site conceptual model shall identify all complete exposure pathways. Information required to develop this model includes: a. Release information - Pertinent release information may include, but is not limited to, the historical use of the property where the release occurred, the approximate age of the release, and the properties of the CoC (e.g., solubility, volatility) that were released. b. Characteristics of the site - Pertinent site characteristics may include, but are not limited to, the soil type, depth to groundwater, hydraulic gradient, groundwater flow direction, seepage velocity, and the physical distribution of CoC around the source. c. Proximity of potential receptors and their construction - The construction specifications (e.g., depth, diameter, and material of construction of a storm sewer) of all potential receptors shall be identified.

Approval Date	Rev. No.	Section	Record of Activity
			d. Current land use of all affected properties - For each property that is impacted, may potentially become impacted, or is adjacent to a potentially impacted property, the current land use shall be identified (e.g., vacant lot, restaurant, school, residence, factory), and tax map submitted as part of the report. e. Applicable zoning or land use ordinances - The local city or county administrative authorities shall be contacted for information pertaining to any applicable zoning and land use ordinances. Zoning ordinances set broad-scale restrictions on property development such as residential, commercial, or industrial. Land use ordinances may establish smaller scale restrictions such as disallowing the installation of drinking water or irrigation wells. A photocopy of the applicable sections or summary of the ordinances shall be provided. If a copy cannot be obtained, name, phone number, and business address of the appropriate authorities shall be provided with the relevant information. 3. Based on the estimated age of the release, known distribution of the CoC, and the potential for migration, all complete and potential exposure pathways shall be identified and summarized for land use (current and future conditions). The following potential exposure pathways shall be considered for evaluation: Identify Data Requirements - Identify the data necessary to characterize the migration potential, and to quantify the potential impact, for each complete, or potentially complete, exposure pathway identified in the site conceptual model above. Enter all identified data requirements in the Site Conceptual Model Tables (Appendix E) to be included in the Tier I Assessment Report (See Section A9).', p.37-38
	3	A6 Section V.A.1.	Added text 'Map scale should be 1 inch = 300 feet.' p.37
	3	A6 Section V.A.1.	Deleted text 'Screening receptors (see Section B1 – Sampling Process Design/Experimental Design' and 'Water Samples (see Section B2 – Sampling Methods', p.37
	3	A6 Section V.A	Added text '2. Immediately upon locating any receptors screen them for hydrocarbons using a properly calibrated screening device. (See Section B1 - Sampling Process Design/Experimental Design) 4. Obtain water samples for all water supply wells and surface water bodies within a 500 foot radius of the site. All municipal supply wells within a 1,000 foot radius shall also have a sample collected and analyzed for the appropriate parameters.(see Section B1 - Sampling Process Design/Experimental Design) 5. Notify the UST Project Manager at (803) 898-2544 as soon as possible if any water samples are collected within a 1,000 foot radius so that the approved SUPERB agreement can be amended. If field screening indicates the presence of hydrocarbons notify the UST Project Manager at (803)-898-2544 within 48 hours of detection and provide the name, address and a contact telephone number for all affected property owners. All field-screening and laboratory data for these receptors shall be included in the Report of Findings.', p.37
	3	A6 Section V.B.3.	Changed text 'facilities boundaries' to 'site', p.38
	3	A6 Section VI.B.5.	Changed 'Table 5 Potential Exposure Pathways' to 'Table 3 Potential Exposure Pathways', p.40
	3	A6	Deleted 'Air

Approval Date	Rev. No.	Section	Record of Activity
		Section VI.B.5.	• inhalation of ambient vapors • explosive hazard a. Surface Water (e.g., lake, river, stream, ditch, marsh) • ingestion • dermal contact • volatile inhalation b. Ground Water • ingestion • dermal contact • volatile inhalation c. Surficial Soil (impacted soil located <3 feet below land surface or exposed at surface) • ingestion • dermal contact • volatile inhalation • leaching to ground water **d.** Subsurface Soil (impacted soil located >3 feet below land surface) • ingestion (during excavation) • dermal contact (during excavation) • volatile inhalation (during excavation) leaching to ground water', p.40
	3	A6 Section VI.B.5.	Added Table 3 Potential Exposure Pathways, p.40
	3	A6 Section VII.A.	Changed text 'step 3' to 'Tier I Evaluation' and 'step 13' to 'No Further Action Decisions', p.41
	3	A6 Section VII.B.	Changed text 'Table 3' to 'Table 2', p.41
	3	A6 Section VIII	Changed text 'Assessment document' to 'Implementation section', p.41
	3	A6 Section IX.A.	Changed text 'direction' to 'direct supervision', p.42
	3	A6 Section X.B.1.	Changed text 'document' to 'Process', p.44
	3	A6 Section XVIII	Changed 'Table 5 Comparison of the Tiers' to 'Table 5 Comparison of the Tiers' and moved from p.18 to p.52-53
	3	A6 Section XIX	Deleted text 'certified', p.53-54
	3	A6 Section XIX	Changed text 'contract certified' to 'state lead', p.53-54
	3	A7	Deleted text, 'It is important not to attach excessive significance to such data, which may only reflect a short-term fluctuation.' p.54
	3	A7 Section A.1.	Changed text 'program' to 'UST Management Division', p.55
	3	A7 Section A.2.	Changed text 'regulatory action levels' to 'RBSLs', p.55
	3	A7 Section A.6.	Added text, 'Sampling error is minimized through proper training on sampling technique and handling that are outlined in the Contractor's SOP. Analytical' and 'Throughout each assessment activity soil and groundwater samples are collected with proper care to protect to the integrity of the sample, so decisions can be made on usable data to determine the severity and extent of the source area versus the edges of the plume that do not contain contamination. Assessment protocols in

Approval Date	Rev. No.	Section	Record of Activity
			Section B1 and requirements set forth in Section B2 of this QAPP provide guidance to eliminate any discrepancies that could affect the quality of data collected and reported.' p.55
	3	A7 Section B.2.	Deleted text, 'trip blanks and' p.56
	3	A8 Section B.2.	Deleted text 'As well drillers work under the direct supervision of the Class I certified contractor, the well driller is not required to sign the QAPP Contractor Addendum.', p.58
	3	A8 Section B.2.	Added text 'Well drillers are required to sign the site-specific QAPP Contractor Addendum or ACQAP stating they have received the most recent version of the UST Programmatic QAPP due to their involvement with Site Rehabilitation activities.', p.58
	3	A8 Section B.3.	Added text 'Laboratory directors are required to sign the site-specific QAPP Contractor Addendum or ACQAP stating they have received the most recent version of the UST Programmatic QAPP.', p.58
	3	A9	Deleted text 'UST Certified', p.59
	3	A9 Section B.1.	Deleted text 'South Carolina' and changed text 'Guidance Document' to 'Process', p.59
	3	A9 Section F.1.	Deleted text 'An original copy of the disposal manifest from the permitted treatment facility that clearly designates the quantity of effluent received, applicable permit numbers, and dates, must be included as an appendix to the final report. Note: If a weight ticket cannot be obtained from disposal facility, then documentation of a measurable device used to ensure an accurate measurement of effluent gallons produced must be provided in the report.', p.60-61
	3	A9 Section G.4.	Deleted text 'under this contract', p.61
	3	A9 Section H.5.a	Changed text 'Procedures Section' to 'Process', p.61
	3	A9 Section I.4.	Added text '3531' and '(http://www.scdhec.gov/environment/docs/slugtest.pdf)', p.62
	3	A9 Section K.6.	Added text '(DHEC Form 3531)', p.64
	3	A9 Section K.10.	Added text 'work (e.g., letter, email, phone conversation, etc.). For all access agreements received those individuals should be courtesy copied on the cover letter of the submitted report and receive an abbreviated copy of the report.', p.65
	3	B1 Section I.A.1.	Deleted text 'The well must be properly developed utilizing a method that is capable of removing enough formation cuttings, drilling fluids, and additives to provide relatively sediment-free water samples that are typical of the aquifer.', p.65
	3	B1 Section I.A.2.	Added text 'two (2) or five (5) foot intervals depending on the anticipated depth of the water table. The lithology of each collected soil sample is described and also screened for organic vapors.', p.65
	3	B1 Section I.A.2.a.	Added text 'The method of field screening to be utilized is at the discretion of the Contractor and shall be included in the site-specific QAPP Contractor Addendum or ACQAP. Any ISO or third party certified technology that accomplishes the IGWA performance standards and meets all regulatory requirements is acceptable.', p.66
	3	B1 Section I.A.2.b.	Changed 'drilling' to 'Geologist/boring', p.66
	3	B1 Section I.A.2.b.	Added text 'viii. Name and signature of person collecting data; ix. Name of Field Supervisor; and x. Location, depth and type of each sample submitted for analysis.', p.66

Approval Date	Rev. No.	Section	Record of Activity
	3	B1 Section I.A.2.d.	Deleted text '<u>With every monitoring well, a soil sample is also collected and analyzed for the appropriate parameters (see Table F3) using field-screening devices.</u>', p.66
	3	B1 Section I.A.2.e	Added text '<u>A soil sample shall be collected from **below the water table** but within the screen interval of the monitoring well installed and forwarded to a geotechnical engineering laboratory for grain size/hydrometer analysis to determine the sand, silt, and clay fractions at 0.074 mm (#200 screen) and at 0.004 mm, respectively</u>.', p.66
	3	B1 Section I.A.3.	Added text '<u>After well installation</u>; a. <u>After a minimum of 24 hours upon well completion, monitoring wells must be properly developed in compliance with SC Well Standards, R. 61-71. The method of development is at the discretion of the SC certified well driller and must be capable of removing enough formation cuttings, drilling fluids, and additives to provide relatively sediment-free water samples that are typical of the aquifer. A well development method should be specified on the Well Development form (DHEC Form 2099 http://www.scdhec.gov/library/D-2099.pdf) which is to be completed during the development process and submitted in the report.</u> b. <u>The static water level shall be measured after the well has been developed and allowed to equilibrate for a minimum of 24 hours. Report the thickness of any free phase product as follows:</u> i. <u>If free product is present, the thickness shall be measured and recorded. The distance from the Top of Well Casing to the free product shall be measure to the nearest 0.01 foot and recorded.</u> ii. <u>The collection of a groundwater sample is not necessary if free product in the well exceeds 0.01 foot (1/8 inch).</u> iii. <u>If no free product is encountered, the well shall be properly purged prior to sampling.</u> c. <u>Groundwater Samples</u> i. <u>Should only be collected after the well has equilibrated for a minimum of 24 hours after development and the groundwater has returned to the pre-drilling conditions. Wells developed with more stressful measures require longer intervals between development and sampling.</u> ii. <u>Monitoring well(s) shall be purged prior to sampling.</u> 1) <u>During purging, indicator parameters shall be monitored and recorded.</u> 2) <u>Purging is considered complete once the groundwater indicator parameters have stabilized according to requirements in Section B2 Groundwater Sampling.</u> 3) <u>Field data sheets documenting purging volumes and measured parameters shall be included as a report attachment.</u> <u>Groundwater samples must be analyzed for the parameters listed in Appendix F, Table F3</u>.', p.66-67
	3	B1 Section II.A.3.b.	Changed '<u>field screening results</u>' to '<u>organic vapor measurement</u>', p.69
	3	B1 Section II.B.1.b.	Added text '<u>bentonite seal</u>' and changed '<u>locking</u>' to '<u>locked</u>', p.69
	3	B1 Section II.B.2.a.	Changed '<u>field-screening concentration</u>' to '<u>organic vapor measurement</u>', p.69
	3	B1 Section II.B.2.b.	Added text '<u>immediate location</u>', p.69
	3	B1 Section II.B.4.a.	Added text '<u>two (2)</u>', p.70

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	3	B1 Section II.B.4.a.ii.	Deleted 'as given in Table F3', p.70
	3	B1 Section II.B.4.c.	Added text 'A second soil sample shall be collected from **below the water table** but within the screen interval of the monitoring well installed at the location of the soil boring with the highest organic vapor measurement and forwarded to a geotechnical engineering laboratory for grain size/hydrometer analysis to determine the sand, silt, and clay fractions at 0.074 mm (#200 screen) and at 0.004 mm, respectively.', p.70
	3	B1 Section II.B.5.a.	Added text 'After a minimum of 24 hours upon well completion, monitoring', 'SC certified well driller and must be capable of removing enough formation cuttings, drilling fluids, and additives to provide relatively sediment-free water samples that are typical of the aquifer. A well development method should be specified on the Well Development form (DHEC Form 2099) which is to be completed during the development process and submitted in the report.' and Changed 'Regulation' to 'SC Well Standards', p.70
	3	B1 Section II.B.5.c.	Changed '6 hours' to '24 hours', and added text 'iii. If no free product is encountered, the well shall be properly purged prior to sampling.', p.70
	3	B1 Section II.C.1.	Added text 'The site-specific QAPP Contractor Addendum or ACQAP shall state what screening device will be used, along with the information required in Section B concerning calibration, maintenance and inspection.', p.71
	3	B1 Section II.C.2.	Added text 'All municipal supply wells within a 1,000 foot radius shall also have a sample collected and analyzed for the appropriate parameters (see Table F3).', p.71
	3	B1 Section II.D.1.	Added text 'It is up to the discretion of the Contractor as to which method will be used to conduct the aquifer test. Note: If water recharge is anticipated to be faster than manual methods allow, then the Agency requires the use of a pressure transducer.', p.71
	3	B1 Section II.D.2.a.	Added text 'Data points (water level measurements) shall be recorded every 5 seconds for the first two (2) minutes for either falling or rising head test. After two minutes the time increments can gradually increase accordingly to the formations hydraulic conductivity.' p.71
	3	B1 Section III.B.1.	Added text 'The method of field screening to be utilized is at the discretion of the Contractor and shall be included in the site-specific QAPP Contractor Addendum or ACQAP', p.72
	3	B1 Section III.B.2.	Added text 'Geologist/boring', p.73
	3	B1 Section III.C.1.	Deleted text 'All industry standard quality assurance and quality control methods shall be followed for sample collection and shipping (sample labels, sealed sample containers, completed chain of custody forms, shipment to the laboratory on ice)', p.73
	3	B1 Section III.D.	Changed 'document' to 'Process', p.73
	3	B1 Section III.E.1.b.v.3.	Changed 'accomplished' to 'performed according to the manufacturer's specifications'; Deleted text '(i.e., if analyzing for gasoline, calibrate the instrument with gasoline)' and '(parts per million TPH as gasoline) instead of span gas equivalents.', p.75
	3	B1 Section III.G.	Deleted text 'All soil cuttings and groundwater generated during boring construction and monitoring well development/purging shall be temporarily stored in suitable, leakproof containers and removed for disposal within 90 days of generation.', p.76
	3	B1 Section III.G.	Deleted text 'Depth to water (or product) shall be determined using equipment capable of detecting the free product/water interface prior to development. If free product is present, the apparent thickness to 0.01-foot accuracy shall be measured.', p.76

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	3	B1 Section III.G.2.	Deleted text 'as regulated by the South Carolina Department of Labor, Licensing and Regulation', p.76
	3	B1 Section III.G.2.a.	Added text 'bentonite seal', p.76
	3	B1 Section III.G.3.	Added text 'two (2)', p.76
	3	B1 Section III.G.3.b.	Added text 'Geologist/boring' and 'Well Development Log (DHEC Form 2099)', p.76
	3	B1 Section III.G.4.	Deleted text 'typically' and added text '5 feet unless pre-approved by the UST Project Manager for greater screen length.' and deleted 'as regulated by the South Carolina Department of Labor, Licensing and Regulation' p.76-77
	3	B1 Section III.G.6.	Added text 'shall be forwarded to a geotechnical engineering laboratory for a grain size/hydrometer analysis to determine the sand, silt and clay fractions at 0.074 mm (#200 screen) and 0.004 mm respectively.', p.77
	3	B1 Section III.G.7.	Deleted text 'If free product is not encountered, the well shall be properly developed prior to sampling and the Ph, specific conductance, temperature, turbidity and dissolved oxygen measured and reported. Development will be considered complete once', p.77
	3	B1 Section III.G.7.	Added text 'After a minimum of 24 hours upon well completion, monitoring wells must be properly developed in compliance with SC Well Standards, R. 61-71. The method of development is at the discretion of the SC certified well driller and must be capable of removing enough formation cuttings, drilling fluids, and additives to provide relatively sediment-free water samples that are typical of the aquifer. A well development method should be specified on the Well Development Log (DHEC Form 2099) which is to be completed during the development process and submitted in the report (See Section A9).', p.77
	3	B1 Section III.H.	Added text 'and groundwater has returned to pre-drilling conditions. Wells developed with more stressful measures require longer intervals between development and 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.', p.77
	3	B1 Section III.H.	Deleted text 'All industry and South Carolina certification quality assurance and quality control methods, as well as those listed in the USEPA approved methodology and this QAPP, shall be followed for shipping (sample labels, sealed sample containers, completed chain of custody forms, shipment to the laboratory on ice).', p.77
	3	B1 Section III.H.1.	Added text 'The static water level shall be measured after the well has been developed and allowed to equilibrate for a minimum of 24 hours. a. If free product is present, the thickness shall be measured and recorded. The distance from the top of well casing to the free product shall be measured to the nearest 0.01 foot and recorded. b. The collection of a groundwater sample is not necessary if free product in the well exceeds 0.01 foot (1/8 inch). If no free product is encountered, the well shall be properly purged prior to sampling.', p.77
	3	B1 Section III.H.2.	Deleted text 'If the monitoring well contains free product exceeding 0.01 feet (1/8 inch), a sample shall not typically be collected.', p.78
	3	B1 Section III.H.3.	Deleted text 'pH, specific conductance, temperature, turbidity, and dissolved oxygen' and 'once pH, specific conductance, temperature, turbidity, and dissolved oxygen measurements have equilibrated.' and 'All purge water shall be containerized and disposed of as appropriate. Once laboratory analysis for soil and

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			groundwater is received, the UST Project Manager may contacted to see if onsite disposal is appropriate., p.78
	3	B1 Section III.H.3.	Added text 'The newly installed well(s)' and 'indicator parameters of the' and 'within requirements set forth in Section B2 Groundwater Sampling.' p.78
	3	B1 Section III.H.4.	Deleted text 'the pH, specific conductance, temperature, turbidity and dissolved oxygen recorded. Purging is considered complete once the groundwater pH, specific conductance, temperature, turbidity and dissolved oxygen measurements have equilibrated. Field data sheets documenting purging volumes and parameters measured shall be included as an attachment to the report of findings. All purge water shall be containerized and disposed of as appropriate. Once laboratory analysis for soil and groundwater is received, the UST Management Division manager may be contacted to see if on site disposal is appropriate.' and added text 'in accordance with Section B2 Groundwater Sampling.', p.78
	3	B1 Section III.H.5.	Deleted text 'dissolved oxygen level' and added text 'all indicator parameters will be monitored and recorded.', p.78
	3	B1 Section III.I.	Added text '1. If receptors are identified that may be impacted, they shall be immediately screened for hydrocarbons using a properly calibrated organic vapor analyzer or other similar screening device. The site-specific QAPP Contractor Addendum or ACQAP shall state what screening device will be used, along with the information required in Section B concerning calibration, maintenance and inspection. a. If field screening indicates the presence of hydrocarbons, notify the UST Project Manager as soon as possible within 48 hours of detection at (803) 898-2544 and provide the name, address, and a contact telephone number for all associated property owners. 1. Water samples shall be obtained for all water supply wells and surface water bodies within a 1,000 foot radius of the site. All municipal supply wells within a 1,000 foot radius shall also have a sample collected and analyzed for the appropriate parameters (See Table F3). a. Notify the UST Project Manager at (803) 898-2544 or by email as soon as possible if any water samples are collected. All field-screening and lab data for these receptors shall be included in the Tier II Assessment Report.', p.78
	3	B1 Section III.J.	Changed 'Characteristics' to 'Evaluation', p.79
	3	B1 Section III.J.1.	Added text 'It is up to the discretion of the Contractor as to which method will be used to conduct the aquifer test.', p.79
	3	B1 Section III.J.1.a.	Added text 'Data points (water level measurements) shall be recorded every 5 seconds for the first two (2) minutes for either falling or rising head test. After two minutes the time increments can gradually increase accordingly to the formations hydraulic conductivity.', p.79
	3	B1 Section III.J.1.b.	Added text 'in the format as shown at http://www.scdhec.gov/environment/docs/slugtest.pdf. The completed forms and all applicable data shall be attached to the report in the appropriate appendix (See Section A9).' and deleted text 'The form and all applicable data must be included in the appropriate appendix in the final report.', p.79
	3	B1 Section III.J.1.c.	Added text 'The shallow aquifer slug test and deep aquifer slug test shall be completed and reported separate in DHEC 3531 form.', p.79
	3	B1 Section III.M.	Changed "document' to 'Process', p.80

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	3	B1 Section III.O.	Added text 'All soil cuttings and groundwater generated during boring construction and monitoring well development/purging shall be temporarily stored in suitable, leak proof containers.' and 'Once laboratory analysis for soil and groundwater is received, the UST Management Division manager may be contacted to see if on site disposal is appropriate.', p.80
	3	B1 Section IV.B.6.	Changed 'Site Rehabilitation' to 'Corrective Action', p.84
	3	B1 Section IV.B.6.c.	Changed text 'Section H' to 'the next section', p.84
	3	B1 Section IV.G.	Changed 'by a' to 'under direct supervision', p.88
	3	B1 Section V.A.	Added text 'Events must be conducted on monitoring or recovery wells with a minimum inner diameter of 2-inches.', p.88
	3	B1 Section V.B.	Added text 'target wells' and 'Fluid levels should be measured in any adjacent wells used to gauge surrounding pressure prior to the start of the event.', p.88
	3	B1 Section V.D.	Added text 'OVA screening devices used to measure vapor concentrations shall be calibrated every eight (8) hours during the operational time periods per day. A calibration log for the event shall be kept onsite with other field documents.', p.88
	3	B1 Section V.E.	Deleted text 'and monitoring wells immediately surrounding the extraction wells.' and 'For example, one would expect perimeter wells to have less vacuum than the extraction wells and smaller graduate interval may be necessary.', p.88
	3	B1 Section V.F.	Added text 'Magnehelic gauges must be installed on at least two (2) water table bracketing monitoring wells immediately surrounding the extraction well(s) and remain attached for the duration of the event. The range of each magnehelic gauge should be selected based on the expected pressure range. For example, one would expect perimeter wells to have less pressure than the extraction wells and smaller graduate interval may be necessary.', p.89
	3	B1 Section V.G.	Added text 'Water level measurements shall be taken on the adjacent wells at the appropriate time intervals throughout the duration of the event.', p.89
	3	B1 Section V.H.	Added text 'equipment chassis', p.89
	3	B1 Section V.I.	Changed 'existing' to 'designated monitoring or recovery'; Added text 'at the vacuum pump intake' and 'The seal may incorporate a "bleeder" valve that must connect with the annulus of the target well to assist with deep recovery if necessary. The "bleeder" valve may not be connected directly to the stinger.' and 'from the depth of water to the terminus depth within the first eight (8) hours of the event.' and 'Once the terminus depth has been achieved then the stinger shall fluctuate throughout the smear zone while maintaining de-watering of the smear zone.'; Deleted text 'until the level where fluid is encountered. This level should be maintained until FPP and/or petroleum vapor concentrations start to diminish. The stinger should then be lowered six (6) inches and the cycle repeated until reaching', p.89
	3	B1 Section V.K.	Added 'target wells', p.89
	3	B1 Section V.L.	Added text 'Magnehelic gauge readings (inches of water) and water level measurements on adjacent wells shall be recorded at two hour intervals for the entire event.', p.89
	3	B1 Section V.M.	Added text 'per required interval measurement. All AFVR units or if required, off-gas treatment units must have a post emissions stack that are a minimum of 10 feet above ground surface.', p.89
	3	B1 Section V.N.	Added text 'Immediately after the completion of the event all fluid levels should be measured in extraction wells (anticipating FPP) and adjacent wells used for pressure gauging.', p.89

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	3	B1 Section V.O.9.	Added 'weight ticket' and 'Appendix G', p.90 Added 'then documentation of a measurable device used to ensure an accurate measurement of effluent gallons produced must be provided in the report.', p.90
	3	B1 Section VI.A.3.	Deleted 'by forced injection or tremie grouting with neat cement from the termination depth of the boring/point to within three inches of the surface' and ' and Added text 'in accordance with the SC Well Standards, R.61-71', p.91
	3	B1 Section VI.C.	Deleted 'The well must be properly developed.' and 'All development water must be containerized and disposed of as appropriate.'; Added text 'After a minimum of 24 hours upon well completion, monitoring wells must be properly developed by a SC certified well driller in compliance with SC Well Standards and Regulations, R.61-71. The development method used is at the discretion of the SC certified well driller and must be capable of removing enough formation cuttings, drilling fluids and additives to provide relatively sediment-free water samples that are typical of the aquifer. A well development method should be specified on the Well Development Log (DHEC Form 2099, http://www.scdhec.gov/library/D-2099.pdf) which is to be completed during the development process and submitted in the report (See Section A9).', p.91
	3	B1 Section VI.G.	Deleted 'record the change in the groundwater table vs. time data for each well. Evaluate the results of the slug test in accordance with commonly accepted methods (e.g., Bouwer and Rice, Hvorslev) and calculate seepage velocity. Enter data on the Slug Test Summary Form (DHEC 3531) found at http://www.scdhec.gov/environment/lwm/forms/slugtest.pdf.'; Added text 'from specified monitoring well(s) located outside of the UST area to determine aquifer characteristics. It is up to the discretion of the Contractor as to which method will be used to conduct the aquifer test. **Note: If water recharge is anticipated to be faster than manual methods allow, then the Agency requires the use of a pressure transducer.** 1. Data Collection a. Data points (water level measurements) shall be recorded every 5 seconds for the first two (2) minutes for either falling or rising head test. After two minutes the time increments can gradually increase accordingly to the formations hydraulic conductivity. b. Data collected shall be evaluated and analyzed in accordance with industry standards (Hvorslev, Bouwer and Rice, etc.). The slug test shall be reported on the Slug Test Summary Form (DHEC Form 3531) in the format as shown at http://www.scdhec.gov/environment/docs/slugtest.pdf. The completed forms and all applicable data shall be attached to the report in the appropriate appendix (See Section A9). c. The hydraulic head from the shallow aquifer should not be assumed to apply to deeper aquifers. The shallow aquifer slug test and deep aquifer slug test shall be completed and reported separately.', p.92
	3	B1 Section VI.H.	Changed 'appropriate' to 'containerized in suitable, leak proof'; Deleted 'Upon receipt of laboraotory analytical results or 90 days whichever is sooner, properly dispose of soil and wastewater in appropriate manner.' and Added text 'and disposed of as appropriate within 90 days of generation. Once laboratory analysis for soil and groundwater is received, the UST Project Manager may be contacted to see if on site disposal is appropriate.', p.92
	3	B1 Section VI.L.	Changed 'necessary' to 'requested'; Added text '(see Section B1 IX. Abandonment of Monitoring Wells)', p.93

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	3	B1 Section VII	Added text 'Wells developed with more stressful measures require longer intervals between development and 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.', p.93
	3	B1 Section VII.B.	Deleted 'The well shall be purged prior to sampling with pH, specific conductance, temperature, turbidity and dissolved oxygen measurements have equilibrated.' and 'Once laboratory analysis for soil and groundwater is received, the UST Project Manager may be contacted to see if on site disposal is appropriate.'; Added text 'The newly installed monitoring well(s) shall be purged prior to sampling in accordance with Section B2 Groundwater Sampling, with all indicator parameters of the groundwater monitored and recorded.', p.93
	3	B1 Section VII.C.	Changed 'dissolved oxygen' to 'indicator parameters'; Added text 'and meets the No-Purge sampling requirements in Section B2 Groundwater Sampling', p.92
	3	B1 Section VII.D.	Changed 'pH, specific conductance, temperature, turbidity and dissolved oxygen' to 'indicator parameters'; Deleted 'Purging is considered complete once the groundwater pH, Specific conductance, temperature, turbidity and dissolved oxygen measurements have equilibrated.' and 'All purge water shall be containerized and disposed of as appropriate. Once laboratory analysis for soil and groundwater is received, the UST Project Manager may be contacted to see if on site disposal is appropriate.'; Added text 'in accordance with Section B2 Groundwater Sampling', p.94
	3	B1 Section VII.E.	Added text 'All development and/or purge water shall be containerized in suitable, leak proof containers and disposed of as appropriate within 90 days of generation. Once laboratory analysis for soil and groundwater is received, the UST Project Manager may be contacted to see if on site disposal is appropriate. If purge water from existing wells meets all requirements specified in Purge Water Management of Section B2 Groundwater Sampling, then on site disposal is appropriate', p.94
	3	B1 Section VII.G.	Changed 'ice' to 'wet ice', p.94
	3	B1 Section VII.H.	Added text 'The final report (one [1] hard copy report and one [1] electronic copy) should be submitted and include the relevant elements as required in **Section A9** of the document.', p.94
	3	B1 Section IX	Deleted 'The wells must be filled from the termination depth to within six inches of the land surface with neat cement, bentonite-cement, or twenty (20) percent high solids sodium bentonite grout using forced injection by tremie pipe', p.95
	3	B2 Section I	Deleted 'Introduction' title, p.95
	3	B2 Section I.A.	Deleted 'Manual techniques and equipment such as hand augers, are usually used for collecting surface or shallow, subsurface soil samples. Power operated equipment is usually associated with deep sampling but can also be used for shallow sampling when the auger hole begins to collapse or when the soil is so tight that manual auguring is not practical.', p.95-96
	3	B2 Section I.B.1.a.ii.	Deleted '(Section 3.15.8)'; Changed 'Section 11.4.1' to 'Special Techniques and Considerations section', p.96
	3	B2 Section I.B.2.	Changed 'any' to 'different'; deleted 'depths of 20 feet or less' and 'continuous split-spoon samplers; specialized hydraulic cone penetrometer rigs"; and added text 'the devices capabilities', p.97
	3	B2 Section I.C.3.	Added text 'a. Repeating a method several times, so the soil sample is adequately mixed (e.g., quartering method, round bowl, etc.). b. Place the sample into an appropriate labeled container(s) using the alternate shoveling method and secure the cap(s) tightly. The

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			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.', p.98
	3	B2 Section I.E.	Changed 'ice' to 'wet ice', p.99
	3	B2 Section II	Deleted 'Introduction' title, p.99
	3	B2 Section II.A.	Changed 'should occur' to 'shall be taken', p.98
	3	B2 Section II.B.	Added text 'Wells that do not bracket the water table must be purged prior to collecting a groundwater sample using standard sample collection methods. The UST Project Manager will determine on a site by site basis whether purging of water table bracketing monitoring wells is required.', p.99
	3	B2 Section II.B.1.	Added text 'HydraSleeve™ Samplers'; Deleted 'for Petroleum Releases', '(For low-flow purging, other field parameters such as dissolved oxygen, may need to be monitoried.)', '(if possible)', 'At a minimum, the well sounding device must be cleaned by washing in a laboratory detergent solution, followed by rinses with tap water and analyte free water. After cleaning, it must be placed in a clean plastic bag or wrapped in foil.' p.100-101 Changed 'Stabilization occurs when pH measurements remain constant within 0.1 Standard Unit (SU), or reproducible to within 0.1 (SU), specific conductance varies no more that 10 percent, and the temperatures are all constant for at least three consecutive readings.' to 'Stabilization occurs when for at least three consecutive measurements, pH measurements remain constant within 0.1 Standard Unit (SU), or reproducible to within 0.1 (SU), dissolved oxygen remains constant within 0.2 mg/L, and specific conductance, temperature and turbidity varies no more than five (5) percent.', p.102 Added text 'including an initial (prior to commencement of purging) set of measurements'; Changed 'If the purge volume is large' to 'For other purging methods'; Added text 'A minimum of two (2) sets of parameter measurements shall be recorded if the well is purged dry before achieving one well volume (including the initial measurements).'; Changed 'chemical' to 'indicator', 'project leader' to 'the Contractor', 'pH, specific conductance, temperature, and turbidity' to 'indicator parameters', p.102 Deleted 'sampled immediately following sufficient recovery (enough volume to allow filling of all sample containers).', p.102 Added text 'allowed to recharge and return to equilibrium before samples are collected.', p.102
	3	B2 Section II.B.2.	Deleted 'Appendix I contains the operating instructions for all pumps commonly used during groundwater investigations.', p.103
	3	B2 Section II.C.	Deleted 'No Purge - For wells meeting specific criteria, collecting a groundwater sample without purging the well may be approved by the directing Program. Prior Program approval for collecting groundwater samples using no-purge methods is required. Analytical results from groundwater samples collected using a no-purge method may not be accepted if the method was not approved by the directing Program prior to sample collection.', p.103
	3	B2 Section II.C.1.	Added text 'The pump/hose assembly used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed.', and 'If the

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			pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown.', p.103
	3	B2 Section II.C.2.	Added text 'Bailers may also be used for purging in appropriate situations; however, the use of bailers for purging is discouraged because the correct technique is operator dependent and improper use may result in an unrepresentative sample.', 'or disposable bailers', and 'Bailers tend to disturb any sediment that may be present in the well, creating or increasing sample turbidity. Bailers, if improperly used, may also strip volatile organic compounds from the water column being sampled.', p.103-104
	3	B2 Section II.C.4.	Changed 'material' to 'product', p.105
	3	B2 Section II.C.5.	Deleted text 'These techniques, however, are only acceptable under certain hydraulic conditions and are not considered standard procedures.', p.105 Added text 'For wells with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging.' And 'The rate of pumping from a well should not exceed the rate that the aquifer can recharge the well (i.e., the water level in the well should remain relatively constant). Purging at a slower rate is allowable, but purging at a higher rate that causes continued drawdown is not allowable, unless the pumping rate is the lowest possible for the pump. This is monitored by measuring the top of the water column with a water level recorder or similar device while pumping. Monitor and record the water level and pumping rate every five (5) minutes or as appropriate during purging. Any adjustments made to the pumping rate, both time and flow rate, should be recorded. If the lowest pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. Stabilization of the water level drawdown must be shown before indicator parameters are monitored d to demonstrate a sufficient purge. The flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting samples. A water level measurement must be taken before samples are collected. These techniques, however, are only acceptable under certain hydraulic conditions and are not considered standard procedures.', p.105
	3	B2 Section II.C.6.	Deleted 'Purging Techniques' from title; Changed 'pH, specific conductance, temperature, turbidity, and dissolved oxygen' to 'indicator parameters', p.105-106
	3	B2 Section II.C.7.	Deleted 'Purging Techniques' from title, p.106
	3	B2 Section II.C.8.	Deleted 'Purge water is either discarded approximately 20 feet downgradient of the well or contained and managed as investigation derived waste, depending on contaminant levels in the water to be determined on a site specific basis.'; Added text 'For groundwater purged from monitoring wells all of the following must be applied. Depending on historical data of contaminant levels in the groundwater, two things are to be determined on a site specific basis. a. Purge water is discarded within approximately a five (5) foot radius of the well from which it was purged; i. The groundwater concentrations shall be less than five (5) times the MCL for all constituents being analyzed. ii. Purge water shall not be allowed to discharge to the storm sewer or surface waters.

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			iii. Purge water shall be applied in such a way that it infiltrates over the delineated plume or within the property boundaries of the site. iv. There shall be no presence of liquid phase petroleum products, to include sheen or emulsion in the purge water being discarded. v. Purge water shall not be discarded onto soil during saturated or frozen ground conditions or onto impervious surface material (e.g., concrete, asphalt, etc.).. If not compliant with the above requirements then purge water must be containerized in suitable, leak proof containers and managed as investigation derived waste.', p.107
	3	B2 Section II.D.1.	Added text 'HydraSleevesTM and PDBs must be evaluated for appropriateness for analytes of concern.', p.107
	3	B2 Section II.D.1.a.	Added text 'or after running the pump and filling the tubing with water, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using this method to prevent introducing water that was in contact with the flexible pump head tubing.', p.107-108
	3	B2 Section II.D.1.f.	Added text 'HydraSleeve™ Sampling - Commercially available HydraSleeve™ samplers may be used to collect groundwater at discreet depths. Disposable colorless nylon rope and a decontaminated weight must be attached to the sampler. The sampler is lowered into the well placing the check valve at the depth of interest. A quick upward pull opens the check valve. The sampler is then held in place allowing water to flow into the sampler until it is full. The sampler is retrieved and the water is emptied into a standard sampling container.', p.109
	3	B2 Section II.D.2.	Added text 'HydraSleeve™ sampling', p.109
	3	B2 Section II.D.2.	Deleted 'd. The well has been previously sampled within the past 12 months.', p.109
	3	B2 Section II.F.1.	Added text 'If an effervescent reaction occurs between the preservative and water, producing large numbers of fine bubbles (e.g., if the groundwater has a high amount of dissolved limestone, which is highly calcareous), 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.', p.110
	3	B2 Section II.G.	Deleted 'Indicator parameter measurements (Ph, conductivity, etc.), including time measurements/volume of water pumped, must be recorded in the field notebook.', and 'such as overgrown vegetation', p.110
	3	B4	Added text 'All UST certified Site rehabilitation contractors will utilize commercial laboratories of their choice that are certified by SCDHEC Laboratory Certification. For samples collected by the Agency staff, the state contracted laboratory will be use to analyze samples. All SCDHEC certified laboratories must maintain a Quality Assurance Manual or a Quality Management Plan and Standard Operating Procedures. Even though these documents for the lab are reviewed during the certification process, the Agency may request submission of some or all SOP's.', p.112 Added text 'Whichever methods the lab will be using shall be identified in the site-specific QAPP Contractor Addendum or SSWP.', p.112
	3	B5 Section A.2.	Added text, 'Field blanks will be an aqueous sample of distilled or de-ionized water that is analyte-free collected during groundwater sampling events to assess potential contamination of samples from the site environment. Field blanks are not required to be submitted during soil sampling events.', p.113

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	3	B5 Section A.3.	Deleted 'One duplicate sample will be collected for each twenty samples, or subset thereof.', p.113
	3	B5 Section A.4	Added text '4. Matrix spike/Matrix spike duplicate – will be prepared by the analyzing laboratory for methodologies in Table F1 and Table F2. MS/MSD samples will be processed at a frequency that is stated in the laboratory Quality Assurance Manual. Not only does the Agency require the data from UST samples used for MS/MSD(s), but also those where other clients' samples have been spiked to serve for batch QC to be reported in the data analytical report. The purpose of MS/MSD is to determine whether the sample matrix contributes bias to the analytical results. The MSD also serves as a check on analytical precision.' p.113
	3	B7 Section G	Added 'Dissolved Oxygen - +0.2 mg/L from the value on the solubility and calibration table.' to Table 8 *Field Parameter Acceptance Criteria*, and Corrective action information is also required in the site-specific QAPP Contractor Addendum or ACQAP.', p.114
	3	B8 Section B.	Added text 'or within the standard operating procedures section of the ACQAP', p.115
	3	C1 Section A.1.	Added text 'but in most cases will be conducted unannounced. The results will include the finding of the visit, any discrepancies, corrective action measure taken, and if any follow-up visits are needed. Corrective actions for audit deficiencies must be corrected by the contractor in the field before activities commence again. An OFA report form will be filled out appropriately by the UST Project Manager in the field. The OFA form will be documented and stored with the project file after it has been scanned and stored electronically at the SCDHEC office. If requested, a copy of the OFA form will be sent to the Contractor via email.', p.118
	3	C2	Added text 'or notify the UST Project Manager via email 4 days prior to initiation of any Site Rehabilitation activities.' and 'If there are any changes or conflicts with the dates of site activities, the UST Project Manager must be contacted within 24 hours of those changes.', p.121
	3	C2	Deleted 'The results will include the finding of the visit, any discrepancies, corrective action measure taken and results of any follow-up visits. The results of the onsite visit will be documented and stored with the project file.', p.121
	3	Appendix B	Changed 'http://www.scdhec.gov/environment/enserv/qaguidance.htm' to 'http://www.scdhec.gov/Environment/docs/OAPP_Guide%20Sept_2008_Finalflags.pdf', p.130
	3	Appendix B Section A1	Added text 'Other signatures may be required and should be added as directed by UST Project Manager. Signatures of all parties who may be involved in UST Site Rehabilitation work stating they have received the most recent version of the UST Programmatic QAPP. (Including those on the Approvals page and in the Distribution List).', p.131
	3	Appendix B Section A3	Added text 'Field Staff' to Table 1A, p.132
	3	Appendix B Section B4	Deleted text '*This can be a full name of a SOP, an abbreviation, or a number. In the latter two cases, the abbreviation or number must be associated with the full name of the SOP. See also Table 8A SOP Abbreviation Key.', p.136
	3	Appendix B Section B7.1.	Deleted 'or lab work', p.137
	3	Appendix B Section B7	Deleted text '*This can be a full name of a SOP, an abbreviation, or a number. In the latter two cases, the abbreviation or number must be associated with the full name of the SOP.', p.137
	3	Appendix C	Changed from 'RBSL Look-up Tables' to 'Site-Specific Work Plan', p.141
	3	Appendix D	Changed from 'Site Conceptual Model' to 'RBSL Look-up Tables', p.144

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	3	Appendix D	Added Table D2 'Action Levels for Groundwater (Oxygenates)', p.146
	3	Appendix D	Changed '0.66' to '0.066' for PAH's in Table D3 & Table D4, p.146-147
	3	Appendix D	Updated Table D5 and Table D6 concentrations, p.148
	3	Appendix D	Added Table D7 'Effective Solubility Limits for Gasoline Constituents', p.149
	3	Appendix E	Changed from 'Analytical Parameters and Methods' to 'Site Conceptual Model', p.150
	3	Appendix F	Changed from 'Preservation and Holding Times' to 'Analytical Parameters and Methods', p.153
	3	Appendix F	Deleted Analytical Method '3050B' for Arsenic, Barium, Cadmium, Chromium, Lead, Selenium and Silver from Table F1, p.155
	3	Appendix F	Deleted Analytical Methods '3020A, 3050B with 7010' for Arsenic, Cadmium, Chromium, Lead, Selenium and Silver from Table F1, p.155
	3	Appendix F	Changed Analytical Method '5030' to '5035' for Naphthalene and MTBE in Table F2 , p.156
	3	Appendix F	Deleted Analytical Methods '3005A and 3010A' for Arsenic, Barium, Cadmium, Chromium, Lead, Selenium and Silver from Table F2, p.157
	3	Appendix F	Deleted Analytical Methods '3020A, 3050B with 7010' for Arsenic, Cadmium, Chromium, Lead, Selenium and Silver from Table F2, p.157
	3	Appendix F	Changed 'wet weight' to 'dry weight' in Table F2, p.157
	3	Appendix F	Added 'Oxygenates' for Groundwater in Table F3, p.158
	3	Appendix G	Changed from 'Leachability Model and Domenico Model' to 'Preservation and Holding Times', p.159
	3	Appendix G	Deleted Analytical Method '3050B' for Arsenic, Barium, Cadmium, Chromium, Lead, Selenium and Silver from Table G1, p.162
	3	Appendix G	Deleted Analytical Methods '3020A, 3050B with 7010' for Arsenic, Cadmium, Chromium, Lead, Selenium and Silver from Table G1, p.162
	3	Appendix G	Deleted Analytical Method '7010' for Arsenic, Cadmium, Lead, Selenium and Silver from Table G2, p.164
	3	Appendix H	Changed from 'Standard Filed Cleaning Operations' to 'Leachability Model and Domenico Model', p.165
	3	Appendix I	Changed from 'Pump Operations' to 'Standard Field Cleaning Procedures', p.184
	3	Appendix I	Deleted 'Redi-Flo2 Pump' section, p.185
	3	Appendix I Section G.5.	Changed 'Fultz' to 'Submersible', p.188
	3	Appendix I Section G.5.	Added text 'For Grundfos pumps or similar, to clean the pump ball check valve: c. Completely dismantle ball check valve. Check for wear and/or corrosion, and replace as needed; d. Using a brush, scrub all components with soap and tap water; d. Rinse with analyte free water; and Reassemble and re-attach the ball check valve to the pump head.' to Submersible Pump Cleaning Procedure, p.188
	3	Appendix I Section H.4.	Changed 'Section B.2.3' to 'Section G.3', p.189
	3	Appendix N	Added definition for 'Direct Supervision', p.204
	3	Appendix N	Added definition for 'Indicator Parameters', p.205
	3.1	Whole Document	Changed, "Table F3" to "Table F4"
	3.1	A6 Section V.E.	Added text, "Water and Soil Disposal – All solids, drilling fluids, development water, and any purge water generated during assessment implementation shall be

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			temporarily stored in suitable, leak proof containers. Upon receipt of laboratory analytical results, the soil and/or water shall be properly disposed of in the appropriate manner", p. 41
	3.1	A6 Section X.B.1.	Added text, "within 500 feet of the down gradient," p.47
	3.1	A9 Section B.1.	Added text, "or within 500 feet of the down gradient edge of the plume, whichever is greater from the source area", p.62
	3.1	A9 Section F.2.	Added text, "off-gas reduction (%) per measurement interval", p. 63
	3.1	A9 Section F.9.	Added text, "(e.g., date stamped photograph)", p.63
	3.1	A9 Section J.1.	Added text, "within 500 feet of", p.65
	3.1	B1 Section I.A.3.a.	Added text, "Monitoring wells shall be developed after filter pack is in place, but prior to installing bentonite/grout seal or after a minimum of 24 hours upon well completion. Any other well development procedure that is consistent with industry standard and meets state regulations can be submitted for review and approval by the Agency", p.69
	3.1	B1 Section I.B.	Added text, "Receptors - Location of all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements) within a 1000 foot radius of the site", p.70
	3.1	B1 Section II.B.5.a.	Added text, "Monitoring wells shall be developed after filter pack is in place, but prior to installing bentonite/grout seal or after a minimum of 24 hours upon well completion. Any other well development procedure that is consistent with industry standard and meets state regulations can be submitted for review and approval by the Agency", p. 73
	3.1	B1 Section II.C.	Added text, "Receptors - Location of all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements) within a 1000 foot radius of the site', p.73
	3.1	B1 Section III.G.4.	Added text, "On a case specific basis and pre-approval by the UST Project Manager, a deep well that is proposed outside the contaminated area and does not contain a confining layer, may not need an outer casing if the hydrologic zone is not segregated", p.79
	3.1	B1 Section III.G.7.	Added text, "Monitoring wells shall be developed after filter pack is in place, but prior to installing bentonite/grout seal or after a minimum of 24 hours upon well completion. Any other well development procedure that is consistent with industry standard and meets state regulations can be submitted for review and approval by the Agency", p. 80
	3.1	B1 Section III.I.	Added text, "Receptors - Location of all private and public water supply wells (drinking and non-drinking) and other potential receptors as defined in the RBCA Process (i.e., utilities, surface waters, wetlands, basements) within a 1000 foot radius of the site', p.81
	3.1	B1 Section III.I.2.	Added text, "or within 500 feet of the down gradient edge of the plume, whichever is greater from the source area", p.81
	3.1	B1 Section V.I.	Added text, "or top of the well screen (if well screen does not bracket water table)", p.92
	3.1	B1 Section V.O.9.	Added text, "(e.g., date stamped photograph)," p.93
	3.1	B1 Section VI.C.	Added text, "Monitoring wells shall be developed after filter pack is in place, but prior to installing bentonite/grout seal or after a minimum of 24 hours upon well

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			completion. Any other well development procedure that is consistent with industry standard and meets state regulations can be submitted for review and approval by the Agency", p. 94
	3.1	B1 Section VI.F.	Added text, "Groundwater samples should be collected after each new groundwater monitoring well has been developed and allowed to equilibrate for a minimum of twenty-four (24) hours. Wells developed with more stressful measures require longer intervals between development and 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", p.94-95
	3.1	B1 Section VII	Deleted text, "Groundwater samples should be collected after each new groundwater monitoring well has been developed and allowed to equilibrate for a minimum of twenty-four (24) hours. Wells developed with more stressful measures require longer intervals between development and 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", p.96; Added text, "Note: The elapsed time between the collection date of the groundwater samples and the received date of the report will be no more than 60 days," p.96-97
	3.1	B2 Section II.A.	Added text, "Extreme caution should be exercised during this procedure to prevent cross-contamination of the wells. This is a critical concern when samples for trace organic compounds or metal analyses are collected," p.102
		B2 Section II.A.2.	Deleted text, "Equipment must be decontaminated according to the procedures specified in Appendix I between measurements at sites," p.103
	3.1	B2 Section II.A.3.	Deleted text, "These devices must be decontaminated according to the procedures specified in Appendix I prior to use at the next well", p.103
	3.1	B2 Section II.B.1.	Deleted text, "Extreme caution should be exercised during this procedure to prevent cross-contamination of the wells. This is a critical concern when samples for trace organic compounds or metal analyses are collected," and "Field parameter measurement may or may not be required, depending on the goals of the investigation," p.104-105
	3.1	B2 Section II.C.1.	Deleted text, "The pump/hose assembly used in purging should be lowered into the top of the standing water columns and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed", p.106
	3.1	B2 Section II.C.2.	Deleted text, "slowly lowered into the top of the water column, allowed to fill and removed. It is critical that bailers be slowly and gently lowered into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents"; Added text, "to be utilized in a way that minimizes agitation to water column and provides a sample representative to that of the surrounding aquifer", p.106
	3.1	B2 Section II.C.8.	Added text, "from previous sampling events", p.109
	3.1	B2 Section II.C.8.b.	Added text. "or there are no historical data tables", p.110
	3.1	B2 Section II.D.	Added text, "It is recommended to store and transport receptor samples (e.g., water supply wells, surface waters, etc.) and groundwater samples separately if possible to prevent any chance of cross contamination", p.110
	3.1	B2 Section II.D.1.a.	Deleted text, "The tubing can be momentarily attached to the pump to fill the tube with water. After the initial water is discharged through the pump head, the tubing is quickly removed from the pump and a gloved thumb placed on the tubing to stop the water from draining out. The tubing is then removed from the well and the water

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			allowed to drain into the sample vials or after running the pump and filling the tubing with water, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials" and "Alternatively, the tubing can be lowered into the well to the desired depth and a gloved thumb placed over the end of the tubing. This method will capture the water contained in the tubing. It can then be removed from the well and the water collected by draining the contents of the tubing into the sample vials", p.110
	3.1	B2 Section II.D.1.c.	Deleted text, "gently immersed in the top of the water column until just filled. At this point, the bailer must be carefully removed"; Added text, "utilized with carefulness to obtain a representative sample", p.111
	3.1	B2 Section II.D.1.d.	Deleted text, "by hanging the bag from a nylon or stainless steel cord attached to the top of the well. The diffusion bag sampler needs to remain in the well until concentrations within the bag reach equilibrium with those in the surrounding groundwater. Typically after a period of two weeks the bag can be withdrawn from the well, emptied into a standard sampling container (e.g., a VOA vial), sealed and shipped for analysis" and "The sampler is then removed and waer is withdrawn from the bag for analysis"; Added text, "and allowed to equilibrate for a period of two weeks. The sampler is then removed and water is emptied into a standard sampling container (e.g., a VOA vial)", p.111
	3.1	B2 Section II.D.1.f.	Deleted text, "is lowered into the well placing the check valve" and "A quick upward pull opens the check valve. The sampler is then held in place allowing water to flow into sampler until it is full"; Added text, "must be positioned at the depth of interest and allowed to equilibrate for a sufficient amount of time per manufacturers recommendations", p.111
	3.1	B2 Section II.D.3.	Added text, "a. Drinking water wells (servicing a resident or building) shall be analyzed for EPA drinking water methods. Non-drinking water wells shall be analyzed for EPA SW-846 methods, but at lower detection limits, Appendix F (Table F1)", p.112
	3.1	B2 Section II.D.4.	Added text, "Field equipment used for field analysis must be calibrated daily prior to analysis of any samples. It is recommended that meters be recalibrated or measured against a calibration standard midpoint during field activities to ensure meters accuracy", p.112
	3.1	B2 Section II.G.	Added text, "daily calibration logs for field instruments", p.113
	3.1	B3 Section A.10.	Added text, "Physical characteristics – identify in Comments (e.g., strong odor, odor or no odor)", p.114
	3.1	B3 Section B	Added text, "Field Duplicate(s) samples should be designated with the 5-digit permit number and the numerical order of collection (e.g., 12345-DUP1)", p.114
	3.1	B5 Section A.2.	Added text, "Field blanks shall also be collected if sampling public or private drinking water wells using drinking water analytical methods. These field blanks shall be collected in the vicinity of a drinking water well being sampled", p.116
	3.1	Appendix D	Changed "50 µg/L" to "10 µg/L" for Arsenic in Table D1, p.148
	3.1	Appendix D	Updated concentrations for Toluene and Xylene in Table D5, p.151
	3.1	Appendix D	Updated concentrations in Table D6, p.151
	3.1	Appendix F	Updated concentrations for Reporting Limits in Table F1, p.157-159
	3.1	Appendix F	Added Table F2 Analytical Precision and Accuracy for Drinking Water Samples, p.159-160
	3.1	Appendix F	Changed "Table F2 Analytical Precision and Accuracy for Soil Samples to Table F3 Analytical Precision and Accuracy for Soil Samples" and "Table F3 Required Sampling Parameters to Table F4 Required Sampling Parameters", p.161-162

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	3.1	Appendix G	Updated Table G1 to include Drinking Water Analytical Methods and Preservation requirements, p.164-167
10/8/2020	4.0	Entire Document	Formatting, headings harmonized, added hyperlinks to related sections and regulations
		Entire Document	Removed references to 3,3-Dimethyl-1-butanol as DMB.
		Entire Document	Updated references to analytical methods 8260B and 8270D to 8260D and 8270E, respectively.
		Sections A1-A3	Sections relabeled to conform with EPA QAPP Template
		Title Page, A1	Date, DHEC Logo Changed, Section Labeled as A1
		Document Revision Record	Moved to Appendix O
		Table of Contents	Updated, Section Labeled as A2
		A1	Names updated
		A3	Names and contact information updated
		A4	Added "All Site Rehabilitation Contractors are responsible for submitting QAPP Addenda with each Site Specific Workplan (SSWP) or Annual Contractor Quality Assurance Project Plan (ACQAP) that describes all South Carolina UST Site work conducted by the contractor, as detailed below in Section A5."…" Contractors are required to notify UST Management Division Project Managers of UST Site work in South Carolina at least 4 days prior to the initiation of field activities."
		A4	Organization Chart Updated
		A5	Substantial Revisions
		A6	Substantial Revisions
		A6	Rephrased and simplified IGWA, Tier I and Tier II Project Description Sections
		A6Ib	Revised RBSL Process Section, Site Assessment and RBCA Sections for clarity
		A6VIa	Added Text: "an estimated increased lifetime cancer risk"
		A6VIB – Table 3	Specified Inhalation Exposure Pathways
		A6VIII	Rephrased text to read: Additional Site Assessment may be required to fully evaluate the current and future exposure pathways identified in the Tier I Evaluation. The Tier II Implementation section outlines a comprehensive Site Assessment approach for obtaining the additional information necessary for a Tier II Evaluation. The Tier II Assessment is used for sites with petroleum releases from regulated underground storage tanks (USTs) where additional investigation of site-specific conditions is warranted based on existing data from previous investigations. Tier II Assessment defines site geology and the extent of the contamination horizontally and vertically. The number and placement of wells and borings are not specified in this QAPP.
		A6VIIId	Deleted text, added link to Section B2.
		A6IXB – Table 4, Figure 2	Clarified Compliance points and Exposure Points
		A6XVIIa	Added text: Aggressive Fluid Vapor Recovery events may be utilized to remove free-phase product from the subsurface as an abatement measure prior to, in lieu of, or as part of the implementation of a corrective action plan. Specifications for AFVR events and reports are presented in Sections B1 and A9, respectively.
	4.0	A6XVIId	Added text: UST project managers may also direct responsible parties or contractors to redevelop wells that have become fouled or contain water that is excessively turbid. Baseline requirements for monitoring well installation and development are presented in Section B1.

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		A6XVIIf	Added text: "Repair and" to section title.
		A6XVIIg	Added Sections: "g. Remedial Injection Remedial injections are used to alter subsurface conditions to effect LNAPL and CoC breakdown or removal as part of Corrective Action Plans or Abatement Measures. A wide variety of remedial additives are employed at UST release sites in South Carolina. Baseline requirements for injection activities are presented in Section B1. h. Remedial Excavations Some UST petroleum releases are remediated using excavation an off-Site disposal. DHEC currently directs responsible parties and their contractors to conduct remedial excavations at release Sites where it is considered to be the most appropriate remedial option. General guidelines for remedial excavation are presented below in Section B1"
		A7	Added text "UST Project Managers and Class I certified contractors are tasked with the evaluation of all data"
		A7I	Minor text changes and links
		A7II	Rephrased Text to Read: "Bias refers to the degree of inaccuracy of a measurement. The sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analytical techniques are all potential sources of bias. Bias may be quantified for by using matrix spike, surrogate, and laboratory control samples."
		A7II	Rephrased text to read:" Sensitivity is assessed primarily through Method Detection Limits and Reporting Limits calculated by analytical laboratories, which are verified by the SCDHEC Laboratory Certification Division."
		A9	Added Text: One paper and one digital copy of all reports must be delivered to the UST Management Division on prior to the due date specified in the Notice to Proceed for the work. Digital copies should include an unsecured .pdf file of the entire document, .xlsx files containing all tables, and .dxf files for all figures.
		A9I-XII	Specified which reports require which sections.
		A9VII	Added Section: "VII. Corrective Action Activity Summary Include in all CASE Reports. 1) Description of overall remedial strategy for the site and progress made. 2) Detailed description of all remedial activities conducted during the current reporting period, including but not limited to any remedial injection, air sparging, AFVR and/or Extraction Events, water treatment system operation or excavation; 3) Presentation of all monitoring and groundwater sampling result data, including vapor, vacuum, and groundwater level monitoring conducted during AFVR and/or extraction events during that reporting period, as described above in Section V; 4) Interpretation of groundwater sample result data in the context of overall remedial strategy, including CoCs and any secondary parameters analyzed, such as sulfate, nitrate, ferrous iron, magnesium and dissolved oxygen; 5) A description of any remedial excavation conducted during the reporting period, including a summary of the amount of material removed, soil disposal location. and the means used for deterring excavation limits; 6) Include a summary table of all remedial activities conducted during the corrective action contract as Appendix L. The summary table should include rows presenting quantities of remedial additives injected; FPP, vapor phase CoCs, and groundwater removed/treated; and number of hours remedial systems were operated. The table should be divided by reporting periods; and 7) Include laboratory reports for all analytical results received during the reporting period and all attendant sampling logs as Appendix B. Logs for all borings and

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			temporary wells installed should be included as Appendix G, and logs for any monitoring wells installed in Appendix E.
	4.0	A9VIII	Added items to Results & Discussion Section: "4) Data Evaluation – Present brief a narrative description of QA/QC sample results, including RPDs calculated from blind field duplicate results and any data usability issues identified in Appendix A.
		A9IX	Revised Table Requirements: "1) Current Analytical data for the site shall be given in tabular form as **Table 1**. At sites that are likely to be adjacent to other petroleum or hazardous material release sites, samples should be designated with the 5-digit permit number and the location ID (e.g. 12345-MW1). Water supply should be designated with the well ID (e.g. 12345-WSW1). Surface water sampling locations should be designated with the location ID (e.g. 12345-SW1). Include water parameter measurements (pH, specific conductance, temperature, turbidity and dissolved oxygen). Analytical sample results should be presented in separate sub-tables for each environmental media and class of analytes, as appropriate, labeled **Table 1a, 1b, 1c etc**. Groundwater analytical data from the previous five sampling events should also be presented on when available; 2) Potentiometric data for the site shall be listed in tabular form for the current and all previous sampling events as **Table 2**. This should include top of casing elevations, screened intervals, depth to water, depth to product, and groundwater elevation for each well;"
		A9X	Added clarification to Figure 3) "Label the Soil CoC map as Figure 3a and the Groundwater CoC map as Figure 3b, when sample results are reported for multiple environmental media."
		A9X	Added clarification to Figure 6) CoC Isopleth Maps (Tier II Assessment, Groundwater Sampling/Monitoring, and CASE Reports) - A map or series of maps showing the predicted migration and attenuation of CoCs through time should be presented. The contractor may decide which CoCs to present in the figures, with individual CoCs at concentrations greater than Screening levels or SSTLs being generally preferred. These maps should be presented as Figures 6a, 6b, etc.
		A9X	Revised Text: "4.) Site Potentiometric map – the map shall indicate the water level elevations for each monitoring well and show the direction of groundwater flow for all aquifers evaluated. Include in Tier I, Tier II, Groundwater Sampling Reports. Label as **Figure 4**. Reports for sites where more than one more aquifer has been evaluated should present separate potentiometric figures for each aquifer evaluated as **4a, 4b, 4c**, for shallow, intermediate, and deep aquifers etc."
		A9XI	Added Historical Data tables to Appendix B: "i. Analytical Data Summary tables that include all current and historical data. Separate tables into different environmental media and/or classes of CoCs as Appendix Tables B1, B2, B3 etc., as appropriate;
		A9XI	Added Appendix L: High Resolution Site Characterization reports, UV Fluorescence Data Report and/or Corrective Action Summary Tables, as Applicable.
		B1	Replaced introductory text with: This section describes the processes used to generate data in the S.C. RBCA program. The assessment and corrective action activities directed by the UST Division are described in detail and requirements for subsurface investigations are presented. Requirements for sample collection are described in the following Section.
	4.0	B1	Throughout section – Moved repeated text describing boring and well installation to Section B1V and added links where appropriate.
		B1Ia	Added text: Soil samples collected during IGWA events should be submitted for the following analyses as appropriate: 9) One sample shall be analyzed for USEPA method USEPA method 8260D (BTEX and Naphthalene);

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			10) A soil sample shall be collected from below the water table but within the anticipated screen interval of the monitoring well installed and forwarded to a geotechnical engineering laboratory for grain size/hydrometer analysis to determine the sand, silt, and clay fractions at 0.074 mm (#200 screen) and at 0.004 mm, respectively. 11) If field screening indicates the likely presence of CoCs, the soil sample with the highest headspace vapor concentrations sample should be analyzed for total petroleum hydrocarbons using USEPA method 8015C (TPH-DRO); and 12) If field screening indicates the likely presence of CoCs, one soil sample collected from the below the "A" horizon but above the water at a nearby background location and analyzed for total organic carbon (TOC). TOC analysis must be performed using a TOC analyzer equipped with a soil sample attachment according to method USEPA 9060A.
		B1IIb – 2)iii	The third monitoring well shall be installed in a position on the site so that the directions of groundwater flow can be determined (i.e. in a presumable downgradient direction).
		B1IId	Changed text to: "Two separate aquifer slug tests shall be completed from a monitoring well located within the source area, unless FPP is present, and a downgradient well to determine aquifer characteristics according to the requirements presented below in Section B1V."
		B1IIIa - 1)	Replaced text with: "Install soil borings to a depth of 25 feet or to the groundwater table, or until the vertical extent of impact has been delineated if evidence suggests that CoCs are present in soil beneath the water table."
		B1IIIa - 2)	Replaced text with: "Borings may be advanced until the vertical extent of impact has been delineated if evidence suggests that CoCs are present in soils below the water table."
		B1IIIg – 3)	Revised text: "The diameter of the deep well boring must be such that installation of the telescoping monitoring well can easily be accomplished. For example, a 6-inch inside diameter (ID) well casing (following ASTM industry standard) shall be advanced at least 10 feet deeper than the bottom of the adjacent water table bracketing well screen or to the first confining unit, whichever is less."
		B1IIIm	Revised text: "A final survey to tie-in field screening points, permanent monitoring well locations, and elevations to a common elevation datum shall be performed and included in the Tier II Assessment Report as Appendix A. After reviewing the data, the UST PM will determine which type of survey (comprehensive or subsequent) will best fit the needs of the site."
		B1IVb – 3)	Changed text to read: "<u>In-Situ Remediation and Injection Guidelines</u>"
		B1IVb – 3)vii.	Added text: A description of secondary parameters, such as nitrate, sulfate, ferrous iron, dissolved oxygen, etc. to be used to evaluate the suitability of the product and its effectiveness;
		B1IVb – 3)xiv.	Changed text to: "Complete description of the bioremediation or injection processes at the site (e.g., application of the product to soil and/or groundwater, aeration of the soil, procedures needed to maintain microbial growth and chemical degradation) and injection pressures;"
		B1IVb – 3)xvi.	Added text: "Means for preventing spills of injectate and cleanup procedures for any spills that occur; and"
		B1IVb – 4)	Added text: "<u>Remedial Excavation Guidelines</u> – Contractors should submit the following information to the UST Management Division project manager prior to the initiation of remedial excavation activities: iv. A site plan with the approximate excavation limits; v. Rationale for the proposed excavation limits, and estimated volume/tonnage of material to be removed;

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			vi. Name and location of the permitted disposal facility; vii. Means for determining the extent of impacted soil and minimizing the amount of excavated material removed from the Site; viii. Type and source of backfill material, means of compaction; and ix. Type and quantities of any remedial additives to be mixed with backfill."
	4.0	B1IVb – 6)	Added text: "Contractors are also required to notify UST Management Division Project Managers of UST Site Rehabilitation work at least 4 days prior to the initiation of field activities."
		B1IVb – 7)	Added Text: "iv. Interpretation of groundwater sample result data in the context of overall remedial strategy, including CoCs and any secondary parameters analyzed, such as sulfate, nitrate, ferrous iron, magnesium and dissolved oxygen;..." vi. A summary table of all remedial activities conducted during the corrective action contract;"
		B1IVb – 8)iii	The reporting limit value is entered for subsequent sample results that are below the reporting limit but greater than the Method Detection Limit, commonly flagged with a "J" in the analytical report;
		B1IVg	Added text: "The UST Division directs AFVR events as a means to abate petroleum releases. AFVR is also utilized by contractors as part of Corrective Action Plans."
		B1IVg – 7)	Revised text to read: "Water level measurements shall be taken on the adjacent wells at the beginning and eight (8) hour time intervals throughout its duration."
		B1IVg – 10)	Added text: "unless stinger depths are being adjusted or water levels are being gauged."
		B1V	Substantial revision, merged repeated text from B1I to B1III as: "V. <u>Boring, Field Screening, and Well Installations</u>" Section
		B1Va	Added text: 5) Continuous geological description of all recovered material including interpretation of formation and/or depositional environment, especially at locations in the coastal plain; 6) Split-spoon or core sample intervals, including percent recovery; ... … Sites located in areas of substantial surficial geologic heterogeneity in the Coastal Plain should be investigated using drilling methods capable of discerning soil strata of higher relative permeability to the maximum relevant depth that include the collection of continuous cores to describe lithology. Traditional environmental drilling methods are not adequate means to assess soil lithology at depths necessary to determine CoC transport in groundwater at some locations. Rotosonic or diamond core drill rigs should be employed to log soil cores in these instances."
		B1Vb3)i.	Added text: "The method(s) will be capable of providing real-time on-site data; i.e. the data is obtained as borings are advanced or within 30 minutes of sample collection. Typical instrumentation includes, but is not limited to, LIF, OIP, MIP, UVF, field gas chromatography and/or other methods that would provide detection limits at or below the RBSL for benzene, naphthalene, MtBE and EDB as a minimum."
		B1Vc 2)	Added Text: "2) Recovery wells are constructed of at least 4-inch diameter PVC and are screened in a manner to maximize the extraction of vapor and dissolved phase CoCs. i. Recovery wells should not be screened across confining layers; and ii. Recovery well screens may be installed in the vadose zone in circumstances when the maximization of vapor phase CoC extraction is intended."
	4.0	B1Vc 4-5)	Revised and added text:

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			4) Any monitoring well(s) completed in heavily trafficked or mowed areas should be flush-mounted with concrete pads and well vaults. Wells installed in wooded or overgrown areas should be marked with a piece of flagging tape attached at eye level or a brightly colored marker at least three (3) feet high. 5) Wells should be identified according to the following convention: i. Monitoring wells should be identified with the prefix "MW-"; ii. Recovery wells should be identified with the prefix "RW-"; iii. Injection wells should be identified with the prefix "IW-'; iv. Wells installed in close proximity and screened at different depths and nested wells should be given the same identification number differentiated by the suffix D, indicating the deeper well (eg. MW-# and MW-#D). Additional deeper wells at the same location should be identified by additional "D"s, such that MW-#DD is installed with a deeper screen than MW-#D; v. Replacement wells should be identified using the same ID as the original well, with the suffix "R" (e.g.) if MW-# is lost or abandoned, it's replacement should be identified as MW-#R; and vi. At sites that are likely to be adjacent to other petroleum or hazardous material release sites, samples should be designated with the 5-digit permit number as an additional prefix (e.g. 12345-MW-#).
		B1VI	Added text: "All newly installed monitoring well(s) shall be purged prior to their initial sampling in accordance with Section B2 Groundwater Sampling, with all indicator parameters of the groundwater monitored and recorded. Field data sheets documenting purging volumes and parameters measured shall be included as an attachment to the report of findings."
		B1Vd – 1)	Removed requirement for monitoring well development by S.C. Certified Driller. Revised text to read: "Monitoring wells must be properly developed in compliance with SC Well Standards and Regulations, R.61-71. The development method must be capable of removing enough formation cuttings, drilling fluids and additives to provide relatively sediment-free water samples that are typical of the aquifer."
		B1Vi - 1-2)	Revised text to read: 1) Abandon all monitoring wells at the assigned site by a Class A, B, or C SC Certified Well Driller in accordance with the SC Well Standards and Regulations, R.61-71. In paved areas, **the lid will be removed** and the vault will be filled with aggregate reinforced concrete or asphalt. In unpaved areas, the pad, vault, and **cover will be removed** and the space filled with soil to level with the surrounding land surface. 2) The final report (one [1] hard copy report and one [1] electronic copy) should be submitted and include the relevant elements as required in Section A9 of the document, **including photographs of each decommissioned well**.
		B2Ib – 3)	Added Text: "though some drill rigs, including air rotary, rotosonic, and diamond core drill rigs can be used to penetrate bedrock."…"Direct Push Rigs allow the collection of continuous cores, which are often removed in from core barrels in single use liners, which prevents the contact of sample material with the tooling. The liners are cut to allow access to the cores for sample collection and for lithology to be logged. Dual tube sampling systems are employed to maintain casing in a borehole while the sampling tooling is removed and replaced."
		B2Ic - 1)	Added text: "Soil samples should be placed directly in the container submitted for laboratory analysis with any required preservative and should not be transferred from plastic bags or other containers used for field screening."
		B2Ie	Added Text: **d. Sample Labeling, Handling, and Shipment**

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			Soil samples should be labeled with the following information, which should correspond with the samples' entry on the chain of custody: 1) The sample location identification, indicated by a prefix, such as "SB-" (soil boring), "BH-" (borehole), "FSP-" (field screening point) etc.. Samples should be designated with the 5-digit UST permit number as an additional prefix (e.g. "12345-SB-") at sites that are likely to be adjacent to other petroleum or hazardous material release sites. 2) Depth of sample collection; 3) Date and time of sample location; 4) UST Release Permit Number; and 5) Designated analysis and preservative used.
		B2II	Substantial revisions, including additional text and reformatting. Highlighted changes are presented below.
		B2IIa – 4)	Added text: "A photograph of FPP present in the bailer should be taken if it has not been previously identified at the Site or is of a different appearance in comparison to FPP previously identified at the Site."
		B2IIa	Water Level Surveys – Added Text: "Well caps should be removed a few minutes before water levels are gauged to allow the water column to reach equilibrium. If a release site is near tidal surface waters, the potential for saltwater intrusion to affect groundwater elevations should be considered and accounted for, and the tidal cycle should be recorded."
		B2IIa	Added text: **Groundwater Sample Identification** Groundwater samples should be labeled with the following information, which should correspond with the samples' entry on the chain of custody: 6) The sampled well identification. Samples collected from monitoring wells should contain the prefix "MW", those collected from water supply wells should contain "WSW-", etc. Samples should be designated with the 5-digit UST permit number as an additional prefix (e.g. 12345-MW-#) at sites that are likely to be adjacent to other petroleum or hazardous material release sites. If previous samples at the location were labeled using a different convention, the prior identification should be used for consistency; 7) Date and time of sample location; 8) UST Release Permit Number; and 9) Designated analysis and preservative used.
		B2IIb	Revised volumetric purge stabilization criteria: "A purge can also be considered adequate when the pH, specific conductance, temperature and dissolved oxygen of the groundwater have stabilized. Stabilization for volumetric purges occurs when, pH remains constant within 0.1 Standard Unit, specific conductance and temperature vary by no more than five (5) percent and turbidity varies no more than ten (10) percent for at least three consecutive measurements. Dissolved oxygen is considered to be stable when it varies by less than ten (10) percent or 0.2 mg/L, whichever is greater for three consecutive measurements. Consecutive turbidity levels less than 10 NTU, and Dissolved Oxygen values less than 0.5 mg/L may also be considered to be stable."
	4.0	B2IIb	Revised text: "No purge sampling can be utilized when the screen of a monitoring well brackets the water table, the continuous lateral flow through the well is usually sufficient to limit the effects of volatilization…"

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	4.0	B2IIb	Added text: "Wells that are not purged contain relatively unmixed water that represents CoC concentrations in the soil strata adjacent to the screen where the sample is collected, irrespective of differences in soil or bedrock permeability along the length of the well screen. Purging effectively removes any stratified groundwater, which is then replaced by groundwater from the most permeable saturated stratum adjacent to the screen. Care should be taken to not over-purge wells to the extent it is effectively dewatered as this has the potential to bias concentrations of volatile CoCs in recharge water low and therefore result in unrepresentative samples. When the influence of saltwater intrusion is suspected to be likely at sites near tidal surface water bodies, as indicated by elevated conductivity readings (~10,000 µS/cm), care should be taken to collect samples during periods in the tidal cycle when saltwater intrusion will be minimized so that CoC concentrations in groundwater are not diluted. Groundwater sampling methods should be selected based on site specific information with consideration of monitoring well construction and soil stratigraphy as decided by the SCDHEC project manager with the advice of the Contractor. It is important for groundwater sampling methods to be as consistent as possible between sampling events at a Site, with the possible exception of the initial sampling event following well installation, when purging is always required."
		B2IIb	Added Section: **"<u>Over-Purging</u>** In some situations, even with slow purge rates, a well may be pumped or bailed until it is effectively dewatered or dry. In these situations, dewatering constitutes the effective limit of purging. If a well is over-purged, it may result in the sample being comprised partially of water contained in the sand pack, which is not representative of groundwater in the soil. In addition, as water re-enters the well, it may cascade down the sand pack or the well screen, leading to the removal of volatile organic constituents that may be present. This practice may also introduce soil fines into the water column. It is important to evaluate drawdown during purging to ensure that wells are not dewatered and the resulting samples compromised. **For wells that are dewatered, it is not necessary that the well be bailed dry additional times before sampling. The well should be allowed to equilibrate for at least three hours or until the water level has reached eighty (80) percent of its level prior to purging before sampling.** The drawdown in a well should be monitored to avoid over-purging and the indicator parameters must be measured during sample collection as the measurements of record. Alternatively, a low purge sampling technique may be more appropriate. The UST project manager should be notified when poor recharge in monitoring wells may affect the quality of groundwater data. Approximate recharge rates, final depth to groundwater, and indicator parameters during or immediately following sampling must be recorded."
		B2IIb	Revised low flow purge stabilization criteria: "Temperature, pH, conductivity, dissolved oxygen and turbidity are monitored at 5-10 minute intervals (greater than the residence time of water within the flow through cell). A low flow purge can be considered adequate when the pH, specific conductance, temperature and dissolved oxygen of the groundwater have stabilized. Stabilization for volumetric purges occurs when, pH remains constant within 0.1 Standard Unit, specific conductance, and temperature vary by no more than five (5) percent and turbidity vary no more than ten (10) percent for at least three consecutive measurements. Dissolved oxygen is considered to be stable when it varies by less than ten (10) percent or 0.2 mg/L, whichever is greater for three consecutive measurements.

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			Consecutive turbidity levels less than 10 NTU, and Dissolved Oxygen values less than 0.5 mg/L may also be considered to be stabilized."
		B2IIb	Alternative No Purge Methods – Added text: "2) SNAP Sampler® - SNAP Samplers® may be used to collect no purge groundwater at discreet depths. SNAP Samplers® are usually dedicated to a specific well. The sampler is deployed at a predetermined depth within the screened interval of the well, and the water within the well is allowed to equilibrate for a minimum of two weeks. The sampler contains an open container which is closed using a trigger from the top of the well. The device and sealed containers are retrieved, and any required preservative is injected into the container prior to being sealed with a screw on cap for transport to the laboratory. A new, decontaminated sample container can then be placed into the sampler, which may be redeployed in the same well. Water quality indicator parameters are either measured by lowering a probe into the well or from a separate designated container included in an additional sampling device."
	4.0	B2IIb	Revised text regarding bailers: "Bailers are to be utilized in a way that minimizes agitation to the water column and provides a sample representative to that of the surrounding aquifer. Bailers should be lowered into the water as gently as possible using colorless nylon string. Samples should be collected with care so as to obtain representative data."
	4.0	B2IIb	Peristaltic Pumps – Added Text: - When peristaltic pumps are used, only the intake tubing is placed into the water column. Sample tubing should be lowered until it is midway within the saturated portion of the screened interval of the well, but at least two feet above the bottom of the well to avoid agitating any particulates present at the bottom of the well. Peristaltic pumps produce a vacuum in tubing placed into a well. The vacuum induced by a peristaltic pump has the potential to incur the loss of volatile contaminants, especially at depths greater than twenty (20) feet. The straw method can be used in cases where low concentrations of VOCs identified in a sample may be used to make a management decision. When purging is complete, the downhole tubing should be filled and disconnected from the flexible pump tubing. The sampler should place a finger, after donning a new nitrile glove, over the tubing, which is removed from the well. Water is then poured from the tubing into the sample containers with minimal contact with air entrained in the tubing. Samples should never be collected directly from the silicone tubing attached to the pump's rotor. Submersible Pumps - Several types of submersible pumps are commonly used for groundwater purging and sampling, including bladder pumps, piston pumps and gear driven pumps. After purging has been accomplished with a submersible pump, the sample may be obtained directly from the pump discharge. The discharge rate of the pump must be minimized during sampling to diminish sampling disturbance. This is especially important for the collection of VOC and metals samples. Submersible pumps must be decontaminated as specified in Appendix I prior to sampling. Equipment Blank Samples should be collected from submersible pumps, following their decontamination, at a rate of one per day of use, as described below in Section B5.
		B2IIb	Purge Water and Sample Location Management - Added text: "Purge water may be treated on-Site using a GAC filter or equivalent treatment system and discharged according to the criteria listed above. The treated purge water should be sampled and analyzed for all CoCs once during each sampling event to verify that concentrations are less than five (5) times the MCL for each CoC."
		B2III	Added Entire Section III. SURFACE WATER SAMPLING – Substantial changes: "3) Surface water temperature, pH, dissolved oxygen, and conductivity, should be

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			measured and recorded in a field form or log book immediately following the collection of samples; 4) Samples should be collected from the portion of the water body closest to the release site, (i.e) from the adjacent bank, not the center of the channel; and 5) Surface water sample locations should be recorded using GPS coordinates and/or photographs and marked with flagging tape hung at eye level or an equivalent maker to allow the location to be accurately resampled….. …..Surface water samples should be labeled with the following information, which should correspond with the samples' entry on the chain of custody: 1) The surface water sample location identification, indicated by the prefix "SW-". Samples should be designated with the 5-digit UST permit number as an additional prefix (e.g. 12345-SW-#) at sites that are likely to be adjacent to other petroleum or hazardous material release sites.If previous samples at the location were labeled with a different identification, the prior identification should be used for consistency; 2) Date and time of sample location; 3) UST Release Permit Number; and 4) Designated analysis and preservative used."
		B5II	Added text: 5) Equipment Blanks - should be collected from submersible pumps, following their decontamination, at a rate of one per day of use.. All parts of the pump, including any power cords and reusable tubing that many contact water during sampling, should be placed in a decontaminated container. The container should be filled with clean, potable water to a level that is sufficient for the pump to be activated and covers the pump and power cords. The pump should be activated, and the Equipment Blank Sample collected from the outlet of the pump. The Equipment Blank Sample should be submitted for the analysis of all parameters analyzed in samples collected at the Site using the pump during the day the equipment blank is collected. Equipment blank sample handling, storage, and transport should be consistent with those of all other samples submitted for analysis. The detection of CoCs in the Equipment Blank Sample may invalidate the results of the samples collected using the pump during the day the equipment blank is collected. These results should be flagged and discussed when reported.
	4.0	B4I	Added text: "An analytical laboratory certified for required parameters through the SCDHEC's Office of Environmental Laboratory Certification program must perform all SC certified analytical methods. The Environmental Laboratory Certification program does not currently offer certification for some methods included in this QAPP (i.e., Ferrous Iron, RSK-175, TO-15, and TO-17)."
		D2-Table 11	Added text: **Co-located Blind Field Duplicates** - Should be submitted to laboratory without information identifying sample location or collection time.
		Appendix D – Table D5	RBSL for EDB adjusted to 0.1 µg/m^3 to correspond with reasonable reporting limits.
		Appendices F&G	Metals Analytical Method 6010C and 6020A replaced with 6010D and 6020B, respectively. Method 3546 added for PAH analysis. Method 8270D was replaced with 8270E.
		Appendix G, Table G1	Hatch 10360 added as an acceptable method for Dissolved Oxygen Analysis. Method 9056 replaced with 9056A for Nitrate and Sulfate Analysis.
		Appendix G, Table G1	Changed the holding time for non-mercury metals from 6 months to 180 days.

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		Appendix G, Table G2	Analytical Method 3535A removed for PAH analysis in soil.