LLNL-TR-849564

Environmental Functional Area
Environment, Safety and Health

Lawrence Livermore National Laboratory
Experimental Test Site, Site 300
S300 Roadway Improvements – 854 Complex
Soil Sampling and Analysis Plan
(June 2023)

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Lawrence Livermore National Laboratory

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ESH-TSD-23-22100

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List of Abbreviations and Acronyms

ALAB	Analytical Laboratory
bgs	below ground surface
CAS	Chemical Abstracts Service
CEL	Consolidated Engineering Laboratories
CoC	Chain of Custody
DMT	Data Management Team
DOE	U.S. Department of Energy
EA	Environmental Analyst
EFA	Environmental Functional Area
EMRL	Environmental Monitoring Radioanalytical Laboratory
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety & Health
GEL	GEL Laboratories LLC
HAZWOPER	Hazardous Waste Operations and Emergency Response
HP	Health Physicist
IST	Integrated Safety Team
LLNL	Lawrence Livermore National Laboratory
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
PID	Photoionization Detector
PMO	Project Management Office
QA/QC	Quality Assurance/Quality Control
RHWM	Radioactive and Hazardous Waste Management
SAP	Sampling and Analysis Plan
SPT	Standard Penetration Test
SSMP	Soils Screening and Management Plan
SSLs	Soil Screening Levels
STLC	Soluble Threshold Limit Concentration
SWPPP	Storm Water Pollution Prevention Plan
TSD	Technical Services Department
TEIMS	The Environmental Information Management System
WCD	Work Control Document
TPH	Total Petroleum Hydrocarbons
VOCs	Volatile Organic Compounds

°C	Celsius
g	gram
µg/L	microgram per liter
mg/kg	milligram per kilogram
mg/L	milligram per liter
ml	milliliter
oz	ounce
pCi/g	picocurie per gram

1 Introduction

This Soil Sampling and Analysis Plan (SAP) was prepared by the Environmental Functional Area (EFA)/Technical Services Department (TSD) of the Environment, Safety & Health (ES&H) Directorate for the Project Management Office (PMO) for the proposed Roadway Improvements Project at the Building 854 Complex (project) (**Figure 1**). The purpose of the SAP was to identify chemicals of concern, describe the procedures for collection and analysis of environmental samples, and evaluation of analytical data (chemical and radiological) to determine management options of excavated soil during project construction. This SAP follows criteria established in Lawrence Livermore National Laboratory's (LLNL) *Soils Screening and Management Plan* (SSMP) (LLNL 2022), which was formalized in accordance with U.S. Environmental Protection Agency (EPA) guidance for developing Data Quality Objectives for environmental data (EPA 2006) and the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (U.S. NRC, U.S. EPA, U.S. DOE, and U.S. DOD 2000). The scope of this SAP is based on preliminary design information provided by PMO.

2 Project Description

The project area is located within the LLNL's Experimental Test Site, Site 300 (Site 300). Site 300 is located off Corral Hollow Road, roughly 15 miles southeast of the City of Livermore and 4 miles southwest of the City of Tracy. Site 300 is comprised of approximately 7,000 acres of largely undeveloped land. Site 300 includes nine Operable Units (OUs). The Building 854 Complex is OU 6 (LLNL 2008).

The Building 854 Complex was used to test the stability of weapons and weapons components under various environmental conditions and mechanical and thermal stresses (LLNL 2008). Analytes detected in soil include volatile organic compounds (VOCs), high explosive compounds, polychlorinated biphenyls (PCBs), dioxins, furans, tritium, and metals. The concentrations for high explosive compounds, metals, and tritium did not pose a risk to human health or the environment; therefore, remediation was not required. The risks and hazards associated with PCBs, dioxins, and furans were mitigated through remediation.

VOCs were detected at levels that posed a threat to human health and the environment. The selected remedy for VOCs in soil included soil vapor extraction and treatment to mitigate inhalation risk for human and ecological receptors, prevent further impacts to ground water, and reduce contaminant concentrations in ground water. The extraction and treatment of soil vapors is an active remediation strategy that permanently removes contaminant mass to meet cleanup standards. Institutional and engineering controls are also implemented to mitigate unacceptable risks to human health. This is performed by controlling excavation activities at designated areas within the OU through a permitting process. The controlled excavation area in OU 6 is outside of the project area.

The project area consists of the existing roadway to access the 854 Complex. Construction of the project will involve earthwork activities associated with the road improvement project which includes

pothole repair and shoulder ditch maintenance. The proposed project will also involve disturbance of materials other than soil, such as asphaltic concrete pavement and road base materials. This SAP assumes that disturbed materials (*e.g.*, soil, asphaltic concrete, and road base) will be disposed of and replaced with new materials.

Since placement of new fill is anticipated, this SAP assumes that excavated materials will not be reused anywhere within the project area and will be disposed of to an appropriate landfill facility. Excavation depths are anticipated to be no deeper than 5 feet from current grade. This SAP proposes to collect environmental samples for analysis where cut is proposed.

3 Conceptual Site Model

LLNL established Site 300 in 1955 to provide a remote location to conduct outdoor tests of explosives. Currently, Site 300 is primarily a non-nuclear explosives and other non-nuclear weapons component test facility. LLNL has been operating Site 300 under the Comprehensive Environmental Response, Compensation, and Liability Act since finalization of the Federal Facilities Act in 1992 between the U.S. Department of Energy (DOE) and EPA Region 9, the Department of Toxic Substances Control, and the Central Valley Regional Water Quality Control Board (LLNL 1992b). Potential constituents of concern listed in the *Site-Wide Record of Decision Lawrence Livermore National Laboratory Site 300* depend on specific locations (*i.e.,* Operable Units), and may include VOCs, dioxins and furans, high explosives compounds, metals, nitrate, perchlorate, polychlorinated biphenyls, silicone oils, tritium, and uranium (LLNL 2008).

To evaluate soil disposition for the proposed project, this SAP proposes to analyze soil samples for VOCs, Total Petroleum Hydrocarbons (TPH), metals, nitrate as nitrogen, perchlorate, high explosives (RDX, HMX, and TNT), and radiological constituents consisting of gross alpha, gross beta, tritium, and radionuclides. Based on historical and current land uses in adjacent areas, this SAP proposes a Tier 2 sampling frequency; therefore, the proposed sample locations shown on **Figure 1** are generally spaced at approximately 172 feet. In addition, this SAP considers historical sample locations PC-B854-040 and PC-B854-041 located within the project area (**Figure 1**). These historical samples were collected in January 2022 and analyzed for gross alpha, gross beta, tritium, metals, and VOCs. Analytes detected above laboratory reporting limits were reported for metals only. All metals detections were below the SSMP screening criteria for reuse. Based on these results, no additional samples are proposed at the locations represented by the historical samples.

4 Organization

The following table identifies the key individuals and/or organizations involved in the project. The description of responsibilities is not comprehensive. For some responsibilities, a person is not identified, but the responsibilities are assigned to a department.

Table 1. Key Personnel Roles and Responsibilities

Role/Department	Name	Responsibilities
PMO Project Manager	Chirag Panchal	• Responsible for reviewing and approving the SAP.
PMO Construction Manager	Jeff Packard	• Ensures subcontractors have received the appropriate training for the project. • Obtains necessary authorizations, such as access to project location and excavation permits.
PMO Design & Engineering Division	Blake Brown, P.E.	• Engineering department lead responsible for providing project design support. The project design will inform the scope of work and the level of effort for the Soils Office.
Integrated Safety Team (IST) Environmental Analyst (EA)	John Dupre	• Responsible for gathering information necessary to define the scope of the soil sampling effort in accordance with the SSMP, including evaluation of historical data (Phase 1 Due Diligence), if any. • Evaluates new analytical data following data validation. Composes memorandum that provides recommendations to the project regarding soil disposition based on analytical data. • Ensures compliance with other environmental and permitting requirements (*e.g.*, SWPPP and waste management). The IST EA is also responsible for requesting additional analysis, if needed.
Soils Office EA and Project Manager	Aaron Felish Reginald Ramirez, P.E.	• Responsible for developing the SAP in coordination with the IST EA. • Coordinates the sampling effort with other departments. • Performs data quality review and validation.
TSD Sampling Technologist	Steve Hall	• Responsible for complying with applicable portions of the SAP and obtaining the required resources to collect soil samples. • Collect soil samples and prepare samples for shipment to the analytical laboratory.
TSD Data Management	Bruce Curtis	• Responsible for reviewing applicable portions of the SAP, entering sample location information into The Environmental Information Management System (TEIMS), and generating Chain of Custodies (CoCs).
Radioactive & Hazardous Waste Management (RHWM)	Claude Cardenas	• Conducts pre-shipment radiological screening of samples. • If necessary, will collect samples if soil is expected to be hazardous or radioactive.
Environmental Monitoring Radioanalytical Laboratory (EMRL)	Richard Bibby	• In-house laboratory that provides radiological analysis. • May also provide technical support for interpretation of radiological data.

Role/Department	Name	Responsibilities
GEL Laboratories (GEL)	Heather Shaffer	• Outside environmental laboratory responsible for providing chemical and radiological testing, including radiological isotope analysis.
Analytical Laboratory (ALAB)	Corazon Madden	• In-house analytical laboratory primarily used for VOC testing.

5 Pre-Drilling Task Roles and Responsibilities

Prior to conducting the proposed drilling and sampling activities, all field sampling personnel, the EA assigned to the project, and the TSD Data Management Team (DMT) are responsible for reviewing the applicable sections of this SAP. Also, prior to the proposed field activities, the following tasks will be completed by PMO.

Line Locating

The PMO Project Manager or their designee, is responsible for marking the proposed boring locations and arranging for locating any underground utilities that may be present in the project area. Proposed boring locations may be adjusted in the field to avoid conflicts but should remain in the general vicinity of the proposed location. Any proposed boring that could not be performed due to a conflict should be communicated back to the Field EA assigned to the project. Prior to drilling activities, all proposed boring locations shall be inspected to verify clearance with underground utilities and to confirm that line locating occurred.

Excavation Permit

The PMO Project Manager or their designee, is responsible for obtaining the excavation permit or any other permits to conduct the drilling on the project and ensuring that the excavation permit has been completed (*e.g.*, reviewed and signed) by the necessary disciplines (*e.g.*, cultural and biological resources) prior to excavation activities.

Scheduling

The PMO Project Manager or their designee, is responsible for scheduling the drilling rig and coordinating sampling with the ES&H team and other staff. The drill rig will be provided by Consolidated Engineering Laboratories (CEL). Geotechnical and environmental samples will be collected by the same drilling contractor. The environmental samples will be preserved and processed by TSD staff, unless noted otherwise in Section 7.1 below.

Site Access and Security

The PMO Project Manager or their designee, is responsible for contacting the LLNL Security Organization and the representative or Area Facility Manager(s), at a minimum, to notify them of the planned drilling operations.

6 Health and Safety

All work will be performed under LLNL's Integrated Safety Management System (DOE 2017). Work will be coordinated through the institutional Work Control Process and ES&H, and TSD Work Control Documents (WCDs) - WCD #100359 - *Water, Air, Monitoring and Analysis Group Field Sampling Activities*.

Only trained personnel shall be permitted to perform surveying or sampling. Outlined below in **Table 2** are the minimum training requirements for field personnel on the project.

Table 2. Training Requirements

Project Role	Training
Drilling/Sampling Personnel	General Employee Radiation Training
Drilling/Sampling Personnel	Valley Fever Awareness Training
Drilling/Sampling Personnel	Site 300 Safety Orientation Training
Drilling/Sampling personnel	Site 300 Competent Worker Training
Drilling/Sampling personnel	40-Hour HAZWOPER(1) Training

(1) HAZWOPER – Hazardous Waste Operations and Emergency Response

All personnel are authorized to pause or stop work at any time when needed to address a safety concern or issue. Prior to commencing field work, all project personnel are required to demonstrate that they are up to date on any project-required training. Safety (tailgate) meetings will be held at the beginning of each day of work to review the scope of work, the safety hazards and controls, radiological controls, and any location, or weather-specific hazards for the day, as well as to discuss any work or safety-related issues and worker feedback.

If debris or suspect items, *e.g.*, drums, boxes, cans, bottles, or discolored, malodourous, or otherwise suspected contaminated soil and debris, are encountered during sampling activities, the samplers will stop all work and immediately notify the ES&H IST EA, Health Physicist (HP) and Industrial Hygienist, and Soils Office. Drilling will resume when the individuals jointly agree that a health risk is not present to the drillers and sampling team by the identified media.

Decontamination procedures will be conducted in accordance with TSD procedures for personnel, tools and equipment, and personal protective equipment. Generally, for radiological contamination, ES&H Health & Safety Technicians will conduct the survey. If radiological contamination is found, the ES&H IST HP will be notified to determine the extent of contamination and direct/supervise appropriate decontamination measures.

7 Work Scope

The proposed drilling, sampling, environmental testing, and data management programs are discussed in the following sections. Evaluation of analytical data, including screening against the Soil Screening Levels (SSLs), will be performed by the Field EA assigned to the project. The proposed boring locations were selected following guidelines in LLNL's SSMP, which is consistent with MARSSIM, and input from CEL, which is PMO's geotechnical consultant.

7.1 Drilling

A total of 7 environmental soil borings (SB-1, SB-3, and SB-5 through SB-9) will be advanced in areas where soil disturbance is proposed (**Figure 1**). All soil borings will be advanced to a target depth of 5 feet below ground surface (bgs). All soil borings will be advanced using a drill rig from ground surface. The drill rig will be operated under the direct supervision of CEL. The

proposed boring identifiers, field markings, boring depths in feet from ground surface, and associated horizontal coordinates are shown in **Table 3**.

Table 3. Proposed Boring Location Identifiers and Horizontal Coordinates[1]

Proposed LLNL Location Identifier	Field Marking[2]	Depth Interval (feet bgs)	Latitude	Longitude
PC-B854-042	SB-1	0 - 5	37.65159739	37.65159739
PC-B854-043	SB-3	0 - 5	37.65189440	37.65189440
PC-B854-044	SB-5	0 - 5	37.65129989	37.65129989
PC-B854-045	SB-6	0 - 5	37.65101968	37.65101968
PC-B854-046	SB-7	0 - 5	37.65122063	37.65122063
PC-B854-047	SB-8	0 - 5	37.65068104	37.65068104
PC-B854-048	SB-9	0 - 5	37.65099457	37.65099457

Final boring locations may be repositioned in the field as needed following underground utility markings and the location of overhead utilities. If drilling refusal is met at a location, the drilling crew will move roughly one to two feet from the original borehole and attempt to advance another boring to the proposed depth. If drilling refusal at the new location occurs, the location will be abandoned – another attempt to drill will not occur (see Section 7.3 for boring abandonment procedures). Logging of the soil lithology will not be performed. The horizontal position of each completed boring (including refusals and redrills) will be recorded using a Trimble device following completion of drilling activities.

7.1.1 Environmental Soil Samples

Soil samples for environmental analyses will be collected using a Modified California or Standard Penetration Test (SPT) split-barrel sampler, in accordance with the procedures contained in ESP-04, Instruction 04 - *Collecting Surface and Subsurface Soil; and Asphalt and/or Concrete Samples*. At each environmental soil boring location (SB-1, SB-3, and SB-5 through SB-9), a discrete sample will be collected at 1.5 feet bgs and a composite sample will be collected by homogenizing available soil from the 5-foot depth interval. The discrete sample will be analyzed for VOCs and the composite sample will be analyzed for TPH in the diesel and motor oil ranges, Title 22 metals, hexavalent chromium, perchlorate, nitrate as nitrogen, high explosives (RDX, HMX, and TNT), gross alpha, gross beta, tritium, and gamma spectroscopy.[3] Additional analysis may be performed depending on analytical results (*e.g.,* soluble metals by Waste Extraction Test or Toxicity Characteristic Leaching Procedure). Compositing will be performed in the field. Any overlying asphalt pavement will be removed prior to drilling to

[1] Horizontal coordinates were estimated from Google Earth.
[2] SB-2 and SB-4 are geotechnical only borings.
[3] Analysis for VOCs is intended to satisfy landfill requirements for daily cover material.

prevent the introduction of asphalt fragments in environmental soil samples which could interfere with analytical testing.

Environmental soil samples will be transported by field personnel (either TSD or RHWM staff) from Site 300 to the Livermore Site for additional radiological scanning and sample preparation (*e.g.*, labeling and preparation of CoCs). None of the samples are anticipated to require special transportation controls for radioactivity. The environmental soil samples will be screened for radioactivity at the Livermore Site by RHWM prior to shipping to an external analytical laboratory.

A portion of the soil collected from each sampling depth interval will be screened for VOCs as follows:

- Wearing nitrile (or appropriate alternative) gloves, place a small amount of soil from each sampling depth interval into a Ziplock®-type, sandwich- or quart-size plastic bag.
- Seal the bag and label the bag with the boring location and approximate depth where the soil was collected.
- Place the sealed bag on a dark surface, *e.g.,* the tailgate of the sampling pickup.
- After roughly 10 to 15 minutes, use a photoionization detector (PID) to check the headspace of the bag for the presence of VOCs.
- Note the PID readings in the daily logbook for the project.
- Empty the soil from the plastic bags into the drilling spoils pile for each boring, before the soil is placed back into the borehole and dispose of the plastic bags.

7.1.2 Geotechnical Soil Samples

Geotechnical soil samples will be collected at SB-1 through SB-8. Soil cores for geotechnical analyses will be collected from the same boring where environmental soil samples are collected. All geotechnical soil cores will be collected in the upper 5 feet of each boring. The geotechnical soil cores will be collected using a Modified California split-barrel sampler sleeved with three 6-inch-long brass liners, or an un-sleeved SPT split-barrel sampler. The brass liners will be sealed using plastic end caps, and the soil core from the SPT sampler will be placed into a plastic zip bag. Bulk soil samples may also be obtained from drilling cuttings, where applicable.

7.2 Laboratory Programs

This section describes the analytical program for environmental soil samples. Testing of environmental soil samples will be performed by GEL, EMRL, RHWM, and ALAB. GEL will analyze samples for TPH, metals, perchlorate, nitrate as nitrogen, chemical explosives, gross alpha, gross beta, tritium, and radiological isotope. EMRL will analyze duplicate samples for gross alpha, gross beta, and tritium. RHWM will screen all environmental soil samples for radioactivity prior to shipping of the samples to GEL. ALAB will analyze samples (including the duplicate sample) for VOCs.

7.2.1 Environmental Testing

Each of the laboratories that will perform the analytical testing is certified by the State of California, under the Environmental Laboratory Accreditation Program, to perform analytical testing. Analytical testing will include TPH, VOCs, metals, perchlorate, nitrate as nitrogen, chemical explosives, gross alpha and beta emitting radionuclides, tritium, and gamma spec analyses.

Based on detected analyte concentrations in the collected samples, additional testing may occur, *i.e.*, specific radiological isotopes will be analyzed for if detected gross alpha or beta activities exceed their respective LLNL SSMP SSL; or, if any detected metal concentration exceeds ten times (10x) its Soluble Threshold Limit Concentration (STLC) the metal or metals will be analyzed for STLC.

All analyses will be requested with a 10-day turn-around-time unless specifically requested by PMO to rush the analyses to meet project schedules. The availability of rush analysis is contingent upon the laboratory's workload and capacity, and there may be instances where it is unavailable.

Appendix A is a listing of sample identifiers and proposed analytical testing groups and laboratories for the soil samples, and the trip blank.

Appendix B is a listing of the analytical groups proposed for the collected samples, types of containers to be used, preservative (if any), and holding times for each of the proposed analytical groups.

Appendix C is a listing of the proposed analytical testing groups, the analytes included within each testing group and their Chemical Abstracts Service (CAS) numbers, and project reporting limits.

7.2.2 Geotechnical Testing

The geotechnical investigation involves laboratory testing of soil cores for foundation recommendations. Soil cores for geotechnical testing will remain at Site 300 until radiological data have been reviewed and validated (see Section 7.7 for validation process). The radiological data will be screened against screening levels established in the SSMP or the volumetric release criteria, as applicable. Once cleared for transportation on public roads, the geotechnical soil cores will be transported by CEL from Site 300 to the geotechnical laboratory. The results of geotechnical analyses will be provided directly by CEL to PMO.

7.3 Borehole Abandonment for Environmental and Geotechnical Borings

Once the total depth is achieved and sampling is completed, drilling refusal is met, or further drilling has been stopped by the HP, each borehole will be backfilled with the drilling cuttings and compacted in-place. Any paved surface drilled through will be patched using asphalt patch

or concrete. Therefore, drilling activities are not anticipated to generate soil waste. Abandonment of all boring locations will be performed under the direct supervision of CEL.

7.4 Quality Control

A minimum of ten percent (10%) duplicate sampling will occur on the project in accordance with the SSMP. A duplicate soil sample for each analysis will be collected at SB-1. A duplicate sample may be collected elsewhere if a duplicate sample cannot be collected at SB-1 (*e.g.,* poor recovery or refusal). Duplicate sample results will be treated as environmental field data. In other words, duplicate sample results will also be screened against SSLs. One trip blank will be included per sample cooler/shipping container sent to ALAB.

7.5 Radiological Screening

7.5.1 Livermore Site Transportation Screening

Prior to drilling, the Soils Office EA will look in TEIMS for radiological data available at and near the project area. As stated above, the radiological activity at the project area is not suspected at a level that would require special transportation requirements. The geotechnical core samples will temporarily be stored at Site 300 until radiological data is received from GEL showing that the samples do not have an anthropogenic radiological signature.

7.5.2 Contract Laboratory Shipping Screening

After the environmental soil samples are transported to the Livermore Site, one of the sample containers from each boring location – normally a 125-milliliter polyethylene bottle, will be delivered to RHWM laboratory for radiological screening. RHWM will scan the soil for radioactivity before the soil sample containers for GEL are shipped pursuant to ES&H ESP-04, Instruction 07 - *Submitting Samples to the Analytical Laboratory*. Radiological screening by RHWM normally takes one business day.

7.6 Shipping

Post radiological screening, the environmental soil samples and trip blank samples will be packaged and shipped to the analytical laboratory or laboratories following the guidelines outlined in ES&H ESP-04, Instruction 07.

7.7 Data Validation and Data Management

All received environmental analytical results will undergo data validation. Data validation will be performed by the Soils Office.

Management of environmental data for the project will be pursuant to ES&H ESP-04 – *Site Evaluation Procedure*; and begins with the entry of the analytical requirements into TEIMS for preparation of CoC documents and sample labels. As sampling proceeds, CoC information is entered in TEIMS. Field notes are retained in the project file.

Laboratory analytical data is delivered to the TSD DMT and the Soils Office in electronic format. The Soils Office will complete a Quality Assurance/Control (QA/QC) validation review of the laboratory data and provides the results to the TSD DMT for upload into TEIMS and Universal Content Management. The laboratory analytical data is released to the ES&H IST Field EA after QA/QC validation for screening and development of recommendations for soil disposition, which are then implemented by PMO.

References

DOE (U.S. Department of Energy). 2017. *Integrated Safety Management System Manual*. Washington D.C.: DOE. M 450.2.

EPA (U.S. Environmental Protection Agency). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. Washington D.C.: EPA. QA/G-4, EPA/240/B-06/001.

LLNL (Lawrence Livermore National Laboratory). 2008. *Site-Wide Record of Decision Lawrence Livermore National Laboratory Site 300*, Livermore, CA: LLNL. UCRL-AR-236665.

LLNL. 2020a. *ESP-04, Site Evaluation Procedure*.

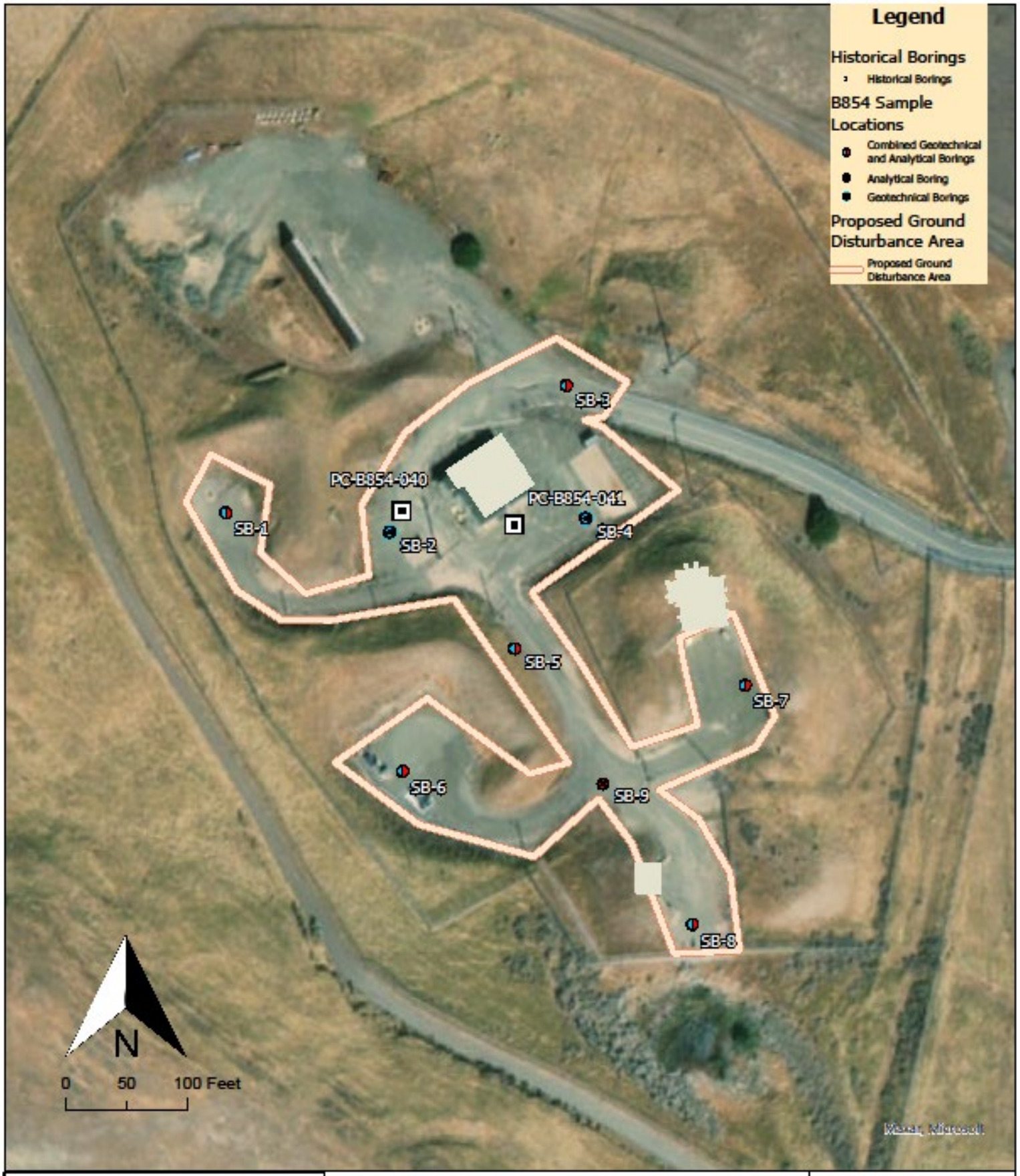
LLNL. 2020b. *ESP-04, Instruction 07 - Submitting Samples to the Analytical Laboratory*.

LLNL. 2022. *Soils Screening and Management Plan.* Livermore, CA: LLNL. LLNL-AR-755337-REV-2-21833.

LLNL. 1988. *Federal Facility Agreement Under CERCLA Section 120 between The United States Environmental Protection Agency and The United States Department of Energy and The California Department of Health Services and The California Regional Water Quality Control Board.*

U.S. NRC, U.S. EPA, U.S. DOE, and U.S. DOD (U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, U.S. Department of Energy, and U.S. Department of Defense). 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).* Revision 1. NUREG-1575, Rev.1, EPA-402-R-97-016, Rev. 1, DOE/EH-0624, Rev. 1.

Figure



Lawrence Livermore National Laboratory

Proposed Sampling Locations
Site 300 Roadway Improvements
854 Complex

Figure 1

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Map Drawn By: Emily Welk, TDS. Project folder: Z:\TSD\Construction Projects\B854 Pavement Rehab

Appendix A
Proposed Analytical Groups by Boring and Depth, and Laboratory

Proposed Analytical Groups by Boring and Depth, and Laboratory

LLNL Sample Identifier	Field Marking	Sample Depth Interval (feet below ground surface)	Analytical Group	RHWM - RHWMSCAN	GEL - EM8015:DIESEL	GEL - EM8015:MOTOROIL	GEL - TTLCMET5:ALL	GEL – E300.0:PERC	GEL – E8330:RHT	GEL - E300.0:NO3-N	GEL - GAMMASPEC	GEL - GABWASTE:ALL	GEL - RADWG:H3	EMRL - EMRLE900	EMRL - EMRLE906	ALAB - W8260MODTC:ALL	ALAB - W8021MOD:ALL	ALAB - TTLCMET5:ALL
Solids - Soil																		
PC-B854-042-01-01-SOT-1.5U	SB-1	1.5	W8260MODTC:ALL													•		
PC-B854-042-01-02-SOTD-1.5U	SB-1	1.5	W8260MODTC:ALL													•		
PC-B854-042-01-03-SC-5U	SB-1	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
PC-B854-042-01-04-SCD-5U	SB-1	0 - 5	EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, EMRLE900, EMRLE906		•	•	•	•	•	•	•			•	•			
PC-B854-043-01-01-SOT-1.5U	SB-3	1.5	W8260MODTC:ALL													•		
PC-B854-043-01-02-SC-5U	SB-3	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
PC-B854-044-01-01-SOT-1.5U	SB-5	1.5	W8260MODTC:ALL													•		
PC-B854-044-01-02-SC-5U	SB-5	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
PC-B854-045-01-01-SOT-1.5U	SB-6	1.5	W8260MODTC:ALL													•		
PC-B854-045-01-02-SC-5U	SB-6	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
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PC-B854-046-01-02-SC-5U	SB-7	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
PC-B854-047-01-01-SOT-1.5U	SB-8	1.5	W8260MODTC:ALL													•		
PC-B854-047-01-02-SC-5U	SB-8	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
PC-B854-048-01-01-SOT-1.5U	SB-9	1.5	W8260MODTC:ALL													•		
PC-B854-048-01-02-SC-5U	SB-9	0 - 5	RHWMSCAN, EM8015:DIESEL, EM8015:MOTOROIL, TTLCMET5:ALL, E300.0:PERC, E8330:RHT, E300.0:NO3-N, GAMMASPEC, GABWASTE:ALL, RADWG:H3	•	•	•	•	•	•	•	•	•	•					
Aqueous																		
Trip Blank	--	--	W8021MOD:ALL														•	

Notes:

Highlighted cells represent duplicate samples.

Proposed Analytical Groups by Boring and Depth, and Laboratory

See Appendix B for the analytical method associated with an analysis code.
See Appendix C for the analytical suite associated with an analytical method.

Appendix B
Analytical Groups and Sampling Requirements

Analytical Groups and Sampling Requirements

LLNL Analysis Code	Analytical Method	Minimum Sample Volume	Container	Preservative	Maximum Holding Time
SOLIDS					
W8260MODTC:ALL (Total VOCs)	EPA 8260B	5 g	3 each pre-weighed VOAs, 60 g amber	4 °C ± 2 °C	48 hours
EM8015:DIESEL (TPH as Diesel)	EPA 8015B	50 g	8 oz glass jar	4 °C ± 2 °C	14 days
EM8015:MOTOROIL (TPH as Oil)	EPA 8015B	50 g	8 oz glass jar	4 °C ± 2 °C	14 days
STLCMETFCR:ALL (Soluble Metals)	EPA 6010B Cr^{+6} EPA 7196A Mercury EPA 7470/7471	50 g	8 oz polyethylene	none	90 days
W8290 (Dioxins)	EPA 8290A	50 g	8 oz glass jar	4 °C ± 2 °C	7 days
TTLCMET5:ALL (Total Metals)	EPA 6010 or 6020 Cr^{+6} EPA 7196A Mercury EPA 7470	50 g	4 oz polyethylene	none	180 days Cr^{+6} – 30 days Hg – 28 days
GABWASTE:ALL (Gross Alpha & Gross Beta)	EPA 900.0	20 g	4 oz polyethylene	none	180 days

Analytical Groups and Sampling Requirements

LLNL Analysis Code	Analytical Method	Minimum Sample Volume	Container	Preservative	Maximum Holding Time
EMRLE 900 (Gross Alpha & Gross Beta)	EPA 900.0	20 g	4 oz polyethylene	none	180 days
RADWG:H3 (Tritium)	EPA 906.0	20 g	4 oz polyethylene	none	180 days
EMRLE 906 (Tritium)	EPA 906.0	20 g	4 oz polyethylene	none	180 days
GAMMASPEC:ALL	Gamma Spec	200 g	250 ml polyethylene	None	180 days
TUPA:ALL	Alpha Spec	200 g	16 oz polyethylene	none	180 days
LLNL Analysis Code	**Analytical Method**	**Minimum Sample Volume**	**Container**	**Preservative**	**Maximum Holding Time**
AQUEOUS					
W8021MOD:ALL	EPA 8260B	40 ml	60 g amber VOA	4 °C ± 2 °C	48 hours

Notes:

g - gram
oz – ounce or ounces
ml – milliliter or milliliters

Appendix C
Analytical Groups and Included Analytes

Analytical Groups and Included Analytes

Soil

W8260MODTC – Volatile Organic Compounds

EPA Method 8260B

Analyte	CAS Number	Project Reporting Limit (mg/kg) [1]
1,1,1,2-Tetrachloroethane	630-20-6	0.005
1,1,1-Trichloroethane	71-55-6	0.005
1,1,2,2-Tetrachloroethane	79-34-5	0.005
1,1,2-Trichloroethane	79-00-5	0.005
1,1-Dichloroethane	75-34-3	0.005
1,1-Dichloroethene	75-35-4	0.005
1,2-Dibromoethane	106-93-4	0.005
1,2-Dichlorobenzene	95-50-1	0.005
1,2-Dichloroethane	107-06-2	0.005
1,2-Dichloroethene (total)	540-59-0	0.005
1,2-Dichloropropane	78-87-5	0.005
1,2,3-Trichloropropane	96-18-4	0.005
1,3-Dichloropropene	542-75-6	0.005
1,3-Dichlorobenzene	541-73-1	0.005
1,4-Dichlorobenzene	106-46-7	0.005
2-Butanone (MEK)	78-93-3	0.005
Acetone	67-64-1	0.005
Benzene	71-43-2	0.005
Benzyl Chloride	100-44-7	0.005
Bromobenzene	108-36-1	0.005
Bromodichloromethane	75-27-4	0.005
Bromoform	75-25-2	0.005
Bromomethane	74-83-9	0.005
Carbon Tetrachloride	56-23-5	0.005
Chlorobenzene	108-90-7	0.005
Chloroethane	75-00-3	0.005
Chloroform	67-66-3	0.005
Chloromethane	74-87-3	0.005

Analytical Groups and Included Analytes

W8260MODTC – Volatile Organic Compounds (cont'd)

EPA Method 8260B

Analyte	CAS Number	Project Reporting Limit (mg/kg) (1)
cis-1,2-Dichloroethene	156-59-2	0.005
cis-1,3-Dichloropropene	10061-01-5	0.005
Dibromochloromethane	124-48-1	0.005
Dibromomethane	74-95-3	0.005
Dichlorodifluoromethane	75-71-8	0.005
Ethylbenzene	100-41-4	0.005
Freon 113	76-13-1	0.005
Methyl isobutyl ketone	108-10-1	0.005
Methyl tert-butyl ether	1634-04-4	0.005
Methylene Chloride	75-09-2	0.005
Styrene	100-42-5	0.005
tert-Butyl alcohol	75-65-0	0.05
Tetrachloroethene	127-18-4	0.005
Toluene	108-88-3	0.005
m-Xylene	108-38-3	0.005
o-Xylene	95-47-6	0.005
p-Xylene	106-42-3	0.005
Total Xylene Isomers	1330-20-7	0.005
trans-1,2-Dichloroethene	156-60-5	0.005
trans-1,3-Dichloropropene	542-75-6	0.005
Trichloroethene	79-01-6	0.005
Trichlorofluoromethane	75-69-4	0.005
Vinyl Chloride	75-01-4	0.005

Notes: (1) mg/kg – milligram per kilogram

Analytical Groups and Included Analytes

EM8015:DIESEL - Total Petroleum Hydrocarbons as Diesel

EPA Method M8015

Analyte	CAS Number	Project Reporting Limit (mg/kg) (1)
TPH as Diesel	68476-34-6	10

Notes: (1) mg/kg – milligram per kilogram

EM8015:MOTOROIL - Total Petroleum Hydrocarbons as Motor Oil

EPA Method M8015

Analyte	CAS Number	Project Reporting Limit (mg/kg) (1)
TPH as Motor Oil	'---	10

Notes: (1) mg/kg – milligrams per kilogram

STLCMETFCR:ALL – STLC Metals

EPA Method 6010 (Mercury – 7470/7471) (Chrome VI - 7196A)

Analyte	CAS Number	Project Reporting Limit (mg/L) (1)
Antimony	7440-36-0	0.1
Arsenic	7740-38-2	0.3
Barium	7440-39-3	0.05
Beryllium	7440-41-7	0.05
Cadmium	7440-43-9	0.05
Chromium	7440-47-3	0.05
Hexavalent Chromium	18540-29-9	
Cobalt	7440-48-4	0.05
Copper	7440-50-8	0.1
Lead	7439-92-1	0.1
Mercury	7439-97-6	0.002
Molybdenum	7439-93-7	0.1
Nickel	7440-02-0	0.05
Selenium	7782-49-2	0.3
Silver	7440-22-4	0.05
Thallium	7440-28-0	0.2

Analytical Groups and Included Analytes

Analyte	CAS Number	Project Reporting Limit (mg/L) (1)
Vanadium	7440-62-2	0.05
Zinc	7440-66-6	0.1

Notes: (1) mg/L – milligram per liter

TTLCMET5:ALL – TTLC Metals
EPA Method 6010 or 6020 (Mercury - 7471) (Chrome VI - 7196A)

Analyte	CAS Number	Project Reporting Limit (mg/kg) (1)
Antimony	7440-36-0	1.0
Arsenic	7740-38-2	1.0
Barium	7440-39-3	0.4
Beryllium	7440-41-7	0.1
Cadmium	7440-43-9	0.2
Chromium	7440-47-3	0.5
Hexavalent Chromium	18540-29-9	0.4
Cobalt	7440-48-4	0.2
Copper	7440-50-8	0.2
Lead	7439-92-1	0.4
Mercury	7439-97-6	0.01
Molybdenum	7439-93-7	0.2
Nickel	7440-02-0	0.4
Selenium	7782-49-2	3.0
Silver	7440-22-4	0.5
Thallium	7440-28-0	0.4
Vanadium	7440-62-2	0.5
Zinc	7440-66-6	2.0

Notes: (1) mg/kg – milligram per kilogram

E300.0:PERC - Perchlorate
EPA 314.0

Analyte	CAS No.	Project Reporting Limit (µg/kg)(1)
Perchlorate	14797-73-0	6.0

Analytical Groups and Included Analytes

Notes: (1) µg/kg – micrograms per kilogram

E300.0:NO3-N - Nitrate
EPA 300.0

Analyte	CAS No.	Project Reporting Limit (µg/kg)(1)
Nitrate	14797-55-8	5.0

Notes: (1) µg/kg – micrograms per kilogram

E8330:RHT – RDX, HMX & TNT
EPA 8330

Analyte	CAS No.	Reporting Limit(1) (mg/kg)(2)
HMX (Octogen)	2691-41-0	0.5
RDX (Cyclonite)	121-82-4	0.5
TNT (2,4,6-Trinitrotoluene)	118-96-7	1.0

Notes: (1) Values listed are GEL's reporting limits
(2) mg/kg – milligrams per kilogram

GABWASTE:ALL / EMRLE 900 – Gross Alpha & Gross Beta
EPA Method 900.0

Analyte	CAS Number	Project Reporting Limit (pCi/g) (1)
Gross Alpha	12587-46-1	1.0
Gross Beta	12587-47-2	3.0

Notes: (1) pCi/g – picocurie per gram

RADWG:H3 / EMRLE 906 - Tritium
EPA Method 906.0

Analyte	CAS Number	Project Reporting Limit (pCi/g) (1)

Analytical Groups and Included Analytes

Tritium	10028-17-8	2.0

Notes: (1) pCi/g – picocurie per gram

GAMMSPEC:ALL

Gamma Spec

Analyte	CAS Number	Project Reporting Limit (pCi/g) (1)
Actinium 228	0215	Best Achievable
Americium 241	0323	Best Achievable
Antimony 124	0403	Best Achievable
Antimony 125	0401	Best Achievable
Beryllium 7	0901	Best Achievable
Bismuth 212	1375	Best Achievable
Bismuth 214	1380	Best Achievable
Cerium 139	1854	Best Achievable
Cerium 141	1858	Best Achievable
Cerium 144	1859	Best Achievable
Cesium 134	1861	Best Achievable
Cesium 136	1863	Best Achievable
Cesium 137	1860	Best Achievable
Chromium 51	2456	Best Achievable
Cobalt 56	2629	Best Achievable
Cobalt 57	2627	Best Achievable
Cobalt 58	2628	Best Achievable
Cobalt 60	2626	Best Achievable
Europium 152	4726	Best Achievable
Europium 154	4727	Best Achievable
Europium 155	4728	Best Achievable
Iron 59	5355	Best Achievable
Lead 210	5456	Best Achievable
Lead 212	5458	Best Achievable
Lead 214	5459	Best Achievable
Manganese 54	5555	Best Achievable

Analytical Groups and Included Analytes

Mercury 203	5605	Best Achievable
Neodymium 147	5841	Best Achievable
Neptunium 237	5844	Best Achievable
Niobium 94	5879	Best Achievable
Potassium 40	7051	Best Achievable
Radium 228	7252	Best Achievable
Ruthenium 106	7470	Best Achievable
Silver 110m	7810	Best Achievable
Sodium 22	7860	Best Achievable
Thallium 208	8301	Best Achievable
Thorium 230	8304	Best Achievable
Thorium 234	8307	Best Achievable
Uranium 235 (in activity)	8858	Best Achievable
Uranium 238 (in activity)	8862	Best Achievable
Yttrium 88	9005	Best Achievable
Zinc 65	9051	Best Achievable
Zirconium 95	9060	Best Achievable
Barium 133	0482	Best Achievable
Barium 140	0485	Best Achievable
Iridium 192	5346	Best Achievable
Neptunium 239	5845	Best Achievable
Promethium 144	7064	Best Achievable
Promethium 146	7066	Best Achievable
Tin 113	8313	Best Achievable

TUPA:ALL
Alpha Spec

Analyte	CAS Number	Project Reporting Limit (pCi/g) [1]
Americium 241	14596-10-2	Best Achievable
Americium 243	14993-75-0	Best Achievable
Plutonium 238	13981-16-3	Best Achievable
Plutonium 239+240	'---	Best Achievable

Analytical Groups and Included Analytes

Thorium 230	14269-63-7	Best Achievable
Thorium 228	14274-82-9	Best Achievable
Thorium 232	7440-29-1	Best Achievable
Uranium 235	15117-96-1	Best Achievable
Uranium 238	7440-61-1	Best Achievable

Notes: (1) pCi/g – picocurie per gram

Analytical Groups and Included Analytes

Aqueous

W8260MOD:ALL – Volatile Organic Compounds

EPA Method 8260B

Analyte	CAS Number	Project Reporting Limit (µg/L) [1]
1,1,1,2-Tetrachloroethane	630-20-6	1.0
1,1,1-Trichloroethane	71-55-6	1.0
1,1,2,2-Tetrachloroethane	79-34-5	1.0
1,1,2-Trichloroethane	79-00-5	1.0
1,1-Dichloroethane	75-34-3	1.0
1,1-Dichloroethene	75-35-4	1.0
1,2-Dichlorobenzene	95-50-1	1.0
1,2-Dichloroethane	107-06-2	1.0
1,2-Dichloroethene (total)	540-59-0	2.0
1,2-Dichloropropane	78-87-5	1.0
1,2,3-Trichloropropane	96-18-4	1.0
1,3-Dichloropropene	542-75-6	2.0
1,3-Dichlorobenzene	541-73-1	1.0
1,4-Dichlorobenzene	106-46-7	1.0
2-Butanone (MEK)	78-93-3	5.0
Acetone	67-64-1	5.0
Benzene	71-43-2	1.0
Benzyl Chloride	100-44-7	5.0
Bromobenzene	108-36-1	1.0
Bromodichloromethane	75-27-4	1.0
Bromoform	75-25-2	1.0
Bromomethane	74-83-9	1.0
Carbon Tetrachloride	56-23-5	1.0
Chlorobenzene	108-90-7	1.0
Chloroethane	75-00-3	1.0
Chloroform	67-66-3	1.0
Chloromethane	74-87-3	1.0

Analytical Groups and Included Analytes

W8260MOD:ALL – Volatile Organic Compounds (cont'd)

EPA Method 8260B

Analyte	CAS Number	Project Reporting Limit (µg/L) (1)
cis-1,2-Dichloroethene	156-59-2	1.0
cis-1,3-Dichloropropene	10061-01-5	1.0
Dibromochloromethane	124-48-1	1.0
Dibromomethane	74-95-3	1.0
Dichlorodifluoromethane	75-71-8	1.0
Ethylbenzene	100-41-4	1.0
Freon 113	76-13-1	5.0
Methyl tert-butyl ether	1634-04-4	1.0
Methylene Chloride	75-09-2	5.0
Styrene	100-42-5	1.0
Tetrachloroethene	127-18-4	1.0
Toluene	108-88-3	1.0
m-Xylene	108-38-3	2.0
o-Xylene	95-47-6	1.0
p-Xylene	106-42-3	2.0
Total Xylene Isomers	1330-20-7	3.0
trans-1,2-Dichloroethene	156-60-5	1.0
trans-1,3-Dichloropropene	542-75-6	1.0
Trichloroethene	79-01-6	1.0
Trichlorofluoromethane	75-69-4	1.0
Vinyl Chloride	75-01-4	1.0

Notes: (1) µg/L – microgram per liter