DRAFT FINAL

VOLUME 2B

QUALITY ASSURANCE PROJECT PLAN

SITE WIDE GROUNDWATER (OPERABLE UNIT 03)

WEST LAKE LANDFILL SITE

November 12, 2019

Project #: 63N-001-001

SUBMITTED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

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QUALITY ASSURANCE/QUALITY CONTROL PLAN
FOR SAMPLING ACTIVITIES
AT OPERABLE UNIT 03
WEST LAKE LANDFILL SITE, BRIDGETON, MISSOURI
PREPARED BY: TRIHYDRO CORPORATION
PREPARED FOR: OU-3 RESPONDENTS

JUSTIN BARKER – USEPA, Project Manager	Date
RYAN SEABAUGH – MDNR, Project Manager	Date
PAUL ROSASCO – Engineering Management Support, Inc., OU-3 Project Coordinator	Date
GARY RISSE – Trihydro Corporation, Project Principal	Date
ALLISON RIFFEL, P.E. – Trihydro Corporation, Project Manager	Date
KELLY BIRKENHAUER, P.G. – Trihydro Corporation, Field Team Lead/Project Geologist	Date
CHRISTINA HIEGEL, P.E. – Trihydro Corporation Quality Assurance Director	Date
BETH SCHRAGE – Pace Analytical Services-Indianapolis Quality Assurance Officer	Date

CHRIS BOYLE – Pace Analytical Services-Indianapolis Project Manager	Date
CHRISTINE SARKAN – Pace Analytical Services-Indianapolis Project Manager	Date
NASREEN DERUBEIS – Pace Analytical Services-Pittsburgh Quality Assurance Officer	Date
CHARLIE BILLINGS (Signing in place of Carin Ferris) – Pace Analytical Services Pittsburgh General Manager	Date
CHARLOTTE WASHLASKI – Pace Analytical Services-Energy Services Quality Assurance Manager	Date
RUTH WELSH – Pace Analytical Services-Energy Services Project Manager	Date
CHARLOTTE WASHLASKI – Pace Analytical Services-Energy Services Quality Assurance Manager	Date
CINDY VARGA – Pace Analytical Services – Green Bay Project Manager	Date
KATE VERBETEN – Pace Analytical Services – Green Bay, WI Quality Assurance Manager	Date
NEIL COOPER – Earth Exploration Project Manager	Date

MIKE WIGGER – Earth Exploration Quality Assurance Manager | Date

GURKAN OZGURAL – Earth Exploration Quality Assurance | Date

PRESTON SPIRES – MCLInc Quality Assurance Manager | Date

JOHN REYNOLDS – MCLInc Project Manager | Date

CHANEY AREND – ALS Quality Assurance Manager (Simi Valley) | Date

SUE ANDERSON – ALS Project Manager (Simi Valley) | Date

DAVID GURDIBANIUK – ALS Quality Assurance Manager (Winnipeg) | Date

LEE-ANN HEMPHILL – ALS Project Manager (Winnipeg) | Date

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List of Acronyms

φ_{MR}	relative standard deviation at any concentration greater than UBGR
3-D	Three-Dimensional
ALS-S	ALS Environmental Laboratories (Simi Valley, CA)
ALS-W	ALS Environmental Laboratories (Winnipeg, Canada)
AMO	AMO Environmental Decisions, Inc.
ANS	American Nuclear Society
ANSI	American National Standards Institute
APM	Assistant Project Manager
ASAOC	Administrative Settlement Agreement/Order on Consent
CEC	Cation-Exchange-Capacity
CCV	Continuing Calibration Verification
CLP	Contract Laboratory Program
CoC	Chain-of-Custody
COPCs	Constituents of Potential Concern
CSM	Conceptual Site Model
DO	Dissolved Oxygen
DOE	Department of Energy
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
EDR	Environmental Data Resources
EVOH	Ethylene Vinyl Alcohol
ft	Feet
ft/day	feet per day

List of Acronyms (cont.)

FSP	Field Sampling Plan
FTL	Field Team Leader
GC	Geospatial Coordinator
GC/MS	Gas Chromatography/Mass Spectrometry
GIS	Geographic Information System
GNSS	Grade Global Navigation Satellite Systems
GPS	Global Positioning System
GRO	Gasoline Range Organics
HASP	Health and Safety Plan
ICV	Initial Calibration Verification
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
LOD	limit of detection
LOQ	limit of quantitation
LUST	Leaking Underground Storage Tank
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MCL	USEPA Maximum Contaminant Level
MCLInc	Materials and Chemistry Laboratory, Inc.
MDC	minimum detectable concentration
MDL	Method Detection Limit
MDNR	Missouri Department of Natural Resources

List of Acronyms (cont.)

mg/kg	milligrams per kilogram
MRL	Method Reporting Limit
MW	monitoring well
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NAD	North American Datum
NAVD88	North American Vertical Datum of 1988
NGDP	National Geospatial Data Policy
NOAA	National Oceanic Atmospheric Administration
NSL	Cotter Corporation
NTU	Nephelometric Turbidity Unit
ORP	Oxygen Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
OU-3	Operable Unit 3
Pace	Pace Analytical Services, Inc.
Pace-E	Pace Analytical Services, Inc. Energy Services in Pittsburgh, Pennsylvania
Pace-G	Pace Analytical Services, Inc. in Green Bay, Wisconsin
Pace-I	Pace Analytical Services, Inc. in Indianapolis, Indiana
Pace-P	Pace Analytical Services, Inc. in Pittsburgh, Pennsylvania
Pace-K	Pace Analytical Services, Inc. in Lenexa, Kansas
PCB	Polychlorinated Biphenyls
pCi/g	average picocuries per gram
pCi/L	picocuries per Liter

List of Acronyms (cont.)

PID	photoionization detector
PM	Project Manager
QA	Quality Assurance
QAD	Quality Assurance Director
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Manual
Ra226	Radium-226
Ra228	Radium-228
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RCS	Radiation Control Supervisor
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIM	Radioactively Impacted Material
RPD	Relative Percent Difference
RSL	Regional Screening Level
RSO	Remediation Safety Officer
SEM/EDS	Scanning Electron Microscope with Energy Dispersive X-ray Spectrometry
SHSO	Site Health and Safety Officer
SOP	Standard Operating Procedure
SOW	Scope of Work

List of Acronyms (cont.)

SQCO	Site Quality Control Officer
SSR	Subsurface Reaction
SVOC	Semi-volatile Organic Compound
TOC	Total Organic Carbon
TOV	Total Organic Vapor
TPH	Total Petroleum Hydrocarbon
Trihydro	Trihydro Corporation
U_{MR}	Required method of Uncertainty
UBGR	Upper Bound Grey Region
USACE	United States Army Corp. of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
XRD	X-Ray Diffraction
WLL	West Lake Landfill

1.0 INTRODUCTION

Trihydro Corporation (Trihydro) prepared this quality assurance project plan (QAPP) on behalf of Bridgeton Landfill, LLC, Cotter Corporation (NSL), and the United States Department of Energy (DOE) (collectively OU-3 Respondents), for site-wide groundwater (Operable Unit 3 or OU-3), at the West Lake Landfill (WLL) site (site) at 13570 St. Charles Rock Road in Bridgeton, Missouri. This QAPP contains the procedures that will be used to help ensure that data collected during OU-3 Remedial Investigation and Feasibility Study (RI/FS) related sampling activities are sufficiently complete, representative, comparable, accurate, and precise to meet the established data quality objectives (DQOs). The QAPP presents the management organization, project and quality assurance (QA) objectives, and QA/Quality Control (QA/QC) activities for the sampling program to complete assessment activities (as appropriate). It also describes the specific protocols that will be followed for sampling, sample handling and storage, chain-of-custody (CoC), field analyses, and laboratory analyses to promote QA/QC. The QA/QC procedures are structured in accordance with applicable technical standards, United States Environmental Protection Agency (USEPA) requirements, regulations, guidance, and technical standards. This document consists of four volumes: an RI/FS Work Plan, a Field Sampling Plan (FSP), this QAPP which addresses the quality procedures that will be used for the work outlined in the RI/FS Work Plan, and a Health and Safety Plan (HASP). The FSP describes the general approach and methods that will be used for collection of groundwater, soil/bedrock, indoor air, leachate, and other applicable samples as outlined in the OU-3 RI/FS Work Plan. In addition, this QAPP covers general procedures for ensuring quality of geospatial data, when collected.

This QAPP has been prepared in general accordance with the following guidance documents:

- *American Nuclear Society Verification and Validation of Radiological Data for use in Waste Management and Environmental Remediation (ANS 2018)*
- *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (USEPA 1997)*
- *Guidance for Data Quality Assessment: Practical Methods for Data Assessment QA/G-9 (USEPA 2000a)* *https://www.epa.gov/sites/production/files/2015-06/documents/g9-final.pdf*
- *USEPA Data Quality Objectives Process for Hazardous Waste Site Investigations (USEPA 2000b),* *https://www.epa.gov/sites/production/files/2015-07/documents/g4hw-final.pdf*
- *USEPA Requirements for Quality Assurance Project Plans (QA/R-5; USEPA 2001),* *https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf*
- *USEPA Guidance for Quality Assurance Project Plans for Modeling (QA/G-5M; USEPA 2002a),* *https://www.epa.gov/sites/production/files/2015-06/documents/g5m-final.pdf*

- *USEPA Guidance for Quality Assurance Project Plans QA/G-5 (USEPA 2002b), https://www.epa.gov/sites/production/files/2015-06/documents/g5-final.pdf*
- *USEPA Guidance on Systematic Planning Using the Data Quality Objectives Process QA/G-4 (USEPA 2006a), https://www.epa.gov/sites/production/files/2015-06/documents/g4-final.pdf*
- *Guidance for Data Usability in Risk Assessment," Office of Solid Waste and Emergency Response (OSWER) (USEPA 1992a) https://semspub.epa.gov/work/05/424356.pdf*
- *Data Quality Assessment: Statistical Methods for Practitioners (USEPA QA/G-9S) (USEPA 2006c), https://www.epa.gov/sites/production/files/2015-08/documents/g9s-final.pdf*
- *USEPA Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) (July 2004a), https://www.epa.gov/radiation/marlap-manual-and-supporting-documents*
- *USEPA Guidance for Data Quality Assessment: Practical Methods for Data Analysis. QA/G-9 (USEPA 2000c), https://www.epa.gov/sites/production/files/2015-06/documents/g9-final.pdfUSEPA QA Field Activities Procedure CIO 2105-P-02.0 (USEPA 2014), https://www.epa.gov/sites/production/files/2015-03/documents/2105-p-02.pdf*
- *USEPA OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air (USEPA 2015), https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf*
- *USEPA New England Environmental Data Review Supplement for Region 1 Data Review Elements and Superfund Specific Guidance/Procedures (USEPA 2018), https://www.epa.gov/sites/production/files/2018-06/documents/r1-dr-supplement-june-2018.pdf*
- *USEPA Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) (USEPA 1989), https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf*
- *USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) (USEPA 2017a), https://www.epa.gov/sites/production/files/2017-01/documents/national_functional_guidelines_for_inorganic_superfund_methods_data_review_01302017.pdf*
- *USEPA National Functional Guidelines for Organic Superfund Methods Data Review (SOM02.4) (USEPA 2017b), https://www.epa.gov/sites/production/files/201701/documents/national_functional_guidelines_for_organic_superfund_methods_data_review_013072017.pdf*

Geospatial Guidance:

- *USEPA Guidance for Geospatial Data Quality Assurance Project Plans QA/G-5G (USEPA 2003), https://www.epa.gov/sites/production/files/2015-06/documents/g5g-final.pdf*
- *USEPA National Geospatial Data Policy (NGDP)(USEPA 2005), https://www.epa.gov/sites/production/files/2014-08/documents/national_geospatial_data_policy_0.pdf*
- *United States Geological Survey (USGS) Methods of Practice and Guidelines for Using Survey-Grade Global Navigation Satellite Systems (GNSS) to Establish Vertical Datum in the United States Geological: Techniques and Methods 11-D1 (USGS 2012), https://pubs.usgs.gov/tm/11d1/tm11-D1.pdf*
- *USGS The National Map Seamless Digital Elevation Model Specifications: Techniques and Methods 11-B9 (USGS 2017), https://pubs.usgs.gov/tm/11b9/tm11B9.pdf*
- *US Army Corps of Engineers Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums (EM 1110-2-6056) (USACE 2010), https://www.publications.usace.army.mil/LinkClick.aspx?fileticket=ZdUNOaOWxkI%3d&tabid=16439&portalid=76&mid=43544*

1.1 DOCUMENT ORGANIZATION

This QAPP for the WLL OU-3 RI/FS is organized as follows:

Section 2.0 – Project Management and Organization – This section describes the project management and organization of the project team for this project.

Section 3.0 – Data Quality Objectives – This section addresses specific quality procedures used in developing DQOs and the DQOs.

Section 4.0 – Data Quality Assessment – This section explains a general approach to data quality assessment. The assessment specifics are detailed in the RI/FS Work Plan.

Section 5.0 – Data Generation and Acquisition – This section specifies how data will be generated and required. Specifics on field and laboratory generation are also included in the FSP and the laboratory Standard Operating Procedures (SOPs).

Section 6.0 – Assessment and Oversight – This section addresses how quality will be assessed and verified (audits, reporting, etc.).

Section 7.0 – Data Validation and Usability – This section specifies data validation and usability standards that will be employed for the RI/FS.

Section 8.0 – References – This section lists references used in preparation of the QAPP.

1.2 ALIGNMENT WITH OU-3 RI/FS WORK PLAN

The objectives of OU-3 site characterization are to collect sufficient data to address the data gaps listed in the scope of work (SOW) as follows: refine the current understanding of the hydrogeologic system, identify the source of Constituents of Potential Concern (COPCs) in groundwater, characterize the current nature and extent of impacts to the hydrogeologic and hydrologic system, predict the potential nature and extent of impacts to the hydrogeologic and hydrologic system, evaluate exposure pathways to determine current and future human health and ecological risk, and evaluate remedies as necessary. These objectives will be met through implementation of nine overall studies tied to the data gaps outlined in the Administrative Settlement Agreement/Order on Consent (ASAOC) SOW. These studies form the basis for the DQO process for the OU-3 RI/FS:

Study #1 - Data Usability and Well Inventory

This study will include an evaluation of the usability of existing data in accordance with USEPA guidance. A detailed well inventory will be completed to evaluate usability of the existing wells identified as part of the OU-3 groundwater well network. Well redevelopment, repairs and/or well replacement will be completed as needed. Compilation of local and regional monitoring well information within a 2-mile radius will be completed using publicly available database information, including water levels, water quality data, well use, pumping rates, and well construction information.

Study #2 - Aquifer Properties

This study will involve collection of aquifer property information including both geology and hydrogeology at the site. Alluvial boreholes will be advanced and logged continuously to obtain hydrostratigraphic data and expand the sequence stratigraphy evaluation. Rock boreholes will be continuously cored and logged using geophysical techniques prior to monitoring well installation. Pneumatic or traditional slug tests are proposed at all new monitoring wells and existing monitoring wells not previously tested to address this data gap. Packer tests are proposed at select intervals and will be identified based on review of geophysical logs from new bedrock wells. A multi-well pumping test will be conducted at a background well with no COPC impacts to provide additional necessary input parameters for a groundwater model after the first phase of site characterization is complete. Continuous water level monitoring will be conducted in a select network of monitoring wells and staff gauges and compared to precipitation data to evaluate recharge rates. A pilot test using a hydraulic profiling tool is proposed to evaluate its potential to provide continuous hydraulic conductivity data. Hydraulic properties, potentiometric surfaces, COPC concentrations, and hydrostratigraphic thicknesses will be used to calculate mass flux and discharge of COPCs and prepare a water balance.

Study #3 - Regional and Localized Hydraulic Gradients

As part of this study, well installation, well gauging, and surface water gauging are proposed to evaluate the spatial variability of hydraulic gradients near-site and off-site. New multi-level wells are proposed to provide water level data to evaluate vertical gradients. Continuous water level monitoring is proposed at a select number of wells and all staff gauges in addition to manual water level and staff gauging to evaluate the temporal variability in areas near surface water or groundwater extraction points. Information from off-site wells will also be compiled to supplement the evaluation of regional groundwater gradients.

Study #4 - Background Groundwater Conditions

Background groundwater may contain appreciable concentrations of radionuclides due to the naturally occurring sources of uranium in bedrock in the St. Louis area. As part of this study, new background wells are proposed in the alluvium and bedrock to expand the existing dataset used by the USGS and develop background values for the COPCs that are representative of the spatial variability of background data. Data will be collected at a spatial and temporal frequency sufficient to establish statistically significant background conditions. Radium-228/Radium-226 (Ra228/Ra226) ratios in groundwater and aquifer matrix materials along with geochemical conditions will be used to evaluate the relative contribution of natural and anthropogenic radium.

Study #5 - Occurrence and Extent of Groundwater Impacts

Groundwater underlying the site and/or down-gradient from the site may contain elevated inorganic and organic constituents. In this study, on-site groundwater conditions will be studied through the installation of new wells, and sampling of both new wells and a subset of the existing wells already installed onsite. Leachate from the former quarry area will also be sampled to evaluate on-site groundwater quality. Off-site groundwater quality will be evaluated through installation of new off-site monitoring wells. The new on-site and off-site wells will be used to understand off-site groundwater conditions as compared to leachate and on-site / near-site water quality data, and estimate background radium activity levels. Water level data from the current and proposed wells will be used to evaluate the current and future distribution of groundwater impacts (if present) and assess exposure pathways. Property information about potential receptors will also be compiled for potentially affected properties. Leachate samples will be collected for comparison with groundwater data. Geochemistry data will be used to evaluate the potential for liberation of radium from alluvial and bedrock aquifer matrix samples.

Study #6 - Groundwater Geochemistry

Different redox conditions, mineralogy, and organic content can attenuate or mobilize radionuclides via exchange, adsorption, desorption, precipitation, co-precipitation, and dissolution. In this study, groundwater and aquifer matrix samples will be collected and tested for redox indicator parameters, inorganic constituents, radionuclide concentrations and mineralogy to evaluate the fate and transport of COPCs.

Study #7 - Effects of the Bridgeton Landfill

Current infrastructure such as the leachate extraction system and landfill gas extraction system at the Bridgeton Landfill could play an important role in the fate and transport of constituents in groundwater. In this study, water levels, pumping rates, groundwater quality, aquifer matrix radium concentrations, and leachate concentrations will be evaluated.

Study #8 - Vapor Intrusion

The potential for vapor intrusion into on-site or off-site structures has not been investigated. In this study, on-site indoor air quality will be assessed through testing of occupied, enclosed on-site structures for radon, methane, and volatile organic compounds (VOCs). Off-site indoor air quality will be evaluated based on the results of the proposed groundwater sampling. Groundwater data will be used to estimate off-site indoor air quality.

Study #9 - Groundwater and Surface Water Temporal and Spatial Variability

Previous investigations documented temporal variability in groundwater levels and flow direction. Groundwater elevations and flow direction may also be influenced by the elevations in nearby surface water bodies, including ponds and the Missouri River. In this study, groundwater and surface water level data will be collected to evaluate both the temporal and spatial variability of groundwater elevations and flow direction. Continuous water level monitoring will be conducted in a select network of wells; monthly manual gauging will be implemented for all monitoring wells within the proposed monitoring network during the OU-3 site characterization activities. Staff gauges will be installed in nearby ponds and stormwater basins located near the site and monitored continuously. Missouri River stage data will be downloaded from the USGS, and precipitation data will be downloaded from National Oceanic Atmosphere Association (NOAA).

2.0 PROJECT MANAGEMENT AND ORGANIZATION

This project will be managed as outlined in the expanded project Organization Chart, included as Figure 2-1. In general, the OU-3 Respondents will direct this project. Trihydro and its subcontractors will perform the field investigation, analyze data, prepare reports, and perform any subsequent studies. An overview of critical roles and responsibilities for regulators, OU-3 Respondents, Trihydro personnel, and laboratory personnel are included below. Additional responsibilities for each of these personnel may be required, as specified in associated guidance documents.

2.1 OU-3 RESPONDENTS RESPONSIBILITIES

The OU-3 Respondents have the responsibility to review and approve reports and verify that they meet the requirements of the RI/FS Work Plan. The OU-3 Respondents will ensure that the sampling activities are conducted in accordance with the applicable regulations and guidance documents, as referenced in the approved OU-3 RI/FS Work Plan, FSP, and Section 1.0 of this document. The OU-3 Respondents will review and propose modifications to the RI/FS Work Plan (as needed), make site visits, and critically review the final reports to ensure that the QA objectives have been achieved.

Additionally, the OU-3 Respondents' responsibilities for the project may include:

- Review and approve reports (deliverables)
- Review project schedule
- Review and analyze overall task performance with respect to planned requirements and authorizations

The OU-3 Respondents will be responsible for overall communication with the USEPA Region VII, MDNR, United States Army Corp. of Engineers (USACE), and the USGS in addition to other stakeholders.

2.2 OU-3 PROJECT COORDINATOR RESPONSIBILITIES

The OU-3 Project Coordinator has the responsibility for overall project completion and communication between the regulators, Respondents and contractors. Additionally, the OU-3 Project Coordinator's responsibilities for the project may include:

- Review, approve and transmit reports (deliverables)
- Prepare OU-3 monthly status reports for submittal to USEPA by the 11th of each month
- Manage overall schedule for the site

- Coordinate OU-3 activities, scope and schedule with the OU-1, OU-2, and OU-3 activities, scope, and schedule
- Notify USEPA and MDNR of field schedules

2.3 TRIHYDRO RESPONSIBILITIES

Trihydro will function as the primary contractor, with Ameriphysics and Feezor Engineering providing radiation safety roles. They will be responsible for the proper implementation and management of the RI/FS Work Plan, sample collection, and preparation of reports. Relevant roles outlined below include Trihydro Project Principal, Project Manager and Assistant Project Manager, Trihydro Field Team Leader, Trihydro Field Team Members, Trihydro Site Quality Control Officer, Trihydro Quality Assurance Director, Trihydro Site Health and Safety Officer, Radiation Safety Officer, Radiological Control Officer, and Trihydro Geospatial Director.

<u>Trihydro Project Principal</u>

The Project Principal maintains overall oversight and his responsibilities include the following:

- Review and approve final reports (deliverables) before their submission to the OU-3 Respondents
- Establish project procedures to address the specific needs of the project as a whole
- Review and analyze overall task performance with respect to planned requirements and authorizations
- Identify and insure commitment by both contractor and subcontractor resources

<u>Trihydro Project Manager and Assistant Project Manager</u>

The Trihydro PM and Trihydro Assistant Project Manager (APM) have the overall responsibility for the investigation with oversight by the OU-3 Respondents. The Trihydro PM and APM are responsible for implementing the project and have the authority to commit the resources necessary to meet project objectives and requirements. The Trihydro PM and APM's primary function is to ensure that regulatory, technical, financial, and scheduling objectives are achieved successfully. The Trihydro PM and APM will:

- Select, coordinate, and schedule staff for the work assignments
- Manage budgets and schedules
- Prepare progress reports for OU-3 Project Coordinator and Respondents
- Maintain and distribute the official approved QAPP
- Monitor and direct subcontractors engaged in implementing the OU-3 RI/FS
- Implement QA measures and any corrective action requirements

- Attend review meetings
- Interface with USEPA
- Perform final data assessment
- Monitor and direct the field leaders
- Develop and meet ongoing project and/or task staffing requirements, including mechanisms to review and evaluate each task product
- Review the work performed on each task to ensure its quality, responsiveness, and timeliness
- Prepare and assure quality of interim and final reports
- Conduct initial site safety training for project team personnel
- Ensure Trihydro and subcontractor field team personnel have read and understand the HASP
- Ensure that work performed by Trihydro is conducted in accordance with safe practices outlined in this plan
- Define project objectives and develop a detailed RI/FS Work Plan schedule
- Acquire and apply technical and corporate resources as needed to ensure performance within budget and schedule constraints
- Orient field leaders and support staff concerning the project's special considerations
- Review the work performed on each task to ensure its quality, responsiveness, and timeliness
- Assist with preparation of monthly progress reports to the USEPA
- Interface and provide project status updates to the OU-3 Respondents and OU-3 Project Coordinator
- Direct the organization of the data and final evidence file

The Trihydro PM and APM have responsibility for ensuring that the project meets the project required objectives and quality standards (outlined in the RI/FS Work Plan, FSP, and Section 1.0 of this QAPP). The Trihydro PM and APM will communicate the schedule of field events with the OU-3 Respondents. The Trihydro PM and APM will report directly to the OU-3 Project Coordinator and are responsible for technical QC and project oversight. The Trihydro PM and APM may communicate directly with the USEPA, MDNR, USACE, USGS, and other stakeholders at the request of the OU-3 Project Coordinator to communicate field events, schedule, and other related project communication.

Trihydro Field Team Leader

The Trihydro Field Team Leader (FTL) will conduct oversight of field activities. The Trihydro FTL will also be responsible for team supervision upon implementation of field activities, which will be in accordance with procedures in the associated EPA-approved FSP and this QAPP. The Trihydro FTL has the overall responsibility for the investigation in the field with oversight by the Trihydro PM and APM. The Trihydro FTL's primary function is to oversee the subsurface investigation and site assessment activities. The Trihydro FTL will:

- Select, coordinate, and schedule staff for the work assignments
- Plan and oversee field assessment activities
- Manage field subcontractors engaged in implementing the OU-3 RI/FS
- Manage the field sample collection team
- Evaluate shallow subsurface geology/hydrology and impacts
- Prepare progress reports to the Trihydro PM
- Ensure that field staff conduct work in accordance with the site HASP and FSP

The Trihydro FTL has the responsibility for ensuring that the field activities meet the guidelines identified in the FSP and RI/FS Work Plan. The Trihydro FTL will report directly to the Trihydro PM and APM.

Trihydro Field Team Members

Field team members will be responsible for conducting site reconnaissance; performing an ecological assessment; conducting a well inventory; oversee borehole advancement, borehole geophysical logging, packer testing, monitoring well installation, monitoring well development, surveying, and monitoring well abandonment; collect soil, aquifer matrix, and groundwater samples; conduct aquifer testing; and install and monitor staff gauges and pressure transducers. Decontamination of sampling equipment will be accomplished by the field team under the direction of the Trihydro FTL. Field team members will complete, and file personal daily time logs and complete field documentation forms, as indicated in the FSP. Field team members will submit field documentation forms to Trihydro and will relinquish custody of field samples to the contracted laboratory as outlined in the QAPP. Field team members will perform sample packaging and shipping. Field team members will comply with the provisions of the site-specific HASP, including the responsibility to stop work. Anyone involved with the project has "stop work authority", which can include stopping work for quality or safety concerns.

Trihydro Site Quality Control Officer

The site Quality Control Officer (SQCO) will check the completion of CoC forms, packaging and shipment of samples, and sample log book entries. The SQCO will check the daily time logs and field data forms for accuracy and compliance with the QAPP and FSP. The SQCO is responsible for maintaining field instrument calibration logs for field instruments. After review of documentation, the SQCO is responsible for storing and forwarding the documentation for filing in accordance with appropriate document control and security measures. The SQCO will be a member of the field team and report to the Trihydro FTL.

Trihydro Quality Assurance Director

The Trihydro Quality Assurance Director (QAD) will have direct access to contact the laboratories with QA/QC questions. The Trihydro QAD is responsible for auditing the implementation of the QA program in conformance with the demands of specific investigations under USEPA Superfund and Trihydro policies. The Trihydro QAD has the authority to stop work on the investigation as deemed necessary in the event of serious QA/QC issues. Specific functions and duties are to:

- Audit field memoranda prepared by field personnel to ensure that the procedures for sample collection and sample custody are strictly adhered to
- Review laboratory reports to ensure that adequate QA/QC procedures are imposed on the laboratory analytical results
- Review and approve QA plans and procedures
- Provide QA technical assistance to project staff
- Provide independent QA review of analytical data as part of the data validation process
- Report on the adequacy, status, and effectiveness of the QA program on a regular basis to the Trihydro PM and APM
- Distribute and re-distribute quality documents initially and upon revision

The Trihydro QAD reports directly to the Trihydro PM and will be responsible for ensuring that procedures for this project are followed. In addition, the Trihydro QAD will be responsible for organizing technical staff to complete Trihydro leveled validation including: Tier I validation/data verification, and/or Tier II, Tier III, or Tier IV data validations of sample results from the analytical laboratory. The specific definition of levels is included as Table 2-1 and validation levels are specified in the RI/FS Work Plan. Validation levels for specific portions of the project will be included in the RI/FS Work Plan.

Trihydro Site Health and Safety Officer

The site Health and Safety Officer (SHSO) will be present on-site during field operations and will be responsible for health and safety activities and delegation of duties to the health and safety staff in the field. The SHSO duties may be conducted by the Trihydro FTL or other on-site personnel, depending on the duties being performed and the ability to perform the role completely without compromising other duties. The SHSO will work with the Radiation Safety Officer (RSO) to verify that radiological control and safety programs are administered. The SHSO will be responsible for implementing the HASP. The SHSO will be responsible for assisting with any stop-work authority, which can be executed by any on-site personnel upon his/her determination of an imminent safety hazard, emergency condition, or other potentially dangerous situations, such as detrimental weather conditions. Authorization to proceed with work will be issued by the SHSO in conjunction with the PM and RSO as needed after such action. The SHSO will initiate and execute contact with support facilities and personnel when this action is appropriate. The SHSO will report to the Trihydro PM and APM and will work in coordination with the Trihydro FTL.

Radiation Safety Officer

The RSO is responsible for executive-level administration of the radiological control and safety program in accordance with prevailing procedures and industry practices. Specific responsibilities include the following:

- Establishing standards and guidelines for radiological operations
- Verify that site personnel are scanned prior to entering or leaving OU-1 Exclusion Zone
- Limiting occupational radiation exposures to levels that are as low as reasonably achievable
- Suspending any operation that presents a radiological or safety threat to employees, the environment, or the general public
- Ensuring the quality of protective equipment for personnel and prescribing usage standards
- Establishing procedures for radiological protection and monitoring
- Assuming overall responsibility for the radiation protection training program

Radiological Control Supervisor

The RSO will assign a designated Radiation Control Supervisor (RCS) to the project. The RCS is responsible for field implementation of the radiological control and safety program at the field level. The RCS has the authority to and shall order any operations suspended when such operations present an imminent radiological or safety threat or hazard to employees, the environment, or the public. The RCS will be present onsite at any time work is conducted in Area 1 or

Area 2. If the RCS must be away from the site, his or her responsibilities will be designated to an appropriately experienced Health-Physics Technician such that continuity of radiological supervision is maintained.

Trihydro Geospatial Coordinator

The Trihydro Geospatial Coordinator (GC) will conduct oversight of collection and use of geospatial data from external or internal sources. The Trihydro GC will also be responsible for communication between survey teams, Geographical Information System (GIS) analysts, the groundwater modeling team, and the Trihydro PM/APM, which will be in accordance with tasks in the associated RI/FS Work Plan and described in the FSP. The Trihydro GC has the overall responsibility for collection and use of geospatial data with oversight by the Trihydro PM and APM. The Trihydro GC will:

- Verify that resolution and accuracy of data collection sources (NGDP (USEPA 2005) Tier 2 Level Accuracy and Precision of 1-5 meter)
- Verify the best available data is used in preparation of figures and models
- Verify that mapping and digitizing meet quality requirements
- Manage geospatial data collection
- Review and verify geospatial points or coordinates

The Trihydro GC has the responsibility for ensuring that the field activities meet the guidelines identified in the FSP and RI/FS Work Plan. The Trihydro GC will report directly to the Trihydro PM and Trihydro APM.

2.4 SUBCONTRACTOR RESPONSIBILITIES

The proposed SOW will require subcontractors for drilling, surveying, sampling, laboratory services, and health and safety. In addition to the Trihydro personnel roles and responsibilities, second tier contractors may be required. These subcontractors were selected based on qualifications and experience related to the task at hand, quality of work, proximity to project site, health and safety record, cost effectiveness, and client approval. These subcontractors will be given the planning documents to review and will be required to commit to the quality and safety requirements referenced in these documents. The Trihydro PM will ensure that the activities of Trihydro's subcontractors will be carefully monitored and coordinated to comply with the safety and quality guidelines outlined in the QAPP and HASP.

2.5 LABORATORY RESPONSIBILITIES

Laboratory services will include groundwater, soil/bedrock, leachate, and indoor air analysis. Due to the range of analytical methods and specialty methods, no one laboratory can perform all of the tests. Therefore, four laboratory firms will be used as part of the OU-3 RI/FS activities, including Pace Analytical Services, Inc. (Pace), Materials and Chemistry Laboratory, Inc. (MCLInc), Earth Exploration, and ALS Environmental Laboratories. These laboratories will analyze groundwater, soil/bedrock, leachate, and indoor air samples as follows:

1. Five Pace locations will be used:
    a. Pace Indianapolis, Indiana (Pace-I) will analyze the groundwater, soil and bedrock samples and leachate for non-radionuclide analyses.
    b. Pace Pittsburgh, Pennsylvania (Pace-P) will provide radiochemistry analytical services.
    c. Pace Energy Services, LLC (Pace-E) Pittsburgh, Pennsylvania (Pace-E) will provide the dissolved gas analyses in groundwater/leachate samples.
    d. Pace Kansas (Pace-K) Lenexa, Kansas will provide analyses of Total Petroleum Hydrocarbon (TPH) and Cation Exchange Capacity (CEC)
    e. Pace Green Bay (Pace-G) Green Bay, Wisconsin will provide analyses of Total Organic Carbons (TOC)
2. Earth Exploration will analyze samples geotechnical samples and will be subcontracted by Pace-I.
3. MCLInc Oak Ridge, Tennessee: MCLInc is a specialty laboratory that will be performing analyses that are not able to be covered by Pace or ALS (large commercial laboratories). Due to the nature of these specialty analyses, the QA/QC procedures may slightly vary or be modified from the procedures discussed for other methods in the QAPP. These methods are described in greater detail in Section 5.1.2.2 and included in Appendix D as part of the laboratory SOPs. MCLInc will be performing: sequential extraction (as defined in Section 5.1.2.2), solids analyses by X-Ray Diffraction (XRD) analyses for major crystalline minerals and Scanning Electron Microscope with Energy Dispersive X-Ray Spectroscopy (SEM/EDS) for analyses of mineral reactivity, elemental identification, and ferrous iron and ferric iron in soils.
4. Two ALS locations will be used:
    a. ALS Environmental (ALS-S) Simi Valley, California will analyze indoor air samples for VOCs and methane.
    b. ALS Environmental (ALS-W) Winnipeg, Canada will analyze indoor air samples for radon.

Laboratory methodology, holding times, preservation requirements, and limits are specified in Tables 2-2 and 2-3. The laboratory organization structures and internal responsibilities for each of the laboratories are described in detail in the quality assurance manuals (QAMs) located in Appendix A. These documents outline specific training and organizational procedures that will be followed by each laboratory. Lastly, the location of laboratory, and associated laboratory SOPs are included in Appendix D.

Laboratory Project Managers

The Laboratory PMs will report directly to the Trihydro PM/APM and will be responsible for the oversight of production and final review of the analytical reports and the case narratives to verify that any data quality issues are thoroughly explained and the requirements of this QAPP have been met. The Trihydro QAD will serve as liaison between the laboratory and the Trihydro PM, APM, and FTL, as needed. They will communicate any special project instructions that affect the way that analyses are to be performed, the data evaluated, sample turnaround time, or the results reported. The operations managers or designee will inform the Laboratory PMs of samples status and will:

- Coordinate laboratory analyses
- Supervise in-house CoC
- Schedule sample analyses
- Oversee data review
- Oversee preparation of analytical reports
- Compare bottle orders (if applicable for the analyses) against bottle sets for accuracy and to ensure proper chemical preservation of bottle sets before they are shipped to the site
- Approve final analytical reports prior to submission to Trihydro
- Sign the title page of the QAPP

Laboratory Quality Assurance Officers

The Laboratory Quality Assurance Officers (QAOs) have the overall responsibility for data after samples arrive at the laboratory, during analyses, and during reporting. In addition, the Laboratory QAOs (or designee) will be:

- Oversee laboratory QA
- Determine compliance with the laboratory certifications
- Oversee QA/QC documentation
- Conduct detailed data review per laboratory requirements

- Determine whether to implement laboratory corrective actions, if required
- Define appropriate laboratory QA procedures
- Prepare and review laboratory SOPs
- Sign the title page of the QAPP
- Verify that instrument controls are in place
- Verify radiological labeling and safety procedures are followed

The Laboratory PMs, prior to release of data will provide internal QA review of data to verify that they are within project objectives and are in accordance with state and federal regulatory requirements and the terms of their accreditations.

<u>Laboratory Sample Custodians</u>

The Laboratory Sample Custodians will report to the Laboratory PMs and be staffed by laboratory personnel. Responsibilities of the Laboratory Sample Custodians are:

- Receiving and inspection of incoming sample containers
- Recording the condition of the incoming sample containers
- Signing appropriate documents
- Verifying CoC documentation
- Notifying the laboratory PM of sample receipt and inspection
- Assigning a unique identification number and customer number, and entering each into the sample receiving log
- Notifying the PM/APM when samples are received indicating the sample names, sample condition, and sample parameters to be analyzed
- With the help of the laboratory PM, initiating transfer of the samples to appropriate lab sections
- Controlling and monitor access/storage/disposal of samples and extracts
- Verify that radiological samples are stored in a restricted area and accessible only to authorized personnel

The Laboratory technical staff will be responsible for sample analysis and identification of corrective actions. The staff will report directly to the laboratory PM and QAO or designee.

3.0 DATA QUALITY OBJECTIVES

DQOs are qualitative and quantitative statements used to clarify the study objectives, define the appropriate type of data to collect, determine the appropriate conditions from which to collect the data, determine the quality of the data used to support decisions at the site, and specify tolerable limits on decision errors. Preparation of these DQOs generally followed the USEPA *Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA QA/G-4)* (USEPA 2006a). Based on the OU-3 site-specific needs, information has been compiled for the seven DQO steps for the OU-3 RI/FS:

1. State the Problem
   1.1. Description of the Problem
   1.2. Conceptual Model of the Environmental Hazard
   1.3. Project Resources - Budget, Personnel, and Schedule
2. Identify the Goal of the Study
   2.1. Identify Principal Study Questions
   2.2. Alternative Outcomes
   2.3. Decision Statements / What Needs Estimated and Key Assumptions
3. Identify Information Inputs
   3.1. Types and Sources of Information
   3.2. Informational Basis of Performance Criteria
   3.3. Availability of Sampling and Analysis Methods or Data
4. Define the Boundaries of the Study
   4.1. Target Population
   4.2. Temporal and Spatial Boundaries
   4.3. Potential Practical Constraints on Data Collection
   4.4. Appropriate Scale for Decision-Making
5. Develop the Analytical Approach
   5.1. Population Parameters

5.2. Action Levels and Decision Rules

6. Specify Performance or Acceptance Criteria

7. Develop the Plan for Obtaining Data

7.1. Sampling Design

7.2. Key Assumptions

Detailed DQOs have been developed for the OU-3 RI and are documented in Table 3-1. The OU-3 DQOs have been organized around the data gaps identified in the ASAOC SOW, which have been consolidated into nine studies:

1. Data Usability and Well Inventory
2. Aquifer Properties
3. Regional and Localized Hydraulic Gradients
4. Background Groundwater Conditions
5. Occurrence and Extent of Groundwater Impacts
6. Groundwater Chemistry
7. Bridgeton Landfill
8. Vapor Intrusion
9. Groundwater and Surface Water Temporal and Spatial Variability

In addition to the tabular format (Table 3-1), a narrative description of the DQOs is also summarized herein. Due to the number of studies, DQO Steps 1-7 are presented for each study individually rather than separately for efficiency purposes. However, Description of the Problem (Step 1.1), Conceptual Model of the Environmental Hazards (Step 1.2), and Project Resources (Step 1.4) are the same for each step and are presented only once below in Sections 3.1 and 3.2.

3.1 DESCRIPTION OF THE PROBLEM (STEP 1.1)

The problem definition is a description of the conditions which led to the initiation of the RI/FS process. For the OU-3 RI/FS, existing on-site groundwater data led to issuance of the ASAOC, which noted that “additional data are needed to determine the nature, extent, and source of groundwater contamination at the site, the potential for such contamination to migrate beyond site boundaries into critical exposure pathways, the mechanisms of contaminant migration and attendant risks posed to human health and the environment" (USEPA 2019a). This statement forms the basis for the problem definition:

Petroleum hydrocarbons, VOCs, trace metals, trace anions, and various radionuclides have been detected in groundwater at the WLL OU-3 site. The nature and extent of site-related impacts to groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.

This problem statement applies to all nine studies noted above in Section 3.0.

3.2 CONCEPTUAL MODEL OF THE HAZARD (STEP 1.2)

A preliminary conceptual model of the hazards for OU-3 groundwater conditions includes the following elements:

1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area.
2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials.
3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater.
4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill.
5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site.
6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors.
7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors.
8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.

3.3 PROJECT RESOURCES - BUDGET, PERSONNEL, AND SCHEDULE (STEP 1.3)

The project resources include the budget for the work, the availability of personnel, and the anticipated project schedule. The current budget estimate for the OU-3 RI completion is $11 million through 2023 exclusive of long-term monitoring and agency fees. Trihydro has identified specific project personnel and subcontractors to complete the OU-3 RI/FS SOW. The OU-3 RI/FS project team is shown on Figure 1-1. Roles for individuals are referenced in Section 2.0. In addition to Trihydro and the Respondents, the USEPA, USACE, USGS, and MDNR will also provide input in the development of the DQOs and planning for the OU-3 RI/FS Work Plan. The project team will include:

- Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE
- OU-3 Project Coordinator: Paul Rosasco (Engineering Management Support, Inc. [EMSI])
- Stakeholders: USEPA Region 7, MDNR, USACE
- Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc. [AMO])
- Trihydro: Allison Riffel (PM), Michael Sweetenham (APM), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Technical Lead for Modeling), Craig Carlson (Technical Lead for Radiation), Andrew Pawlisz (Technical Lead for Risk Assessment), Justin Pruis (Technical Lead for Vapor Intrusion)
- Subcontractors: Ameriphysics (Radiation Safety, Health Physicist); Feezor Engineering (Radiation Safety, Field support); Chad Drummond (Geochemical/ Radionuclide Modeling); and these laboratories: Pace; MCLInc; Earth Exploration; and ALS.

This project resource description applies to all nine studies noted above in Section 3.0.

3.4 STUDY #1 - DATA USABILITY AND WELL INVENTORY

3.4.1 DATA GAPS (STEP 1.3)

Over 100 monitoring wells were previously installed on-site and near-site to characterize impacts to groundwater. A portion of these wells were plugged/abandoned over time. There are currently 86 existing monitoring wells, which are located on-site or near-site. The existing wells have been sampled from 1979 to 2019. The adequacy and usability of data collected from these wells to characterize impacts needs evaluated for the parameters that will be utilized as part of the OU-3 studies.

The usability of historical data is important in understanding potential extent of impacts and transport. It is unknown whether additional validation efforts are necessary for the desired data set; however it is likely that the more recent data have already been validated to meet the requirements of the OU-3 QAPP.

As part of the OU-3 investigation, these 86 existing wells are proposed to be included as part of the overall OU-3 well network. The OU-3 well network will include the 86 existing wells and 64 proposed wells, resulting in a proposed network of 150 wells. It is unknown whether the proposed OU-3 well network will ultimately be sufficient for evaluating nature and extent of site-related impacts and characterize background groundwater conditions.

Additionally, there may be existing wells offsite that may provide useful hydrogeologic information, but an off-site well inventory has not been completed since 2018. There may be existing wells offsite within a two-mile radius which may be impacted by groundwater from the site. Sampling of these wells may be necessary to determine if groundwater has been impacted from the site. No drinking water wells were identified in 2018 within two miles of the site, but that may have changed over time.

3.4.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.4.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #1 Data Usability and Well Inventory**) is to answer the following questions:

1. Are the existing monitoring wells (86 wells) currently constructed such that representative samples can be collected?
2. Is the existing, plus proposed well network adequate for future groundwater monitoring in terms of horizontal and vertical distribution?
3. Are historical data from the existing monitoring wells of sufficient quality to use for future data analysis?
4. Are the well survey data accurate given the potential for land subsidence at the site and are the data consistently based on the same datum: North American Datum (NAD) 83 State Plane (horizontal) and North American Vertical Datum of 1988 (NAVD88) (vertical)?
5. Are there existing monitoring wells that need repaired?
6. Are there existing monitoring wells that need to be plugged/abandoned?
7. Do existing wells need redevelopment?
8. What wells exist within a 2-mile radius of the site?

9. Are there drinking water wells within a 2-mile radius of the site that may be impacted by the site groundwater?

10. Are any of the wells to be sampled as part of the OU-3 activities going to be removed due to the OU-1 remedial implementation?

3.4.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

The assumption for **Study #1 Data Usability and Well Inventory** is that the existing available data is inadequate to complete the RI/FS and that updated site-specific information is needed from an expanded monitoring well network to address this data gap. However, alternative outcomes are possible and may slightly change the approach. Some of those outcomes may include:

1. The existing well network may be adequate without any well repairs or well plugging/abandonment.

2. New wells are necessary near the site to provide data from the area surrounding the site where the well spacing is too large and where an incomplete vertical interval is being monitored. New wells are also necessary off-site since this area has not yet been assessed. There are a number of different potential wells that could be proposed to complete the well network based on vertical and lateral spatial distribution. In some locations, not all five zones may be present as anticipated based on nearby lithology, which could trigger the need for additional wells elsewhere. Another alternate outcome is that access is not granted to off-site properties for the proposed well installation activities.

3. None, some or all of the historic data set may be of sufficient quality for future data analysis.

4. All or some of the existing monitoring wells may need to be resurveyed to determine current vertical elevation and lateral location using the same data.

5. None, some, or all of the existing monitoring wells may need to be repaired.

6. None, some, or all of the existing monitoring wells may need to be plugged/abandoned.

7. The wells may need redeveloped or may not require redevelopment.

8. The same number of wells may be identified offsite within a 2-mile radius as in 2018, or more wells or fewer wells are identified.

9. The same number of drinking water wells may be identified within a 2-mile radius as in 2018, or more wells are identified.

10. It is possible that the proposed turbidity threshold of 5 NTU is not achievable.

3.4.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

The OU-3 RI/FS Work Plan and FSP includes procedures for installing additional monitoring wells, testing the subsurface hydrogeologic conditions, performing multi-media sampling, and implementing a 2-year quarterly monitoring plan. After completion and review of the quarterly sampling monitoring results, if additional wells, testing, and/or sampling are deemed necessary, additional work will be proposed. In order to complete **Study #1 Data Usability and Well Inventory**, the following information will be obtained and documented in a Well Inventory Summary Report:

1. The lateral and vertical well spacing.
2. A review of historical data to determine final data quality.
3. New northing, easting, and vertical elevation data for existing wells. Corrections need to be made to historical datasets to create an accurate historical record of water level elevations.
4. A list of wells that need repaired.
5. A list of wells that need plugged/abandoned.
6. A list of wells that need redeveloped.
7. Geospatial, well construction, water level, water quality, and well use information for wells within a 2-mile radius of the site.

3.4.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next, a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.4.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #1 Data Usability and Well Inventory**. Historical documents from OU-1, OU-2 and regional publications are available with well construction information, well location and screening interval information, and water level and water quality information. A professional land surveyor will be used as a source of survey data for the existing and proposed OU-3 wells.

Site visits will be coordinated for the well inventory to identify wells requiring repairs if damaged casing or wells pads, or missing components, including well lids, bolts, gaskets, j-plugs, or locks are observed. Historical documents and the site visits will be used to determine whether there are any wells that will need to be plugged/abandoned. In order to determine if any wells require redevelopment, turbidity readings will be collected using a Horiba Flow-Through Cell field parameter meter or similar during groundwater sampling activities. Total depth readings will also be a source of data to determine if well redevelopment is necessary; however, any dedicated pumps within the wells must be removed from the existing wells to collect this reading.

Historical documents will also be used as a resource to evaluate well distribution relative to potential groundwater flow directions, potential sources of groundwater impacts, and receptors. In addition to historical documents, data from the proposed OU-3 Remedial Investigation (RI) off-site wells can be used to determine if the proposed and existing well network is adequately defining the groundwater nature and extent.

Missouri State well databases, Environmental Data Resources (EDR) database reports, and OU-1/OU-2 historical reports are available to identify potential wells (including drinking water wells) in the area. Water connection information may be available from the local water providers to identify parcels without tap water service.

3.4.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The suitability of the information obtained in **Study #1 Data Usability and Well Inventory** will be evaluated relative to the following resources:

- The Missouri State Well code will be used to establish criteria for the well inspection and for making decisions with respect to well repairs, well abandonment, and well replacement.
- The basis for the determining the need for well redevelopment will be by degree of turbidity and degree of sedimentation of the screened interval in the well. A turbidity threshold of 5 Nephelometric Turbidity Unit (NTU) is a goal established by Puls and Barcelona (USEPA 1996), which will be used, where achievable, to reduce the possible error associated with the presence of particulates biasing total metals/radionuclide data. The basis for the well screen occlusion criteria is 10% or greater as per the guidance document entitled *USEPA Groundwater Forum, Monitoring Well Development Guidelines for Superfund Project Managers, April 1992* (USEPA 1992b).
- The number of and distribution of monitoring wells will be evaluated for adequacy by including sufficient wells to delineate off-site groundwater impacts from the site (if any), establish background water quality, provide sufficient information to populate a groundwater flow model, provide sufficient information to complete a human health and ecological risk assessment, and design a remedy (if needed).

- Previously collected data will be evaluated relative to the data validation standards in Section 7.0 to the extent possible to determine if results can be used as is, or if the data require qualification, or cannot be relied upon. Data that have already been validated in accordance with this QAPP will not be revalidated. The level of validation for older data without the Level IV QA/QC data package will be validated to the level possible based on the QA/QC data available for that particular data set.
- Historical documents will be used to compare the new survey data, including previous survey datum.
- Existing off-site well information may be included in the OU-3 database if it meets the requirements of this QAPP in terms of data quality as defined in Section 7.0.

3.4.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources noted above for **Study #1 Data Usability and Well Inventory** are generally available from the OU-1 and OU-2 WLL USEPA administrative record and MDNR website, including historical documents with well inventory information, survey data, water level data, and water quality information. Significant portions of the available well data from historical reports have already been compiled. Well inventory procedures are also available and were used to generate a proposed well inventory form, which was included in the FSP. In terms of procedures for analyzing the adequacy of the number of wells, the evaluation method will consist of tabulation of the number of wells per vertical interval, the spatial distribution of wells, an evaluation of the well screen depths, and followed by a statistical test to evaluate if sufficient data are available in each zone (e.g., shallow, intermediate, and deep alluvium; St. Louis/Upper Salem; and Lower Salem) and/or model layer.

3.4.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.4.4.1 TARGET POPULATION (STEP 4.1)

The target population for the well inventory included in **Study #1 Data Usability and Well Inventory** includes the 86 existing monitoring wells listed in the OU-3 RI/FS Work Plan Table 5-3 and illustrated Figure 5-5. The target data population for the off-site well search includes existing groundwater wells within a 2-mile radius of the site, including active or inactive domestic, drinking water, irrigation, livestock, industrial water supply, injection wells, monitoring wells, and extraction wells.

3.4.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

The temporal boundary for the well inventory includes historical onsite well construction, water level, and water quality data is limited to the date of well installation at the site, which is 1979 for the 86 wells in the proposed OU-3 well network.

The spatial boundary for the off-site well search is a 2-mile radius around the facility, which includes the properties west of the site up to the Missouri River and the developed properties north of the site. The temporal boundary for the off-site well search will be limited to the date the MDNR well records began. Online well records are available for wells drilled after 1987; offline records are available for older wells from MDNR. The spatial boundary for the on-site and off-site OU-3 well network is shown on Figure 3-16 of the RI/FS Work Plan as the study area. The vertical boundary of the well network is the base of the Keokuk Formation.

3.4.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #1 Data Usability and Well Inventory**. Historical documents may have missing or incorrect well construction information such as records which do not reflect subsequent well modifications. Well installation logs may be incomplete due to poor or no recovery during coring. Well location data may include different survey datum from current standards, which may or may not be evident in the available documentation. Existing water quality data may require a significant level of effort to migrate the data into a modern database format, the laboratory data may be incomplete, and laboratory QA/QC documentation may be missing.

Potential obstacles for the well survey and well inventory could include lack of access to the well location due to landfill or other site activities. During the well inventory, wells may also not be able to be located due to land disturbances and/or vegetation growth. During completion of well plugging/abandonment, practical constraints may arise such as atypical well construction. Collection of turbidity readings may be incomplete due to insufficient water in the well or damage to the well or pump. The presence of a dedicated pump may create an obstacle for collection of total depth readings. Total depth readings could skew turbidity readings if sediment at the base of the well is disturbed.

The proposed off-site well search may be constrained by inaccurate or incomplete state well databases or environmental database report. Locating private water wells may be challenging due to lack of landowner information.

3.4.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for Study #1 Data Usability and Well Inventory is the individual well being evaluated as part of the well inventory. Decisions based on the data from the professional land survey and total depth readings will be made based on the nearest 0.1 feet (ft) (lateral) and 0.01 ft (vertical). Decisions based on the turbidity measurements will be made to the nearest 0.1 NTU.

3.4.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.4.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #1 Data Usability and Well Inventory** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #1, the population is generally the individual wells and the data obtained from each well, including well condition, survey data, water level, and water quality data.

3.4.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

The decision rules for **Study #1 Data Usability and Well Inventory** include:

- Wells that are damaged, compromised, or not adequately constructed will be evaluated to determine if they can be repaired or need to be replaced. In some instances, a well could be useable for water levels but not sampling depending on the well defect. If existing wells need repairs in order to meet Missouri Well Code and provide representative data, the well repairs will be conducted prior to sampling as part of the OU-3 RI activities. If existing wells need to be plugged/abandoned due to irreparable damage, the well plugging/abandonment will also be conducted. Wells that are to be abandoned/removed as part of upcoming OU-1 remedial action will be evaluated to determine if replacement at a nearby location is necessary and/or feasible. If turbidity readings at individual wells exceed 5 NTU or more than 10% of the well screen is occluded with sediment, wells will be redeveloped prior to sampling.
- If the well spacing (lateral) or vertical distribution is insufficient for the purposes of delineation of groundwater impacts, preparation of a groundwater model, or a risk assessment, additional wells will be installed as part of the OU-3 RI.
- If historical data are not of sufficient quality to use as part of a groundwater model or risk assessment or site characterization, the data will be evaluated to determine if it requires qualification or rejection.

- If necessary, corrections will be made to the historical water level records to account for differences in datum. If the new survey data indicates that vertical subsidence has potentially occurred, the historical data will be corrected as noted in the OU-3 RI/FS Work Plan.
- Wells located within a 2-mile radius from the site will be evaluated for the potential risks due to groundwater impacts and will be evaluated to determine if select data from the well may be helpful for the groundwater model or risk assessment. If human health or ecological risks exist related to the use of well water impacted from the WLL OU-3 site, corrective measures will be evaluated on a case by case basis.

3.4.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #1 Data Usability and Well Inventory**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified.

A decision error could occur if wells are identified as suitable for sampling but have issues which prevent sampling or bias the data. The spatial distribution of the well network could be deemed adequate but additional wells may be necessary for the risk assessment, the groundwater model, or to completely characterize groundwater conditions. The completeness objective for the well inventory is that 95% of the data will meet data quality objectives. The acceptable limits of uncertainty for the well survey will be 0.1 ft (lateral) and 0.1 ft (vertical). The acceptable limits of uncertainty for turbidity will be 0.1 NTU. The acceptable level of uncertainty with total depth measurements will be 0.1 ft.

3.4.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.4.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #1 Data Usability and Well Inventory** includes the following tasks:

1. Complete an inventory of 86 existing monitoring wells as noted in Table 5-3 of the OU-3 RI/FS Work Plan. Document the well integrity on the Well Inspection Form (Appendix A of FSP) and in the USEPA-accessible database.

2. Collect two years of quarterly groundwater monitoring data at 150 wells (86 existing wells and 64 new wells) to evaluate groundwater flow direction and water quality near-site and off-site. Based on the results of the first two quarters of groundwater data, determine if additional wells are necessary to complete lateral and vertical delineation, support the groundwater flow model, and the risk assessment.

3. Review historical data set relative to QAPP requirements if data were not previously validated and apply data qualifiers if necessary. Update the USEPA-accessible database with the historical data.

4. Complete a well survey and prepare a table with well northing, easting, and vertical top of casing and ground surface elevation measurements. Update the USEPA-accessible database. Compare new elevations with previous elevations and identify potential areas of subsidence or other inconsistencies. Determine if historical water level readings need correction or omission from further use.

5. Complete repairs on wells as necessary. Document repairs in the field log book and database.

6. Evaluate timing for wells requiring plugging/abandonment based on OU-1 and OU-2 field activities, risks associated with the well, and overall schedule.

7. Redevelop wells with elevated turbidity (5 NTU) or occluded screens (>10% of the well screen) prior to sampling. Document redevelopment on the field form (Appendix L of FSP), log book, and in the USEPA-accessible database.

8. Submit request for state well database records and environmental database records. Compile findings and identify potential receptors. Also identify wells which may provide helpful data for the risk assessment and groundwater model. Evaluate approaching private well owners as necessary for well access.

9. Determine if drinking water well testing or water replacement is warranted based on off-site groundwater well data, flow direction, drinking water well depth, and well use.

3.4.7.2 KEY ASSUMPTIONS (STEP 7.2)

Key assumptions associated with **Study #1 Data Usability and Well Inventory** include:

1. Inactive/unknown wells are accessible for well survey/inventory.

2. Access will be granted for proposed off-site wells by landowners.

3. Historical data has sufficient QC information from which to validate the data.

4. Wells are accessible for surveying. Historic water level data datum is known.

5. Wells can be accessed for repairs.

6. Wells can be accessed for plugging/abandonment activities. Timing of well plugging/abandonment can be evaluated on a case-by-case basis to avoid interfering with other work tasks in OU-1, OU-2, and OU-3.
7. Wells can be redeveloped successfully to reach 5 NTU during sampling and if 5 NTU cannot be achieved, the well will be redeveloped by removing 10 well casing volumes prior to sampling.
8. Well records include desired data regarding location, well construction, ownership, etc.

3.5 STUDY #2 – AQUIFER PROPERTIES

3.5.1 DATA GAPS (STEP 1.3)

Recharge and discharge rates and hydraulic conductivities have been measured at some locations, but additional site-wide data is required for a complete fate and transport evaluation.

3.5.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.5.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of **Study #2 Aquifer Properties** is to answer the following questions:

1. What is the aquifer recharge rate for each water-bearing zone within the study area?
2. What is the aquifer discharge rate for each water-bearing zone within the study area?
3. What is the hydraulic conductivity for each water-bearing zone within the study area?
4. What are the other important aquifer properties (saturated thickness, transmissivity, specific yield, storage coefficients, porosity) for each water-bearing zone within the study area?
5. Are significant fractures or cavities present in bedrock which may affect groundwater transport?
6. What is the off-site geology within the alluvium and bedrock?

3.5.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

It is possible that previous reports might have correct or incorrect geological and hydrogeological information and conclusions. The assumption for **Study #2 Aquifer Properties** is that the reliance on the existing monitoring wells and aquifer characterization data is not adequate to prepare a thorough Conceptual Site Model (CSM) and complete the

RI/FS. However, alternative outcomes are possible and may slightly change the approach. Some of those outcomes may include:

1. The recharge rate may be low, medium, or high.
2. The discharge rate may be low, medium, or high.
3. The hydraulic conductivities for off-site locations and untested on-site locations is either similar or substantially different from previously estimated values.
4. The other aquifer properties of each water-bearing zone are similar or different from previously estimated values, or the other aquifer properties may not have been previously estimated.
5. The uppermost portion of the Salem Formation may contain no fractures, no significant fractures, or significant fractures. Cavities may be present in the bedrock or not, and may or may not be of significance to the CSM.
6. The off-site geology may vary from the documented on-site lithology.

3.5.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #2 Aquifer Properties**, a series of geologic and hydrogeologic parameters need to be determined. These parameters will be used to construct a groundwater model, which is needed to consolidate the aquifer property information for the purposes of evaluating groundwater fate and transport. Historical reports are needed to obtain surface water and groundwater elevation data. Monthly manual measurements from the proposed OU-3 well network of 150 wells as listed in Table 5-3 in RI/FS Work Plan are needed, which includes the 86 existing wells and 64 proposed wells.

Due to the potential temporal variability in groundwater levels, continuous data collection is needed in areas where the temporal fluctuations are rapid. A subset of the proposed well network has been identified for continuous groundwater level data collection based on two factors:

1. The proximity to surface water bodies which may have rapid temporal changes in water levels.
2. Spatial distribution such that triplicate well nests are available to perform a three-point problem for groundwater gradient calculations.

There are 70 wells identified for continuous groundwater level monitoring based on these criteria, including 50 of the new wells and 20 of the existing wells as listed in Table 5-5 in the OU-3 RI/FS Work Plan. Nine staff gauges are needed to collect continuous surface water data over a two-year period. Precipitation records from the area (including

Lambert Field) will be used for precipitation data. Borehole logging and downhole geophysics data (resistivity and formation conductivity) will be needed for understanding lithology, including cavities and fractures. Packer tests and slug tests are needed to measure hydraulic conductivity. Grain size analysis is needed to estimate the porosity of each aquifer zone. Groundwater velocity, transmissivity, and other properties will be estimated from water levels, estimated groundwater gradients, measured and published hydraulic conductivity values, and calculations of aquifer thicknesses based on water level measurements.

3.5.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.5.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #2 Aquifer Properties:**

1. Precipitation reports published by NOAA from the area will be a source of recharge data.
2. Historical surface water elevations in nearby surface water bodies will be a source of recharge data. New surface water elevation data will be collected as part of the OU-3 RI activities from staff gauges.
3. Historical reports will be used as a source of water levels, and hydraulic conductivity values. New hydraulic conductivity data will be collected through packer tests and slug testing within the study area as part of the OU-3 RI activities.
4. Historical reports will be used as a source for aquifer properties. New data will be collected on aquifer properties within the study area as part of the OU-3 RI activities.
5. Visual inspection of bedrock cores, images of borehole walls, and borehole diameter measurements will be sources of data on fractures and cavities.
6. Visual inspection of soil and bedrock cores, resistivity, formation conductivity, bulk density, grain size analysis, and Atterberg Limits will be sources of geologic characterization data.

3.5.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The suitability of the information obtained in **Study #2 Aquifer Properties** will be evaluated relative to historical reports to identify and qualify potential outlier data.

3.5.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #2 Aquifer Properties** are available, including precipitation data from Lambert Airport and Missouri River surface water elevations, including USGS St. Charles Missouri River Gauge (0693596). To supplement the Missouri River surface water data, nine proposed staff gauges are included in the OU-3 RI/FS Work Plan. Seven of these staff gauges are located on private property, installation at these locations is dependent upon obtaining access agreements with the respective property owners. Field analysis methods are available for the proposed tasks, including packer testing and slug testing methodology for measuring hydraulic conductivity, borehole logging, and downhole geophysics. Laboratory methods are available for mineralogic analysis of the aquifer matrix samples. Groundwater models are available (MODFLOW or finite element models) to evaluate aquifer properties and fate and transport questions.

3.5.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.5.4.1 TARGET POPULATION (STEP 4.1)

For precipitation and surface water data, the target population is data from existing and proposed rain and staff gauges. The target population for **Study #2 Aquifer Properties** includes existing well locations with documented aquifer property information, or that can be tested for aquifer properties, as well as the proposed wells in the OU-3 RI/FS Work Plan.

3.5.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

Missouri River stage data is available back to 1929, but information dating that far back will likely not bring added value to the investigation. The temporal boundary for the aquifer characteristics like mineralogy, hydraulic conductivity, and permeability is unlimited since these parameters are unlikely to change over time. The spatial boundary for the aquifer properties data will be the model boundary since this information is necessary for the groundwater model.

3.5.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #2 Aquifer Properties**. The collection of historical precipitation data and surface water data could be constrained by lack of availability or gaps in the historical record. The collection of new surface water data and installation of new wells could be hindered by lack of access to private property or landfill operations.

3.5.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #2 Aquifer Properties** is the individual rain gauge, staff gauge, or well being monitored. Decisions based on the data will be made based on the following minimum scales:

1. Precipitation data scale is 0.01 inches.
2. Surface water elevation scale is 0.01 inches.
3. Depth to water readings during slug testing from transducer scale is 0.01 ft. The hydraulic conductivity scale will be three significant digits in feet per day (ft/day).
4. The scale for the groundwater velocity is 0.01 ft/day. The scale for transmissivity is 0.1 gallons per day per ft. The scale for aquifer thickness is 0.1 ft.

3.5.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.5.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #2 Aquifer Properties** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #2, the population is generally the individual rain gauges, staff gauges, and wells, and the data obtained from each rain gauge, staff gauge and well, including precipitation data, water level, and aquifer matrix data.

3.5.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

Once historical and new data collected as part of **Study #2 Aquifer Properties** are evaluated to identify outliers and qualified if necessary, the data will be added to the USEPA-accessible database. These data will be used to refine the CSM, construct a groundwater model, and prepare summary figures. New slug testing data, water level data and aquifer thicknesses will be evaluated to identify outliers and qualified if necessary. Then these data will be used to calculate aquifer properties.

3.5.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #2 Aquifer Properties**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified.

A decision error could occur if the data collected on the aquifer properties of the water-bearing zones do not contain representative data or decisions are made based on an inadequate sample set. Performance criteria for the slug tests will be based on the recovery period and water level changes. Aquifer/waste property tests that exhibit a short recovery period (<30 seconds), small head/pressure change (<0.5 ft), or both, will carefully evaluated and reviewed to determine the acceptability of those data. Tests experiencing longer recovery periods and larger head/pressure changes are typically able to test a larger portion of the aquifer farther away from the borehole, and therefore often yield better and more representative conductivity data. Measurement errors can occur with the data recording equipment and field implementation and could also lead to decision error. The test results will also be compared to a plausible range of aquifer/waste properties obtained from the previous site investigations as well as technical research of published values for the formations and types of geologic units.

The completeness objective for precipitation data, and new water level, surface water readings, and aquifer thickness measurements is that 95% of the data will meet data quality objectives. The uncertainty with the precipitation data is ±0.1% (Geonore T-200B Rain Gauge). The uncertainty with water level readings is ±0.05% of the pressure at the depth of deployment (Solinst Levellogger) or 0.006 ft; the associated barometric pressure logger uncertainty is 0.0346 ft. The uncertainty with surface water level readings is ±0.01" based on the vented In Situ Level Troll 700H. The uncertainty is ±0.01 ft for the manual water level meter (Solinst). Results from two rising head slug tests will be analyzed; the geometric mean of the two hydraulic conductivity measurements will be used. The uncertainty with the packer test flow readings is ±1 gallon per minute. The uncertainty with aquifer thickness measurements is ±0.01 ft.

3.5.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.5.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #2 Aquifer Properties** includes the following tasks:

1. Download hourly precipitation data from NOAA Lambert Field rain gauge in inches back to 1938. Update site database with measurements. Evaluate data for outliers that may need to be qualified.

2. Install staff gauges in nine surface water locations. Install pressure transducers (In Situ Level Troll 700H or similar) in each staff gauge to monitor surface water elevation. Deploy barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar). Program pressure transducers to collect water level data every hour. Download surface water elevation data monthly. Collect manual surface water elevation readings monthly for correlation purposes. Correct surface water elevation readings for barometric pressure. Evaluate variability in surface water elevations on a daily, weekly, monthly, seasonal, and yearly basis. Compare groundwater elevations to surface water elevations and determine if groundwater discharges to surface water.

3. After proposed monitoring wells are installed:

    - Deploy pressure transducers (In Situ Level Troll or similar) in 20 existing wells and 50 proposed wells to monitor water level elevations. Deploy barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar). Program pressure transducers to collect water level data every hour. Download water well elevation data monthly. Collect manual water level elevation readings monthly for correlation purposes. Correct water level elevation readings for barometric pressure. Evaluate variability in water level elevations on a daily, weekly, monthly, seasonal, and yearly basis. Compare groundwater elevations to surface water elevations and determine if groundwater discharges to surface water.

    - Complete slug testing of all new wells (64 new wells) and untested existing wells within the proposed well network. Two rising head tests slug tests will be performed. Manual slug tests using a solid slug will be performed on shallow alluvial wells; pneumatic slug tests will be performed on the wells within the other zones. Slug data will be analyzed using Aqtesolv to estimate hydraulic conductivity.

    - Complete packer testing in all new wells within the proposed well network. Determine the hydraulic conductivity of each water-bearing zone.

4. Utilize water level elevations, hydraulic conductivity measurements, and aquifer thickness measurements to calculate groundwater gradients, groundwater velocity, and transmissivity. Utilize grain size analysis data to estimate porosity.

3.5.7.2 KEY ASSUMPTIONS (STEP 7.2)

Key assumptions associated with **Study #2 Aquifer Properties** include:

1. Precipitation data continues to be collected from Lambert Field.

2. Access is granted for staff gauge installation and data downloading.

3. Access is granted for off-site well installation on private property.

4. Access is granted for off-site well slug testing. Existing well casing is not crooked or angled such that a solid slug can be deployed for slug testing or a pump can be deployed for sampling. Note, pumps and solid slugs will not be introduced to drinking water wells.

3.6 STUDY #3 - REGIONAL AND LOCALIZED HYDRAULIC GRADIENTS

3.6.1 DATA GAPS (STEP 1.3)

Horizontal and vertical hydraulic gradients within the alluvial and bedrock aquifers will be more fully evaluated to understand how various temporal and spatial stresses on the system may affect groundwater flow directions.

3.6.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.6.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study **(Study #3 - Regional and Localized Hydraulic Gradients**) is to answer the following questions:

1. What is the horizontal hydraulic gradient within alluvial and bedrock aquifers?
2. What is the vertical hydraulic gradient between alluvial and bedrock aquifers?
3. How do the gradients change over time (seasonally)?
4. How do the gradients vary across the study area and model boundary?
5. What groundwater withdrawals are present which may influence groundwater gradients and flow direction?

The available historical water level related data will be carefully reviewed, and if deemed suitable, incorporated into the site-specific data management system. The monitoring and testing program developed for the OU-3 RI/FS proposes to collect water level data over a 2-year period, and evaluate groundwater flow gradients, directions, rates, and interconnections (flow/flux rates) within and between the different hydrogeologic intervals and between the water table aquifer and nearby surface water bodies.

3.6.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

The assumption for **Study #3 - Regional and Localized Hydraulic Gradients** is that the historical groundwater level and flow data are not adequate for the completion of the RI/FS effort. However, alternative outcomes are possible and may slightly change the approach. Some of those outcomes may include:

1. The additional investigation may confirm the prior findings that the horizontal groundwater gradients historically have been relatively low onsite and regionally.
2. Downward vertical gradients have been observed on-site in the bedrock wells, but regional vertical gradients are documented to be upwards within bedrock aquifers.
3. Changes in recharge and infiltration may occur due to surface water levels.
4. Horizontal gradients may vary vertically and in part based on distance to the Missouri River and surface water elevations. Horizontal gradients may also have temporal variability due to these and other factors.
5. Localized groundwater depressions and mounding has been observed which likely affects gradients. Leachate withdrawal from the extraction system and increased pressures from the SSR may influence these water levels and gradients.

3.6.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #3 - Regional and Localized Hydraulic Gradients**, the following data are needed:

1. Water level data is needed from on-site and off-site wells screened within and between the alluvial aquifer and upper and lower intervals of the bedrock aquifer system (Mississippian age).
2. Co-located wells are needed on-site and off-site to verify vertical gradients between water-bearing zones.
3. Precipitation data is needed from the study area to evaluate recharge.
4. Seasonal water level data is needed to evaluate temporal variability.
5. An inventory of potential extraction locations and rates is needed.

3.6.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.6.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #3 - Regional and Localized Hydraulic Gradients:**

1. Historical reports will be used as a resource for surface water and groundwater elevation data.
2. New transducer readings will be used as a resource for surface water and groundwater elevation data.
3. Precipitation records from the area (including Lambert Field) will be a resource.
4. Well inventory records will be used as a resource for identifying third-party groundwater extraction or injection wells (irrigation, pumping, injection).

3.6.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The suitability of the information obtained in **Study #3 - Regional and Localized Hydraulic Gradients** will be evaluated relative to historical reports to identify and qualify potential outlier readings.

3.6.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #3 - Regional and Localized Hydraulic Gradients** are available, including:

1. Historic surface water elevation data is available for the USGS St. Charles Missouri River Gauge (0693596). A total of eight of the nine proposed staff gauges in the OU-3 RI/FS Work Plan will be located on private property. If surface water elevation data has been collected at other off-site surface water bodies such as the Earth City flood control structures; this information will need to be requested from the property owners.
2. Transducers, deployment procedures, data analysis procedures, barometric pressure correction procedures, and operation/maintenance procedures are readily available for surface water and groundwater well transducer deployment.
3. Precipitation data from Lambert Airport is available, which is less than 2 miles from the site.
4. Well records are available from the MDNR and third-party environmental database companies such as EDR.

3.6.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.6.4.1 TARGET POPULATION (STEP 4.1)

For **Study #3 - Regional and Localized Hydraulic Gradients**, the target population includes the Lambert Field rain gauge, the nine staff gauges and Missouri River gauges, and the existing and new wells in the proposed well network. Additional off-site wells will be used to supplement the OU-3 well network where available within the model boundary, including wells with the potential for pumping rates which could be significant (irrigation, livestock, industrial water supply, injection wells, and extraction wells). The target population for transducer deployment includes near-site surface water bodies and select monitoring wells near pumping wells within the model domain.

3.6.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #3 - Regional and Localized Hydraulic Gradients**, the temporal boundary for the precipitation records is 1938 based on the date when precipitation records are available from the Lambert Field rain gauge. Water level data is available for the existing well network back to 1979. Surface water data is available for the Missouri River back to 1929. The temporal boundary for the other surface water bodies in the area is unknown.

The temporal boundary for the off-site well search will be limited to the date the MDNR well records began. Online well records are available for wells drilled after 1987; offline records are available for older wells from MDNR. The spatial boundary for this study will be the model boundary.

3.6.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #3 - Regional and Localized Hydraulic Gradients**. The collection of historical precipitation data and surface water data could be constrained by lack of availability or gaps in the historical record. The collection of new surface water data and installation of new wells could be hindered by lack of access to private property or landfill and other site operations. Potential obstacles for the well search include inaccurate or incomplete state well database or environmental database reports, and lack of access to private property (if necessary) to verify well information.

3.6.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #3 - Regional and Localized Hydraulic Gradients** is the individual rain gauge, staff gauge, or well being monitored. Decisions based on the data will be made based on the following minimum scales:

1. Surface water elevation scale is 0.01 inches.
2. Depth to water readings from transducer scale is 0.01 ft.

3. Precipitation data scale is 0.01 inches.
4. The scale for the well search will be limited by the available information and may be at a different scale than the water level, well depth, and other pertinent well details which may be useful for the site decision-making.

3.6.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.6.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #3 - Regional and Localized Hydraulic Gradients** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #3, the population is generally the individual rain gauges, staff gauges, and wells, and the data obtained from each well, including precipitation data, water level, and the available information from third-party wells.

3.6.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

If the historical and new data collected as part of **Study #3 - Regional and Localized Hydraulic Gradients** are evaluated to identify outliers and qualified, if necessary, the data will be added to the USEPA-accessible database, used to refine the CSM and construct a groundwater model, and prepare summary figures. If new data (water level, precipitation, surface water levels) are evaluated to identify outliers and qualified, if necessary, these data will be used to evaluate gradients. Water well information for off-site wells will be evaluated to determine if the well is located down-gradient from the site; if the well may be potentially impacted (now or in the future) from the site; if water level information from the well may be helpful for the purposes of the CSM, model, and risk assessment; and if collection of water quality information from the well is warranted. Factors that will be used to make this decision include: if the well is located in an area without groundwater information (horizontally or vertically), if the well is located hydraulically downgradient from the site, if the well is screened within a zone that may be impacted or could become impacted over time, current and future use of the property, current and future use of the well, and availability of lithologic logging information for the well.

3.6.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #3 - Regional and Localized Hydraulic Gradients**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified.

A decision error could occur if the data collected do not contain representative data or decisions are made based on an inadequate sample set. Measurement errors can occur with the data recording equipment and field implementation and could also lead to decision error. The test results will also be compared to data obtained from the previous site investigations for consistency.

The completeness objective for precipitation data, new water level, and surface water measurements is that 95% of the data will meet data quality objectives. The uncertainty with the precipitation data is ±0.1% (Geonore T-200B Rain Gauge or similar). The uncertainty with surface water and water level readings is ±0.05% (Solinst Levellogger, In Situ Troll 700H or similar) and ±0.1 ft for manual water level meter (Solinst). The uncertainty with off-site water well data is unknown at this time pending identification of the wells and availability of information from the private well owner regarding measurement uncertainty.

3.6.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.6.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #3 - Regional and Localized Hydraulic Gradients** includes the following tasks:

1. Nine staff gauges will be installed surface water locations. Each staff gauge will be equipped with pressure transducers (In Situ Level Troll 700H vented or similar) to monitor surface water elevation. Barometric pressure loggers (if probes are not vented) such as In Situ BaroTroll (or similar) will be deployed for atmospheric pressure corrections. The pressure transducers will be programmed to collect water level data every hour. Each month, surface water elevation data will be downloaded in conjunction with collection of manual surface water elevation readings. Surface water elevation readings will be corrected for barometric pressure. Using the data collected in this task, horizontal groundwater gradients both locally and regionally will be calculated to determine if groundwater and surface water are connected hydraulically. The transducers will be maintained on a regular basis, as discussed in the FSP.

2. After proposed monitoring wells are installed, pressure transducers (In Situ Level Troll or similar) will be deployed in a subset of existing wells and all proposed wells to monitor water level elevations. Barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar) will also be deployed. The pressure transducers will be programmed to collect water level data every hour. On a monthly basis, accumulated water well elevation data will be downloaded from the transducers. Concurrent manual water level elevation readings will be collected monthly for correlation purposes. Water level elevation readings will also be corrected for barometric pressure. Local and regional horizontal hydraulic gradients will be calculated using available water level data from three nearby wells to form a three-point problem. Similarly, local and regional vertical hydraulic gradients will be calculated using available water data to determine upward, downward or variable flow direction.
3. Hourly precipitation data will be downloaded from NOAA Lambert Field rain gauge in inches back to 1938. Evaluate precipitation data and surface cover to determine potential impact on groundwater gradients.
4. Using water well records obtained in Study #1, information on off-site wells will be input into the site database and evaluated for relative importance to the CSM, model and risk assessment based on the decision rules.

3.6.7.2 KEY ASSUMPTIONS (STEP 7.2)

Key assumptions associated with **Study #3 - Regional and Localized Hydraulic Gradients** include:

1. Access is granted for staff gauge installation and data downloading.
2. Access is granted for off-site well installation on private property.
3. Precipitation data continues to be collected from Lambert Field.
4. Well records include desired data regarding location, well construction, ownership, etc.

3.7 STUDY #4 - BACKGROUND GROUNDWATER CONDITIONS

3.7.1 DATA GAPS (STEP 1.3)

For **Study #4 – Background Groundwater Conditions**, the data gap can be described as follows. Background groundwater conditions near the site in the alluvial and bedrock aquifers have not been established and should be established due to the presence of elevated concentrations of naturally-occurring radionuclides and other COPCs in groundwater. The USGS did not determine background Radium-226 and Radium-228 concentrations in groundwater due to a limited dataset, which included 17 alluvial samples from 14 alluvial wells and 11 bedrock samples from 6 bedrock wells. This is identified as an important data gap for the risk assessment and remedy decision-making (USGS 2015). Background radionuclide concentrations and ratios are an important component of evaluating the extent of potential impacts related to the site and identifying the source of radionuclides present in groundwater at the site.

Nearby off-site sources may be contributing to groundwater quality within the study area, including leaking underground storage tank sites and the Champ Landfill.

3.7.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.7.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #4 – Background Groundwater Conditions**) is to answer the following questions:

1. What is the level of radionuclide activity in groundwater near the site and off-site?
2. What is the background level of radionuclide activity in groundwater off-site?
3. What is the ratio of Ra228/Ra226 in groundwater at the site compared to ratios in background areas?
4. What is the ratio of Ra228/Ra226 in groundwater in off-site wells? Can these data be used to distinguish whether off-site radium is coming from the Radioactively Impacted Materials (RIM) onsite, is coming from background sources of radium or both?
5. Is groundwater within the study area potentially impacted by off-site sources of non-radionuclide constituents, such as naturally occurring metals from the aquifer matrix, fuels from leaking underground storage sites, chlorinated solvents from commercial properties, or leachate indicator parameters from Champ Landfill?

There is the potential for groundwater to become impacted due to the release of radionuclides under varying geochemical conditions. Therefore, this study will also look at levels of radionuclide activity in soils and bedrock matrices.

3.7.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

The assumption for **Study #4 – Background Groundwater Conditions** is that historical on-site groundwater quality data are not adequate to provide the necessary background groundwater quality data for the completion of the RI/FS effort. The RI/FS proposes a monitoring and sampling effort to collect background groundwater quality samples on a quarterly basis over a two-year period. After collection and review of these background groundwater quality data, if additional sampling and/or monitoring well installation are deemed necessary, additional work will be proposed as part of the OU-3 RI/FS. A range of alternate outcomes exist:

- Radionuclides may be present in groundwater near and/or off-site or may not be present above background levels. Background concentrations of radionuclides in groundwater may be at, above, or below off-site, downgradient activity levels. Radionuclide activity levels in soil and bedrock may indicate the potential for migration to groundwater.

- Radium ratios in groundwater on-site may be unique or similar to background radium ratios.
- Radium ratios in groundwater may indicate that radionuclide activity levels off-site are similar to on-site ratios, which may be potentially indicative of contributions from RIM.
- Alternatively, radium ratios may be similar to background radionuclide ratios groundwater in the area.
- Alternatively, the off-site radium ratios may not be conclusive, which may indicate a mixture of both site-related and background radium sources.
- Alternate sources of non-radionuclide constituents such as benzene in off-site groundwater impacts may not be detected within the study area. If alternate sources are detected, the constituents may be present at either low-level or high-level concentrations.

3.7.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #4 – Background Groundwater Conditions**, the following parameters need to be estimated:

1. Groundwater activity levels of radionuclides near and off-site are needed, including total and dissolved concentrations.
2. Background groundwater activity levels of radionuclides are needed.
3. Radium isotope ratios in soil and groundwater are need for on-site area.
4. Radium isotope ratios are needed in soil and groundwater for off-site downgradient and background locations.
5. Potential off-site sources (landfills, spills, cleanup sites, Leaking Underground Storage Tanks (LUST) sites, Resource Conservation and Recovery Act (RCRA) generators, etc.) need to be identified (if present) within the study area. COPCs may include metals, fuels, chlorinated solvents, as well as landfill leachate indicator parameters such as chloride, chemical oxygen demand, and other constituents as described under Section 3.10.7.1. Groundwater quality data, location, and cleanup history associated with a potential source is needed, if available.

3.7.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.7.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #4 – Background Groundwater Conditions.** Groundwater data from on-site, near-site, and background wells can be a source of data for radioisotope activity levels, including wells within the proposed OU-3 well network. Off-site third-party wells can also be a source of groundwater data (as necessary and if available). Aquifer matrix materials can be analyzed for radioisotopes from borehole cores proposed in the OU-3 RI/FS Work Plan. Radium isotope ratios can then be calculated for the locations with available data. Radium isotope ratios are available as part of prior data collection for the OU-1 RIM (USGS 2015). Local, state, and federal databases may provide information on potential sources within the study area. Groundwater quality data collected historically and as part of the proposed OU-3 activities may also be useful for identifying constituents unrelated to the site.

3.7.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The suitability of the information obtained in **Study #4 – Background Groundwater Conditions** will be evaluated relative to historical reports to identify and qualify potential outlier readings. Results will be compared to USEPA Maximum Contaminant Levels (MCLs) if available, and on-site and off-site groundwater concentrations. Aquifer matrix radium concentrations will be converted to radium ratios and evaluated similar to Vinson et al. 2012. Groundwater results which may be associated with off-site sources will be compared to on-site concentrations and MCLs and Regional Screening Level (RSLs; USEPA 2019b).

3.7.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #4 – Background Groundwater Conditions** are available, including, groundwater and aquifer matrix radionuclide laboratory methods. Records for registered cleanup sites are available through public and private databases.

3.7.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.7.4.1 TARGET POPULATION (STEP 4.1)

For **Study #4 – Background Groundwater Conditions**, the target population for groundwater sampling includes the existing and proposed wells (150 wells) in the proposed well network plus additional off-site wells within the model boundary which may have historical water quality data or which could be sampled to provide necessary information for the risk assessment or groundwater model. The target population for the aquifer matrix sampling includes the new wells, but may be supplemented by well data from within the modeling domain which may have historical water quality data or which could be sampled to provide necessary information for the risk assessment or groundwater model.

3.7.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #4 – Background Groundwater Conditions**, the temporal boundary for near-site and off-site groundwater radionuclide data is based on the available of on-site and off-site third-party data. On-site radionuclide groundwater data for the existing wells are available back to the date of installation of each well; the oldest data are from 1979. The temporal boundary for the near-site and off-site aquifer matrix data is unlimited since this data does not generally change over time. The spatial boundary for groundwater and aquifer matrix radionuclide data is the study boundary. The temporal boundary for the compilation of data from potential off-site source sites is unlimited. The spatial boundary for the groundwater and aquifer matrix data, and the compilation of off-site source data is the study boundary.

3.7.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #4 – Background Groundwater Conditions**. The key practical constraints related to the proposed installation and sampling of the background monitoring wells include obtaining off-site right of access, obtaining applicable well drilling permits/authorization, and overhead/subsurface utility clearance. The cost of installing large number of deep wells through bedrock is another potential obstacle. Potential obstacles regarding evaluation of off-site sources include incomplete database records, unreported spills, and co-mingled plumes with similar contaminants.

3.7.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #4 – Background Groundwater Conditions** is the individual well being monitored. Background well locations were identified up-gradient and over 3,000 feet from the site. The scale for deciding the adequacy of the number of background wells is based on the number of wells within each water-bearing zone within the study area. At least three wells within each water-bearing zone are proposed.

The scale for deciding whether there are potential off-site sources is based on the size of the various parcels within the study area. The smallest size parcel in the vicinity of the site appears to be approximately 300 ft wide.

3.7.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.7.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #4 – Background Groundwater Conditions** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #4, the population is generally the individual wells, the data obtained from each well, and the available information from third-party wells. The population also includes the soil and bedrock matrix radionuclide concentrations, which will be used to evaluate potential leaching to groundwater.

3.7.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

As part of **Study #4 – Background Groundwater Conditions**, radionuclide concentrations in near-site and down-gradient off-site groundwater wells will be compared to MCLs and background radionuclide concentrations. A background radionuclide concentration will be established as an alternate concentration limit. If down-gradient off-site radionuclide concentrations are lower than background radionuclide concentrations, no additional wells are necessary for delineation purposes. If down-gradient off-site radionuclide concentrations are higher than background radionuclide concentrations, additional wells may be necessary for delineation purposes.

Radium isotope ratios for alluvial aquifer and bedrock aquifer materials will be compared to determine if off-site radium may be emanating from the on-site RIM (lower Ra228/Ra226 ratio), from background (higher Ra228/Ra226 ratio), or from both. If the radium in off-site wells appears to be migrating from the on-site RIM, then the feasibility study will include how to address the potential for off-site radium migration. If the radium in off-site wells appears to be from background sources, an evaluation will be done regarding whether the WLL OU-3 site may be increasing the background radium concentrations through changing the redox environment (see Study# 6).

If potential sources of groundwater impacts are identified within the study area near proposed well locations, available data for the area will be compiled to determine if the nature of the off-site source is similar to the WLL OU-3 groundwater constituents. If the constituents are similar, an alternate concentration limit may need to be established. If off-site third-party wells are present within the modeling domain which may provide useful information on water quality related to radionuclides or off-site sources of groundwater impacts, an evaluation will be completed to determine if data from the well could be important to the groundwater model or risk assessment. If the data from the off-site third-party well are critical, efforts will be undertaken to obtain access to the third-party well(s) for gauging and sampling as part of additional OU-3 RI activities.

3.7.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #4 – Background Groundwater Conditions**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified.

A decision error could occur if the data collected do not contain representative data or decisions are made based on an inadequate sample set. Historical background data meeting Section 7.0 data quality requirements and new background data will be used to calculate a 95% Upper Prediction Limit and identify a background concentrations of COPCs. Additional data will be collected as necessary to provide an adequate data set for the statistical evaluation.

The completeness objective for groundwater and aquifer solids data collection and laboratory analysis is that 95% of the data will meet data quality objectives. The lowest achievable detection limits will be used for as a performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. The radionuclide method detection limit is 1 picocuries per Liter (pCi/L) for groundwater and 0.001 picocuries per gram (pCi/g) in aquifer matrix materials.

The uncertainty associated with the potential off-site source data is unknown and will depend on the available information.

3.7.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.7.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #4 – Background Groundwater Conditions** includes the following tasks:

- Collect groundwater samples from 15 new off-site background wells for total and dissolved radiological isotopes in groundwater (same as above) including lab analysis. Collect groundwater samples quarterly for two years. Calculate the background Ra226 and Ra228 background concentrations using a 95% Upper Prediction Limit after each quarterly event. Once sufficient data is available, the resulting background value will be calculated, but may be revised until the new wells have been sampled for two years.
- Collect aquifer matrix material samples for total radiological isotopes, including Ra226, Ra228, Uranium 234, Uranium 235, Uranium 238, Thorium 228, Thorium 230, and Thorium 232.
- Collect groundwater samples for non-radionuclide COPCs including the analytical suite identified in Section 3.8.7.1. Data will be collected from the 15 background wells to establish background concentrations. Data will also be collected from the other 21 off-site wells located potentially down-gradient from the site in order to identify potential sources within the down-gradient area. Compile available data on potential off-site sources (landfills, spills, cleanup sites, LUST sites, RCRA generators, etc.) within the study area. If groundwater quality data and water level data are available, the data will be evaluated to determine if it can be added to the site database to assist with development of the CSM, the risk assessment, and the groundwater model.

3.7.7.2 KEY ASSUMPTIONS (STEP 7.2)

Key assumptions associated with **Study #4 – Background Groundwater Conditions** include:

1. Access to off-site properties for well installation.
2. Property owners are willing to provide information if records searches are unsuccessful.
3. Groundwater quality and water level data are available from potential source sites.

3.8 STUDY #5 - OCCURRENCE AND EXTENT OF GROUNDWATER IMPACTS

3.8.1 DATA GAPS (STEP 1.3)

For **Study #5 – Occurrence and Extent of Groundwater Impacts**, the data gap can be described as follows. Off-site downgradient monitoring wells have not yet been installed to evaluate the potential occurrence and extent of groundwater impacts. The USGS identified four potential sources for radium in on-site groundwater but was unable to quantify the relative contribution of each source. The present lack of understanding of the spatial distribution of groundwater impacts limits the ability to evaluate the site for potential receptors (present and future). The potential receptors for groundwater-related exposure to site-related impacted media has not yet been evaluated to determine which pathways may exist and which may be complete.

3.8.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.8.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #5 – Occurrence and Extent of Groundwater Impacts**) is to answer the following questions:

1. Is off-site groundwater impacted by site-related constituents or could it be in the future?
2. What is the spatial distribution (horizontally and vertically) of the impacts (if present) currently and in the future?
3. What are the potential receptors for groundwater-related exposure to site-related constituents currently and in the future?
4. Which exposure pathways are potentially complete currently and in the future?

3.8.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

Alterative outcomes for **Study #5 – Occurrence and Extent of Groundwater Impacts** include:

1. Groundwater may have detectable site-related constituents near the site and/or offsite due to groundwater migration from onsite. Groundwater concentrations may change over time and could increase due to leaching and migration from the source materials, changes in redox conditions, and/or radium in-growth. Groundwater concentrations may also decrease due to OU-1 remedial actions or natural attenuation processes, or remain similar to current levels.
2. The extent of groundwater impacts may be limited to near-site or extend off-site to adjacent properties. Over time, the spatial distribution may change as groundwater migrates off-site depending on the flow gradients, redox conditions over time, and other influential factors.
3. The surrounding area downgradient from the site is currently commercial/industrial and is located within a flood plain, so future land use is unlikely to change. However, potential residential receptors are included in the Preliminary CSM (Figure 3-1 of the QAPP).

4. Exposure pathways may be complete depending on the extent of the current and future groundwater use or groundwater discharge. Affected media could include groundwater, surface water, sediment, and sediment pore water.

3.8.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #5 – Occurrence and Extent of Groundwater Impacts**, the following parameters need to be estimated:

1. Representative groundwater concentrations of COPCs will be needed within each of the five water-bearing zones. Well screens will be placed within the vertical interval with the highest hydraulic conductivity based on field logging and geophysical logging. A sufficient data set is needed to calibrate a groundwater model to evaluate future groundwater concentrations; a minimum of two years of quarterly groundwater monitoring is needed to achieve a statistically viable data set.
2. Off-site groundwater COPC concentration data are needed to define the horizontal and vertical nature and extent of impacts (if present). This includes existing and proposed off-site wells. A groundwater model is needed to estimate the spatial extent of groundwater impacts in the future.
3. Property ownership, zoning, property use, and deed restrictions in the area down-gradient from the site are needed. The current and future extent of groundwater impacts is needed to assess potential receptors. The potential receptors need to be documented in a Baseline Risk Assessment Work Plan.
4. Groundwater and surface water elevations are needed to evaluate the hydraulic communication between media and determine whether exposure pathways are complete. Since there may be temporal variations in groundwater and surface water elevations and flow directions, these factors will need to be evaluated. The complete exposure pathways need to be documented in a Baseline Risk Assessment Work Plan.

3.8.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.8.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #5 – Occurrence and Extent of Groundwater Impacts.** Current and proposed groundwater wells are a source of data. Property information is available from city and county property records, zoning maps, and state deed restriction databases to evaluate potential receptor information. Risk Assessment Guidance for Superfund (RAGS) guidance is available for evaluating potential receptors. Groundwater and surface water level data will be available from current and proposed wells and staff gauges to determine if exposure pathways are complete. RAGS guidance is available for evaluating exposure pathways.

3.8.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The suitability of the groundwater quality data obtained in **Study #5 – Occurrence and Extent of Groundwater Impacts** will be evaluated relative to historical reports to identify and qualify potential outlier readings. Results will be compared to MCLs if available and RSLs (if no MCL exists) for screening purposes. On-site and off-site down-gradient groundwater concentrations will be compared to evaluate the extent of groundwater impacts. Background groundwater concentrations will be used as a basis for establishing alternate concentration limits as appropriate.

Property ownership information is available from the St. Louis County GIS Viewer. Zoning information is available from the City of Bridgeton Public Works Department for properties within the incorporated city limits and St. Louis County GIS Viewer for properties outside city limits. Deed restriction information is available from the Office of the St. Louis City Recorder of Deeds. Groundwater and surface water levels will be compared to historical records and manual measurements to identify potential outliers and qualify data as necessary for the purposes of evaluating exposure pathways.

3.8.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #5 – Occurrence and Extent of Groundwater Impacts** including groundwater laboratory methods are available for the analytical suite as shown in Table 2-3 of the QAPP. Procedures for low-flow groundwater sampling and water level measurement based on USEPA guidance are readily available (USEPA 1996). Data are available regarding property parcels, zoning, and deed restrictions. RAGS guidance (USEPA 1989) is available for evaluating potential receptors and for evaluating whether exposure pathways are complete.

3.8.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.8.4.1 TARGET POPULATION (STEP 4.1)

For **Study #5 – Occurrence and Extent of Groundwater Impacts**, the target population for groundwater sampling includes the existing and proposed wells (150 wells) in the proposed well network plus additional off-site wells within the model boundary which may have historical water quality data, or which could be sampled to provide necessary information for the risk assessment or groundwater model.

3.8.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #5 – Occurrence and Extent of Groundwater Impacts**, the temporal boundary for near-site and off-site groundwater data is based on the date the wells within the study were installed and first sampled, which dates back to 1979 for the existing on-site/near-site wells. The spatial boundary for groundwater radionuclide and offsite water level data is the study boundary.

The temporal boundary for the compilation of property information is the current ownership. The spatial boundary for the compilation of property information is the study area but will focus on the properties within 100 ft of the boundary of groundwater impacts.

3.8.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #5 – Occurrence and Extent of Groundwater Impacts**. The key practical constraints related to the proposed installation and sampling of monitoring wells include obtaining off-site right of access, obtaining applicable well drilling permits/authorization, and overhead/subsurface utility clearance. The cost of installing large number of deep wells through bedrock is another potential obstacle. Potential obstacles regarding compilation of property information includes incomplete or missing records. Potential obstacles to evaluating exposure pathways include incomplete data to determine if a pathway is complete.

3.8.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #5 – Occurrence and Extent of Groundwater Impacts** is the individual well being monitored. The scale for groundwater decision-making is further refined to be within wells that are considered down-gradient and up-gradient. The scale for deciding the number of down-gradient groundwater wells determines the proposed well spacing. The well spacing proposed around the perimeter of the site (MW-200/300/400 series) is approximately 500 to 800 ft. The proposed well spacing for the off-site downgradient wells (MW-500 series) is approximately 1,700 to 2,200 ft apart, and 1,300 to 1,800 ft to the north and west from the site. The proposed well spacing is approximately 1/4 of the down-gradient length of the northern and western face of the site and should provide adequate coverage.

3.8.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.8.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #5 – Occurrence and Extent of Groundwater Impacts** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #5, the population is generally the individual wells, the data obtained from each well, and the available information from third-party wells. Population parameters will also include property information, zoning maps, and deed restriction information for evaluating potential receptors. The study will compile population parameters (i.e. groundwater quality, water level data, surface water levels, groundwater use, and land use) to provide a basis to determine whether exposure pathways are complete, which will be documented in a Baseline Risk Assessment Work Plan.

3.8.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

As part of **Study #5 – Occurrence and Extent of Groundwater Impacts**, the following action levels and decision rules have been identified:

- Groundwater concentrations in near-site and down-gradient off-site groundwater wells will be compared to MCLs (or RSLs if no MCLs are available); and background metal and radionuclide concentrations. The spatial extent of impacts will be plotted for constituents with exceedances. If exceedances are observed in off-site down-gradient wells, the need for additional step-out wells may need to be completed as part of an addendum to the OU-3 RI Work Plan. If concentrations of semi-volatile organic compounds (SVOCs), polychlorinated biphenyl (PCBs), fuels, and pesticides are non-detect in on-site wells during the first monitoring event, a proposal will be made to the USEPA to delete these parameters from future monitoring events.
- If property records are not available for properties within the spatial footprint of the groundwater impacts, door-to-door visits or mailings will be used to request the necessary information on potential receptors.
- If groundwater and surface water elevations indicate a hydraulic connection with a surface water body including the Missouri River, the sediment exposure pathway will be evaluated through collection of sediment and sediment pore water samples. If sediment and sediment pore water quality indicate groundwater-related impacts, the surface water and aquatic life exposure pathway will be evaluated.

- Once groundwater quality data are available from the first round of sampling, the vapor intrusion pathway will be evaluated. Properties located within 100 ft of groundwater impacts that could result in a potential for vapor intrusion (e.g. VOCs, radon, or methane) will be assessed for the potential for a complete vapor intrusion pathway.

3.8.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #5 – Occurrence and Extent of Groundwater Impacts**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified.

A decision error could occur if COPCs are present above background, MCLs, or Applicable or Relevant and Appropriate Requirements (ARARs) downgradient of the WLL OU-3 site in a potential exposure pathway or route, but that location was not sampled or tested. This type of error is not readily quantifiable for evaluation with respect to statistical tolerance limits but will be controlled by careful consideration and placement of the proposed new monitoring wells, implementing the quarterly groundwater monitoring program, and evaluating the rate of groundwater movement through the subsurface.

The completeness objective for groundwater data collection and laboratory analysis is 95%. The groundwater method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used for as a performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision-making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary. The completeness objective for obtaining property information on off-site properties will vary based on the limitations of the sources and cooperation of the property owners. The acceptance criteria for the data collection and evaluation of the exposure pathway will be determinations based on statistically valid and representative data.

3.8.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.8.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #5 – Occurrence and Extent of Groundwater Impacts** includes the following tasks:

1. Install a total of 64 new groundwater wells to delineate off-site groundwater conditions. Well screens will target the vertical intervals with the highest hydraulic conductivity measurements based on field logging and downhole geophysics. The groundwater wells (150 total) will be sampled for a broad range of analytes for characterization purposes quarterly for two years, including:

   <u>Constituents of Potential Concern</u>:

   - Radionuclides: total and dissolved radium, uranium, and thorium
   - Organic Compounds: VOCs, SVOCs*, PCBs*, fuels*, and pesticides* (*may only be sampled once based on non-detect results from on-site wells)
   - Dissolved and Total Metals (32): arsenic, aluminum, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, silicon, thallium, thorium, tin, titanium, uranium, vanadium, zinc

2. Preparation of summary tables comparing the results of on-site vs. offsite and background concentrations. Complete a determination on whether off-site groundwater impacts (if present) are attributable to the site, and to what extent (horizontally and vertically) the impacts may extend. Update the existing three-dimensional (3-D) visualization model (Leapfrog) with analytical results and prepare updated cross-sectional figures of the extent of groundwater impacts (if present). Determine if additional step-out wells are needed to delineate site-related groundwater impacts laterally and vertically to provide adequate information for the risk assessment and groundwater model.

3. Identify potential receptors for each potentially complete exposure pathway. For off-site properties, obtain property information for parcels within 100 ft of the spatial extent of groundwater impacts (if present) and determine current use and potential future use of groundwater from this area.

4. Evaluate groundwater data to determine which exposure pathways are potentially complete. If additional data are necessary, prepare an addendum to the OU-3 RI Work Plan and collect additional data.

3.8.7.2 KEY ASSUMPTIONS (STEP 7.2)

The key assumption associated with **Study #5 – Occurrence and Extent of Groundwater Impacts** is that access is granted to off-site properties for well and staff gauge installation and well sampling.

3.9 STUDY #6 - GROUNDWATER GEOCHEMISTRY

3.9.1 DATA GAPS (STEP 1.3)

For **Study #6 – Groundwater Geochemistry**, the data gap can be described as follows. Multiple subsurface conditions typical of a landfill environment can result in alterations of naturally occurring geochemical parameters in surrounding groundwater. Different redox conditions, mineralogy, and organic content can attenuate or mobilize radionuclides via exchange, adsorption, desorption, precipitation, co-precipitation, and dissolution. The redox environment at the site may be reducing in the vicinity of leachate influence, but redox can also be aerobic within river valleys. The presence of available metals for sorption under certain pH levels and redox conditions can result in lower radionuclide concentrations in groundwater. Higher organic carbon content can lead to sorption onto aquifer matrix solids and lower groundwater concentrations, but organic carbon content is unknown. A better understanding of how radionuclide concentrations in groundwater at and near the site may be changing spatially due to each of these potential influences is warranted.

3.9.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.9.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #6 – Groundwater Geochemistry**) is to answer the following questions:

1. What is the geochemical environment within the study area?
2. How has the geochemical environment affected radionuclide concentrations in groundwater off-site in terms of transformation, co-precipitation, dissolution, mobilization, and sorption?
3. What is the influence of organic material radionuclide fate and transport?

3.9.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

Alterative outcomes for **Study #6 – Groundwater Geochemistry** include:

1. The redox environment may be more oxidative the closer to the Missouri River and more reducing closer to the site and other off-site sources. The pH of the groundwater may be different on-site in comparison to the Missouri River based on typical surface water and groundwater quality differences.
2. Reducing conditions may result from landfill capping, leachate interaction with groundwater, and/or the dissolution of landfill gas into groundwater. Naturally-occurring radionuclides may become more mobile within reducing

geochemical environments. Limestone environments may have a lower sportive capacity, and therefore, higher groundwater concentrations of radionuclides (Szabo et al. 2012). High radium concentrations have been correlated with elevated iron and manganese concentrations (USGS 2015), so the radionuclide concentrations may fluctuate with the composition of the geochemical environment. The geochemical environment may also be different in the alluvial aquifer zones in comparison with the lower bedrock aquifer zones.

3. The presence of organic material may decrease the concentration of radionuclides in groundwater due to sorption. Or there may be insignificant organic material present to affect groundwater quality. The amount of organic material may vary vertically and horizontally, with more organic material likely present in the shallower aquifer materials closer to the Missouri River and other surface water bodies.

3.9.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #6 – Groundwater Geochemistry**, the following parameters need to be estimated:

1. The ORP and DO concentrations are direct indicators of the redox environment. Redox pair concentration is needed to further support the type of redox environment present. The pH of the groundwater and soil are also important for mineral transformation analysis. Dissolved and total metals concentrations in groundwater are needed to determine the geochemical environment. Information is also needed regarding the aquifer matrix materials, including concentrations of total metals and key cations/anions. Minerology of the aquifer matrix solids is needed.
2. In addition to the items noted above in item 1, the groundwater concentration of radionuclides (dissolved and total) and aquifer solids concentrations of radionuclides are needed. Also needed are dissolved phase concentrations of radionuclides within different geochemical environments which can be mimicked through extraction sequences.
3. Total and dissolved organic carbon content in groundwater, and total organic carbon content within the aquifer matrix materials is needed to evaluate the effect of organic material on radionuclide concentrations.

3.9.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.9.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #6 – Groundwater Geochemistry**. Current and proposed groundwater wells are a source of groundwater and aquifer matrix information on redox environment, including field parameter readings and laboratory testing. Geochemical modeling is also a source of information regarding the geochemical environment.

3.9.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The suitability of the groundwater geochemical data obtained in **Study #6 – Groundwater Geochemistry** will be evaluated relative to historical reports to identify and qualify potential outlier readings. The informational basis for the hypothesis that redox may be affecting inorganic constituent concentrations is OSWER Directive 9200.4-17P (USEPA 1999a). The importance of the interaction of radionuclides and organic matter is established in published literature (Lin and Hendry 2011).

3.9.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #6 – Groundwater Geochemistry** including analytical methods are available for the groundwater and aquifer matrix analyses as shown on QAPP Table 2-3. Methods are also available for geochemical evaluation and modeling to evaluate aqueous speciation, saturation, kinetics, mass transfer, and reactive transport including the geochemical specific groundwater model, PHREEQC (USGS 2019).

3.9.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.9.4.1 TARGET POPULATION (STEP 4.1)

For **Study #6 – Groundwater Geochemistry**, the target population for groundwater sampling includes the existing and proposed wells (150 wells) in the proposed well network plus additional off-site wells within the model boundary which may have historical water quality data or which could be sampled to provide necessary information for the risk assessment or groundwater model.

3.9.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #6 – Groundwater Geochemistry**, the temporal boundary for the groundwater geochemistry data will be based on the date the water quality information is available, which will vary by well. The existing on-site/near-site well data set includes data back to 1979. The temporal boundary for aquifer matrix solids data is unlimited if obtained from areas that have been undisturbed since the data were collected. The temporal boundary for the groundwater fate and transport model will be 1976 based on available groundwater quality data. The spatial boundary for the geochemical data is the modeling boundary.

3.9.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #6 – Groundwater Geochemistry**. The key practical constraints related to the proposed installation and sampling of monitoring wells include obtaining off-site right of access, obtaining applicable well drilling permits/authorization, and overhead/subsurface utility clearance. The cost of installing large number of deep wells through bedrock is another potential obstacle. Additionally, it can be challenging to obtain ORP and DO readings for groundwater that are representative of in situ concentrations due to sampling methodology. It can also be challenging to obtain and preserve groundwater samples that maintain the relative speciation of metal ions. Lastly, only a limited number of laboratories have the capabilities to perform the laboratory method for sequential extraction.

3.9.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #6 – Groundwater Geochemistry** is the individual well being monitored. The geochemical environment will also be evaluated within each of the five aquifer zones (vertical variability) and based on spatial relationship to the site (on-site, near-site, upgradient, downgradient). The smallest scale for groundwater quality and aquifer matrix quality decision-making will be the laboratory Method Reporting Limit (MRL) which may be referenced as “Reporting Limit” by some laboratories. If the MRL concentration is above the applicable standard, the Method Detection Limit (MDL) may be used instead of the MRL for that analyte. Groundwater data will be input into a the existing 3-D visualization tool (Leapfrog) and interpolated where data are unavailable to assist with decision-making.

3.9.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.9.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #6 – Groundwater Geochemistry** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #6, the population is generally the individual wells and boreholes, and the data obtained from each location on redox environment, radionuclide concentrations, major ion chemistry, total and dissolved organic carbon and mineralogy.

3.9.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

As part of **Study #6 – Groundwater Geochemistry**, the following action levels and decision rules have been identified:

1. Negative ORP and low DO concentrations will indicate reducing environments. Redox pairs will be evaluated to determine if the more reducing of the ion pairs is present, which will be used as a line of evidence that reducing conditions exist. Low pH environments (<pH 6) will indicate a higher potential for mobilization of some soluble constituents (e.g. trace metals) relative to neutral or basic groundwater conditions (>pH 8), which may increase the solubility of other constituents.
2. Radionuclide concentrations in groundwater will be correlated with metals concentrations and mineral species to evaluate whether minerology is influencing the concentration of radionuclides in groundwater.
3. Total organic carbon content in aquifer matrix materials will be correlated with radionuclide concentrations in groundwater to evaluate whether organic material may be influencing the concentration of radionuclides in groundwater.

3.9.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #6 – Groundwater Geochemistry**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified. Geochemical parameters are generally not COPCs; acceptance criteria for these data will be based on the standard laboratory data validation process rather than project-related objectives. The completeness objective for data collection and laboratory analysis is 95%. The groundwater and aquifer matrix materials method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used as performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision-making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.

3.9.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.9.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #6 – Groundwater Geochemistry** includes the following tasks:

1. The 64 proposed wells are co-located in well nests and clusters such that there are a total of 19 unique well sites. The following data will be collected for evaluation of the geochemical environment from the deepest borehole at each well site at a frequency of one sample every 10 vertical feet.
   - Collect soil and bedrock samples for mineralogical analysis, including XRD, SEM/EDS, and CEC.
   - Collect aquifer matrix samples for analysis of pH and total organic carbon.
   - Collect aquifer matrix samples for analysis of total metals (32 total metals as noted above in Study #5), and redox species (ferric iron, ferrous iron, carbonate, cation+anion).
   - Collect groundwater samples for analysis of geochemical indicator parameters, including pH, redox pairs (sulfate, sulfide, nitrate, nitrite, ammonium, ferrous iron, ferric iron, chromium III, chromium VI) for laboratory analysis. Collect field parameters for pH, DO and ORP. Collect groundwater samples from 150 wells on a quarterly basis for two years.
   - Collect the following data for evaluation of the fate and transport of radionuclides relative to the geochemical environment from each well site (19 total):
     - Aquifer matrix samples will be collected and submitted for sequential extraction to evaluate the influence of different geochemical environments on pH, sulfur, radium, uranium, thorium concentrations.
     - Aquifer matrix samples will be collected and submitted for total isotopes of radium, uranium, and thorium.
   - Collect groundwater for total and dissolved organic carbon concentrations from 150 wells quarterly for two years. Collect aquifer matrix samples for total organic carbon concentrations from each well site (19 total) at a frequency of one sample every 10 vertical feet.

Depending on the estimated thickness of the alluvial and bedrock aquifers, a total of 10 samples will be collected from the alluvial aquifer zones and 14 samples will be collected from the bedrock aquifers.

3.9.7.2 KEY ASSUMPTIONS (STEP 7.2)

The key assumption associated with **Study #6 – Groundwater Geochemistry** is that access is granted to off-site properties for well installation and sampling.

3.10 BRIDGETON LANDFILL

3.10.1 DATA GAPS (STEP 1.3)

For **Study #7 – Bridgeton Landfill**, the conceptual model of the data gap can be described as follows. The Bridgeton Landfill operated as a limestone quarry prior to landfilling activities. The hydraulic characteristics of the landfill materials may be affecting groundwater movement and flow direction. Groundwater was removed from the quarry during quarrying operations. Since the North and South Quarries are unlined, groundwater can enter into the landfill through the sides of the quarries. During landfilling operations, groundwater (and subsequently leachate) were removed. Leachate is currently removed from the landfill through leachate collection sumps and dual extraction gas wells and is pumped to the leachate pretreatment system. Current infrastructure such as the leachate extraction system and landfill gas extraction system in the Bridgeton Landfill could play an important role in the localized geochemical characteristics of groundwater. The removal of leachate may be providing some benefit to surrounding groundwater quality by hydraulically containing landfill leachate. Whether landfill gas has impacted groundwater offsite has not been evaluated. It is also unknown whether organic constituents from the landfill have impacted off-site groundwater, which could also potentially lower redox conditions.

3.10.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the related principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.10.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #7 – Bridgeton Landfill**) is to answer the following questions:

1. Is leachate extraction affecting the fate and transport of constituents in groundwater? If so, is the influence significant to the overall fate and transport of constituents in groundwater, including groundwater flow direction?
2. Has landfill gas impacted groundwater? If so, is the influence of the landfill gas extraction system significant to the overall fate and transport of constituents in groundwater?
3. Is landfill leachate entering near-site and/or off-site groundwater and is the leachate attributable to the site?

4. Is landfill leachate in groundwater affecting concentrations of radionuclides if present?
5. Are dissolved landfill gasses (methane, carbon dioxide) present in groundwater and attributable to the site?

3.10.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

Alterative outcomes for **Study #7 – Bridgeton Landfill** include:

1. The leachate system may be providing localized drawdown that reduces off-site migration of leachate or the extraction may not result in a significant impact on groundwater levels and gradients.
2. The landfill gas extraction system (including cover material) may be removing volatile gasses from the site, which may be reducing the quantity of dissolved gasses entering groundwater. Alternatively, the landfill gas extraction system may be removing landfill gasses, but the mass removal is insignificant to the overall fate and transport from the site.
3. Landfill leachate may be migrating offsite if it is not fully captured by the leachate collection system, or the leachate collection system may be effective at capturing leachate and limiting migration.
4. If leachate-related impacts are present in off-site groundwater, the level of radionuclide activity may be higher, the same, or lower than within a comparable area without leachate present. Leachate-related impacts, if present, could lower redox conditions and increase radionuclide activity levels in on-site or potential off-site groundwater.
5. Landfill gases may be impacting groundwater off-site despite operation of the landfill gas extraction system. Dissolved phase methane and carbon dioxide concentrations may indicate the presence of landfill gases off-site if concentrations are above background levels. Alternatively, the off-site methane and carbon dioxide concentrations may be similar or lower than background levels.

3.10.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #7 – Bridgeton Landfill**, the following parameters need to be estimated:

1. Fluid levels in groundwater monitoring wells surrounding the Bridgeton Landfill are needed to determine groundwater flow direction around the landfill and to assess the effects of the leachate collection system on groundwater levels and flow directions. Fluid levels will be collected from the leachate collection sumps and at other locations within the Bridgeton Landfill (e.g., gas extraction wells) to the extent such measurements can be obtained given the construction and operation of the particular infrastructure point, effect of Bridgeton Landfill operations, and potential health and safety issues (high temperatures or high gas or water pressures). The

representativeness of such measurements will be assessed prior to their use for evaluation of groundwater flow directions and the effects of the leachate collection system on fluid levels and groundwater flow.

2. A water balance is needed to evaluate the overall influence of the various site features on groundwater discharge and recharge.

3. Landfill indicator parameter data are needed on-site, near-site, downgradient, and background in both groundwater and leachate (untreated).

4. Groundwater quality data for radionuclides is needed on-site, near-site, downgradient, and offsite. Analyses of radionuclide occurrences in untreated leachate are also necessary. An evaluation is needed to determine if a correlation exists between the landfill leachate indicator parameter concentrations and radionuclide concentrations.

5. Dissolved phase landfill gas concentration data are needed, including methane and carbon dioxide from on-site, near-site, downgradient, and offsite locations. An evaluation is needed to determine if there is a correlation between the landfill leachate indicator parameters and dissolved gas concentrations.

3.10.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.10.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #7 – Bridgeton Landfill**. Bridgeton Landfill leachate collection sumps may be used to obtain samples. New flow meters will be installed as necessary to quantify leachate removal from each sump. Surrounding groundwater wells will be used for water level and groundwater sampling for leachate indicator parameters, radionuclides, and dissolved landfill gases. Current operational and temperature information about the leachate and landfill gas extraction systems will be obtained from Bridgeton Landfill personnel.

3.10.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

The water levels, and leachate and groundwater quality data obtained in **Study #7 – Bridgeton Landfill** will be evaluated relative to historical reports to identify and qualify potential outlier readings. Flow data from the individual flow meters on the leachate collection system sumps will be compared to the totalizer value to determine if the sum of the volumes match the total. Groundwater quality and temperature data will be evaluated to determine if there is a correlation. Dissolved landfill gas data (methane and carbon dioxide) will be compared within the study area to determine if a correlation exists between dissolved gases and radionuclide activity levels.

3.10.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #7 – Bridgeton Landfill** including analytical methods are available for the groundwater and aquifer matrix analyses as shown on QAPP Table 2-3. Fluid level measurements in the leachate collection sumps and other wells (e.g., gas extraction wells) within the Bridgeton Landfill may not be possible due to infrastructure access and/or construction constraints, constraints imposed by ongoing Bridgeton Landfill operations, or health and safety concerns (high temperature or pressure conditions).

3.10.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.10.4.1 TARGET POPULATION (STEP 4.1)

For **Study #7 – Bridgeton Landfill**, the target population for groundwater sampling includes the existing and proposed wells (150 wells) in the proposed well network plus additional off-site wells within the model boundary which may have historical water quality data. Viable wells near the Bridgeton Landfill systems will be identified after the well inventory. The target population for leachate water level and leachate quality and temperature data includes current and historical onsite leachate collection system data, including leachate collection system wells that are no longer operational.

3.10.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #7 – Bridgeton Landfill**, the temporal boundary for the leachate quality data will be the date the leachate collection sumps were first sampled, which was in 1997. The spatial boundary for the groundwater and leachate quality data and fluid levels in the surrounding wells is the study area.

3.10.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

There may be practical constraints on the proposed data to be collected and analyzed for **Study #7 – Bridgeton Landfill**. Collection of data from around the South Quarry may be limited by the SSR, which has affected landfill leachate collection sump infrastructure in this area. Leachate is not always present within a sump, which could present a practical constraint on data collection. Some of the leachate sumps are equipped with inoperable pumps due to the elevated temperatures and pressures in the vicinity, which may limit data collection. The SSR does not affect access to groundwater wells located along the margins of the landfill.

3.10.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #7 – Bridgeton Landfill** is the individual well being monitored. The smallest scale for groundwater quality decision-making will be the laboratory MRL or MDL based on the units for that analyte. The smallest scale for groundwater fluid levels is 0.01 ft. The smallest scale for leachate volume is 1 gallon.

3.10.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.10.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #7 – Bridgeton Landfill** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #7, the population parameters will be the individual wells and leachate collection system points from which historic and new water quality and fluid level data are available. The study will also include groundwater temperature, leachate pumping rates from individual sumps, and the overall system totalizer.

3.10.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

As part of **Study #7 – Bridgeton Landfill**, the following action levels and decision rules have been identified:

1. If nearby groundwater wells indicate an inward gradient based on preparation of a water balance, the leachate system will be determined to have an observed impact on groundwater flow potential. The magnitude of the inward gradient will be used to determine if the gradient is lower or higher than the natural surrounding gradient.
2. If landfill leachate parameters are present above background in groundwater in the down-gradient flow direction from the site, the groundwater will be determined to have landfill leachate influence.
3. If the landfill leachate indicator constituents are similar in concentration, magnitude and/or ratios to groundwater found off-site, that will provide a line of evidence that off-site groundwater may have landfill leachate present.
4. If radionuclide activity levels are higher within groundwater with known leachate influence relative to groundwater without landfill leachate influence, the presence of landfill leachate in groundwater may be having an effect on

radionuclide activity levels. An additional evaluation will be required to determine whether the radionuclides are naturally-occurring or site-related or both.

5. If landfill dissolved gases in groundwater (methane and carbon dioxide) are detected at concentrations above background in off-site wells and near-site wells, the groundwater in those areas will be determined to have landfill gas effects. This is important for assessing the redox conditions of the groundwater and geochemical environment as noted above in Study #6.

3.10.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #7 – Bridgeton Landfill**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified. The completeness objective for water level and flow rate data collection, groundwater, leachate, and aquifer matrix data collection and laboratory analysis is 95%.

The method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used as performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.

3.10.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.10.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #7 – Bridgeton Landfill** includes the following tasks:

1. Regarding leachate at the site:
   - Install flow meters on individual landfill leachate sumps as necessary. Evaluate landfill leachate flow rates and volumes in each available sump monthly over two years.

- Incorporate data into groundwater fate and transport model to evaluate effects of leachate pumping on water levels, groundwater flow direction and gradients.
- Collect groundwater samples from 150 wells quarterly for two years for the following leachate indicator parameters:
  - Landfill Leachate and Human Waste Indicators: bromide, iodide, pH, total organic carbon, chloride, chemical oxygen demand, ammonium, phosphate, and total and dissolved metals (sodium, magnesium, potassium, calcium, iron, lead, nickel, copper, zinc, strontium, and boron)
  - Inorganic Parameters: pH, dissolved organic carbon, alkalinity, total hardness, total suspended solids, total dissolved solids, and major ions (cations+anions, nitrate, sulfate, phosphate, carbonate, chloride, sodium, potassium, magnesium, calcium)
  - Dissolved landfill gases: methane and carbon dioxide
- Collect landfill leachate samples (untreated) from viable leachate sumps for characterization purposes. Leachate will be sampled for the same parameters as the groundwater parameters quarterly for two years.

2. Regarding the landfill gas extraction system at the site:
   - Collect groundwater samples for dissolved landfill gases (methane and carbon dioxide) from 150 wells quarterly for two years. Evaluate whether landfill gases are present in near-site and off-site wells above background. Evaluate whether there is a correlation between the presence of dissolved landfill gases and radionuclide concentrations.
   - Collect landfill leachate samples (untreated) from viable leachate sumps for dissolved landfill gases (methane and carbon dioxide). Leachate will be sampled for the same parameters as the groundwater parameters quarterly for two years.
3. Regarding potential leachate-related impacts to off-site groundwater:
   - Collect groundwater samples from 150 wells quarterly for two years for the above leachate indicator parameters.
   - Collect landfill leachate samples (untreated) from viable leachate sumps for the same parameters as groundwater. Compare results from groundwater and leachate to determine if a correlation exists based on the distance from the site.

4. Regarding radionuclide and leachate:

   - Collect groundwater samples from 150 wells quarterly for two years for the above leachate indicator parameters and radionuclides. Compare radionuclide concentrations from wells within areas with potential leachate influence with radionuclide concentrations from wells outside of leachate areas to determine if a correlation exists. Also evaluate redox groundwater conditions to identify naturally-occurring and/or anthropogenic sources of radium.

5. Regarding dissolved landfill gases:

   - Collect groundwater samples from 150 wells and leachate from leachate collection system sumps quarterly for two years for dissolved methane and dissolved carbon dioxide (landfill gases), bicarbonate alkalinity, calcium, and magnesium. Correlate concentrations of these constituents with distance from the site.

3.10.7.2 KEY ASSUMPTIONS (STEP 7.2)

The key assumption associated with **Study #7 – Bridgeton Landfill** is that access is granted to off-site properties for well installation and sampling. It is also assumed that leachate quality data are available from on-site.

3.11 VAPOR INTRUSION

3.11.1 DATA GAPS (STEP 1.3)

For **Study #8 – Vapor Intrusion**, the data gap can be described as follows. The potential for vapor intrusion into on-site structures has not recently been investigated. Indoor air sampling of enclosed buildings (5 total) will be conducted to address this data gap. The vapor intrusion pathway has not yet been evaluated but will be completed using off-site groundwater data obtained as part of the OU-3 RI activities. Additional data gaps may exist if these groundwater data indicate a potential for vapor intrusion, including potentially sub-slab, soil gas, and/or indoor air concentrations.

3.11.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.11.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #8 – Vapor Intrusion**) is to answer the following questions:

1. Are radon, methane, and/or VOCs present within enclosed structures on-site at elevated levels?
2. Do groundwater concentrations near the site and offsite contain radon, methane, or volatile compounds which could pose a risk to indoor air?

3.11.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

As part of **Study #8 – Vapor Intrusion**, radon, methane, and VOCs may be present in indoor air onsite from surrounding soil and/or groundwater. Ambient air radon samples are collected around the site currently which do not indicate an ambient air issue exists. Of the five enclosed buildings at the site, those structures closest to potential radon sources may have higher radon activity. Buildings with more foundation/slab penetrations or cracks may exhibit higher radon activity in indoor air.

Offsite radon, methane, and VOC groundwater concentrations may be below concentrations which could indicate a risk due to volatilization or may be above threshold concentrations depending on the spatial distribution of groundwater impacts within the shallowest alluvial aquifer.

3.11.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #8 – Vapor Intrusion**, radon activity, methane, and VOC indoor air concentration data are needed from within the five enclosed buildings onsite. Radon, methane, and VOC data in groundwater are also needed to evaluate the risk to indoor air off-site. The estimated potential indoor air concentrations within off-site structures will then be calculated from the groundwater concentrations of these constituents to determine if further vapor testing is needed.

Due to the presence of naturally-occurring radon gas in the St. Louis area, background radon levels in groundwater are necessary to evaluate the potential sources of radon in groundwater down-gradient from the site. The average indoor radon levels in Saint Louis County is 3.5 pCi/L, which is close to the 4 pCi/L USEPA radon action level (St. Louis County 2019).

Rather than rely only on the presence of radon gas in groundwater, the extent of site-related groundwater impacts is needed (from Study #5) in order to define the radon study area only to those areas with site-related impacts.

3.11.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.11.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #8 – Vapor Intrusion**. Indoor air data is a source of information about the potential risk to on-site workers. Groundwater concentrations are the source of information about the potential volatilization to indoor air of radon, methane and VOCs. It is worth noting that there is not a commercially available laboratory rest for radon in groundwater, and radium concentrations in groundwater cannot be used to predict the occurrence of radon in groundwater despite the fact that 226Ra decay is the source of radon (or 222Rn). This is due to the different behaviors of radium and radon in the environment. First, the 226Ra/222Rn activity ratio in the natural water is not constant. Radon gas can leak and diffuse from the rocks and sediment to the water, while the dissolution of radium in the rock/sediment to the water is a slower process. This causes higher radon concentrations than that of 226Ra in the natural water. Additional factors influencing this poor correlation include differences in the isotopes' half-lives and differences in the chemical behavior of multiple parent isotopes. Therefore, radon in groundwater data will be obtained using field screening data.

In addition to data collected from the proposed OU-3 well network, published data may also be used to supplement proposed background radon in groundwater data collection. Distance from groundwater to ground surface measurements will be a useful source of information. Structural information may also become important for buildings being evaluated.

3.11.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

In **Study #8 – Vapor Intrusion,** indoor air data from on-site structures will be compared to the USEPA RSLs for VOCs and the USEPA radon action level for indoor air of 4 pCi/L to evaluate the need for mitigation of onsite structures. Methane levels will be compared to 10% of the lower explosive limit (LEL) since there is no MCL for methane.

Groundwater VOC concentrations will be evaluated against target values estimated using the most current USEPA Vapor Intrusion Screening Level (VISL) calculator. The estimated indoor air concentration will be calculated using

Henry's Law for radon and methane, which do not have USEPA RSLs. For reference, the target groundwater radon activity level is 2,500 pCi/L based on an attenuation factor of 0.001 and Henry's Law Constant of 1.6 (Kil et al. 2010).

3.11.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #8 – Vapor Intrusion** including analytical methods are available for the indoor air as shown on QAPP Table 2-3. Short-term and long-term radon sampling and analysis methodology is available from USEPA (USEPA 1992c, USEPA 1993). Short-term testing refers to real-time field screening measurements, while long-term testing involves collection of data for laboratory analysis. Indoor air testing procedures for VOCs and methane are readily available using TO-15 and TO-3 methods (USEPA 2015). Methodology for using the USEPA VISL calculator is available from USEPA's website (User Guide and FAQ). The same methodology will be used for radon but calculated manually. The sampling methodology for measuring radon concentrations in groundwater is available from the manufacturer of the field screening meter, the RAD7 with H2O attachment (Durridge).

3.11.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.11.4.1 TARGET POPULATION (STEP 4.1)

For **Study #8 – Vapor Intrusion**, the target population for indoor air testing is the on-site, occupied, enclosed buildings (5 total). The target population for the off-site vapor intrusion evaluation includes structures within 100 ft of the estimated extent of groundwater impacts above target groundwater values as calculated by the VISL calculator or Henry's Law (for radon).

3.11.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #8 – Vapor Intrusion**, the temporal boundary for the vapor sampling is dependent on changes to structures, site conditions, groundwater concentrations, and groundwater depths. Significant changes in any of these parameters may limit the temporal boundary for vapor data to current conditions. The temporal boundary for the groundwater sampling used to evaluate indoor air is also limited to current conditions. The spatial boundary for the vapor sampling is the study area, which may change if groundwater conditions indicate a larger area may need assessed now or in the future.

3.11.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

For **Study #8 – Vapor Intrusion**, the USEPA protocol for short-term radon sampling involves closing ventilation points for 12-hours. Since the on-site enclosed structures are generally used around the clock daily for facility operations, this aspect of the short-term sampling protocol is impractical for the site. Therefore, long-term testing will be completed to verify the results of the short-term testing. Groundwater sampling may be limited by the potential lack of access to off-site properties for installation of the proposed wells. Radon has a short-half-life such that laboratory analysis of radon activity in groundwater is not practical. Field measurements will be performed with the RAD7 radon meter with H2O attachment which has a minimum activity level of 10 pCi/L (see Appendix L-6 of the FSP). If off-site vapor testing is required as part of the OU-3 RI/FS activities, access to off-site properties for vapor testing may be limited depending on landowner consent.

3.11.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #8 – Vapor Intrusion** is on a per building basis. For off-site properties, the decision scale is per parcel and per building (if more than one structure is present and substantially far from each other).

3.11.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.11.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #8 – Vapor Intrusion** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #8, the population parameters will be the five enclosed structures onsite which will be tested for VOCs and radon. The study will compile groundwater data on VOCs and radon, and depths to groundwater.

3.11.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

As part of **Study #8 – Vapor Intrusion**, if onsite indoor air concentrations of VOCs, methane, and radon exceed the USEPA RSLs, 10% of the LEL, or USEPA Radon Action Level, respectively, the need for subslab depressurization systems or other mitigation measures will be evaluated for each affected building.

If off-site VOC and methane groundwater concentrations exceed the target groundwater concentrations, properties located within 100 ft of the measuring point will be identified and further evaluated. Due to the ubiquitous nature of radon gas in the St. Louis area, a statistically derived background radon activity in groundwater will be calculated and taken into account when analyzing the groundwater data collected as part of this study. Additionally, vapor intrusion assessments for radon will be limited to within the lateral extent of site-related groundwater impacts to address the presence of background radon. Radon and methane are not included in the VISL calculator, so the target groundwater concentrations will be manually calculated.

Each area will be assessed for the potential presence of background impacts from LUST sites or other spill-related impacts. If soil gas sampling indicates indoor air concentrations may exceed USEPA RSLs, indoor air testing may be recommended, or mitigation systems offered to property owners. Details regarding soil gas and indoor air testing would be included in an OU-3 RI Work Plan.

3.11.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #8 – Vapor Intrusion**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified. In this study, possible decision errors include overestimation of the spatial extent of potential indoor air issues based on available groundwater data. However, further vapor testing needs will be evaluated on a case-by-case basis using site-specific information.

The completeness objective for indoor air testing is 100%. The RAD7 field meter radon range is 0.1 to 20,000 pCi/L with a ±5% accuracy. The RAD7 H2O radon meter sensitivity is ~10 pCi/L for radon in groundwater. Note, the radon in groundwater value will be used to estimate the radon in indoor air activity, which due to attenuation will be several orders of magnitude below the 4 pCi/L indoor air USEPA guideline. The completeness objective for groundwater data collection and laboratory analysis is that 95% of the data will meet data quality objectives. The method detection limit for VOCs (by Method TO-15), methane (TO-3) and radon is listed in Table 2-3 of the QAPP. The lowest achievable detection limits will be used as a performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision-making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.

3.11.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.11.7.1 SAMPLING DESIGN (STEP 7.1)

The proposed sampling design for **Study #8 – Vapor Intrusion** includes the following tasks:

1. Complete real-time field survey using a RAD7 Radon Detector in 5 enclosed on-site buildings over=48-hours to provide a short-term radon. Long-Term Electret Ion Chambers will be used to estimate long-term (90 days) radon exposure which covers potential fluctuations over the day, weeks, and months. Collect one ambient air sample outside of the Engineering Office as part of the long-term radon test to evaluate potential radon sources (if present).
2. Collect groundwater samples for VOCs and dissolved methane gas for laboratory analysis. Collect groundwater samples to measure radon activity using a RAD7 radon meter equipped with the H2O accessory. Collect VOC, methane, and radon samples from the upper-most water-bearing zone within the proposed well network. Shallow groundwater samples will be collected and analyzed for radon on a quarterly basis for two years to develop an adequate data set for comparison of background well radon activity with near-site and down-gradient wells. Existing published data with background radon activity in groundwater will be used to supplement new data as necessary.

3.11.7.2 KEY ASSUMPTIONS (STEP 7.2)

The key assumption associated with **Study #8 – Vapor Intrusion** is that access is granted to the asphalt plant building by the tenant for testing. Other assumptions include the validity of the use of real-time radon testing. The real-time testing will not be consistent with standard USEPA methodology which requires no entry into the room for 12-hours; this restriction is not implementable given the continuous operations within most of these buildings. Therefore, the real-time radon test will be used as an indicator of acute risk and the long-term test will be used to assess overall risk. For future off-site vapor testing (if warranted), off-site access will be a key assumption for further vapor data collection.

3.12 STUDY #9 - GROUNDWATER AND SURFACE WATER TEMPORAL AND SPATIAL VARIABILITY

3.12.1 DATA GAPS (STEP 1.3)

For **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, the data gap can be described as follows. Previous investigations evaluated temporal variability in groundwater levels and flow direction at varying frequencies. Additional characterization of groundwater levels and flow directions is needed in response to potential influences such as surface water, precipitation, and pumping.

3.12.2 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

In Step 2, the principal study questions are identified. For each question, a range of possible alternative outcomes are identified and used to create a decision statement or estimation statement.

3.12.2.1 IDENTIFY PRINCIPAL STUDY QUESTIONS (STEP 2.1)

The goal of this study (**Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**) is to answer the following questions:

1. What is the groundwater flow direction locally and regionally?
2. Does the groundwater flow direction vary seasonally locally and regionally?
3. How might the groundwater flow direction vary over time locally and regionally?

3.12.2.2 ALTERNATIVE OUTCOMES (STEP 2.2)

As part of **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, data may indicate that groundwater flow direction is radially outward from the site in general except in areas with leachate extraction. Flow direction locally may be west towards the Missouri River and towards local pumping wells. Flow direction may shift towards to the north, consistent with the expected regional groundwater flow direction and parallel to the Missouri River. These directions may change regionally or locally in response to changes in river stage levels, leachate and groundwater extraction rates, surface water recharge rates, and precipitation such as flood events, droughts, and other water balance-related changes.

3.12.2.3 DECISION STATEMENTS / WHAT NEEDS ESTIMATED AND KEY ASSUMPTIONS (STEP 2.3)

For **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, groundwater levels and surface water elevations are needed on-site, near-site, and off-site. The same information is needed from the historical record and the proposed well network to evaluate sensitivity of the flow direction to temporal changes in recharge rates and water-balance changes. Continuous water level elevation data is needed in areas where rapid changes maybe occurring in groundwater levels and surface water levels. A 3-D groundwater flow model is needed to evaluate the overall groundwater system and flow direction questions.

3.12.3 IDENTIFY INFORMATION INPUTS (STEP 3)

As part of Step 3, the types and sources of information needed to resolve the decision statements above are identified, including whether new data collection is necessary. Also described in Step 3 is the information basis for establishing the analytic approach. Next a performance or acceptance criteria is established for each data element. Lastly, this section addresses whether a methodology exists for the proposed sampling and/or analysis step.

3.12.3.1 TYPES AND SOURCES OF INFORMATION (STEP 3.1)

There are several types and sources of information for **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**. Historical water level, precipitation, and pumping data are important sources of data. New water level measurements from the proposed well network and staff gauges are another source of information. Historical and current pumping data from the on-site leachate collection system and other significant pumping wells is another source of data.

3.12.3.2 INFORMATIONAL BASIS OF PERFORMANCE CRITERIA (STEP 3.2)

In **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability,** water level measurements, transducer readings, precipitation records and flow data will be compared to the historical records to identify potential outliers and qualify data. Flow data from the individual flow meters on the leachate collection system sumps will be compared to the totalizer value to determine if the sum of the volumes match the total. Manual groundwater and surface water readings, and transducer readings will be compared for consistency.

3.12.3.3 AVAILABILITY OF SAMPLING AND ANALYSIS METHODS OR DATA (STEP 3.3)

The data sources and methods noted above for **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability** are readily available, including procedures for water level measurements from water wells, surface water, and leachate sumps. Transducer programming and data transfer methods are available from the equipment vendors. Suitable flow meters designed for leachate and potentially high temperatures are available to be installed on individual leachate collection sumps if not currently present to obtain flow rates and volumes to the nearest 1 gallon per minute.

3.12.4 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

In Step 4, the boundaries of the study are defined, including the target population, the spatial and temporal boundaries, practical constraints, and the scale of inference (i.e., decision unit or scale of estimation).

3.12.4.1 TARGET POPULATION (STEP 4.1)

For **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, the target population is the wells and leachate collection system points to be used for leachate water level and leachate flow data. The target population for the historical surface water and new groundwater elevation data includes the groundwater wells and staff gauges where data will be collected from each aquifer zone within the model domain. The target population for the collection of continuous water level elevation data is from 70 of the 150 wells, which includes 50 of the proposed new wells and 20 of the existing wells (Table 5-5 of the OU-3 RI/FS Work Plan). This subset of wells was identified based on proximity to surface water bodies where the elevation may change rapidly and based on the spatial distribution of wells necessary to complete gradient calculations. The availability and quality of the off-site groundwater extraction data (e.g. flow rates for the Earth City Flood Control District levee pressure relief wells) is unknown at this time and could affect the water balance and/or groundwater modeling efforts.

3.12.4.2 TEMPORAL AND SPATIAL BOUNDARIES (STEP 4.2)

In **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, the temporal boundary for the water level data is 1979 based on onsite well data. The temporal boundary for surface water level data is 1976 based on available data. The spatial boundary for the groundwater and surface water levels is the model boundary.

3.12.4.3 POTENTIAL PRACTICAL CONSTRAINTS ON DATA COLLECTION (STEP 4.3)

For **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, potential obstacles for the collection of new surface water data includes lack of access to private property to install the proposed surface water staff gauges. Potential obstacles to the collection of water level data from transducers include the potential lack of access to private property for installation of the proposed wells and landfill or other site operations.

3.12.4.4 APPROPRIATE SCALE FOR DECISION-MAKING (STEP 4.4)

The scale for decisions and estimates for **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability** is the individual well and leachate collection system point. The smallest scale for surface water, leachate and groundwater fluid levels is 0.01 ft. The smallest scale for leachate volume is 1 gallon. The groundwater model discretization will be determined in conjunction with the initial OU-3 RI sampling and geologic logging activities and will be documented in the Groundwater Modeling Work Plan.

3.12.5 DEFINE THE ANALYTIC APPROACH (STEP 5)

This section includes a description of the analytic approach to be used during analysis of the study results and how conclusions will be drawn from the data.

3.12.5.1 POPULATION PARAMETERS (STEP 5.1)

The population parameters for **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability** are parameters which are most relevant for making inferences and conclusions on the target population. For Study #9, the population parameters will be historical and new water levels, leachate fluid levels, leachate pumping rates from individual sumps and the overall system totalizer, and pumping/flow rates for off-site groundwater extraction wells (e.g., Earth City Flood Control District levee pressure relief wells).

3.12.5.2 ACTION LEVEL AND DECISION RULE (STEP 5.2)

As part of **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, if the groundwater flow direction varies, the proposed well network will be updated, if necessary, to provide representative down-gradient groundwater quality data within the range of potential flow directions. The groundwater model will be calibrated using the variable flow directions and used to assess groundwater flow in the future based on the calibrated model.

3.12.6 PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

For decision problems for **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability**, this section specifies the decision rule, examines the consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors. For estimation problems related to the study, a summary of the acceptable limits on estimation uncertainty are specified. In this study, possible decision errors include inadequately located or spaced wells to detect temporal variations. The completeness objective for water level, leachate level, surface water level, and leachate flow rate data collection is 95%.

3.12.7 DEVELOP THE PLAN FOR OBTAINING THE DATA (STEP 7)

The last DQO step involves the development of a resource-effective strategy for collection and compilation of the data needed to complete the study in a manner that is sufficient to fulfill the study objectives and maximizes the amount of data collected within a fixed budget in accordance with the performance or acceptance criteria.

3.12.7.1 SAMPLING DESIGN (STEP 7.1)

For **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability** after proposed monitoring wells are installed, pressure transducers (In Situ Level Troll or similar) will be deployed in a subset of existing wells (86 total), all proposed wells (64 total), and all staff gauges (9 total) to monitor water level elevations. Barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar) will be deployed in select wells and all staff gauges and programmed to collect water level data every hour. Transducer data will be downloaded monthly along with collection of manual water level elevation readings for correlation purposes. Water level elevation readings will be corrected for barometric pressure. Potentiometric surface contour figures will be prepared monthly using groundwater elevation data and illustrate localized and off-site flow directions. Azimuth frequency charts will be prepared to identify flow directions throughout the year on a monthly basis for two years. The data set will be evaluated to determine the influence of adjacent surface water elevation changes, precipitation events, and pumping effects.

3.12.7.2 KEY ASSUMPTIONS (STEP 7.2)

The key assumption associated with **Study #9 – Groundwater and Surface Water Temporal and Spatial Variability** is that access is granted for off-site well and staff gauge installation on private property. Another key assumption is that information on off-site groundwater extraction data (e.g., flow rates for the Earth City Flood Control District levee pressure relief wells) will be available and of sufficient quality for use in the water balance calculations and/or groundwater modeling efforts.

3.13 CRITERIA FOR MEASUREMENT DATA

Six quantitative/qualitative measures of quality will be employed during site activities:

- Precision
- Accuracy/Bias
- Completeness
- Representativeness

- Comparability
- Sensitivity

The QA objectives for these criteria and procedures to compare calculated values to the objectives are described in greater detail below.

3.13.1 PRECISION

Precision is the degree of agreement between the numerical values of a set of replicate samples performed in an identical fashion. Field precision is assessed by the collection of blind duplicates at a rate of 1 duplicate for every 10 field samples. Field duplicate samples will be taken concurrently with the parent sample. Laboratory precision will be assessed through calculation of the relative percent differences (RPDs) for replicate analyses of samples including matrix spikes (MS), matrix spike duplicates (MSD), laboratory control samples (LCS), and laboratory control samples duplicates (LCSD). LCSDs are not part of routine analyses for the laboratories but may be prepared when the MS is prepared from another client's sample or not prepared at all. LCS and/or MS pairs shall be prepared on a 5% basis or at least one per analytical batch (unless otherwise specified in the method-specific SOP). For soil samples, the matrix spike pairs may not provide good accuracy measurement since soil samples are inherently nonhomogeneous. If a laboratory is unable to prepare an MS/MSD pair, an LCS and LCSD is required for the analyses in order to have some measure of precision. MS samples are not required for air sample analyses and an LCSD will be prepared to account for laboratory precision.

3.13.1.1 PRECISION FOR ANALYTICAL DATA AND FIELD REPLICATE ANALYSES

Precision will be based on the analytical data from the laboratory and field replicate analyses (radiological analyses will is addressed below). Precision analyses may be reported as RPD as expressed by the following formula:

$$\text{RPD} = \frac{(C_1 - C_2)}{\frac{(C_1 + C_2)}{2}} * 100\%$$

Where:

C1 and C2 are the concentrations of duplicate samples.

A summary of laboratory acceptance criteria for precision analyses is included in Appendix C and also in accordance with the method-specific SOPs located in Appendix D. Third-party data validation review of duplicates will be conducted according to the *USEPA New England Environmental Data Review Supplement for Region 1 Data Review Elements and Superfund Specific Guidance/Procedures* (USEPA 2018). For third-party data validation, the RPD for water field duplicate constituents must be less than 30%, the RPD for soil field duplicates must be less than 50%, and the RPD for air samples must be less than 25%.

3.13.1.2 PRECISION FOR RADIOLOGICAL ANALYSES

Laboratory and field replicate samples may be analyzed during the analytical processes. The objective is to measure laboratory precision based on each sample matrix. Precision may be assessed in accordance with the following criteria:

If the average concentration (x)< upper bound grey region (UBGR):

Statistic: $abs(x1 - x2)$
Warning limit: 2.83 u_{MR}
Control limit: 4.24 u_{MR}
x=Sample concentration
u_{MR}=Required method uncertainty

If the average x ≥ UBGR:

$abs(x1-x2)$
Statistic: RPD$\frac{abs(x1-x2)}{average(x)}$=

Warning limit: 2.83 $\varphi_{MR} \times 100$ %
Control limit: 4.24 $\varphi_{MR} \times 100$ %
φ_{MR}=relative standard deviation at any concentration greater than UBGR

A summary of laboratory acceptance criteria for precision analyses is included in Appendix C, which is in accordance with the method-specific radiochemical SOPs (Appendix D). Third-party data validation for radiochemical data will be performed using the criteria defined in Chapter 8 of the USEPA MARLAP, document number *USEPA 402-B-04-001A* (USEPA 2004a) and the *American Nuclear Society (ANS) Standard 41.5-2012* (ANS 2018).

3.13.2 ACCURACY/BIAS

Accuracy or bias is the measure of agreement of a result to the accepted (or true) value. Errors may arise from personnel, instrumental, or method factors. Accuracy in the field is assessed through use of field, equipment, and trip blanks and adherence to sample handling procedures, preservation methods, and holding times (Table 2-2). Field, equipment, and trip blanks will be collected as documented in Section 5.1.3.1.

LCS and/or MS pairs shall be prepared on a 5% basis or at least one per analytical batch (unless otherwise specified in the method-specific SOP). LCSDs are not part of routine analyses for the laboratories but may be prepared when the MS is prepared from another client's sample or not prepared at all. If a laboratory is unable to prepare an MS/MSD pair an LCS and LCSD is required for the analyses. For soil samples the matrix spike pairs may not provide a good accuracy measurement because of highly possible sample inhomogeneity and the results may not be useable. Therefore, if a laboratory is unable to prepare an MS, at least an LCS is required for the analyses in order to have some measure of accuracy. MS samples are not required for air sample analyses and an LCS will be prepared to account for laboratory accuracy.

3.13.2.1 ACCURACY/BIAS FOR ANALYTICAL DATA

For field and laboratory accuracy using blank samples, the analytical data will be assessed based on the methods recommended by the USEPA Contract Laboratory Program (CLP) for common laboratory contaminants (radiological analyses will be addressed in 3.13.2.2). The following procedures for third-party data validation will be used to assess blanks collected in the field and analyzed in the laboratory: If a contaminant is detected in an equipment blank, field blank, trip blank, or laboratory blank (as prepared to assess possible laboratory contamination), the detected concentrations of that contaminant in any associated environmental sample will be qualified as follows: if the contaminant concentration in the environmental sample is found to be within 10 times contaminant concentration of the blank, the associated environmental sample concentration will be 'JB' qualified and considered an estimated value due to possible cross-contamination. As noted in the Data Validation Variance Documentation (Appendix B), Trihydro uses a "10 times" rule for possible contaminants identified in the blank samples. However, if contaminants are detected in environmental samples at values below the original blank detection or the associated MRL, the contaminants will be qualified with a "U" and considered non-detect (and biased low) at the MRL.

Laboratory accuracy is assessed by evaluating LCS, LCSD, MS, MSD, and organic system monitoring compounds (surrogate) percent recoveries. Although LCSDs (or another form assessing laboratory precision) are not part of routine analyses for the laboratories, they may be prepared when the MS is prepared from another client's sample or the MS/MSD is not prepared at all. Analytical accuracy or bias is estimated from the recovery of spiked analytes from the matrix of interest. Laboratory performance in a clean matrix is estimated from the recovery of analytes in the LCS. The recovery of each spiked analyte in the MS, MSD (if performed), LCS, LCSD (if performed), and surrogate is completed using the following formula:

$$\text{Percent Recovery} = \%R = \frac{(C_s - C_u)}{C_n} * 100\%$$

Where:

C_s = Measured concentration of the spiked sample aliquot

C_u = Measured concentration of the unspiked sample aliquot (use 0 for the LCS or surrogate)

C_n = Nominal (theoretical) concentration increase that results from spiking the sample, or the nominal concentration of the spiked aliquot (for LCS or surrogate)

3.13.2.2 ACCURACY/BIAS FOR RADIOLOGICAL ANALYSES

Blank results for radiological analyses are generated by carrying all reagent and preparation materials normally used to prepare a sample through the same preparation process. It establishes how much, if any, of the measured analytes are contributed by the reagents and equipment used in the preparation processes. Measured results are usually corrected for instrument background and may be corrected for reagent background. Therefore, it is possible to obtain final blank results that are less than zero (USEPA 2004a). Blank samples may be evaluated in accordance with the following evaluation criteria (USEPA 2004a):

Concentration:
Statistic: Measured concentration
Warning limits: $\pm 2u_{MR}$
Control limits: $\pm 3u_{MR}$
u_{MR}=Required method uncertainty

Total Activity:
Statistic: Measured total activity
Warning limits: $\pm 2u_{MR}\ m_S$
Control limits: $\pm 3u_{MR}\ m_S$
u_{MR}=Required method uncertainty
m_S=Typical aliquot size

The objective of the LCS is to measure the response of the analytical process to a QC sample with a matrix similar to the sample. This will allow inferences to be drawn about the reliability of the analytical process (USEPA 2004a). The requirements for LCS results are displayed below:

Statistic: $\%D = \frac{SSR-SA}{SA} * 100$

Warning limits: $\pm 2\varphi_{MR} \times 100\ \%$

Control limits: $\pm 3\varphi_{MR} \times 100\ \%$

%D=percent deviation

SSR= is the measured result (spiked sample result)

SA= is the spike activity (or concentration) added

φ_{MR}=relative standard deviation at any concentration greater than UBGR

Another possible measure of laboratory accuracy are matrix spike samples. Matrix spike samples provide information about the effect of each sample matrix on the preparation and measurement methodology (USEPA 2004a). The requirements for MS results are displayed below:

$$Z = \frac{SSR-SR-SA}{\varphi MR\sqrt{(SSR2+}\max(SR,UBGR)2}$$

Z=the Z score

SSR= the spiked sample result

SR=the unspiked sample result

SA= the spike concentration added (total activity divided by aliquant size).

UBGR= upper bound grey region

A summary of laboratory acceptance criteria for accuracy/bias analyses is included in Appendix C and also in accordance with the method-specific radiochemical SOPs (Appendix D). Third-party data validation for radiochemical data will utilize the criteria defined in *Chapter 8 of the USEPA MARLAP, document number USEPA 402-B-04-001A* (USEPA 2004a) and the *ANS Standard 41.5-2012* (ANS 2018).

3.13.3 COMPLETENESS

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Completeness is the ratio of the number of validated sample analyses to the total number of sample results required by the sampling program, calculated as follows:

$$\text{Completeness} = \frac{\text{Number of valid samples collected}}{\text{Number of samples planned or expected}} * 100\%$$

The field completeness objective for this project will be 95%. If necessary, the field crew may be required to return to the site in order to meet completeness objectives. Trihydro will coordinate with USEPA on these decisions.

Laboratory completeness is a measure of the amount of valid measurements obtained from the total number of laboratory measurements taken in this project. The laboratory completeness objective for this project, with respect to the data validation quality parameters established in the DQOs is 95%. The ability to meet or exceed a completeness objective is dependent on the nature of samples submitted for analysis. If validated data cannot be reported without qualifications, project completeness goals may still be met if the qualified data (i.e., if the data are not rejected) are suitable for specified project goals. Data will be qualified as specified in Appendix B.

3.13.4 REPRESENTATIVENESS

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. Representativeness may include both qualitative and quantitative terms. QC data for other data quality indicators (i.e., data quality indicators for precision and accuracy) will be used to help ensure that the samples are representative of the actual environmental conditions. If the data quality indicators for precision and accuracy are acceptable without rejection, it will be determined that the data may representative of environmental conditions at the site. Overall data representativeness is a function of the design of the sampling program as discussed in Section 3.0 as part of the DQOs. Corrective action, when representativeness is not met, is specified in Section 6.1.3.

Qualitative terms for representativeness of data include adherence to methods specified in the FSP and laboratory SOPs (Appendix D) for calibration, maintenance, and monitoring of field instruments to ensure representativeness of field data. Field personnel will have previous data available at the time of sampling, will be able to qualitatively evaluate representativeness of field measurements in “real time,” and can take corrective action, if needed, to ensure that field measurements are representative. Field procedures are discussed in detail in the FSP.

Another quantitative term for data representativeness is if the samples are of acceptable temperature and preservation to be representative of actual site environmental conditions. Where applicable to the analytical method, the laboratory will maintain and verify that the sample temperatures and applicable preservations were met. These will be assessed upon receipt to the laboratory and as described in each laboratory sample receipt procedures specified in Appendix D. Sample temperatures will be verified using a temperature blank in each cooler and/or verification using an infrared gun at the laboratory. Samples bottles will be provided to the field team with the appropriate sample preservative.

3.13.5 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared with another. Comparability is dependent upon the proper design of a sampling program and will be satisfied by ensuring that the sampling plan is followed and that appropriate sampling protocols are used. The DQOs were prepared following review of historical data associated with the site. Therefore, data will be compared to previously collected data, as specified in the RI/FS Work Plan. Additionally, comparability is dependent upon the laboratory's ability to maintain required method certifications and adequately train personnel to analyze data in accordance with required analytical methods. Therefore, comparability measures are assessed using the data validation procedures for accuracy and precision. Detailed procedures for data validation are discussed in Appendix B and accuracy and precision measures in Section 3.13.1 and 3.13.2, respectively.

3.13.6 SENSITIVITY

The sensitivity of each laboratory instrument will be dependent upon the required reporting limit and then the corresponding method required to meet the detection limit. Therefore, the sensitivity requirements will be variable for each method. The sensitivity requirements are specified in each laboratory SOP (see Appendix D). Reporting limits, corresponding detection limits, and minimum detectable concentrations (MDCs) for radionuclides are included in QAPP Table 2-3.

Sensitivity will be determined by through data validation review. Dilutions and accuracy measurements will be assessed to ensure that dilutions were applied only when needed and that accuracy measurements were met in accordance with the referenced methodology used for analyses. In addition, sensitivity will be assessed through review of calibration logs and data provided by the laboratory and field personnel.

3.14 SPECIAL TRAINING AND CERTIFICATIONS

Field and Laboratory personnel will participate in site-specific training and acquire specified certifications as required in this QAPP and associated FSP. Trihydro site personnel requirements for safety are described further in the site-specific HASP. Laboratory personnel will conduct training in accordance with descriptions listed in their QAM (Appendix A). Field personnel will participate in site-specific orientation.

3.14.1 TRAINING

Field personnel are required to be familiar with the applicable company field procedures. Asbestos training may be required for drilling on-site wells. Field personnel will also have radiation awareness safety training as specified in the

OU-1 Radiation Safety Plan and have a Missouri Well Installation Contractor license (for well installation oversight). The Trihydro PM will keep the training records for Trihydro field personnel.

Laboratory personnel will be required to undergo training as specified in the laboratory QAMs (Appendix A). The training records for the laboratory personnel will be kept with the laboratory QA departments.

3.14.2 CERTIFICATION

Personnel involved in this project as PMs, Quality Officers, and the Trihydro FTL (and associated personnel) will be required to review this QAPP and sign the front cover (or equivalent) indicating that they are familiar with the QAPP. A record of the signature page(s) will be kept in the project file at Trihydro, as follows:

- The Kansas Department of Environment and Health primarily (Appendix A-1B), certifies Pace-I to perform analyses.
- The Commonwealth of Pennsylvania Department of Environmental Protection (Appendix A-2B) and American National Standards Institute (ANSI) National Accreditation Board (Appendix A-2C), certifies Pace-P to perform analyses.
- The Pennsylvania Department of Environmental Protection, Bureau of Laboratories (Appendix A-3B), certifies Pace-E to perform analyses.
- The Kansas Department of Environment and Health (Appendix A-4B), certifies Pace-K to perform analyses.
- The Wisconsin Department of Natural Resources (Appendix A-5B) certifies Pace-G in Green Bay, Wisconsin to perform analyses.
- The American Association of State Highway and Transportation Officials (Appendix 6A), certifies Earth Exploration Laboratory to perform analyses.
- The Perry Johnson Laboratory Accreditation for ISO/IEC 17025 as part of the DOECAP Program (Appendix A-7B), certifies MCL, Inc. to perform analyses.
- The Oregon Environmental Laboratory Accreditation Program (Appendix A-8B), certifies ALS-S to perform analyses.
- The Canadian Association of Laboratory Accreditations, Inc. (Appendix A-9B), certifies ALS-W to perform analyses.

A rigorous QA/QC program will be maintained in accordance with this QAPP and the associated FSP to ensure that data quality is sufficient to meet the objectives of the investigation.

3.15 DOCUMENTATION AND RECORDS

Documentation and records will be maintained to help ensure field and laboratory observations and data are communicated appropriately and archived pursuant to the site requirements. Detailed descriptions of these records are discussed below.

3.15.1 DOCUMENTATION

Field observations are critical to the verification and interpretation of the laboratory data. Field observations during sampling will be recorded on the field form and/or applicable electronic means (data-logger, global positioning system (GPS) unit, etc.). Field forms are presented in the FSP. In addition, the field activities will be documented in a bound field logbook with numbered pages. Entries in the logbook will be made with indelible ink. The information documented will include, at a minimum: field staff names that are involved in sample collection activities for the specific day; photos with descriptions and locations; sample collection times and container sizes; amounts and types of any measurements; weather conditions; and/or GPS coordinates collected at each sampling point. Field documentation procedures are outlined in the FSP.

3.15.2 RECORDS

Trihydro will be the custodian of records and will maintain the contents of records for the site activities, including relevant reports, logs, field notebooks, pictures, subcontractor reports and data reviews in a secured, limited access area and under custody of the Trihydro PM. Electronic data will be stored in a secure cloud storage database with appropriate cybersecurity measures. Field data types may include field screening, water quality, fluid level, and location data. The final records may include:

- Field logbooks
- Field data and data deliverables
- Boring and well construction records
- Photographs
- Drawings/Figures
- Laboratory data deliverables

- Data validation reports
- Progress reports, QA reports, interim project reports, etc.
- Custody documentation
- Groundwater sample collection logs with well screening parameters
- Leachate sample collection logs
- Soil sample collection logs
- Air sample collection logs

Additional sample logs may be necessary if additional media are added to the OU-3 RI/FS field activities.

Trihydro will maintain site records at their Laramie, Wyoming, office for at least 10 years after the completion of site activities, or as deemed necessary by OU-3 Respondents. Additionally, the laboratory will retain records for 10 years after analyses.

The laboratory records will be kept with the Laboratory Project Managers. Data package deliverables from the laboratory meeting the requirements of the USEPA CLP specified data package deliverables, with modifications as required reflecting the use of USEPA approved methods will be maintained by Trihydro and each Laboratory. For analyses that do not have CLP forms, the results will be provided in a standard laboratory information management system (LIMS) report and then as part of a data package. These data packages will be sufficient for the specified level of data validation. The laboratory reports will contain the information needed to sufficiently and unambiguously document and recreate laboratory results. Sample custody and associated analyses will be completely documented. Data packages will contain information to completely document laboratory analysis procedures.

4.0 DATA QUALITY ASSESSMENT

Existing project data may be used to meet some project objectives for the current project SOW. However, these data may not be of the quality necessary to meet the current the DQOs discussed in this QAPP. If planning to use existing data, the data will be evaluated relative to the projects DQOs by obtaining and reviewing project metadata (i.e., information that describes the data and their quality criteria). Once possible existing data and metadata are identified for the project, the following steps will be taken to help evaluate the existing data as discussed in Section 3.0 of the *Guidance for Quality Assurance Project Plans (USEPA QA/G-5)* (USEPA 2002b):

1. Determine the data needs
2. Identify existing data sources that might meet project needs
3. Evaluate existing data to the project's data quality specifications
4. Document quality issues in planning documents and the final report

Data quality assessments are the evaluation of data to determine if data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. Data quality assessment completes the data life cycle by providing an assessment to determine if the planning objectives were achieved. Trihydro will use their data validation processes and data validation reports to document the data quality assessment for the site environmental data. Data quality assessment procedures will be performed in accordance with the *Guidance for Data Quality Assessment: Practical Methods for Data Analysis QA/G-9 (USEPA 2000a) and the Data Quality Assessment: A Reviewer's Guide QA/G-9R* (USEPA 2006b).

Existing data (if determined useable based on the procedures discussed above) and newly-collected data will be evaluated against a five-step statistical process described in detail in the *Data Quality Assessment: Statistical Methods for Practitioners* (USEPA 2006c). Five linear-statistical steps will be employed during the evaluation of the laboratory data:

1. Review of the site's objectives and sampling design: The goal of this activity is to develop quantitative statements of the reviewer's tolerance for uncertainty in the conclusions drawn from the data and in actions based on those conclusions.
2. Conduct a preliminary data review: The goal of this step is to review calculations of basic statistical methods and graphical representation data.

3. Select the statistical method: The goal of this step is to identify the appropriate statistical method that will be used to draw conclusions from the data.
4. Verify the assumptions of the statistical method: The goal of this step is to assess the validity of the statistical test chosen.
5. Draw conclusions from the data: The goal of this step is to use the chosen statistical test to draw conclusions to ensure that the data are adequate for the objectives described in Step 1.

The actual process for data evaluation is outlined in the RI/FS Work Plan and specified in the DQOs (Section 3.0).

5.0 DATA GENERATION AND ACQUISITION

The purpose of this section is to describe the data generation and acquisition that will be implemented by the project team. This appropriate tracking of data generation and acquisition will ensure that the data collected are of sufficient quality to meet overall project objectives as specified in the DQOs (Section 3.0). Data that may be generated as part of the work discussed in the RI/FS Work Plan, include:

- Historical and new chemistry/analytical data from groundwater/leachate, fluid levels, soil/bedrock, or indoor air samples
- Historical and new geospatial data from maps, figures, databases, new sample and well locations, and previous samples and well locations

The SOW and approach for this project includes a phased, lines-of-evidence approach that will provide an efficient, thorough, and cost-effective method to completing the project. The project design is outlined in the specific section of the RI/FS Work Plan for the work being performed.

Table 2-3 includes a complete list of project target compounds and current laboratory determined detection limits for each analyte in addition to the sampling methods for groundwater, soil, and air. Laboratory method MDLs and MRLs have been determined according to *Appendix B of 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants"* as noted in the laboratory QAMs (Appendix A). For radiological analyses, the laboratory uses documented procedures for the determination of the limit of detection (LOD) and limit of quantitation (LOQ) or MRL for each analyte and matrix. The procedures for the radiological LOD and LOQ are determined using the specific analytical method and *Appendix B of 40 CFR 136, "Definition and Procedure for the Determination of the Method Detection Limit – Revision 2"* as noted in the QAM (Appendix A).

The laboratory will attempt, through the standardized analytical methods, to achieve these MRLs. However, MRLs are highly dependent on specific sample matrix effects. In order to achieve the most useable results, Trihydro will work with each laboratory to achieve the lowest possible MRL within the appropriate levels of precision and accuracy. To ensure that data are useful for addressing the principal objectives of the RI/FS, samples will be analyzed and evaluated in accordance with this QAPP. A summary of laboratory reporting limits compared to potential risk-based criteria or clean up levels is included as Table 2-3.

5.1 SAMPLE HANDLING AND CUSTODY

A majority of the data for this project will be generated in the laboratories in accordance with the laboratories' QAMs (Appendix A). However, some data will also be generated in the field during sample collection. The procedures for analytical and chemical data generated in the laboratory and field are explained in the following sections.

5.1.1 SAMPLE HANDLING AND CUSTODY

From sample collection through laboratory analysis to the final evidence files, the procedures for sample handling and custody of the samples are described below. A sample or evidence file is in one's custody if it is:

- In one's physical possession
- In one's view, after being in one's possession
- In one's physical possession and placed in a secured location
- In a secured area restricted to authorized personnel only

As few people as practical should have custody of the samples to reduce the chance of mishandling.

5.1.1.1 FIELD CUSTODY PROCEDURES

The Trihydro FTL (or qualified designee) is generally responsible for implementation of field custody procedures. Specific field custody procedures are discussed, in detail, in the FSP.

5.1.1.2 LABORATORY CUSTODY PROCEDURES

The analytical laboratory assumes responsibility for the integrity and security of the samples after custody transfer is completed from the sampling team or the transportation service (if appropriate) to the laboratory. The laboratory custody procedures are described in the QAMs in Appendix A. Sample receipt and disposal procedures are described in the SOPs in Appendix D. Analytical holding times and bottle requirements are included in Table 2-2.

5.1.2 ANALYTICAL METHODS

Both field and laboratory analytical procedures will be performed during this project. Environmental samples will be submitted to the laboratory for prescribed chemical analyses (Table 2-3). A summary of the field and laboratory analytical procedures are described below.

5.1.2.1 FIELD ANALYTICAL PROCEDURES

Samples will be collected in accordance with the sampling practices described in the FSP. Samples will be collected using methods to avoid cross-contamination, sample agitation, and the most volatile analyses will be collected first, as specified in the FSP. This section is specifically related to QA of field analytical procedures.

5.1.2.1.1 GROUNDWATER AND LEACHATE PROCEDURES

Groundwater samples will be analyzed using procedures discussed, in detail, in the FSP. Samples will be field analyzed for the following field parameters: pH, temperature, specific conductance, turbidity, DO, and ORP. Collection procedures for these analyses are specified in the FSP and are in accordance with USEPA requirements. These variances will be on each field form and verified prior to collecting samples. Hand entry of field parameters will be subject to 100% QC checks. Data entered from dataloggers will be subject to spot checks (e.g., 10%) to confirm data were recorded and uploaded correctly. If problems are identified during spot checks, additional QC measures will be implemented.

The precision criteria for the each of the instruments is described in are described in the SOPs in the FSP appendices. The multi-meter calibration readings will be ±10% from the indicated calibration standard. Calibration forms will be kept with the project field forms for each day of calibration.

5.1.2.1.2 SOIL AND BEDROCK PROCEDURES

Soil and bedrock samples will be screened for total organic vapor (TOV) using a photoionization detector (PID). The PID will be used to measure the TOV for each interval. This information will be recorded in the logbook and field data sheet. The precision criteria for the TOV readings will be ±10% from the 100-parts per million (ppm) isobutylene in air calibration standard. Boreholes will be continuously cored, logged by a field geologist, and field screened using a PID, MicroR detector for gamma radiation, and the Ludlum Model 2350 Scaler/Ratemeter/Data Logger with the Model 44-10 sodium iodide probe and the Model 43-93 alpha/beta probe. Specific collection procedures for soil and bedrock are detailed in the FSP.

5.1.2.1.3 INDOOR AIR PROCEDURES

For indoor air sampling, a questionnaire will be completed with the property owner to determine potential for sources of VOCs, methane, and radon that could affect test results. In addition, the property will be screened with a low-level PID. Lastly, an ambient air sample will be collected in the vicinity of the building to verify no external sources are affecting the samples.

5.1.2.1.4 RADON PROCEDURES

For indoor air sampling, radon samples will be collected using both a Continuous/Short-Term and Electret Ion Chamber Procedures. Radon sampling via continuous short-term monitoring and electret ion chamber procedures will be conducted in accordance with the SOP provided in the *Indoor Radon and Radon Decay Product Measurement Device Protocols (USEPA-402-R-92-004 (USEPA 1992c).* The EPA-402-R-92-004 (USEPA 1992c) provides calibration procedures and other applicable QA procedures to help ensure field procedures are conducted with accuracy. The laboratory will follow procedures in Method EPA-402-R-92-004 with the deviation that the electret stability check will follow the Rad-Elec E-Perm System user manual’s limits (Short term – 6 volts/month over 1 month and long-term – 4 volts/month over 3 months) rather than the USEPA limits as the Rad-Elec document is directly from the manufacturer.

5.1.2.1.5 GEOSPATIAL PROCEDURES

Geospatial projects may involve collection of data through GPS measurements, aerial photography, imagery, shape files, geodatabases, latitude/longitude coordinate information, and land surveying. The project may also require acquisition of data from other external sources and databases. Prior to collecting any data, the types of data that may be needed will be verified with the Trihydro PM and APM. Any geospatial data collected for this project will be of sufficient quality to be paired with previously collected data, as follows:

1. Any geospatial datasets will be gathered from federal, state, or local government sponsored internet sites.
2. Collected geospatial data will be in digital form or converted to digital form.
3. Geospatial data will be stored in a project specific geospatial file and database.
4. Geospatial data will be accompanied by metadata that is up to date.
5. The data will be projected into the following coordinate system and datum: NAD83 State Plane Missouri East US Feet 2401.
6. Meet, at minimum, NGDP Tier 2 standards of 1-5 m accuracy and precision.

GPS coordinates will be used for general samples. However, the location of the new groundwater wells will be surveyed for horizontal location in latitude/longitude coordinates and referenced in State Plane NAD 1983 coordinates by a Professional Licensed Surveyor in the State of Missouri. Geospatial measurement instruments will be field calibrated against the applicable federal database prior to each use.

5.1.2.2 LABORATORY ANALYTICAL PROCEDURES

Groundwater, leachate, soil/bedrock, and indoor air samples will be analyzed as specified in the RI/FS Work Plan. A summary of the analytes and analytical methods are listed in Table 2-3. The laboratories will implement the project-required SOPs (Appendix D). The geotechnical laboratory will use published ASTM standards for grain size analysis (ASTM D422), liquid/plastic limits (ASTM D4318), and density (D7263).

The laboratory SOPs are based on the promulgated versions of analytical methods and other laboratory-developed procedures with the exception of highly-specialized analyses (analyzed by MCLInc). Specialized analyses are required for sequential extraction, XRD, SEM/EDS, Ferrous and Ferric Iron in soils. Due to the specialized nature of these Methods, the QA/QC data will vary, based on the SOP. These methods are described in greater detail below and in Appendix D.

- Sequential extraction procedures will be performed in general accordance with the method used by Liu and Hendry as published in "*Applied Geochemistry in December 2011 entitled, Controls on 226Ra during raffinate* neutralization at the Key Lake uranium mill, Saskatchewan, Canada" (Liu and Hendry 2011). Minor modifications have been made to the Method to address concerns with health and safety and to enhance the Method. The SOP for this procedure is included in Appendix D-7. The premise for the sequential extraction is to use a series of solutions (lixiviates) to exchange or leach the contaminants of interest, performed in a sequence of increasing aggressiveness, to help categorize the potential mobilization of the contaminant. While these sequential extraction procedures cannot be used to identify the actual chemical or physical form of a given metal in soil (true "speciation"), they are useful in categorizing the metal partitioning into several operationally defined geochemical fractions, relating to the tenacity of contaminant binding and thus the relative potential for mobility. The species determined in the extracts typically include iron (contributed from the predominant hydrous oxide component in soil that often retards the migration of uranium and other multi-valent cations) and a select suite analyte (e.g., radionuclides, RCRA-toxic metals, or other species of Site-specific interest).
- QC for sequential extractions: No standard reference material is available for sequential extractions, nor are MS/MSDs applicable because the soluble analyte in the spiking solution will extract in the first extraction and not follow the less soluble analyte in the soil that would be extracted later. Therefore, a set of laboratory-created sample duplicates, one per batch, will be analyzed to measure precision. The analysis of the extracts will have method blanks and LCS.
- XRD will be used to identify crystalline minerals and SEM/EDS will be used to identify bulk elements. The purpose of the inclusion of these methods is to potentially identify minerals and elements not identified as part of the other analyses (Table 2-3b). The Methods are described in Appendix D-7.

These SOPs provide sufficient details to evaluate quality of the analytical methods and are applicable to the data goals and sample media of this investigation. The documentation of appropriate method validation for the project target compounds is included in Appendix D of this QAPP, and includes the criteria for acceptance, rejection, and qualification of data.

Additionally, the laboratories will be requested to send preliminary data for initial review within the standard turn-around-time for the analytical method. Non-conformances or re-analyses will be addressed by the Trihydro QAD with the lab as soon as possible to meet QA and holding time requirements.

5.1.3 QUALITY CONTROL

The QA objectives provide quantitative and qualitative measures of the ability to produce high quality results through a properly designed sampling and analysis program. The objectives of the overall QA/QC program are to:

- Ensure that procedures are documented, including any changes from the RI/FS Work Plan protocol, FSP, or QAPP requirements.
- Ensure that sampling and analytical procedures are conducted according to sound scientific principles.
- Monitor the performance of the field sampling team and laboratory with a systematic audit program and provide for corrective action necessary to assure quality.
- Evaluate the quality of the analytical data through a system of quantitative and qualitative criteria.
- Ensure that data and observations are recorded and archived, as specified in Section 3.15.

5.1.3.1 FIELD QUALITY CONTROL CHECKS

The level of QC effort will be consistent with that required under Test Methods for Evaluating Solid Waste. The number/frequency for each QA sample type is summarized below and specified in Table 5-1:

- Blind Duplicate Samples: 1 blind duplicate per 10 groundwater samples will be collected for each groundwater and LCS leachate analyses (VOCs, SVOCs, metals, PCB, hydrocarbons, organochlorine pesticides, radiological chemistry, dissolved gases, and general chemistry), as sufficient sample is available. Blind duplicate samples will not be collected for soil/bedrock samples as they are inherently non-homogenous. Indoor air samples will not be duplicated. Radon analyses will not be duplicated due to the sample method.
- Equipment Blanks: 1 aqueous equipment blank per 20 groundwater, or LCS leachate samples will be collected for analyses of VOCs, SVOCs, metals, PCB, hydrocarbons, organochlorine pesticides, radiological chemistry,

dissolved gases, and general chemistry. 1 aqueous equipment blank per 20 soil and bedrock samples will also be collected for analyses of total metals, radiological analyses, major minerals and reactivity, mineralogy, and cation/anions.

- Field Blanks: 1 field blank per 10 groundwater, and LCS leachate will be collected for analyses of VOCs, TPH-GRO and radiological chemistry analyses.
- Trip Blanks: 1 trip blank within the shipping container containing samples for shipment of VOCs and TPH-GRO in groundwater and/or LCS leachate samples.
- Matrix Spike and Matrix Spike Duplicate: 1 MS/MSD duplicate pair will be collected for every 20 samples of groundwater, leachate, alluvial soil, or bedrock, as sufficient sample is available. Matrix spike and matrix spike duplicates are not required by Method TO-15 or TO-3 for indoor air analyses and some radiochemical analyses as specified in the SOPs (i.e. if MS/MSDs are not applicable, the method utilizes a stable carrier or radiotracer for sample-specific yield determination and for gamma spectroscopy where the MS/MSDs does not apply).
- Ambient Blank: One ambient blank per event will be collected during each indoor air sampling event for VOCs. Short- and long-term ambient blanks will also be collected for radon analyses.

If a blind duplicate fails the acceptance criteria, the laboratory will be contacted to evaluate the possible cause of the error. If duplicate samples do not meet the acceptance criteria (30% for groundwater/leachate and 50% for soils/bedrock), and 25% for indoor air, the parent and duplicate sample results will be qualified with “J” flags to indicate an estimated value. If the RPD is greater than or equal to 100%, associated sample results will be qualified with “J” flags for detections of that constituent or “UJ” for non-detections. When corrective action is taken because of field QC checks, the effectiveness of the corrective action will be measured based on the rate of reoccurrence of failure. In some cases, qualification of the data may be sufficient for evaluation of the data. In order to minimize the chance of cross-contamination, field and equipment blanks will be stored and shipped separately from source area samples, to the extent practicable. If quality procedures are not met and field personnel must return to the site to recollect data, the same quality procedures will be adhered to as above.

5.1.3.2 LABORATORY QUALITY CONTROL CHECKS

The laboratories have QC programs in place to ensure the reliability and validity of the analyses performed at the laboratory. Analytical procedures are documented in writing as SOPs and each SOP includes a QC section that addresses the minimum QC requirements for the analytical procedure. The internal QC checks differ slightly for each individual procedure, but, in general, the QC requirements include the following items:

- Holding Times and Preservation
- Instrument Tunes for Gas Chromatography/Mass Spectrometry (GC/MS) Analyses
- Initial and Continuing Calibrations Verification (ICV and CCV)
- System Performance Checks
- Internal Standard Areas for GC/MS Analyses
- Laboratory Blanks
- System Monitoring Compounds (i.e. Surrogates)
- LCS/LCSD (LCSDs will only be performed if necessary, as discussed further in Section 3.13.2)
- MS/MSD (MS/MSD samples will be collected as described in Section 5.1.3.1)
- Field Duplicates (field duplicate samples will be collected as described in Section 5.1.3.1)
- Laboratory Duplicates

<u>For Radiological Analyses:</u>

- Holding Times and Preservation
- Background
- ICV/CCV
- Laboratory Blanks
- LCS/LCSD (LCSDs will only be performed if necessary, as discussed further in Section 3.13.2)
- MS/MSD (MS/MSD samples will be collected as described in Section 5.1.3.1)
- Field Duplicates (field duplicate samples will be collected as described in Section 5.1.3.1)
- Laboratory Duplicates
- Chemical Yield
- Analyte Quantitation
- Negative Results

Slight differences may be required for specialty analyses (i.e. XRD, SEM/EDS, Soil Characteristics, etc.). These analyses will be analyzed in accordance with their specific SOPs (see Appendix D). Data obtained will be recorded in accordance with the established in the QAM (Appendix A). The data packages will be sufficient to perform data verification, Tier II, Tier III, or Tier IV data validations (as specified in the RI/FS Work Plan) and as defined in Table 2-1. Sample results may be rejected based on the data validation (as described in Section 7.1). In this case, the laboratory may be requested by the Laboratory or Trihydro QAM to reanalyze the samples. In the case that QA criteria are not met; the laboratory will contact the Trihydro QAM to discuss the need for reanalysis. The determination if reanalysis is necessary will be on a case-by-case basis and determined depending on the importance of the results, the difficulty to recollect the samples, and the ability for reanalysis to occur within the proper holding time. The laboratory will re-analyze samples analyzed in nonconformance with the QC criteria, if sufficient sample volume/mass is available. It is expected that sufficient volumes/mass of samples will be collected to allow for reanalysis, when necessary. Preservation requirements, sample volumes, holding times, and sample containers are contained in Table 2-2. If the QC fails and data are not usable, the laboratory will contact Trihydro. Trihydro and the OU-3 Respondents will determine the next steps on a case-by-case basis.

5.1.4 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

This section describes the procedures for maintaining the accuracy of instruments and measuring equipment which will be used for conducting field tests and laboratory analyses. Instruments and equipment will be maintained in order to promote the collection of precise and accurate data and to allow the project to proceed on schedule. To address the potential for impacted equipment interfering with sample readings, radiological screening of equipment, such as drilling rigs, will be completed prior to sampling, following sampling, and prior to leaving the site.

5.1.4.1 FIELD EQUIPMENT MAINTENANCE

The cornerstones of the field preventative maintenance program are the checking and calibration of field instruments before they are shipped or carried to the field, and the provision for backup instruments and equipment. Equipment used for sampling will be identified by the project field manager or field task manager prior to mobilization. Each instrument will be checked and certified by the shipper, rental company, or Trihydro FTL prior to each field event. Routine maintenance will be conducted in accordance with the FSP and specific instrumentation manuals. Routine calibration will minimize the potential for inaccurate field measurements.

Routine calibration will be conducted in accordance with procedures outlined in the FSP and specific instrumentation manuals. Routine calibration will minimize the potential for inaccurate field measurements.

5.1.4.2 LABORATORY INSTRUMENTS MAINTENANCE

A routine preventative maintenance program is conducted by each laboratory to minimize the occurrence of instrument failure and other system malfunctions. Designated laboratory employees regularly perform routine scheduled maintenance and repair of, or coordinate with the vendor for the repair of, laboratory instruments. Performed maintenance is documented in the laboratory's operating record. Laboratory instruments are maintained in accordance with manufacturer's specifications. Appendix A provides the maintenance protocols used by the laboratory to ensure proper operation of laboratory equipment. The laboratory operation procedures are verified by the accrediting bodies.

5.1.5 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Equipment will be inspected and calibrated at the start of each field day. Instrument calibration must be checked anytime during the field day that unexpected or unexplained readings are obtained and the instrument re-calibrated, if necessary. For instruments and equipment that are calibrated on an operational basis, calibration generally consists of the measurement of instrumental response to standards of known composition and concentration and may include the preparation of a standard response curve for the compound or parameter at different concentrations. Equipment will be calibrated in accordance with the specific SOPs or manufacturer guidelines.

5.1.5.1 FIELD INSTRUMENT CALIBRATION

Routine calibration will minimize the potential for inaccurate field measurements. Field instruments will be calibrated in accordance with procedures included in the FSP.

5.1.5.2 LABORATORY INSTRUMENT CALIBRATION

For a description of the calibration procedures for a specific laboratory instrument, refer to the applicable SOPs in Appendix D of this QAPP. The SOP for each analysis performed in the laboratory describes the calibration procedures, their frequency, acceptance criteria, and the conditions that will require recalibration. The laboratory shall maintain the following information within their records: instrument identification, date of calibration, analyst, calibration solutions run, and the samples associated with these calibrations.

5.1.6 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Equipment and supplies will be inspected prior to use. Faulty or defective supplies will be replaced to protect the integrity of the samples. Trihydro's company quality program addresses the acceptance of supplies and consumables. Trihydro will track any non-conformance of supplies and consumables and note them in corresponding quality discussions in the RI report.

5.2 EVALUATION OF OTHER NON-MEASUREMENT SOURCES

Data acquired from non-measurement sources, such as computer databases, spreadsheets, programs, and literature files, will be presented with references and guidance on understanding the application of the non-direct sources. Historical data quality will be assessed using methods described in Section 3.0.

5.3 DATA MANAGEMENT

Both field and laboratory data shall be collected as part of this project. Overall project data quality will be managed through a system of review extending from field and laboratory through the data reduction and reporting process. The Trihydro QAD or delegate will review the data entered into the project database and check that no encoding errors were made during transfer from field or laboratory data sheets. Other data analysis elements include the evaluation of data through storage and retention of data. Electronic copies of relevant data will be retained by Trihydro through the duration of the project. Electronic copies (electronic scans of reports) of the data will also be retained by the Laboratory PMs.

Once sampling and laboratory analyses are completed, the Trihydro QAD (or designee) will complete an initial Trihydro Tier I data validation/data verification and tracking form where general laboratory and field requirements are checked. The data validation levels are defined in Table 2-1. The results of the form are stored in a Trihydro-managed database and a request is sent to appropriate personnel for completion of data validation and QC. Data results will be maintained on a secure electronic network at the Trihydro office in Laramie, Wyoming. The electronic network is backed up to a cloud database daily. Field and laboratory data management will be completed as described in the following sections. Once data validation and Trihydro QC procedures (described in Section 7.1.1) are completed, the data will be exported into an USEPA-accessible database.

5.3.1 FIELD DATA MANAGEMENT PROCEDURES

The field data will include field observations, field parameter measurements, and health and safety data. Data and observations will be recorded in the instrument, field logbook or field forms. The forms are provided in the FSP. These forms and field books will be scanned into electronic format and kept with the project files for reference during data evaluation. Field data will be either directly input to the Trihydro database via the instrument or hand entered from the field data sheet. A second check will be used to verify that the data were correctly entered into the database. Once field data are reviewed and accepted, the field data will be exported into an USEPA-accessible database.

5.3.2 LABORATORY DATA MANAGEMENT PROCEDURES

Laboratory data management procedures will be performed according to the following protocol. Raw analytical data will be recorded in numerically identified laboratory notebooks (referenced by the laboratory as logbooks, analytical prep sheets, or similar) or in the LIMS. Data will be recorded in this notebook, laboratory SOP, or LIMS along with other pertinent information, such as the sample identification number and the sample tag number. Other details, such as the analytical method used, name of analyst, date of analysis, sample matrix, reagent concentrations, instrument settings, and the raw data will also be recorded in the laboratory notebook, analytical prep sheets or LIMS. Each page of the notebook (if applicable) will be initialed and dated by the analyst. Copies of any strip chart printouts (such as gas chromatograms) (if applicable) will be maintained on file. Periodic review of these notebooks (if applicable) by the laboratories will take place prior to final data reporting. The Laboratory QAOs will maintain records of notebook (if applicable) entry inspections.

For this project, the equations that will be employed in reducing data are presented in the SOPs in Appendix D of this document. Matrix effects are handled differently in each method and are specified in each method-specified SOP (Appendix D). Laboratories' will perform two levels of review for each data set including an analyst and a second level reviewer trained to verify data. Unacceptable data shall be appropriately qualified in the project report. The QA department will also review 10% of laboratory methods used on at least a quarterly basis, including a review of the raw data and data report for each reviewed method. Errors will be noted, and corrections made, but the original notations will be crossed out legibly, initialed and dated. QC data (e.g., laboratory duplicates, surrogates, MS/MSDs, LCS/LCSDs) will be compared to the historical limits unless a specific set of limits is set by the laboratory. Data considered acceptable will be entered into the LIMS and/or analytical reports (or similar). The data summary will be sent to the laboratory PM for review. Case or project narratives will be either manually or electronically generated to include information concerning data that fell outside acceptance limits, data qualifiers, and any other anomalous conditions encountered during sample preparation and analysis. The laboratories data package review departments are responsible for the review and assembly of each data package and they will ensure all sample and QC data are included and accurate prior to issuance. EDDs will be created by each lab (as possible) or will be entered into the electronic database by Trihydro. Once data validation and Trihydro QC procedures (described in Section 7.1.1) are completed, the data will be exported into an USEPA-accessible database.

5.3.3 GEOSPATIAL DATA MANAGEMENT PROCEDURES

The Trihydro GC will ensure data are stored in the project ArcSDE (Structured Query Language) database working from a Trihydro server in the Laramie, Wyoming office. ArcSDE allows for a more efficient storage and control of the data. During database construction only the Trihydro PM, Trihydro APM, and the Trihydro GC will have access to the data. Once the database is constructed and has been accepted by the Trihydro QA officer, the data will be used to create project figures and maps.

Any downloaded vector datasets will be projected into NAD 83 State Plane Missouri East US Feet 2401. These data will be combined using the “merge” tool in the ArcMap toolbox. These data will be clipped to the site boundary using the “clip” tool in the ArcMap toolbox. These layers will be managed in ArcCatalog with final storage in an ArcSDE database. Raster datasets downloaded will projected into NAD 83 State Plane Missouri East US Feet 2401. These data will be combined using the “append” tool in the ArcMap toolbox. These data will be clipped to the boundary using the “Clip” tool in the ArcMap toolbox. These layers will be managed in ArcCatalog with final storage in an ArcSDE database.

6.0 AUDITS AND OVERSIGHT

The field and laboratory data collected during this investigation will be used to evaluate the extent of contamination. The QC results associated with each analytical parameter will be compared to the objectives presented in the SOPs included in Appendix D. Only data generated in association with QC results meeting these objectives will be considered reliable for decision-making purposes.

6.1 AUDITS AND RESPONSE ACTIONS

Performance and system audits will be completed to assess whether the project personnel followed the appropriate QA and QC programs during field and laboratory activities. The Trihydro PM (or designee) will conduct internal field audits. The laboratories will conduct internal laboratory audits and the appropriate certification authorities may conduct external audits. Note that the members of the project team can stop work if an assessor in the field or laboratory observes that work is not in accordance with this QAPP, the FSP, the RI/FS Work Plan, or the Laboratory QAMs or SOPs. In this instance, the assessor will contact the project team promptly to communicate the issue and proposed corrective action.

6.1.1 FIELD AUDITS

The Trihydro PM may schedule audits of field activities. The evaluation is directed toward the extent to which the procedures in the RI/FS Work Plan, the FSP, and this document are being followed. The Trihydro PM (or designee) will check to see that CoC procedures are being followed and that samples are being kept in custody at all times. Field documents pertaining to sample identification and control will be examined daily for completeness and accuracy by the Trihydro PM (or designee) to see that all entries are dated and signed, and the contents are legible, written in indelible material, and contain accurate and inclusive documentation of project activities. The Trihydro PM (or designee) will review field notebooks and field data forms. An example field-audit form is presented as Appendix E. If deficiencies are identified during the audit, the auditor will decide whether to repeat sample collection and analysis based on the extent of the deficiencies and their importance in the overall context of the project.

The external field audit may be performed by the USEPA and/or MDNR. External field audits may be conducted any time during the field operations. These audits may or may not be announced and are at the discretion of the USEPA/MDNR. External field audits will be conducted according to the field activity information presented in this document. The external field audit process may include the assessment of (but not be limited to) the following:

- Sampling equipment decontamination procedures
- Sample bottle preparation procedures
- Sampling procedures
- Examination of field sampling and safety plans
- Sample vessel cleanliness and QA procedures
- Procedures for verification of field duplicates
- Procedures for the collection of filtered samples
- Sample preservation and preparation for shipment
- Field screening practices
- Split sample collection and analyses
- Procedures for field calibration of GPS and/or survey equipment (as specified in the FSP)

For indoor air analyses, 100% complete canister certification will also be required by the laboratory. Additionally, prior to sampling, the gauges will be checked to verify that the canister is working properly.

6.1.2 LABORATORY AUDITS

The laboratories' QAOs will conduct the internal laboratory audits. The internal system audits will be done on at least an annual basis. The internal system audits will include an examination of laboratory documentation on sample receiving, sample login, sample storage, CoC procedures, sample preparation, sample analysis, instrument operating records, etc. The internal performance audits will be conducted as specified in the QAMs (Appendix A). The performance audits may involve preparing blind QC samples and submitting them along with project samples to the laboratory for analysis. The Laboratory Quality Manager will evaluate the analytical results of these blind performance samples to ensure the laboratory maintains acceptable QC performance. Laboratory audit procedures, criteria, and schedules are outlined in the QAMs located in Appendix A.

An external audit may be conducted in association with certification of the laboratory. Failure of any or all audit procedures can lead to laboratory disqualification and the requirement that another suitable laboratory be chosen.

An external on-site review may consist of examination of the following items and procedures:

- Sample receipt procedures
- Custody and sample security and login procedures
- Sample tracking procedures
- Instrument calibration records review
- Instrument logs review
- QA procedures review
- Logbooks review
- Sample preparation procedures
- Sample storage procedures
- Sample disposal procedures
- Sample analytical SOP review
- Field instrument review
- Personnel interviews
- Glassware prep

It is common practice when conducting an external laboratory audit to review one or more data packages from sample lots recently analyzed by the laboratory. This review would most likely include but not be limited to:

- Comparison of resulting data to the SOP or method, including coding for deviations
- Verification of ICV and CCV within control limits (ICV acceptance criteria varies by method and may not be the same as the CCV acceptance criteria)
- Verification of surrogate recoveries and instrument timing results, where applicable
- Review of extended quantitation reports for comparisons of library spectra to instrument spectra, where applicable
- Review of recoveries from laboratory control sample analyses
- Review of run logs with run times, ensuring proper order of analyses
- Review of spike recoveries/QC sample data
- Review of suspected manually integrated GC data and its cause (if applicable)

- Review of GC peak resolution for isolated compounds as compared to reference chromatograms (if applicable)
- Assurance that samples were run within holding times

Ideally, the data should be reviewed while on the premises, so that any data called into question can be discussed with the laboratory staff.

6.1.3 RESPONSE ACTIONS

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out of QC performance, which can affect data quality. Field team members may identify problems during sampling and laboratory analysts may identify problems during chemical analyses. Problems may be identified by the project managers and QAOs during the audit procedures. Corrective actions are described in the statements below.

Proposed and implemented laboratory corrective action will be documented in the regular QA reports to management. The Trihydro PM, or their designee, will only implement the proposed corrective action after approval from the OU-3 Respondents. If immediate corrective action is required, approvals secured by telephone from the Trihydro PM will be documented in an additional memorandum.

For noncompliance problems, a formal corrective action program will be determined and implemented at the time the problem is identified. The person who identifies the problem is responsible for notifying the Trihydro PM, who in turn will notify the OU-3 Respondents. The OU-3 Respondents will be promptly notified from the time the problem was communicated to the Trihydro PM. If the problem is analytical in nature, information about the problem will be promptly communicated to the OU-3 Respondents. Implementation of corrective action will be confirmed in writing through the same channels. For problems that involve sampling that has not been done previously at a location, or for a new parameter, or for more conservative reporting limits, the corrective action will be determined based on the goals established in the RI/FS Work Plan for that investigation. Note that the Trihydro PM has the ability to stop work due to a nonconformance issue.

Any nonconformance with the established QC procedures in this document will be identified and corrected in accordance with the QAPP. The Trihydro PM, or designee, will issue a nonconformance report for each nonconformance condition. The effectiveness of the applied corrective action will be measured based on internal audits and observations, which will be reported to the OU-3 Respondents. Nonconformance reports will be provided to

USEPA and MDNR within 30 days of identification of any nonconformance condition unless suitable rational for additional time is provided, subject to USEPA approval.

6.1.3.1 FIELD CORRECTIVE ACTION

Corrective action in the field may be needed when the sample network is changed (i.e., more/less samples, sampling locations other than those specified in the QAPP, etc.), or if sampling procedures and/or field analytical procedures require modification, etc., due to unexpected conditions. It will be the responsibility of the Trihydro PM to ensure the corrective action has been implemented.

If the corrective action will supplement the existing sampling plan using existing and approved procedures in the QAPP, corrective action approved by the Trihydro PM will be documented. If corrective actions result in fewer samples (or analytical fractions), alternate locations, etc., which may cause project QA objectives not to be achieved, the OU-3 Respondents will be notified of the reason for the deviation.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected due to unapproved or improper use of approved methods. The Trihydro PM (or designee) will identify deficiencies and recommend corrective action. The field team will implement the corrective actions. Corrective actions will be documented in the corresponding progress report.

Corrective actions will also be implemented and documented in the field records. Staff members will not initiate corrective action without prior communication of findings through the proper channels. If corrective actions are insufficient, the Trihydro PM may stop work. If at any time a corrective action issue is identified which directly affects project objectives, the OU-3 Respondents will be notified immediately.

6.1.3.2 LABORATORY CORRECTIVE ACTION

In general, the inability to achieve the QA objectives discussed in this QAPP may result in laboratory corrective action. A detailed description of laboratory responses to correct these deficiencies is presented in the laboratory SOPs. If the laboratory cannot correct the deficiencies, they will be handled in one of three ways:

- The laboratory will be asked to reanalyze the samples in question, if sample holding times have not been exceeded. Otherwise, the laboratory may be asked to re-quantify relevant peaks in the chromatograms or reprocess other instrumental output, when applicable.

- Trihydro will demonstrate that the noncompliance does not compromise the successful achievement of the RI/FS Work Plan objectives.
- Additional samples will be collected and analyzed to eliminate the non-compliance.

The Trihydro QAD may identify the need for corrective action during either the data validation or data assessment. Potential types of corrective action may include re-sampling by the field team or re-injection/re-analysis of samples by the laboratory. These actions are dependent upon the ability to mobilize the field team and whether the data to be collected is necessary to meet the required QA objectives (e.g., the holding time for samples is not exceeded, etc.). If the Trihydro QAD identifies a corrective action situation during data assessment, it is the Trihydro PM, OU-3 Respondents, and the USEPA who will be responsible for approving the implementation of corrective action, including re-sampling. The Trihydro QAD will document all corrective actions of this type. Laboratory noncompliance and corrective actions will be discussed in the subsequent progress reports.

6.1.4 GEOSPATIAL DATA ASSESSMENT AND RESPONSE

Each of the geospatial datasets will be reviewed. The Trihydro GC will be checking for display errors and attribute errors between datasets from different sources or newly collected and historical datasets.

The Trihydro GC will perform an assessment of the data by searching for display discontinuities and attribute discrepancies. Finding display errors is completed through visual inspection and looking for errors in the site border matches and, secondly, verifying that each dataset has similar features and attributes. If the datasets do not match, the Trihydro GC will review the projection. Any projection conflicts will be corrected. If this action shows the two datasets do not represent continuous data, a new search for matching data will take place. If these inconsistencies cannot be corrected, these datasets will not be included in the final database.

If attribute errors are found, anomalous data will be identified by its deviation from the expected or normal range of spatial location or value. This will be done through verification using field maps and field data. Raster datasets, such as the GIS maps, groundwater models and land use images will be assessed for general accuracy by looking at the values of different types or classes of pixels and their associated spatial patterns. In addition, we will use permanent features, such as roads, streams, and land features to compare metadata to aerial photos and ensure that the two sources are in agreement.

If problems are identified in any of the datasets, the Trihydro GC will contact the Trihydro PM or Trihydro APM to discuss additional assessment and solutions. The Trihydro GC will correct any data inaccuracies when there is sufficient information to support these corrective changes. Spatial data that cannot be verified or that appears to have errors that cannot be explained by resolution, acquisition date or other metadata entries may be discarded from this project.

6.2 REPORTS TO MANAGEMENT

Both field and laboratory data will be reported first to the Trihydro PM and APM and then the data will be sent to the Trihydro QAD for review. Once data are reviewed and determined to be final, they will be used for reporting purposes to OU-3 respondents and the regulatory agencies.   Data reporting procedures shall be carried out for both field and laboratory operations, as described below.

6.2.1 FIELD DATA REPORTING

Field data reporting shall be conducted principally through the transmission of field data sheets containing tabulated results of all measurements made in the field, and documentation of all field calibration activities. Additionally, a separate QA section of the RI/FS report will be used to convey data usability, bias, results of the assessments, approved changes to the QAPP (if necessary), major personnel changes, corrective actions performed, and any other relevant QA information. Reports to management shall be completed by the Trihydro PM (or designee) and submitted to the OU-3 Respondents. For specific information related to field data reporting, see Section 3.20 of the FSP.

6.2.2 LABORATORY DATA REPORTING

The task of reporting laboratory data begins after the appropriate internal laboratory QA review has been concluded. Leveled data packages (II, III, and IV) will be available from all laboratories, as needed. The communication/notification, reporting requirements, and analyses requirements are described in greater detail in Trihydro's Tier I and Tier II Laboratory Performance Guidelines and Tier III and Tier IV Laboratory Performance Guidelines in Appendix F-1 and F-2, respectively and as defined in Table 2-1. Standard turnaround times will be met by the laboratories unless otherwise requested. However, it should be noted that there may be a variation in the turnaround time for radiochemistry data and level IV data packages as they are more complex than the standard analytical suite and take longer to produce. Requirements may vary due to the analytical procedure requirements. These variations will be discussed with the Trihydro QAD prior to sample collection.

Any program of environmental measurement can produce outlier results that are outside the "expected" range of values. Outlier values may be the result of:

- A catastrophic unnatural (but real) occurrence, such as a spill
- Inconsistent sampling or analytical chemistry methodology
- Variation in field conditions (e.g., if construction work is being conducted near the site)
- Errors in the transcription of data values or decimal points
- True but extreme variability in concentration measurements

Documentation and validation of the cause of outliers will accompany the data; values will not be altered. Outlier values will not be omitted from the raw data reported to the USEPA and MDNR but will be identified as outliers within the data summary tables are prepared and may be "rejected" if determined incorrect during data validation review. Reasons for the outlying behavior will be provided in the data summary tables or in the Trihydro Tier II, Tier III, or Tier IV data validation reports (defined in Table 2-1).

Data below detection limits will be expressed as determined by individual Method SOPs and each laboratories' QAMs. If possible (as determined by the laboratory SOP or QAM), the data will be flagged with a "J" when detected between the MRL and MDL, for non-radiochemistry data. Data above the detection limit will be expressed in units of micrograms per liter or milligrams per liter for groundwater, milligrams per kilogram (mg/kg) dry weight for soil, or micrograms per cubic meter ($\mu g/m^3$) or parts per million volume for indoor air samples. Solid radiochemistry results will be reported in units of picocuries per gram (pCi/g). Water radiochemistry results will be reported in units of pCi/L. Uncertainty qualifiers are not applied to radiochemistry data and would be applied during validation. Therefore, the laboratory will qualify results, as appropriate for radiochemistry data; which will be in accordance with guidelines from Chapter 8 of the *USEPA MARLAP, document number USEPA 402-B-04-001A (USEPA 2004a) and the ANS Standard 41.5-2012 (ANS 2018).*

The deliverables associated with the tasks identified in the RI/FS Work Plan will contain data quality information collected during the task. Those reports will be the responsibility of the respective laboratories' Project Manager or designee and will include the QC summary for the accuracy, precision, and completeness of the data, as well as the results of the performance and system audits, and any corrective action needed or taken during the project. The laboratory data are reported through the LIMS. A copy of the laboratory data report will be included in the reports to the OU-3 Respondents, USEPA, and MDNR.

6.2.3 GEOSPATIAL DATA REPORTING

Geospatial data reporting will be started by the Trihydro GC (or designee) upon request from the Trihydro PM or Trihydro APM to create a figure or map. The map will be reviewed by the Trihydro GC for any of the errors discussed in Section 6.1.1. If errors are found, the Trihydro PM and Trihydro APM will be contacted to discuss solutions. The map will be revised until the Trihydro GC feels that the map is correct and can be released for quality review. The map will be reviewed by another trained Trihydro geospatial specialist, to verify that features are properly labeled, and attributes are properly shown. The reviewer will also check for any missed geospatial attribute errors. The map or figure will then go to the Trihydro PM/Trihydro APM for review. The map or figure will be reviewed in detail to again verify that features are properly labeled, and attributes are properly shown. This two-step review will all for reviews from both a technical expert and a project expert.

7.0 DATA VALIDATION AND USABILITY

Data generated through field activities or by the laboratory shall be reduced and validated prior to reporting. Data shall be disseminated by the laboratory and the Trihydro QAD after it has been subjected to the laboratory QA/QC and review procedures. This section covers procedures to compile, validate, and report the data collected during the groundwater, soil/bedrock, leachate, and indoor air analyses investigations.

7.1 DATA REVIEW, VERIFICATION, AND VALIDATION

The process of data validation is the examination of objective evidence that the requirements of the specified QC acceptance criteria are met. Data validation procedures shall be performed for both field and laboratory operations, as described below. Data will be validated in accordance with the Trihydro data validation process.

7.1.1 FIELD DATA

The procedures to evaluate field data for this investigation include checking for transcription errors and review of field logbooks, on the part of the field team. The Trihydro FTL (or designee) will review the field notes after completion of sampling. The objectives of this review are to identify and correct errors in the field notes. The Trihydro QAD will review the field audit and field notes and determine whether the samples were collected and handled according to this QAPP.

7.1.2 LABORATORY DATA

Trihydro will perform data validation review on data received from the laboratory. The data validation will include Trihydro Tier I, and Tier II, Tier III, or Tier IV data validation reviews as described in Sections 7.1.2.1, 7.1.2.2, and 7.1.2.3, respectively. Trihydro levels of data validation are in accordance with full USEPA data validation levels and are defined in Table 2-1. The level of validation for each study are specified in the DQOs and RI/FS Work Plan.

As described in Section 7.1.2.4, data qualifiers will be applied to the data based on the data validation review. These qualifiers will be maintained in the database with each data point.

Organic data will be evaluated in accordance with the general validation criteria set forth in the *USEPA CLP National Functional Guidelines for Organic Superfund Methods Data Review* (USEPA 2017a) with additional reference to *USEPA CLP National Functional Guidelines for Organic Data Review* (USEPA 1999b). Data from inorganic analyses will be evaluated according to validation criteria set forth in the *USEPA CLP National Functional Guidelines for Inorganic Superfund Methods Data Review* (USEPA 2017b), with additional reference to the *USEPA CLP National*

Functional Guidelines for Inorganic Data Review, (USEPA 2004b). Review of duplicates will be conducted in accordance with *EPA New England Environmental Data Review Supplement for Region 1 Data Review Elements and Superfund Specific Guidance/Procedures* (USEPA 2018). Data for radiological analyses will be validated in accordance with guidelines from *Chapter 8 of the USEPA MARLAP, document number USEPA 402-B-04-001A* (USEPA 2004a) and *the ANS Standard 41.5-2012* (ANS 2018). Alternative qualification approaches may be required as determined by the validator and their professional judgement, and if it is allowed per the guidance documents noted above. In these instances where application of an alternative protocol is necessary, the reason and approach will be documented in the corresponding data validation report to allow for USEPA review and approval.

Each analytical data report will be reviewed by the Laboratory PM (or qualified designee). The data validation reports will be verified by a radiochemist with at least 2 years of radiochemical separations and measurement experience. The data validator will also evaluate the overall completeness of the data package. Completeness checks will be administered on data to evaluate whether deliverables specified in the QAPP are present. The following sections describe data validation procedures in greater detail.

7.1.2.1 TIER I DATA VALIDATION / DATA VERIFICATION

In addition to the field data validation procedures, the Tier I data validation is performed to verify and document that samples in the data set were analyzed according to the project requirements and that the laboratory analytical report is complete. An electronic Tier I validation checklist will be prepared in an electronic format for each laboratory analytical sample group. Tier I validations will be performed by a competent person with knowledge of the project requirements. The Tier I validation will include a review of the following elements:

- Review of the cover letter signed by the Laboratory PM or designee.
- Review of the case narrative discussing any technical problems or deviations from the analytical methods including if the laboratory received the samples in good condition. Samples are considered in good condition if the samples are at the proper temperature (4 degrees Celsius [°C] ± 2°C) (if applicable) or chemical preservative (if applicable), and if sample receipt condition is acceptable (i.e., the bottles are not broken, and the cooler custody seals are intact). Some analytical methods (e.g., radiochemical analyses and isotopes) may have specific temperature or chemical preservation requirements. These are noted in Table 2-4 of the FSP and Table 2-2 of this QAPP.
- Review of date and time of receipt.
- Review of CoC forms to verify that samples were maintained under strict CoC with signatures from the field personnel and the lab personnel.

- Comparison of sampling dates to sample extraction dates and analysis dates to check that samples were extracted and/or analyzed within proper holding times.
- Review of target constituent list, analytical methods, and detection limits or MDCs to verify conformance with the RI/FS Work Plan.
- Review of lab validation summary/chronicle describing client ID/analysis, laboratory identification number, prep number, collection date, extraction/prep date, analysis date, and analytical section manager sign off.
- Review of sample data report including the results listed in alphabetical order (or by analytical method) with sample preparation, extraction, cleanup, digestion, and analytical methods, analysis date, extraction date, analyst initials, and qualifiers included.
- Review of QC summary report including date of analyses, parameters determined, system monitoring compound summary, method blank data, sample duplicates and control samples, surrogate spike recoveries, and MS and MSD results.
- Review of additional performance criteria specific to analytical methods.
- Evaluation of corrective actions that may have been necessary and possible data quality assessment items.
- Review of canister certifications to verify that canisters were sufficiently clean prior to sample collection.
- Review of canister pressures to verify that there was not additional loss of pressure during transit.

7.1.2.2 TIER II DATA VALIDATION

In addition to the Tier I validation requirements, the Tier II evaluation will include a review of the basic laboratory QC data. A detailed data validation report, as shown in template (Appendix G), which provides sufficient detail to explain data qualifiers and data inadequacies, is produced by the reviewer. The Tier II data validation process provides sufficient detail for the data user to have an accurate idea of the data quality and reliability, and an understanding of how well the project objectives were met. The Tier II data validation is performed by a chemist or other trained scientist who is familiar with contract laboratory procedures and the methodology. The Tier II data validation will include a review of Tier I elements as well as the following criteria:

- Review of field and laboratory blanks to evaluate possible contamination sources; consideration should be given to preparation techniques and frequencies, as well as the analytical results.
- Review of field duplicate data for evaluation of field and laboratory precision.
- Review of laboratory QA data for compliance with method or project required acceptance criteria.

- Review of the analytical results to verify compliance with the specified project goals.
- Review of additional method specific performance criteria, as appropriate, if provided by the laboratory.

The following criteria will be evaluated during the Tier I and II data validation process:

- Chain-of-Custody: Is the CoC complete and were the analytical method(s) specified?
- Sample Check in Conditions: Did the samples arrive at the correct temperature and with the correct container count? Were the sample labels complete and was integrity of the samples and the container maintained? Were the samples received properly preserved?
- Holding Times: Were the samples extracted/digested within the method specified holding times? Were the samples analyzed within the method specified holding time?
- Dilutions/Method Reporting Limits: Were any samples diluted to an extent that the resulting reporting limits were raised to a degree which would render the associated data points unsuitable for the projects DQOs? Were the dilutions necessary and unavoidable? Is re-analysis of the sample extract possible or feasible?
- Laboratory Control Samples/Laboratory Control Sample Duplicates (Second Source Standards): Was the LCS/LCSD compound list complete and were required analytes contained in the spike solution? Was the LCS/LCSD performance within the method specified limits for each compound?
- Matrix Spike/Matrix Spike Duplicate Recovery: Was the specified sample from this project sample set used as the MS/MSD parent sample? Was the MS/MSD compound list complete and were required analytes contained in the spike solution? Were the MS/MSD recovery values within the method specified limits for each compound? The degree of matrix interferences in a sample can vary significantly, even within a sample set collected from the same site. Therefore, data qualifications will be assigned based on an evaluation of associated QC data and the professional judgment of the reviewer.
- Duplicate Sample Repeatability (Field and Laboratory Duplicate Samples): Field duplicate RPD limits for groundwater/leachate are set at 0-30%, for soil/bedrock are set at 0-50%, and for indoor air are set at 0-25%, and laboratory RPD limits reference published or method specified limits. In cases where a compound is detected at concentrations less than five times the detection limit, the precision goals will not apply in accordance with USEPA data validation guidelines. Repeatability (precision) failures will be "J" flagged. Duplicate samples and evaluation of field precision will be assessed on a case-by-case basis. The parent sample and duplicate sample may be flagged based on the results of the validation. Field duplicate samples will be evaluated in the overall quality of the associated data set.

- Surrogate Recoveries: Surrogate compound recoveries are expected to be within the method or laboratory specified acceptance limits.
- Radiochemical analyses will be validated as described in Appendix B, and in accordance with guidelines from *Chapter 8 of the USEPA MARLAP, document number USEPA 402-B-04-001A* (USEPA 2004a) and the *ANS Standard 41.5-2012* (ANS 2018). Changes to data validation procedures for radiological analyses may be made at the discretion of the data validator and will be documented in the data validation reports.

7.1.2.3 TIER III AND TIER IV DATA VALIDATION

A detailed data validation report, as shown in Appendix F-2, which provides sufficient detail to explain data qualifiers and data inadequacies, is produced by the reviewer. A Tier IV data validation will include a review of the raw analytical data, which is examined in detail to check for correctness of concentration calculations, compound identification and anomalies in the data. A detailed data validation report, provides sufficient detail to explain data qualifiers and data inadequacies, is produced by the reviewer. The Tier III and IV data validation processes provide sufficient detail for the data user to have an accurate idea of the data quality and reliability, and an understanding of how well the project objectives were met. The Tier III and IV data validations will verify that the data were adequately analyzed, to allow their use in formal legal proceedings, risk assessments, and closures. Tier III and IV data validations are performed by a chemist or other trained scientist who is familiar with contract laboratory procedures. The Tier III and IV data validation will include a review of Tier I elements as well as some or all of the following criteria:

- Review of field and laboratory blanks to evaluate possible contamination sources; consideration should be given to preparation techniques and frequencies, as well as the analytical results.
- Review of field duplicate data for evaluation of field and laboratory precision.
- Review of laboratory QA data (MS/MSD recoveries and RPD calculations, surrogate spike recoveries, LCS/LCSD recoveries and RPD calculations) for compliance with method or project required acceptance criteria.
- Review of the analytical results to verify compliance with the specified project goals.
- Review of laboratory summary of tuning and calibration checks.
- Review of QC packages and sample raw data and calculations (the raw data and calculations are reviewed specifically with Tier IV data validation).
- Review of serial dilutions (if applicable to the method requirements).
- Limited review of chromatograms.
- Review of ICV and CCV results (may have been conducted in a Tier II but required for a Tier III).

- Review of instrument performance results (if applicable to the method requirements).
- Review of internal standard results (if applicable to the method requirements).
- Review of ICP interference check sample results (if applicable to the method requirements).
- Review of method detection limit verifications.
- Review of instrument and calibrations performance summaries (if provided).
- Review of additional method specific performance criteria, as appropriate, if provided by the laboratory.

The following criteria will be evaluated during the Tier III/IV data validation process:

- Chain-of-Custody: Is the CoC complete and were the analytical method(s) specified?
- Sample Check in Conditions: Did the samples arrive at the correct temperature and with the correct container count? Were the sample labels complete and was integrity of the samples and the container maintained?
- Holding Times: Were the samples extracted within the method specified holding times? Were the samples analyzed within the method specified holding time?
- Dilutions/Method Reporting Limits: Were any samples diluted to an extent that the resulting reporting limits were raised to a degree, which would render the associated data points unsuitable for the projects DQOs? Were the dilutions necessary and unavoidable? Is re-analysis of the sample extract possible or feasible? Were the same project quantitation limits used for each sampling event? If possible, from the laboratory, did the laboratory "J" flag detected results between the reporting limit and method detection limit?
- Laboratory Control Samples/Laboratory Control Sample Duplicates (Second Source Standards): Was the LCS/LCSD compound list complete and were all required analytes contained in the spike solution? Was the LCS/LCSD performance within the method specified limits for each compound?
- Matrix Spike/Matrix Spike Duplicate Recovery: Was the specified sample from this project sample set used as the MS/MSD parent sample? Was the MS/MSD compound list complete and were all required chemicals contained in the spike solution? Were the MS/MSD recovery values within the method specified limits for each compound? The degree of matrix interferences in a sample can vary significantly, even within a sample set collected from the same site. Therefore, data qualifications will be assigned based on an evaluation of all associated QC data and the professional judgment of the reviewer.
- Duplicate Sample Repeatability (Field and Laboratory Duplicate Samples): Field duplicate RPD limits for groundwater/leachate are set at 0-30%, for soil/bedrock are set at 0-50%, for indoor air at 0-25%, and laboratory RPD limits reference published or method specified limits. In cases where an analyte is detected at concentrations

less than five times the detection limit, the precision goals will not apply in accordance with USEPA data validation guidelines. Repeatability (precision) failures will be "J" flagged. Duplicate samples and evaluation of field precision will be assessed on a case-by-case basis. The parent sample and duplicate sample may be flagged based on the results of the validation. Field duplicate samples will be evaluated in the overall quality of the associated data set.

- Surrogate Recoveries: Surrogate compound recoveries are expected to be within the method or laboratory specified acceptance limits.
- Internal Standards and Retention Time Windows (if available): The data sets will be required to fully meet the method specified requirements for these criteria.
- CV and CCV; if available: ICV and CCVs will be checked to confirm that they met the method specified limits for accuracy and periodicity. If an ICV and/or CCV failure is noted, the data validator will document that samples analyzed prior to the ICV and/or CCV failure were re-analyzed after the instrument was re-calibrated.
- Instrument Performance Checks (if available): The data validator will confirm that the method specified instrument performance checks were run and met the method requirements.

7.1.2.4 DATA VALIDATION QUALIFIERS

The data quality flags used to qualify analytical data will be similar to those outlined within the USEPA Data Validation Functional Guidelines for Evaluating Environmental Analyses and Appendix B. *MARLAP* (USEPA 2004a) and the *ANS Standard 41.5-2012* (ANS 2018) will be used for the validation of radiological data. The most commonly used data quality flags are included in the Data Validation Variance Documentation in Appendix B.

7.1.2.5 GEOSPATIAL DATA VALIDATION

The Trihydro GC will be responsible for final verification and validation and ensuring that the QA checks (Section 6.2.3) were completed. For each dataset, the Trihydro GC will verify the:

1. Dataset was acquired from a state or federal sponsored website
2. Dataset has updated metadata from source
3. Data is projected into NAD83 State Plane Missouri East US Feet 2401
4. Data matches visually
5. Data attribute information matches across the site

7.1.2.6 DATA DEFICIENCIES

The data set will be reviewed for conformance to the method-specified recovery or repeatability values for each individual constituent in each required QC analysis. Analytical data points that are associated with procedural or analytical irregularities will be evaluated according to the following protocol:

- Minor deficiencies: Deficiencies which are determined to have no significant effect on the accuracy of the data will be regarded as minor deficiencies. These occurrences will be noted and explained in the data validation report but will not affect the usability of the data points and the data will not be qualified.
- Significant deficiencies: Significant deficiencies are serious enough to call the veracity of a given data point(s) into question. In these cases, the deficiencies are judged to result in known or probable variation from the normal analytical method performance standards, with relation to the precision and/or accuracy of the data point. Subject data points will be qualified with the appropriate qualifiers per USEPA data validation guidelines (Section 7.1.2).
- Major deficiencies: Irregularities in the sample handling or analytical process which compromise the analytical result(s) to such an extent that the data are deemed unusable or unreliable. Such data points will typically be rejected, and the reason(s) will be explained in the data validation report on a sample-by-sample basis.

QC data will be discussed in detail in a QA section of the RI/FS report. QA information will be included in other chapters to the extent that it affects the interpretation of sample data. For radiochemistry data, data deficiency will result in either correction or recollection of the data.

7.2 RECONCILIATION WITH USER REQUIREMENTS

The data will be reconciled with this QAPP and the DQOs (described in the RI/FS Work Plan) to evaluate the data usability, including a comparison with the media-specific screening values, an evaluation of whether additional data gaps exist, and an assessment of the need for further remedial investigation or action.

Results of the data validation process and DQO assessment will be reported to the USEPA with the RI/FS report. This process is documented in a Tier II, Tier III, or Tier IV Data Validation. Summary tables documenting analytical data will be denoted with any flags resulting from the Trihydro data validation process, in addition to the laboratory data qualifier flags. For example, samples that are rejected as part of the data validation process ("R" flag) would not meet the DQOs for the site.

As stated above, nonconformance with the QA objectives will result in corrective action and will be reported to the OU-3 Respondents. The data review will include an evaluation of the precision, accuracy, representativeness, comparability, and completeness according to the limits specified with the laboratory reports.

For geospatial data, if the data is not conforming to the QC criteria and assessment procedures, the data will not be used until those procedures are met. The accuracy of the data must be sufficient to be used for creating figures and maps that will be used to determine the current site conditions.

8.0 REFERENCES

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TABLES

TABLE 2-1. DATA VALIDATION LEVELS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Review Item[1,2]	Tier I	Tier II	Tier III	Tier IV
Laboratory Notes and Narrative	Review	Review/Implications	Review/Implications	Review/Implications
Laboratory Qualifiers	Review	Review/Implications	Review/Implications	Review/Implications
Chain-of-Custody	Review	Review/Implications	Review/Implications	Review/Implications
Detection Limits	Review	Implications	Implications	Implications
Analytical Methods	Review	Review/Implications	Review/Implications	Review/Implications
Sample Receipt	Review	Review/Implications	Review/Implications	Review/Implications
Sample Preservation	Review	Review/Implications	Review/Implications	Review/Implications
Sample Temperature	Review	Review/Implications	Review/Implications	Review/Implications
Holding Times	Review	Review/Implications	Review/Implications	Review/Implications
Reported Units	Review	Review/Implications	Review/Implications	Review/Implications
Constituent Lists	Review	Implications	Implications	Implications
Method Blank /Preparation Blanks Completeness	--	Review/Implications	Review/Implications	Review/Implications
Method Blank /Preparation Blanks Detections	--	Review/Implications	Review/Implications	Review/Implications
Matrix Spike Completeness	--	Review/Implications	Review/Implications	Review/Implications
Matrix Spike Compliance	--	Review/Implications	Review/Implications	Review/Implications
Laboratory Control Sample Completeness	--	Review/Implications	Review/Implications	Review/Implications
Laboratory Control Sample Compliance	--	Review/Implications	Review/Implications	Review/Implications
Deuterated Monitoring Compounds/Surrogate Recoveries	--	Review/Implications	Review/Implications	Review/Implications
Trip/Field/Equipment Blanks Completeness	Review	Review/Implications	Review/Implications	Review/Implications
Trip/Field/Equipment Blanks Detections	Review	Review/Implications	Review/Implications	Review/Implications
Field Duplicate Completeness	Review	Review/Implications	Review/Implications	Review/Implications
Field Duplicate RPD Compliance	--	Review/Implications	Review/Implications	Review/Implications
Laboratory Duplicate Completeness	--	Review/Implications	Review/Implications	Review/Implications
Laboratory Duplicate RPD Compliance	--	Review/Implications	Review/Implications	Review/Implications
Initial Calibration	--	If Problems are Suspected	Review/Implications	Review/Implications
Initial Calibration Verification	--	If Problems are Suspected	Review/Implications	Review/Implications
Continuing Calibration Verification	--	If Problems are Suspected	Review/Implications	Review/Implications
Internal Standards	--	If Problems are Suspected	Review/Implications	Review/Implications
Continuing Calibration Blanks	--	If Problems are Suspected	Review/Implications	Review/Implications
Initial Calibration Blanks	--	If Problems are Suspected	Review/Implications	Review/Implications
Instrument Check Standards	--	If Problems are Suspected	Review/Implications	Review/Implications
Instrument Tunes	--	If Problems are Suspected	Review/Implications	Review/Implications
Serial Dilutions	--	If Problems are Suspected	Review/Implications	Review/Implications
Post-Digestion Spikes	--	If Problems are Suspected	Review/Implications	Review/Implications
Interference Check Samples	--	If Problems are Suspected	Review/Implications	Review/Implications
Reporting Limit Check Standards	--	If Problems are Suspected	Review/Implications	Review/Implications
Target Compound Identification	--	If Problems are Suspected	Review/Implications	Review/Implications
Tentatively Identified Compounds (TICs)	--	If Provided	Review/Implications	Review/Implications
System Performance Factors	--	--	Review/Implications	Review/Implications
Raw Data Calculations Verification	--	--	If Problems are Suspected	Review/Implications
Chromatogram Review	--	If Provided	If Problems are Suspected	Review/Implications
Retention Time Verification	--	--	If Problems are Suspected	Review/Implications
Deliverables				
	Check List	Report	Report+Summary	Report+Summary

[1]Review items vary by methodology and may include more or less than specified in this list.

[2]Radiochemical analyses will be validated as described in Attachment B, and in accordance with guidelines from Chapter 8 of the USEPA MARLAP, document number EPA 402-B-04-001A (USEPA 2004) and the American Nuclear Society Standard 41.5-2012 (ANS 2018). Changes to data validation procedures for radiological analyses are discussed in Appendix B.

TABLE 2-2A. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR GROUNDWATER/LEACHATE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Total Metals	Total Metals	USEPA 6010B	250mL in plastic container	Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.	Pace - I
	Total Metals	USEPA 6020	250mL in plastic container	Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.	Pace - I
	Total Mercury	USEPA 7470A	250mL in plastic container	Nitric Acid to pH <2* Cool to ≤6°C	Analysis must be completed within 28 days of collection date.	Pace - I
	Chromium (III)	Calculation	NA	NA	NA	Pace - I
	Chromium (VI)	USEPA 7196A	250mL in plastic container	Cool to ≤6°C	Analysis must be completed within 24 hours of collection date.	Pace - I
Dissolved Metals	Dissolved Metals	USEPA 6020	250mL in plastic container	Field Filtration Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.	Pace - I
	Dissolved Metals	USEPA 6010B	250mL in plastic container	Field Filtration Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.	Pace - I
	Dissolved Metals	USEPA 6010B	250mL in plastic container	Field Filtration Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.	Pace - I
	Dissolved Mercury	USEPA 7470A	500mL in plastic container	Field Filtration Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Analysis must be completed within 28 days of collection date.	Pace - I
Semi-Volatile Organic Compounds	Semi-Volatile Organic Compounds	USEPA 8270C	2x100mL amber glass container with Teflon-lined lid, preferably wide mouth	Cool to ≤6°C	Sample must be extracted within 7 days of collection date and extract must be analyzed within 40 days of extraction date.	Pace - I
	Semi-Volatile Organic Compounds	USEPA 8270C SIM	2x100mL amber glass container with Teflon-lined lid, preferably wide mouth	Cool to ≤6°C	Sample must be extracted within 7 days of collection date and extract must be analyzed within 40 days of extraction date.	Pace - I
Volatile Organic Compounds	Volatile Organic Compounds	USEPA 8260C Low Level	Minimum 3 VOA vials. Additional sample is required if MS/MSD is required.	Acidified w/ 1:1 Hydrochloric Acid to pH<2, no headspace Cool to ≤6°C	pH>2: Analysis must be completed within 7 days of collection date. pH <2: Analysis must be completed within 14 days of collection date. (pH determined post analysis)	Pace - I
	Volatile Organic Compounds	USEPA 8011	Minimum 3 VOA amber vials. Additional sample is required if MS/MSD is required.	Preserved w/ sodium thiosulfate, no headspace Cool to ≤6°C	Analysis must be completed within 14 days of collection date.	Pace - I
PCBs	Polychlorinated Biphenyls (PCBs)	USEPA 8082A	2x100mL wide mouth amber glass bottle	Cool to ≤6°C	Extract within 6 months of collection and analyze within 40 days of extraction	Pace - I

TABLE 2-2A. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR GROUNDWATER/LEACHATE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Hydrocarbons	TPH-GRO	USEPA 8260 TPH	Minimum 3 VOA vials. Additional sample is required if MS/MSD is required.	Acidified w/ 1:1 Hydrochloric Acid to pH<2, no headspace Cool to ≤6°C	pH>2: Analysis must be completed within 7 days of collection date. pH <2: Analysis must be completed within 14 days of collection date. (pH determined post analysis)	Pace - K
	TPH-DRO, TPH-ORO	USEPA 8270 TPH	(2) 100mL amber glass bottle	Cool to ≤6°C	Sample must be extracted within 7 days of collection date and extract must be analyzed within 40 days of extraction date.	Pace - K
Organochlorine Pesticides	Organochlorine Pesticides	USEPA 8081B	(2) 100mL amber glass bottle	Cool to ≤6°C	Sample must be extracted within 7 days of collection date and extract must be analyzed within 40 days of extraction date.	Pace - I
Radiological Chemistry	Isotopic Thorium (Th-228, Th-230, Th-232) Dissolved Isotopic Thorium (Th-228, Th-230, Th-232)	HASL-300 Method U-02	1L plastic or glass container	Nitric acid pH<2	Sample must be analyzed within 180 days	Pace - P
	Isotopic Uranium (U-234, U-235, U-238) Dissolved Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	1L plastic or glass container	Nitric acid pH<2	Sample must be analyzed within 180 days	Pace - P
	Radium-226	USEPA 903.1	1L plastic or glass container	Nitric acid pH<2	Sample must be analyzed within 180 days	Pace - P
	Radium-228	USEPA 904.0	1L plastic or glass container	Nitric acid pH<2	Sample must be analyzed within 180 days	Pace - P
	Dissolved Isotopic Radium-226	USEPA 903.1	1L plastic or glass container	Nitric acid pH<2	Sample must be analyzed within 180 days	Pace - P
	Dissolved Isotopic Radium-228	USEPA 904.0	1L plastic or glass container	Nitric acid pH<2	Sample must be analyzed within 180 days	Pace - P
Geochemistry	Alkalinity	SM 2320B	250mL minimum in plastic container	Cool to ≤6°C	Sample must be analyzed within 14 days of collection date.	Pace - I
	Bromide	USEPA 9056A	250mL minimum in plastic container	Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I
	Carbonate	SM 2320B	250mL minimum in plastic container	Cool to ≤6°C	Sample must be analyzed within 14 days of collection date.	Pace - I
	Total Dissolved Solids	SM 2540C	250mL minimum in plastic container	Cool to ≤6°C	Sample must be analyzed within 7 days of collection date.	Pace - I
	Total Suspended Solids	SM 2540D	1L minimum in plastic container	Cool to ≤6°C	Sample must be analyzed within 7 days of collection date.	Pace - I
	Total Hardness	USEPA 6010B/2340B Calculation	250mL in plastic container	Nitric Acid to pH <2* Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.	Pace - I
	Cations + Anions	Calculation	NA	NA	NA	Pace - I
	Iodide	USEPA 9056A	250mL in plastic container	Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I

TABLE 2-2A. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR GROUNDWATER/LEACHATE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Geochemistry (Cont.)	Chloride Fluoride Sulfate	USEPA 9056A	250mL in plastic container	Cool to ≤6°C	Nitrate or Nitrite: Analysis must be completed within 48 hours of collection date/time. Other Anions: Analysis must be completed within 28 days of collection date.	Pace - I
	Phosphate	USEPA 365.1	250mL in glass or plastic container	Preserved with H2SO4 to a pH<2, Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I
	Sulfide	SM 4500-S^{2}-D	250mL in plastic container. Fill container completely without overflowing.	pH>9 with 1mL of 1:1 Sodium Hydroxide plus 0.5mL of 1N Zinc Acetate per 250mL sample. Cool to ≤6°C	Analysis must be completed within 7 days of collection.	Pace - I
	Chemical Oxygen Demand	USEPA 410.4 Rev 2	One 250mL plastic or glass container	Sulfuric Acid to pH <2 Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I
	Nitrogen, Nitrate + Nitrite	USEPA 353.2 Rev 2	250mL in plastic container.	For combined nitrate/nitrite analysis Sulfuric Acid to pH <2 For nitrate or nitrite individually, unpreserved. Cool to ≤6°C	For preserved samples, analysis must be completed within 28 days of collection date. For unpreserved samples, analysis must be completed within 48 hours of collection.	Pace - I
	Nitrogen, Ammonia	SM 4500-NH_3 G	250mL in plastic or glass container.	Sulfuric Acid to pH <2 Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I
	Nitrogen, Nitrate	USEPA 9056A	250mL in plastic container.	Cool to ≤6°C	For unpreserved samples, analysis must be completed within 48 hours of collection.	Pace - I
	Nitrogen, Nitrite	USEPA 9056A	250mL in plastic container.	Cool to ≤6°C	For unpreserved samples, analysis must be completed within 48 hours of collection.	Pace - I
	pH	SM 4500H+B	250mL minimum in plastic container	Cool to ≤6°C	Sample must be analyzed within 15 minutes of collection date.	Pace - I
	Total Organic Carbon	SM 5310C	250mL amber glass bottle	Sulfuric Acid to pH <2 Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I
	Dissolved Organic Carbon	SM 5310C	250mL amber glass bottle	Field Filtered, Sulfuric Acid to pH <2 Cool to ≤6°C	Sample must be analyzed within 28 days of collection date.	Pace - I

TABLE 2-2A. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR GROUNDWATER/LEACHATE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Dissolved Gases	Methane	AM20GAX	(2) 40mL vials	TSP, Cool to ≤6°C	Analysis must be completed in 14 days within 14 days of collection date.	Pace - E
	Carbon Dioxide	AM20GAX	(2) 40mL vials	TSP, Cool to ≤6°C	Analysis must be completed in 14 days within 14 days of collection date.	Pace - E

Notes:
GRO: Gasoline Range Organics
DRO: Diesel Range Organics
HASL: Health and Safety Laboratory
L: Liter
mL: milliliter
NA: Not applicable
ORO: Oil Range Organics
Pace - E: PACE Analytical, Inc. Energy Services in Pittsburgh, Pennsylvania
Pace - I: PACE Analytical, Inc. Indianapolis
Pace - K: PACE Analytical, Inc. Kansas
Pace - P - PACE Analytical, Inc. Pittsburgh
PCBs: Polychlorinated biphenyl
SIM: Selective Ion Monitoring
SM: Standard Methods for the Examination of Water and Wastewater
TSP: Trisodium phosphate dodecahydrate
TPH: Total Petroleum Hydrocarbons
USEPA: United States Environmental Protection Agency
VOA: Volatile organic analysis

TABLE 2-2B. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR ALLUVIAL SOILS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Total Metals	Total Metals	USEPA 6010B	4-oz glass with Teflon Lid	None	Must be analyzed within 6 months of the collection date.	Pace - I
	Total Metals	USEPA 6020	4-oz glass with Teflon Lid	None	Must be analyzed within 6 months of the collection date.	Pace - I
	Total Mercury	USEPA 7471A	4-oz glass with Teflon Lid	Cool to ≤6°C	28 days	Pace - I
	Ferrous Iron	SM 3500-Fe B, modified	4-oz glass with Teflon Lid	Protect from Air before analysis	30 days	MCLInc
	Total Iron	USEPA 6010B	4-oz glass with Teflon Lid	Cool to ≤6°C	180 days	MCLInc
	Ferric Iron	Calculation (Total - Ferrous)	4-oz glass with Teflon Lid	NA	NA	MCLInc
Radiological Chemistry	Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	4-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
	Isotopic Thorium (Th-228,Th-230, Th-232)	HASL-300 Method U-02	4-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
	Radium-226	USEPA 903.1	16-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
	Radium-228	USEPA 904.0	16-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
Major Minerals and Mineral Reactivity	X-Ray Diffraction	MCL-7712	16 oz glass	None	None	MCLInc
	Scanning Electron Microscope with Energy Dispersive X-Ray Spectrometry (SEM/EDS)	MCL-7708	16 oz glass	None	None	MCLInc
Mineralogical	Cation Exchange Capacity	USEPA 9081	4-oz glass with Teflon Lid	Cool to ≤6°C	Sample must be analyzed within 180 days	Pace - K
Cation/Anion	pH	USEPA 9045C	4-oz glass with Teflon Lid	Cool to ≤6°C	Immediately	Pace - I
	Total Organic Carbon	Walkley-Black Procedure	4-oz amber glass with Teflon Lid	Cool to ≤6°C	28 days	Pace - G
	Total Alkalinity (carbonate and bicarb)	SM 2320B	4-oz glass with Teflon Lid	Cool to ≤6°C	14 days	Pace - I
	Cations + Anions	Calculation	NA	NA	NA	NA

TABLE 2-2B. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR ALLUVIAL SOILS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Radionuclide Speciation	Following Sequential Extraction Analysis (Dissolved Radium)	USEPA 903.1/904.0	(2) 1L Plastic**	HNO3	Sample must be analyzed within 180 days	MCLInc and Pace - P
	Following Sequential Extraction Analysis (Total Uranium)	USEPA 6020	250mL Plastic**	HNO3	Sample must be analyzed within 180 days	MCLInc and Pace - I
	Following Sequential Extraction Analysis (Total Metals-Barium, Calcium, Iron, Manganese, Sulfur)	USEPA 6020	250mL Plastic	HNO3	Sample must be analyzed within 180 days	MCLInc
	Following Sequential Extraction Analysis (pH)	USEPA 9045	250mL Plastic	Cool to ≤6°C	Sample must be analyzed within 15 minutes of collection date.	MCLInc
Geotechnical Parameter	Grain Size Distribution by Sieve Analysis	ASTM D422	Bulk Sample	None	Sample must be analyzed within 180 days	Earth Exploration
	Grain Size Distribution by Hydrometer Analysis	ASTM D422	Bulk Sample	None	Sample must be analyzed within 180 days	Earth Exploration
	Atterberg Limits	ASTM D4318	Bulk Sample	None	Sample must be analyzed within 180 days	Earth Exploration
	Density	ASTM 7263	Bulk Sample	None	Sample must be analyzed within 180 days	Earth Exploration

Notes:
* Samples received at pH >2 must be preserved to pH <2 with HNO3 and be allowed to equilibrate for 24 hours before being prepared for analysis. Acidification date and time are recorded in the Sample Preservation Logbook.
** Limited sample extract will be available from sequential extraction procedure.
HASL: Health and Safety Laboratory
HNO3: Nitric acid
L: Liter
MCLInc& MCL: Materials and Chemistry Laboratory, Inc.
mL: milliliter
NA: Not applicable
oz: Ounce
Pace - G: PACE Analytical, Inc. Green Bay
Pace - I: PACE Analytical, Inc. Indianapolis
Pace - K: PACE Analytical, Inc. Kansas
Pace - P: PACE Analytical, Inc. Pittsburgh
SM: Standard Methods for the Examination of Water and Wastewater
SOP: Standard Operating Procedure
USEPA: United States Environmental Protection Agency
VOA: Volatile Organic Analysis

TABLE 2-2C. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR BEDROCK
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Total Metals	Total Metals	USEPA 6010B	4-oz glass with Teflon Lid	None	Must be analyzed within 6 months of the collection date.	Pace - I
	Total Metals	USEPA 6020	4-oz glass with Teflon Lid	None	Must be analyzed within 6 months of the collection date.	Pace - I
	Total Mercury	USEPA 7471A	4-oz glass with Teflon Lid	Cool to ≤6°C	28 days	Pace - I
	Ferrous Iron	SM 3500-Fe B, modified	4-oz glass with Teflon Lid	Protect from Air before analysis	30 days	MCLInc
	Total Iron	USEPA 6010B	4-oz glass with Teflon Lid	Cool to ≤6°C	180 days	MCLInc
	Ferric Iron	Calculation (Total - Ferrous)	4-oz glass with Teflon Lid	Cool to ≤6°C	24 hours	MCLInc
Radiological Chemistry	Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	4-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
	Isotopic Thorium (Th-228,Th-230, Th-232)	HASL-300 Method U-02	4-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
	Radium-226	USEPA 903.1	16-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
	Radium-228	USEPA 904.0	16-oz glass with Teflon Lid	None	Sample must be analyzed within 180 days	Pace - P
Major Minerals and Mineral Reactivity	X-Ray Diffraction	MCL-7712	16 oz glass	None	None	MCLInc
	Scanning Electron Microscope with Energy Dispersive X-Ray Spectrometry (SEM/EDS)	MCL-7708	16 oz glass	None	None	MCLInc
Mineralogical	Cation Exchange Capacity	USEPA 9081	4-oz glass with Teflon Lid	Cool to ≤6°C	Sample must be analyzed within 180 days	Pace - K
Cation/Anion	pH	USEPA 9045C	4-oz glass with Teflon Lid	Cool to ≤6°C	Immediately	Pace - I
	Total Organic Carbon	Walkley-Black Procedure	4-oz amber glass with Teflon Lid	Cool to ≤6°C	28 days	Pace - G
	Total Alkalinity (carbonate and bicarb)	SM 2320B	4-oz glass with Teflon Lid	Cool to ≤6°C	14 days	Pace - I
	Cations + Anions	Calculation	NA	NA	NA	NA

Notes:
* Samples received at pH >2 must be preserved to pH <2 with HNO3 and be allowed to equilibrate for 24 hours before being prepared for analysis. Acidification date and time are recorded in the Sample Preservation Logbook.
ASAP: As soon as possible
HASL: Health and Safety Laboratory
HNO3: Nitric acid
L: Liter
MCLInc & MCL: Materials and Chemistry Laboratory, Inc.
mL: milliliter
NA: Not applicable
oz: Ounce
Pace - GB: PACE Analytical, Inc. Green Bay
Pace - I: PACE Analytical, Inc. Indianapolis
Pace - K: PACE Analytical, Inc. Kansas
Pace - P: PACE Analytical, Inc. Pittsburgh
SM: Standard Methods for the Examination of Water and Wastewater
VOA: Volatile Organic Analysis

TABLE 2-2D. ANALYTES, HOLDING TIME AND PRESERVATION REQUIREMENTS FOR INDOOR AIR
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Analytical Group	Analytical Method	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation / analysis)	Laboratory
Volatile Organic Compounds	TO-15	1 – 6 Liter Summa Can	NA	30 Days	ALS-S
Methane	TO-3 Modified	1 – 6 Liter Summa Can	NA	30 Days	ALS-S
Radon	USEPA 402-R-92-004	Rad Elec electret	NA	NA	ALS-W

Notes:
ALS-S: ALS Simi Valley, WA
ALS-W: ALS Winnipeg, MB
SIM: Selective Ion Monitoring
NA: Not applicable
USEPA: United States Environmental Protection Agency

TABLE 2-3a. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR GROUNDWATER AND LEACHATE SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	Laboratory	Method	EPA Maximum Contamination Level (µg/L)[2]	Tap Water Regional Screening Levels (µg/L)[2] THQ = 1.0	Tap Water Regional Screening Levels (µg/L)[2] THQ = 0.1	MDNR Groundwater Protection Standards (µg/L)[3]	MDNR Groundwater Protection Standards (µg/L)[4]	Lowest Screening Level EPA MCL/MDNR GWPS (µg/L)	Pace Analytical Services, LLC		Comparison of Laboratory Limits to Water Cleanup Levels[5]
										MRL (µg/L)	MDL (µg/L)	
Total Metals[6]												
Aluminum	7429-90-5	PACE Analytical, Inc. Indianapolis	USEPA 6010B	NL	20000	2000	NL	50-200	50	200	53.9	Screening Level Cannot be Met
Antimony	7440-36-0		USEPA 6020	6	7.8	0.78	6	6	0.78	1	0.18	Screening Level between MRL and MDL
Arsenic	7440-38-2		USEPA 6020	10	0.052	0.052	50	10	0.052	1	0.223	Screening Level Cannot be Met
Barium	7440-39-3		USEPA 6010B	2000	3800	380	2000	2000	380	10	0.53	MRL below Screening Level
Beryllium	7440-41-7		USEPA 6020	4	25	2.5	4	4	2.5	0.2	0.038	MRL below Screening Level
Boron	7440-42-8		USEPA 6010B	NL	4000	400	2000	NL	400	100	7.71	MRL below Screening Level
Cadmium	7440-43-9		USEPA 6020	5	NL	NL	5	5	5	0.2	0.03	MRL below Screening Level
Calcium	7440-70-2		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	500	72.93	Not Applicable
Chromium	7440-47-3		USEPA 6020	100	NL	NL	NL	10	10	2	0.177	MRL below Screening Level
Chromium (III)	18540-29-9		Calculation	NL	0.035	0.035	100	NL	0.035	10	3.5	Screening Level Cannot be Met
Chromium (VI)	1066-30-4		USEPA 7196	NL	NL	NL	NL	NL	Not Applicable	10	3.5	Not Applicable
Cobalt	7440-48-4		USEPA 6010B	NL	6	0.6	1000	NL	0.6	5	0.75	Screening Level Cannot be Met
Copper	7440-50-8		USEPA 6020	1300	800	80	1300	1000	80	1	2.35	MRL below Screening Level
Iron	7439-89-6		USEPA 6010B	NL	14000	1400	300	300	300	50	32.4	MRL below Screening Level
Lead	7439-92-1		USEPA 6020	15	15	15	15	NL	15	1	0.227	MRL below Screening Level
Lithium	7439-93-2		USEPA 6010B	NL	40	4	NL	NL	4	20	4.73	Screening Level Cannot be Met
Magnesium	7439-95-4		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	500	57.5	Not Applicable
Manganese	7439-96-5		USEPA 6010B	NL	NL	NL	50	50	50	5	1.12	MRL below Screening Level
Molybdenum	7439-98-7		USEPA 6010B	NL	100	10	NL	NL	10	10	0.64	MRL below Screening Level
Mercury	7439-97-6		USEPA 7470A	2	0.63	0.063	2	2	0.063	0.2	0.1	Screening Level Cannot be Met
Nickel	7440-02-0		USEPA 6010B	NL	390	39	100	NL	39	10	1.45	MRL below Screening Level
Potassium	7440-09-7		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	1000	84.3	Not Applicable
Selenium	7782-49-2		USEPA 6020	50	100	10	50	50	10	1	0.311	MRL below Screening Level
Silver	7440-22-4		USEPA 6020	NL	94	9.4	50	100	9.4	0.5	1.24	MRL below Screening Level
Silicon	7440-21-3		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	200	120	Not Applicable
Sodium	7440-23-5		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	1000	39.3	Not Applicable
Strontium	7440-24-6		USEPA 6010B	NL	12000	1200	NL	NL	1200	10	0.38	MRL below Screening Level
Thallium	7440-28-0		USEPA 6020	2	0.2	0.02	2	2	0.02	1	0.049	Screening Level Cannot be Met
Thorium	7440-29-1		USEPA 6020	NL	NL	NL	NL	NL	Not Applicable	1	0.25	Not Applicable
Tin	7440-31-5		USEPA 6010B	NL	12000	1200	NL	NL	1200	10	2.28	MRL below Screening Level
Titanium	7440-32-6		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	10	1.37	Not Applicable
Uranium	7440-61-1		USEPA 6020	NL	NL	NL	NL	NL	Not Applicable	1	0.011	Not Applicable
Vanadium	7440-62-2		USEPA 6020	NL	86	8.6	NL	NL	8.6	1	0.219	MRL below Screening Level
Zinc	7440-66-6		USEPA 6010B	NL	6000	600	5000	NL	600	20	6.92	MRL below Screening Level
Dissolved Metals[6]												
Aluminum	7429-90-5	PACE Analytical, Inc. Indianapolis	USEPA 6010B	NL	20000	2000	NL	50-200	2000	200	53.9	MRL below Screening Level
Antimony	7440-36-0		USEPA 6020	6	7.8	0.78	6	6	0.78	1	0.18	Screening Level between MRL and MDL
Arsenic	7440-38-2		USEPA 6020	10	0.052	0.052	50	10	0.052	1	0.223	Screening Level Cannot be Met
Barium	7440-39-3		USEPA 6010B	2000	3800	380	2000	2000	380	10	0.53	MRL below Screening Level
Beryllium	7440-41-7		USEPA 6020	4	25	2.5	4	4	2.5	0.2	0.038	MRL below Screening Level
Boron	7440-42-8		USEPA 6010B	NL	4000	400	2000	NL	400	100	7.71	MRL below Screening Level
Cadmium	7440-43-9		USEPA 6020	5	NL	NL	5	5	5	0.2	0.03	MRL below Screening Level
Calcium	7440-70-2		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	500	72.93	Not Applicable
Chromium	7440-47-3		USEPA 6020	100	NL	NL	NL	10	10	2	0.177	MRL below Screening Level
Cobalt	7440-48-4		USEPA 6010B	NL	6	0.6	1000	NL	0.6	5	0.75	Screening Level Cannot be Met
Copper	7440-50-8		USEPA 6020	1300	800	80	1300	1000	80	1	2.35	MRL below Screening Level
Iron	7439-89-6		USEPA 6010B	NL	14000	1400	300	300	300	50	32.4	MRL below Screening Level
Lead	7439-92-1		USEPA 6020	15	15	15	15	NL	15	1	0.227	MRL below Screening Level
Lithium	7439-93-2		USEPA 6010B	NL	40	4	NL	NL	4	20	4.73	Screening Level Cannot be Met
Magnesium	7439-95-4		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	500	57.5	Not Applicable
Manganese	7439-96-5		USEPA 6010B	NL	NL	NL	50	50	50	5	1.12	MRL below Screening Level
Molybdenum	7439-98-7		USEPA 6010B	NL	100	10	NL	NL	10	10	0.64	MRL below Screening Level
Mercury	7439-97-6		USEPA 7470	2	0.63	0.063	2	2	0.063	0.2	0.1	Screening Level Cannot be Met
Nickel	7440-02-0		USEPA 6010B	NL	390	39	100	NL	39	10	1.45	MRL below Screening Level
Potassium	7440-09-7		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	1000	84.3	Not Applicable
Selenium	7782-49-2		USEPA 6020	50	100	10	50	50	10	1	0.311	MRL below Screening Level
Silver	7440-22-4		USEPA 6020	NL	94	9.4	50	100	9.4	0.5	1.24	MRL below Screening Level
Silicon	7440-21-3		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	200	120	Not Applicable
Sodium	7440-23-5		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	1000	39.3	Not Applicable
Strontium	7440-24-6		USEPA 6010B	NL	12000	1200	NL	NL	1200	10	0.38	MRL below Screening Level
Thallium	7440-28-0		USEPA 6020	2	0.2	0.02	2	2	0.02	1	0.049	Screening Level Cannot be Met
Thorium	7440-29-1		USEPA 6020	NL	NL	NL	NL	NL	Not Applicable	1	0.25	Not Applicable
Tin	7440-31-5		USEPA 6010B	NL	12000	1200	NL	NL	1200	10	2.28	MRL below Screening Level
Titanium	7440-32-6		USEPA 6010B	NL	NL	NL	NL	NL	Not Applicable	10	1.37	Not Applicable
Uranium	7440-61-1		USEPA 6020	NL	NL	NL	NL	NL	Not Applicable	1	0.011	Not Applicable
Vanadium	7440-62-2		USEPA 6020	NL	86	8.6	NL	NL	8.6	1	0.219	MRL below Screening Level
Zinc	7440-66-6		USEPA 6010B	NL	6000	600	5000	NL	600	20	6.92	MRL below Screening Level

TABLE 2-3a. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR GROUNDWATER AND LEACHATE SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	Laboratory	Method	EPA Maximum Contamination Level (µg/L)[2]	Tap Water Regional Screening Levels (µg/L)[2] THQ = 1.0	Tap Water Regional Screening Levels (µg/L)[2] THQ = 0.1	MDNR Groundwater Protection Standards (µg/L)[3]	MDNR Groundwater Protection Standards (µg/L)[4]	Lowest Screening Level EPA MCL/MDNR GWPS (µg/L)	Pace Analytical Services, LLC MRL (µg/L)	Pace Analytical Services, LLC MDL (µg/L)	Comparison of Laboratory Limits to Water Cleanup Levels[5]
Semi-Volatile Organic Compounds												
Acenaphthene	83-32-9	PACE Analytical, Inc. Indianapolis	USEPA 8270C SIM	NL	530	53	1200	NL	53	1	0.015	MRL below Screening Level
Acenaphthylene	208-96-8		USEPA 8270C SIM	NL	NL	NL	NL	NL	Not Applicable	1	0.0131	Not Applicable
Acetophenone	98-86-2		USEPA 8270C	NL	1900	190	NL	NL	190	10	3.5	MRL below Screening Level
Anthracene	120-12-7		USEPA 8270C SIM	NL	1800	180	9600	NL	180	0.1	0.0125	MRL below Screening Level
Atrazine	1912-24-9		USEPA 8270C	3	0.3	0.3	3	NL	0.3	10	4.05	Screening Level Cannot be Met
Benzaldehyde	100-52-7		USEPA 8270C	NL	19	19	NL	NL	19	50	2.98	Screening Level between MRL and MDL
Benz[a]anthracene	56-55-3		USEPA 8270C SIM	NL	0.03	0.03	0.0044	NL	0.0044	0.1	0.0272	Screening Level Cannot be Met
Benzo[a]pyrene	50-32-8		USEPA 8270C SIM	0.2	0.025	0.025	0.2	NL	0.025	0.1	0.0262	Screening Level Cannot be Met
Benzo[b]fluoranthene	205-99-2		USEPA 8270C SIM	NL	0.25	0.25	0.0044	NL	0.0044	0.1	0.031	Screening Level Cannot be Met
Benzo[g,h,i]perylene	191-24-2		USEPA 8270C SIM	NL	NL	NL	NL	NL	Not Applicable	0.1	0.0236	MRL below Screening Level
Benzo[k]fluoranthene	207-08-9		USEPA 8270C SIM	NL	2.5	2.5	0.0044	NL	0.0044	0.1	0.0199	Screening Level Cannot be Met
Benzyl alcohol	100-51-6		USEPA 8270C	NL	2000	200	NL	NL	200	10	3.87	MRL below Screening Level
Biphenyl (1,1 - biphenyl or Diphenyl)	92-52-4		USEPA 8270C	NL	0.83	0.083	NL	NL	0.083	10	2.1	Screening Level Cannot be Met
bis(2-chloroethoxy) methane	111-91-1		USEPA 8270C	NL	59	5.9	NL	NL	5.9	10	3.77	Screening Level between MRL and MDL
bis(2-chloroethyl) ether	111-44-4		USEPA 8270C	NL	0.014	0.014	0.03	NL	0.014	10	3.91	Screening Level Cannot be Met
bis(2-chloro-1-methylethyl) ether*	108-60-1		USEPA 8270C	NL	710	71	300	NL	71	10	3.94	MRL below Screening Level
bis(2-ethylhexyl) phthalate	117-81-7		USEPA 8270C	6	5.6	5.6	6	NL	5.6	10		Screening Level Cannot be Met
4-Bromophenyl phenyl ether	101-55-03		USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	10	3.55	Not Applicable
Butyl benzyl phthalate	85-68-7		USEPA 8270C	NL	16	16	3000	NL	16	10	4.85	MRL below Screening Level
4-Chloroaniline	106-47-8		USEPA 8270C	NL	0.37	0.37	NL	NL	0.37	10	3.75	Screening Level Cannot be Met
4-Chloro-3-methylphenol (p-chloro-m-Cresol)	59-50-7		USEPA 8270C	NL	1400	140	NL	NL	140	10	5.43	MRL below Screening Level
2-Chloronaphthalene	91-58-7		USEPA 8270C	NL	750	75	NL	NL	75	10	2	MRL below Screening Level
2-Chlorophenol	95-57-8		USEPA 8270C	NL	91	9.1	0.1	NL	0.1	10	4.25	Screening Level Cannot be Met
4-Chlorophenyl phenyl ether	7005-72-3		USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	10	2.86	Not Applicable
Caprolactam	105-60-2		USEPA 8270C	NL	9900	990	NL	NL	990	10	4.08	MRL below Screening Level
Carbazole	86-74-8		USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	10	4.26	Not Applicable
Chrysene	218-01-9		USEPA 8270C SIM	NL	25	25	0.0044	NL	0.0044	0.5	0.0199	Screening Level Cannot be Met
Dibenz[a,h]anthracene	53-70-3		USEPA 8270C SIM	NL	0.025	0.025	0.0044	NL	0.0044	0.1	0.0707	Screening Level Cannot be Met
Dibenzofuran	132-64-9		USEPA 8270C	NL	7.9	0.79	NL	NL	0.79	10	3.24	Screening Level Cannot be Met
Di-*n*-butyl phthalate	84-74-2		USEPA 8270C	NL	900	90	2700	NL	90	10	6.56	MRL below Screening Level
3,3'-Dichlorobenzidine	91-94-1		USEPA 8270C	NL	0.13	0.13	NL	NL	0.13	20	3.78	Screening Level Cannot be Met
2,4-Dichlorophenol	120-83-2		USEPA 8270C	NL	46	4.6	93	NL	4.6	10	4.39	Screening Level between MRL and MDL
Diethyl phthalate	84-66-2		USEPA 8270C	NL	15000	1500	23000	NL	1500	10	4.68	MRL below Screening Level
2,4-Dimethylphenol	105-67-9		USEPA 8270C	NL	360	36	540	NL	36	10	4.61	MRL below Screening Level
7,12-Dimethylbenz(a)anthracene	57-97-6		USEPA 8270C	NL	0.0001	0.0001	NL	NL	0.0001	20	1.86	Screening Level Cannot be Met
Dimethylphthalate	131-11-3		USEPA 8270C	NL	NL	NL	313000	NL	313000	10	5.16	MRL below Screening Level
4,6-Dinitro-2-methylphenol	534-52-1		USEPA 8270C	NL	1.5	0.15	13	NL	0.15	20	5.84	Screening Level Cannot be Met
2,4-Dinitrophenol	51-28-5		USEPA 8270C	NL	39	3.9	70	NL	3.9	50	3.87	Screening Level between MRL and MDL
2,4-Dinitrotoluene	121-14-2		USEPA 8270C	NL	0.24	0.24	0.04	NL	0.04	10	5.56	Screening Level Cannot be Met
2,6-Dinitrotoluene	606-20-2		USEPA 8270C	NL	0.049	0.049	NL	NL	0.049	10	4.37	Screening Level Cannot be Met
Di-*n*-octyl phthalate	117-84-0		USEPA 8270C	NL	200	20	NL	NL	20	10	5.83	MRL below Screening Level
Fluoranthene	206-44-0		USEPA 8270C SIM	NL	800	80	300	NL	80	1	0.0153	MRL below Screening Level
Fluorene	86-73-7		USEPA 8270C SIM	NL	290	29	1300	NL	29	1	0.0362	MRL below Screening Level
Hexachlorobenzene	118-74-1		USEPA 8270C	1	0.0098	0.0098	NL	NL	0.0098	10	3.91	Screening Level Cannot be Met
Hexachloro-1,3-butadiene	87-68-3		USEPA 8270C	NL	0.14	0.14	NL	NL	0.14	10	1.11	Screening Level Cannot be Met
Hexachlorocyclopentadiene	77-47-4		USEPA 8270C	50	0.41	0.041	NL	NL	0.041	10	1.56	Screening Level Cannot be Met
Hexachloroethane	67-72-1		USEPA 8270C	NL	0.33	0.33	2	NL	0.33	10	0.94	Screening Level Cannot be Met
Indeno[1,2,3-cd]pyrene	193-39-5		USEPA 8270C SIM	NL	0.25	0.25	0.0044	NL	0.0044	0.1	0.0727	Screening Level Cannot be Met
Isophorone	78-59-1		USEPA 8270C	NL	78	78	36	NL	36	10	4.33	MRL below Screening Level
2-Methylphenol (o-Cresol)	95-48-7		USEPA 8270C	NL	930	93	NL	NL	93	10	3.78	MRL below Screening Level

TABLE 2-3a. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR GROUNDWATER AND LEACHATE SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	Laboratory	Method	EPA Maximum Contamination Level (µg/L)[2]	Tap Water Regional Screening Levels (µg/L)[2] THQ = 1.0	Tap Water Regional Screening Levels (µg/L)[2] THQ = 0.1	MDNR Groundwater Protection Standards (µg/L)[3]	MDNR Groundwater Protection Standards (µg/L)[4]	Lowest Screening Level EPA MCL/MDNR GWPS (µg/L)	Pace Analytical Services, LLC MRL (µg/L)	Pace Analytical Services, LLC MDL (µg/L)	Comparison of Laboratory Limits to Water Cleanup Levels[5]
Semi-Volatile Organic Compounds (Cont.)												
3 & 4-Methylphenol (m & p Cresols)[1]	108-39-4, 106-44-5	PACE Analytical, Inc. Indianapolis	USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	10	3.94	Not Applicable
1-Methylnaphthalene	90-12-0		USEPA 8270C SIM	NL	1.1	1.1	NL	NL	1.1	1	0.0139	MRL below Screening Level
2-Methylnaphthalene	91-57-6		USEPA 8270C SIM	NL	36	3.6	NL	NL	3.6	1	0.0147	MRL below Screening Level
N-Nitroso-di-*n*-propylamine	621-64-7		USEPA 8270C	NL	0.011	0.011	NL	NL	0.011	50	4.27	Screening Level Cannot be Met
N-Nitrosodiphenylamine	86-30-6		USEPA 8270C	NL	12	12	5	NL	5	10	4.49	Screening Level between MRL and MDL
Naphthalene	91-20-3		USEPA 8270C SIM	NL	0.17	0.17	NL	NL	0.17	1	0.0141	Screening Level between MRL and MDL
2-Nitroaniline	88-74-4		USEPA 8270C	NL	190	19	NL	NL	19	10	5.8	MRL below Screening Level
3-Nitroaniline	99-09-2		USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	10	5.03	Not Applicable
4-Nitroaniline	100-01-6		USEPA 8270C	NL	3.8	3.8	NL	NL	3.8	10	4.87	Screening Level Cannot be Met
Nitrobenzene	98-95-3		USEPA 8270C	NL	0.14	0.14	NL	NL	0.14	10	4.12	Screening Level Cannot be Met
2-Nitrophenol	88-75-5		USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	10	5.27	Not Applicable
4-Nitrophenol	100-02-7		USEPA 8270C	NL	NL	NL	NL	NL	Not Applicable	50	6.05	Not Applicable
Pentachlorophenol	87-86-5		USEPA 8270C	1	0.041	0.041	1	NL	0.041	50	4.47	Screening Level Cannot be Met
Phenanthrene	85-01-8		USEPA 8270C SIM	NL	NL	NL	NL	NL	Not Applicable	1	0.0213	Not Applicable
Phenol	108-95-2		USEPA 8270C	NL	5800	580	300	NL	300	10	2.4	MRL below Screening Level
Pyrene	129-00-0		USEPA 8270C SIM	NL	120	12	960	NL	12	1	0.0197	MRL below Screening Level
1,2,4,5-Tetrachlorobenzene	95-94-3		USEPA 8270C	NL	1.7	0.17	NL	NL	0.17	10	1.87	Screening Level Cannot be Met
2,3,4,6-Tetrachlorophenol	58-90-2		USEPA 8270C	NL	240	24	NL	NL	24	10	4.79	MRL below Screening Level
2,4,5-Trichlorophenol	95-95-4		USEPA 8270C	NL	1200	120	2600	NL	120	10	4.9	MRL below Screening Level
2,4,6-Trichlorophenol	88-06-2		USEPA 8270C	NL	4.1	1.2	2	NL	1.2	10	4.77	Screening Level Cannot be Met
Volatile Organic Compounds												
Acetone	67-64-1	PACE Analytical, Inc. Indianapolis	USEPA 8260C LL	NL	14000	1400	NL	NL	1400	20	10	MRL below Screening Level
Acrolein	107-02-8		USEPA 8260C LL	NL	0.042	0.0042	320	NL	0.0042	20	10	Screening Level Cannot be Met
Acrylonitrile	107-13-1		USEPA 8260C LL	NL	0.052	0.052	0.058	NL	0.052	100	50	Screening Level Cannot be Met
Benzene	71-43-2		USEPA 8260C LL	5	0.46	0.46	5	NL	0.46	1	0.5	Screening Level Cannot be Met
Bromobenzene	108-86-1		USEPA 8260C LL	NL	62	6.2	NL	NL	6.2	1	0.5	MRL below Screening Level
Bromodichloromethane	75-27-4		USEPA 8260C LL	80	0.13	0.13	0.56	NL	0.13	1	0.5	Screening Level Cannot be Met
Bromoform	75-25-2		USEPA 8260C LL	80	3.3	3.3	4.3	NL	3.3	1	0.5	MRL below Screening Level
Bromomethane (Methyl Bromide)	74-83-9		USEPA 8260C LL	NL	7.5	0.75	48	NL	0.75	5	2.5	Screening Level Cannot be Met
Bromochloromethane	74-97-5		USEPA 8260C LL	NL	83	8.3	90	NL	8.3	1	0.5	MRL below Screening Level
2-Butanone (MEK)	78-93-3		USEPA 8260C LL	NL	5600	560	NL	NL	560	20	10	MRL below Screening Level
n-Butylbenzene	104-51-8		USEPA 8260C LL	NL	1000	100	NL	NL	100	1	0.5	MRL below Screening Level
sec-Butylbenzene	135-98-8		USEPA 8260C LL	NL	2000	200	NL	NL	200	1	0.5	MRL below Screening Level
tert-Butylbenzene	98-06-6		USEPA 8260C LL	NL	690	69	NL	NL	69	1	0.5	MRL below Screening Level
Carbon disulfide	75-15-0		USEPA 8260C LL	NL	810	81	NL	NL	81	5	2.5	MRL below Screening Level
Carbon tetrachloride	56-23-5		USEPA 8260C LL	5	0.46	0.46	5	NL	0.46	1	0.5	Screening Level Cannot be Met
Chlorobenzene	108-90-7		USEPA 8260C LL	100	78	7.8	100	NL	7.8	1	0.5	MRL below Screening Level
Chloroethane (Ethyl Chloride)	75-00-3		USEPA 8260C LL	NL	21000	2100	NL	NL	2100	2	1	MRL below Screening Level
Chloroform	67-66-3		USEPA 8260C LL	80	0.22	0.22	5.7	NL	0.22	1	0.5	Screening Level Cannot be Met
Chloromethane (Methyl Chloride)	74-87-3		USEPA 8260C LL	NL	190	19	5	NL	5	2	1	MRL below Screening Level
2-Chlorotoluene	95-49-8		USEPA 8260C LL	NL	240	24	100.0	NL	24	1	0.5	MRL below Screening Level
4-Chlorotoluene	106-43-4		USEPA 8260C LL	NL	250	25	100.0	NL	25	1	0.5	MRL below Screening Level
Cyclohexane	110-82-7		USEPA 8260C LL	NL	13000	1300	NL	NL	1300	20	10	MRL below Screening Level
Dibromochloromethane	124-48-1		USEPA 8260C LL	80	0.87	0.87	0.41	NL	0.41	1	0.5	Screening Level Cannot be Met
1,2-Dibromoethane (EDB)	106-93-4		USEPA 8011	0.1	0.0075	0.0075	0.05	NL	0.0075	0.035	0.005	Screening Level between MRL and MDL
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8		USEPA 8011	0.2	0.00033	0.00033	0.2	NL	0.00033	0.035	0.005	Screening Level Cannot be Met
Dibromomethane (Methylene Bromide)	74-95-3		USEPA 8260C LL	NL	8.3	0.83	NL	NL	0.83	1	0.5	Screening Level between MRL and MDL
trans-1,4-Dichloro-2-butene	110-57-6		USEPA 8260C LL	NL	0.0013	0.0013	NL	NL	0.0013	100	50	Screening Level Cannot be Met
1,2-Dichlorobenzene	95-50-1		USEPA 8260C LL	600	300	30	600	NL	30	1	0.5	MRL below Screening Level
1,3-Dichlorobenzene	541-73-1		USEPA 8260C LL	NL	NL	NL	600	NL	600	1	0.5	MRL below Screening Level
1,4-Dichlorobenzene	106-46-7		USEPA 8260C LL	75	0.48	0.48	75	NL	0.48	1	0.5	Screening Level Cannot be Met
Dichlorodifluoromethane	75-71-8		USEPA 8260C LL	NL	200	20	NL	NL	20	2	1	MRL below Screening Level
1,1-Dichloroethane (DCA)	75-34-3		USEPA 8260C LL	NL	2.8	2.8	NL	NL	2.8	1	0.5	MRL below Screening Level
1,2-Dichloroethane (EDC)	107-06-2		USEPA 8260C LL	5	0.17	0.17	5	NL	0.17	1	0.5	Screening Level Cannot be Met
1,1-Dichloroethene	75-35-4		USEPA 8260C LL	7	280	28	7	NL	7	1	0.5	MRL below Screening Level
cis-1,2-Dichloroethene	156-59-2		USEPA 8260C LL	70	36	3.6	70	NL	3.6	1	0.5	MRL below Screening Level
trans-1,2-Dichloroethene	156-60-5		USEPA 8260C LL	100	360	36	100	NL	36	1	0.5	MRL below Screening Level
1,2-Dichloropropane	78-87-5		USEPA 8260C LL	5	0.85	0.82	0.52	NL	0.52	1	0.5	Screening Level between MRL and MDL
1,3-Dichloropropane	142-28-9		USEPA 8260C LL	NL	370	37	NL	NL	37	1	0.5	MRL below Screening Level
2,2-Dichloropropane	594-20-7		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	1	0.5	Not Applicable
1,1-Dichloropropene	563-58-6		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	1	0.5	Not Applicable
cis-1,3-Dichloropropene	10061-01-5		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	1	0.5	Not Applicable
trans-1,3-Dichloropropene	10061-02-6		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	1	0.5	Not Applicable
1,4-Dioxane (p-Dioxane)	123-91-1		USEPA 8260C LL	NL	0.46	0.46	NL	NL	0.46	100	50	Screening Level Cannot be Met
Diethyl ether	60-29-7		USEPA 8260C LL	NL	3900	390	NL	NL	390	20	10	MRL below Screening Level
Ethylbenzene	100-41-4		USEPA 8260C LL	700	1.5	1.5	700	NL	1.5	1	0.5	MRL below Screening Level

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WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	Laboratory	Method	EPA Maximum Contamination Level (µg/L)[2]	Tap Water Regional Screening Levels (µg/L)[2] THQ = 1.0	Tap Water Regional Screening Levels (µg/L)[2] THQ = 0.1	MDNR Groundwater Protection Standards (µg/L)[3]	MDNR Groundwater Protection Standards (µg/L)[4]	Lowest Screening Level EPA MCL/MDNR GWPS (µg/L)	Pace Analytical Services, LLC MRL (µg/L)	Pace Analytical Services, LLC MDL (µg/L)	Comparison of Laboratory Limits to Water Cleanup Levels[5]
Volatile Organic Compounds (Cont.)												
Ethyl methacrylate	97-63-2	PACE Analytical, Inc. Indianapolis	USEPA 8260C LL	NL	630	63	NL	NL	63	20	10	MRL below Screening Level
Hexachloro-1,3-butadiene	87-68-3		USEPA 8260C LL	NL	0.14	0.14	0.45	NL	0.14	1	0.5	Screening Level Cannot be Met
n-Hexane	110-54-3		USEPA 8260C LL	NL	1500	150	NL	NL	150	5	2.5	MRL below Screening Level
2-Hexanone	591-78-6		USEPA 8260C LL	NL	38	3.8	NL	NL	3.8	20	10	Screening Level Cannot be Met
Iodomethane	74-88-4		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	5	2.5	Not Applicable
Isopropylbenzene (Cumene)	98-82-8		USEPA 8260C LL	NL	450	45	NL	NL	45	1	0.5	MRL below Screening Level
p-Isopropyltoluene	99-87-6		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	1	0.5	Not Applicable
Methyl Acetate	79-20-9		USEPA 8260C LL	NL	20000	2000	NL	NL	2000	20	10	MRL below Screening Level
Methylcyclohexane	108-87-2		USEPA 8260C LL	NL	NL	NL	NL	NL	Not Applicable	20	10	Not Applicable
Methylene Chloride (Dichloromethane)	75-09-2		USEPA 8260C LL	5	11	11	NL	NL	5	5	0.5	MRL below Screening Level
4-Methyl-2-pentanone (MIBK)	108-10-1		USEPA 8260C LL	NL	6300	630	NL	NL	630	20	10	MRL below Screening Level
Methyl-tert-butyl-Ether (MTBE)	1634-04-4		USEPA 8260C LL	NL	14	14	NL	NL	14	4	2	MRL below Screening Level
n-Propylbenzene	103-65-1		USEPA 8260C LL	NL	660	66	NL	NL	66	1	0.5	MRL below Screening Level
Styrene	100-42-5		USEPA 8260C LL	100	1200	120	100	NL	100	1	0.5	MRL below Screening Level
1,1,1,2-Tetrachloroethane	630-20-6		USEPA 8260C LL	NL	0.57	0.57	70	NL	0.57	1	0.5	Screening Level between MRL and MDL
1,1,2,2-Tetrachloroethane	79-34-5		USEPA 8260C LL	NL	0.076	0.076	0.17	NL	0.076	1	0.5	Screening Level Cannot be Met
Tetrachloroethene (PCE)	127-18-4		USEPA 8260C LL	5	11	4.1	0.8	NL	0.8	1	0.5	Screening Level between MRL and MDL
Toluene	108-88-3		USEPA 8260C LL	1000	1100	110	1000	NL	110	1	0.5	MRL below Screening Level
1,2,3-Trichlorobenzene	87-61-6		USEPA 8260C LL	NL	7	0.7	NL	NL	0.7	1	0.5	Screening Level between MRL and MDL
1,2,4-Trichlorobenzene	120-82-1		USEPA 8260C LL	70	1.2	0.4	70	NL	0.4	1	0.5	Screening Level Cannot be Met
1,1,1-Trichloroethane (TCA)	71-55-6		USEPA 8260C LL	200	8000	800	200	NL	200	1	0.5	MRL below Screening Level
1,1,2-Trichloroethane	79-00-5		USEPA 8260C LL	5	0.28	0.041	5	NL	0.041	1	0.5	Screening Level Cannot be Met
1,1,2-Trichlorotrifluoroethane	76-13-1		USEPA 8260C LL	NL	10000	1000	NL	NL	1000	1	0.5	MRL below Screening Level
Trichloroethene (TCE)	79-01-6		USEPA 8260C LL	5	0.49	0.28	5	NL	0.28	1	0.5	Screening Level Cannot be Met
Trichlorofluoromethane	75-69-4		USEPA 8260C LL	NL	5200	520	2000	NL	520	2	1	MRL below Screening Level
1,2,3-Trichloropropane	96-18-4		USEPA 8260C LL	NL	0.00075	0.00075	40	NL	0.00075	1	0.5	Screening Level Cannot be Met
1,2,4-Trimethylbenzene	95-63-6		USEPA 8260C LL	NL	56	5.6	NL	NL	5.6	5	2.5	MRL below Screening Level
1,3,5-Trimethylbenzene	108-67-8		USEPA 8260C LL	NL	60	6	NL	NL	6	5	2.5	MRL below Screening Level
Vinyl Acetate	108-05-4		USEPA 8260C LL	NL	410	41	NL	NL	41	20	10	MRL below Screening Level
Vinyl Chloride (Chloroethene)	75-01-4		USEPA 8260C LL	2	0.019	0.019	2	NL	0.019	1	0.5	Screening Level Cannot be Met
m,p-Xylenes	MPXylene		USEPA 8260C LL	NL	190	19	NL	NL	19	2	1	MRL below Screening Level
o-Xylenes	95-47-6		USEPA 8260C LL	NL	190	19	NL	NL	19	1	0.5	MRL below Screening Level
Xylenes, Total	1330-20-7		USEPA 8260C LL	10000	190	19	10000	NL	19	3	1.5	MRL below Screening Level
Polychlorinated Biphenyls												
Aroclor 1016	12674-11-2	PACE Analytical, Inc. Indianapolis	USEPA 8082A	0.5	0.22	0.14	NL	NL	0.14	0.1	0.072	MRL below Screening Level
Aroclor 1221	11104-28-2		USEPA 8082A	0.5	0.0047	0.0047	NL	NL	0.0047	0.1	0.087	Screening Level Cannot be Met
Aroclor 1232	11141-16-5		USEPA 8082A	0.5	0.0047	0.0047	NL	NL	0.0047	0.1	0.077	Screening Level Cannot be Met
Aroclor 1242	53469-21-9		USEPA 8082A	0.5	0.0078	0.0078	NL	NL	0.0078	0.1	0.077	Screening Level Cannot be Met
Aroclor 1248	12672-29-6		USEPA 8082A	0.5	0.0078	0.0078	NL	NL	0.0078	0.1	0.064	Screening Level Cannot be Met
Aroclor 1254	11097-69-1		USEPA 8082A	0.5	0.0078	0.0078	NL	NL	0.0078	0.1	0.081	Screening Level Cannot be Met
Aroclor 1260	11096-82-5		USEPA 8082A	0.5	0.0078	0.0078	NL	NL	0.0078	0.1	0.071	Screening Level Cannot be Met
Total PCBs	12767-79-2		USEPA 8082A	0.5	NL	NL	NL	NL	0.5	0.1	0.1	MRL below Screening Level
Hydrocarbons												
Total Petroleum Hydrocarbons - Gasoline Range Organics	8006-61-9	PACE Analytical, Inc. Kansas	USEPA 8260 TPH	NL	NL	NL	NL	NL	Not Applicable	500	92	Not Applicable
Total Petroleum Hydrocarbons - Diesel Range Organics	68334-30-5		USEPA 8270 TPH	NL	NL	NL	NL	NL	Not Applicable	1000	500	Not Applicable
Total Petroleum Hydrocarbons - Oil Range Organics	NA		USEPA 8270 TPH	NL	NL	NL	NL	NL	Not Applicable	1000	500	Not Applicable
Organochlorine Pesticides												
Aldrin	309-00-2	PACE Analytical, Inc. Indianapolis	USEPA 8081B	NL	0.00092	0.00092	0.00013	NL	0.00013	0.05	0.0077	Screening Level Cannot be Met
alpha - BHC	319-84-6		USEPA 8081B	NL	0.0072	0.0072	0.0022	NL	0.0022	0.05	0.0116	Screening Level Cannot be Met
beta - BHC	319-85-7		USEPA 8081B	NL	0.025	0.025	0.0022	NL	0.0022	0.05	0.0111	Screening Level Cannot be Met
Lindane	58-89-9		USEPA 8081B	0.2	0.042	0.042	0.2	NL	0.042	0.05	0.0112	Screening Level between MRL and MDL
delta - BHC	319-86-8		USEPA 8081B	NL	NL	NL	0.0022	NL	0.0022	0.05	0.0086	Screening Level Cannot be Met
cis-Chlordane	5103-71-9		USEPA 8081B	NL	NL	NL	NL	NL	Not Applicable	0.5	0.0095	Not Applicable
trans-Chlordane	5103-74-2		USEPA 8081B	NL	NL	NL	NL	NL	Not Applicable	0.5	0.01	Not Applicable
Chlordane	12789-03-6 and 57-74-9		USEPA 8081B	2.0	0.02	0.02	NL	NL	0.02	0.5	0.16	Screening Level Cannot be Met
4,4'-DDD	72-54-8		USEPA 8081B	NL	0.032	0.0063	0.00083	NL	0.00083	0.1	0.0166	Screening Level Cannot be Met
4,4'-DDE	72-55-9		USEPA 8081B	NL	0.046	0.046	0.00059	NL	0.00059	0.1	0.0179	Screening Level Cannot be Met
4,4'-DDT	50-29-3		USEPA 8081B	NL	0.23	0.23	0.00059	NL	0.00059	0.1	0.0194	Screening Level Cannot be Met
Dieldrin	60-57-1		USEPA 8081B	NL	0.0018	0.0018	0.00014	NL	0.00014	0.1	0.0165	Screening Level Cannot be Met
Endosulfan I	959-98-8		USEPA 8081B	NL	NL	NL	NL	NL	Not Applicable	0.05	0.0084	Not Applicable
Endosulfan II	33213-65-9		USEPA 8081B	NL	NL	NL	NL	NL	Not Applicable	0.1	0.025	Not Applicable
Endosulfan sulfate	1031-07-8		USEPA 8081B	NL	110	11	NL	NL	11	0.1	0.0144	MRL below Screening Level
Endrin	72-20-8		USEPA 8081B	2.0	2.3	0.23	2	NL	0.23	0.1	0.0152	MRL below Screening Level
Endrin aldehyde	7421-93-4		USEPA 8081B	NL	NL	NL	0.75	NL	0.75	0.1	0.0183	MRL below Screening Level
Endrin ketone	53494-70-5		USEPA 8081B	NL	NL	NL	NL	NL	Not Applicable	0.1	0.0169	Not Applicable
Heptachlor	76-44-8		USEPA 8081B	0.4	0.0014	0.0014	0.4	NL	0.0014	0.05	0.0097	Screening Level Cannot be Met
Heptachlor epoxide	1024-57-3		USEPA 8081B	0.2	0.0014	0.0014	0.2	NL	0.0014	0.05	0.0092	Screening Level Cannot be Met
Methoxychlor	72-43-5		USEPA 8081B	40	37	3.7	40.0	NL	3.7	0.5	0.1572	MRL below Screening Level
Toxaphene	8001-35-2		USEPA 8081B	3	0.071	0.071	3	NL	0.071	1	0.14	Screening Level Cannot be Met

TABLE 2-3a. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR GROUNDWATER AND LEACHATE SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	Laboratory	Method	EPA Maximum Contamination Level (µg/L)[2]	Tap Water Regional Screening Levels (µg/L)[2] THQ = 1.0	Tap Water Regional Screening Levels (µg/L)[2] THQ = 0.1	MDNR Groundwater Protection Standards (µg/L)[3]	MDNR Groundwater Protection Standards (µg/L)[4]	Lowest Screening Level EPA MCL/MDNR GWPS (µg/L)	Pace Analytical Services, LLC MRL (µg/L)	Pace Analytical Services, LLC MDL (µg/L)	Comparison of Laboratory Limits to Water Cleanup Levels[5]
Radiological Chemistry												
Total Isotopic Thorium - 228	Not Applicable	PACE Analytical, Inc. Pittsburgh	HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Dissolved Isotopic Thorium - 228	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Thorium - 230	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Dissolved Isotopic Thorium - 230	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Thorium - 232	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Dissolved Isotopic Thorium - 232	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Uranium - 234	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Dissolved Isotopic Uranium - 234	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Uranium - 235	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Dissolved Isotopic Uranium - 235	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Uranium - 238	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Dissolved Isotopic Uranium - 238	Not Applicable		HASL 300	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Radium- 226	Not Applicable		USEPA 903.1	5 pCi/L	NL	NL	NL	NL	5 pCi/L	Not Applicable	1pCi/L	Screening Level between MRL and MDL
Dissolved Isotopic Radium- 226	Not Applicable		USEPA 903.1	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Total Isotopic Radium- 228	Not Applicable		USEPA 904.0	5 pCi/L	NL	NL	NL	NL	5 pCi/L	Not Applicable	1pCi/L	Screening Level between MRL and MDL
Dissolved Isotopic Radium- 228	Not Applicable		USEPA 904.0	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	1pCi/L	Not Applicable
Geochemistry/General Chemistry												
Alkalinity	NA	PACE Analytical, Inc. Indianapolis	SM 2320B	NL	NL	NL	NL	NL	Not Applicable	2 mg/L	1	Not Applicable
Bromide	24959-67-9		USEPA 9056A	NL	NL	NL	NL	NL	Not Applicable	0.05 mg/L	0.01439	Not Applicable
Carbonate (HCO3-)	3812-32-6		SM 2320B	NL	NL	NL	NL	NL	Not Applicable	2 mg/L	1	Not Applicable
Total Dissolved Solids	Not Applicable		SM 2540C	NL	NL	NL	NL	0.5	0.5	10 mg/L	10	Screening Level Cannot be Met
Total Suspended Solids (0.45 micron filter)	7732-18-5, 9004-34-6		SM 2540D	NL	NL	NL	NL	NL	Not Applicable	5 mg/L	5	Not Applicable
Total Hardness	Not Applicable		USEPA 6010B/2340B Calculation	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Cations + Anions	Calculation		Calculation	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Iodide	7553-56-2		USEPA 9056A	NL	200	20	NL	NL	20	0.5 mg/L	0.094	Screening Level between MRL and MDL
Chloride	16887-00-6		USEPA 9056A	NL	NL	NL	NL	NL	Not Applicable	0.25 mg/L	0.0911	Not Applicable
Fluoride	16984-48-8		USEPA 9056A	4000	800	80	NL	NL	80	0.1 mg/L	0.012	Screening Level between MRL and MDL
Phosphate	14265-44-2		USEPA 365.1	NL	NL	NL	NL	NL	Not Applicable	0.1 mg/L	0.05	Not Applicable
Sulfate	14808-79-8		USEPA 9056A	NL	NL	NL	NL	NL	Not Applicable	0.25mg/L	0.173	Not Applicable
Sulfide	18496-25-8		SM 4500-S2-D	NL	NL	NL	NL	NL	Not Applicable	1 mg/L	0.017	Not Applicable
Chemical Oxygen Demand	Not Applicable		USEPA 410.4	NL	NL	NL	NL	NL	Not Applicable	10 mg/L	3.74	Not Applicable
Nitrite + Nitrate as Nitrogen	Not Applicable		USEPA 353.2	10000	NL	NL	NL	NL	10000	0.1 mg/L	0.02	Screening Level between MRL and MDL
Nitrogen as Ammonia	Not Applicable		SM 4500-NH3 G	NL	NL	NL	NL	NL	Not Applicable	0.1 mg/L	0.0266	Not Applicable
Nitrite as Nitrogen	Not Applicable		USEPA 353.2	1000	NL	NL	NL	NL	1000	0.1 mg/L	0.005	Screening Level between MRL and MDL
Nitrate as Nitrogen	Not Applicable		USEPA 353.2	10000	NL	NL	10000	NL	10000	0.1 mg/L	0.02	Screening Level between MRL and MDL
pH	Not Applicable		SM4500H+B	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Total Organic Carbon	7440-44-0		SM 5310C	NL	NL	NL	NL	NL	Not Applicable	1 mg/L	0.146	Not Applicable
Dissolved Organic Carbon	7440-44-0		SM 5310C	NL	NL	NL	NL	NL	Not Applicable	1 mg/L	0.146	Not Applicable
Dissolved Gasses												
Methane	74-82-8	PACE Analytical, Inc. Energy	AM20GAX	NL	NL	NL	NL	NL	Not Applicable	0.5	0.094	Not Applicable
Carbon Dioxide	124-38-9		AM20GAX	NL	NL	NL	NL	NL	Not Applicable	5 mg/L	0.472 mg/L	Not Applicable
Field Test												
Ammonium	Field Test	Field	Field Test	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Ferric Iron	20074-52-6		Calculation	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Ferrous Iron	15438-31-0		HACH 8146	NL	NL	NL	NL	NL	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Notes:
1-Screening levels for 4-methylphenol were used because it was more conservative than those of 3-methylphenol.
2-USEPA. Regional Screening Levels (RSLs) - Generic Tables ((TR=1E-06 THQ=0.1)). November 2019; Both used for screer
3-MDNR Groundwater Protection Standards (GWPS)- Table A1. Criteria for Designated Uses and health Advisory Levels. Division 20, Chapter 7. January 2019
4-MDNR Groundwater Protection Standards (GWPS) - Division 60, Chapter 4 Section 60-4.030 and 60-4.070. January 2019
5-Where MRL or MDLs to not meet the screening levels, the lowest limit will be used.

Abbreviations:
µg/L: micrograms per Liter
GWPS: Groundwater Protection Standards
HASL: Health and Safety Laboratory
HNO3: Nitric acid
L: Liter
MDL: Method Detection Limit
MDNR: Missouri Department of Natural Resources
mg: milligram
MRL: Method Reporting Limit
NL: Not listed in referenced document
RL: Reporting Limit
RSL: Regional Screening Level
SIM: Selective Ion Monitoring
SM: Standard Methods for the Examination of Water and Wastewater
USEPA: United States Environmental Protection Agency

TABLE 2-3b. LIST OF PACE CONSTITUENTS AND DESIRED REPORTING LIMITS FOR SOIL AND BEDROCK SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes	CAS Number	Laboratory	Method	MRL (mg/kg - unless otherwise noted)	MDL (mg/kg - unless otherwise noted)
Total Metals					
Aluminum	7429-90-5	PACE Analytical, Inc. Indianapolis	USEPA 6010B	50	3.68
Antimony	7440-36-0		USEPA 6010B	1	0.24
Arsenic	7440-38-2		USEPA 6010B	1	0.2
Barium	7440-39-3		USEPA 6010B	1	0.06
Beryllium	7440-41-7		USEPA 6010B	0.5	0.02
Boron	7440-42-8		USEPA 6010B	5	0.48
Cadmium	7440-43-9		USEPA 6010B	0.5	0.02
Calcium	7440-70-2		USEPA 6010B	50	9.84
Chromium	7440-47-3		USEPA 6010B	1	0.29
Cobalt	7440-48-4		USEPA 6010B	1	0.03
Copper	7440-50-8		USEPA 6010B	1	0.12
Iron	7439-89-6		USEPA 6010B	50	4.92
Lead	7439-92-1		USEPA 6010B	1	0.15
Lithium	7439-93-2		USEPA 6010B	5	1
Magnesium	7439-95-4		USEPA 6010B	50	2.83
Manganese	7439-96-5		USEPA 6010B	1	0.12
Molybdenum	7439-98-7		USEPA 6010B	1	0.05
Total Mercury	7439-97-6		USEPA 7471A	0.2	0.1
Nickel	7440-02-0		USEPA 6010B	1	0.11
Potassium	7440-09-7		USEPA 6010B	50	5.81
Selenium	7782-49-2		USEPA 6010B	1	0.37
Silver	7440-22-4		USEPA 6010B	0.5	0.28
Sodium	7440-23-5		USEPA 6010B	50	8.19
Strontium	7440-24-6		USEPA 6010B	1	0.07
Thallium	7440-28-0		USEPA 6010B	1	0.24
Thorium	7440-29-1		USEPA 6020	0.1	0.05
Tin	7440-31-5		USEPA 6010B	5	2.02
Titanium	7440-32-6		USEPA 6010B	1	0.09
Uranium	7440-61-1		USEPA 6020	0.1	0.05
Vanadium	7440-62-2		USEPA 6010B	1	0.11
Zinc	7440-66-6		USEPA 6010B	1	0.35
Ferric Iron	20074-52-6	MCLinc	Calculation (Total - Ferrous)	Not Applicable	Not Applicable
Ferrous Iron	15438-31-0		SM 3500-Fe B, modified	5	Not Applicable
Total Iron	15438-31-0		USEPA 6010B	2	Not Applicable

TABLE 2-3b. LIST OF PACE CONSTITUENTS AND DESIRED REPORTING LIMITS FOR SOIL AND BEDROCK SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Radiological Chemistry[1]					
Total Isotopic Thorium - 22ε	Not Applicable	PACE Analytical, Inc. Pittsburgh	HASL-300 Method U-02	Not Applicable	0.001 pCi/g
Total Isotopic Thorium - 23(	Not Applicable		HASL-300 Method U-02	Not Applicable	0.001 pCi/g
Total Isotopic Thorium - 23:	Not Applicable		HASL-300 Method U-02	Not Applicable	0.001 pCi/g
Total Isotopic Uranium - 23⁄	Not Applicable		HASL-300 Method U-02	Not Applicable	0.001 pCi/g
Total Isotopic Uranium - 23ξ	Not Applicable		HASL-300 Method U-02	Not Applicable	0.001 pCi/g
Total Isotopic Uranium - 23ε	Not Applicable		HASL-300 Method U-02	Not Applicable	0.001 pCi/g
Total Isotopic Radium- 22(	Not Applicable		USEPA 903.1	Not Applicable	0.001 pCi/g
Total Isotopic Radium- 228	Not Applicable		USEPA 904.0	Not Applicable	0.001 pCi/g
X-Ray Diffraction[2]					
Abundance of Major Minerals	Not Applicable	MCLInc	MCL-7712	Not Applicable	Not Applicable
Scanning Electron Microscope with Energy Dispersive X-Ray Spectrometry (SEM/EDS[3])					
Elemental Association	Not Applicable	MCLInc	MCL-7708	Not Applicable	Not Applicable
Cation/Anions					
Cation Exchange Capacity	Not Applicable	Pace Analytical, Inc. Kansas	USEPA 9081	0.1 meq/100g	0.050
pH	Not Applicable	PACE Analytical, Inc. Indianapolis	USEPA 9045D	Not Applicable	Not Applicable
Iodide	7553-56-2		USEPA 9056A	5	5
Bromide	24959-67-9		USEPA 9056A	0.5	0.5
Fluoride	7782-41-4		USEPA 9056A	1	1
Chloride	16887-00-6		USEPA 9056A	2.5	2.5
Sulfate	14808-79-8		USEPA 9056A	2.5	2.5
Total Alkalinity	Not Applicable		SM 2320B	100	50
Carbonate (HCO3-)	3812-32-6		SM 2320B	100	50
Cation + Anion	Calculation		Calculation	Not Applicable	Not Applicable
Total Organic Carbon	7440-44-0	PACE Analytical, Inc. Green Bay	Walkley-Black Procedure	644.2 mg/kg (LOQ)	193.27 mg/kg (LOD)

TABLE 2-3b. LIST OF PACE CONSTITUENTS AND DESIRED REPORTING LIMITS FOR SOIL AND BEDROCK SAMPLING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Sequential Extraction (Soils Only					
Dissolved Radium	Not Applicable	**Pace - P**	USEPA 903.1/904.0	Not Applicable[4]	Not Applicable[4]
Total Thorium	Not Applicable	**Pace - I**	USEPA 6020	Not Applicable[4]	Not Applicable[4]
pH	Not Applicable	**MCLInc**	USEPA 9045D	Not Applicable[4]	Not Applicable[4]
Total Barium	7440-39-3		USEPA 6010B	Not Applicable[4]	Not Applicable[4]
Total Calcium	7440-70-2		USEPA 6010B	Not Applicable[4]	Not Applicable[4]
Total Iron	7439-89-6		USEPA 6010B	Not Applicable[4]	Not Applicable[4]
Total Manganese	7439-96-5		USEPA 6010B	Not Applicable[4]	Not Applicable[4]
Total Sulfur	7704-34-9		USEPA 6020	Not Applicable[4]	Not Applicable[4]
Total Uranium	Not Applicable		USEPA 6020	Not Applicable[4]	Not Applicable[4]
Characteristics (Soils Only)					
Grain Size Distribution by Sieve Analyses	Not Applicable	**Earth Exploration**	ASTM D422	Not Applicable	Not Applicable
Grain Size Distribution by Hydrometer Analyses	Not Applicable		ASTM D422	Not Applicable	Not Applicable
Atterberg Limits	Not Applicable		ASTM D4318	Not Applicable	Not Applicable
Density	Not Applicable		ASTM 7263	Not Applicable	Not Applicable

Notes:
1 - The radiological data will be determined by analysis of a filtered aqueous sample. The results will be pCi/L and converted to pCi/g by dividing by 1000.
2 - X-Ray Diffraction (XRD) quantifies the abundance of major minerals. Procedures for this analysis are provided in standard operating procedure (SOP) MCL-7708 (Appendix D).
3 - Scanning Electron Microscope with Energy Dispersive x-ray Spectrometry (SEM/EDS), provides a semi-quantitative method for elemental association. Procedures for this analysis are provided in SOP MCL-7712 (Appendix D).
4 - Sequential Extraction results in a variety of limits due to the nature of the methodology. Procedures for sequential extraction are discussed in the QAPP text and Appendix D.

Abbreviations:
ASTM: American Society of Testing and Materia
g: gram
LOD: Limit of Detection
LOQ: Limit of Quantitation
MCLInc & MCL: Materials and Chemistry Laboratory, Inc.
meq: Milliequivalents
MRL: Method Reporting Limit
MDL: Method Detection Limit
MDNR: Missouri Department of Natural Resources
mg/kg: milligrams per kilogram
MRBCA: Missouri Risk-Based Corrective Actior
NL: Not listed in referenced document
Pace - I: PACE Analytical, Inc. Indianapolis
Pace - P: PACE Analytical, Inc. Pittsburgh
RSL: Regional Screening Level
mg/kg: milligrams per kilogram
USEPA: United States Environmental Protection Agency

TABLE 2-3c. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR INDOOR AIR ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	OSHA PELs (µg/m^3 unless otherwise noted)	Industrial RSL (µg/m^3 unless otherwise noted)[5] HQ = 0.1	Industrial RSL (µg/m^3 unless otherwise noted)[5] HQ = 1.0	ALS Method Reporting Limit (µg/m^3 unless otherwise noted)[6]	ALS Method Detection Limit (µg/m^3 unless otherwise noted)[6]	Comparison of Laboratory Limits to OSHA PEL	Comparison of Laboratory Limits to Industrial RSL
1,1,1-Trichloroethane	71-55-6	1900000	2200	22000	0.54	0.066	PEL above MDL	ISL above MDL
1,1,2,2-Tetrachloroethane	79-34-5	35000	0.21	0.21	0.53	0.074	PEL above MDL	ISL above MDL
1,1,2-Trichloroethane	79-00-5	45000	0.088	0.77	0.53	0.054	PEL above MDL	ISL above MDL
1,1-Dichloroethane	75-34-3	400000	7.7	7.7	0.51	0.078	PEL above MDL	ISL above MDL
1,1-Dichloroethene	75-35-4	NL	88	880	0.53	0.074	NA	ISL above MDL
1,2,4-Trichlorobenzene	120-82-1	NL	0.88	8.8	0.55	0.13	NA	ISL above MDL
1,2,4-Trimethylbenzene	95-63-6	NL	26	260	0.53	0.074	NA	ISL above MDL
1,2-Dibromo-3-chloropropane[4]	96-12-8	9.67	0.002	0.002	0.53	0.1	PEL above MDL	ISL above MDL
1,2-Dibromoethane[3]	106-93-4	153800	0.02	0.02	0.53	0.062	PEL above MDL	ISL above MDL
1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	76-14-2	700000	NL	NL	0.51	0.084	PEL above MDL	NA
1,2-Dichlorobenzene[2]	95-50-1	300000	88	880	0.54	0.079	PEL above MDL	ISL above MDL
1,2-Dichloroethane[3]	107-06-2	202500	0.47	0.47	0.53	0.059	PEL above MDL	ISL above MDL
1,2-Dichloropropane	78-87-5	350000	1.8	3.3	0.53	0.066	PEL above MDL	ISL above MDL
1,3,5-Trimethylbenzene	108-67-8	NL	26	260	0.52	0.077	NA	ISL above MDL
1,3-Butadiene[4]	106-99-0	2210	0.41	0.41	0.53	0.088	PEL above MDL	ISL above MDL
1,3-Dichlorobenzene	541-73-1	NL	NL	NL	0.54	0.08	NA	NA
1,4-Dichlorobenzene	106-46-7	450000	1.1	1.1	0.53	0.082	PEL above MDL	ISL above MDL
1,4-Dioxane	123-91-1	360000	2.5	2.5	0.53	0.063	PEL above MDL	ISL above MDL
2-Propanol (Isopropyl Alcohol)	67-63-0	980000	88	880	2.1	0.22	PEL above MDL	ISL above MDL
3-Chloro-1-propene (Allyl Chloride)	107-05-1	3000	0.44	2	0.53	0.072	PEL above MDL	ISL above MDL
4-Ethyltoluene	622-96-8	NL	NL	NL	0.52	0.085	NA	NA
4-Methyl-2-pentanone (MIBK)	108-10-1	410000	1300	13000	0.53	0.073	PEL above MDL	ISL above MDL
Acetone	67-64-1	2400000	14000	140000	5.3	1.2	PEL above MDL	ISL above MDL
Acetonitrile	75-05-8	7000	26	260	0.53	0.13	PEL above MDL	ISL above MDL
Acrolein	107-02-8	250	0.0088	0.088	1.1	0.15	PEL above MDL	ISL above MDL
Acrylonitrile	107-13-1	NL	0.18	0.18	0.53	0.11	NA	ISL above MDL
alpha-Pinene	80-56-8	NL	NL	NL	0.52	0.082	NA	NA
Benzene[3]	71-43-2	31900	1.6	1.6	0.53	0.077	PEL above MDL	ISL above MDL
Benzyl Chloride	100-44-7	5000	0.25	0.25	1.1	0.12	PEL above MDL	ISL above MDL
Bromodichloromethane	75-27-4	NL	0.33	0.33	0.53	0.077	NA	ISL above MDL
Bromoform	75-25-2	5000	11	11	0.53	0.11	PEL above MDL	ISL above MDL
Bromomethane[2]	74-83-9	80000	2.2	22	0.5	0.074	PEL above MDL	ISL above MDL
Carbon Disulfide[3]	75-15-0	62282	310	3100	1.1	0.16	PEL above MDL	ISL above MDL
Carbon Tetrachloride[3]	56-23-5	62920	2	2	0.53	0.074	PEL above MDL	ISL above MDL
Chlorobenzene	108-90-7	350000	22	220	0.53	0.071	PEL above MDL	ISL above MDL
Chloroethane	75-00-3	2600000	4400	44000	0.51	0.066	PEL above MDL	ISL above MDL
Chloroform[2]	67-66-3	240000	0.53	0.53	0.53	0.071	PEL above MDL	ISL above MDL
Chloromethane[3]	74-87-3	206543	39	390	0.5	0.086	PEL above MDL	ISL above MDL
cis-1,2-Dichloroethene	156-59-2	NL	NL	NL	0.53	0.075	NA	NA

TABLE 2-3c. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR INDOOR AIR ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	OSHA PELs ($\mu g/m^3$ unless otherwise noted)	Industrial RSL ($\mu g/m^3$ unless otherwise noted)[5] HQ = 0.1	Industrial RSL ($\mu g/m^3$ unless otherwise noted)[5] HQ = 1.0	ALS		Comparison of Laboratory Limits to OSHA PEL	Comparison of Laboratory Limits to Industrial RSL
					Method Reporting Limit ($\mu g/m^3$ unless otherwise noted)[6]	Method Detection Limit ($\mu g/m^3$ unless otherwise noted)[6]		
cis-1,3-Dichloropropene	10061-01-5	NL	NL	NL	0.56	0.083	NA	NA
Cyclohexane	110-82-7	1050000	2600	26000	1.1	0.15	PEL above MDL	ISL above MDL
Dibromochloromethane	124-48-1	NL	NL	NL	0.53	0.07	NA	NA
Dichlorodifluoromethane (CFC 12)	75-71-8	4950000	44	440	0.52	0.087	PEL above MDL	ISL above MDL
d-Limonene	5989-27-5	NL	NL	NL	0.5	0.11	NA	NA
Ethanol	64-17-5	1900000	NL	NL	5.3	0.37	PEL above MDL	NA
Ethyl Acetate	141-78-6	1400000	31	310	1.1	0.28	PEL above MDL	ISL above MDL
Ethylbenzene	100-41-4	435000	4.9	4.9	0.53	0.075	PEL above MDL	ISL above MDL
Hexachlorobutadiene	87-68-3	NL	0.56	0.56	0.53	0.11	NA	ISL above MDL
Isopropylbenzene (Cumene)	98-82-8	245000	180	1800	0.53	0.077	PEL above MDL	ISL above MDL
m+p-Xylene	179601-23-1	NL	NL	NL	1.1	0.14	NA	NA
Methyl Butyl Ketone (2-Hexanone)	591-78-6	410000	13	130	0.53	0.066	PEL above MDL	ISL above MDL
Methyl Ethyl Ketone (2-Butanone)	78-93-3	590000	2200	22000	1.1	0.11	PEL above MDL	ISL above MDL
Methyl Methacrylate	80-62-6	410000	310	3100	1.1	0.19	PEL above MDL	ISL above MDL
Methylene Chloride[3,4]	75-09-2	87500	260	1200	0.53	0.15	PEL above MDL	ISL above MDL
Methyl-tert-Butyl Ether	1634-04-4	NL	47	47	0.54	0.063	NA	ISL above MDL
n-Butyl Acetate	123-86-4	710000	NL	NL	0.53	0.073	PEL above MDL	NA
n-Heptane	142-82-5	2000000	180	1800	0.53	0.085	PEL above MDL	ISL above MDL
n-Hexane	110-54-3	1800000	310	3100	0.53	0.11	PEL above MDL	ISL above MDL
Naphthalene	91-20-3	50000	0.36	0.36	0.53	0.13	PEL above MDL	ISL above MDL
n-Nonane	111-84-2	NL	8.8	88	0.53	0.089	NA	ISL above MDL
n-Octane	111-65-9	2350000	NL	NL	0.53	0.12	PEL above MDL	NA
n-Propylbenzene	103-65-1	NL	440	4400	0.53	0.077	NA	ISL above MDL
o-Xylene	95-47-6	NL	44	440	0.53	0.077	NA	ISL above MDL
Propene	115-07-1	NL	1300	13000	0.52	0.13	NA	ISL above MDL
Styrene[3]	100-42-5	425930	440	4400	0.53	0.086	PEL above MDL	ISL above MDL
Tetrachloroethene[3]	127-18-4	678323	18	47	0.53	0.069	PEL above MDL	ISL above MDL
Tetrahydrofuran (THF)	109-99-9	590000	880	8800	0.53	0.067	PEL above MDL	ISL above MDL
Toluene[3]	108-88-3	753619	2200	22000	0.53	0.065	PEL above MDL	ISL above MDL
trans-1,2-Dichloroethene	156-60-5	NL	NL	NL	0.54	0.074	NA	NA
trans-1,3-Dichloropropene	10061-02-6	NL	NL	NL	0.53	0.11	NA	NA
Trichloroethene[3]	79-01-6	537423	0.88	3	0.53	0.072	PEL above MDL	ISL above MDL
Trichlorofluoromethane	75-69-4	5600000	NL	NL	0.53	0.081	PEL above MDL	NA
Trichlorotrifluoroethane (CFC 113)	76-13-1	7600000	2200	22000	0.53	0.076	PEL above MDL	ISL above MDL
Vinyl Acetate	108-05-4	NL	88	880	5.3	1.2	NA	ISL above MDL
Vinyl Chloride[4]	75-01-4	2556	2.8	2.8	0.52	0.057	PEL above MDL	ISL above MDL
Methane[8]	74-82-8	NL	NL	NL	1.0 ppm	0.28 ppm	NA	NA

TABLE 2-3c. LIST OF CONSTITUENTS AND DESIRED REPORTING LIMITS FOR INDOOR AIR ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Target Analytes[1]	CAS Number	OSHA PELs ($\mu g/m^3$ unless otherwise noted)	Industrial RSL ($\mu g/m^3$ unless otherwise noted)[5] HQ = 0.1	Industrial RSL ($\mu g/m^3$ unless otherwise noted)[5] HQ = 1.0	ALS Method Reporting Limit ($\mu g/m^3$ unless otherwise noted)[6]	ALS Method Detection Limit ($\mu g/m^3$ unless otherwise noted)[6]	Comparison of Laboratory Limits to OSHA PEL	Comparison of Laboratory Limits to Industrial RSL
Radon[7]								
Radon - Short Term	EPA 402-R-92-004	4.0 pCi/L	NL	NL	6 Bq/m^3 = 0.162 pCi/L	NA	PEL above MDL	NA
Radon - Long Term	EPA 402-R-92-004	4.0 pCi/L	NL	NL	7 Bq/m^3 = 0.189 pCi/L	NA	PEL above MDL	NA

Notes:
1. Target analyte list is based on ALS Global TO-15 Low Level list.
2. OSHA Ceiling limit as found using https://www.chemsafetypro.com/Topics/USA/OSHA_PELs_Permissible_Exposure_Limits.html
3. 8-Hour TWA as determined using https://www.chemsafetypro.com/Topics/USA/OSHA_PELs_Permissible_Exposure_Limits.html
4. Cal OSHA Value as determined using https://www.chemsafetypro.com/Topics/USA/OSHA_PELs_Permissible_Exposure_Limits.html
5. Industrial Regional Screening Levels were used with a THQ of 0.1 (April 2019) as found from the following website: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
6. EPA Test Method TO-15 for 6-Liter Canister
7. Conversion based on 1 pCi/L is equal to 37 Bq/m^3
8. Analyzed using EPA Method TO-3

Abbreviations:
Bq/m3 - Becquerel per meters cubed
CAS: Chemical Abstracts Service
ISL: Industrial Screening Level
MRL: Method Reporting Limit
MDL: Method Detection Limit
NA: Not Applicable
NL: Not listed in referenced document
OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
pCi/L: picocurie per liter
RSL: Regional Screening Level
TWA: Time-weighted Average
$\mu g/m^3$: micrograms per cubic meter

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	<u>1. Data Usability and Well Inventory</u> - Over 100 monitoring wells were previously installed on-site and near-site to characterize impacts to groundwater. A portion of these wells were plugged/abandoned over time. There are currently 86 existing monitoring wells, which are located on-site or near-site. The existing wells have been sampled from 1979 to 2019. The adequacy and usability of data collected from these wells to characterize impacts needs evaluated for the parameters that will be utilized as part of the OU-3 studies. The usability of historical data is important in understanding potential extent of impacts and transport. It is unknown whether additional validation efforts are necessary for the desired data set; however it is likely that the more recent data have already been validated to meet the requirements of the OU-3 QAPP. As part of the OU-3 investigation, these 86 existing wells are proposed to be included as part of the overall OU-3 well network. The OU-3 well network will include the 86 existing wells and 64 proposed wells, resulting in a proposed well network of 150 wells. It is unknown whether the proposed OU-3 well network will be sufficient for evaluating nature and extent of site-related impacts and characterize background groundwater conditions. Additionally, there may be existing wells offsite that may provide useful hydrogeologic information, but an off-site well inventory has not been completed since 2018. There may be existing wells offsite within a two-mile radius which may be impacted by groundwater from the site. Sampling of these wells may be necessary to determine if groundwater has been impacted from the site. No drinking water wells were identified in 2018 within two miles of the site, but that may have changed over time.	<u>1. Personnel:</u> - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE <u>2. Budget:</u> $11 MM through 2023 for RI activities <u>3. Schedule:</u> - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s). - Consider alternative outcomes or actions that can occur upon answering the question(s). - For decision problems, develop decision statement(s), organize multiple decisions. - For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1.Are the existing monitoring wells (86 wells) currently constructed such that representative samples can be collected? 2.Is the existing, plus proposed well network adequate for future groundwater monitoring in terms of horizontal and vertical distribution? 3.Are historical data from the existing monitoring wells of sufficient quality to use for future data analysis? 4.Are the well survey data accurate given the potential for land subsidence at the site and are the data consistently based on the same datum: North American Datum (NAD) 83 State Plane (horizontal) and North American Vertical Datum of 1988 (NAVD88) (vertical)? 5.Are there existing monitoring wells that need repaired? 6.Are there existing monitoring wells that need to be plugged/abandoned? 7.Do existing wells need redevelopment? 8.What wells exist within a 2-mile radius of the site? 9.Are there drinking water wells within a 2-mile radius of the site that may be impacted by the site groundwater? 10.Are any of the wells to be sampled as part of the OU-3 activities going to be removed due to the OU-1 remedial implementation?	1. The existing well network may be adequate without any well repairs or well plugging/abandonment. 2. New wells are necessary near the site to provide data from the area surrounding the site where the well spacing is too large and where an incomplete vertical interval is being monitored. New wells are also necessary off-site since this area has not yet been assessed. There are a number of different potential wells that could be proposed to complete the well network based on vertical and lateral spatial distribution. In some locations, not all five zones may be present as anticipated based on nearby lithology, which could trigger the need for additional wells elsewhere. Another alternate outcome is that access is not granted to off-site properties for the proposed well installation activities. 3. None, some or all of the historic data set may be of sufficient quality for future data analysis. 4. All or some of the existing monitoring wells may need to be resurveyed to determine current vertical elevation and lateral location using the same data. 5. None, some, or all of the existing monitoring wells may need to be repaired. 6. None, some, or all of the existing monitoring wells may need to be plugged/abandoned. 7. The wells may need redeveloped or may not require redevelopment. 8. The same number of wells may be identified offsite within a 2-mile radius as in 2018, or more wells or fewer wells are identified. 9. The same number of drinking water wells may be identified within a 2-mile radius as in 2018, or more wells are identified. 10. It is possible that the proposed turbidity threshold of 5 NTU is not achievable.	1. The lateral and vertical well spacing. 2. A review of historical data to determine final data quality. 3. New northing, easting, and vertical elevation data for existing wells. Corrections need to be made to historical datasets to create an accurate historical record of water level elevations. 4. A list of wells that need repaired. 5. A list of wells that need plugged/abandoned. 6. A list of wells that need redeveloped. 7. Geospatial, well construction, water level, water quality, and well use information for wells within a 2-mile radius of the site. 1-9. The above information needs to be compiled and submitted as a Well Inventory Summary Report.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates. - Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process. - Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1. Historical documents will be used as a resource. However, a site visit to each well will be conducted to evaluate the viability of each existing well in the proposed well network. 2. Historical documents will be used as a resource to evaluate well distribution relative to potential groundwater flow directions, potential sources of groundwater impacts, and receptors. In addition to historical documents, data from the proposed OU-3 Phase I RI off-site wells can be used to determine if the proposed and existing well network is adequately defining the groundwater nature and extent. 3. Historical data from past reports will be used as a resource. 4. Surveys by a professional land survey licensed in Missouri will be used to measure current northing, easting, and vertical elevation of the ground surface and top of casing for the proposed OU-3 groundwater network wells. 5. Site visits will be used to determine whether the wells need repaired (if damaged or missing), including well lids, bolts, gaskets, j-plugs, locks, well pads, and casing. 6. Site visits and historical data will be used to determine whether the wells need plugged/abandoned. 7. Turbidity readings will be collected and used as a data source. Total depth readings will be collected and compared to the design well depths as a data source to determine if the well needs redeveloped. 8. State well databases, environmental databases, and historical reports (including OU-1 and OU-2) will be used as resources for possible offsite wells. Potential well locations will also be field verified. 9. The local water provider records will be requested and compared against property addresses to confirm parcels that are serviced by city water. Potential drinking water wells will also be field verified.	1. Well construction will be compared to Missouri State Well code for suitability. 2. The number of monitoring wells and distribution of monitoring wells will be evaluated for adequacy by including sufficient wells to delineate off-site groundwater impacts from the site (if any), establish background water quality, provide sufficient information to populate a groundwater flow model, provide sufficient information to complete a human health and ecological risk assessment, and design a remedy (if needed). 3. Previously collected data will be evaluated relative to the QAPP data validation standards to determine if results can be used as is, or if the data require qualification, or cannot be relied upon. Data that have already been validated in accordance with this QAPP will not be revalidated. The level of validation for older data without the Level IV QA/QC data package will be validated to the level possible based on the QA/QC data available for that data set. 4. Review of historical documents will be used to determine survey datum. 5. The Missouri Well Code will be used to determine if wells need repaired. 6. The Missouri Well Code will be used to determine if wells to be abandoned. 7. The basis for the turbidity threshold of 5 NTU is Puls and Barcelona (USEPA 1996). The basis for the well screen occlusion criteria of 10% is USEPA April 1992 Groundwater Forum, Monitoring Well Development Guidelines for Superfund Project Managers. 8. Inclusion of existing off-site wells in databases and historical reports will form the basis for generating a list of potential wells. 9. Inclusion of existing off-site wells in databases and historical reports will form the basis for generating a list of drinking water wells. The omission of a parcel from the City of St. Louis Water Division records may indicate that a drinking water well may be present.	1. Historical documents from OU-1 and OU-2 are available with well construction information. 2. Historical documents from OU-1 and OU-2 are available with well location and screening interval information. 3. Historical documents from OU-1, OU-2, and regional publications are available with potentially useful data. 4. A professional land surveyor can be subcontracted to survey the proposed OU-3 well network. 5. Site visits can be coordinated for the well inventory. 6. Site visits can be coordinated for well plugging/abandonment. 7. Turbidity readings will be collected using a Horiba Flow-Through Cell field parameter meter during groundwater sampling activities. Total depth readings will be measured using a water level indicator; however dedicated pumps must be removed from the existing wells to collect this reading. 8. Missouri State well databases, EDR database reports, and OU-1/OU-2 historical reports are available to identify potential wells in the area. 9. Missouri State well databases, EDR database reports, and OU-1/OU-2 historical reports are available to identify potential drinking water wells in the area. It is not confirmed whether water connection information will be provided by the local water providers.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1-7. The target data population is the existing wells (86 wells) proposed to be included in the OU-3 well network. 8-9. The target data population is the existing groundwater wells within a 2-mile radius of the site, including active or inactive domestic, drinking water, irrigation, livestock, industrial water supply, injection wells, monitoring wells, and extraction wells.	1-7. The spatial boundary for the on-site and off-site OU-3 well network is shown on Figure 3-16 as the study area. The vertical boundary of the well network is the base of the Keokuk Formation. The temporal boundary is based on the date the well was installed. However, limited data is available prior to 1979 based on the oldest available on-site groundwater data. 8-9. The spatial boundary for the off-site well search is a 2-mile radius around the facility, which includes the properties west of the site up to the Missouri River and the developed properties north of the site. The temporal boundary for the off-site well search will be limited to the date the MDNR well records began. Online well records are available for wells drilled after 1987; offline records are available for older wells from MDNR.	1. Potential obstacles with reviewing historical documentation for well construction information includes incomplete or missing well construction forms, inaccurate historical documents, or wells where field modifications were made after the well construction diagrams were prepared. 2. Potential obstacles for utilizing historical documentation to obtain well location data could include different survey datum from current standards. 3. Potential obstacles for analyzing the suitability of existing data include having to migrate old data into a modern database format, incomplete data reports, or missing laboratory quality assurance/quality control documentation. 4-5. Potential obstacles for the well survey and well inventory could include lack of access to the well location due to landfill activities. 6. Potential obstacles for the well plugging/abandonment could include atypical well construction or repairs requiring a driller to complete. 7. Potential obstacles for the collection of turbidity readings includes insufficient water in the well or damage to the well or pump. The presence of a dedicated pump may create an obstacle for collection of total depth readings. Total depth readings could skew turbidity readings if sediment at the base of the well is disturbed. 8. Potential obstacles for the well search include inaccurate or incomplete state well database or environmental database report. 9. Potential obstacles for the location of drinking water wells is lack of landowner information.	1-9. The scale for decisions about existing and new wells will be made on a per well basis. 4. The scale for the well survey will be 0.1 ft (lateral) and 0.01 ft (vertical). 7. The turbidity measurement scale will be to the 0.1 NTU. The total depth readings will be to the nearest 0.01 ft.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
Population Parameters	**Action Level and Decision Rule**
1. The study will estimate the number and depth of wells necessary for the RI activities. 2. The study will ensure only data meeting QAPP standards is used in the database. 3. The study will create a uniform database of survey data. 4. The study will identify wells needing repair. 5. The study will identify wells needing plugged/abandoned. 6. The study will identify wells needing redevelopment. 7. The study will identify off-site wells which may be impacted from the site, and identify wells that may be useful for data collection for the refinement of the site conceptual model, groundwater model and risk assessment. 8. The study will also identify potential receptors for the drinking water pathway (if complete).	1. Wells that are damaged, compromised, or not adequately constructed will be evaluated to determine if they can be repaired or need to be replaced. In some instances, a well could be useable for water levels but not sampling depending on the well defect. 2. If the well spacing (lateral) or vertical distribution is insufficient for the purposes of delineation of groundwater impacts, preparation of a groundwater model, or a risk assessment, additional wells will be installed as part of the OU-3 RI. 3. If historical data are not of sufficient quality to use as part of a groundwater model or risk assessment or site characterization, the data will be evaluated to determine if it requires qualification or rejection. 4. If necessary, corrections will be made to the historical water level records to account for differences in datum. If the new survey data indicates that vertical subsidence has potentially occurred, the historical data will be corrected as noted in the Work Plan. 5. If existing wells need repaired to meet Missouri Well Code and provide representative data, the well repairs will be conducted prior to sampling as part of the OU-3 RI activities. 6. If existing wells need plugged/abandoned due to irreparable damage, the well plugging/abandonment will be conducted as part of the OU-3 RI activities. 7. If turbidity readings exceed 5 NTU or more than 10% of the well screen is occluded with sediment, wells will be redeveloped prior to sampling as part of the OU-3 RI activities. 8-9. Wells located within a 2-mile radius from the site will be evaluated for the potential risks due to groundwater impacts, and will be evaluated to determine if data from the well may be helpful for the groundwater model or risk assessment. If human health or ecological risks exist related to the use of well water impacted from the West Lake Landfill site, corrective measures will be evaluated on a case by case basis.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. - For estimation problems, specify acceptable limits on estimation uncertainty.**
Performance or Acceptance Criteria	
1-9. A decision error could occur if wells are identified as suitable for sampling but have issues which prevent sampling or bias the data. The spatial distribution of the well network could be deemed adequate but additional wells may be necessary for the risk assessment, groundwater model, or to completely characterize groundwater conditions. 1-3, 5, 6, 8, 9. The completeness objective for the well inventory is 95%. 4. The acceptable limits of uncertainty for the well survey will be 0.1 ft (lateral) and 0.1 ft (vertical). 7. The acceptable limits of uncertainty for turbidity will be 0.1 NTU. The acceptable level of uncertainty with total depth measurements will be 0.1 ft.	

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6.** **- Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use.** **- Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1. Complete an inventory of 86 existing monitoring wells as noted in Table 5-3 of the OU-3 RI/FS Work Plan. Document the well integrity on the Well Inspection Form (Appendix A of FSP) and in the USEPA-accessible database. 2. Collect two years of quarterly groundwater monitoring data at 150 wells (86 existing wells and 64 new wells) to evaluate groundwater flow direction and water quality near-site and off-site. Based on the results of the first two quarters of groundwater data, determine if additional wells are necessary to complete lateral and vertical delineation, support the groundwater flow model, and the risk assessment. 3. Review historical data set relative to QAPP requirements if data were not previously validated and apply data qualifiers if necessary. Update the USEPA-accessible database with the historical data. 4. Complete a well survey and prepare a table with well northing, easting, and vertical top of casing and ground surface elevation measurements. Update the USEPA-accessible database. Compare new elevations with previous elevations and identify potential areas of subsidence or other inconsistencies. Determine if historical water level readings need correction or omission from further use. 5. Complete repairs on wells as necessary. Document repairs in the field log book and database. 6. Evaluate timing for wells requiring plugging/abandonment based on OU-1 and OU-2 field activities, risks associated with the well, and overall schedule. 7. Redevelop wells with elevated turbidity (5 NTU) or occluded screens (>10% of the well screen) prior to sampling. Document redevelopment on the field form (Appendix L of FSP), log book, and in the USEPA-accessible database. 8. Submit request for state well database records and environmental database records. Compile findings and identify potential receptors. Also identify wells which may provide helpful data for the risk assessment and groundwater model. Evaluate approaching private well owners as necessary for well access. 9. Determine if drinking water well testing or water replacement is warranted based on off-site groundwater well data, flow direction, drinking water well depth, and well use. 1-9. The above procedures and results will be compiled in a Well Inventory Summary Report.	1. Inactive/unknown wells are accessible for well survey/inventory. 2. Access will be granted for proposed off-site wells by landowners. 3. Historical data has sufficient QC information from which to validate the data. 4. Wells are accessible for surveying. Historic water level data datum is known. 5. Wells can be accessed for repairs. 6. Wells can be accessed for plugging/abandonment activities. Timing of well plugging/abandonment can be evaluated on a case-by-case basis to avoid interfering with other work tasks in OU-1, OU-2, and OU-3. 7. Wells can be redeveloped successfully to reach 5 NTU during sampling and if 5 NTU cannot be achieved, the well will be redeveloped by removing 10 well casing volumes prior to sampling. 8-9. Well records include desired data regarding location, well construction, ownership, etc.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem** **- Identify leader and members of the planning team.** **- Develop a conceptual model of the environmental hazard to be investigated.** **- Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	2. Aquifer Properties - Recharge and discharge rates and hydraulic conductivities have been measured at some locations but site-wide evaluation is proposed as a component of fate and transport evaluation.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s). - Consider alternative outcomes or actions that can occur upon answering the question(s). - For decision problems, develop decision statement(s), organize multiple decisions. - For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1. What is the aquifer recharge rate for each water-bearing zone within the study area? 2. What is the aquifer discharge rate for each water-bearing zone within the study area? 3. What is the hydraulic conductivity for each water-bearing zone within the study area? 4. What are the other important aquifer properties (saturated thickness, transmissivity, specific yield, storage coefficients, porosity) for each water-bearing zone within the study area? 5. Are significant fractures or cavities present in bedrock which may affect groundwater transport? 6. What is the off-site geology within the alluvium and bedrock?	1-6. Previous reports might have correct or incorrect geological and hydrogeological information and conclusions. 1. The recharge rate may be low, medium, or high. 2. The discharge rate may be low, medium, or high. 3. The hydraulic conductivities for off-site locations and untested on-site locations is either similar or substantially different from previously estimated values. 4. The other aquifer properties of each water-bearing zone are similar or different from previously estimated values, or the other aquifer properties may not have been previously estimated. 5 The uppermost portion of the Salem Formation may contain no fractures, no significant fractures, or significant fractures. Cavities may be present in the bedrock or not, and may or may not be of significance to the CSM. 6. The off-site geology may vary from the documented on-site lithology.	1. Precipitation data for the area is needed. 2. Water levels are needed to calculate groundwater gradients. Vertical and horizontal groundwater gradients at co-located wells are needed. Continuous water level data is needed in select locations based on proximity to surface water and spatial distribution. 3. Packer tests and slug tests are needed to measure hydraulic conductivity. 4. Groundwater velocity, transmissivity, and other properties will be estimated from water levels, estimated groundwater gradients, and aquifer thicknesses. Grain size analysis is needed to estimate porosity. 5. Analysis of bedrock fractures and cavities is needed. 6. Detailed lithology for off-site locations is needed. 1-6. A groundwater model is needed to consolidate the aquifer property information for the purposes of evaluating groundwater fate and transport.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates. - Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process. - Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1. Precipitation reports published by NOAA from the area will be a source of recharge data. 2. Historical surface water elevations in nearby surface water bodies will be a source of recharge data. New surface water elevation data will be collected as part of the OU-3 RI activities from staff gauges. 3. Historical reports will be used as a source of water levels, and hydraulic conductivity values. New hydraulic conductivity data will be collected through packer tests and slug testing within the study area as part of the OU-3 RI activities. 4. Historical reports will be used as a source for aquifer properties. New data will be collected on aquifer properties within the study area as part of the OU-3 RI activities. 5. Visual inspection of bedrock cores, images of borehole walls, and borehole diameter measurements will be sources of data on fractures and cavities. 6. Visual inspection of soil and bedrock cores, resistivity, formation conductivity, bulk density, grain size analysis, and Atterberg Limits will be sources of geologic characterization data.	1-6. Data will be compared with the historical record to identify and qualify potential outlier readings.	1. Precipitation data from Lambert Airport is available, which is near the site. 2. Missouri River surface water elevations are available, including USGS St. Charles Missouri River Gauge (0693596). The 9 proposed staff gauges in the OU-3 RI Work Plan are located on private property; access may not be available pending access agreement negotiations. 3. Packer testing and slug testing methodology for measuring the proposed hydraulic conductivity is available. 4. Aquifer property analytical methods are available. 5. Bedrock core logging methods are available. Methods for acoustic televiewer downhole imaging of boreholes are available. Methods for using borehole caliper probes are available. 6. Soil logging methods are available. Geotechnical parameter methods are available for grain size analysis, Atterberg Limits, and density. Downhole tooling methods are available for geologic interpretation, including resistivity, formation conductivity, and gamma-gamma density. 1-6. Groundwater models are available (MODFLOW or finite element models) to evaluate aquifer properties and fate and transport questions.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1,2. For precipitation and surface water data, the target population is data from existing rain and staff gauges, and the proposed staff gauges. 3-6. The target population also includes existing well locations with documented aquifer property information or which can be tested for aquifer properties, as well as the proposed well locations (64 wells).	1. The temporal boundary for the precipitation data is 1938 based on the available data from Lambert Field. The spatial boundary for precipitation data will be the model boundary. 2. Missouri River data is available back to 1929, but this data is not anticipated to provide necessary information. The spatial boundary for the surface water elevation data is the model boundary. 3. The temporal boundary for the packer testing and slug testing is unlimited. The spatial boundary for the packer testing and slug testing is the model boundary. 4. The temporal boundary for the evaluation of aquifer properties is unlimited. The spatial boundary for the aquifer property analysis is the model boundary.	1. The collection of historical precipitation data and surface water data could be constrained by lack of availability or gaps in the historical record. 2. There is no potential obstacle with downloading historic surface water data beyond lack of availability or gaps in the historical record. Potential obstacles for the collection of new surface water data includes lack of access to private property to install the proposed surface water staff gauges. 3. Potential obstacles to the proposed packer testing and slug testing of existing and proposed monitoring wells include the potential lack of access to private property for installation of the proposed wells and landfill operations. 4. Potential obstacles to the proposed calculation of aquifer properties using water levels and slug testing data from existing and proposed monitoring wells include the potential lack of access to private property for installation of the proposed wells and landfill operations.	1. Precipitation data scale is 0.01 inches. 2. Surface water elevation scale is 0.01 -inch. 3. Depth to water readings during slug testing from transducer scale is 0.01 ft. The hydraulic conductivity scale will be three significant digits in ft/day. 4. The scale for the groundwater velocity is 0.01 ft/day. The scale for transmissivity is 0.1 gallons per day per ft. The scale for aquifer thickness is 0.1 ft.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
Population Parameters	**Action Level and Decision Rule**
1. The study will compile precipitation data. 2. The study will compile surface water elevation data. 3. The study will compile water level readings and flow readings from the packer test. 4. The study will compile aquifer properties using water levels and aquifer thicknesses to calculate aquifer properties. The study will compile slug testing data to estimate hydraulic conductivities within each water-bearing zone.	1-4. The data will be added to the USEPA-accessible database. These data will be used to refine the CSM, construct a groundwater model, and prepare summary figures. New slug testing data, water level data and aquifer thicknesses will be evaluated to identify outliers and qualified if necessary. Then these data will be used to calculate aquifer properties.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.** **- For estimation problems, specify acceptable limits on estimation uncertainty.**
<u>Performance or Acceptance Criteria</u>	

1-4. A decision error could occur if the data collected do not contain representative data or decisions are made based on an inadequate sample set. Measurement errors can occur with the data recording equipment and field implementation and could also lead to decision error. The test results will also be compared to data obtained from the previous site investigations for consistency.
The completeness objective for precipitation data, and new water level, surface water readings, and aquifer thickness measurements is 95%.
1. The uncertainty with the precipitation data is ±0.1% (Geonore T-200B Rain Gauge).
2. The uncertainty with surface water readings is ±0.05% (In Situ Troll 700H).
3. The uncertainty with water level transducer is ±0.05% (Solinst Levellogger) and ±0.01 ft for water level meter (Solinst). Results from two rising head slug tests will be analyzed; the geometric mean of the two hydraulic conductivity measurements will be used. The uncertainty with the packer test flow readings is ±1 gallon per minute.
4. The uncertainty with aquifer thickness measurements is ±0.01 ft.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6. - Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use. - Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1. Download hourly precipitation data from NOAA Lambert Field rain gauge in inches back to 1938. Update site database with measurements. Evaluate data for outliers that may need qualified. 2. Install staff gauges in 9 surface water locations. Install pressure transducers (In Situ Level Troll 700H or similar) in each staff gauge to monitor surface water elevation. Deploy barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar). Program pressure transducers to collect water level data every hour. Download surface water elevation data monthly. Collect manual surface water elevation readings monthly for correlation purposes. Correct surface water elevation readings for barometric pressure. Evaluate variability in surface water elevations on a daily, weekly, monthly, seasonal, and yearly basis. Compare groundwater elevations to surface water elevations and determine if groundwater discharges to surface water. 3. After proposed monitoring wells are installed: - Deploy pressure transducers (In Situ Level Troll or similar) in 20 existing wells and 50 proposed wells to monitor water level elevations. Deploy barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar). Program pressure transducers to collect water level data every hour. Download water well elevation data monthly. Collect manual water level elevation readings monthly for correlation purposes. Correct water level elevation readings for barometric pressure. Evaluate variability in water level elevations on a daily, weekly, monthly, seasonal, and yearly basis. Compare groundwater elevations to surface water elevations and determine if groundwater discharges to surface water. - Complete slug testing of all new wells (64 new wells) and untested existing wells within the proposed well network. Two rising head tests will be performed. Analyze slug data using Aqtesolv to estimate hydraulic conductivity. - Complete packer testing in all new wells and untested existing wells within the proposed well network. Determine the hydraulic conductivity of each water-bearing zone. 4. Utilize water level elevations, hydraulic conductivity readings, and aquifer thickness measurements to calculate groundwater gradients, groundwater velocity, transmissivity. Utilize grain size analysis data to estimate porosity.	1. Precipitation data continues to be collected from Lambert Field. 2. Access is granted for staff gauge installation and data downloading. 3. Access is granted for off-site well installation on private property. 4. Access is granted for off-site well slug testing. Existing well casing is not crooked or angled such that a solid slug can be deployed for slug testing or a pump can be deployed for sampling. Note, pumps and solid slugs will not be introduced to drinking water wells.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	3. Regional and Localized Hydraulic Gradients - Horizontal and vertical hydraulic gradients within alluvial and bedrock aquifers will be more fully evaluated to understand how various temporal and spatial stresses on the system may affect groundwater flow directions.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s).** **- Consider alternative outcomes or actions that can occur upon answering the question(s).** **- For decision problems, develop decision statement(s), organize multiple decisions.** **- For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1. What is the horizontal hydraulic gradient within alluvial and bedrock aquifers? 2. What is the vertical hydraulic gradient between alluvial and bedrock aquifers? 3. How do the gradients change over time (seasonally)? 4. How do the gradients vary across the study area and model boundary? 5. What groundwater withdrawals are present which may influence groundwater gradients and flow direction?	1. The additional investigation may confirm the prior findings that the horizontal groundwater gradients historically have been relatively low onsite and regionally. 2. Downward vertical gradients have been observed on-site in the bedrock wells, but regional vertical gradients are documented to be upwards within bedrock aquifers. 3. Changes in recharge and infiltration may occur due to surface water levels. 4. Horizontal gradients may vary vertically and in part based on distance to the Missouri River and surface water elevations. Horizontal gradients may also have temporal variability due to these and other factors. 5. Localized groundwater depressions and mounding has been observed which likely affects gradients. Leachate withdrawal from the extraction system and increased pressures from the SSR may influence these water levels and gradients.	1. Water level data is needed from on-site and off-site wells screened within and between the alluvial aquifer and upper and lower intervals of the bedrock aquifer system (Mississippian age). 2. Co-located wells are needed on-site and off-site to verify vertical gradients between water-bearing zones. 3. Precipitation data is needed from the study area to evaluate recharge. 4. Seasonal water level data is needed to evaluate temporal variability. 5. An inventory of potential extraction locations and rates is needed.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates.** **- Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process.** **- Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1. Historical reports will be used as a resource for surface water and groundwater elevation data. 2. New transducer readings will be used as a resource for surface water and groundwater elevation data. 3. Precipitation records from the area (including Lambert Field) will be a resource. 4. Well inventory records will be used as a resource for identifying third-party groundwater extraction or injection wells (irrigation, pumping, injection).	1-5. Data will be compared with the historical record to identify and qualify potential outlier readings.	1. Historic surface water elevation data is available for the USGS St. Charles Missouri River Gauge (0693596). A total of eight of the nine proposed staff gauges in the OU-3 RI/FS Work Plan will be located on private property. If surface water elevation data has been collected at other off-site surface water bodies such as the Earth City flood control structures; this information will need to be requested from the property owners. 2. Transducers, deployment procedures, data analysis procedures, barometric pressure correction procedures, and operation/maintenance procedures are readily available for surface water and groundwater well transducer deployment. 3. Precipitation data from Lambert Airport is available, which is less than 2 miles from the site. 4. Well records are available from the MDNR and third-party environmental database companies such as EDR.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
<u>Target Population</u>	**<u>Temporal and Spatial Boundaries</u>**	**<u>Potential Practical Constraints on Data Collection</u>**	**<u>Appropriate Scale for Decision-Making</u>**
1. The target population for the historical surface water and groundwater elevation data includes data from within the model domain. 2. The target population for transducer deployment includes near-site surface water bodies and select monitoring wells near pumping wells within the model domain. 3. The target population for the precipitation records includes the Lambert Field rain gauge records. 4. The target population for the well inventory includes wells within the model boundary, including wells with the potential for pumping rates which could be significant, including irrigation, livestock, industrial water supply, injection wells, monitoring wells, and extraction wells.	1. Missouri River data is available back to 1929, but this amount of data is not anticipated to be needed. 2. The temporal boundary for transducer data is 1979 when water level data is available for the existing on-site wells. The spatial boundary for transducer data will be the model boundary. 3. The temporal boundary for the precipitation data is 1938 based on the available data from Lambert Field. The spatial boundary for precipitation data will be the model boundary. 4. The spatial boundary for the off-site well search is the model boundary, which includes the properties west of the site up to the Missouri River and the developed properties north of the site. The temporal boundary for the off-site well search will be limited to the date the MDNR well records began. Online well records are available for wells drilled after 1987; offline records are available for older wells from MDNR.	1. Potential obstacles for the collection of new surface water data includes lack of access to private property to install the proposed surface water staff gauges. The collection of historical surface water data could be constrained by lack of availability or gaps in the historical record. 2. Potential obstacles to the collection of water level data from transducers include the potential lack of access to private property for installation of the proposed wells and landfill or other site operations. 3. The collection of historical precipitation data could be constrained by lack of availability or gaps in the historical record. 4. Potential obstacles for the well search include inaccurate or incomplete state well database or environmental database report, and lack of access to private property (if necessary) to verify well information.	1. Surface water elevation scale is 0.01-inch. 2. Depth to water readings from transducer scale is 0.01 ft. 3. Precipitation data scale is 0.01 inches. 4. The scale for the well search will be limited by the available information and may be at a different scale than the water level, well depth, and other pertinent well details which may be useful for the site decision-making.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
<u>Population Parameters</u>	**<u>Action Level and Decision Rule</u>**
1. The study will compile surface water data (historic and new). 2. The study will compile water level elevation data (historic and new). 3. The study will compile precipitation data (historic and new). 4. The study will compile water well information, including location, water levels, well depth, well use, pumping rates, and other well construction information.	1. Surface water elevation data will be evaluated for suitability in inclusion in the groundwater model and potentiometric maps. 2. Water level data will be evaluated for suitability in inclusion in the groundwater model and potentiometric maps. 3. Precipitation data will be evaluated for suitability for inclusion in the groundwater model. 4. Water well information for off-site wells will be evaluated to determine if the well is located down-gradient from the site; if the well may be potentially impacted (now or in the future) from the site; if water level information from the well may be helpful for the purposes of the CSM , model, and risk assessment; and if collection of water quality information from the well is warranted. Factors that will be used to make this decision include if the well is located in an area without groundwater information (horizontally or vertically), if the well is located hydraulically downgradient from the site, if the well is screened within a zone that may be impacted or could become impacted over time, current and future use of the property, current and future use of the well, and availability of lithologic logging information for the well.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.** **- For estimation problems, specify acceptable limits on estimation uncertainty.**
<u>Performance or Acceptance Criteria</u>	
1-4. A decision error could occur if the data collected do not contain representative data or decisions are made based on an inadequate sample set. Measurement errors can occur with the data recording equipment and field implementation and could also lead to decision error. The test results will also be compared to data obtained from the previous site investigations for consistency. The completeness objective for the new surface water readings, new water level readings, and new precipitation data is 95%. 1. The uncertainty with surface water readings is ±0.05% (In Situ Troll 700H). 2. The uncertainty with water level transducer is ±0.05% (Solinst Levellogger or similar) and ±0.01 ft for water level meter (Solinst or similar). 3. The uncertainty with the precipitation data is ±0.1% (Geonore T-200B Rain Gauge or similar). 4. The uncertainty with off-site water well data is unknown at this time pending identification of the wells and availability of information from the private well owner regarding measurement uncertainty.	

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6.** **- Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use.** **- Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1. Nine staff gauges will be installed surface water locations. Each staff gauge will be equipped with pressure transducers (In Situ Level Troll 700H vented or similar) to monitor surface water elevation. Barometric pressure loggers (if probes are not vented) such as In Situ BaroTroll (or similar) will be deployed for atmospheric pressure corrections. The pressure transducers will be programmed to collect water level data every hour. Each month, surface water elevation data will be downloaded in conjunction with collection of manual surface water elevation readings. Surface water elevation readings will be corrected for barometric pressure. Using the data collected in this task, horizontal groundwater gradients both locally and regionally will be calculated to determine if groundwater and surface water are connected hydraulically. The transducers will be maintained on a regular basis, as discussed in the FSP. 2. After proposed monitoring wells are installed, pressure transducers (In Situ Level Troll or similar) will be deployed in a subset of existing wells and all proposed wells to monitor water level elevations. Barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar) will also be deployed. The pressure transducers will be programmed to collect water level data every hour. On a monthly basis, accumulated water well elevation data will be downloaded from the transducers. Concurrent manual water level elevation readings will be collected monthly for correlation purposes. Water level elevation readings will also be corrected for barometric pressure. Local and regional horizontal hydraulic gradients will be calculated using available water level data from three nearby wells to form a three-point problem. Similarly, local and regional vertical hydraulic gradients will be calculated using available water data to determine upward, downward or variable flow direction. 3. Hourly precipitation data will be downloaded from NOAA Lambert Field rain gauge in inches back to 1938. Evaluate precipitation data and surface cover to determine potential impact on groundwater gradients. 4. Using water well records obtained in Study #1, information on off-site wells will be input into the site database and evaluated for relative importance to the CSM, model and risk assessment based on the decision rules.	1. Access is granted for staff gauge installation and data downloading. 2. Access is granted for off-site well installation on private property. 3. Precipitation data continues to be collected from Lambert Field. 4. Well records include desired data regarding location, well construction, ownership, etc.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem** **- Identify leader and members of the planning team.** **- Develop a conceptual model of the environmental hazard to be investigated.** **- Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	4. Background Groundwater Conditions - Background groundwater conditions near the site in the alluvial and bedrock aquifers have not been established and should be established due to the presence of elevated concentrations of naturally-occurring radionuclides and other COPCs in groundwater. The USGS did not determine background Radium-226 and Radium-228 concentrations in groundwater due to a limited dataset, which included 17 alluvial samples from 14 alluvial wells and 11 bedrock samples from 6 bedrock wells. This is identified as an important data gap for the risk assessment and remedy decision-making (USGS 2015). Background radionuclide concentrations and ratios are an important component of evaluating the extent of potential impacts related to the site and identifying the source of radionuclides present in groundwater at the site. Nearby off-site sources may be contributing to groundwater quality within the study area, including leaking underground storage tank sites and the Champ Landfill.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
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Step 2 - Identify the Goal of the Study		**- Identify principal study question(s).** **- Consider alternative outcomes or actions that can occur upon answering the question(s).** **- For decision problems, develop decision statement(s), organize multiple decisions.** **- For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements /** **What Needs Estimated and Key Assumptions**
1. What is the level of radionuclide activity in groundwater near the site and off-site? How does these levels vary under different geochemical conditions and within different soil and bedrock matrices? 2. What is the background level of radionuclide activity in groundwater off-site? 3. What is the ratio of Ra228/Ra226 in groundwater at the site compared to ratios in background areas? 4. What is the ratio of Ra228/Ra226 in groundwater in off-site wells? Can these data be used to distinguish whether off-site radium is coming from the Radioactively Impacted Materials (RIM) onsite, is coming from background sources of radium or both? 5. Is groundwater within the study area potentially impacted by off-site sources of non-radionuclide constituents, such as naturally occurring metals from the aquifer matrix, fuels from leaking underground storage sites, chlorinated solvents from commercial properties, or leachate indicator parameters from Champ Landfill?	1. Radionuclides may be present in groundwater near and/or off-site or may not be present above background levels. Background concentrations of radionuclides in groundwater may be at, above, or below off-site, downgradient activity levels. Radionuclide activity levels in soil and bedrock may indicate the potential for migration to groundwater. 2. Radium ratios in groundwater on-site may be unique or similar to background radium ratios. 3. Radium ratios in groundwater may indicate that radionuclide activity levels off-site are similar to on-site ratios, which may be potentially indicative of contributions from RIM. 4. Alternatively, radium ratios may be similar to background radionuclide ratios groundwater in the area. 5. Alternatively, the off-site radium ratios may not be conclusive, which may indicate a mixture of both site-related and background radium sources. 6. Alternate sources of non-radionuclide constituents such as benzene in off-site groundwater impacts may not be detected within the study area. If alternate sources are detected, the constituents may be present at either low-level or high-level concentrations.	1. Groundwater activity levels of radionuclides near and off-site are needed, including total and dissolved concentrations. 2. Background groundwater activity levels of radionuclides are needed. 3. Radium isotope ratios in soil and groundwater are need for on-site area. 4. Radium isotope ratios are needed in soil and groundwater for off-site downgradient and background locations. 5. Potential off-site sources (landfills, spills, cleanup sites, Leaking Underground Storage Tanks (LUST) sites, Resource Conservation and Recovery Act (RCRA) generators, etc.) need to be identified (if present) within the study area. COPCs may include metals, fuels, chlorinated solvents, as well as landfill leachate indicator parameters such as chloride, chemical oxygen demand, and other constituents. Groundwater quality data, location, and cleanup history associated with a potential source is needed, if available.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 3 - Identify Information Inputs		- Identify types and sources of information needed to resolve decisions or produce estimates. - Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process. - Select appropriate sampling and analysis methods for generating the information.
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1. Groundwater data from on-site, near-site, and background wells can be a source of data for radioisotopes activity levels, including wells within the proposed OU-3 well network. Off-site third-party wells can also be a source of groundwater data (as necessary and if available). 2. Groundwater in background areas can be analyzed for radioisotopes. 3-4. Alluvial aquifer material and bedrock aquifer matrix samples can be analyzed for radioisotopes in the laboratory. Radium isotope ratios can then be calculated. 5. Local, state, and federal databases may provide sources of information on potential sources within the study area. Groundwater quality data may also be useful for identifying constituents unrelated to the site.	1. Groundwater radioisotope concentrations will be compared to historical reports to identify potential outliers. Results will also be compared to MCLs if available. 2. Background radioisotope concentrations will be compared to historical reports to identify potential outliers. Results will be compared to MCLs if available, and on-site and off-site groundwater concentrations. Data will be analyzed and validated as specified in the QAPP and in accordance with MARLAP and ANSI 41-5 guidance. In addition SOPs and certification requirements will be met by the laboratories. 3-4. Alluvial aquifer material and bedrock aquifer matrix radium concentrations will be converted to radium ratios and evaluated similar to Vinson et al. 2012. 5. Groundwater results which may be associated with off-site sources will be compared to on-site concentrations and MCLs and RSLs.	1-2. Groundwater radionuclide laboratory methods are available. Laboratory analytical methodology are specified in QAPP Table 2-3. 3-4. Alluvial aquifer material and bedrock aquifer matrix radionuclide laboratory methods are available. 5. Records for registered cleanup sites are available through public and private databases.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1-2,4. The target population for groundwater analysis includes data from the existing and proposed wells in the OU-3 well network (150 wells) within the study area, but may be supplemented by well data from within the modeling domain where available. 3. The target population for aquifer matrix samples includes data from the proposed well sites (19 total), but may be supplemented by well data from within the modeling domain which may have historical water quality data or which could be sampled to provide necessary information for the risk assessment or groundwater model.	1-2. The temporal boundary for near-site and off-site groundwater radionuclide data is based on the available of on-site and off-site third-party data. On-site radionuclide groundwater data for the existing wells are available back to the date of installation of each well; the oldest data are from 1979. The spatial boundary for groundwater radionuclide data is the study boundary. 3-4. The temporal boundary for the near-site and off-site alluvial aquifer material and bedrock aquifer matrix data is unlimited. The spatial boundary for solids radionuclide data is the study boundary. 5. The temporal boundary for the compilation of data from potential off-site source sites is unlimited. The spatial boundary for the compilation of off-site source data is the study area.	1-4. Potential obstacles to the collection of groundwater and solids radionuclide data include the potential lack of access to private property for installation of the proposed wells, obtaining applicable well drilling permits/authorization, and overhead/subsurface utility clearance. The cost of installing large number of deep wells through bedrock is another potential obstacle. 5. Potential obstacles regarding evaluation of off-site sources include incomplete database records, unreported spills, and co-mingled plumes with similar contaminants.	1-4. The scale for this study is the individual well being monitored. Background well locations were identified up-gradient and over 3,000 feet from the site. The scale for deciding the adequacy of the number of background wells is based on the number of wells within each water-bearing zone within the study area. At least three wells within each water-bearing zone are proposed. 5. The scale for deciding whether potential off-site sources are present is based on the size of the various parcels within the study area. The smallest size parcel in the vicinity of the site appears to be approximately 300 ft wide.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
<u>Population Parameters</u>	**<u>Action Level and Decision Rule</u>**
1. The study will compile groundwater radionuclide data from near-site and off-site wells. 2. The study will compile groundwater radionuclide data from background wells. 3. The study will compile calculated radium isotope ratios for aquifer matrix materials from on-site wells. 4. The study will compile calculated radium isotope ratios for aquifer matrix materials from off-site downgradient and background wells. 5. The study will compile available information on potential off-site sources, including water quality, water level data, cleanup history, and other pertinent information.	1-2. Radionuclide concentrations in near-site and down-gradient off-site groundwater wells will be compared to MCLs and background radionuclide concentrations. A background radionuclide concentration will be established as an alternate concentration limit. If down-gradient off-site radionuclide concentrations are lower than background radionuclide concentrations, no additional wells are necessary for delineation purposes. If down-gradient off-site radionuclide concentrations are higher than background radionuclide concentrations, additional wells may be necessary for delineation purposes. 3-4. Radium isotope ratios for alluvial aquifer and bedrock aquifer materials will be compared to determine if off-site radium may be emanating from the on-site RIM (lower Ra228/Ra226 ratio), from background (higher Ra228/Ra226 ratio), or from both. If the radium in off-site wells appears to be migrating from the on-site RIM, then the feasibility study will include how to address the potential for off-site radium migration. If the radium in off-site wells appears to be from background sources, an evaluation will be done regarding whether the WLL OU-3 site may be increasing the background radium concentrations through changing the redox environment (see Study# 6). 5. If potential sources of groundwater impacts are identified within the study area near proposed well locations, available data for the area will be compiled to determine if the nature of the off-site source is similar to the WLL OU-3 groundwater constituents. If the constituents are similar, an alternate concentration limit may need to be established. If off-site third-party wells are present within the modeling domain which may provide useful information on water quality related to radionuclides or off-site sources of groundwater impacts, an evaluation will be completed to determine if data from the well could be important to the groundwater model or risk assessment. If the data from the off-site third-party well are critical, efforts will be undertaken to obtain access to the third-party well(s) for gauging and sampling as part of additional OU-3 RI activities.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. - For estimation problems, specify acceptable limits on estimation uncertainty.**
<u>Performance or Acceptance Criteria</u>	

1-4. A decision error could occur if the data collected on the aquifer properties of the water-bearing zones do not contain representative data or decisions are made based on an inadequate sample set. Historical background data meeting Section 7.0 data quality requirements and new background data will be used to calculate a 95% Upper Prediction Limit and identify a background concentrations of COPCs. Additional data will be collected as necessary to provide an adequate data set for the statistical evaluation.

The completeness objective for groundwater and aquifer solids data collection and laboratory analysis is 95%. The lowest achievable detection limits will be used for as a performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.
1-2. The groundwater radionuclide method detection limit is 1 pCi/L.
3-4. The soil radionuclide detection limit is 0.001 pCi/g.
5. The uncertainty associated with the potential offsite source data is unknown, and will depend on the available information.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6. - Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use. - Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1-2. Collect groundwater samples from 15 new off-site background wells for total and dissolved radiological isotopes in groundwater (same as above) including lab analysis. Collect groundwater samples quarterly for two years. Calculate the background Ra226 and Ra228 background concentrations using a 95% Upper Prediction Limit after each quarterly event. Once sufficient data is available, the resulting background value will be calculated, but may be revised until the new wells have been sampled for two years. 3-4. Collect aquifer matrix material samples for total radiological isotopes, including Ra226, Ra228, Uranium 234, Uranium 235, Uranium 238, Thorium 228, Thorium 230, and Thorium 232. 5. Collect groundwater samples for non-radionuclide COPCs including the analytical suite identified in Section 3.8.7.1. Data will be collected from the 15 background wells to establish background concentrations. Data will also be collected from the other 21 off-site wells located potentially down-gradient from the site in order to identify potential sources within the down-gradient area. Compile available data on potential off-site sources (landfills, spills, cleanup sites, LUST sites, RCRA generators, etc.) within the study area. If groundwater quality data and water level data are available, the data will be evaluated to determine if it can be added to the site database to assist with development of the CSM, the risk assessment, and the groundwater model.	1-4. Access to off-site properties for well installation. 3. Property owners are willing to provide information if records searches are unsuccessful. 4. Groundwater quality and water level data are available from potential source sites.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	5. Occurrence and Extent of Groundwater Impacts - Off-site downgradient monitoring wells have not yet been installed to evaluate the potential occurrence and extent of groundwater impacts. The USGS identified four potential sources for radium in on-site groundwater but was unable to quantify the relative contribution of each source. The present lack of understanding of the spatial distribution of groundwater impacts limits the ability to evaluate the site for potential receptors (present and future). The potential receptors for groundwater-related exposure to site-related impacted media has not yet been evaluated to determine which pathways may exist and which may be complete.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s). - Consider alternative outcomes or actions that can occur upon answering the question(s). - For decision problems, develop decision statement(s), organize multiple decisions. - For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1. Is off-site groundwater impacted by site-related constituents or could it be in the future? 2. What is the spatial distribution (horizontally and vertically) of the impacts (if present) currently and in the future? 3. What are the potential receptors for groundwater-related exposure to site-related constituents currently and in the future? 4. Which exposure pathways are potentially complete currently and in the future?	1. Groundwater may have detectable site-related constituents near the site and/or offsite due to groundwater migration from onsite. Groundwater concentrations may change over time and could increase due to leaching and migration from the source materials, changes in redox conditions, and/or radium in-growth. Groundwater concentrations may also decrease due to OU-1 remedial actions or natural attenuation processes, or remain similar to current levels. 2. The extent of groundwater impacts may be limited to near-site or extend off-site below adjacent properties. Over time, the spatial distribution may change as groundwater migrates off-site depending on the flow gradients, redox conditions over time, and other influential factors. 3. The surrounding area downgradient from the site is currently commercial/industrial and is located within a flood plain, so future land use is unlikely to change. However, potential residential receptors are included in the Preliminary CSM (Figure 3-1 of the QAPP). 4. Exposure pathways may be complete depending on the extent of the current and future groundwater use or groundwater discharge. Affected media could include groundwater, surface water, sediment, and sediment pore water.	1. Representative groundwater concentrations of COPCs will be needed within each of the five water-bearing zones. Well screens will be placed within the vertical interval with the highest hydraulic conductivity based on field logging and geophysical logging. A sufficient data set is needed to calibrate a groundwater model to evaluate future groundwater concentrations; a minimum of two years of quarterly groundwater monitoring is needed to achieve a statistically viable data set. 2. Off-site groundwater COPC concentration data are needed to define the horizontal and vertical nature and extent of impacts (if present). This includes existing and proposed off-site wells. A groundwater model is needed to estimate the spatial extent of groundwater impacts in the future. 3. Property ownership, zoning, property use, and deed restrictions in the area down-gradient from the site are needed. The current and future extent of groundwater impacts is needed to assess potential receptors. The potential receptors need to be documented in a Baseline Risk Assessment Work Plan. 4. Groundwater and surface water elevations are needed to evaluate the hydraulic communication between media and determine whether exposure pathways are complete. Since there may be temporal variations in groundwater and surface water elevations and flow directions, these factors will need to be evaluated. The complete exposure pathways need to be documented in a Baseline Risk Assessment Work Plan.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates. - Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process. - Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1-2. Current and proposed groundwater wells are a source of data. 3. Property information is available from city and county property records, zoning maps, and state deed restriction databases to evaluate potential receptor information. RAGS guidance is available for evaluating potential receptors. 4. Groundwater and surface water level data are available from current and proposed wells and staff gauges to determine if exposure pathways are complete. RAGS guidance is available for evaluating exposure pathways.	1-2. Groundwater data will be compared to MCLs (if available) and RSLs (if no MCL exists) for screening purposes. 3. Property ownership information is available from the St. Louis County GIS Viewer. Zoning information is available from the City of Bridgeton Public Works Department for properties within the incorporated city limits and St. Louis County GIS Viewer for properties outside city limits. Deed restriction information is available from the Office of the St. Louis City Recorder of Deeds. 4. Groundwater and surface water levels will be compared historical records and manual measurements to identify potential outliers and qualify data as necessary for the purposes of evaluating exposure pathways.	1-2. Groundwater laboratory methods are available for the analytical suite as shown in Table 2-3 of the QAPP. Low-flow groundwater sampling methods based on USEPA guidance are readily available (EPA/540/S-95/504). 3. Data are available regarding property parcels, zoning, and deed restrictions. RAGS guidance (USEPA 2001) is available for evaluating potential receptors. 4. Field procedures for the collection of groundwater data and fluid level gauging are readily available. RAGS guidance (USEPA 2001) is available for evaluating whether exposure pathways are complete.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1-2. The target population for groundwater analysis includes data from the existing and proposed wells in the OU-3 well network (150 wells) within the study area, but may be supplemented by well data from within the modeling domain where available. 3-4. The target population for identification of potential receptors for complete exposure pathways will be based on the extent of current and potential future groundwater impacts which will be estimated by a groundwater model.	1-2, 4. The temporal boundary for near-site and off-site groundwater radionuclide and water level data is based on the date the wells within the study were installed and first sampled, which dates back to 1979 for the existing on-site/near-site wells. The spatial boundary for groundwater radionuclide and offsite water level data is the study boundary. 3. The temporal boundary for the compilation of property information is the current ownership. The spatial boundary for the compilation of property information is the study area, but will focus on the properties within and within 100 ft of the boundary of groundwater impacts.	1-2,4. Potential obstacles to the collection of groundwater and water level data include the potential lack of access to private property for installation of the proposed wells, obtaining applicable well drilling permits/authorization, and overhead/subsurface utility clearance. The cost of installing large number of deep wells through bedrock is another potential obstacle. 3. Potential obstacles regarding compilation of property information includes incomplete or missing records. 4. Potential obstacles to evaluating exposure pathways includes incomplete data to determine if a pathway is complete.	1-2,4. The scale for deciding the number of groundwater wells determines the proposed well spacing. The well spacing proposed around the perimeter of the site (MW-200/300/400 series) is approximately 500 to 800 ft. The proposed well spacing for the off-site downgradient wells (MW-500 series) is approximately 1,700 to 2,200 ft apart, and 1,300 to 1,800 ft to the north and west from the site. The proposed well spacing is approximately 1/4 of the down-gradient length of the northern and western face of the site and should provide adequate coverage. 3. The scale for the property information will be limited by the available information.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
Population Parameters	**Action Level and Decision Rule**
1-2. The study will compile groundwater quality data from near-site and off-site wells. 3. The study will compile property information, zoning maps, and deed restriction information for evaluating potential receptors. This will be documented in a Baseline Risk Assessment Work Plan. 4. The study will compile groundwater quality, water level data, and surface water levels to determine whether exposure pathways are complete. This will be documented in a Baseline Risk Assessment Work Plan.	1. Groundwater concentrations in near-site and down-gradient off-site groundwater wells will be compared to MCLs (or RSLs if no MCLs are available); and background metal and radionuclide concentrations. The spatial extent of impacts will be plotted for constituents with exceedances. If exceedances are observed in off-site down-gradient wells, the need for additional step-out wells may need to be completed as part of an addendum to the OU-3 RI Work Plan. If concentrations of semi-volatile organic compounds (SVOCs), polychlorinated biphenyl (PCBs), fuels, and pesticides are non-detect in on-site wells during the first monitoring event, a proposal will be made to the USEPA to delete these parameters from future monitoring events. 2. If property records are not available for properties within the spatial footprint of the groundwater impacts, door-to-door visits or mailings will be used to request the necessary information on potential receptors. 3. If groundwater and surface water elevations indicate a hydraulic connection with a surface water body including the Missouri River, the sediment exposure pathway will be evaluated through collection of sediment and sediment pore water samples. If sediment and sediment pore water quality indicate groundwater-related impacts, the surface water and aquatic life exposure pathway will be evaluated. 4. Once groundwater quality data are available from the first round of sampling, the vapor intrusion pathway will be evaluated. Properties located within 100 ft of groundwater impacts that could result in a potential for vapor intrusion (e.g. VOCs, radon, or methane) will be assessed for the potential for a complete vapor intrusion pathway.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. - For estimation problems, specify acceptable limits on estimation uncertainty.**
<u>Performance or Acceptance Criteria</u>	
1-2,4. A decision error could occur if COPCs are present above background, MCLs, or Applicable or Relevant and Appropriate Requirements (ARARs) downgradient of the WLL OU-3 site in a potential exposure pathway or route, but that location was not sampled or tested. This type of error is not readily quantifiable for evaluation with respect to statistical tolerance limits but will be controlled by careful consideration and placement of the proposed new monitoring wells, implementing the quarterly groundwater monitoring program, and evaluating the rate of groundwater movement through the subsurface. The completeness objective for groundwater data collection and laboratory analysis is 95%. The groundwater method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used for as a performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision-making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary. 3. The completeness objective for obtaining property information on off-site properties will vary based on the limitations of the sources and cooperation of the property owners. 4. The acceptance criteria for the data collection and evaluation of the exposure pathway will be determinations based on statistically valid and representative data.	

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	- Compile all information and outputs generated in Steps 1 through 6. - Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use. - Select and document a design that will yield data that will best achieve your performance or acceptance criteria.
Sampling Design	**Key Assumptions**
1. Install a total of 64 new groundwater wells to delineate off-site groundwater conditions. Well screens will target the vertical intervals with the highest radiation readings based on the handheld field meter and natural gamma survey. The groundwater wells (150) will be sampled for a broad range of analytes for characterization purposes quarterly for two years, including: Potential Constituents of Concern: - Radionuclides: total and dissolved radium, uranium, and thorium - Organic Compounds: VOCs, SVOCs*, PCBs*, fuels*, and pesticides* (*may only be sampled once) - Dissolved and Total Metals (32): arsenic, aluminum, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, silicon, thallium, thorium, tin, titanium, uranium, vanadium, zinc 2. Preparation of summary tables comparing the results of on-site vs offsite and background concentrations. Complete a determination on whether off-site groundwater impacts (if present) are attributable to the site, and to what extent (horizontally and vertical) the impacts extend. Update 3-dimensional visualization model with analytical results and prepare cross-sectional figures of the extent of groundwater impacts (if present). Determine if additional step-out wells are needed to completely delineate site-related groundwater impacts laterally and vertically to provide adequate information for the risk assessment and groundwater model. 3. Compile potential receptors for each complete exposure pathway (item 4 below). For off-site properties, obtain property information for parcels within 100 ft of the spatial extent of groundwater impacts (if present). 4. Evaluate groundwater data collected as part of task 1 above to determine which exposure pathways are potentially complete. If additional data are necessary, prepare an OU-3 Phase II RI Work Plan and collect additional data.	1. Access is granted for off-site well installation and sampling. 4. Access is granted for installation of surface water level staff gauges.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 1 - State the Problem			- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	6. Groundwater Geochemistry - Multiple subsurface conditions typical of a landfill environment can result in alterations of naturally occurring geochemical parameters in surrounding groundwater. Different redox conditions, mineralogy, and organic content can attenuate or mobilize radionuclides via exchange, adsorption, desorption, precipitation, co-precipitation, and dissolution. The redox environment at the site may be reducing in the vicinity of leachate influence, but redox can also be aerobic within river valleys. The presence of available metals for sorption under certain pH levels and redox conditions can result in lower radionuclide concentrations in groundwater. Higher organic carbon content can lead to sorption onto aquifer matrix solids and lower groundwater concentrations, but organic carbon content is unknown. A better understanding of how radionuclide concentrations in groundwater at and near the site may be changing spatially due to these influences is warranted.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s).** **- Consider alternative outcomes or actions that can occur upon answering the question(s).** **- For decision problems, develop decision statement(s), organize multiple decisions.** **- For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1. What is the geochemical environment within the study area? 2. How has the geochemical environment affected radionuclide concentrations in groundwater off-site in terms of transformation, co-precipitation, dissolution, mobilization, and sorption? 3. What is the influence of organic material radionuclide fate and transport?	1. The redox environment may be more oxidative the closer to the Missouri River and more reducing closer to the site and other off-site sources. The pH of the groundwater may be different on-site in comparison to the Missouri River based on typical surface water and groundwater quality differences. 2. Reducing conditions may result from landfill capping, leachate interaction with groundwater, and/or the dissolution of landfill gas into groundwater. Naturally-occurring radionuclides may become more mobile within reducing geochemical environments. Limestone environments may have a lower sorptive capacity, and therefore, higher groundwater concentrations of radionuclides (Szabo et al. 2012). High radium concentrations have been correlated with elevated iron and manganese concentrations (USGS 2015), so the radionuclide concentrations may fluctuate with the composition of the geochemical environment. The geochemical environment may also be different in the alluvial aquifer zones in comparison with the lower bedrock aquifer zones. 3. The presence of organic material may decrease the concentration of radionuclides in groundwater due to sorption. Or there may be insignificant organic material present to affect groundwater quality. The amount of organic material may vary vertically and horizontally, with more organic material likely present in the shallower aquifer materials closer to the Missouri River and other surface water bodies.	1. The ORP and DO concentrations are direct indicators of the redox environment. Redox pair concentration is needed to further support the type of redox environment present. The pH of the groundwater and soil are also important for mineral transformation analysis. Dissolved and total metals concentrations in groundwater are needed to determine the geochemical environment. Information is also needed regarding the aquifer matrix materials, including concentrations of total metals and key cations/anions. Minerology of the aquifer matrix solids is needed. 2. In addition to the items noted above in item 1, the groundwater concentration of radionuclides (dissolved and total) and aquifer solids concentrations of radionuclides are needed. Also needed are dissolved phase concentrations of radionuclides within different geochemical environments which can be mimicked through extraction sequences. 3. Total and dissolved organic carbon content in groundwater, and total organic carbon content within the aquifer matrix materials is needed to evaluate the effect of organic material on radionuclide concentrations.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates.** **- Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process.** **- Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1-3. Groundwater from the proposed well network and aquifer matrix solids sampling from the proposed new wells is a source of information on redox environment. Groundwater and aquifer matrix solids data sources include field parameter readings and laboratory testing. Geochemical modeling is also a source of information regarding the geochemical environment.	1. Geochemical data will be compared to historical reports to compare measurements and identify potential outliers and qualify data if necessary. Data will be analyzed and validated as specified in the QAPP. In addition SOPs and certification requirements will be met by the laboratories. 2. The informational basis for hypothesis that redox may be affecting inorganic constituent concentrations is OSWER Directive 9200.4-17P (USEPA 1999). 3. The importance of the interaction of radionuclides and organic matter is established in available literature (Lin and Hendry 2011).	1-3. Analytical methods are available for the groundwater and aquifer matrix analyses as shown on QAPP Table 2-3. 2. Methods are available for geochemical evaluation and modeling to evaluate aqueous speciation, saturation, kinetics, mass transfer, and reactive transport including PHREEQC. Methods are available for preparation of a water balance for the study area.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1-3. The target population for groundwater and aquifer matrix data includes the existing and proposed wells in the OU-3 well network (150 wells) within the study area, but may be supplemented by well data from within the modeling domain where available.	1-3. The temporal boundary for the groundwater data will be based on the date the water quality information is available, which will vary by well. The existing on-site/near-site well data set includes data back to 1979. The temporal boundary for aquifer matrix solids data is unlimited if obtained from areas that have been undisturbed since the data were collected. The temporary boundary for the groundwater fate and transport model will be 1976 based on available groundwater quality data. The spatial boundary for the geochemical data is the modeling boundary.	1-3. Potential obstacles to the collection of groundwater and aquifer matrix solids samples include the potential lack of access to private property for installation of the proposed wells. Additionally it can be challenging to obtain ORP and DO readings for groundwater that are representative of in situ concentrations due to sampling methodology. It can also be challenging to obtain and preserve groundwater samples that maintain the relative speciation of metal ions. 2. The laboratory method for sequential extraction is available from only a limited number of laboratories; the standard data quality package and electronic data deliverable files may not be available.	1-3. The smallest scale for groundwater quality and aquifer matrix quality decision-making will be the laboratory Method Reporting Limit (MRL) which may be referenced as "Reporting Limit" by some laboratories. If the MRL concentration is above the applicable standard, the Method Detection Limit (MDL) may be used instead of the MRL for that analyte. The smallest scale for decision-making regarding the geochemical would be at an individual well location; however, the geochemical environment will be evaluated within each of the five aquifer zones (vertical variability) and based on spatial relationship to the site (on-site, near-site, upgradient, downgradient). This information will be input into a 3-dimensional visualization tool and interpolated where data are unavailable to assist with decision-making.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates. - For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it. - For estimation problems, specify the estimator and the estimation procedure.**
<u>Population Parameters</u>	**<u>Action Level and Decision Rule</u>**
1. The study will compile groundwater and aquifer matrix data, which will be used to assess the geochemical environment. Information about the redox environment will be collected. 2. The study will compile data on the minerology, radionuclide concentrations relative to geochemical environment, and major ion chemistry. 3. The study will compile data on the total and dissolved organic carbon content in groundwater and total organic carbon content in soil.	1. Negative ORP and low DO concentrations will indicate reducing environments. Redox pairs will be evaluated to determine if the more reducing of the ion pairs is present, which will be used as a line of evidence that reducing conditions exist. Low pH environments (<pH 6) will indicate a higher potential for mobilization of some soluble constituents (e.g. trace metals) relative to neutral or basic groundwater conditions (>pH 8), which may increase the solubility of other constituents. 2. Radionuclide concentrations in groundwater will be correlated with metals concentrations and mineral species to evaluate whether minerology is influencing the concentration of radionuclides in groundwater. 3. Total organic carbon content in aquifer matrix materials will be correlated with radionuclide concentrations in groundwater to evaluate whether organic material may be influencing the concentration of radionuclides in groundwater.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. - For estimation problems, specify acceptable limits on estimation uncertainty.**
Performance or Acceptance Criteria	
1-3. The completeness objective for groundwater and aquifer matrix data collection and laboratory analysis is 95%. Geochemical parameters are generally not COPCs; acceptance criteria for these data will be based on the standard laboratory data validation process rather than project-related objectives. The method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used as performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.	

TABLE 4-1. DATA QUALITY OBJECTIVES
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Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6. - Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use. - Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1. The 64 new proposed wells are co-located in well nests and clusters such that there are a total of 19 unique well sites. The following data will be collected for evaluation of the geochemical environment from the deepest borehole at each well site at a frequency of one sample every 10 vertical feet. - Collect soil and bedrock samples for mineralogical analysis, including XRD, SEM/EDS, and CEC. - Collect aquifer matrix samples for analysis of pH and total organic carbon. Collect aquifer matrix samples for analysis of total metals (32 total metals as noted above in Study #5), and redox species (ferric iron, ferrous iron, carbonate, cation+anion). - Collect groundwater samples for analysis of geochemical indicator parameters, including pH, redox pairs (sulfate, sulfide, nitrate, nitrite, ammonium, ferrous iron, ferric iron, chromium III, chromium VI) for laboratory analysis. Collect field parameters for pH, DO and ORP. Collect groundwater samples from 150 wells on a quarterly basis for two years. 2. Collect the following data for evaluation of the fate and transport of radionuclides relative to the geochemical environment from each well site (19 total): - Aquifer matrix samples will be collected and submitted for sequential extraction to evaluate the influence of different geochemical environments on pH, sulfur, radium, uranium, thorium concentrations. - Aquifer matrix samples will be collected and submitted for total isotopes of radium, uranium, and thorium. 3. Collect groundwater for total and dissolved organic carbon concentrations from 150 wells quarterly for two years. Collect aquifer matrix samples for total organic carbon concentrations from each well site (19 total) at a frequency of one sample every 10 vertical feet. 1-3. Depending on the estimated thickness of the alluvial and bedrock aquifers, a total of 10 samples will be collected from the alluvial aquifer zones and 14 samples will be collected from the bedrock aquifers.	1-3. Access is granted for off-site well installation.

TABLE 4-1. DATA QUALITY OBJECTIVES
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Step 1 - State the Problem			**- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	7. Bridgeton Landfill - The Bridgeton Landfill operated as a limestone quarry prior to landfilling activities. The hydraulic characteristics of the landfill materials may be affecting groundwater movement and flow direction. Groundwater was removed from the quarry during quarrying operations. Since the North and South Quarries are unlined, groundwater can enter into the landfill through the sides of the quarries. During landfilling operations, groundwater (and subsequently leachate) were removed. Leachate is currently removed from the landfill through leachate collection sumps and dual extraction gas wells and is pumped to the leachate pretreatment system. Current infrastructure such as the leachate extraction system and landfill gas extraction system in the Bridgeton Landfill could play an important role in the localized geochemical characteristics of groundwater. The removal of leachate may be providing some benefit to surrounding groundwater quality by hydraulically containing landfill leachate. Whether landfill gas has impacted groundwater offsite has not been evaluated. It is unknown also whether organic constituents from the landfill have impacted off-site groundwater, which could also potentially lower redox conditions.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s). - Consider alternative outcomes or actions that can occur upon answering the question(s). - For decision problems, develop decision statement(s), organize multiple decisions. - For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1. Is leachate extraction affecting the fate and transport of constituents in groundwater? If so, is the influence significant to the overall fate and transport of constituents in groundwater, including groundwater flow direction? 2. Has landfill gas impacted groundwater? If so, is the influence of the landfill gas extraction system significant to the overall fate and transport of constituents in groundwater? 3. Is landfill leachate entering near-site and/or off-site groundwater and is the leachate attributable to the site? 4. Is landfill leachate in groundwater affecting concentrations of radionuclides if present? 5. Are dissolved landfill gases (methane, carbon dioxide) present in groundwater and attributable to the site?	1. The leachate system may be providing localized drawdown that reduces off-site migration of leachate or the extraction may not result in a significant impact on groundwater levels and gradients. 2. The landfill gas extraction system (including cover material) may be removing volatile gasses from the site, which may be reducing the quantity of dissolved gasses entering groundwater. Alternatively, the landfill gas extraction system may be removing landfill gasses, but the mass removal is insignificant to the overall fate and transport from the site. 3. Landfill leachate may be migrating offsite if it is not fully captured by the leachate collection system, or the leachate collection system may be effective at capturing leachate and limiting migration. 4. If leachate-related impacts are present in off-site groundwater, the level of radionuclide activity may be higher, the same, or lower than within a comparable area without leachate present. Leachate-related impacts, if present, could lower redox conditions and increase radionuclide activity levels in on-site or potential off-site groundwater. 5. Landfill gases may be impacting groundwater off-site despite operation of the landfill gas extraction system. Dissolved phase methane and carbon dioxide concentrations may indicate the presence of landfill gases off-site if concentrations are above background levels. Alternatively, the off-site methane and carbon dioxide concentrations may be similar or lower than background levels.	1. Fluid levels in groundwater monitoring wells surrounding the Bridgeton Landfill are needed to determine groundwater flow direction around the landfill and to assess the effects of the leachate collection system on groundwater levels and flow directions. Fluid levels will be collected from the leachate collection sumps and at other locations within the Bridgeton Landfill (e.g., gas extraction wells) to the extent such measurements can be obtained given the construction and operation of the particular infrastructure point, effect of Bridgeton Landfill operations, and potential health and safety issues (high temperatures or high gas or water pressures). The representativeness of such measurements will be assessed prior to their use for evaluation of groundwater flow directions and the effects of the leachate collection system on fluid levels and groundwater flow. 2. A water balance is needed to evaluate the overall influence of the various site features on groundwater discharge and recharge. 3. Landfill indicator parameter data are needed on-site, near-site, downgradient, and background in both groundwater and leachate (untreated). 4. Groundwater quality data for radionuclides is needed on-site, near-site, downgradient, and offsite. Analyses of radionuclide occurrences in untreated leachate are also necessary. An evaluation is needed to determine if a correlation exists between the landfill leachate indicator parameter concentrations and radionuclide concentrations. 5. Dissolved phase landfill gas concentration data are needed, including methane and carbon dioxide from on-site, near-site, downgradient, and offsite locations. An evaluation is needed to determine if there is a correlation between the landfill leachate indicator parameters and dissolved gas concentrations.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates. - Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process. - Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1. New flow meters if necessary will be installed to quantify leachate removal from each sump. Surrounding groundwater wells will be used for water level and water quality information. 2. Current operational information about the landfill gas extraction system will be obtained from Bridgeton Landfill personnel. Surrounding groundwater wells will be used for water quality information. 3. Bridgeton Landfill leachate collection sumps may be used to obtain leachate samples. Surrounding wells will be used to obtain groundwater samples for landfill leachate indicator parameters. 4. Surrounding wells will be used to obtain groundwater samples for landfill leachate indicator parameters and radionuclides. 5. Bridgeton Landfill leachate collection sumps may be used to obtain leachate samples for dissolved landfill gases. Surrounding wells will be used to obtain groundwater samples for landfill leachate indicator parameters and dissolved landfill gases.	1. Water level measurements from wells surrounding the Bridgeton Landfill will be compared the historical water levels and manual measurements to identify potential outliers and qualify data. Flow data from the individual flow meters on the leachate collection system sumps will be compared to the totalizer value to determine if the sum of the volumes match the total. 2. Groundwater quality data surrounding the Bridgeton Landfill will be evaluated for the potential influence of the system assuming dissolved landfill gases are present in groundwater. 3-4. Leachate and groundwater analytical data will be compared to identify potential trends. 5. Groundwater quality data for dissolved gases will be compared within the study area to determine if a correlation exists between groundwater migrating from the site and the presence of dissolved gases and relatively higher radionuclide concentrations.	1. Fluid level measurements in the leachate collection sumps and other wells (e.g., gas extraction wells) within the Bridgeton Landfill may not be possible due to infrastructure access and/or construction constraints, constraints imposed by ongoing Bridgeton Landfill operations, or health and safety concerns (high temperature or pressure conditions). 2-5. Analytical methods are available for analysis of groundwater and leachate for landfill indicators, volatile organic compounds, radionuclides, and dissolved gases. Data will be analyzed and validated as specified in the QAPP and in accordance with CLP guidelines. In addition SOPs and certification requirements will be met by the laboratories. Laboratory analytical methodology are specified in QAPP Table 2-3.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1-5. The target population for leachate water level and leachate quality data includes current and historical onsite LCS data, including LCS wells that are no longer operational. The target population for the groundwater quality will be determined after the well inventory to identify viable wells near the Bridgeton Landfill system, which may change over time.	1-5. The temporal boundary for the leachate quality data will be the date the leachate collection sumps were first sampled, which was in 1997. The spatial boundary for the groundwater and leachate quality data and fluid levels is the study area.	1-5. Collection of data from around the South Quarry may be limited by the SSR, which has affected landfill leachate collection sump infrastructure in this area. Leachate is not always present within a sump, which could present a practical constraint on data collection. Some of the leachate sumps are equipped with inoperable pumps due to the elevated temperatures and pressures in the vicinity, which may limit data collection. The SSR does not affect access to groundwater wells located along the margins of the landfill.	1. The smallest scale for leachate and groundwater fluid levels is 0.01 ft. The smallest scale for leachate volume is 1 gallon. 2-5. The smallest scale for groundwater and leachate quality decision-making will be the MRL or MDL based on the units for that analyte.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
Population Parameters	**Action Level and Decision Rule**
1. The study will compile historic and new water level and leachate fluid levels. The study will also compile leachate pumping rates from individual sumps and the overall system totalizer. 2-6. The study will compile groundwater and leachate quality data from on-site, near-site, and background wells for leachate indicator parameters, radionuclides, and dissolved landfill gases. The study will compile historical groundwater and leachate quality data from the site and offsite if available.	1. If nearby groundwater wells indicate an inward gradient based on preparation of a water balance, the leachate system will be determined to have an observed impact on groundwater flow potential. The magnitude of the inward gradient will be used to determine if the gradient is lower or higher than the natural surrounding gradient. 2. If landfill leachate parameters are present above background in groundwater in the down-gradient flow direction from the site, the groundwater will be determined to have landfill leachate influence. 3. If the landfill leachate indicator constituents are similar in concentration, magnitude and/or ratios to groundwater found off-site, that will provide a line of evidence that off-site groundwater may have landfill leachate present. 4. If radionuclide activity levels are higher within groundwater with known leachate influence relative to groundwater without landfill leachate influence, the presence of landfill leachate in groundwater may be having an effect on radionuclide activity levels. An additional evaluation will be required to determine whether the radionuclides are naturally-occurring or site-related or both. 5. If landfill dissolved gases in groundwater (methane and carbon dioxide) are detected at concentrations above background in off-site wells and near-site wells, the groundwater in those areas will be determined to have landfill gas effects. This is important for assessing the redox conditions of the groundwater and geochemical environment as noted above in Study #6. If dissolved gases in groundwater are detected at concentrations above background in offsite wells and near-site wells, the groundwater be determined to have landfill gas influence.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. - For estimation problems, specify acceptable limits on estimation uncertainty.**
Performance or Acceptance Criteria	
1-5. The completeness objective for water level and flow rate data collection, groundwater, leachate, and aquifer matrix data collection and laboratory analysis is 95%. The method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used as performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.	

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6. - Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use. - Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1.Regarding leachate at the site: - Install flow meters on individual landfill leachate sumps as necessary. Evaluate landfill leachate flow rates and volumes in each available sump monthly over two years. - Incorporate data into groundwater fate and transport model to evaluate effects of leachate pumping on water levels, groundwater flow direction and gradients. - Collect groundwater samples from 150 wells quarterly for two years for the following leachate indicator parameters: - Landfill Leachate and Human Waste Indicators: bromide, iodide, pH, total organic carbon, chloride, chemical oxygen demand, ammonium, phosphate, and total and dissolved metals (sodium, magnesium, potassium, calcium, iron, lead, nickel, copper, zinc, strontium, and boron) - Inorganic Parameters: pH, dissolved organic carbon, alkalinity, total hardness, total suspended solids, total dissolved solids, and major ions (cations+anions, nitrate, sulfate, phosphate, carbonate, chloride, sodium, potassium, magnesium, calcium) - Dissolved landfill gases: methane and carbon dioxide - Collect landfill leachate samples (untreated) from viable leachate sumps for characterization purposes. Leachate will be sampled for the same parameters as the groundwater parameters quarterly for two years. 2.Regarding the landfill gas extraction system at the site: - Collect groundwater samples for dissolved landfill gases (methane and carbon dioxide) from 150 wells quarterly for two years. Evaluate whether landfill gases are present in near-site and off-site wells above background. Evaluate whether there is a correlation between the presence of dissolved landfill gases and radionuclide concentrations. - Collect landfill leachate samples (untreated) from viable leachate sumps for dissolved landfill gases (methane and carbon dioxide). Leachate will be sampled for the same parameters as the groundwater parameters quarterly for two years. 3.Regarding potential leachate-related impacts to off-site groundwater: - Collect groundwater samples from 150 wells quarterly for two years for the above leachate indicator parameters. - Collect landfill leachate samples (untreated) from viable leachate sumps for the same parameters as groundwater. Compare results from groundwater and leachate to determine if a correlation exists based on the distance from the site. 4.Regarding radionuclide and leachate: - Collect groundwater samples from 150 wells quarterly for two years for the above leachate indicator parameters and radionuclides. Compare radionuclide concentrations from wells within areas with potential leachate influence with radionuclide concentrations from wells outside of leachate areas to determine if a correlation exists. Also evaluate redox groundwater conditions to identify naturally-occurring and/or anthropogenic sources of radium. 5.Regarding dissolved landfill gases: - Collect groundwater samples from 150 wells and leachate from leachate collection system sumps quarterly for two years for dissolved methane and dissolved carbon dioxide (landfill gases), bicarbonate alkalinity, calcium, and magnesium. Correlate concentrations of these constituents with distance from the site.	1-6. Access is granted for off-site well installation. 5. Leachate and groundwater quality data are available from on-site.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	8. Vapor Intrusion - The potential for vapor intrusion into on-site structures has not recently been investigated. Indoor air sampling of enclosed buildings (5 total) will be conducted to address this data gap. The vapor intrusion pathway has not yet been evaluated but will be completed using off-site groundwater data obtained as part of the OU-3 RI activities. Additional data gaps may exist if these groundwater data indicate a potential for vapor intrusion, including potentially sub-slab, soil gas, and/or indoor air concentrations.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s). - Consider alternative outcomes or actions that can occur upon answering the question(s). - For decision problems, develop decision statement(s), organize multiple decisions. - For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements / What Needs Estimated and Key Assumptions**
1. Are radon, methane, and/or VOCs present within enclosed structures on-site at elevated levels? 2. Do groundwater concentrations near the site and offsite contain radon, methane, or volatile compounds which could pose a risk to indoor air?	1. Radon, methane, and volatile organic compounds may be present in indoor air onsite from surrounding soil and/or groundwater. Ambient air radon activity samples are collected around the site currently, but do not indicate an ambient air issue exists. Of the five enclosed buildings at the site, those structures closest to potential radon sources may have higher radon activity. Buildings with more foundation/slab penetrations or cracks may exhibit higher radon activity in indoor air. 2. Offsite radon, methane, and volatile organic compound groundwater concentrations may be below concentrations which could indicate a risk due to volatilization, or may be above threshold concentrations depending on the spatial distribution of groundwater impacts within the shallowest alluvial aquifer.	1. Radon activity, methane, and volatile organic compound concentration data is needed from within the 5 enclosed buildings onsite. 2. Radon, methane, and volatile organic compound data in groundwater is needed to evaluate the risk to indoor air off-site. Due to the presence of naturally-occurring radon gas in the St. Louis area, background radon levels in groundwater are necessary to evaluate the potential sources of radon in groundwater down-gradient from the site. The average indoor radon levels in Saint Louis County is 3.5 pCi/L, which is close to the 4 pCi/L USEPA radon action level (St. Louis County 2019). Rather than rely only on the presence of radon gas in groundwater, the extent of site-related groundwater impacts is needed (from Study #5) in order to define the radon study area only to those areas with site-related impacts. Published data may also be used to supplement proposed background radon groundwater data collection. Estimated indoor air concentrations need to be calculated. Properties that need further assessment for indoor air impacts based on site-related constituents need to be identified.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		**- Identify types and sources of information needed to resolve decisions or produce estimates.** **- Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process.** **- Select appropriate sampling and analysis methods for generating the information.**
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1-2. Indoor air data is a source of information about the potential risk to on-site workers. Groundwater concentrations are the source of information about the potential volatilization to indoor air of radon, methane and VOCs. It is worth noting that there is not a commercially available laboratory rest for radon in groundwater, and radium concentrations in groundwater cannot be used to predict the occurrence of radon in groundwater despite the fact that 226Ra decay is the source of radon (or 222Rn). This is due to the different behaviors of radium and radon in the environment. First, the 226Ra/222Rn activity ratio in the natural water is not constant. Radon gas can leak and diffuse from the rocks and sediment to the water, while the dissolution of radium in the rock/sediment to the water is a slower process. This causes higher radon concentrations than that of 226Ra in the natural water. Additional factors influencing this poor correlation include differences in the isotopes' half-lives and differences in the chemical behavior of multiple parent isotopes. Therefore, radon in groundwater data will be obtained using field screening data. In addition to data collected from the proposed OU-3 well network, published data may also be used to supplement proposed background radon in groundwater data collection. Distance from groundwater to ground surface measurements will be a useful source of information. Structural information may also become important for buildings being evaluated.	1. Indoor air data from on-site structures will be compared to the USEPA RSLs for VOCs and the USEPA radon action level for indoor air of 4 pCi/L to evaluate the need for mitigation of onsite structures. Methane levels will be compared to 10% of the lower explosive limit (LEL) since there is no MCL for methane. Data will be analyzed and validated as specified in the QAPP . In addition SOPs and certification requirements will be met by the laboratories. 2. Groundwater VOC concentrations will be evaluated against target values estimated using the most current USEPA Vapor Intrusion Screening Level (VISL) calculator. The estimated indoor air concentration will be calculated using Henry's Law for radon and methane, which do not have USEPA RSLs. For reference, the target groundwater radon activity level is 2,500 pCi/L based on an attenuation factor of 0.001 and Henry's Law Constant of 1.6 (Kil et al. 2010).	1. Short-term and long-term radon activity sampling and analysis methodology is available from USEPA (EPA 402-R-92-003, EPA 402-R-92-004). The volatile organic compound (TO-15) and methane (TO-3) analytical methods are available. Indoor air testing procedures are readily available (USEPA 2015). 2. Methodology for using the USEPA VISL calculator is available from USEPA's website (User Guide and FAQ). The same methodology will be used for radon activity, but calculated manually. The sampling methodology for measuring radon concentrations in groundwater is available from the manufacturer of the field screening meter, the RAD7 with H2O attachment (Durridge).

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1. The target population for the on-site indoor air testing includes the occupied, enclosed buildings (5 total). 2. The target population for the off-site vapor intrusion evaluation includes structures within 100 ft of the estimated extent of groundwater impacts above target groundwater values as calculated by the VISL calculator or Henry's Law (for radon).	1-2. The temporal boundary for vapor sampling is dependent on changes to structures, site conditions, groundwater concentrations, and groundwater depths. Significant changes in any of these parameters may limit the temporal boundary for vapor data to current conditions. The temporal boundary for the groundwater sampling is limited to current conditions. The spatial boundary for the vapor sampling is the study area, which may change if groundwater conditions indicate a larger area may need assessed now or in the future.	1. The USEPA protocol for short-term radon sampling involves closing ventilation points for 12-hours. Since the on-site enclosed structures are generally used around the clock daily for facility operations, this aspect of the short-term sampling protocol is impractical for the site. Therefore, long-term testing will be completed to verify the results of the short-term testing. Groundwater sampling may be limited by the potential lack of access to off-site properties for installation of the proposed wells. Radon has a short-half-life such that laboratory analysis of radon activity in groundwater is not practical. Field measurements will be performed with the RAD7 radon meter with H2O attachment which has a minimum activity level of 10 pCi/L (see Appendix L-6 of the FSP). If off-site vapor testing is required as part of the OU-3 RI/FS activities, access to off-site properties for vapor testing may be limited depending on landowner consent. 2. Access to off-site property for vapor testing may be limited depending on landowner consent.	1. The scale for decision-making for the on-site buildings is per building location. 2. The scale for decision-making for the off-site properties is per parcel and per building (if more than one structure is present and substantially far from each other).

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates.** **- For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it.** **- For estimation problems, specify the estimator and the estimation procedure.**
<u>Population Parameters</u>	**<u>Action Level and Decision Rule</u>**
1. The study will compile indoor air quality data from 5 enclosed structures onsite for volatile organic compounds, methane and radon activity. 2. The study will compile groundwater data on volatile organic compounds, methane, and radon activity, and depths to groundwater.	1. If onsite indoor air concentrations of VOCs, methane, and radon exceed the USEPA RSLs, 10% of the LEL, or USEPA Radon Action Level, respectively, the need for subslab depressurization systems or other mitigation measures will be evaluated for each affected building. 2. If off-site VOC and methane groundwater concentrations exceed the target groundwater concentrations, properties located within 100 ft of the measuring point will be identified and further evaluated. Due to the ubiquitous nature of radon gas in the St. Louis area, a statistically derived background radon activity in groundwater will be calculated and taken into account when analyzing the groundwater data collected as part of this study. Additionally, vapor intrusion assessments for radon will be limited to within the lateral extent of site-related groundwater impacts to address the presence of background radon. Radon and methane are not included in the VISL calculator, so the target groundwater concentrations will be manually calculated. Each area will be assessed for the potential presence of background impacts from LUST sites or other spill-related impacts. If soil gas sampling indicates indoor air concentrations may exceed USEPA RSLs, indoor air testing may be recommended, or mitigation systems offered to property owners. Details regarding soil gas and indoor air testing would be included in an OU-3 RI Work Plan.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. - For estimation problems, specify acceptable limits on estimation uncertainty.**
Performance or Acceptance Criteria	
1. Possible decision errors include overestimation of the spatial extent of potential indoor air issues based on available groundwater data. However, further vapor testing needs will be evaluated on a case-by-case basis using site-specific information. The completeness objective for indoor air testing is 100%. The method detection limit for volatile organic compound (TO-15) constituents is listed in Table 2-3 of the QAPP. The RAD7 field meter radon activity range is 0.1 to 20,000 pCi/L with a ±5% accuracy. 2. The RAD7 H2O radon meter sensitivity is ~10 pCi/L for radon in groundwater. Note, the radon in groundwater value will be used to estimate the radon in indoor air activity, which due to attenuation will be several orders of magnitude below the 4 pCi/L indoor air USEPA guideline. The completeness objective for groundwater data collection and laboratory analysis is 95%. The method detection limits are included on Table 2-3 of the QAPP. The lowest achievable detection limits will be used as a performance criterion. A qualitative evaluation will be performed on the areas where detection limits exceed the lowest screening limit applicable. If a sample result is "Rejected", then the data are not adequate or useable. Determination of if resampling will be necessary for the data that are critical in the final decision-making process. If groundwater concentrations are reported between MDLs and MRLs the points will be qualified as estimates. Additionally, analytical data will be evaluated for quality using data validation. Data qualifiers will be assigned indicating estimated data. Estimated data will be evaluated during the qualitative summary.	

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6.** **- Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use.** **- Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
Sampling Design	**Key Assumptions**
1. Complete real-time field survey using a RAD7 Radon Detector in 5 enclosed on-site buildings over=48-hours to provide a short-term radon. Long-Term Electret Ion Chambers will be used to estimate long-term (90 days) radon exposure which covers potential fluctuations over the day, weeks, and months. Collect one ambient air sample outside of the Engineering Office as part of the long-term radon test to evaluate potential radon sources (if present). 2. Collect groundwater samples for VOCs and dissolved methane gas for laboratory analysis. Collect groundwater samples to measure radon activity using a RAD7 radon meter equipped with the H2O accessory. Collect VOC, methane, and radon samples from the upper-most water-bearing zone within the proposed well network. Shallow groundwater samples will be collected and analyzed for radon on a quarterly basis for two years to develop an adequate data set for comparison of background well radon activity with near-site and down-gradient wells. Existing published data with background radon activity in groundwater will be used to supplement new data as necessary.	1. Access is granted to the asphalt plant building by tenant for testing. Application of the real time testing method will not be consistent with standard methodology which requires no entry into the room for 12-hours; this restriction is not implementable given the 24-hour operations at the site. Therefore, the real-time radon test will be used as an indicator of acute risk and the long-term test will be used to assess overall risk. 2. For future off-site vapor testing (if warranted), off-site access will be a key assumption for further vapor data collection.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 1 - State the Problem			**- Give a concise description of the problem - Identify leader and members of the planning team. - Develop a conceptual model of the environmental hazard to be investigated. - Determine resources -budget, personnel, and schedule.**
Description of the Problem	**Conceptual Model of the Environmental Hazard**	**Data Gaps**	**Project Resources - Budget, Personnel, Schedule**
Statement of Problem: Petroleum hydrocarbons, volatile organic compounds, trace metals, trace anions, and various radionuclides have been detected in groundwater at the West Lake Landfill site. The nature and extent of site-related impacts to off-site groundwater, surface water, sediment, and indoor air are unknown, and will be determined by the OU-3 RI work.	A preliminary Conceptual Site Model (CSM) of the hazards for OU-3 groundwater conditions includes the following elements: 1. Potential source contribution of COPCs from OU-1 and/or OU-2 into groundwater within the OU-3 on-site area. 2. Potential geochemical interactions between landfill leachate and/or landfill gas within groundwater, and natural aquifer matrix materials. 3. Background groundwater quality and geochemical conditions that may affect the determination of potential off-site COPC distribution, such as naturally occurring radiological constituents in groundwater. 4. Effects on groundwater flow and OU-3 water balance, resulting from leachate extraction at the Bridgeton Landfill. 5. Hydraulic interactions between waste disposal areas within OU-1 and OU-2 and alluvial and bedrock hydrostratigraphic units at the site. 6. Off-site groundwater flow in alluvial and bedrock hydrostratigraphic units, potential COPC transport away from on-site sources, and related potential for impacts to off-site groundwater receptors. 7. Temporal variability in groundwater levels and flow directions and temporal and spatial effects of surface water-groundwater interactions, particularly at Earth City ponds and the Missouri River, on groundwater flow and potential transport of COPCs, and related potential for impacts to surface water, sediments, and/or ecological receptors. 8. Potential movement of COPCs from shallow groundwater into soil vapor, or potential movement of landfill gas, and related potential for impacts to indoor air receptors.	9. Groundwater and Surface Water Temporal and Spatial Variability - Previous investigations evaluated temporal variability in groundwater levels and flow direction at varying frequencies. Additional characterization of groundwater levels and flow directions is needed in response to potential influences such as surface water, precipitation, and pumping.	1. Personnel: - Respondents: Representatives of Bridgeton Landfill, LLC, Cotter Corporation (NSL), DOE - OU-3 Project Coordinator: Paul Rosasco (EMSI) - Technical Advisor: Ralph Golia (AMO Environmental Decisions, Inc.) - Trihydro Corporation: Gary Risse (Project Principal), Allison Riffel (Project Manager), Michael Sweetenham (Assistant Project Manager), Dan Gravelding (Technical Director), Wilson Clayton, PhD (Modeling Technical Lead), Craig Carlson (Radiation Technical Lead), Andrew Pawlisz (Risk Assessment Technical Lead), Justin Pruis (Vapor Intrusion Technical Lead) - Subcontractors: Ameriphysics (Radiation Safety, Health Physicist), Chad Drummond (Geochemical/Radionuclide Modeling), Feezor Engineering (Radiation Safety, Field Support), Pace Analytical Laboratory, Materials and Chemical Laboratory, Inc. (MCLInc), Earth Exploration Laboratory, ALS Laboratory - Stakeholders: USEPA Region 7, MDNR, USACE 2. Budget: $11 MM through 2023 for RI activities 3. Schedule: - Finalized OU-3 RI/FS Work Plan - January 2020 - RI Field Work - Spring 2020 - Fall 2022* - Well Inventory Summary Report - Fall 2020 - Addendum to RI Work Plan - Winter 2020 - Additional RI Field Work - Spring 2021* - Groundwater Modeling Work Plan - Summer 2021 - Groundwater Modeling Report - Fall 2022 - RI Report - Spring 2023 - Baseline Risk Assessment Report - Spring 2023

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 2 - Identify the Goal of the Study		**- Identify principal study question(s).** **- Consider alternative outcomes or actions that can occur upon answering the question(s).** **- For decision problems, develop decision statement(s), organize multiple decisions.** **- For estimation problems, state what needs to be estimated and key assumptions.**
Identify Principal Study Questions	**Alternative Outcomes**	**Decision Statements /** **What Needs Estimated and Key Assumptions**
1. What is the groundwater flow direction locally and regionally? 2. Does the groundwater flow direction vary seasonally locally and regionally? 3. How might the groundwater flow direction vary over time locally and regionally?	1-3. Groundwater flow direction may be radially outward from the site in general except in areas with leachate extraction. Flow direction locally may be west towards the Missouri River and towards local pumping wells. Flow direction may shift away from the site towards to the north, consistent with the expected regional groundwater flow direction and parallel to the Missouri River. These directions may change regionally or locally in response to changes in river stage levels, leachate and groundwater extraction rates, surface water recharge rates, and precipitation such as flood events, droughts, and other water balance-related changes.	1-3. Groundwater levels and surface water elevations are needed on-site, near-site, and off-site. The same information is needed from the historical record and the proposed well network to evaluate sensitivity of the flow direction to seasonal changes and water-balance changes. Continuous water level elevation data is needed in areas where rapid changes maybe occurring in groundwater levels and surface water levels. A 3-dimensional groundwater flow model is needed to evaluate the overall groundwater system and flow direction questions.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 3 - Identify Information Inputs		- Identify types and sources of information needed to resolve decisions or produce estimates. - Identify the basis of information that will guide or support choices to be made in later steps of the DQO Process. - Select appropriate sampling and analysis methods for generating the information.
Types and Sources of Information	**Informational Basis of Performance Criteria**	**Availability of Sampling and Analysis Methods or Data**
1-3. Historical water level, precipitation, and pumping data are important sources of data. New water level measurements from the proposed well network and staff gauges are another source of information. Historical and current pumping data from the on-site leachate collection system and other significant pumping wells is another source of data.	1-3. Water level measurements will be compared the historical water levels and manual measurements to identify potential outliers and qualify data. Flow data from the individual flow meters on the leachate collection system sumps will be compared to the totalizer value to determine if the sum of the volumes match the total. Surface water data from historical reports will be compared with new readings and manual measurements to identify and qualify potential outlier values. Transducer readings will be evaluated compared to the historical record (where available) and manual water level measurements to identify and qualify potential outlier values.	1-3. Water level measurement procedures for water wells, surface water, and leachate sumps are available. Both manual and transducer-based measurements will be employed. Suitable flow meters designed for leachate and potentially high temperatures are available to be installed on individual leachate collection sumps if not currently present to obtain flow rates and volumes to the nearest 1 gallon per minute.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 4 - Define the Boundaries of the Study			**- Define the target population of interest and its relevant spatial boundaries. - Define what constitutes a sampling unit. - Specify temporal boundaries and other practical constraints**
Target Population	**Temporal and Spatial Boundaries**	**Potential Practical Constraints on Data Collection**	**Appropriate Scale for Decision-Making**
1-3. The target population is the wells and leachate collection system points to be used for leachate water level and leachate flow data. The target population for the historical surface water and new groundwater elevation data includes the groundwater wells and staff gauges where data will be collected from each aquifer zone within the model domain. The target population for the collection of continuous water level elevation data is from 70 of the 150 wells, which includes 50 of the proposed new wells and 20 of the existing wells (Table 5-5 of the OU-3 RI/FS Work Plan). This subset of wells was identified based on proximity to surface water bodies where the elevation may change rapidly and based on the spatial distribution of wells necessary to complete gradient calculations. The availability and quality of the off-site groundwater extraction data (e.g. flow rates for the Earth City Flood Control District levee pressure relief wells) is unknown at this time and could affect the water balance and/or groundwater modeling efforts. The target population for the precipitation records includes the Lambert Field rain gauge and its associated records.	1-3. The temporal boundary for the water level data is 1979 based on onsite well data. The temporal boundary for surface water level data is 1976 based on available data. The spatial boundary for the groundwater and surface water levels is the model boundary.	1-3. Potential obstacles for the collection of new surface water data includes lack of access to private property to install the proposed surface water staff gauges. Potential obstacles to the collection of water level data from transducers include the potential lack of access to private property for installation of the proposed wells and landfill or other site operations.	1-3. The smallest scale for leachate and groundwater fluid levels is 0.01 ft. The smallest scale for the surface water transducers is 0.01-inch. The smallest scale for leachate volume is 1 gallon. The groundwater model discretization will be determined in conjunction with the Phase I RI sampling and geologic logging activities and will be documented in the Groundwater Modeling Work Plan.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 5 - Define the Analytic Approach	**- Specify appropriate population parameters for making decisions or estimates. - For decision problems, choose a workable Action Level and generate an "If … then … else" decision rule which involves it. - For estimation problems, specify the estimator and the estimation procedure.**
Population Parameters	**Action Level and Decision Rule**
1-3. The study will compile historic and new water level and leachate fluid levels. The study will also compile leachate pumping rates from individual sumps and the overall system totalizer, and pumping/flow rates for off-site groundwater extraction wells (e.g., Earth City Flood Control District levee pressure relief wells).	1-3. If the groundwater flow direction varies, the proposed well network will be updated if necessary to provide representative down-gradient groundwater quality data within the range of potential flow directions. The groundwater model will be calibrated using the variable flow directions and used to assess groundwater flow in the future based on the calibrated model.

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 6 - Specify Performance or Acceptance Criteria	**- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.** **- For estimation problems, specify acceptable limits on estimation uncertainty.**
Performance or Acceptance Criteria	
1-3. Possible decision errors include inadequately located or spaced wells to detect temporal variations. The completeness objective for water level, leachate level, surface water level, and leachate flow rate data collection is 95%.	

TABLE 4-1. DATA QUALITY OBJECTIVES
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAND LANDFILL OU-3

Step 7 - Develop the Plan for Obtaining Data	**- Compile all information and outputs generated in Steps 1 through 6.** **- Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use.** **- Select and document a design that will yield data that will best achieve your performance or acceptance criteria.**
<u>Sampling Design</u>	**<u>Key Assumptions</u>**
1-3. After proposed monitoring wells are installed, pressure transducers (In Situ Level Troll or similar) will be deployed in a subset of existing wells (86 total), all proposed wells (64 total), and all staff gauges (9 total) to monitor water level elevations. Barometric pressure loggers (if probes are not vented) such as In Situ Barologger (or similar) will be deployed in select wells and all staff gauges and programmed to collect water level data every hour. Transducer data will be downloaded monthly along with collection of manual water level elevation readings for correlation purposes. Water level elevation readings will be corrected for barometric pressure. Potentiometric surface contour figures will be prepared monthly using groundwater elevation data and illustrate localized and off-site flow directions. Azimuth frequency charts will be prepared to identify flow directions throughout the year on a monthly basis for two years. The data set will be evaluated to determine the influence of adjacent surface water elevation changes, precipitation events, and pumping effects.	1-3. Access is granted for off-site well and staff gauge installation on private property. Another key assumption is that information on off-site groundwater extraction data (e.g., flow rates for the Earth City Flood Control District levee pressure relief wells) will be available and of sufficient quality for use in the water balance calculations and/or groundwater modeling efforts.

TABLE 5-1a. SAMPLING PLAN AND QA SAMPLES FOR GROUNDWATER ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF DUPLICATES[1]	NUMBER OF TRIP BLANKS[2]	NUMBER OF FIELD BLANKS[2]	NUMBER OF EQUIPMENT BLANKS[2]	NUMBER OF MS and MSDs[3]	TOTAL NUMBER OF SAMPLES
Total Metals	Total Metals	USEPA 6010B	W	1200	120	0	0	120	60	1500
	Total Metals	USEPA 6020	W	1200	120	0	0	120	60	1500
	Total Mercury	USEPA 7470A	W	1200	120	0	0	120	60	1500
	Chromium (III)	Calculation	W	1200	120	0	0	120	60	1500
	Chromium (VI)	USEPA 7196A	W	1200	120	0	0	120	60	1500
Dissolved Metals	Dissolved Metals	USEPA 6020	W	1200	120	0	0	120	60	1500
	Dissolved Metals	USEPA 6010B	W	1200	120	0	0	120	60	1500
	Dissolved Metals	USEPA 6010B	W	1200	120	0	0	120	60	1500
	Dissolved Mercury	USEPA 7470A	W	1200	120	0	0	120	60	1500
Semi-Volatile Organic Compounds	Semi-Volatile Organic Compounds	USEPA 8270C	W	1200	120	0	0	120	60	1500
	Semi-Volatile Organic Compounds	USEPA 8270C SIM*	W	1200	120	0	0	120	60	1500
Volatile Organic Compounds	Volatile Organic Compounds	USEPA 8260C Low Level	W	1200	120	120	60	120	60	1680
	Volatile Organic Compounds	USEPA 8011	W	1200	120	120	60	120	60	1680
PCBs	Polychlorinated Biphenyls (PCBs)	USEPA 8082A	W	1200	120	0	0	120	60	1500
Hydrocarbons	TPH-GRO	USEPA 8260 TPH	W	1200	120	120	60	120	60	1680
	TPH-DRO, TPH-ORO	USEPA 8270 TPH	W	1200	120	0	0	120	60	1500
Organochlorine Pesticides	Organochlorine Pesticides	USEPA 8081B	W	1200	120	0	0	120	60	1500
Radiological Chemistry	Isotopic Thorium (Th-228, Th-230, Th-232) Dissolved Isotopic Thorium (Th-228, Th-230, Th-232)	HASL-300 Method U-02	W	1200	120	0	60	120	60	1560
	Isotopic Uranium (U-234, U-235, U-238) Dissolved Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	W	1200	120	0	60	120	60	1560
	Radium-226	USEPA 903.1	W	1200	120	0	60	120	60	1560
	Radium-228	USEPA 904.0	W	1200	120	0	60	120	60	1560
	Dissolved Isotopic Radium-226	USEPA 903.1	W	1200	120	0	60	120	60	1560
	Dissolved Isotopic Radium-228	USEPA 904.0	W	1200	120	0	60	120	60	1560
Geochemistry	Alkalinity	SM 2320B	W	1200	120	0	0	120	60	1500
	Bromide	USEPA 9056A	W	1200	120	0	0	120	60	1500
	Carbonate	SM 2320B	W	1200	120	0	0	120	60	1500
	Total Dissolved Solids	SM 2540C	W	1200	120	0	0	120	60	1500
	Total Suspended Solids	SM 2540D	W	1200	120	0	0	120	60	1500
	Total Hardness	USEPA 6010B/2340B Calculation	W	1200	120	0	0	120	60	1500
	Cations + Anions	Calculation	W	1200	120	0	0	120	60	1500
	Iodide	USEPA 9056A	W	1200	120	0	0	120	60	1500

TABLE 5-1a. SAMPLING PLAN AND QA SAMPLES FOR GROUNDWATER ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF DUPLICATES[1]	NUMBER OF TRIP BLANKS[2]	NUMBER OF FIELD BLANKS[2]	NUMBER OF EQUIPMENT BLANKS[2]	NUMBER OF MS and MSDs[3]	TOTAL NUMBER OF SAMPLES
Geochemistry (Cont.)	Chloride Fluoride Sulfate	USEPA 9056A	W	1200	120	0	0	120	60	1500
	Phosphate	USEPA 365.1	W	1200	120	0	0	120	60	1500
	Sulfide	SM 4500-S^{2}-D	W	1200	120	0	0	120	60	1500
	Chemical Oxygen Demand	USEPA 410.4 Rev 2	W	1200	120	0	0	120	60	1500
	Nitrogen, Nitrate + Nitrite	USEPA 353.2 Rev 2	W	1200	120	0	0	120	60	1500
	Nitrogen, Ammonia	SM 4500-NH_3 G	W	1200	120	0	0	120	60	1500
	Nitrogen, Nitrate	USEPA 9056A	W	1200	120	0	0	120	60	1500
	Nitrogen, Nitrite	USEPA 9056A	W	1200	120	0	0	120	60	1500
	pH	SM 4500H+B	W	1200	120	0	0	120	60	1500
	Total Organic Carbon	SM 5310C	W	1200	120	0	0	120	60	1500
	Dissolved Organic Carbon	SM 5310C	W	1200	120	0	0	120	60	1500
Dissolved Gases	Methane	AM20GAX	W	1200	120	0	0	120	60	1500
	Carbon Dioxide	AM20GAX	W	1200	120	0	0	120	60	1500

Notes:
* - SVOC-SIM will be used to analyze PAHs.
[1] One duplicate per 10 samples.
[2] Includes Trip, Equipment, and Field. Trip blank samples will be collected for VOCs and TPH-GRO, only. Field blank samples will be collected for VOCs, TPH-GRO, and radiochemistry, only.
[3] Considers an MS and MSD as one sample
GRO: Gasoline Range Organics
DRO: Diesel Range Organics
MS//MSD: Matrix Spike/Matrix Spike Duplicate
ORO: Oil Range Organics
PCBs: Polychlorinated biphenyl
SIM: Selective Ion Monitoring
SM: Standard Methods for the Examination of Water and Wastewater
TPH: Total Petroleum Hydrocarbons
TSP: Trisodium phosphate dodecahydrate
USEPA: United States Environmental Protection Agency
VOA: Volatile organic analysis
W: Water Matrix

TABLE 5-1b. SAMPLING PLAN AND QA SAMPLES FOR LEACHATE ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF DUPLICATES[1]	NUMBER OF TRIP BLANKS[2]	NUMBER OF FIELD BLANKS[2]	NUMBER OF EQUIPMENT BLANKS[2]	NUMBER OF MS and MSDs[3]	TOTAL NUMBER OF SAMPLES
Total Metals	Total Metals	USEPA 6010B	W	48	5	0	0	5	3	61
	Total Metals	USEPA 6020	W	48	5	0	0	5	3	61
	Total Mercury	USEPA 7470A	W	48	5	0	0	5	3	61
	Chromium (III)	Calculation	W	48	5	0	0	5	3	61
	Chromium (VI)	USEPA 7196A	W	48	5	0	0	5	3	61
Dissolved Metals	Dissolved Metals	USEPA 6020	W	48	5	0	0	5	3	61
	Dissolved Metals	USEPA 6010B	W	48	5	0	0	5	3	61
	Dissolved Metals	USEPA 6010B	W	48	5	0	0	5	3	61
	Dissolved Mercury	USEPA 7470A	W	48	5	0	0	5	3	61
Semi-Volatile Organic Compounds	Semi-Volatile Organic Compounds	USEPA 8270C	W	48	5	0	0	5	3	61
	Semi-volatile Organic Compounds	USEPA 8270C SIM*	W	48	5	0	0	5	3	61
Volatile Organic Compounds	Volatile Organic Compounds	USEPA 8260C Low Level	W	48	5	5	3	5	3	69
	Volatile Organic Compounds	USEPA 8011	W	48	5	5	3	5	3	69
PCBs	Polychlorinated Biphenyls (PCBs)	USEPA 8082A	W	48	5	0	0	5	3	61
Hydrocarbons	TPH-GRO	USEPA 8260 TPH	W	48	5	5	3	5	3	69
	TPH-DRO, TPH-ORO	USEPA 8270 TPH	W	48	5	0	0	5	3	61
Organochlorine Pesticides	Organochlorine Pesticides	USEPA 8081B	W	48	5	0	0	5	3	61
Radiological Chemistry	Isotopic Thorium (Th-228, Th-230, Th-232) Dissolved Isotopic Thorium (Th-228, Th-230, Th-232)	HASL-300 Method U-02	W	48	5	0	3	5	3	64
	Isotopic Uranium (U-234, U-235, U-238) Dissolved Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	W	48	5	0	3	5	3	64
	Radium-226	USEPA 903.1	W	48	5	0	3	5	3	64
	Radium-228	USEPA 904.0	W	48	5	0	3	5	3	64
	Dissolved Isotopic Radium-226	USEPA 903.1	W	48	5	0	3	5	3	64
	Dissolved Isotopic Radium-228	USEPA 904.0	W	48	5	0	3	5	3	64
Geochemistry	Alkalinity	SM 2320B	W	48	5	0	0	5	3	61
	Bromide	USEPA 9056A	W	48	5	0	0	5	3	61
	Carbonate	USEPA 2320B	W	48	5	0	0	5	3	61
	Total Dissolved Solids	SM 2540C	W	48	5	0	0	5	3	61
	Total Suspended Solids	SM 2540D	W	48	5	0	0	5	3	61
	Total Hardness	USEPA 6010BCalc	W	48	5	0	0	5	3	61
	Cations + Anions	Calculation	W	48	5	0	0	5	3	61
	Iodide	USEPA 9056A	W	48	5	0	0	5	3	61

TABLE 5-1b. SAMPLING PLAN AND QA SAMPLES FOR LEACHATE ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF DUPLICATES[1]	NUMBER OF TRIP BLANKS[2]	NUMBER OF FIELD BLANKS[2]	NUMBER OF EQUIPMENT BLANKS[2]	NUMBER OF MS and MSDs[3]	TOTAL NUMBER OF SAMPLES
Geochemistry (Cont.)	Chloride Fluoride Sulfate	USEPA 9056A	W	48	5	0	0	5	3	61
	Phosphate	USEPA 365.1	W	48	5	0	0	5	3	61
	Sulfide	SM 4500-S^{2}-D	W	48	5	0	0	5	3	61
	Chemical Oxygen Demand	USEPA 410.4 Rev 2	W	48	5	0	0	5	3	61
	Nitrogen, Nitrate + Nitrite	USEPA 353.2 Rev 2	W	48	5	0	0	5	3	61
	Nitrogen, Ammonia	SM 4500-NH_3 G	W	48	5	0	0	5	3	61
	Nitrogen, Nitrate	USEPA 9056A	W	48	5	0	0	5	3	61
	Nitrogen, Nitrite	USEPA 9056A	W	48	5	0	0	5	3	61
	pH	SM 4500H+B	W	48	5	0	0	5	3	61
	Total Organic Carbon	SM 5310C	W	48	5	0	0	5	3	61
	Dissolved Organic Carbon	SM 5310C	W	48	5	0	0	5	3	61
Dissolved Gases	Methane	AM20GAX	W	48	5	0	0	5	3	61
	Carbon Dioxide	AM20GAX	W	48	5	0	0	5	3	61

Notes:
* - SVOC-SIM will be used to analyze PAHs.
[1] One duplicate per 10 samples.
[2] Includes Trip, Equipment, and Field. Trip blank samples will be collected for VOCs and TPH-GRO, only. Field blank samples will be collected for VOCs, TPH-GRO, and radiochemistry, only.
[3] Considers an MS and MSD as one sample
GRO: Gasoline Range Organics
DRO: Diesel Range Organics
MS/MSD: Matrix Spike/Matrix Spike Duplicate
ORO: Oil Range Organics
PCBs: Polychlorinated biphenyl
SIM: Selective Ion Monitoring
SM: Standard Methods for the Examination of Water and Wastewater
TPH: Total Petroleum Hydrocarbons
TSP: Trisodium phosphate dodecahydrate
USEPA: United States Environmental Protection Agency
VOA: Volatile organic analysis
W: Water Matrix

TABLE 5-1c. SAMPLING PLAN AND QA SAMPLES FOR ALLUVIAL MATRIX ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF DUPLICATES[1]	NUMBER OF TRIP BLANKS[2]	NUMBER OF FIELD BLANKS[2]	NUMBER OF EQUIPMENT BLANKS[2]	NUMBER OF MS and MSDs[3]	TOTAL NUMBER OF SAMPLES
Total Metals	Total Metals	USEPA 6010B	S	170	0	0	0	17	9	196
	Total Metals	USEPA 6020	S	170	0	0	0	17	9	196
	Total Mercury	USEPA 7471A	S	170	0	0	0	17	9	196
	Ferrous Iron	SM 3500-Fe B, modified	S	170	0	0	0	17	9	196
	Total Iron	USEPA 6010B	S	170	0	0	0	17	9	196
	Ferric Iron	Calculation (Total - Ferrous)	S	170	0	0	0	17	9	196
Radiological Chemistry	Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	S	170	0	0	9	17	9	205
	Isotopic Thorium (Th-228,Th-230, Th-232)	HASL-300 Method U-02	S	170	0	0	9	17	9	205
	Radium-226	USEPA 903.1	S	170	0	0	9	17	9	205
	Radium-228	USEPA 904.0	S	170	0	0	9	17	9	205
Major Minerals and Mineral Reactivity	X-Ray Diffraction	MCL-7712	S	170	0	0	0	17	9	196
	Scanning Electron Microscope with	MCL-7708	S	170	0	0	0	17	9	196
Mineralogical	Cation Exchange Capacity	USEPA 9081	S	170	0	0	0	17	9	196
Cation/Anion	pH	USEPA 9045D	S	170	0	0	0	17	9	196
	Total Organic Carbon	Walkley-Black Procedure	S	170	0	0	0	17	9	196
	Total Alkalinity (carbonate and bicarb)	SM 2320B	S	170	0	0	0	17	9	196
	Cations + Anions	Calculation	S	170	0	0	0	17	9	196
Radionuclide Speciation	Following Sequential Extraction Analysis (Dissolved Radium)	USEPA 903.1/904.0	S	170	0	0	0	0	9	179
	Following Sequential Extraction Analysis (Total Uranium)	USEPA 6020	S	170	0	0	0	0	9	179
	Following Sequential Extraction Analysis (Total Metals-Barium, Calcium, Iron, Manganese, Sulfur)	USEPA 6020	S	170	0	0	0	0	9	179
	Following Sequential Extraction Analysis (pH)	USEPA 9045D	S	170	0	0	0	0	9	179
Geotechnical Parameter	Grain Size Distribution by Sieve Analysis	ASTM D422	S	170	0	0	0	17	9	196
	Grain Size Distribution by Hydrometer Analysis	ASTM D422	S	170	0	0	0	17	9	196
	Atterberg Limits	ASTM D4318	S	170	0	0	0	17	9	196
	Density	ASTM 7263	S	170	0	0	0	17	9	196

Notes:
[1] One duplicate per 10 samples.
[2] Includes Trip, Equipment, and Field. Trip and Field blank samples will be collected for VOCs only.
[3] Considers an MS and MSD as one sample
ASTM: American Society for Testing and Materials
HASL: Health and Safety Laboratory
MCL: Materials and Chemistry Laboratory, Inc.
MS/MSD: Matrix Spike/Matrix Spike Duplicate
S: Soil Matrix
SM: Standard Methods for the Examination of Water and Wastewater
USEPA: United States Environmental Protection Agency

TABLE 5-1d. SAMPLING PLAN AND QA SAMPLES FOR BEDROCK ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF DUPLICATES[1]	NUMBER OF TRIP BLANKS[2]	NUMBER OF FIELD BLANKS[2]	NUMBER OF EQUIPMENT BLANKS[2]	NUMBER OF MS and MSDs[3]	TOTAL NUMBER OF SAMPLES
Total Metals	Total Metals	USEPA 6010B	S	140	0	0	0	14	7	161
	Total Metals	USEPA 6020	S	140	0	0	0	14	7	161
	Total Mercury	USEPA 7471A	S	140	0	0	0	14	7	161
	Ferrous Iron	SM 3500-Fe B, modified	S	140	0	0	0	14	7	161
	Total Iron	USEPA 6010B	S	140	0	0	0	14	7	161
	Ferric Iron	Calculation (Total - Ferrous)	S	140	0	0	0	14	7	161
Radiological Chemistry	Isotopic Uranium (U-234, U-235, U-238)	HASL-300 Method U-02	S	140	0	0	7	14	7	168
	Isotopic Thorium (Th-228,Th-230, Th-232)	HASL-300 Method U-02	S	140	0	0	7	14	7	168
	Radium-226	USEPA 903.1	S	140	0	0	7	14	7	168
	Radium-228	USEPA 904.0	S	140	0	0	7	14	7	168
Major Minerals and Mineral Reactivity	X-Ray Diffraction	MCL-7712	S	140	0	0	0	14	7	161
	Scanning Electron Microscope with	MCL-7708	S	140	0	0	0	14	7	161
Mineralogical	Cation Exchange Capacity	USEPA 9081	S	140	0	0	0	14	7	161
Cation/Anion	pH	USEPA 9045D	S	140	0	0	0	14	7	161
	Total Organic Carbon	Walkley-Black Procedure	S	140	0	0	0	14	7	161
	Total Alkalinity (carbonate and bicarb)	SM 2320B	S	140	0	0	0	14	7	161
	Cations + Anions	Calculation	S	140	0	0	0	14	7	161

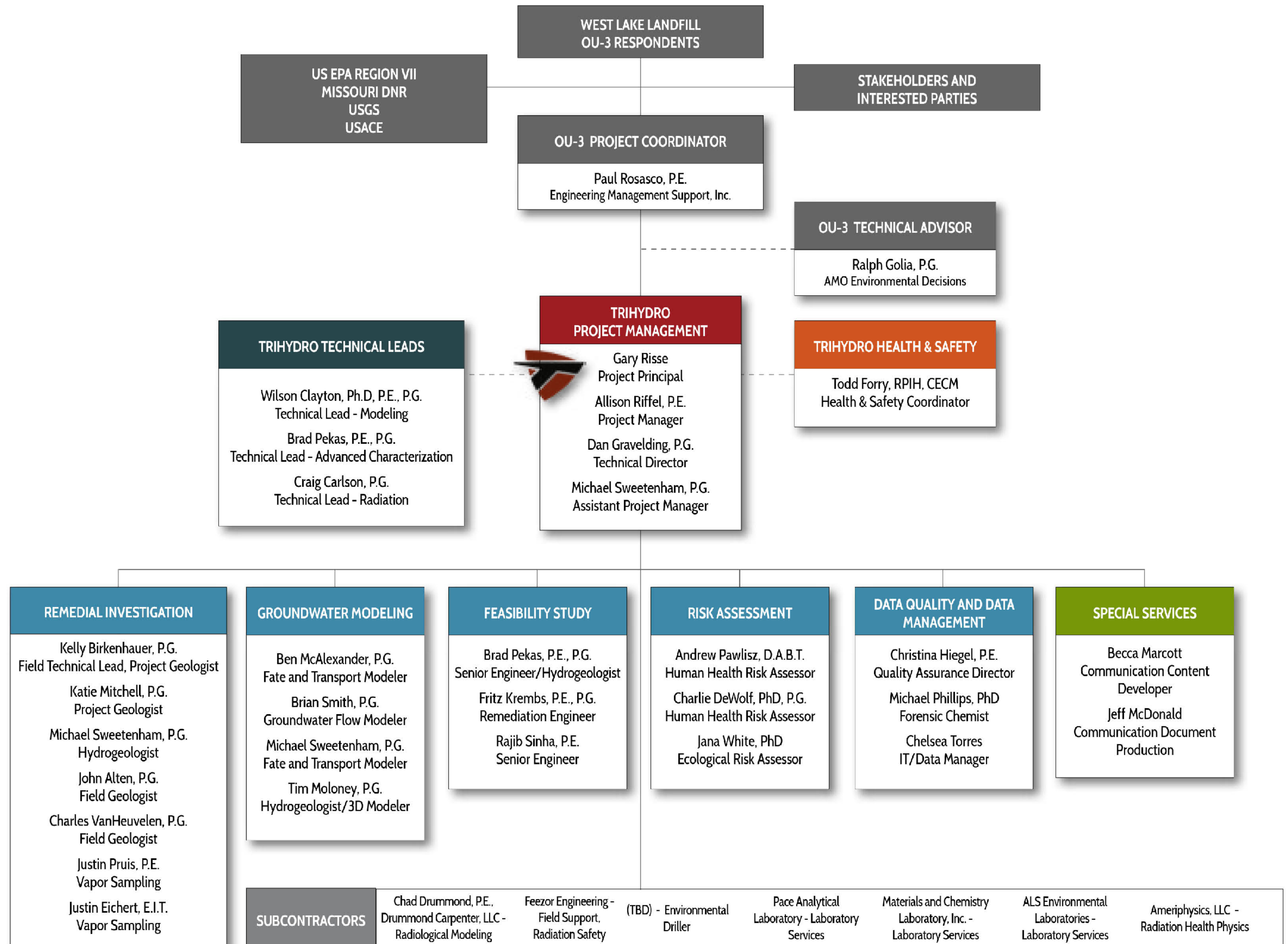
Notes:
[1] One duplicate per 10 samples.
[2] Includes Trip, Equipment, and Field. Trip and Field blank samples will be collected for VOCs only.
[3] Considers an MS and MSD as one sample
S: Soil Matrix
HASL: Health and Safety Laboratory
MCL: Materials and Chemistry Laboratory, Inc.
MS/MSD: Matrix Spike/Matrix Spike Duplicate
SM: Standard Methods for the Examination of Water and Wastewater
USEPA: United States Environmental Protection Agency

TABLE 5-1e. SAMPLING PLAN AND QA SAMPLES FOR INDOOR AIR ANALYSES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN

Category	Analytical Group	Analytical Method	MATRIX	NUMBER OF SAMPLES	NUMBER OF AMBIENT BLANKS[1]	TOTAL NUMBER OF SAMPLES
Volatiles	Volatile Organic Compounds	TO-15	A	8	1	9
Methane	Methane	TO-3 Modified	A	8	1	9
Radon	Radon	USEPA 402-R-92-004	A	8	1	9

Notes:
[1] Ambient blanks will be collected up-gradient of the site.
A: Air
USEPA: United States Environmental Protection Agency

FIGURES



NOTES:

US EPA - UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
DNR - DEPARTMENT OF NATURAL RESOURCES
USGS - UNITED STATES GEOLOGICAL SURVEY
OU-3 - OPERABLE UNIT 3
P.E. - PROFESSIONAL ENGINEER
P.G. - PROFESSIONAL GEOLOGIST
USACE – UNITED STATES ARMY CORP. OF ENGINEERS
RPIH - REGISTERED PROFESSIONAL INDUSTRIAL HYGIENIST
CECM - CERTIFIED ENVIRONMENTAL COMPLIANCE MANAGER
USACE – UNITED STATES ARMY CORP. OF ENGINEERS

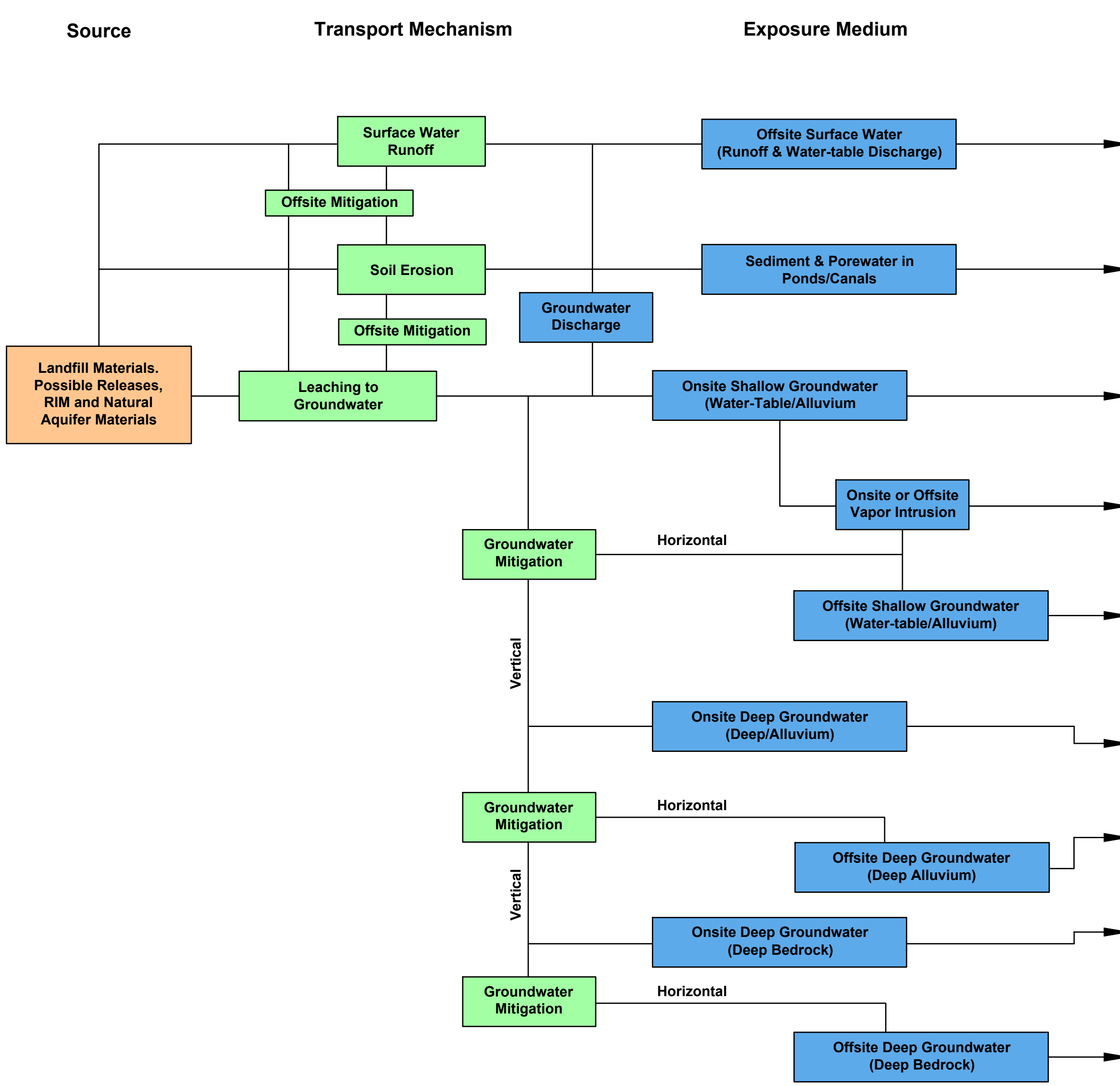
Trihydro CORPORATION
1252 Commerce Drive
Laramie, WY 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE 2-1

PROJECT ORGANIZATIONAL CHART

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN

Drawn By: KEJ	Checked By: MS		Date: 11/11/19	File: 2-1_OrgChart_Fig2-1.mxd



Potential Exposure Routes	Current Potential Receptors									Future Potential Receptors									
	Onsite				Offsite					Onsite				Offsite					
	Onsite Commercial/ Industrial Worker	Onsite Construction/ Utility Worker	Onsite Remediation Worker	Hypothetical Onsite Trespasser	Hypothetical Offsite Resident (Adult/Child)	Offsite Commercial/ Industrial Worker	Offsite Commercial/ Utility Worker	Hypothetical Offsite Recreationalist	Ecological Receptors	Onsite Commercial/ Industrial Worker	Onsite Construction/ Utility Worker	Onsite Remediation Worker	Hypothetical Onsite Trespasser	Hypothetical Offsite Resident	Offsite Commercial/ Industrial Worker	Offsite Commercial/ Utility Worker	Hypothetical Offsite Farmer	Hypothetical Offsite Recreationalist	Ecological Receptors
Incidental Ingestion								PC	PC								PC	PC	PC
Dermal Contact								PC	PC								PC	PC	PC
Inhalation of Volatile Particulate Emissions (Outdoor Air)								PC	PC								PC	PC	PC
Ingestion of Fish Tissue								PC	PC									PC	PC
Direct Radiation								PC	PC								PC	PC	PC
Incidental Ingestion								PC	PC									PC	PC
Dermal Contact								PC	PC									PC	PC
Direct Radiation								PC	PC									PC	PC
Incidental Ingestion		PC	PC	PC							PC	PC	PC						
Dermal Contact		PC	PC	PC							PC	PC	PC						
Inhalation of Volatile Emissions (Outdoor Air)		PC	PC	PC							PC	PC	PC						
Inhalation of Volatile Emissions (Indoor Air)	PC									PC									
Direct Radiation		PC	PC	PC							PC	PC	PC						
Inhalation of Volatile Emissions (Outdoor Air)		PC	PC	PC			PC	PC	PC		PC	PC	PC			PC	PC	PC	PC
Inhalation of Volatile Emissions (Indoor Air)	PC				PC	PC				PC				PC	PC				
Incidental Ingestion							PC									PC	PC		
Dermal Contact							PC									PC	PC		
Inhalation of Volatile Emissions (Outdoor Air)							PC									PC	PC		
Inhalation of Volatile Emissions (Indoor Air)					PC	PC								PC	PC				
Direct Radiation							PC									PC	PC		
Ingestion as Potable Water	PC									PC									
Dermal Contact via Working/Bathing	PC									PC									
Inhalation of Volatile Emissions via Bathing	PC									PC									
Ingestion as Potable Water					PC	PC								PC	PC		PC		
Dermal Contact via Working/Bathing					PC	PC								PC	PC		PC		
Inhalation of Volatile Emissions via Bathing					PC	PC								PC	PC		PC		
Ingestion as Potable Water	PC									PC									
Dermal Contact via Working/Bathing	PC									PC									
Inhalation of Volatile Emissions via Bathing	PC									PC									
Ingestion as Potable Water					PC	PC								PC	PC		PC		
Dermal Contact via Working/Bathing					PC	PC								PC	PC		PC		
Inhalation of Volatile Emissions via Bathing					PC	PC								PC	PC		PC		

NOTES:

1. EXCLUDES WIND TRANSPORT (ASSUMED PART OF OU-1)
2. THE CSM WILL BE UPDATED BASED ON THE RESULTS OF THE PROPOSED OU-3 RI ACTIVITIES PRIOR TO THE BASELINE RISK ASSESSMENT
3. ☐ - NOT APPLICABLE OR NEGLIGIBLE
4. PC - POTENTIALLY COMPLETE EXPOSURE PATHWAY SUBJECT TO FURTHER QUALITATIVE OR QUANTITATIVE ASSESSMENT AND REFINEMENT IN THE BASELINE RISK ASSESSMENT ACCORDING TO THE INFORMATION OBTAINED FROM THE PROPOSED OU-3 RI ACTIVITIES

Trihydro CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE 3-1

PRELIMINARY CONCEPTUAL SITE MODEL

WEST LAKE LANDFILL OU-3, REMEDIAL INVESTIGATION / FEASIBILITIY STUDY WORK PLAN

Drawn By: JLP | Checked By: AR | Scale: NONE | Date: 10/24/19 | File: 63N-RIFSWP_CSMCHART_201910

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