Cove Mesa II Erosion and Removal Time-Critical Action

FINAL

Air Monitoring and Soil Scanning Work Plan

Response, Assessment, and Evaluation Services (RAES)

Contract No. EP-S9-17-03

Task Order 0021

August 26, 2019

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

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ACRONYMS AND ABBREVIATIONS

µg/m^3	Microgram per cubic meter
µm	Micrometer
§	Section
AHA	Activity hazards analyses
AEC	Atomic Energy Commission
ALARA	As low as reasonably achievable
ANSI/HPS	American National Standards Institute - Health Physics Society
ARAR	Applicable or relevant and appropriate requirements
AUM	Abandoned uranium mine
BTV	Background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHP	Certified health physicist
Clawson	Clawson Excavation
CLP	Contract Laboratory Program
CO	Contracting Officer
COPC	Contaminants of potential concern
cpm	Counts per minute
CSM	Conceptual site model
CY	Cubic yards
DBA	Database administrator
DMP	Data Management Plan
DOE	U.S. Department of Energy
DQO	Data quality objectives
EDD	Electronic data deliverable
EE/CA	Engineering Evaluation/Cost Analysis
ERG	Environmental Restoration Group, Inc.
ERS	Emergency Response Section
FGDC	Federal Geographic Data Committee
FSP	Field Sampling Plan
FUSRAP	Formerly Utilized Sites Remedial Action Program
GIS	Geographic information system
GPS	Global positioning system
HASP	Health and Safety Plan
HPIC	High Pressure Ionization Chamber

ACRONYMS AND ABBREVIATIONS (CONTINUED)

IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
iiná bá	iiná bá, Inc.
LPM	Liters per minute
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MDC	Minimum detectable concentration
mg/m^3	Milligram per cubic meter
mm	Millimeter
NAAQS	U.S. National Ambient Air Quality Standards
NAMLRP	Navajo Nation Abandoned Mine Lands Reclamation Program
NAUM	Navajo-area abandoned uranium mine
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
Neptune	Neptune and Company
NNEPA	Navajo Nation Environmental Protection Agency
NORM	Naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Commission Regulation
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PE	Professional engineer
PEL	Permissible exposure limits
PO	Project Officer
PTFE	Polytetrafluoroethylene
QA	Quality assurance
QC	Quality control
QAPP	Quality Assurance Project Plan
R	Roentgen
Ra-226	Radium-226
RAES	Response, Assessment and Evaluation Services
ROPC	Radionuclide of potential concern
RPP	Radiation Protection Program
RSE	Removal Site Evaluations
RSSI	Radiation site survey investigation
SAP	Sampling and Analysis Plan
SERAS	Scientific, Engineering, Response & Analytical Services
SOP	Standard operating procedure

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SOW	Scope of work
SWP	Safe work practice
T&E	Threatened and endangered
TCRA	Time critical removal action
Tetra Tech	Tetra Tech, Inc.
TOCOR	Task Order Contract Officer's Representative
TO 0021	Task Order 0021
TSG	TerraSpectra Geomatics
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	U.S. Army Corps of Engineers
USEPA	U. S. Environmental Protection Agency
USGS	U.S. Geological Survey
Weston	Weston Solutions, Inc.
WGS	World Geodetic System
WRCC	Western Regional Climate Center
yd^3	Cubic yards
XRF	X-ray fluorescence

1.0 INTRODUCTION

1.1 PURPOSE

Under Task Order 0021 (TO 0021), the U.S. Environmental Protection Agency (USEPA) tasked Tetra Tech, Inc. (Tetra Tech) to develop a work plan for conducting air monitoring and gamma scanning of soils to support the USEPA Cove Mesa II Erosion Repair and Removal Time-Critical Removal Action (Mesa II TCRA) at the Mesa II abandoned uranium mine (AUM) sites within the Northern Agency Region of the Navajo Nation. Tetra Tech team members iiná bá, Inc. (iiná bá) and Environmental Restoration Group, Inc. (ERG) are providing local experience, logistics, and radiological air monitoring experience. USEPA is the Lead Agency and the Navajo Nation Environmental Protection Agency (NNEPA) is the Supporting Agency and, together, they will be referred to as the "Agencies." The air monitoring and soil scanning will be conducted at the Mesa II AUM site within the Cove Chapter of the Navajo Nation in northeastern Arizona. The Mesa II AUM is being addressed as a USEPA time-critical action. This work was assigned under TO 0021 of the Response, Assessment, and Evaluation Services (RAES) contract (EP-S9-17-03).

This Air Monitoring and Soil Scanning Work Plan describes the objectives, methods, and procedures for conducting air monitoring and gamma scanning of soils at the Mesa II AUM site. This work plan will comply with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Title 40 *Code of Federal Regulations* (40 CFR) Section (§) 300.410-300.415, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, and *Multi-Agency Radiation Site Survey Investigation Manual* (MARSSIM) (USEPA 2000b).

This Air Monitoring and Soil Scanning Work Plan and its appendices present background information, data quality objectives (DQO), data gaps, sampling design rationale, quality assurance (QA) and quality control (QC), and requirements for sampling and analysis. The primary objective of the air monitoring and soil scanning at the Mesa II AUM site is to ensure that no contaminated soil migrates outside the exclusion zone as dust and that any contaminated soil in the path of the Mesa II TCRA is identified before the soil is disturbed so that it can be avoided or handled appropriately by USEPA and its contractor, Clawson Excavation (Clawson).

1.2 REGULATORY FRAMEWORK

The Formerly Utilized Sites Remedial Action Program (FUSRAP) focuses on protecting human health and the environment; the cleanup of FUSRAP sites is primarily accomplished pursuant to CERCLA and its implementing regulations in the NCP. The cleanup of the AUM sites within the Navajo Nation will comply with CERCLA and the NCP. The lead agency for the cleanup of AUM sites on the Navajo Nation is USEPA Region 9. Pursuant to CERCLA § 126 and the NCP at 40 CFR § 300.515(b), the governing body of an Indian tribe is treated substantially the same way as states. Therefore, NNEPA is the support agency, providing guidance on cleanup pursuant to tribal law. In addition to NNEPA, the Diné Uranium Remediation Advisory Commission, which was formed on January 25, 2018, to study and reach conclusions about the impacts of uranium mining and uranium processing on the Navajo Nation, will make recommendations regarding cleanup of the AUM sites pursuant to tribal law.

1.2.1 CERCLA

CERCLA and the NCP provide a framework for investigating, identifying, and addressing releases of hazardous substances.

CERCLA §121(d) and the NCP at 40 CFR § 300.415(j) require that CERCLA response actions attain (or justify the waiver of) federal environmental laws and regulations, or more stringent state laws and regulations, determined to be legally applicable to the hazardous substance, pollutant, or contaminant or relevant and appropriate under the circumstances of the release (referred to as applicable or relevant and appropriate requirements [ARAR]). The NCP at 40 CFR § 300.5 defines states to include Indian tribes. Therefore, tribal law that meets the requirements for consideration as ARARs will be evaluated similarly to state laws.

1.2.2 Navajo Nation Code

The Navajo Nation has promulgated requirements in the Navajo Nation Code, including the Navajo Nation Environmental Policy Act in Title 4, Chapter 9. The Navajo Nation Environmental Policy Act, and other Navajo Nation environmental requirements that meet the criteria for evaluation as tribal ARARs, will be evaluated when it is determined that a removal or remedial action is necessary.

1.3 WORK PLAN ORGANIZATION

This work plan presents the information needed to perform air monitoring and soil scanning at the Mesa II site and is organized as follows:

- Section 1.0 provides the introduction and background, including a summary of previous investigations, scope of work and objectives, site identification and location, and physical setting.
- Section 2.0 presents an overview on the project management, field management approach, and technical approach.
- Section 3.0 presents an overview of the field sampling activities for the air monitoring and soil scanning.
- Section 4.0 presents a discussion on health and safety.
- Section 5.0 presents a discussion on data quality assurance.
- Section 6.0 outlines the project schedule for field activities and report submittals.
- Section 7.0 summarizes the works cited in this work plan.

Additional information is presented in individual reports included in three appendices to this work plan, which are as follows:

- Appendix A – Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP)
- Appendix B – Site-Specific Data Management Plan (DMP)

- Appendix C – Health and Safety Plan (HASP)

1.4 HISTORICAL BACKGROUND

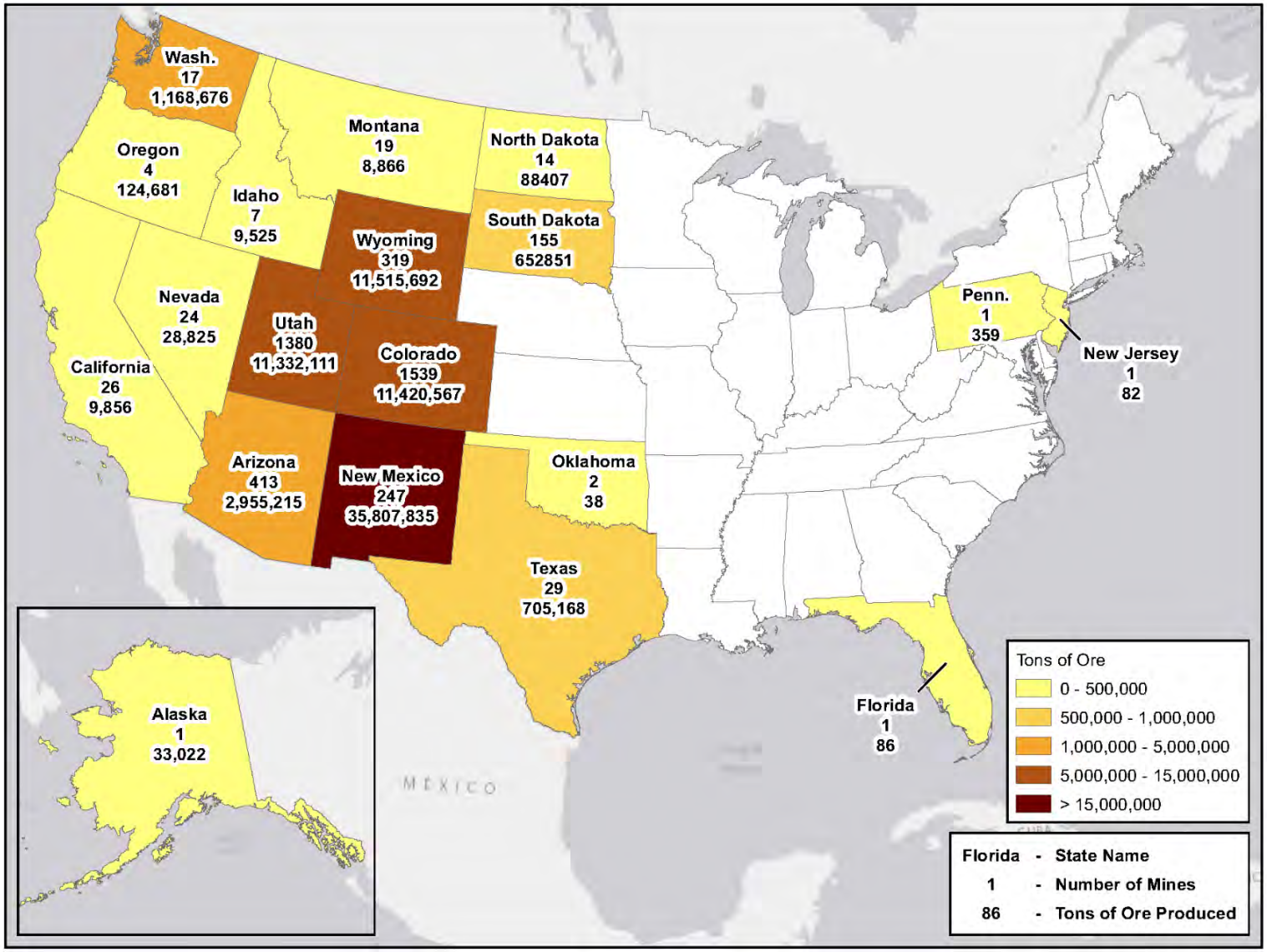
This subsection presents a brief history of uranium mining in the United States, Navajo Nation, and Monument Valley region.

1.4.1 Uranium Mining in the United States

Uranium mining began in the Colorado Plateau, on which the Navajo Nation is situated, in the early twentieth century. Uranium ore was processed primarily for its vanadium (used to harden steel) and radium content. The Colorado Plateau became one of the world's most important source of uranium ore, providing about 14 percent of the uranium oxide needs of the Manhattan Project (Atomic Heritage Foundation 2018). Similarly, radium was used extensively during the twentieth century in military, industrial, and pharmaceutical products (Tyler and others 2013). Uranium mining on the Colorado Plateau declined significantly in the mid-1920s when rich uranium deposits were found in the Belgian Congo.

On August 1, 1946, Congress enacted the Atomic Energy Act, which created a new civilian-controlled Atomic Energy Commission (AEC). Continuing the policy established in World War II, the federal government controlled all nuclear facilities and uranium and was the only producer of fissionable materials. While mining and milling of uranium were left to the private sector, the government was the sole customer and retained total control over the industry (Federation of American Scientists 2013).

The AEC stimulated a major increase in domestic uranium mining to meet the increasing demand to fuel plutonium production reactors and uranium enrichment plants and to supplement foreign supply. This increase led to a mining boom in the Colorado Plateau, as well as other locations, including the Black Hills of South Dakota; northwest Nebraska; eastern Washington; the Wind River Indian Reservation and other sites in central Wyoming; the Powder River Basin in Wyoming and Montana; and the Texas Gulf coast. The U.S Department of Energy (DOE) compiled a list of defense-related uranium mines, including the number of mines and production per mine within each state, as shown on Figure 1 (DOE 2014a, 2014b).



Source: U.S. Department of Energy. 2014. "Defense-Related Uranium Mines Location and Status Topic Report." LMS/S10693.

Figure 1. Defense-Related Uranium Mine Production in United States

The uranium mining boom on the Navajo Reservation led to the discovery of other ores, and mining companies promptly entered into agreements that included requirements to hire and train tribal members. In the Colorado Plateau alone, uranium mining increased from 54,000 tons of ore in 1948 to 8 million tons in 1960. AEC uranium purchases in 1960 exceeded $2.4 billion (2013 dollars). The uranium industry depended heavily on Native American miners in the Colorado Plateau. By the 1970s, an estimated 3,000 to 5,000 of the 12,000 uranium miners employed in the United States were Navajo (Federation of American Scientists 2013).

By the mid-1950s, production of fissionable materials was approaching its peak. In the 1960s, President Johnson ended production of highly enriched uranium for weapons and sharply curtailed plutonium production. The uranium market became stagnant, with many mining companies on the Colorado Plateau ceasing production. Between 1961 and 1966, U.S. domestic uranium ore production dropped by 50 percent. AEC uranium purchases ended in 1971 (Federation of American Scientists 2013). The Energy Reorganization Act of 1974 transferred the regulatory functions of the AEC to the newly formed Nuclear Regulatory Commission (NRC), which began operations on January 19, 1975. The Energy Research and Development Administration was later incorporated into the DOE (NRC 2017).

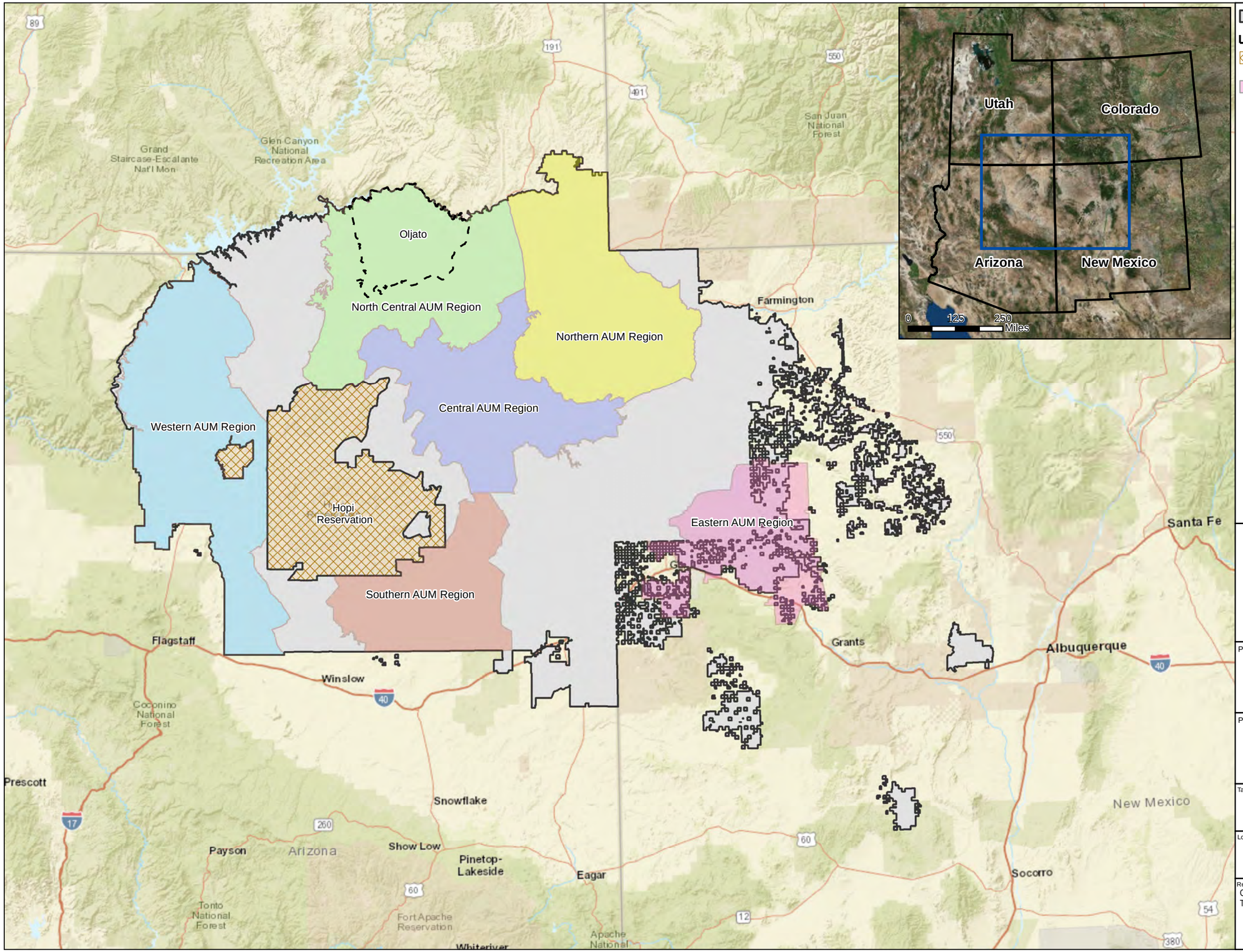
1.4.2 Uranium Mining in the Navajo Nation and Mesa II AUMs

The Navajo Nation is the largest Native American reservation in the United States, spanning over 27,000 square miles of New Mexico and parts of Utah and Arizona. Its unique geology hosts an abundance of uranium deposits. From the late 1940s to the 1980s, multiple mining companies mined millions of tons of uranium ore on or near the Navajo Nation.

Uranium mining and milling activities no longer occur on Navajo lands, but the legacy of these activities remains. More than 500 AUMs and thousands of mine features such as pits, trenches, and holes are found throughout the region. Elevated levels of uranium, radium, and other radionuclides and related metals are present in water sources and structures. Uranium and other elements, such as arsenic and selenium, also occur naturally at elevated levels in rock, soil, surface water, and groundwater across the Navajo Nation and the broader Colorado Plateau.

The many AUM sites on the Navajo Nation can be spatially divided between six distinct geopolitical Navajo Nation AUM regions for assessment purposes. Figure 2 presents the distinct regions including Northern AUM Region, North Central AUM Region, Central AUM Region, Western AUM Region, Southern AUM Region, and Eastern AUM Region.

The focus of this Air Monitoring and Soil Scanning Work Plan is the Mesa II AUM site within a localized area of the Northern AUM Region, as shown on Figure 2. The AUM site and associated features of interest for this project are shown in Figure 3.



REGIONAL AUM MAP OF THE NAVAJO NATION

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Task Order No.:	Contract No.:
TO 0021	EP-S9-17-03
Location:	**Date:**
NAVAJO NATION	08/12/2019

Reference:
COORDINATE SYSTEM: NAD 1983 UTM ZONE 12
TRANSVERSE MERACTOR

Figure No.: 2

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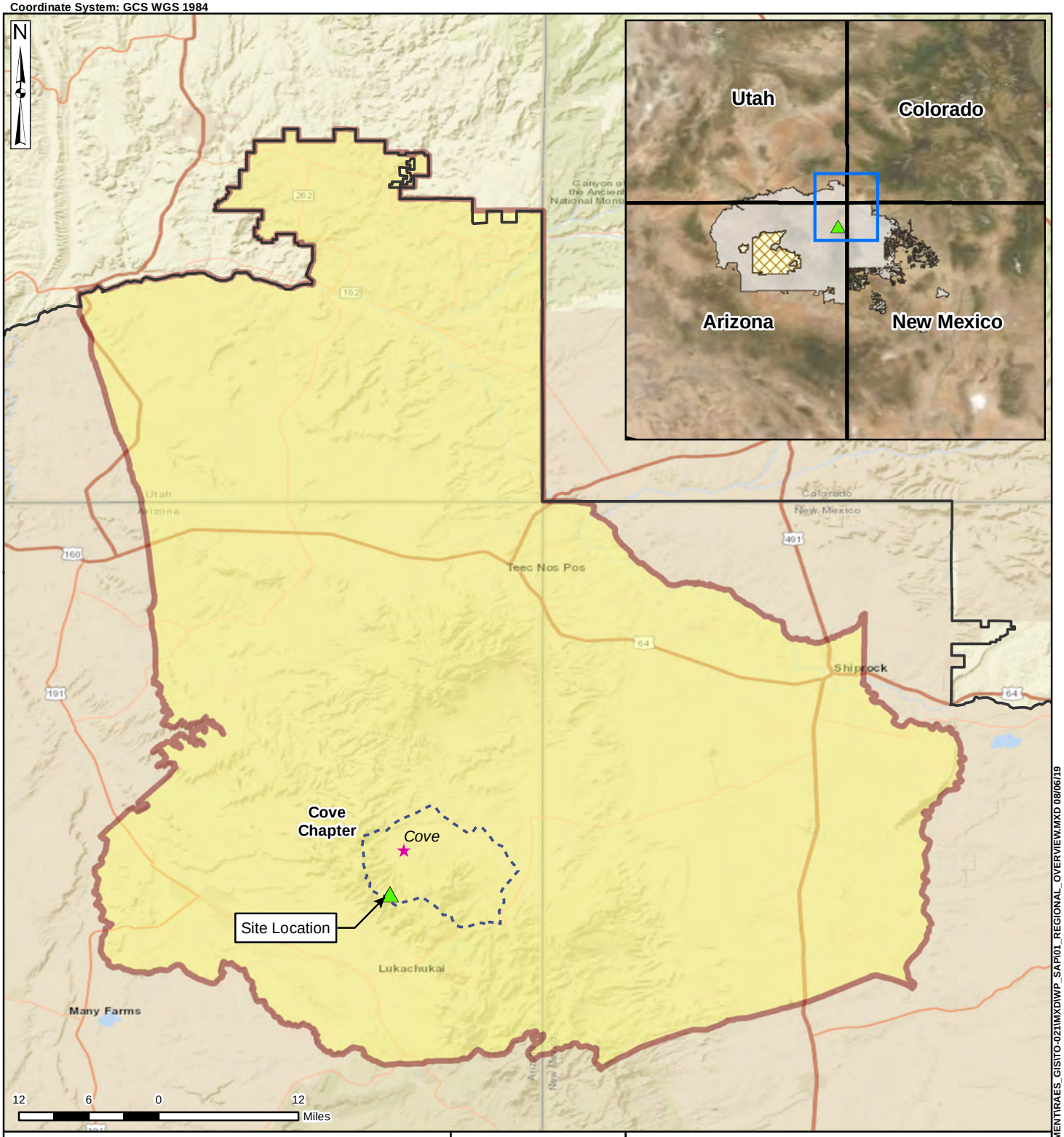
Coordinate System: GCS WGS 1984



- ★ Populated Place
- ▲ Mesa II Mine Complex
- Affected Chapter Boundary
- Navajo Nation Boundary
- Hopi Reservation
- Northern Abandoned Uranium Mine Region

Prepared for: U.S. EPA Region 9

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REGIONAL OVERVIEW OF MESA II MINE COMPLEX

Task Order No.:	Contract No.:	Figure No.:
TO0021	EP-S9-17-03	3
Location: COVE CHAPTER NAVAJO NATION	Date: 8/6/2019	

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1.4.3 Abandoned Uranium Mine Definition and Legacy

In several locations in the United States, gamma radiation from mine or mill tailings contributes to the exposure of local populations, but almost all areas were remediated under the 1970 FUSRAP (DOE 2011), CERCLA, or 1978 Uranium Mill Tailings Radiation Control Act (UMTRCA). The AUM complex within the Navajo Nation includes areas where significant amounts of contamination remain, and the local populations continue to be affected.

State and federal agencies use several definitions of the terms "mine" and "abandoned mine" (DOE 2014b). One definition, not attributed to a particular source, is the following:

> An abandoned mine (and related features, facilities, and equipment) is a mine on or affecting public lands under the jurisdiction, custody, or control of a federal agency at which, under the authority of the 1872 Mining Law (Title 30 United States Code Sections 22–54), persons or entities outside of the federal government conducted exploration, development, mineral extraction, processing, reclamation, maintenance, or other operations, all of which activities have ceased with (1) no evidence that the mine operator or any identified successor, claimant, operator, or other third party intends to resume those activities and (2) no other evidence of active claim or claimant activity.

An AUM site is generally associated with a patented or unpatented mining claim established under the 1872 Mining Law, as amended, or a lease of federal state, tribal, or private lands (DOE 2014b). An AUM site may be a single feature, such as a surface or underground excavation, or may include an area containing a complex of multiple, interrelated excavations (DOE 2014b). An AUM site may include associated features such as mine adits and portals, surface pits and trenches, highwalls, overburden or spoils piles, waste rock dumps, structures, ventilation shafts, ore stockpiles and stockpile pads, mine-water retention basins or treatment ponds, close-spaced development drill holes, trash and debris piles, and onsite roads (DOE 2014b).

Uranium recovery activities (mining and milling) are major sources of radioactive contamination in regions where uranium is found (Cerne and others 2012). Synergistic effects yielded by metals and radionuclides may be expected in these contaminated areas as well and may cause substantial biological effects (Evseeva and others 2004). Improper management of wastes can spread radioactive contaminants to soils, sediment, surface and groundwaters, and air (International Atomic Energy Agency [IAEA] 2003). Figure 4 illustrates the common physical hazards and pathways for radiation exposure associated with a typical AUM site (DOE 2014a).

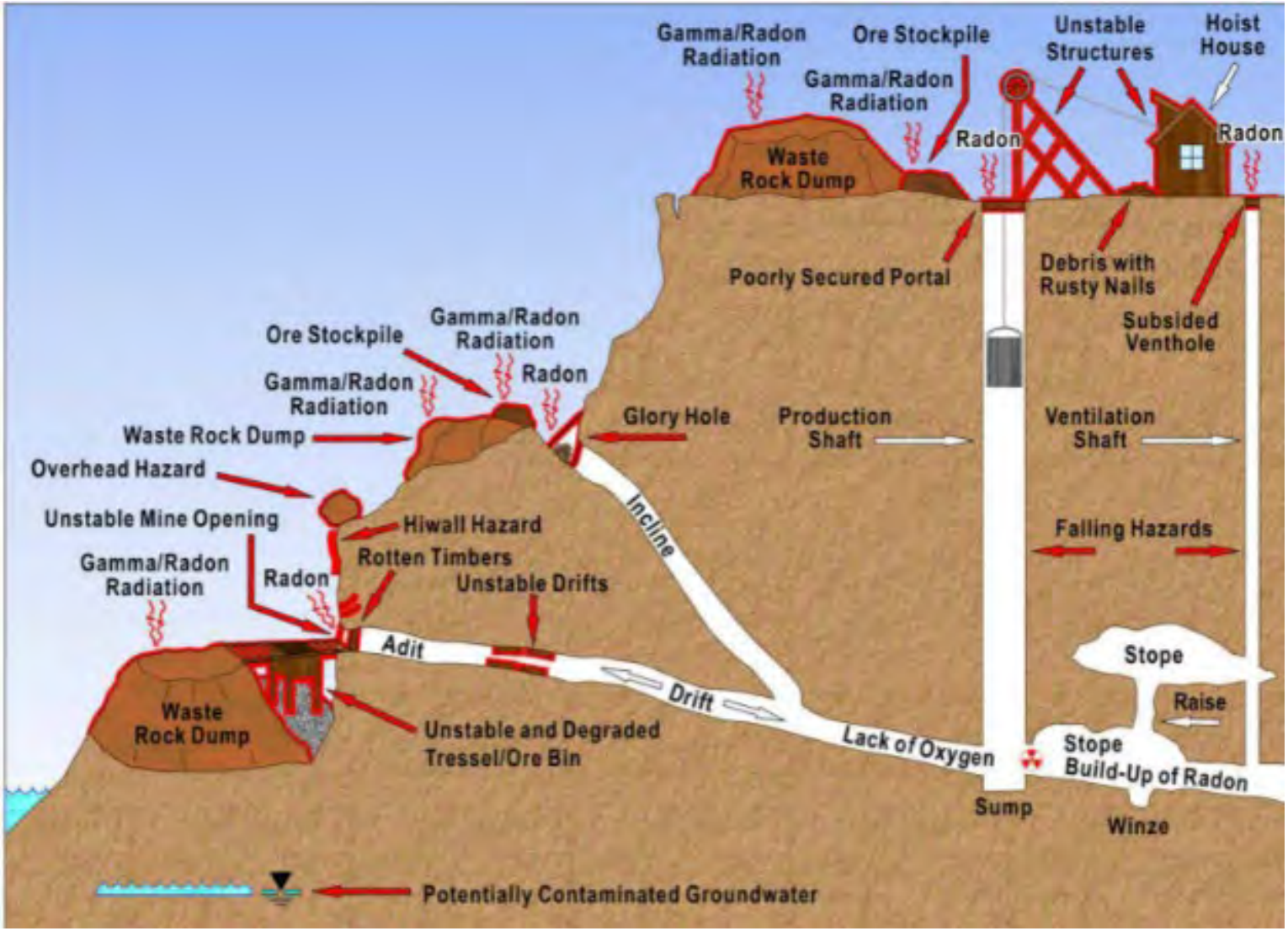


Figure 4. Common Physical Hazards and Pathways Radiation Exposure in Abandoned Uranium Mine Sites (DOE 2014a)

1.4.4 Mesa II AUM Site History

The Mesa II TCRA site is made up of two historic mines: Mesa II, Mine No. 1, P-150 and Mesa II, Mine No. 1 & 2, P-21 (also known as Mesa II P-21). The operation of these two mines spanned 1952 to 1967, and approximately 277,000 tons of ore was removed in that timeframe. Mining operations at Mesa II, Mine No. 1 stopped in 1955 after a total of 3,825 tons of ore had been removed. Production of ore in the Lukachukai Mountains was particularly high in 1958 because of the production at Mesa II P-21, and in 1960, 80 percent of the total uranium mined in the area was from Mesa II P-21. The production at Mesa II P-21 began to decrease in 1961 and continued to decline until operations ceased in 1967.

As a result of these mining activities, elevated levels of uranium and radium, as well as other radionuclides and metals, are present in waste rock, sediment, water sources, and structures. Uranium and other elements, such as arsenic, molybdenum, selenium, and vanadium, also occur naturally at elevated levels in rock, soil, surface water, and groundwater throughout the Four Corners region (Neptune and Company [Neptune] and TerraSpectra Geomatics [TSG] 2017).

1.4.5 Reclamation and Previous Investigations

The following subsections provide information on previous investigations and actions at Mesa II AUMs.

1.4.5.1 *Historical Investigation and Reclamation*

Beginning in August 1988, activities were conducted by the Navajo Nation Abandoned Mine Lands Reclamation Program (NAMLRP) to understand site conditions related to mining, both coal and other mining (that is, uranium), throughout the Navajo Nation. NAMLRP completed an inventory, prioritized abandoned mine sites, and determined which sites to reclaim based on factors such as physical environmental problems and overall safety for reclamation employees. Work conducted by NAMLRP focused on removing immediate physical hazards, including sealing the mine portals with concrete blocks, consolidating loose accessible mine waste, and capping it with uncontaminated fill material.

Reclamation work was performed by NAMLRP at both Mesa II, Mine No. 1, P-150 and Mesa II P-21 as part of the NA-0312A Cove 3 Phase II reclamation project, which commenced on July 18, 2001 and ended on December 25, 2001. The reclamation activities at Mesa II, Mine No. 1, P-150 included the closure of five portals (Portals 42a, 42b, 42c, 40, and 41), which were all excavated, stabilized, backfilled with polyurethane foam, and covered with fill material (Neptune and TSG 2018). Waste Pile 42 (renamed by Tetra Tech as Waste Pile M28) was inaccessible during the reclamation activities and left unreclaimed. Weston Solutions, Inc. (Weston) (2010) estimated 463 cubic yards (yd^3) remain on the site. According to the USEPA geodatabase (Neptune and TSG 2018), the waste pile is the only unreclaimed feature at the site.

The reclamation activities at Mesa II P-21 included the closure of four portals (Portals 34, 35, 38, and 39) by excavating, backfilling, closing with polyurethane foam, and covering with fill material. Portal 36 was closed by excavating and backfilling the portal. Portal 37 was closed with solid cinder block bulkhead with two polyvinyl chloride (PVC) drain pipes to prevent water

buildup. According to the reclamation history provided in Neptune and TSG (2018), the two PVC pipes from Portal 37 were connected to Drainfield 37. The drainfield was backfilled 5 feet with cover material. Waste Pile 38 was excavated (3,000 yd^3) and placed in Burial Cell 39. The waste pile was backfilled to a minimum depth of 1.5-feet. Waste Pile 39 was also placed into Burial Cell 39 (30,000 yd^3). Ore bins and railroad track were placed in the burial cell along with a total of 33,000 yd^3 of mine waste. The burial cell has a 1.5-foot cover of fill material. Channel 39 was reconstructed to the south of the burial cell using boulders for erosion purposes.

1.4.5.2 *2018 Tetra Tech Investigation*

In 2018, Tetra Tech conducted Removal Site Evaluations (RSE) for 39 Northern Agency Tronox Mines, including Mesa II, No. 1, P-150 and Mesa II P-21. Gamma-radiation walkover surveys, X-ray fluorescence (XRF surveys), and soil sampling were all conducted as part of the RSE with the objective of characterizing each mine site to assist in future clean-up efforts. A total of 26 contaminants of potential concern (COPC) were identified across both Mesa II mine sites impacted by the Mesa II TCRA, 8 of which were listed as primary COPCs (arsenic, lead, molybdenum, radium-226 (Ra-226), selenium, thorium, uranium, and vanadium). The RSE also established background threshold values (BTV) for gamma radiation of 11,378 counts per minute (cpm) at Mesa II P-21 and 9,703 cpm at Mesa II, No. 1, P-150 (Tetra Tech 2019a; 2019b).

1.5 SCOPE OF WORK AND PROJECT OBJECTIVES

The purpose of the activities presented in this Air Monitoring and Soil Scanning Work Plan is to support the erosion repair and removal time-critical action at Mesa II AUMs within the Cove Chapter of the Navajo Nation. The scope of work (SOW) for TO 0021 of the RAES Contract includes the following general tasks:

- Planning – design a site-specific work plan, including a SAP, QAPP, DMP, and HASP
- Site Clearance – provide support to USEPA for site mapping, site access, biological surveys, and cultural surveys, as necessary, to gain access to conduct the Mesa II TCRA field work and to provide notice of field work and sampling
- Air and Soil Sampling – conduct field work, including real-time air monitoring for respirable dust, particulate air sample collection, gamma-radiation walkover surveys, and XRF scanning. The sample design for this study will be based on the areas that will be disturbed as part of the Mesa II TCRA and the evaluation of the results from the Baseline Study. The results of the air monitoing and soil scanning activities will be used to guide decisionmaking in regards to dust mitigation, borrow source location and roadway reipar.
- Data Management – provide appropriate project data in electronic format that can be imported into Scribe, a software tool developed by USEPA to assist in managing environmental data. Field, analytical, and other pertinent data will be loaded into Scribe project databases.

The primary objectives that will be achieved through the Mesa II air monitoring and soil scanning are to:

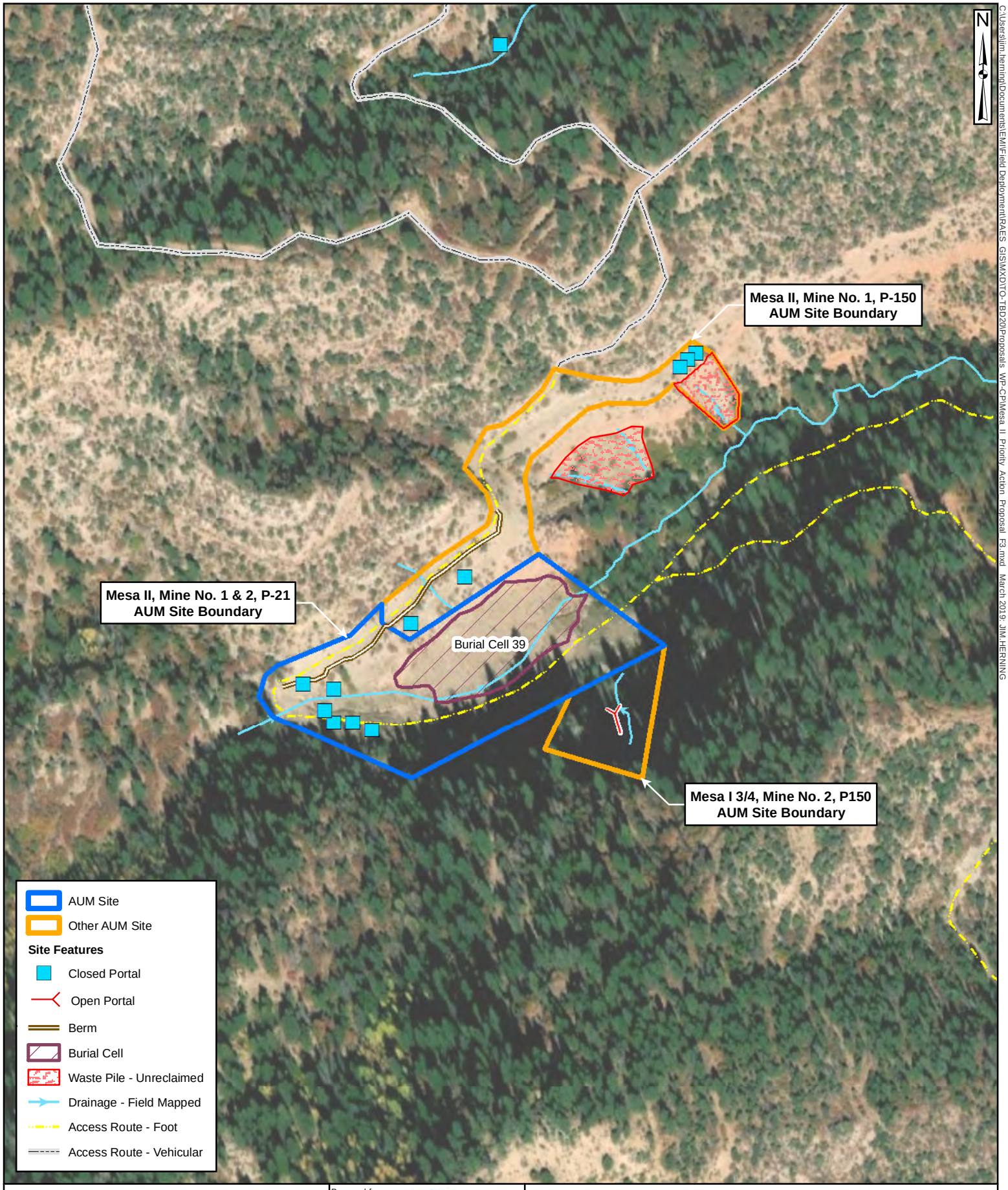
- Conduct gamma-radiation walkover surveys and XRF field surveys using approved methodology throughout the Mesa II TRCA to identify areas of contaminated soil that may be disturbed during erosion repair and road repair work.
- Use real-time dust monitors to monitor fine particulate matter suspended in the air with aerodynamic diameters of less than or equal to 2.5 micrometers (μm) (also known as PM2.5) particles near the perimeter of the work area to ensure dust control methods are effective at preventing dust from migrating off-site.
- Conduct particulate air sampling at perimeter air monitoring locations for gross alpha and gross beta radiation.
- Conduct personnel sampling for gross alpha and gross beta radiation, as well as primary metals of potential concern identified during the Mesa II RSEs, for six workers representing different work tasks that will be carried out throughout the Mesa II TCRA.

Tetra Tech will furnish all necessary and appropriate personnel, materials, and services to conduct the air monitoring and soil scanning as described in this Air Monitoring and Soil Scanning Work Plan. Tetra Tech will conduct all activities in a manner generally consistent with CERCLA, MARSSIM, and the RAES contract.

1.6 PHYSICAL SETTING

The site is part of a complex of mines located on Mesa II in the Lukachukai Mountains in Apache County, Arizona. The Mesa II area is administered by the Cove Chapter and accessed by driving 45 minutes from Cove, Arizona, south on the Mesa V access road and east to the Mesa II access road. Once on the Mesa II access road, it is an approximate 15-minute drive east to the Mesa II base camp. The northern portion of the site is a 10-minute moderate hike on an old haul road from the Mesa II base camp. There is currently no vehicle access on the old haul road to the site because there are large boulders present and other obstacles preventing vehicular access. The site location and access, along with nearby drainages, are shown in Figure 5.

COORDINATE SYSTEM: NAD 1983 STATEPLANE WASHINGTON NORTH FIPS 4601 FEET



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SITE FEATURES MAP

Project:	Contract No.:	
NAVAJO NATION AUM	EP-S9-17-03	5
Location: COVE CHAPTER NAVAJO NATION	Date: 3/18/2019	

1.6.1 Climate

The Colorado Plateau experiences frequent occurrences of severe weather, including thunderstorms and blizzards, especially at high elevations in the Lukachukai Mountains. Days are typically clear or partly cloudy with monsoonal precipitation patterns in the summer and variable snowfall in the winter. During the summer, site conditions are hot and dry. High winds and cold temperatures characterize the winter months. Quick changes in weather pose a danger of flash flooding. While this danger is greatest July through September, flash floods can occur at any time of the year.

Daily temperature and precipitation data from the Western Regional Climate Center (WRCC) for station 025129 in Lukachukai, Arizona, was examined for the years 1914 to 2010 (WRCC 2019). Data from 2010 to the present for this station and other stations near the site were not available. Temperatures are highest in July, averaging in the high 80s, and lowest in January, averaging in the 40s. June receives the least amount of rainfall, and July and August typically receive the most. Average annual precipitation for 1914 to 2010 was 9.29 inches. The area receives snowfall from October to April, primarily from November to March.

2.0 PROJECT APPROACH

This section presents Tetra Tech's project approach for performing air monitoring and soil scanning at the Mesa II AUM sire in support of the Mesa II TCRA. The elements presented in this section include project management, the field management approach, and the technical approach.

2.1 PROJECT MANAGEMENT

Table 1 presents key project personnel and contact information for USEPA and the Tetra Tech team. One of the first steps in the DQO process described in Section 3.1 and presented in detail in the SAP/QAPP in Appendix A is to identify the planning team and decision makers. An overall project management organizational chart is provided in Figure 6 that shows the key decision makers for this project and the framework of the management team at USEPA and Tetra Tech.

Table 1. Key Project Management Personnel

Role	Name of Key Personnel	Agency/ Company	Phone Numbers	Email Address
U.S. Environmental Protection Agency				
USEPA CO	Autumn Roe	USEPA Region 9	415.972.3178 (O)	roe.autumn@epa.gov
USEPA PO	Tana Alert	USEPA Region 9	415.972.3090	alert.tana@epa.gov
USEPA TOCOR	Edwin "Chip" Poalinelli	USEPA Region 9	415.972.3390 (O)	poalinelli.edwin@epa.gov
Tetra Tech				
RAES Program Manager	Kenyon Larsen	Tetra Tech	510.302.6359 (O) 510.821.4795 (C)	kenyon.larsen@tetratech.com
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Notes:

C Cell phone number
CO Contracting Officer
ERG Environmental Restoration Group
O Office phone number
PO Project Officer
QC Quality Control
RAES Response, Assessment, and Evaluation Services
TOCOR Task Order Contract Officer's Representative
USEPA U.S. Environmental Protection Agency

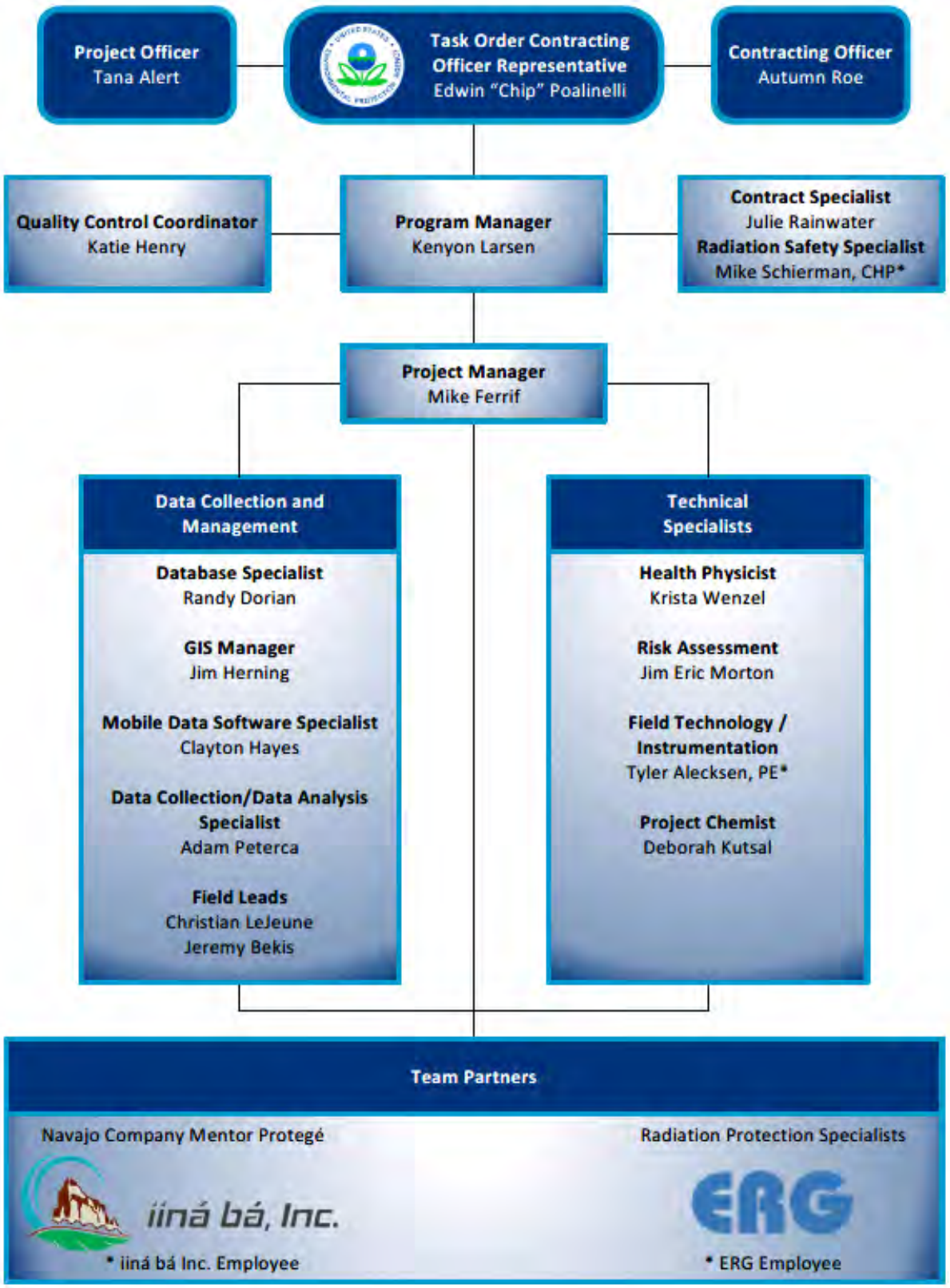

Figure 6. Project Management Organization Chart

2.2 FIELD MANAGEMENT APPROACH

2.2.1 Field Investigation

Gamma-radiation walkover surveys and XRF surveys will precede any soil-disturbing work within the exclusion zone to screen for gamma radiation and metal COPCs so that areas of contaminated soil can be identified prior to disturbance. If gamma radiation or metal COPCs are detected above background levels, USEPA will use field screening data from gamma and XRF scanning to help guide the decision of whether to avoid or remove the potentially contaminated soils.

Real-time particulate monitors will be stationed outside the work area but within the exclusion zone to continuously monitor for PM2.5. If any 1-hour average of the PM2.5 concentration exceeds the U.S. National Ambient Air Quality Standards (NAAQS) 24- hour fine particle standard of 35 micrograms per cubic meter ($\mu g/m^3$), the USEPA Task Order Contract Officer's Representative (TOCOR) will be notified and dust control measures adjusted.

Particulate samples will be collected at the perimeter air monitoring stations and analyzed for gross alpha and gross beta radiation to ensure that radiological contamination is not migrating from the work area outside of the exclusion zone. Personnel samples will be collected during the first week of soil-disturbing work and analyzed for gross alpha and gross beta, as well as the non-radiological COPCs.

The sampling team will consist of two team members with experience and training necessary to collect the samples and operate the gamma scanning and XRF equipment. Sampling teams may consist of Tetra Tech personnel, iiná bá personnel, or both.

2.2.2 Site Clearance

Before any site is accessed, the Agencies will determine whether Navajo individuals have an interest in the area, which may include individuals who (1) have a homesite lease; (2) have an interest in land in the vicinity of an AUM site; (3) are allottees of allotted lands proximate to an AUM site; or (4) have a grazing permit for land within an AUM site.

Tetra Tech provided maps of areas of potential soil disturbance to USEPA to allow sufficient time for the Agencies to request access from the appropriate parties. All such persons were notified of the nature of the work anticipated and informed of what access will be necessary to perform the work.

USEPA requested access from the Cove Chapter to access roads which lead to Mesa V for road improvements and to access mine sites for RSEs. The Cove Chapter approved access at a chapter meeting on March 12, 2017, and provided a written resolution to the USEPA (Cove Chapter 2017). The resolution from March 12, 2017, states that "access is approved to allow USEPA Region 9 to grade Mesa V to improve access roads to several mine sites for road clearing; this access will also include all mountain access roads and to conduct removal site evaluations."

USEPA also requested access to mine areas from the grazing committees in the following areas:

- Cove Chapter Grazing Areas
- Round Rock Chapter District #11 Grazing Areas
- Teec Nos Pos Chapter Grazing Areas

Grazing permit holders in the Cove Chapter consented to access in January 2017 by providing written consent to NNEPA and USEPA (2017a). The District #11 Grazing Committee indicated there are no existing and active grazing permittees in the areas mapped for abandoned mine cleanup by submitting a letter to the Superfund Division Community Involvement section of USEPA Region 9. The letter was signed by the District #11 Grazing Committee Chair (Navajo Nation District #11 2018). Grazing permit holders in the Teec Nos Pos Chapter consented to access in November 2017 by providing written consent to NNEPA and USEPA (2017b).

The representatives from the above-listed grazing areas granted access to USEPA for the following purposes:

- Conducting radiological surveys
- Collecting soil, water, sediment, air, plant, or other potential hazardous waste surveys
- Improving roads
- Other response actions as deemed necessary by USEPA or NNEPA to address the release or threatened release of a hazardous substance at or around the grazing areas

To address potential issues with AUM site access arising during field activities, Tetra Tech will arrange to have at least one Navajo-speaking individual on an AUM site during all field activities.

2.2.2.1 *Cultural Surveys*

Tetra Tech will provide cultural survey support to USEPA as needed to support initial consultations with the Navajo Nation Heritage and Historic Preservation Department. Additional technical support includes creating maps that identify the boundaries of each site and intrusive field activities.

2.2.2.2 *Biological Surveys*

iiná bá prepared a biological assessment (Tetra Tech 2019c) to support the Mesa II TCRA. Based upon iiná bá's findings, the following effects are expected to threatened and endangered (T&E) species during the Mesa II TCRA:

- Zuni fleabane – No effect
- Navajo sedge – No effect
- Mexican spotted owl – May affect, but not likely to adversely effect
- American dipper – No effect

- Yellow-billed cuckoo – No effect
- Zuni bluehead sucker – No effect

A determination of **may affect, not likely to adversely affect** resulted for the threatened Mexican spotted owl because individuals are known to occur in the action area and the potential for noise disturbances to resident owls exists. The action area encompasses areas that may be directly and indirectly affected by dust, construction and traffic noise, and human presence during the Mesa II TCRA.

The Mesa II TCRA is taking place in previously disturbed areas, such as roadways, man-made drainage channels, and an existing burial cell. Mesa II TCRA activities will not disturb mixed conifer stands or riparian areas. Standard best management practices will ensure that no debris or earthen material is released to the drainages where debris could impair surface water quality, vegetation, and potential habitat.

2.3 TECHNICAL APPROACH

This section provides an overview of sampling station design, sampler setup and calibration, and sampling activities.

2.3.1 Sampling Station Design

Each of the four air monitoring stations will consist of a TSI DustTrak II Aerosol Monitor (or equivalent) taking real-time PM2.5 particulate measurements and a GilAir Plus low-volume particulate air sampler (or equivalent) connected to a 47-millimeter (mm) polytetrafluoroethylene (PTFE) filter in a cassette at a flow rate of approximately 3 liters per minute (LPM). Particulate sampling and particulate monitoring will take place for the duration of each work day in which soil is disturbed, approximately 8 to 10 hours. Stations will be placed around the perimeter of the active work area between the work and the exclusion zone established by USEPA and its contractor, Clawson. One station will be placed upwind of the active work area, one station will be placed downwind of the active work area, and the remaining two stations will be placed crosswind on opposite sides of the active work area (outlined in Figure 7).

The Mesa II TCRA involves repairing access roads leading to the Mesa II AUM sites and because of the nature of road repair work, the active work area will move along the road in a linear fashion. To account for this, Tetra Tech will work with Clawson and USEPA to ensure the active work area is well defined at the start of each day and that air monitoring stations are deployed to the correct locations.

DustTrack air monitors and low-volume particulate samplers will be mounted to a tripod such that the DustTrak probe and particulate sample cassette are at least 4 feet above the ground.

All the air monitoring and sampling equipment will be battery-operated. Equipment will be collected at the end of each work day so batteries can be charged overnight. When possible, Tetra Tech will have spare batteries and air samplers to protect against equipment or battery failure.

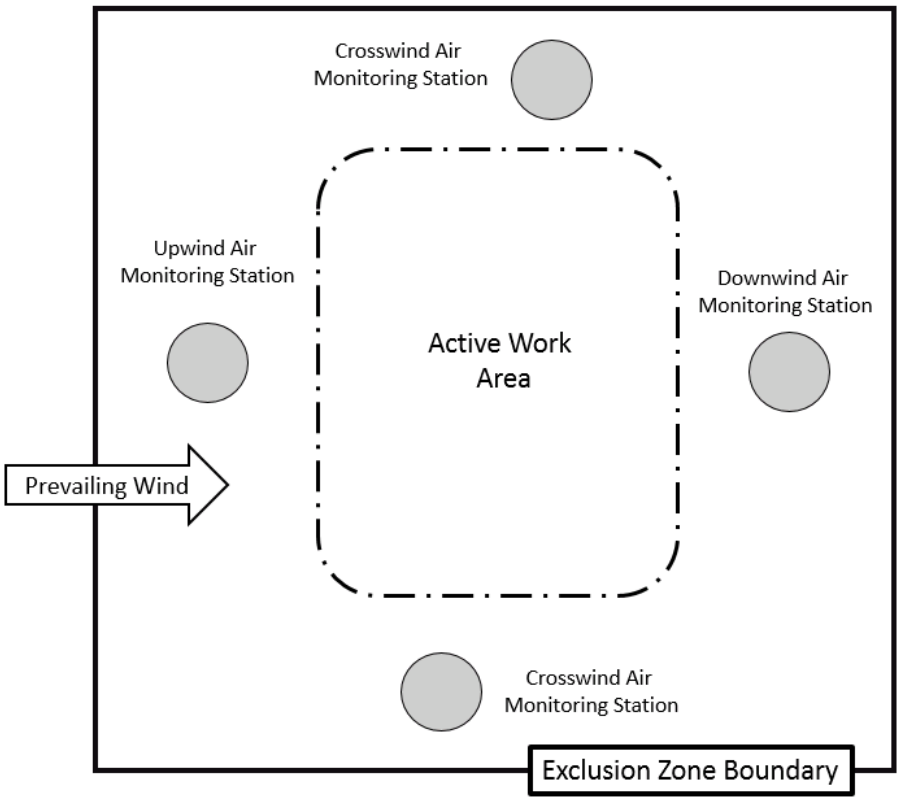

Figure 7. General Air Monitoring Station Placement

2.3.2 Equipment Setup and Calibration

DustTrak particulate air monitors are factory calibrated and will not require calibration during the Mesa II TCRA. A zero-calibration check shall be performed per manufacturer specifications each morning before station deployment and again at the end of each work day.

Low-volume particulate air samplers will be calibrated to a flow rate of 3 LPM at the beginning of each day prior to deployment and a calibration check will be performed at the end of each day. Further description of equipment setup and calibration can be found in the SAP/QAPP (Appendix A).

2.3.3 Air Sample Collection

Samples will be collected daily. Once the cassettes have been collected from the air monitoring stations and sealed, they will be held in a secure location overnight for field analysis of gross alpha and gross beta using a tray counter the following morning. The sample is held overnight to allow interference from radon-222 to decay away (following Radiation Protection Plan Standard Operating Procedure [SOP] 006). Twenty-five percent of the perimeter radionuclide samples will be collected in duplicate. Duplicate samples will not be field counted but will be shipped to Inter-Mountain Labs, Inc. following the Scientific, Engineering, Response & Analytical Services (SERAS) SOP (located in an attachment to the SAP/QAPP) to be analyzed for gross alpha and gross beta and support field counted data.

Perimeter particulate samples, collected inside the exclusion zone, will be analyzed for gross alpha and gross beta. Given the current land use of the Mesa II site as an AUM, the distance to the closest areas of known residence (2+ miles) and enforcement of an exclusion zone at the Mesa II site, it is very unlikely to have any long-term complete exposure pathways to COPCs (primarily via inhalation of fugitive dusts) by unauthorized personnel near the site. Stringent dust mitigation methods and real-time PM2.5 particulate monitoring will further minimize the risk of dust migrating from the site.

Personnel samples will also be collected from six Clawson workers during the first week of soil-disturbing activities. Samples will be collected using a GilAir Plus low-volume particulate air sampler (or equivalent) connected to a 47-mm PTFE filter in a cassette at a flow rate of approximately 3 LPM. The samples collected from Clawson personnel will be analyzed for gross alpha and gross beta, as well as for non-radiological metal COPCs identified during the Mesa II RSE. Analytical results of the personnel samples will be compared to the applicable Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL) and used to inform dust mitigation and worker exposure decision-making.

3.0 FIELD SAMPLING ACTIVITIES

This section presents an overview of the DQO process and describes the general purpose of and methodology for the air monitoring and soil scanning that will be conducted during the Mesa II TCRA. The details for the sampling approach are provided in the following sections. A more detailed discussion of field sampling methodology, including field and laboratory analytical procedures, frequency of laboratory testing, and QC measurements and procedures, is in the SAP/QAPP included as Appendix A.

3.1 DATA QUALITY OBJECTIVE PROCESS

USEPA has developed a systematic planning process called the DQO process for data collection. The process focuses on a decision that is supported by the data so that only those data required for evaluating a decision will be collected, ensuring that the right quality and quantity of data are collected to make a specific decision (American National Standard Institute [ANSI] 2014). Feedback from the project team was used to develop the DQOs for the Cove Mesa II TCRA.

The DQO process is a systematic planning approach for data collection based on the scientific method (USEPA 2006). The overall DQO process, USEPA orders, and federal regulations that mandate a Quality System are described in USEPA's guidance document *Guidance for the Data Quality Objectives Process* (USEPA 2006). The document addresses all environmental data operations, from initial characterization to final cleanup and release. The latest version of this document segregates the type of project by the final objective: decision or estimation. Other guidance is found in Chapter 2 of MARSSIM and American National Standards Institute - Health Physics Society (ANSI/HPS) N13.59-2008 (R2014) for applying the DQO process specifically to sites contaminated with radioactive materials. A chart depicting the seven steps of the DQO process is presented in Figure 8.

The complete DQOs for this project are presented in the SAP/QAPP (Appendix A). Section 3.1.1 provides the problem statement (STEP 1) and Section 3.1.2 identifies the study goals or questions (STEP 2) to be addressed by the study. The remaining steps of the DQO process are presented in detail within the SAP/QAPP.

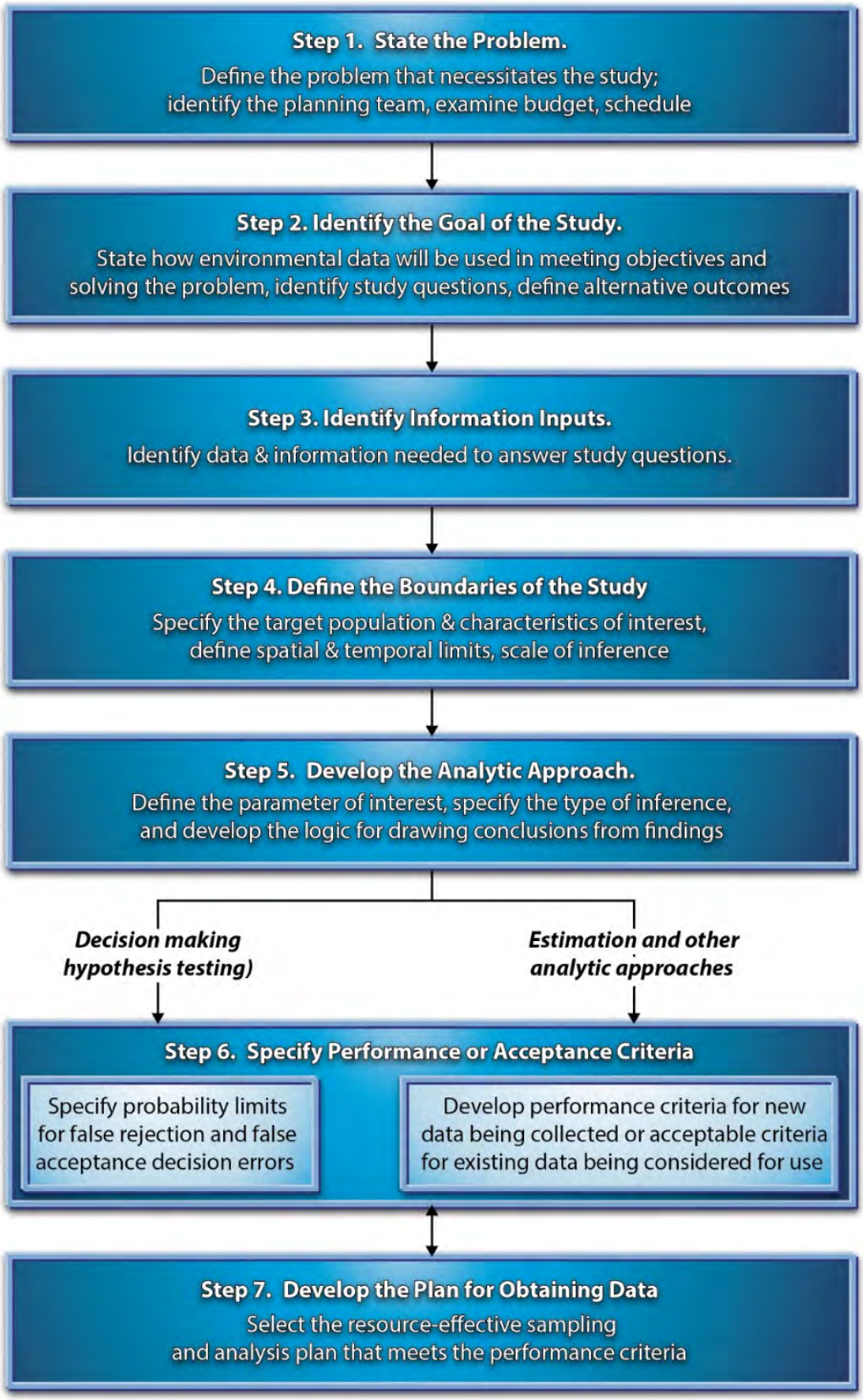

Figure 8. Data Quality Objectives Process Flow Chart (USEPA 2006)

3.1.1 STEP 1: Problem Statement

This step (STEP 1) involves providing a concise description of the problem or issue to be addressed by a study or investigation. Often, the problem statement is used to focus the scope of the planned study or investigation to the resources available or specific portion of the overall CERCLA process.

The following problem statement was developed for the Mesa II TCRA:

> Historical uranium mining activities have resulted in radionuclide and metals contamination above background levels at various locations within the Lukachukai Mountains and surrounding communities in the Navajo Nation.
>
> The Mesa II Mine is a former underground uranium mine in the Lukachukai Mountains that operated in the 1950s and consists of a 2.2-acre uranium waste reclamation cell that is eroding into the Cove Wash. A drainage channel needs to be re-established to carry water away from the waste reclamation cell to prevent further erosion and contamination of water in the Cove Wash.

3.1.2 STEP 2: Air Monitoring and Soil Scanning Study Goals

This step (STEP 2) involves identifying the principal study questions to be assessed by field observations and measurements, sample collection, and field or laboratory analysis. Study questions are often used to quantitatively compare radiological or chemical concentrations with a background value, regulatory benchmark, or risk-based screening level. Study questions are also used to estimate the extent of contamination at a site or how far a chemical may have migrated.

The following principal study questions were identified to address the objectives of the Mesa II TCRA:

1. Will contaminated soils be encountered or disturbed during the time-critical repair work?
2. Are dust control measures implemented during the time-critical erosion repair effective at preventing dust from migrating off-site?
3. Is the concentration of radionuclides of potential concern (ROPC) in dust above background levels established during the Cove remedial site evaluations?
4. Are non-radiological metal COPCs and/or ROPCs present in the worker breathing zone?

Application of the DQO process for the Mesa II air monitoring and soil scanning objectives is described in detail in the SAP/QAPP (Appendix A).

The ROPCs to be investigated are:

- Gross alpha
- Gross beta
- Gamma-emitting radionuclides

The COPCs to be investigated are:

- PM2.5
- Arsenic
- Lead
- Molybdenum
- Selenium
- Thorium
- Uranium
- Vanadium

3.2 PM 2.5 MONITORING

A TSI DustTrak II Aerosol Monitor capable of monitoring for particulate concentrations down to 0.001 milligram per cubic meter (mg/m^3) will be used to measure real-time levels of fine particulate matter suspended in the air with aerodynamic diameters of less than or equal to 2.5 µm (PM 2.5). The 1-hour average PM2.5 concentration measured during the Mesa II TCRA work will be compared to the NAAQS 24-hour fine particle standard of 35 $µg/m^3$ as an action level to initiate more stringent dust control measures.

3.3 PARTICULATE SAMPLING AND ANALYSIS

Particulate samples will be collected using a GilAir Plus Air Sampling Pump (or equivalent particulate sampler). Each sample will be collected on a 47-mm PTFE filter at a flow rate of 3 LPM over the duration of the work day, approximately 8 to 10 hours.

This section presents a general overview of the sampling activities and analyses that will be performed. Worksheet #11 of the SAP/QAPP (Appendix A) describes the detailed DQOs for the sampling methods.

3.3.1 Field Analysis of Radiological Samples

Particulate samples will be analyzed in the field using a Ludlum 2929 with 43-10-1 tray counter (or equivalent). Background alpha counts will be determined by counting a clean/blank filter sample for at least 30 minutes. It is recommended to count for at least 30 minutes to ensure the minimum detectable concentration (MDC) is less than 10 percent of the uranium ore dust derived air concentration. Particulate samples will be counted for a minimum of 20 minutes each, and the MDC will be calculated following the methods presented in the SAP/QAPP (Appendix A). Field counting of radiological samples requires removing the filter from the cassette to be placed in the tray counter. Only perimeter radiological samples will be counted in the field. Three of the six personnel samples will be field counted for gross alpha and gross beta. The remaining three personnel samples will be analyzed by the laboratory for non-radiological metal COPCs.

3.3.2 USEPA Method 900.0 (Standard Method 7110B)

This method is a drinking water method. The first step in the method is to evaporate the water to dryness and then weigh and use scintillation counting to measure the analytes. Therefore, the method can also be modified to use a weighed aliquot collected from an air sample collected on a filter. USEPA Method 900.0 will be used to analyze gross alpha and gross beta.

3.3.3 USEPA Methods IO-3.1 and IO-3.5

USEPA Method IO-3.1 will be used to prepare the samples for analysis. The material for analysis will be taken from a 47-mm PTFE filter in a cassette. USEPA Method IO-3.1 uses acid digestion to extract metals into a matrix that can be analyzed using USEPA Method IO-3.5 by an inductively coupled plasma mass spectrometer. After preparation, USEPA Method IO-3.5 will be used to analyze for the following metals at a minimum:

- Arsenic
- Lead
- Molybdenum
- Selenium
- Thorium
- Uranium
- Vanadium

3.3.4 Gamma-Radiation Walkover Surveys

Gamma radiation is a mechanism by which excess energy is emitted from certain radionuclides as highly energetic electromagnetic radiation from the nucleus of an atom. Gamma radiation is not a mode of decay, such as alpha or beta decay. On open ground, about two-thirds of the background gamma radiation exposure comes from terrestrial radionuclides, contained in the top 15 to 20 centimeters of soil out to a distance of 6 meters from where a person stands with a small contribution from airborne radon decay products (NRC 1994; NCRP 2009). The overall gamma emissions in an area are the result of the combined radioactive decay of a variety of radionuclides (Berens and others 2017). Examples of radionuclides and their decay products that may be present at mine waste sites include thorium, radium, radon, and uranium (USEPA 2000a). The contaminants of concern for the Mesa II TCRA are naturally occurring radionuclides associated with historical mining operations, with Ra-226 as the risk driver being investigated. Ra-226 is not a major gamma emitter; however, its short-lived daughters are and can often be directly correlated to gamma exposure rate.

Tetra Tech will conduct a gamma-radiation walkover survey using global positioning system (GPS)-linked Ludlum Model 2221 gamma scanner with a Ludlum 44-10 Gamma Scintillation Probe as described in the SAP/QAPP (Appendix A). The gamma-radiation walkover surveys will be conducted ahead of any soil-disturbing activities to identify any areas emitting gamma radiation above the background levels established during the RSE conducted at Mesa II as discussed in Section 1.4.5.2. To account for the shielding effect of surface soils described above, a gamma-radiation walkover survey will be conducted each time a soil-disturbing activity removes approximately 20 centimeters of soil.

3.3.5 XRF Field Surveys

Field portable XRF analyzers are useful tools for screening and assessing contaminated areas that allow in situ trace element concentrations to be measured both rapidly and easily (Peinado and others 2010; Parsons and others 2013). Field portable XRF technology also generates reliable, high-quality elemental concentration data for metal-contaminated soils (Rouillon and Taylor 2016). One of the main advantages of the XRF analyzer is the portable nature of the instrument, enabling users to generate real-time quantitative information easily in the field

(Rouillon and Taylor 2016). XRF field surveys are widely used in the field of environmental engineering as a non-destructive, cost-effective, and rapid tool for screening soils or characterizing hazardous waste sites or sites contaminated with mine waste.

Tetra Tech will conduct XRF field screening as part of the Mesa II TCRA to screen soils for surficial metals contamination above background levels prior to any soil-disturbing activities as outlined in the SAP/QAPP (Appendix A). Tetra Tech will utilize a Niton XRF XL5 spectrum analyzer (or equivalent), which uses an X-ray tube to irradiate soil samples. The source X-rays excite electrons in the surface soil sample, dislodging electrons from atomic shells and creating vacancies. As electrons from the vicinity fill the vacancies and change energy state, photons are released at specific wavelengths. These photons are detected by a photomultiplier tube detector. This process allows the XRF instrument to identify elements present based on the unique spectra emitted and to estimate metal concentrations in soil based on emitted flux. The Niton XRF XL5 spectrum analyzer collects data for 26 analytes; however, the primary metals of potential concern identified during the Mesa II RSE include arsenic, lead, molybdenum, selenium, thorium, uranium, and vanadium.

4.0 HEALTH AND SAFETY

Tetra Tech has prepared a HASP, which includes a radiation protection program (RPP). The protocols for health and safety, including radiation protection, are framed to be a dynamic process to be followed throughout the field activities that will occur during the Mesa II TCRA.

The site-specific HASP is provided as Appendix C and includes accompanying safe work practices (SWP), which were prepared to provide pertinent information to Tetra Tech field personnel and its subcontractors working at the sites so that they can all perform the work safely. The HASP defers to the RPP (included as an attachment) for issues associated with radiation protection.

The HASP and SWPs identify hazards and include directives, controls, and specific operating procedures that will be used to mitigate hazards and promote the health and safety of the public and workers performing the activities as part of the Mesa II TCRA. The HASP was prepared in accordance with USEPA's Standard Operating Safety Guide (USEPA 1992b) and all applicable OSHA regulations found at 29 CFR Part 1910.

The RPP, integral to the HASP, addresses the salient issues associated with radiation protection; for example, radiation protection limits and action levels, an exposure monitoring plan, an as low as is reasonably achievable (ALARA) program, personnel protective equipment, external and internal dosimetry, SWPs; and training and record keeping, all of which are based on the (1) nature of work to be performed during the investigation and (2) requirements for radiation protection in the following:

- 10 CFR Part 20, Standards for Protection Against Radiation
- Tetra Tech, Inc., Health and Safety Program Manual, Volume III, SWP No. 5-21, Radiation Safety Practices (as referenced in the RAES contract)

Tetra Tech intends to maintain all employee radiation exposure levels ALARA in accordance with its ALARA program. Tetra Tech has established this program for its employees working under RAES and other contracts. Tetra Tech also has established exposure monitoring programs under RAES and other contracts to determine:

- External occupational doses, using optically stimulated luminescent (doses to whole body) detectors and thermoluminescent dosimeters (doses to extremities), and
- Internal occupational doses, using air monitoring.

5.0 DATA QUALITY ASSURANCE

During the Mesa II TCRA, Tetra Tech will endeavor to minimize sources of error, such as sampling and measurement error through QA and QC planning. Tetra Tech has prepared a task order-level combined SAP and QAPP, including field sampling planning, which is presented in Appendix A.

Tetra Tech will implement a data management system designed to minimize the introduction of errors and maximize accuracy and efficiency. Several techniques will be used for data QA and QC, including (1) audits of field notes and the use of automated electronic field forms to minimize error; (2) validation of laboratory and field-collected data; (3) verification of data sets before data are published to a repository such as the Scribe database; and (4) final quality control checks by Tetra Tech's QA manager.

All data management practices will be implemented in accordance with the regional Tronox Inc. Bankruptcy Settlement Data Management Plan (USEPA 2015c) and the site-specific DMP provided in Appendix B. Both the regional DMP and site-specific DMP are dynamic documents that may evolve as the project progresses and new technologies are identified (USEPA 2015c).

5.1 SAMPLING AND ANALYSIS PLAN/QUALITY ASSURANCE PROJECT PLAN

Tetra Tech has developed a combined SAP/QAPP to accompany this Air Monitoring and Soil Scanning Work Plan in support of the Mesa II TCRA work. The combined SAP/QAPP was developed following the Sampling and Analysis Plan Guidance and Template from USEPA Region 9 for documenting procedural and analytical requirements (R9QA/009.1) (USEPA 2014a) and Guidance for Quality Assurance Project Plans (EPA QA-G5) (USEPA 2002b). A tracking approach was used in development of the document to ensure that the document included all required elements identified in both R9QA/009.1 and EPA QA-G5. The SAP/QAPP is provided in Appendix A.

Tetra Tech developed DQOs as part of the SAP/QAPP based on USEPA's seven step DQO development process. The problem statement and study goals steps are presented in Section 3.1, a complete set of DQOs the data needs and sample designs steps are presented in the SAP/QAPP.

5.2 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC will be a priority throughout all air monitoring and soil data collection activities. Specific QA/QC procedures will be implemented to both minimize and evaluate potential sources of inaccuracy during sample collection and analysis. QA/QC procedures are designed to consider relevant guidance from USEPA, as well as MARSSIM and the *Multi-Agency Radiological Laboratory Analytical Protocols Manual*. In addition to Tetra Tech's QA/QC procedures, the selected analytical laboratory(s) will provide a laboratory QAPP(s). All QA/QC procedures are described in detail in the SAP/QAPP (Appendix A).

A summary of laboratory and field QA/QC procedures is provided below.

- Tetra Tech will contract a USEPA-approved laboratory(s) to perform chemical and radiochemical analyses. The laboratory will be a Contract Laboratory Program (CLP)-compliant/state certified analytical laboratory. This laboratory will provide a laboratory quality assurance plan that meets the requirements for this project and is consistent with the QAPP. The SAP/QAPP (Appendix A) provides additional details on laboratory QA/QC procedures.
- Tetra Tech will validate 90 percent of the data using CLP level III validation using internal (Tetra Tech staff), and 10 percent of the samples will be validated using level IV validation (Tetra Tech staff).
- Data sets will be verified before they are published in the Scribe database. The data verification process will include, at a minimum, allowed character checks; cardinality checks (verify that each record has a valid number of related records); consistency checks (verify consistency between fields); and additional checks using Scribe auditor rules (USEPA 2015c).
- Field-collected data, logbooks, and field forms will be reviewed and audited on a regular basis.
- Field QA/QC procedures will include the collection of duplicate samples and equipment rinsate blanks. Precision will be assessed through collection of duplicate samples, and accuracy will be evaluated through the analysis of equipment rinsate blank and field blank samples.
- QC measurements, including a background check and source check, will be performed twice daily during gamma surveys. Initial and subsequent calibration checks will be performed on the XRF detector daily, and QC samples will be analyzed before samples are analyzed. XRF surveys will include analyses of sample duplicates. Specific QA/QC procedures for radiological and XRF surveys are provided in the SAP/QAPP (Appendix A).

5.3 DATA MANAGEMENT

Tetra Tech has prepared a site-specific DMP (Appendix B) to be used in conjunction with the USEPA regional Tronox settlement data management plans. These documents describe the generation, management, validation, and distribution of project deliverables. The DMP also includes discussions of both tabular and spatial (geographic information systems [GIS]) data management and data management processes. These plans are not intended to be static and will evolve as new best practices, technologies, and tools are identified. All data collected and reported will comply with Section D - Data Management Support of the RAES contract.

During field data collection activities, Tetra Tech anticipates generating four primary data streams:

- Information entered into custom electronic forms on tablet computers
- Gamma and XRF field survey data

- Geospatial data
- Laboratory electronic data deliverables (EDD)

Each of these data streams is described in detail in the SAP/QAPP (Appendix A) and site-specific DMP (Appendix B).

On a daily basis, Tetra Tech field team leaders will download tabular files that contain all data captured during that day's field activities. The field team leader will perform a QC review of the information included in the tabular files. DustTrak and gamma field survey data will be processed by field task leaders and the database administrator (DBA) in accordance with the DMP (Appendix B) before distribution. Once the data meet QC standards, the files will be transferred to the Tetra Tech DBA. The DBA will directly upload the QC-checked files to the project-specific Scribe database.

Geospatial data will be downloaded from GPS instruments daily and evaluated for any errors using GIS software by the field task leaders. Geospatial data will then be transferred to the DBA and directly uploaded to the project-specific Scribe database.

Laboratory EDDs will be promptly uploaded to the Scribe database when they are received with a designation to indicate that data are preliminary and have not been validated. Laboratory EDDs and associated reports will be provided to chemists for data validation. Chemists will create a validation EDD based on their review of the laboratory report and will generate an associated data validation report. Once the data validation report and validation EDD have undergone a technical and QC review, the validation EDD will be provided to the DBA and directly uploaded to the Scribe database.

Tetra Tech's DBA will develop a custom Scribe database to house all project tabular data. The DBA will also develop a set of custom auditor rules that will be used to perform automated QC checks on all database uploads to avoid the inclusion of any errant or incorrectly formatted data in the project database.

5.4 FIELD PROCEDURES AND DOCUMENTATION

Tetra Tech will implement field work in accordance with the SAP/QAPP (Appendix A) and the HASP and integral RPP (Appendix C). All sample locations, sample names, and field documentation processes are provided in the SAP/QAPP (Appendix A). In general, Tetra Tech will document field data in logbooks and mobile devices using electronic forms. Tetra Tech anticipates generating four primary data streams during field data collection activities. Tetra Tech will use both digital data capture techniques and logbooks to capture and record data in the field. The electronic form data will be aggregated and downloaded in a tabular format for review by field task leaders preceding transfer to the DBA.

Field task leaders will review logbooks on a daily basis. Tetra Tech will adhere to the following steps to document and process field data as described in the SAP/QAPP (Appendix A):

- Gamma and XRF field survey data will be processed daily by field task leaders.

- Geospatial data will be downloaded from GPS instruments daily and evaluated for any errors using GIS software. Geospatial data will then be transferred to the DBA, and directly uploaded to the project-specific Scribe database.
- Laboratory EDDs will be promptly uploaded to the Scribe database when they are received with a designation to indicate that data are preliminary and have not been validated. Laboratory EDDs and associated laboratory reports will be provided to chemists for data validation. Chemists will create a validation EDD based on their review of the laboratory report and will generate an associated data validation report. Once the data validation report and validation EDD have undergone a technical and QC review, the validation EDD will be provided to the DBA and directly uploaded to the Scribe database.
- Tetra Tech's DBA will develop a custom Scribe database to house all project tabular data. The DBA will also develop a set of custom auditor rules that will be used to perform automated QC checks on all database uploads to avoid the inclusion of any errant or incorrectly formatted data in the project database.
- Spatially referenced data and geospatial data included in the GIS will be provided in the ESRI File Geodatabase format.
- Tetra Tech will use the World Geodetic System (WGS) 1984 geographic coordinate system (GCS WGS 1984) for all feature datasets/classes delivered in a file geodatabase. Each spatial data submittal will include metadata consistent with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998). Metadata are to use the USEPA profile and are to follow the USEPA's Geospatial Metadata Technical Specification, Version 1.0 (USEPA 2007b). All data collected and reported will comply with Section D - Data Management Support of the RAES contract.

6.0 SCHEDULE AND REPORTING

Tetra Tech plans to initiate field sampling activities (air monitoring and soil scanning) to support the Mesa II TCRA on September 2, 2109. This anticipated start depends on the erosion repair contractor mobilization date and approval of this Air Monitoring and Soil Scanning Work Plan. Tetra Tech will notify the Agencies with 2 weeks' notice prior to the start of any field sampling. This advance notice will assist the Agencies in providing appropriate oversight and coordination with applicable stakeholders.

Upon commencement of all field activities for the Mesa II TCRA, Tetra Tech will prepare a Cove Mesa II Air Monitoring and Soil Scanning Report. The draft Cove Mesa II Air Monitoring and Soil Scanning Report will be submitted to USEPA no later than 60 days from the completion of field work for comment. The final Air Monitoring and Soil Scanning Report will be submitted no later than 30 days from the receipt of USEPA comments on the draft.

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APPENDIX A

SAMPLING ANALYSIS PLAN/QUALITY ASSURANCE PROJECT PLAN

Cove Mesa II Erosion and Removal Time-Critical Action

FINAL
Appendix A
Air Monitoring and Soil Scanning Sampling and Analysis Plan

Response, Assessment, and Evaluation Services (RAES)

Contract No. EP-S9-17-03

Task Orders 0021

August 26, 2019

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612

APPENDIX A
Air Monitoring and Soil Scanning
Sampling and Analysis Plan

Response, Assessment, and Evaluation Services (RAES)
Contract No. EP-S9-17-03
RAES Task Order Number 00021

Tetra Tech, Inc.
1999 Harrison Street, Suite 500,
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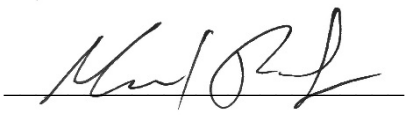
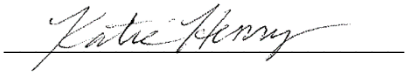
August 26, 2019
Date

Tetra Tech Project Manager	Mike Ferrif	
Tetra Tech Program Manager	Kenyon Larsen	
Tetra Tech QC Coordinator	Katie Henry	

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ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ANSI/HPS	American National Standards Institute - Health Physics Society
AUM	Abandoned uranium mine
BSA	Background Study Area
BTV	Background threshold value
CFR	Code of Federal Regulations
COPC	Contaminant of potential concern
cpm	Counts per minute
DMP	Data Management Plan
DQO	Data quality objective
ERG	Environmental Restoration Group, Inc.
GPS	Global Positioning System
HASP	Health and Safety Plan
M27	Mesa II, Mine No. 1 & 2, P-21
M28	Mesa II, No. 1, P-150
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum detectable concentration
NAUM	Navajo-area abandoned uranium mine
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NNEPA	Navajo Nation Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
pCi/g	Picocuries per gram
QA	Quality assurance
QC	Quality control
QAPP	Quality Assurance Project Plan
Ra-226	Radium-226
RAES	Response, Assessment and Evaluation Services
Rb-87	Rubidium-87
RPP	Radiation Protection Program
RSE	Removal Site Evaluations
RSO	Radiation Safety Officer
SAP	Sampling and Analysis Plan

ACRONYMS AND ABBREVIATIONS (CONTINUED)

TCRA	Time-critical removal action
Tetra Tech	Tetra Tech, Inc.
TO 0021	Task Order 0021
USEPA	U. S. Environmental Protection Agency
USGS	U.S. Geological Survey
XRF	X-ray fluorescence

1.0 INTRODUCTION

Air monitoring, air field analysis and confirmation sampling, personnel air sampling, and soil surveys (radionuclides and metals) will be conducted to support the Mesa II erosion repair and time critical removal action (Mesa II TCRA) at the Mesa II abandoned uranium mine (AUM) sites in the Cove, Arizona, area of the Navajo Nation. The site is situated within the Cove Wash watershed and extends from the highest elevations in the Lukachukai Mountains downstream to Cove, Arizona. The watershed contains approximately 52 miles of tributaries and is identified by the U.S. Geological Survey (USGS) as Hydrologic Unit Code 14801050903. Annual precipitation averages 12 to 16 inches throughout the watershed.

No prior monitoring or sampling of Cove community airborne contaminants has been performed. For the Mesa II TCRA, perimeter air monitoring will be performed for ultrafine particulate matter (particulate matter with a diameter of 2.5 microns or less [PM2.5]). In addition, particulate samples will be collected from perimeter air monitoring stations and will be field analyzed for gross alpha and gross beta. One duplicate (confirmation) sample will be collected from the perimeter air monitoring stations each day and sent to the laboratory to be analyzed for gross alpha and gross beta to compare against field analyzed samples.

In addition, personnel air samples will be collected from Clawson Excavation Inc (EPA contractor performing soil disturbing work) personnel performing work due to their proximity to onsite hazards for the first week. They will be field analyzed for gross alpha, and gross beta and confirmation air samples will be sent to the lab for select metals, gross alpha and gross beta. Gross alpha and gross beta results will be compared to the derived air concentration (DAC) for uranium ore. If there are no exceedances of permissible exposure limits (PELs) to the non-radiological metals and 10 percent of the DAC for uranium ore in the first week, personnel air sampling will be discontinued. If there are exceedances, dust management practices will be implemented and USEPA Region 9 will decide whether to continue personnel air sampling for the duration of the project.

Tetra Tech will perform gamma-radiation walkover soil surveys throughout the Mesa II TCRA project area to define areas of contamination and screen soils in borrow source areas. Gamma surveys will be conducted with a gamma radiation detection system linked to a GPS. Areas to be surveyed include roads leading to Mesa II, potential borrow areas, removal work areas, and the reclamation cell. In addition to the gamma radiation survey, Tetra Tech will evaluate the levels of select metals in project area soil and borrow source area soil using x-ray fluorescence (XRF).

This sampling and analysis plan (SAP) is an appendix to the Work Plan (WP), which contains a summary level description of the study. The WP also includes as appendices, the data management plan (Appendix B) and the health and safety plan (HASP) (Appendix C). The quality assurance project plan (QAPP) is included as Attachment A1 to this SAP.

1.1 PROJECT AREA

The Mesa II Mine site is in the Northern AUM Region of the Navajo Nation. Figure A-1 provides the geographic location of the site and indicates the Navajo Nation boundary and the Navajo Nation AUM regional boundaries.

To conduct the necessary erosion control and repair work, road improvements will be made and any contaminated soil encountered will be avoided or removed and placed in the existing repository in Mesa II. Dust suppression or encapsulation will be implemented to prevent off-site migration of dust during work activities. Once the road is improved, the contractor will construct/repair the water diversion channel to reduce the volume of water impacting the repository cap. In addition, the erosion channel that is encroaching on the reclamation cell will be backfilled, and the reclamation cell will be stabilized. Figure A-2 presents an overview of the project area and site features.

1.2 RESPONSIBLE AGENCY

USEPA Region 9 is the responsible regulatory agency for this project. Tetra Tech, Inc. (Tetra Tech), on behalf of USEPA, will be responsible for arranging and conducting the tasks described in this SAP. Tetra Tech updated preliminary versions of the Uniform Federal Policy QAPP and this SAP, both of which were drafted by under the Scientific, Engineering, Response, and Analytical Services (SERAS) contract. Tetra Tech will review and manage all project data on behalf of USEPA Region 9.

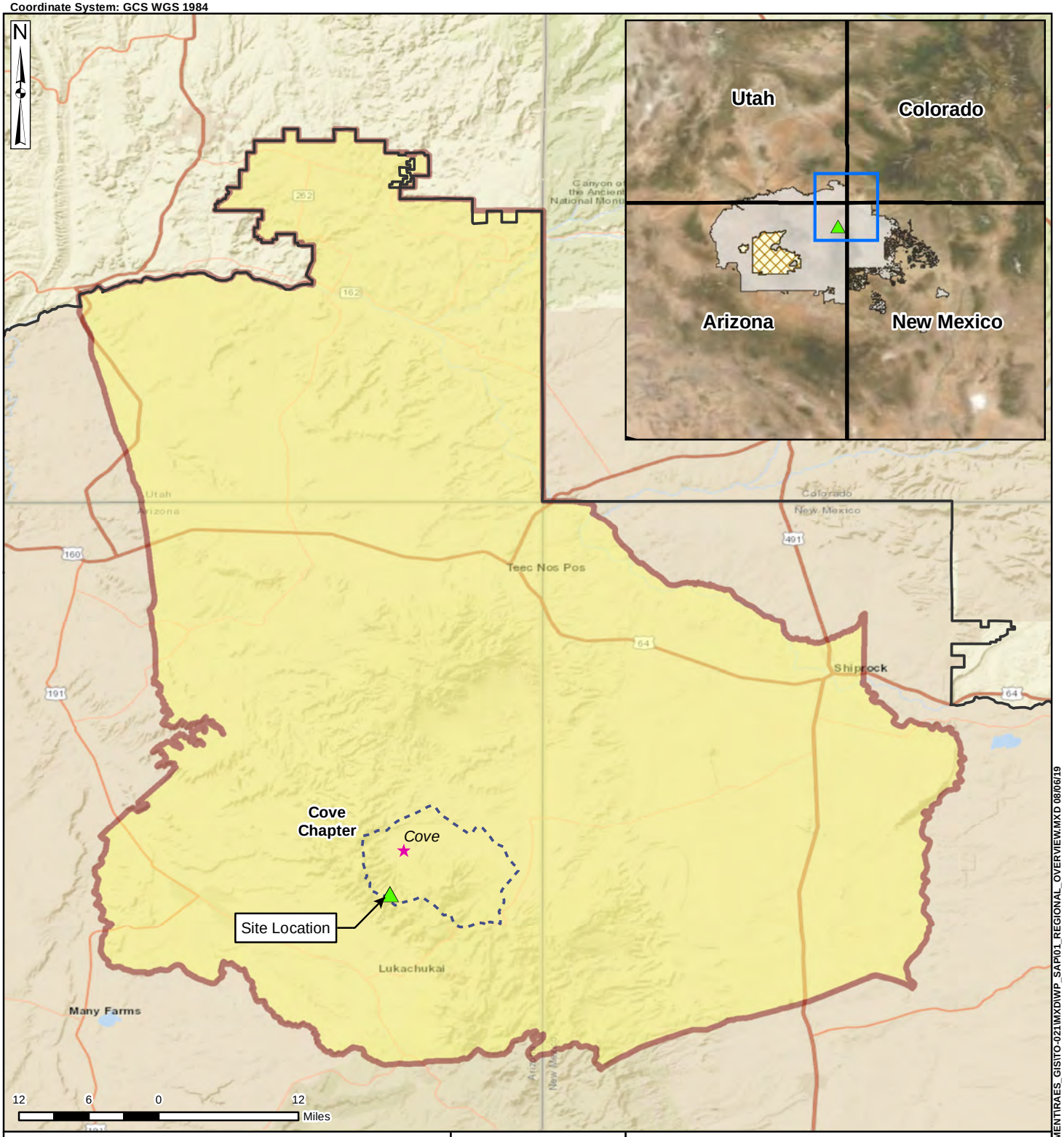
1.3 PROJECT ORGANIZATION

Worksheet #3 of the QAPP (Attachment A1) presents the key project personnel contact information and roles for the Mesa II TCRA. Worksheet #5 of the QAPP presents the key project personnel organization chart for the project.

Air monitoring, air field analysis and confirmation sample collection, and soil surveys will be conducted by Tetra Tech. Inter-Mountain Laboratories (IML) in Sheridan, Wyoming, will analyze the confirmation air samples. Tetra Tech is responsible for all data management and reporting tasks.

The Tetra Tech data manager will be the main collector of information for the project. The sampling team will forward all sampling information (in both hard copy and electronic format) to the data manager. The sampling team will send all confirmation samples to the laboratory under chain-of-custody (COC) records. The laboratory will provide preliminary and final analytical results, along with the corresponding analytical data packages, to Tetra Tech. Hard copies of sampling information and other project documentation will be stored at Tetra Tech's Oakland, California office.

Coordinate System: GCS WGS 1984



- ★ Populated Place
- ▲ Mesa II Mine Complex
- Affected Chapter Boundary
- Navajo Nation Boundary
- Hopi Reservation
- Northern Abandoned Uranium Mine Region

Prepared for: U.S. EPA Region 9

Prepared By:

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REGIONAL OVERVIEW OF MESA II MINE COMPLEX

Task Order No.:	Contract No.:	Figure No.:
TO0021	EP-S9-17-03	A-1
Location: COVE CHAPTER NAVAJO NATION	Date: 8/6/2019	

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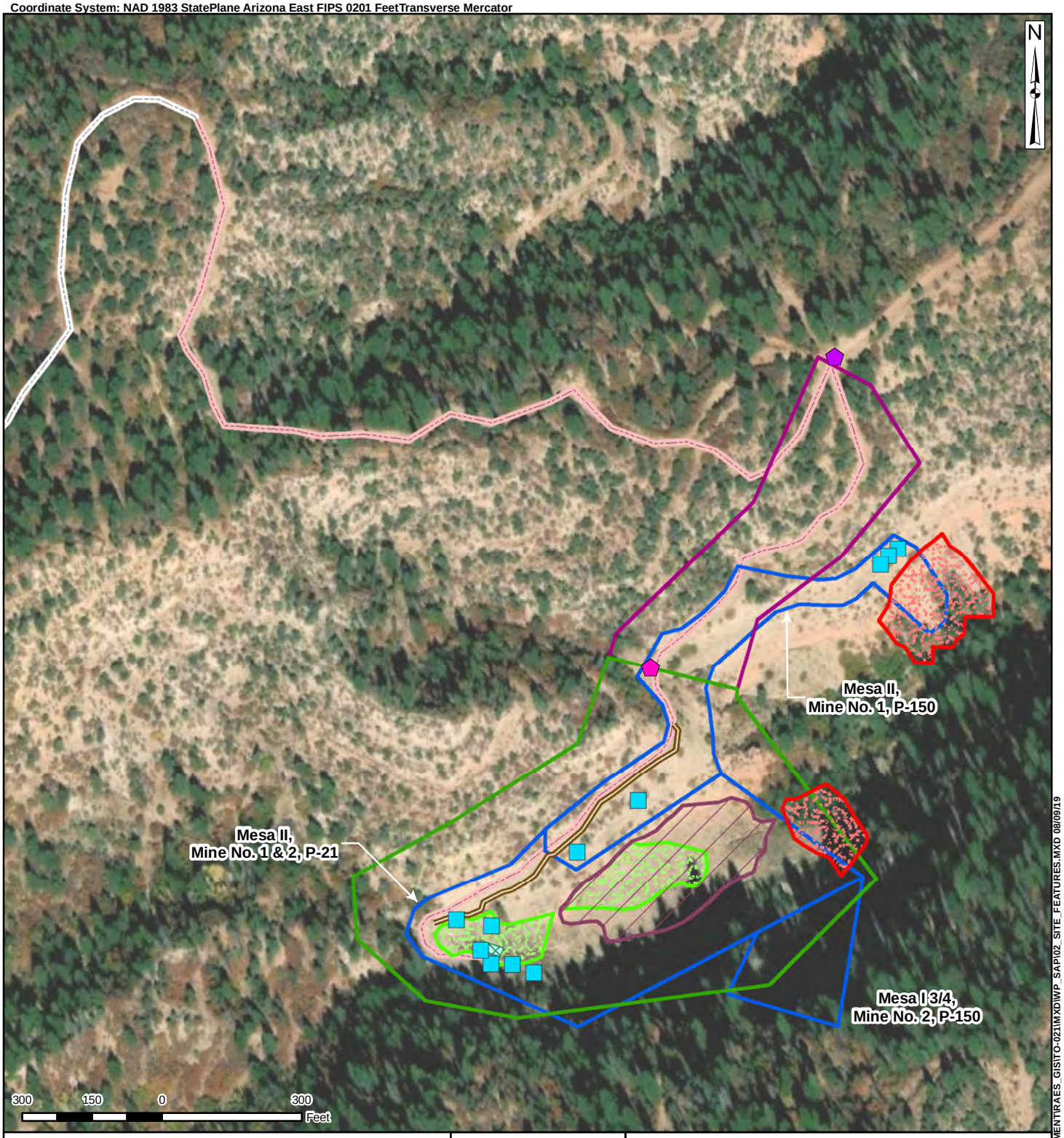
Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Access Route

- Access Route *No Modifications*
- Access Route *Proposed Grade and Fill*

Staging Area

- Preliminary
- Secondary

Exclusion Zone

- Preliminary
- Secondary

Site Features

- Closed Portal
- Berm
- Drainfield
- Burial Cell
- Waste Pile - Reclaimed
- Waste Pile - Unreclaimed

Prepared for: U.S. EPA Region 9

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SITE FEATURES MAP

Task Order No.:	Contract No.:	Figure No.:
TO0021	EP-S9-17-03	A-2
Location: COVE CHAPTER NAVAJO NATION	Date: 8/9/2019	

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2.0 BACKGROUND

2.1 INVESTIGATION AREA DESCRIPTION

Air monitoring for particulate matter and field analysis and confirmation sampling for radionuclides will occur at four air monitoring and sampling stations within the Mesa II TCRA project area. During the road repair work, the stations may be moved on a daily basis depending on progress along the road. Due to the challenging terrain while working on the road, the locations will be as follows: 1) ahead of the active work area, 2) behind the active work area, 3 and 4) on each side of the road in locations that are safe to access. Once the road is complete, the air monitoring and sampling stations will be placed around the perimeter of the erosion repair work area inside the exclusion zone to detect migrating dust before it reaches the exclusion zone boundary. The locations of the air monitoring and sampling stations will be recorded using a mobile GPS unit.

Gamma radiation walkover surveys will precede any soil disturbing work within the exclusion zone(s) established by USEPA and Clawson Excavation (Clawson). Real-time results will be compared to background threshold values (BTVs) established for the two AUM sites (Mesa II, No. 1, P-150 [M28] and Mesa II, Mine No. 1 & 2, P-21 [M27]) during the Mesa II Removal Site Evaluation conducted by Tetra Tech in 2018. The established BTVs for gamma radiation at M27 is11,378 counts per minute (cpm) and 9,703 cpm at M28. In addition to the gamma radiation walkover surveys, the survey areas will be screened using an XRF and compared to non-radiological contaminants of potential concern (COPCs) outlined in Section 4.5.

2.2 PROJECT AREA HISTORY

Uranium outcrops were discovered within the Cove Wash watershed in the late 1940s. Uranium and vanadium ore shipments from the watershed began in 1950 with mine sites situated along mesas throughout the watershed. Uranium and vanadium mining ceased in the 1960s, and the mine sites were subsequently abandoned. The Navajo Nation reclaimed this area in the 1990s, but mine waste is present throughout the watershed.

The Mesa II Mine is a former underground uranium mine that operated in the 1950s and consists of a 2.2-acre uranium waste reclamation cell that is eroding into the Cove Wash. Contaminants contained in the uranium waste include uranium and its progeny, radium-226, which have resulted in gamma and alpha ionizing radiation in the Cove Wash watershed. Other inorganic contaminants may also be of concern.

2.3 PREVIOUS INVESTIGATIONS/REGULATORY INVOLVEMENT

The following reports from previous studies of the area were provided by USEPA Region 9, and have been reviewed to assist with the planning phase of the Mesa II TCRA:

- Biological Baseline Data and Geology of the Cove Region, Apache County, Arizona, May 2015 (Clifford 2015)

- Draft Biological Assessment, Mesa II Complex (Tetra Tech, Inc. and iiná bá, Inc., April 2019)
- Cove Removal Assessment Actions Biological Assessment Report. Consultation No. 02EAAZ00-2015-I-0452. June 2017 (USEPA Region 9 2017)
- Draft Removal Site Evaluation reports for Mesa II sites (Tetra Tech 2019)
- Final Mexican Spotted Owl Survey Report for 2018 Nesting Season (Tetra Tech 2019).

2.4 CLIMATOLOGICAL INFORMATION

Attachment A2 contains a wind rose depicting the wind pattern from the NNEPA meteorological station in Shiprock, New Mexico, which is approximately 30 miles to the east of the site and is considered representative of site conditions.

The annual precipitation for Shiprock, New Mexico, is 7.68 inches. The average daily high temperature is 70.5 °F, the average daily low temperature is 36.5 °F, and the average daily temperature is 53.5 °F (https://www.usclimatedata.com/climate/shiprock/new-mexico/united-states/usnm0301).

2.5 ENVIRONMENTAL AND HUMAN IMPACT

Contamination of airborne dust with radionuclides may result in inhalation (by humans and/or ecological receptors) of radionuclides, specifically alpha particles. These dust particles are too large to permeate through the epidermis but exhibit a highly carcinogenic effect when organs and soft tissue are exposed via inhalation of dust.

Metals are typically found in areas rich in uranium and are commonly a component of uranium mine tailings. Human exposure to airborne metal contamination may pose acute and long-term carcinogenic effects.

3.0 PROJECT QUALITY OBJECTIVES

3.1 PROJECT OBJECTIVES AND PROBLEM DEFINITION

The objective of perimeter air monitoring, field analysis, and sampling is to determine the nature and extent of particulate matter and radionuclides migrating off site due to road repair and erosion control-TCRA activities. If air monitoring, field analysis, and/or confirmation sampling results are above project action limits (PAL), Tetra Tech will notify USEPA Region 9 and additional mitigation measures may be implemented.

The objective of personnel air sampling is to determine personnel exposure levels to metals and radionuclides during road repair and erosion control-TCRA activities.

The objective of the gamma radiation and XRF soil surveys is to identify any areas of contamination (uranium and metals) in the road and the borrow soil areas so they can be avoided or properly stored within the existing burial cell at the Mesa II TCRA site.

3.2 DATA QUALITY OBJECTIVES

The USEPA has developed a systematic planning process called the DQO process for data collection. The process focuses on a decision that is supported by the data so that only those data required for evaluating a decision will be collected, ensuring that the right quality and quantity of data are collected to make a specific decision (American National Standard Institute [ANSI] 2014). Feedback from the project team was used to develop the DQOs for the Mesa II TCRA.

The DQO process is a systematic planning approach for data collection based on the scientific method (USEPA 2006). The overall DQO process, USEPA orders, and federal regulations that mandate a Quality System are described in USEPA's guidance document Guidance for the Data Quality Objectives Process (USEPA 2006). The document addresses all environmental data operations, from initial characterization to final cleanup and release. The latest version of this document segregates the type of project by the final objective: decision or estimation. Other guidance is found in Chapter 2 of MARSSIM and ANSI/HPS N13.59-2008 (R2014) for applying the DQO process specifically to sites contaminated with radioactive materials. A chart depicting the seven steps of the DQO process is presented in Figure 9 of the Work Plan.

The complete DQOs for this project are presented in Worksheet 11 of the QAPP (Attachment A1). Project measurement performance criteria are summarized on Worksheets 12-1 and 12-2. Project PALs, project quantitation limit goals, and laboratory-specific quantitation limits are summarized on Worksheets 15-1 and 15-2. A summary of field QC samples to be collected is shown in Worksheet 20. Laboratory quality control (QC) samples and associated measurement performance criteria are summarized on Worksheets 28-1 and 28-2.

3.3 DATA REVIEW AND VALIDATION

Tetra Tech chemists, under direction of the Tetra Tech QA manager, will be responsible for validating laboratory data. Tetra Tech plans to validate 100 percent of chemical and radiological laboratory data. Ninety percent of the data will undergo Stage 2B (Level III) cursory validation and ten percent of the data will receive Level IV full validation.

Tetra Tech will follow the most current USEPA guidelines for completing data validation. These include:

- USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review
- Multi-Agency Radiological Laboratory Analytical Protocols Manual

Data that do not meet the data quality objectives outlined in the QAPP will be flagged as estimated or rejected in accordance with USEPA 2017. Decisions about corrective actions (e.g., reanalysis or resampling) due to rejected data, will be made by USEPA Region 9.

3.4 DATA MANAGEMENT

Quarterly reports will be generated by Tetra Tech and will include and/or reference: sampling worksheets, logbooks, raw laboratory reports, and validated data packages.

Tetra Tech will be the main repository of information for the project. It will be archived by Tetra Tech in accordance with the DMP. The sampling team will forward all sampling information (in both hard copy and electronic format) to the Tetra Tech data manager. The sampling team will send all samples to the laboratory under COC records. The laboratory will provide preliminary and final analytical results, along with the corresponding analytical data packages, to Tetra Tech. Hard copies of sampling information and other project documentation will be stored at Tetra Tech's Oakland, California office. Project documents and records are listed in Worksheet #29 of the QAPP (Attachment A1).

3.5 ASSESSMENT OVERSIGHT

Assessment oversight will be performed by USEPA Region 9. Planned project assessments can be found in Worksheet #31 of the QAPP (Attachment A1). Corrective action responses can be found in Worksheet #32 of the QAPP. The types and frequency of quality assurance (QA) management reports will be determined by USEPA Region 9.

4.0 SAMPLING RATIONALE AND FIELD PROCEDURES

4.1 PERIMETER AIR PARTICULATE MATTER MONITORING

Perimeter air particulate matter monitoring will be conducted continuously during all Mesa II TCRA road repair and erosion-control activities. The objective of perimeter air monitoring is to determine the extent of particulate matter migrating off site due to road repair and erosion control-TCRA activities.

Four stations (north, east, south and west) will surround the work to achieve representative exposure data. Due to the linear nature of road work and terrain access issues, monitoring station locations will not be selected until field activities begin. Stations will be selected based on adequacy of space for placement of low-volume samplers, accessibility, and orientation surrounding the work being performed. They will be placed just inside the exclusion zone.

Perimeter monitoring stations will be set up before work begins, monitored throughout the work day and be taken down at the end of each work day. DustTraks are factory calibrated and therefore do not require calibration, except for a zero calibration that will be completed each morning and again at the end the day. Tetra Tech personnel will conduct periodic checks of the monitoring stations (three times per day at a minimum). The checks will entail the following: assessment of the physical condition of the equipment, verification that the desired data are being collected, and assurance that the results are not approaching site-specific action levels. Real-time readings will be recorded on all air monitoring devices for download onto a computer at the end of each day.

The perimeter monitoring stations will be TSI DustTrak II Aerosol Monitors (DustTraks). These are capable of monitoring particulate concentrations down to 0.001 milligram per cubic meter (mg/m^3). DustTraks will be used to detect particulate matter 2.5 micrometers or less in diameter (PM2.5). During the periodic checks, Tetra Tech will take DustTrak readings and record readings in the logbook or on field data sheets. If air monitoring data exceed PALs, Tetra Tech will notify the USEPA Region 9 so additional mitigation measures can be implemented. Worksheets 15-1 and 15-2 of the QAPP (Attachment A1) present the applicable PALs.

Data irregularities and problems will be identified, flagged, and investigated throughout the day. At the end of each working day, all data will be reviewed for accuracy. Air monitoring data will be compiled in a central database.

4.2 PERIMETER AIR RADIONUCLIDE SAMPLING

Perimeter air radionuclide field analysis and confirmation sampling will be conducted during all Mesa II TCRA road repair and erosion-control activities for gross alpha, gross beta, and uranium ore. The objective of perimeter air radionuclide field analysis and confirmation sampling is to determine the extent of radionuclides migrating off site due to road repair and erosion control-TCRA activities.

Four perimeter air confirmation sampling stations will be situated at the same locations as the perimeter air particulate matter monitoring stations. The perimeter air confirmation sampling

stations will consist of low-volume air pumps (GilAir Plus Air Sampling Pump or similar) connected to Tygon tubing fitted with radiological (gross alpha, gross beta, and uranium ore) sampling trains. The sampling trains will be attached to a tripod or other stationary device such that the sample cassette is approximately four feet above the ground surface.

One confirmation sample will be collected per day at one of the perimeter air sampling locations (to be selected randomly), by placing a second low-volume air pump next to the first one. One low-volume pump will collect the original air sample and the second low-volume pump will collect a confirmation air sample. The confirmation air samples will be sent to IML for analysis and the original air samples will be field analyzed by the procedures outlined in Section 4.4.

For the perimeter air samples, attached to each air pump will be a 47 millimeter (mm) polytetrafluoroethylene (PTFE) filter in a cassette at a flow rate of approximately 3 liters per minute (LPM) over a sample period of approximately 8 hours, for a minimum total sample volume of approximately 1,440 liters (L) per cassette. The confirmation samples will be collected using a 47-mm PTFE filter in a cassette at the same flow rate and for the same time period as the original sample.

The air sampling stations will be set up before soil disturbing work begins, monitored throughout the work day and be taken down at the end of each work day. The inlet cap of all filter cassettes will be removed (such that it is open-faced) during sampling; the cassette will be positioned downward and perpendicular to the wind direction. With complete sampling trains attached, each ambient air sampling pump will be pre- and post-calibrated using a primary standard such as a MesaLabs BIOS Defender 520 DryCal Air Flow Calibrator primary flow meter capable of calibrating pumps from 1 to 5 L/min. Sampling will be conducted in accordance with the USEPA ERT SERAS SOP No. 2008, “General Air Sampling Guidelines” (Attachment A3) Pre- and post-calibration flow rates will be documented on the chain-of-custody form and the average flow rate will be used to determine the volume of the sample collected.

Tetra Tech personnel will conduct periodic monitoring (at a minimum of three times per day) of the perimeter air sampling stations to ensure the sampling equipment is functional. Periodic monitoring will consist of checking on the physical condition of the equipment, assessing the equipment to ensure the pump is running and air is moving through the sample cassette. If an issue with a pump is discovered, the time and issue will be noted and a new pump will be connected to the sample chain to continue sample collection.

Tetra Tech personnel will record all start and stop times for the low-volume pumps and calculate the total volume of air for each sample at the end of the day. The sample cassettes will be removed from the sampler, the ends of the cassette will be sealed and placed in an anti-static plastic bag that will be labeled with the sample information. The confirmation samples will be stored in a secure container pending shipment to IML. At the end of each day, Tetra Tech will field analyze the perimeter air samples by the procedures in Section 4.4.

One field blank will be collected and submitted weekly to IML. Field blanks will consist of filters shipped from the lab, but not loaded into the air samplers. These filters will be labeled and sent to the laboratory to assess possible interference/cross contamination from sample collection

and shipping procedures. The field blanks will be analyzed for the same analytes as the perimeter air samples.

The purpose of perimeter air radionuclide field analysis and confirmation sampling (gross alpha, gross beta, and uranium ore) is to ensure that levels of uranium ore-related radionuclides in the air remain below 10 percent of the uranium ore derived air concentration (DAC). The DAC is the concentration of radioactive material in air, that will result in an annual limit of intake if an individual breathes that air for a year. The DAC for uranium ore is 6×10^{-11} (µCi/ml), and 10 percent of the DAC is 6×10^{-12} (µCi/ml). Using 10 percent of the DAC as a project action level is a conservative value as the duration of the project (8 weeks) is 15 percent of the year. If air sample results are above PALs or above 10 percent of the DAC, Tetra Tech will notify USEPA Region 9, who will determine appropriate action. Data irregularities and problems will be identified, flagged, and investigated throughout the day. At the end of each working day, all data will be reviewed for accuracy.

The confirmation air samples will be shipped to IML for analysis for gross alpha, and gross beta. IML will use USEPA Method 900.0 for gross alpha and gross beta, and the concentration of uranium ore will be calculated from the radiological results using the calculations described in Section 4.4.

See Worksheet #18 of the QAPP for sample collection details including the analytes of interest, any sampling SOP references, and the rationale for each sample location. Detailed descriptions of sample containers, preservatives, and holding times are summarized in Worksheet #19 of the QAPP (Attachment A1). Requirements for collecting field QC samples are included in Worksheet #20.

4.3 PERSONNEL AIR SAMPLING

Personnel air samples will be collected from subcontractor personnel (Clawson) performing work due to their proximity to onsite hazards for the first week. The objective of personnel air sampling is to determine the personnel exposure levels of metals and radiation during road repair and erosion control-TCRA activities. The samples will be analyzed for metals arsenic, molybdenum, selenium, uranium, and vanadium as they are COPCs for the Cove Air Study and were also identified as COPCs in Mesa II in the Draft Removal Site Evaluation reports for Mesa II sites (Tetra Tech 2019). The samples will also be analyzed for gross alpha, gross beta, and uranium ore.

If there are no exceedances of OSHA PELs and 10 percent of the DAC for uranium ore in the first week, the personnel air sampling will be discontinued. If there are exceedances, USEPA Region 9 will be notified immediately, dust management practices will be adjusted and USEPA Region 9 will decide whether to continue personnel air sampling for the duration of the project. Samples representing typical full-shift employee exposure will be collected daily from six personnel. Three of the samples will be radiologically (gross alpha, gross beta, uranium ore) field analysis and three will be sent to IML for metals analysis (arsenic, molybdenum, selenium, uranium, vanadium) and confirmation gross alpha, gross beta, and uranium ore.

Analytical results of the metals will be compared to the applicable OSHA permissible exposure limits (PELs) and used to inform dust mitigation and worker exposure decision-making, available in Worksheets #15-1 and #15-2 of the QAPP. Tetra Tech and ERG will be using the assumptions in 10 CFR 20 Appendix B, note 3 for calculations of uranium ore concentrations in air samples. The derived air concentration (DAC) of uranium ore is 6×10^{-11} µCi/ml, and exceedances in the field analysis will be any concentrations of uranium ore over 10 percent of the DAC (6×10^{-12} µCi/ml).

4.3.1 Personnel Air Sampling Methods

Each participant will be fitted with a GilAir 5 (or similar) low-volume air sampling pump consisting of Tygon tubing fitted with the metals and radiological sampling trains. The sampling trains will be attached to the lapel or on their PPE in the workers' breathing zone located in a hemisphere of 6 to 9 inches around the individual's face (SERAS SOP 2008, Attachment A3). The Tygon tubing should be attached to the workers' clothing or PPE in such a manner as not to restrict their motion during site activities or present an entanglement hazard.

Samples will be collected over a continuous full shift period (i.e. with sampling periods of at least 7 hours, in accordance with OSHA specifications). With complete sampling trains attached, each personal sampling pump will be pre- and post-calibrated using a primary standard such as a MesaLabs BIOS Defender 520 DryCal Air Flow Calibrator or equivalent to a flow rate combined with the intended sampling period to achieve an acceptable volume for the metals appropriate for the analysis that the laboratory would be performing. Pre and post calibration flow rates will be documented on the chain-of-custody form and the average flow rate will be used to determine the volume of the sample collected. For the lab confirmation samples, attached to each air pump will be a 47-mm polytetrafluoroethylene (PTFE) filter in a cassette. For the radiological (gross alpha, gross beta, uranium ore) field analysis samples, attached to each air pump will be a 47 mm glass fiber filter in a cassette. The radiological (gross alpha, gross beta, and uranium ore) field analysis is outlined in Section 4.4.

4.3.1.1 Field Collection Procedures for Personnel Air Monitoring

1. Select a calibrated lapel air sampler and install a 47 mm diameter filter in the filter cassette head, check cassette size. Keep cassette filter inlet covered until ready to begin sampling

2. Determine the time and flow rate necessary to sample a volume sufficient to ensure that an adequate MDC is obtained. It is recommended to operate at 3.0 LPM. A five (5) to eight (8) hour sample is preferable.

3. Select a worker with the highest potential for exposure to airborne radioactive materials. Instruct the worker on proper use of the wearing of the lapel sampler. Position the filter head in the breathing zone. Make sure the filter head is pointing downwards to prevent interference from particulates settling rather than sampled from the breathing zone.

4. Start the pump just prior to the worker entering the work area and record in the field logbook (or appropriate form) name of the monitored worker, nature of the work, date, pump start time and pump flow rate.

5. Record any time the pump is started or paused/stopped. While pump is not running, cover the inlet with inlet cap. If cap is not available, a piece of tape can ensure no material is gained or lost while sampling paused.

   Note: It is integral to know the amount of time sampled at a given flow rate (i.e. the total volume of air sampled) for calculations. While the air pump should keep track of total time sampled, loss of battery power, user error, or other situations can cause this number to not be accurate and it should not be solely relied upon. Accurate account of start/stop times can ensure total volume is known.

6. At the end of the BZ sampling period, turn off the pump, remove the filter cassette from the flexible connector tube and re-plug the inlet/outlet openings to the cassette chamber at the end of the monitoring period (prior to transport/delivery for subsequent sample analysis at the designated filter counting location).

Tetra Tech personnel will review the monitoring data collected from the low-flow air pumps on a daily basis. Data irregularities and problems will be identified, flagged, and investigated. At the end of each working day, all field data will be reviewed for accuracy. Air sampling field data will be compiled in a central database.

Filters will be sent from a laboratory in an appropriate cassette. After sampling, the filter cassette will be removed from the sampler, the ends of the cassette will be sealed and placed in an anti-static plastic bag that will be labeled with the sample information. The samples will be stored in a secure container pending radiological field analysis or shipment to IML. Confirmation samples for will be shipped to IML for analysis under 72-hour turn-around time for the metals analysis.

4.3.2 Personnel Air Sampling Analysis – Lab Metals and Confirmation Radiological

Confirmation samples will be submitted to IML via the following methods:

- Analysis for metals will be conducted in accordance with USEPA Methods IO 3.1 using NIOSH 7300 Elements by ICP (Inductively Coupled Argon Plasma, Atomic Emissions Spectroscopy) and IML SOP for Agilent Inductively Coupled Plasma Mass Spectrometer for analytes: arsenic, molybdenum, selenium, uranium and vanadium.
- Gross alpha and beta via USEPA Method 900.0 and IML SOP for Analysis of Gross Alpha-Beta
- Uranium ore will be calculated from the radiological results through same calculations as in the radiological field analysis (see Section 4.4)

Recognizing that this work may require extended work days (i.e. >8 hours a day) and/or work weeks (i.e. > 40 hours in a work week), it will be necessary to modify the occupational exposure limits (OEL) which are based on a typical work day and work week. These modifications will be

computed on both a daily and weekly basis, and then the more restrictive OEL result will be used follows:

OEL Adjustments for extended work days (> 8 hours):

Adjusted OEL = OEL x [8 hours / hd] x [(24 hours – hd) / 16]

hd = Actual or planned hours worked per day

OEL Adjustments for extended work weeks (>40 hours):

Adjusted OEL = OEL x [40 hours/ hw] x [(168- hw) / 128]

hw = Actual or planned hours per work week

Personnel air sampling will be conducted in accordance with the applicable regulatory requirements and with approved NIOSH air sampling methods described in this SAP. Recognizing that several substances could represent inhalation hazards associated with this work, and that there is a distinct sampling method necessary for each of these substances, a "representative sampling" approach will be used. This will involve identifying workers who would be expected to have similar exposures, and regarding the results to be valid for the representative group. Pump calibration flow rates and the duration of sampling periods will be established to obtain appropriate sample volumes in accordance with the air sampling methods referenced in this SAP.

Detailed descriptions of sample containers, preservatives, and holding times are summarized in Worksheet #19 of the QAPP (Attachment A1). Requirements for collecting field QC samples are included in Worksheet #20.

4.4 RADIOLOGICAL FIELD ANALYSIS

Radiological field analysis data will be recorded using the Alpha Air Particulate Sampling Survey Form provided by ERG and in Attachment A3. Radiological field analysis procedures were provided by ERG:

Summary and basic recommendations:

- Count field samples the day following sample collection (to allow interference from Rn-222 to decay away).
- Count **background** for at least 30 minutes.
- Count **samples** for at least 20 minutes.

Record all results in appropriate forms. Background should be counted at the beginning of the project and the end of the project, at a minimum. If time permits, perform a background count daily.

Detailed procedures:

BACKGROUND

1. Using a Ludlum 2929 with 43-10-1 tray counter (or equivalent), determine background alpha counts by counting a clean/blank filter. It is recommended to count for at least 30 minutes to ensure the minimum detectable concentration (MDC) is less than 10 percent of the uranium ore dust DAC.
2. The MDC can be calculated using the equation below:

$$MDC, \frac{\mu Ci}{mL} = \frac{2.71 + 3.29 * 1.25\sqrt{\frac{Bkg\ counts}{t_{BG}} * t_S\left(1 + \frac{t_{BG}}{t_S}\right)}}{2.22x10^6\left(\frac{dpm}{\mu Ci}\right) * Efficiency\ \left(\frac{cpm}{dpm}\right) * Volume\ (mL) * t_S}$$

   Where:

   - t_{BG} = Time background (clean) filter was counted (Recommended at least 30 minutes)
   - t_S = Time sample is counted (Recommended at least 20 minutes)
   - Efficiency = Measured or calculated from calibration sheets (15-20 percent efficiency expected)
   - Volume = Volume of air sampled (Flow rate [LPM] * Sample collection time [minutes] * 1000 mL/L)

3. If the MDC is not less than 10 percent of the DAC (i.e. MDC < 10 percent of 6E-11 µCi/mL) increase the background and/or field sample counting times.

FIELD SAMPLE

Using a Ludlum 2929 with 43-10-1 tray counter (or equivalent), determine gross alpha and beta activity as follows:

1. Remove the sampling filter from the cassette with tweezers (avoid touching the filter with hands). Place the filter sample into the measurement counting planchet. Ensure that the filter is placed on the planchet such that the inlet side (where dust/particulates collected) faces up towards the detector. Then place the counting planchet into the counting tray.
2. Count the field sample. (*Recommended to count for at least 20 minutes*, per MDC discussion above)
3. The gross alpha and beta activity can be calculated using:

$$C = \frac{(S - BG)(FA)}{(2.22x10^6)(E)(V)}$$

Where:

- C = concentration in air, µCi/ml
- S = Sample alpha count rate (cpm) = gross sample counts / sample count time (min)
- BG = Background count rate (cpm) = background counts / background count time (min)
- E = Detector efficiency, cpm/dpm
- V = Volume sampled (mL) = Average flow rate (LPM) x sample collecting time (min) x 1000 mL/L
- FA = Filter absorption factor, 1.25 for glass fiber filter, 1.00 for beta counting
- 2.22×10^6 = Conversion factor, dpm to µCi

4. In the event a sampling result returns a percentage of the DAC value greater than 10 percent, recount the sample. If the elevated counting result persists, the original counting result will be considered the official result. If not, the recount will be considered the official result. If the limit is still exceeded, the sample must be recounted every 24 hours for at least 72 hours after initial count. This is to allow any remaining radon or thoron daughters collected on the filter to decay. If the result still exceeds the applicable limit, notify the site Radiation Safety Officer or Health and Safety Officer.

4.5 SOIL SURVEYS

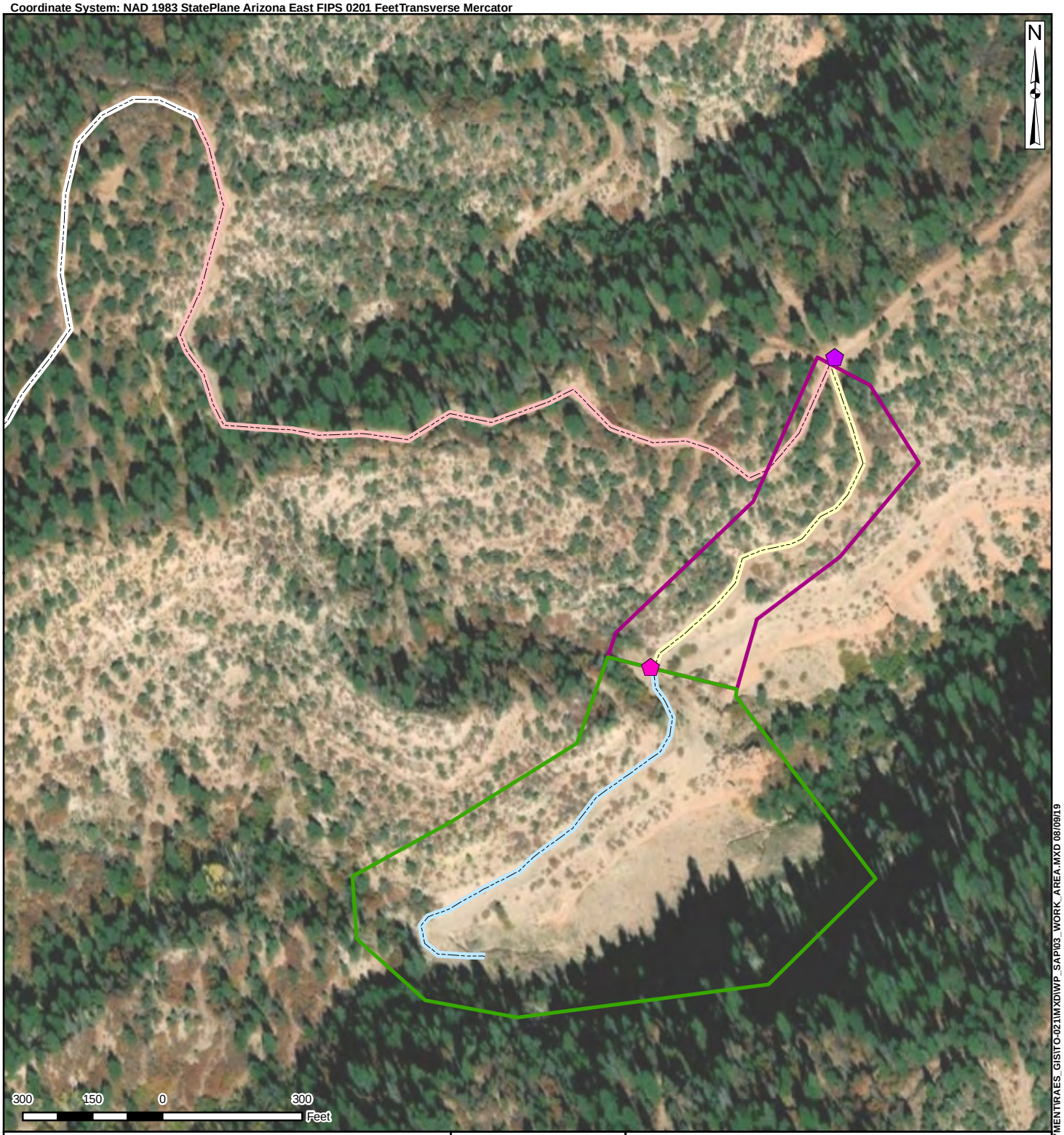
Tetra Tech will perform gamma-radiation walkover surveys throughout the Mesa II TCRA project area using a gamma meter. Tetra Tech will follow the gamma scans with in-situ XRF scans for metals of the road and borrow soil areas. The object of the soil survey is to identify any areas of contamination (heavy metals and uranium) in the road and the borrow soil areas so they can be avoided or properly stored within the existing burial cell.

Gamma surveys will be conducted with a gamma radiation detection system linked to a GPS. Areas to be surveyed include roads leading to Mesa II, potential borrow areas, removal work areas, and the reclamation cell. Before work commences on the road repair, Tetra Tech will scan the road inside the exclusion area with the Ludlum Model 2221, RS232 Mod with Bluetooth gamma scanner and Ludlum 44-10 Gamma Scintillation Probe (also known as a RadScout system). Tetra Tech will follow the gamma scans with in-situ XRF scans of the road.

In-situ XRF scans will follow Tetra Tech SOP 004: Field-Portable X-Ray Fluorescence Analyzer Measurement (Attachment A3). Three scans will be performed approximately every 10-feet, evenly distributed across the road. If any gamma scans and/or XRF readings are above the applied BTV, Tetra Tech will demarcate these locations with survey flags and notify USEPA Region 9. The USEPA Region 9 will utilize the scan data to guide decision making regarding avoiding or removing contaminated soil.

The metal primary contaminants of concern were identified in the Mesa II in the Draft Removal Site Evaluation reports for Mesa II sites (Tetra Tech 2019). Applied BTVs for the project area were taken from Appendix H27 and Appendix H28 of the of the Tronox Draft RSE report (Mesa II in the Draft Removal Site Evaluation reports for Mesa II sites, Tetra Tech 2019). Figure A-3 depicts the M27 and M28 AUM outlines and the project area. The more conservative value between the M27 and M28 AUM applied BTVs is shown in Table A-1.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Access Route

- Access Route *No Modifications*
- Access Route *Stage 1 Grade and Fill*
- Access Route *Stage 2 Grade and Fill*
- Access Route *Stage 3 Grade and Fill*

Staging Area

- Preliminary *Stage 1 and 2 Modifications*
- Secondary *Stage 3 Modifications*

Exclusion Zone

- Preliminary *Stage 1 and 2 Modifications*
- Secondary *Stage 3 Modifications*

Prepared for: U.S. EPA Region 9

Prepared By:

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OVERVIEW OF PROJECT AREA

Task Order No.:	Contract No.:	Figure No.:
TO0021	EP-S9-17-03	A-3
Location: COVE CHAPTER NAVAJO NATION	Date: 8/9/2019	

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Table A-1. Applied Background Threshold Values for M27 and M28

Analyte	Units	Applied BTV[1]	Applied BTV Selection[2]
Aluminum	mg/kg	4,090	Site-Specific BTV BSA-29
Antimony	mg/kg	0.14	Regional BTV Jml
Arsenic	mg/kg	2.0	Site-Specific BTV BSA-29
Barium	mg/kg	138	Site-Specific BTV BSA-24
Beryllium	mg/kg	0.51	Regional BTV
Cadmium	mg/kg	0.063	Site-Specific BTV BSA-29
Calcium	mg/kg	22,900	Site-Specific BTV BSA-29
Chromium	mg/kg	3.8	Site-Specific BTV BSA-29
Cobalt	mg/kg	3.4	Site-Specific BTV BSA-29
Copper	mg/kg	6.6	Site-Specific BTV BSA-24
Iron	mg/kg	8,000	Regional BTV
Lead	mg/kg	9.9	Site-Specific BTV BSA-30
Lithium	mg/kg	5.3	Site-Specific BTV BSA-30
Magnesium	mg/kg	2,510	Site-Specific BTV BSA-29
Manganese	mg/kg	329	Site-Specific BTV BSA-29
Mercury	mg/kg	0.0111	Site-Specific BTV BSA-29
Molybdenum	mg/kg	0.26	Site-Specific BTV BSA-29
Nickel	mg/kg	3.6	Site-Specific BTV BSA-29
Potassium-40	pCi/g	21.3	Site-Specific BTV BSA-29
Radium-226	pCi/g	0.85	Site-Specific BTV BSA-29
Radium-228	pCi/g	0.6	Site-Specific BTV BSA-30
Selenium	mg/kg	0.92	Site-Specific BTV BSA-29
Silver	mg/kg	0.037	Regional BTV Jml
Sodium	mg/kg	35	Site-Specific BTV BSA-10
Thallium	mg/kg	0.069	Site-Specific BTV BSA-29
Thorium	mg/kg	3.6	Regional BTV
Uranium	mg/kg	0.64	Site-Specific BTV BSA-30
Vanadium	mg/kg	12	Site-Specific BTV BSA-29
Zinc	mg/kg	23	Site-Specific BTV BSA-29
Gamma Radiation	cpm	9,703	Site-Specific BTV BSA-24

Notes:

[1] The lower of the BTVs for M27 and M28.

[2] The origin of the Applied BTV based on which BTV was lower between the site-specific or regional background evaluation in M27 and M28.

BSA-24 Background Study Area 24
BSA-29 Background Study Area 29
BSA-30 Background Study Area 30
BSA-10 Background Study Area 10
BTV Background threshold value
cpm Count per minute
Jml Lower Morrison Formation
mg/kg Milligram per kilogram
pCi/g Picocurie per gram

5.0 FIELD METHODS AND EQUIPMENT

The following section describes the procedures and equipment that will be used during the site activities. Field activities will be conducted in accordance with the following standard methods, guidelines, and SOPs:

- Tetra Tech SOP 004: Field-Portable X-Ray Fluorescence Analyzer Measurement
- Tetra Tech SOP 019: Packaging and Shipping Samples
- Tetra Tech SOP 024: Recording Notes in Field Logbooks
- Tetra Tech SOP 064: Calibration of Air Sampling Pump
- Tetra Tech and ERG RPP SOP 001: Calibration of a Radiological Survey Detector
- Tetra Tech and ERG RPP SOP 002: Calibration of a Radiological Survey Meter
- Tetra Tech and ERG RPP SOP 006: Personnel, Environmental, and Work Area Air Sampling
- SERAS SOP #2008: General Air Sampling Guidelines
- SERAS SOP #2101: Retrieving Meteorological Information
- SERAS SOP #2119: Air Sampling for Metals [NIOSH Method 7300, Elements]
- SERAS SOP #2130: Operation of the DryCal DC-Lite Primary Flow Calibrator

These SOPs are included in Attachment A3. All methods and procedures are subject to change until they are finalized.

5.1 FIELD EQUIPMENT

5.1.1 List of Equipment Needed

Platforms and enclosures, including a means of sound dampening, will be purchased or constructed to house the sampling instruments at each location. Power will be provided by DustTrak external batteries.

For PM2.5 monitoring, the following equipment is required:

- TSI DustTrak II Aerosol Monitor
- DustTrak external batteries and charger
- DustTrak enclosure and tripod
- Forceps

For radiological and metals sampling, the following equipment is required:

- Low-flow air pumps (GilAir Plus Air Sampling Pump or similar)

- 25-millimeter (mm)-diameter, 0.8-micrometer (µm) mixed cellulose ester membrane (MCE) filter cassette (or 5.0 µm polyvinyl chloride membrane)
- A 4- to 5-foot-high cassette tripod stand
- MesaLabs BIOS Defender 520 DryCal Air Flow Calibrator or equivalent Tygon tubing
- Forceps

For personnel air sampling, the following equipment is required:

- GilAir 5 low volume air sampling pump
- Tygon tubing
- Metals and radiological sampling trains
- MesaLabs BIOS Defender 520 Drycal Air Flow Calibrator or equivalent
- 37 mm diameter, 0.8 µm MCE filter cassette

At least one extra set of sampling and calibration apparatus of each type will also be on site or stored in the vicinity. The additional unit will be maintained at the site in the event of an equipment failure.

For soil scanning, the following equipment is required:

- Ludlum Model 2221, RS232 Mod with Bluetooth gamma scanner
- Ludlum 44-10 Gamma Scintillation Probe
- GPS, Trimble PRO-XRT w/Omni Star Service
- Niton XL5 portable XRF scanner

For decontamination scanning, the following equipment is required:

- Ludlum 12 ratemeter
- Ludlum 44-9 G-M pancake probe

5.1.2 Calibration of Field Equipment

Routine calibration and performance checks for all equipment will be conducted based on the procedures outlined in the respective SOPs, which are included in Attachment A3. Recalibration and maintenance will be performed by the sampling team as needed. All equipment calibration and maintenance will be documented in the site logbook. The logbook(s) will be kept by the sampling team between sampling events and scanned to the appropriate electronic project file. Worksheet #22 of the QAPP contains a list of field equipment/instrument calibration, maintenance, testing, and inspection items.

5.1.3 Decontamination Procedures

Air sampling generally does not require decontamination because of the nature of the sampling equipment. The air samplers will be scanned at the end of each day with a Ludlum 12 connected to a Ludlum 44-9 G-M alpha/beta pancake detector (also known as a pancake probe). If any radiological contamination is found, they will be washed with water onsite and rescanned until they are decontaminated. The equipment will be cleaned in accordance with manufacturer specification prior to use, but the use of disposable filters for sampling does not require the sampling equipment to be decontaminated between events.

6.0 SAMPLE CONTAINERS, PRESERVATION, PACKAGING, AND SHIPPING

Filter media and containers will be provided by the laboratories performing the analysis.

6.1 LAB CONFIRMATION SAMPLES

Filters for metal and radiological confirmation samples will be pre-assembled in cassette cases supplied by the laboratory; after sampling, the and cassette unit will be placed in the original metal canister and returned to the laboratory. Filters should not, at any point, be removed from the cassette. Sample canisters will be placed into pre-labeled anti-static bags. Sample packages will be placed into a shipping box with the corresponding COC record and appropriate packaging material to separate the samples and prevent damage. Sample packaging and shipment will be done in accordance with Tetra Tech SOP 019, Sample Packing and Shipment. The sample coolers will be shipped within 1 to 5 days following sample collection to IML.

6.2 PACKAGING AND SHIPPING

Sample packing and shipping procedures will be conducted according to Tetra Tech SOP 019. All sample containers will be placed in a strong-outside shipping container. The following outlines the packaging procedures that will be followed for low concentration samples:

1. When ice is used, pack it in zip-lock, double plastic bags. Seal the drain plug of the cooler with tape to prevent melting ice from leaking out of the cooler.
2. Optionally, the bottom of the cooler may be lined with bubble wrap to prevent breakage during shipment. A plastic bag may be used to line the entire interior of the cooler to prevent leakage from the cooler. The bag would be tied and taped to securely seal the water inside.
3. Affix sample labels onto the outer container/bag with clear tape.
4. If applicable, wrap all glass sample containers in bubble wrap to prevent breakage.
5. Seal all sample containers in heavy duty, plastic zip-lock bags. Write the sample numbers (or place an additional label) on the outside of the plastic bags with indelible ink.
6. Place samples in a sturdy cooler(s). Enclose the appropriate COC(s) in a zip-lock plastic bag affixed to the underside of the cooler lid.
7. Fill empty space in the cooler with bubble wrap.
8. Ice used to cool samples will be double sealed in two zip-lock plastic bags and placed on top and around the samples to chill them to the correct temperature.
9. Each ice chest will be securely taped shut with tape, and custody seals will be affixed to the front, right, and back of each cooler.

7.0 DISPOSAL OF RESIDUAL MATERIALS

In the process of collecting environmental samples, the sampling team may generate different types of potentially contaminated investigation-derived waste (IDW) that include the following:

- Used personal protective equipment (PPE)

The USEPA's National Contingency Plan (NCP) requires that management of IDW generated during sampling comply with all applicable or relevant and appropriate requirements to the extent practicable. The sampling plan will follow the *Office of Emergency and Remedial Response (OERR) Directive 9345.3-02* (May 1991) or SERAS SOP 2049, Investigation-Derived Waste Management, which provides the guidance for the management of IDW. In addition, other legal and practical considerations that may affect the handling of IDW will be considered.

- Used PPE and disposable equipment will be double bagged and placed in a municipal refuse dumpster. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE and disposable equipment that is to be disposed of that can still be reused will be rendered inoperable before disposal in the refuse dumpster.

8.0 SAMPLE DOCUMENTATION AND SHIPMENT

8.1 FIELD NOTES

All on-site activities relevant to the investigation should be recorded in a logbook or on field data sheets.

8.1.1 Field Logbooks

Logbooks will be used on-site in accordance with Tetra Tech SOP 024, Recording Notes in Field Logbooks. The purpose of the dedicated site logbook is to provide an accurate summary of field events to allow future reconstruction of circumstances in the writer's absence. Entries must detail the activities of all personnel involved in field activities and must be made by all personnel on site. Each entry must be made in a bound, consecutively numbered logbook and signed by the person making the entry. The sequence of site activities must be clear to a reader who was not at the site. Site logbooks will reflect only those activities related to the site regardless of duration.

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location and description
- Sampler's name(s) and affiliation
- Date and time of sample collection
- Type of sample
- Type of sampling equipment used
- Field instrument readings and calibration
- Field observations and details related to analysis or integrity of samples (for example, weather conditions, noticeable odors, and colors)
- Sample preservation
- Lot numbers of the sample containers, sample identification numbers and any explanatory codes, and COC form numbers
- Shipping arrangements (overnight air bill number)
- Name(s) of recipient laboratory(ies)

In addition to the sampling information, the following specific information will also be recorded in the field logbook for each day of sampling:

- Team members and their responsibilities
- Time of arrival/entry on site and time of site departure
- Other personnel on site

- Summary of any meetings or discussions with tribal, contractor, or federal agency personnel
- Deviations from sampling plans, site safety plans, and QAPP procedures
- Changes in personnel and responsibilities with reasons for the changes
- Levels of safety protection
- Calibration readings for any equipment used and equipment model and serial numbers

8.1.2 Photographs

Photographs will be taken at the sampling stations, at a minimum, before or during the first sampling event. They will serve to verify information entered in the field logbook. For each photograph taken, the following information will be written in the logbook or recorded in a separate field photography log:

- Time, date, location, and weather conditions
- Description of the subject photographed
- Name of person taking the photograph

8.2 LABELING

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The samples will have pre-assigned, identifiable, and unique numbers. At a minimum, the sample labels will contain the following information: station location, date and time of collection, and analytical parameter(s). Every sample, including samples collected from a single location but going to separate laboratories, will be assigned a unique sample number.

The sampling team will follow the example below to generate a unique sample ID for each perimeter sample:

Mesa2-X-PER-2019mmdd-Z

The sampling team will follow the example below to generate a unique sample ID for each personnel sample:

Mesa2-workername-2019mmdd

Where:

- X is a one-digit indicator for the station location (N-North, S-South, E-East, or W-West) (see QAPP Worksheet #18, or FB for field blanks)
- MM is a two digit indicator for the month of collection “01” through “12” for the collection

- DD is a two-digit indicator for the day of collection "01" through "31" for the collection
- Z is a one-digit indicator for the method ("M" for metals sampling filters or "R" for radionuclide sampling filters)

8.3 SAMPLE CHAIN-OF-CUSTODY FORMS AND CUSTODY SEALS

COC procedures will follow the Tetra Tech SOP 019: Packaging and Shipping Samples. All sample shipments for analyses will be accompanied by a COC record. The COC form(s) will be completed and sent with the samples for each laboratory and each shipment (that is, each day). If multiple coolers/sample packages are sent to a single laboratory on a single day, the form(s) will be completed and sent with the samples for each cooler/sample package.

The COC form will identify the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is in someone's custody if it is in someone's physical possession or view, locked up, or kept in a secured area that is restricted to authorized personnel. Until the samples are shipped, the custody of the samples will be the responsibility of the sampling team (Tetra Tech). The sampling team leader or designee will sign the COC form in the "relinquished by" box and note the date, time, and air bill number.

A self-adhesive custody seal will be placed across the exterior of each sample container. The shipping containers in which the samples are stored (a sturdy picnic cooler or ice chest) will be sealed with self-adhesive custody seals any time they are not in someone's possession or view before shipping. All custody seals will be signed and dated.

The COC records will include, at a minimum, the sample identification number, number of samples collected, sample collection date and time, sample type, sample matrix, sample container type, sample analysis requested, sample preservation, and the name(s) and signature(s) of samplers and all individuals who have had custody. Custody seals will demonstrate that a sample container or cooler has not been opened or tampered with. The sampler will sign and date the custody seal and affix it to the container or cooler in such a manner that it cannot be opened without breaking the seal.

9.0 QUALITY CONTROL

9.1 FIELD QUALITY CONTROL

Field QC protocols will consist of proper equipment calibration; and adherence to instrument manufacturer user manuals and Tetra Tech SOPs for air monitoring, sampling, and documenting activities in the site logbook as described in the Tetra Tech SOP No. 024, "Recording of Notes in Field Logbook". All direct-reading instruments will be calibrated daily before use and according to manufacturer instructions. Table A-2 describes the anticipated equipment calibrations.

Table A-2. Equipment Calibrations

Instrument	Parameters to Measure	Frequency of Calibration	Calibration gas/conc.
DustTrak	Particulates	NA (annual factory calibration)	NA (annual factory calibration)
Gillian 5 low-flow Pump	Particulates	Twice Daily	NA

Note:
NA Not applicable

Field QC protocols will also include the collection of one lot blank sample per lot of PTFE filter cassettes used and one field blank per day. Field blanks will be collected to evaluate whether contaminants are being introduced into the samples during the sampling because of ambient conditions or from sample containers. Field blank samples will be obtained by subjecting sample filters to the same shipping, set-up, and storage procedures as would be applied to a sample. However, no air will be mechanically pulled through the field blank filter. The field blanks that are collected will be analyzed for compound lists identical to the field sample analyses applicable for the specific media.

The Tetra Tech field team lead will be responsible for ensuring that sample quality and integrity are maintained, and that sample label and documentation procedures are in accordance with this plan.

9.2 LABORATORY QUALITY CONTROL

Laboratory QC protocols are described in the QAPP (Attachment A1).

10.0 FIELD VARIANCES

As conditions in the field may vary, it may become necessary to implement minor modifications to sampling as presented in this plan. When appropriate, the Tetra Tech Project Manager and QC coordinator or QA Manager will be notified, and a verbal approval will be obtained before implementing the changes. Modifications to the approved plan will be documented on field change forms and in the sampling project report.

11.0 FIELD HEALTH AND SAFETY PROCEDURES

Several organizations will be performing on-site field work on this project, including Tetra Tech, the USEPA, and Clawson Excavation, Inc. It is the responsibility of each on-site entity to provide their own HASP. Appendix C of the WP contains the Tetra Tech HASP.

In cases where the entity's HASP differs from the Tetra Tech HASP, the more stringent of the requirements will be followed.

ATTACHMENT A1

QUALITY ASSURANCE PROJECT PLAN

ATTACHMENT A1

QUALITY ASSURANCE PROJECT PLAN
Mesa II Air Monitoring and Soil Scanning
Mesa II Mine Erosion Repair and Time Critical Removal Action
Cove, Arizona

Prepared for:
United States Environmental Protection Agency/Region 9
San Francisco, CA

and

United States Environmental Protection Agency/Environmental Response Team
Edison, New Jersey

By:
Tetra Tech, Inc.
1999 Harrison Street, Suite 500, Oakland, CA 94612
RAES Contract EP-S9-17-03 Task Order Number: 00021

Based on the Intergovernmental Data Quality Task Force Uniform
Federal Policy for Quality Assurance Project Plans
(Final Version 1, March 2005)

August 26, 2019

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EXHIBITS

QAPP Worksheet #1: Title and Approval Page

Site Name/Project Name: Mesa II Air Monitoring and Soil Scanning
Site Location: Navajo Nation, Cove Chapter, Apache County, Arizona (AZ)

Document Title: Quality Assurance Project Plan (QAPP) for Mesa II Air Monitoring and Soil Scanning

Lead Organization: U.S. Environmental Protection Agency (USEPA)

Preparer's Name and Organizational Affiliation: Mike Ferrif, Tetra Tech, Inc.

Preparer's Address, Telephone Number, and Email Address: 1999 Harrison Street, Suite 500, Oakland CA 94611 (510) 302-6320, mike.ferrif@tetratech.com

Preparation Date (Day/Month/Year): 8/26/2019

Lead Organization's Project Manager: _____ Signature

Printed Name/Title: Mike Ferrif/Tetra Tech Project Manager

Approval Signatures: _____ Signature

Printed Name/Title: Katie Henry/Tetra Tech QC Coordinator

Approval Signaturese: _____ Signature

Printed Name/Title: Kenyon Larsen/Tetra Tech Program Manager

QAPP Worksheet #2: QAPP Identifying Information

Site Name/Project Name: Mesa II Air Monitoring and Soil Scanning
Site Location: Navajo Nation, Cove Chapter, Apache County, AZ
Site Number/Code: Not applicable
Operable Unit: Not applicable
Contractor Name: Tetra Tech, Inc.
Contract Number: EP-W-09-031

Contract Title: RAES
Task Order Number: 0021

1. Identify regulatory program: Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
2. Identify approval entity: USEPA
3. The QAPP is (select one): ☐Generic ☒Project Specific
4. List dates of scoping sessions that were held: 8/1/2019
5. List dates and titles of QAPP documents written for previous site work, if applicable:

Title	Approval Date
Not applicable	Not applicable

6. List organizational partners (stakeholders) and connection with lead organization:
   USEPA Region 9 (R9)
7. List data users:
   USEPA R9
8. If any required quality assurance project plan (QAPP) elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusions below:

   Worksheet 37: USEPA Region 9 will be responsible for assessing the usability of the data.

QAPP Worksheet #2: QAPP Identifying Information (Continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to QAPP Worksheet
Project Management and Objectives		
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2.3 Distribution List and Project Personnel Sign-Off Sheet 2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	- Distribution List - Project Personnel Sign-Off Sheet	3 4
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2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	- Project Planning Session Documentation (including Data Needs tables) - Project Scoping Session Participants Sheet - Problem Definition, Site History, and Background - Site Maps (historical and present)	 9 10
2.6 Project Quality Objectives and Measurement Performance Criteria 2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	- Site-Specific PQOs - Measurement Performance Criteria Table	11 12

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QAPP Worksheet #2: QAPP Identifying Information (Continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to QAPP Worksheet
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5.3 Streamlining Data Review 5.3.1 Data Review Steps To Be Streamlined 5.3.2 Criteria for Streamlining Data Review 5.3.3 Amounts and Types of Data Appropriate for Streamlining		

Note:
NA = Not applicable

☐ Worksheet Not Applicable (State Reason)

QAPP Worksheet #3: Distribution List

QAPP Recipients	Title	Organization	Telephone Number	Fax Number	E-mail Address
Edwin "Chip" Poalinelli	Task Order Contract Officer Representative	USEPA	(415) 972-3390	(415) 947-3530	poalinelli.edwin@epa.gov
Sophia Serda	Quality Coordinator	USEPA	(415) 972-3057	Not available	Serda.Sophia@epa.gov
Christian LeJeune	Field Team Leader	Tetra Tech	(505) 235-2966	Not available	christian.lejeune@tetratech.com
Jeremey Bekis	Field Team Leader	Tetra Tech	(505) 715-1405	Not available	jeremey.bekis@tetratech.com
Randy Dorian	Data Manager	Tetra Tech	(303) 312-8832	(303) 295-2818	randy.dorian@tetratech.com
Mike Ferrif	Project Manager and QAPP Preparer	Tetra Tech	(510) 302-6320	Not available	mike.ferrif@tetratech.com
Deborah Kutsal	Project Chemist and Data Reviewer	Tetra Tech	(509) 688-5957	Not available	deborah.kutsal@tetratech.com
Katie Henry	QC Coordinator	Tetra Tech	(510) 302-6298	Not available	katie.henry@tetratech.com
Kenyon Larsen	Program Manager	Tetra Tech	(510) 302-6359	Not available	kenyon.larsen@tetratech.com

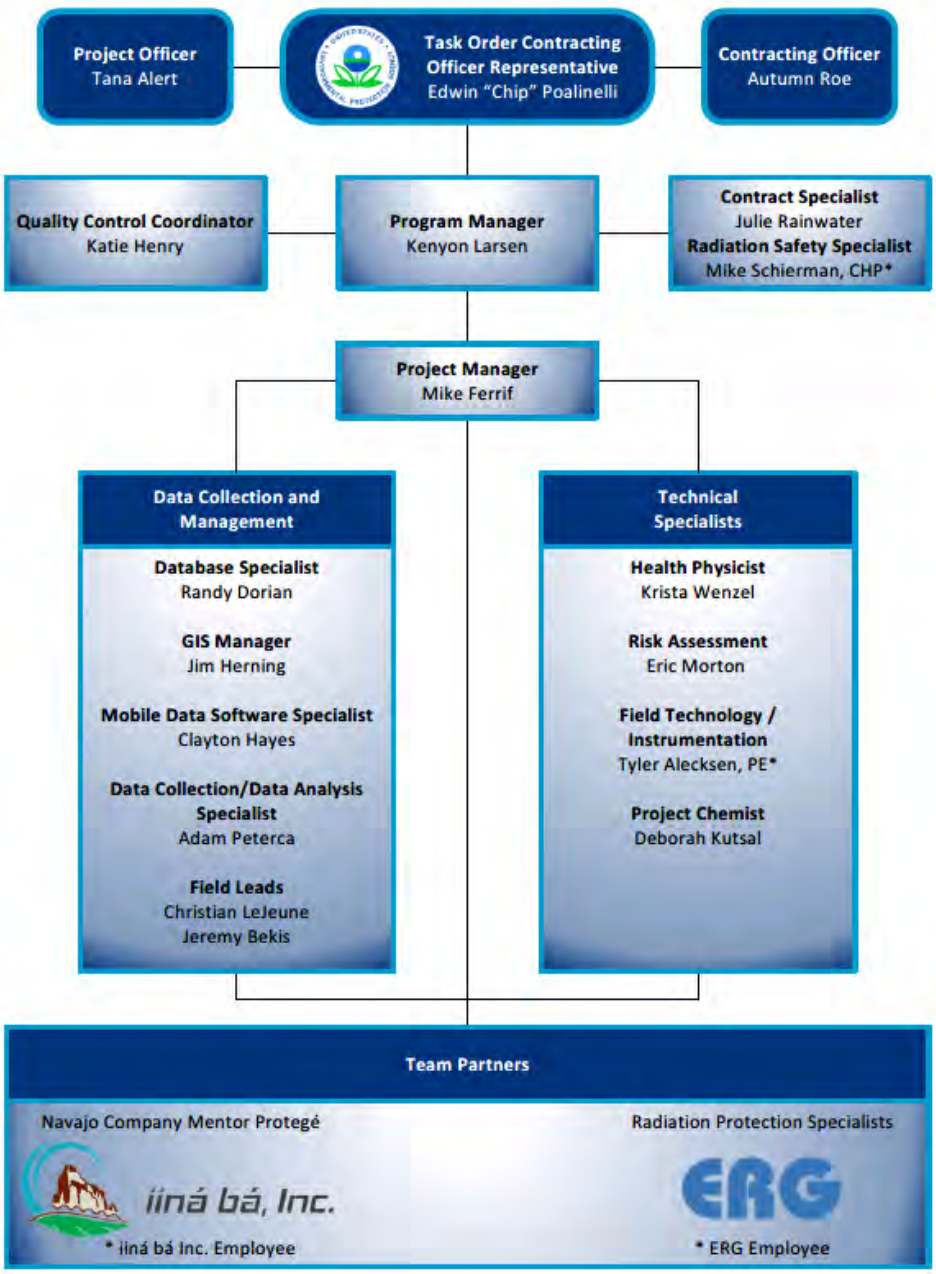
QAPP Worksheet #4: Project Personnel Sign-Off Sheet

Organization: Tetra Tech/USEPA Region 9

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Edwin “Chip” Poalinelli	USEPA R9 TOCOR	(415) 972-3390		
Randy Dorian	Tetra Tech Data Manager	(303) 312-8832		
Mike Ferrif	Tetra Tech Project Manager	(510) 302-6320		
Christian LeJune	Field Team Leader	(505) 235-2966		
Jeremey Bekis	Field Team Leader	(505) 715-1405		
Eric Brandjord	Inter-Mountain Laboratories	(307) 461-4940		
TBD	TBD Data Validator	TBD		

☐ Worksheet Not Applicable (State Reason)

QAPP Worksheet #5: Project Organizational Chart



☐ Worksheet Not Applicable (State Reason)

QAPP Worksheet #6: Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Approval of initial QAPP and any amendments	USEPA R9 RPM USEPA R9 Quality Coordinator	Edwin "Chip" Poalinelli Sophia Serda	(415) 972-3390 (415) 972-3057	Peer review followed by USEPA R9 approval; implementation of changes effective only with approved QAPP or QAPP Change Form.
Nonconformance and corrective action	Sampling Team Leader USEPA R9 RPM USEPA R9 Quality Coordinator Tetra Tech Project Manager	Christian LeJune Edwin "Chip" Poalinelli Sophia Serda Mike Ferrif	(505) 235-2966 (415) 972-3390 (415) 972-3057 (510) 302-6320	Use of the Field Change Form for field issues.
Delivery of quarterly deliverables to EPA	Tetra Tech Project Manager	Mike Ferrif	(510) 302-6320	Delivered via email in accordance with project schedule.
Health and Safety On-Site Meeting	Field Team Leader and/or Site Health and Safety Officer	Christian LeJune Jeremey Bekis	(505) 235-2966 (505) 715-1405	Explains site hazards, personal protective equipment, and local hospital.

☐ Worksheet Not Applicable (State Reason)

QAPP Worksheet #7: Personnel Responsibilities and Qualification Table

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Christian LeJune	Field Team Leader	Tetra Tech	Project Supervision/Field Investigation, Field Health and Safety, Reporting Air Monitoring Operations/ Air Sampling Operations	B.S. degree plus a minimum of 5 years of related experience/Employee Files
Jeremey Bekis	Field Team Leader	Tetra Tech	Project Supervision/Field Investigation, Field Health and Safety, Reporting Air Monitoring Operations/ Air Sampling Operations	B.S. degree plus a minimum of 5 years of related experience/Employee Files
Edwin “Chip” Poalinelli	RPM	USEPA R9	Technical Direction/Project Coordinator	USEPA job-related responsibilities/USEPA Employee Files
Sophia Serda	Toxicologist/Risk Assessor	USEPA R9	Quality Assurance Oversight	USEPA job-related qualifications/USEPA Files
Stephen Blaze	Quality Coordinator	EPA	Quality Assurance Oversight	USEPA job-related qualifications/USEPA Files
Mike Ferrif	Project Manager/Report Writer	Tetra Tech	Data Validation/Analytical Report	B.S. degree plus a minimum of 10 years of related experience/Employee Files
Deborah Kutsal	Project Chemist/Report Writer	Tetra Tech	Data Validation/Analytical Report and Electronic Data Deliverable (EDD) Review	B.S. degree plus a minimum of 10 years of related experience/Employee Files
Randy Dorian	Data Manager	Tetra Tech	EDD Preparation and Data Management	B.S. degree plus a minimum of 10 years of related experience/Employee Files

QAPP Worksheet #8: Special Personnel Training Requirements Table

Project Function	Specialized Training – Title or Description of Course	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
Project Oversight	Health & Safety Training	Christian LeJune	Sampling Team Leader	Health & Safety Files

QAPP Worksheet #9: Project Scoping Session Participants Sheet

Project Name: Air Monitoring and Soil Scanning **Projected Field Work Date(s):** September 2019 to October 2019 **Project Manager:** Edwin "Chip" Poalinelli	**Site Name:** Mesa II Mine **Site Location:** Navajo Nation, Cove Chapter, Arizona

Date of Session: 7/19/19. 8/1/19
Scoping Session Purpose: Discuss project-related tasks

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Edwin "Chip" Poalinelli	TOCOR	USEPA Region 9	(415) 972-3390	poalinelli.edwin@epa.gov	Project Coordination and Implementation
Tyler Alecksen		Environmental Restoration Group (ERG)	(505) 298-4224	tyleralecksen@ergoffice.com	Technical Direction
Mike Ferrif	Project Manager	Tetra Tech	(808) 498-5092	mike.ferrif@tetratech.com	Tetra Tech Project Manager
Cynthia Breene	Scientist III	Tetra Tech	(510) 302-6341	cynthia.breene@tetratech.com	SAP/QAPP Preparation
Eric Morton	Risk Assessor	Tetra Tech	(312) 201-7797	eric.morton@tetratech.com	Technical Direction
Christian LeJeune	H&S Officer/Field Team Lead	Tetra Tech	(505) 235-2966	christian.lejeune@tetratech.com	Field Team Lead
Jeremey Bekis	H&S Officer, Field Team Lead	Tetra Tech	(505) 715-1405	jeremey.bekis@tetratech.com	Field Team Lead

The objective of air monitoring and sampling is to determine the nature and extent of particulates migrating off site because of road repair and erosion repair-TCRA activities. Air monitoring data will be recorded digitally or by using a site logbook and field data sheets to compare the data with site-specific action levels. Air sampling results will be analyzed onsite and the results of duplicate (confirmation) samples received from the off-site analytical laboratory, maintained in an electronic database, and compared to site-specific action levels. If air monitoring data or air sampling results are above action goals, Tetra Tech will notify the EPA so additional mitigation measures can be implemented.

Perimeter real-time particulate monitoring will be conducted daily throughout road repair and erosion-repair TCRA actions. Radiological air sampling will also be conducted at the perimeter particulate monitoring stations daily throughout road repair and erosion-repair TCRA actions. Sample locations will be selected during field mobilization because of the linear nature of road repair work and terrain access issues. Personnel air samples will be collected from Clawson Excavation (USEPA contractors performing the work) peronnel due to their proximity to onsite hazards for the first week and analyzed for metals and gross alpha/beta. If there are no exceedances for the select metals or radionucleotides in the first week, the personnel air sampling will be discontinued. If there are exceedances, USEPA will be notified immediately, dust management practices will be adjusted and USEPA will decide whether to continue personnel air sampling for the duration of the project .

Comments/Decisions: The 7/19/19 conference call between Chip, Mike, Christian and Jeremy established a meeting location of the Cove Chapter House at approximately 0900 on 7/25/19 prior to a pre-work site walk of the Mesa II TCRA area. The purpose of the site walk was to walk throught he progression of work and to scout potential air monitoring station locations as well as perform an initial gamma scan of a potential borrow source area. On the 7/25/19 site walk, the

initial and secondary staging areas were established which will mark the boundary of the exclusion zones as work progresses (Figure 2 in the SAP). Initial gamma scanning was also conducted along the road and at a potential borrow source.

A conference call including everyone listed above was held on 8/1/2019 to discuss specific project tasks. Tyler (ERG) explained the gross alpha and beta field counting process using a Ludlum 2929 with a 43-10-1 tray counter and confirmed that a low-flow breathing zone type air sampler would be sufficient to collect particulate air samples to be compared to the derived air concentration (DAC) for uranium ore. The XRF and gamma scanning strategy was also discussed and it was agreed that XRF screening will occur approximately every 10 feet along the road before soil disturbance. At each screening locarion, three evenly spaced measurements will be taken; one from either side of the road and one from the middle. A similar approach will be used for scanning the borrow source areas. Gamma scanning will also preceed soil disturbance on the road and borrow source areas. In areas where soil is going to be disturbed to a depth of more than approximately 20 cm (8 inches) below the ground surface, the soil will be rescanned with the gamma scanning equipment and XRF to account for the shielding effect of soil on radiation. EPA will be notified of areas that are above the background levels established during the Mesa II Removal Site Evaluation (RSE) and use the scan data to guide decisions about avoiding or removing ares of contaminated soil. This approach was selected by EPA because this is a time-critical action to repair the erosion around the burial cell in Mesa II and re-establish the drainage channel intended to divert water around it.

QAPP Worksheet #10: Problem Definition

Historical uranium mining activities may have resulted in radionuclide and metals contamination above background levels at various locations within the Lukachukai Mountains and surrounding communities in the Navajo Nation. The Mesa II Mine (Mine) is a former underground uranium mine that operated in the 1950s and consists of a 2.2-acre uranium waste reclamation cell which is eroding into the Cove Wash. Contaminants contained in the uranium waste include uranium and its progeny, radium-226, which have resulted in gamma and alpha ionizing radiation.

The nature and extent of this contamination are not fully known. There is the potential for surficial and subsurface contamination to pose unacceptable risks to human health and the environment and for contaminants to migrate off site via drainages and groundwater pathways, compromising drinking water resources and sensitive ecological environments. Furthermore, there is the potential for surficial contamination to migrate off site by wind erosion. Finally, physical hazards may also be present at these sites, which pose a risk to site visitors and wildlife.

The stormwater diversion channel around the Mesa II burial cell jumped its banks and formed a new channel that has been eroding contaminated soils. The water in the wash below Mesa II has also some of the highest concentrations of contaminants detected in the area.There are also water flows on top of the Mesa II burial cell that will be captured in a way to prevent further erosion and divert the flow into the desired drainage channel. To access the Mesa II site to carry out the erosion repair, the access road needs to be re-graded as it is heavily rutted and eroded in areas. The path of the access road was cut into a section of hillside with geologic characteristics indicating that naturally occurring uranium may be present beneath surface soils.

QAPP Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements

Step 1: State the problem

Historical uranium mining activities may have resulted in radionuclide and metals contamination above background levels at various locations within the Lukachukai Mountains and surrounding communities in the Navajo Nation.

Due to erosion, water and contaminated soil are migrating off of the Mesa II site. In order to perform an erosion control-TCRA, the road to access Mesa II also needs to be repaired. Contaminants of potential concern (COPC) and radionuclides of potential concern (ROPC) in the soil, including non-radiological metals and radionuclides, need to be identified via field screening prior to soil disturbance. In addition to field screening of surface soils, airborne particulates also need to be monitored for prevention of off-site migration and worker health and safety.

Step 2: Identify the goal of the study:

This step involves identifying the principal study questions to be assessed by field observations and measurements, sample collection, and field or laboratory analysis. Study questions are often used to quantitatively compare radiological or chemical concentrations with a background value, regulatory benchmark, or risk-based screening level. Study questions are also used to estimate the extent of contamination at a site or how far a chemical may have migrated.

The following principal study questions were identified to address the objectives of Mesa II TCRA air monitoring.

Mesa II Mine air monitoring Questions:

- Is the soil moved from/to the road during the road repair contaminated with ROPCs?
- Do soil borrow sources contain COPCs or ROPCs above background threshold values (BTVs) established during the Mesa II RSE?
- Do the air concentrations of COPCs or ROPCs in air in the Mesa II mine during the road repair and erosion control TCRA exceed established background levels or regional screening levels (RSL)?

Step 3: Identify information inputs:

The necessary information is air concentrations of COPCs and ROPCs in the Mesa II Mine area, and gamma scans of the road soil.

The ROPCs to be investigated are gross alpha, and gross beta which shall be compared to the derived air concentration (DAC) for uranium ore.

The list of COPCs to be investigated are arsenic, barium, lead, molybdenum, selenium, thorium, uranium, and vanadium.

Step 4: Define the boundaries of the study:

Portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore on Navajo Nation tribal lands for national defense and energy purposes led to a legacy of abandoned uranium mines (AUM) and AUM waste sites. The spatial boundary of the study is the Mesa II Mine and adjoining road area.

Step 5: Develop the analytic approach:

The parameters of interest are gamma readings and XRF of the road soil and borrow sources, the concentrations of COPCs and ROPCs in air, as well as meteorological data on wind direction and wind speed. Airborne PM2.5 will be monitored, and perimeter air samples will be collected and analyzed for gross alpha, gross gamma, uranium ore, arsenic, barium, lead, molybdenum, selenium, uranium, and vanadium (samples will be collected on a 47-mm PTFE filter for metals speciation via USEPA IO-3.5). Airborne radionuclides of concern are uranium ore (samples will be collected on a 47-mm PTFE filter for laboratory analysis of gross alpha/beta analysis and a 47-mm glass filter field screening for gross alpha/beta analysis). Meteorological data will be used to assist with the attribution of specific observations of concentration to likely sources.

Step 6: Specify performance or acceptance criteria: For this study, performance criteria are most appropriate. The quantitation limits for the samples are specified on Worksheet #15. Worksheets #12 and #28 show the measurement performance criteria that are needed for the quality indicators. Worksheet #20 shows the field quality control (QC) samples required.
Step 7: Develop the plan for obtaining the data: Four sampling stations will be placed at locations identified by Tetra Tech and USEPA Region 9. Samples will be collected from these stations daily and shipped to IML for analysis of the parameters identified above. Data will be validated and provided to USEPA for assessment purposes.

QAPP Worksheet #12-1: Measurement Performance Criteria Table – Metals

Matrix	Air
Analytical Group	Metals
Concentration Level	Low

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assess Error for Sampling (S), Analytical (A) or Both (S&A)
Tetra Tech and ERG RPP SOP 6, Tetra Tech SOP 064, and SERAS SOP #2130	USEPA Method IO-3.1 (Prep) and USEPA Method IO-3.5	Precision	±20% RPD	Field Collocated Sample	S & A
		Accuracy	< RL	Initial Calibration Blank	A
		Accuracy	%R ± 20% of true value	LCS	A
		Precision	± 20% of true value	Interference Check Standard	A
		Precision	RPD ≤ 20%	Duplicate/Spike Duplicate	A
		Accuracy	± 10% of undiluted sample	Serial Dilution	A
		Accuracy	± 5% of true value	High Standard Verification	A
		Accuracy	< RL	Continuing Calibration Blanks	A
		Accuracy	< RL	Reagent or Method Blank	A
		Completeness	>90% Sample Collection >90% Analysis Completed	Data Completeness Check	S&A
		Accuracy/Bias	%R = 75-125%	MS	A
		Accuracy/Bias (Contamination)	<RL	Field Blank	S & A

[1]Reference number from Worksheet #21

[2]Reference number from Worksheet #23

QAPP Worksheet #12-2: Measurement Performance Criteria Table - Radionuclides

Matrix	Air
Analytical Group	Radionuclides
Concentration Level	Low

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
Tetra Tech and ERG RPP SOP 6, Tetra Tech SOP 064, and SERAS SOP #2130	USEPA 900.0 (SM 7110 B), IML SOP R-GAB-4.3	Precision	±20% RPD	Field Collocated Sample	S & A
		Accuracy	+/- 15 ug/ for unexposed filters	Annual Balance Audit	A
		Accuracy	Initial filter weight and every 10 samples difference ≤ 3ug	Balance Check	A
		Precision	Duplicate Filter Weighing ± 15 ug difference	Balance Check	A

[1]Reference number from Worksheet #21
[2]Reference number from Worksheet #23

QAPP Worksheet #13: Existing Data Criteria and Limitations Table

Existing Data	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Limitations on Data Use
BTVs for Mesa II AUM sites	Appendix H27 and Appendix H28 of the of the Tronox Draft RSE reports for Mesa II sites, Tetra Tech 2019	Tetra Tech, gamma radiation walkover survey data, XRF survey data and soil sampling data, 2018	BTVs will be used to compare real-time soil screening data and guide EPA decision-making	Not applicable

BTV = Background threshold value

QAPP Worksheet #14: Summary of Project Tasks

Sampling Tasks:
Particulate matter air monitoring will be conducted continuously during all Mesa II TCRA road repair and erosion-repair activities. The objective of air monitoring is to determine the extent of particulates migrating off site due to road repair and erosion control-TCRA activities. Four stations (north, east, south and west) will surround the work to achieve representative exposure data. Due to the linear nature of road work and terrain access issues, monitoring station locations will not be selected until field activities begin. Stations will be selected based on adequacy of space for placement of low-volume samplers, accessibility, and orientation surrounding the work being performed. They will be placed just inside the exclusion zone.
Perimeter air samples will be collected during all Mesa II TCRA road repair and erosion-repair activities. The objective of air sampling is to determine the extent of particulates and radiation migrating off site due to road repair and erosion control-TCRA activities. The four air sampling stations will be placed at the same locations as the air monitoring stations.
Personnel air samples will be collected from Clawson personnel due to their proximity to onsite hazards for the first week.
Tetra Tech will perform gamma-radiation walkover surveys throughout the Mesa II TCRA project area using a gamma meter. Tetra Tech will follow the gamma scans with in-situ XRF scans for metals of the road.

Analysis Tasks:
- 128 perimeter air samples will be collected for radiological (gross alpha and gross beta) field analysis
- 40 perimeter air samples (including field blanks) will be collected for radiological (gross alpha, gross beta, and uranium ore) IML confirmation analyses.
- 12 personnel samples will be collected for radiological (gross alpha, gross beta, and uranium ore) field screening
- 12 personnel samples will be collected for metals and radiological (gross alpha, gross beta, and uranium ore) IML confirmation analysis
- Analyses for gross alpha and gross beta will be performed using USEPA Method 900.0 (Standard Method [SM] 7110 B).
- Analyses for metals will be performed using USEPA Method IO-3.5.

Quality Control Tasks:
Refer to Worksheets #12, 15, and 28 for analytical QC requirements.

Existing Data:
BTVs established during the 2018 Mesa II RSE will be used as screening levels for the gamma radiation walkover surveys and XRF field screening.

Data Management Tasks:
Field data will be recorded on gamma scanning equipment, DustTrak internal memory, field sampling forms and in field notebooks.

Documentation and Records:
All observations noted during field efforts will be documented in accordance with Tetra Tech SOP #024-2, Recording Notes in Field Logbooks, and SERAS SOP #2002, Sample Documentation. Documents and records that will be generated during this project include the WP (including SAP, QAPP, HASP, and DMP appendices), field logbooks, maps, instrument printouts, DustTrak data, GPS data, data reduction records, data assessment forms, field change forms (if necessary), weekly data summary reports, and quarterly data reports. Hard copies of the deliverables will be provided to USEPA on request.

Assessment/Audit Tasks:
A monthly assessment of field operations is anticipated for this project. If these assessments determine the sampling warrants minimal oversight, the assessments may be performed on a bimonthly basis. Management system reviews establish compliance with prevailing management structure, policies, and procedures and ensures that the required data are obtained.

Data Review Tasks:
All Tetra Tech project deliverables will receive an internal peer review prior to release per guidelines established in the Tetra Tech RAES Quality Management Plan. Data for radionuclides and metals will be validated by QC chemists.

QAPP Worksheet #15-1: Reference Limits and Evaluation Table - Metals

Matrix: Air

Analytical Group: Metals

Concentration Level: Low

Analyte	CAS Number	OSHA PEL (µg/m³)	Project Quantitation Limit (µg/m³)	Analytical Method (USEPA IO-3.5)		IML Achievable Laboratory Limits	
				MDLs (µg/m³)	Method QLs (µg/m³)	MDLs (µg/m³) [1]	QLs (µg/m³) [1]
Arsenic	7440-38-2	500	250	0.0003	NS	0.00012	0.046875
Lead	7439-92-1	50	25	0.00001	NS	0.00562	0.046875
Molybdenum	7439-98-7	5,000	2,500	0.00002	NS	0.00011	0.046875
Selenium	7782-49-2	200	100	0.0011	NS	0.00161	0.046875
Thorium	7440-29-1	NS	NS	0.00001	NS	NS*	NS*
Uranium	7440-61-1	50	25	0.00001	NS	0.0000044	0.046875
Vanadium	7440-62-2	500	250	0.00001	NS	0.005625	0.046875

NS = Not specified

* = IML will provide MDLs and QLs as soon as possible

1 = MDLs and QLs based on MDL of 2.5 µg/filter and QL of X ug/filter and sampling volume of 1,440 liters.

QAPP Worksheet #15-2: Reference Limits and Evaluation Table – Radionuclides (Gross Alpha/Beta/Gamma and Radium)

Matrix: Air

Analytical Group: Radionuclides

Concentration Level: Low

Analyte	CAS Number	Project Action Limit (µCi/mL)	Project Quantitation Limit (µCi/mL)	Analytical Method		IML Achievable Laboratory Limits	
				MDLs (µCi/mL)*	Method QLs (µCi/mL)	MDLs (µCi/mL)	QLs (µCi/mL)
Gross Alpha (1)	--	NS	NS	3.00E-9	NS	4.86E-12	1.04E-11
Gross Beta (1)	--	NS	NS	4.00E-9	NS	6.94E-12	1.39E-11

NS = Not specified.
* - does not account for sample volume
(1) – USEPA 900.0 (SM 7110 B)

QAPP Worksheet #16: Project Schedule Timeline Table

Activities	Organization	Dates (MM/DD/YY)		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Field Work - Sampling	Tetra Tech	September 2, 2019	October 24, 2019	Draft Cove Mesa II Air Monitoring and Soil Scanning Report	60 days from the completion of field work
				Final Cove Mesa II Air Monitoring and Soil Scanning Report	30 days from the receipt of EPA comments on the draft
Laboratory Analysis	IML	September 5, 2019	November 11, 2020	Level IV Analytical Data Packages	10 Business Days after receipt of each sample set
Field Assessment	Tetra Tech	Weekly	October 24, 2019	Field Log Book	While on-site
Data Validation/Analytical Report and EDD Preparation	IML	September 9, 2019	November 18, 2019	(Final Analytical Report)	7 days after analytical data set is finalized
Data Management	Tetra Tech	September 3, 2019	December 18, 2019	Final Cove Mesa II Air Monitoring and Soil Scanning Report	30 days from the receipt of EPA comments on the draft
Project Completion	Tetra Tech, USEPA R9	February 12, 2020	February 12, 2020	Final Cove Mesa II Air Monitoring and Soil Scanning Report	TBD

TBD To be determined

QAPP Worksheet #17: Sampling Design and Rationale

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach):

Sample locations will be selected during field mobilization because of the linear nature of road work, and terrain access issues. Locations will be selected that have adequate space for placement of DustTrak PM 2.5 particulate monitors and low-volume sample pumps and are far enough from tall structures or land features to limit their influence on sample intake. Four locations will be chosen chosen each day to encompass the active work area and achieve representative exposure data.

Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) [May refer to Worksheet #18 for details]:

A total of 128 perimeter air samples will be collected for radiological (gross alpha and gross beta) field analysis using methods outlined in Section 4.2.3 of the SAP. A total of 32 perimeter air samples (including field blanks) will be collected for radiological (gross alpha, gross beta) IML confirmation analyses using USEPA Method 900.0 (SM 7110B). Flow rates for perimeter air samples will be approximately 3 LPM over a sample period of approximately 8 hours for a minimum total sample volume of approximately 1,440 liters (L) per cassette.

A total of 12 personnel samples will be collected for radiological (gross alpha, gross beta, and uranium ore) field screening using method outlined in Section 4.2.3 of the SAP. A total of 12 personnel samples will be collected for metals and radiological (gross alpha, gross beta, and uranium ore) IML confirmation analysis, using USEPA Method 900.0 for gross alpha, gross beta. Analyses for metals will be performed using USEPA Method IO-3.5. Uranium ore calculation will be performed according to Section 4.2.3 of the SAP. Flow rates for personnel air samples will be approximately 3 LPM over a sample period of approximately 8 hours for a minimum total sample volume of approximately 1,440 liters (L) per cassette

- 128 perimeter air samples will be collected for radiological (gross alpha and gross beta) field analysis
- 40 perimeter air samples (including field blanks) will be collected for radiological (gross alpha, gross beta, and uranium ore) IML confirmation analyses.
- 12 personnel samples will be collected for radiological (gross alpha, gross beta, and uranium ore) field screening
- 12 personnel samples will be collected for metals and radiological (gross alpha, gross beta, and uranium ore) IML confirmation analysis
- Analyses for gross alpha and gross beta will be performed using USEPA Method 900.0 (Standard Method [SM] 7110 B).

Analyses for metals will be performed using USEPA Method IO-3.5.

QAPP Worksheet #18: Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ ID Number	Matrix	Analytical Group(s)	Concentration Level	Number of Samples	Sampling SOP Reference	Rationale for Sampling Location
North (Perimeter)	Air	Radionuclides (Field Analysis)	Low	32	SERAS SOP #2201	Biased
South (Perimeter)	Air	Radionuclides (Field Analysis)	Low	32	SERAS SOP #2201	Biased
East (Perimeter)	Air	Radionuclides (Field Analysis)	Low	32	SERAS SOP #2201	Biased
West (Perimeter)	Air	Radionuclides (Field Analysis)	Low	32	SERAS SOP #2201	Biased
Duplicat Perimeter Sample	Air	Radionuclides (Lab Analysis)	Low	32	SERAS SOP #2201	Biased
WKR1 (Personnel)	Air	Radionuclides (Field Analysis)	Low	4	SERAS SOP #2201 SERAS SOP #2203	Biased
WKR2 (Personnel)	Air	Radionuclides (Field Analysis)	Low	4	SERAS SOP #2201 SERAS SOP #2203	Biased
WKR3 (Personnel)	Air	Radionuclides (Field Analysis)	Low	4	SERAS SOP #2201 SERAS SOP #2203	Biased
WKR4 (Personnel)	Air	Radionuclides Metals	Low Low	4	SERAS SOP #2201 SERAS SOP #2203	Biased
WKR5 (Personnel)	Air	Radionuclides Metals	Low Low	4	SERAS SOP #2201 SERAS SOP #2203	Biased
WKR6 (Personnel)	Air	Radionuclides Metals	Low Low	4	SERAS SOP #2201 SERAS SOP #2203	Biased

Note: All personnel samples being analyzed for metals will be sent to IML for analysis of metals and gross alpha and gross beta
Section 8.2 of the SAP (Appendix A) presents the sample ID scheme to be used for each sample.

QAPP Worksheet #19: Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference [1]	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Air	Metals	Low	USEPA IO-3.1 and USEPA IO-3.5 / IML SOPs M-IO3.1-2.0 and M-Agilent_ICPMS-2.3	1,440 Liters	47-mm PTFE filters	Wet Ice	180 days
Air	Radionuclides	Low	USEPA 900.0 (SM 7110 B)/ IML SOP R-GAB-4.3	1,440 Liters	47-mm PTFE filters	None	NS

NS = Not specified.

QAPP Worksheet #20: Field Quality Control Sample Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference	No. of Samples	No. of Collocated Field Duplicates	Inorganic No. of MS	No. of Field Blanks	No. of Equip. Blanks	No. of PT Samples	Total No. of Samples to Lab
Air	Metals	Low	USEPA IO3.1/IO-3.5	24	0	NA	1	NA	0	25
Air	Radionuclides	Low	USEPA 900.0	152	0	NA	8	NA	0	160

QAPP Worksheet #21: Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Check if yes)	Comments
Tetra Tech SOP 004	Field-Portable X-Ray Fluorescence Analyzer Measurement	Tetra Tech	XRF Analyzer	☐	
Tetra Tech SOP 019	Packaging and Shipping Samples	Tetra Tech	NA	☐	
Tetra Tech SOP 024	Recording Notes in Field Logbooks	Tetra Tech	NA	☐	
Tetra Tech SOP 064	Calibration of Air Sampling Pump	Tetra Tech	Low-volume air sampling pump	☐	
Tetra Tech and ERG RPP SOP 1	Calibration of a Radiological Survey Detector	Tetra Tech and ERG	Radiological survey detector	☐	
Tetra Tech and ERG RPP SOP 2	Calibration of a Radiological Survey Meter	Tetra Tech and ERG	Radiological survey meter	☐	
Tetra Tech and ERG RPP SOP 6	Personnel, Environmental, and Work Area Air Sampling	Tetra Tech and ERG	Low-volume air sampling pump	☐	
SERAS SOP #2008	General Air Sampling Guidelines	SERAS	NA	☐	
SERAS SOP #2101	Retrieving Meteorological Information	SERAS	NA	☐	
SERAS SOP #2119	Air Sampling for Metals [NIOSH Method 7300, Elements]	SERAS	NA	☐	
SERAS SOP #2130	Operation of DryCal DC-Lite Primary Flow Calibrator	SERAS	DryCal Air Flow Calibrator	☐	
IML SOP 1	Standard Operating Procedures for Agilent Inductively Coupled Plasma Mass Spectrometer	IML	Inductively Coupled Plasma Mass Spectrometer	☐	
IML SOP 2	Standard Operating Procedures for Digestion By Method IO3.1	IML	NA	☐	
IML SOP 3	Standard Operating Procedure for Analysis of Gross Alpha-Beta	IML	NA	☐	

NA = Not applicable
Source: http://www.epaosc.org/site/site_profile.aspx?site_id=2107

QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Particulate air monitor	NA (factory calibrated)	NA	Zero calibration check	Visual inspection	Twice Daily	±0	Clean instrument, contact manufacturer if unable to rectify issues	Field personnel	SOP No. 2008
Low-volume air sampler	Flow Rate	NA	NA	Visual inspection	Before and after sample colleciton	Average flow rate is calculated using pre-and post- sample flow rates	NA	Field personnel	SERAs SOP No. 2130
Portable X-Ray Flourescence scanner	Internal istrument calibration check	Clean scanning window	NA	Visual inspection	Daily	Manufacturer specifications	NA	Field personnel	TT SOP 004
Radiological survey meter	Model specific ERG calibration checklist	NA	NA	Visual inspection	Per manufacturer specifications	Manufacturer specifications	NA	Equipment owner	RPP SOP 002
Radiological survey detector	Model specific ERG calibration checklist	NA	NA	Visual inspection	Per manufacturer specifications	Manufacturer specifications	NA	Equipment owner	RPP SOP 001

QAPP Worksheet #23: Analytical SOP References Table

Reference Number*	Title, Revision Date, and/or Number*	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
USEPA IO-3.5	Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air: Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS), USEPA/625/R-96/010a, IML SOPs M-IO3.1_2 0 and M-Agilent_ICPMS	Definitive	Metals	ICP-MS	IML	No
USEPA 900.0 (SM 7110 B)	Method 900.0 - Gross Alpha and Gross Beta Radioactivity in Drinking Water, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, USEPA 600/4-80-032, NAREL SOP AM/SOP-5 Standard Method 7110 B - Gross Alpha and Gross Beta Radioactivity (Total, Suspended, and Dissolved) in Water by Evaporation and Anticoincidence-Circuitry Proportional Counter, IMP SOP R-GAB-4.3	Definitive	Radionuclides	Gas-flow internal proportional or scintillation detector counter	IML	Yes

*References and SOP titles, revision dates, and/or numbers will be updated to laboratory-specific SOPs for final QAPP

QAPP Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Tennelec LB 4110 Gas flow proportional counter with 2 in. detectors or equivalent	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	IML Analyst	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions
Accumet AB-30 Conductivity meter or equivalent	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	IML Analyst	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions
ICP-MS	Initial calibration	Beginning of each run	Minimum correlation coefficient > 0.995	Recalibrate	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions
	Initial Calibration Verification (ICV)	Beginning of each run	Recovery within ±10% of true value	Do not use results for failing elements, unless ICV>110% and sample result< PQ:/reporting limit	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions
	Initial Calibration Blank (ICB)	Beginning of each run	Absolute value of ICB<RL or project specific reporting limit	Do not use results if sample ≥ PQL/reporting limit and < 10x ICB level	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions
	High Standard Verification	Beginning of each run	Within ±5% of true value	Correct problem then reanalyze	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions

QAPP Worksheet #24 Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
ICP-MS	Continuing Calibration Verification (CCV)	After every 10 samples and at end of run.	Recovery within ± 10% of true value	Do not use bracketed sample results for failing elements, unless CCV>110% and sample result < PQL/reporting limit. Correct problem.	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions
	Continuing Calibration Blank (CCB)	After every 10 samples and at end of run.	Absolute value of CCB < PQL or project specific reporting limit	Do not use sample results for failing elements.	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions
	Preparation Blank	One per batch of 20 samples.	Less than PQL (standard practice), or based on the project guidelines.	Investigate source of contamination. Re-digest and reanalyze samples if sample concentration ≥ PQL and <10x the blank concentration.	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2.3and instrument operating instructions

*References and SOP titles, revision dates, and/or numbers will be updated to laboratory-specific SOPs for final QAPP

QAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference*
Tennelec LB 4110 Gas flow proportional counter with 2 in. detectors	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	IML Analyst	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions
Accumet AB-30 Conductivity meter or equivalent	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions	IML Analyst	In accordance with IML SOP R-GAB-4.3 and instrument operating instructions
ICP-MS	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions	IML Analyst	In accordance with IML SOP M-Agilent_ICPMS-2. 3 and instrument operating instructions

*References and SOP titles and/or numbers will be updated to laboratory-specific SOPs for final QAPP

QAPP Worksheet #26: Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Tetra Tech
Sample Packaging (Personnel/Organization): Tetra Tech
Coordination of Shipment (Personnel/Organization): Tetra Tech
Type of Shipment/Carrier: Overnight air delivery or Ground delivery
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Laboratory Analysts / IML
Sample Custody and Storage (Personnel/Organization): Sample Receiving Technician/ IML
Sample Preparation (Personnel/Organization: Laboratory Analysts / IML
Sample Determinative Analysis (Personnel/Organization): Laboratory Analysts / IML
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): Samples will be stored for 6 months from sample collection.
Sample Extract/Digestate Storage (No. of days from extraction/digestion): Extracts and digestates will be stored for 6 months from sample collection.
Biological Sample Storage (No. of days from sample collection): Not applicable
SAMPLE DISPOSAL
Personnel/Organization: Sample Technician/ IML
Number of Days from Analysis: 6 months

QAPP Worksheet #27: Sample Custody Requirements

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Filters for metals and radiological sampling will be placed into cassette cases supplied by the laboratory and then into pre-labeled anti-static bags. Sample packages will be placed into plastic shipping bags or boxes and the corresponding chain-of-custody (COC) record. Sample packaging and shipment will be done in accordance with SERAS SOP #2004 and Tetra Tech SOP 019. The sample packages will be shipped within 1 to 5 days following sample collection to IML.
Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal): A sample custodian at the laboratory will accept custody of the shipped samples and check them for discrepancies, proper preservation, integrity, etc. If noted, issues will be forwarded to the laboratory manager for corrective action. The sample custodian will relinquish custody to the appropriate department for analysis.
Sample Identification Procedures: COC records will include, at a minimum, sample identification number, number of samples collected, sample collection date and time, sample type, sample matrix, sample container type, sample analysis requested, sample preservation, and the name(s) and signature(s) of samplers and all individuals who have had custody. Custody seals will demonstrate that a sample container has not been opened or tampered with. The sampler will sign and date the custody seal and affix it to the container or cooler in such a manner that it cannot be opened without breaking the seal. Sample ID format is presented in Section 9.2 of the SAP.
Chain-of-Custody Procedures: Chain-of-custody procedures provide an accurate written record that traces the possession of individual samples from the time they are collected in the field to the time they are accepted at the laboratory, and will be performed in accordance with SERAS SOP #4005, Chain of Custody Procedures.

QAPP Worksheet #28-1: QC Samples Table – Metals

Matrix	Air
Analytical Group	Metals
Concentration Level	Low
Sampling SOP	Tetra Tech and ERG RPP SOP 6, Tetra Tech SOP 064, and SERAS SOP #2130
Analytical Method/ SOP Reference	USEPA Method IO-3.1 (Prep) and USEPA Method IO-3.5, IML SOPs M-IO3.1-2.0 and M-Agilent_ICPMS-2.3
Sampler's Name	TBD
Field Sampling Organization*	Tetra Tech
Analytical Organization	IML
No. of Sample Locations	6 per day for 4 days

QC Sample:	**Frequency/Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
Field Blank	1 per sampling event (week)	NA	Evaluate effect on data	Data Review QA/QC Chemist	Accuracy/Bias (Contamination)	<RL

QAPP Worksheet #28-2: QC Samples Table – Radionuclides (USEPA 900.0)

Matrix	Air
Analytical Group	Radionuclides (USEPA 900.0 [SM 7110 B])
Concentration Level	Low
Sampling SOP	Tetra Tech and ERG RPP SOP 6, Tetra Tech SOP 064, and SERAS SOP #2130
Analytical Method/ SOP Reference	USEPA 900.0 (SM 7110 B), IML SOP R-GAB-4.3
Field Sampling Organization*	Tetra Tech
Analytical Organization	IML
No. of Sample Locations	1 per week for 8 weeks

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	25% or perimeter samples (one per day)	Project Specific	Document	Sampling Team Leader	Precision	±20% RPD
Field Blank	1 per week	NA	Evaluate effect on data	Data Review QA/QC Chemist	Accuracy/Bias (Contamination)	<RL

QAPP Worksheet #29: Project Documents and Records Table

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records	Other
Chain-of-Custody (COC) Records Sample Labels Custody Seals Field Data Sampling Worksheets Field Change Forms (if necessary) Radiation Meter Readings Performance Check Records Particulate Air Monitor Readings	Gross Alpha and Gross Beta Analysis Forms	Instrument Run Logs Sample Extraction Logs Preventive Maintenance Logs Instrument Printouts Internal COC Records Standard Receipt Logs Data Reduction Records Data Review Records Analytical Results Sample Digestion Logs Laboratory Logbooks	Data Assessment Forms Data Validation Check Records UFP-QAPP Verification Checklist	Technical Memorandum Laboratory Reports Analytical Report UFP-QAPP

QAPP Worksheet #30: Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Location/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number
Air	Metals	Low	See Worksheet #18	IML	2-3 BD	IML, Eric Brandjord, (307) 461-4940	NA
Air	Gross Alpha/Beta	Low	See Worksheet #18	IML	10 BD	IML, Eric Brandjord, (307) 461-4940	NA

BD = business days

QAPP Worksheet #31: Planned Project Assessments Table

Assessment Type	Frequency	Internal (I) or External (E)	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Laboratory Quality Systems	Every 2 years	E	Regulatory Agency	Regulatory Agency	QA/QA Officer, IML	Lab Manager, IML	Regulatory Agency
Laboratory Quality Systems	Annual	I	Laboratory	QA/QA Manager, IML	Laboratory Director, IML	Analyst, IML	QA/QA Manager, IML
Performance Evaluation (PE) Samples	Annual	E	Regulatory Agency	Regulatory Agency	QA/QA Officer, IML	Lab Manager, IML	QA/QA Officer, IML

QAPP Worksheet #32: Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Lab Performance Audit	Audit Report	Eric Brandjord, IML	As per laboratory's QA Manual	Corrective Action Plan	Laboratory QA Manager, IML	As per laboratory's QA Manual
Field observations/ Deviations from Work Plan	Logbook	Christian Lejeune/ Jeremy Bekis, Field Team Leaders (Tetra Tech)	Immediately	Logbook	Rob Tisdale, Project Manager (Tetra Tech)	Within 24 hours of deviation
Peer Review	Directly on Deliverable	Christian Lejeune/ Jeremy Bekis, Field Team Leaders (Tetra Tech)	Prior to deliverable due date	Comments directly on deliverable	Mike Ferrif, Project Manager (Tetra Tech)	Prior to deliverable due date
PE Samples	PE Report	Eric Brandjord, IML	As per laboratory's QA Manual	Corrective Action Plan	Laboratory QA Manager, IML	As per laboratory's QA Manual

QAPP Worksheet #33: QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Data Validation Report	Weekly	As needed	Deborah Kutsal, QA/QC Chemist, Tetra Tech	Mike Ferrif, Project Manager, Tetra Tech
Weekly Data Summary	Weekly	Friday	Mike Ferrif, Project Manager, Tetra Tech	Edwin “Chip” Poalinelli, TOCOR, USEPA R9
Field Procedures Assessment Report	Weekly	Friday	Mike Ferrif, Project Manager, Tetra Tech	Edwin “Chip” Poalinelli, TOCOR, USEPA R9

QAPP Worksheet #34: Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Completeness Check	Review of planning documents, generated maps and illustrative design figures, as applicable, using the UFP-QAPP checklist	Internal	Edwin "Chip" Poalinelli, (USEPA), Sophia Serda (USEPA), Christian LeJune (Tetra Tech)
Deliverables	Document review	Internal	Christian LeJune (Tetra Tech), Eric Brandjord (IML), Randy Dorian (Tetra Tech)
Field logbooks	Field notes will be prepared daily by the Field Team Leader (FTL) and will be complete, appropriate to the project tasks, and legible. The FTL will review logbooks for accuracy and completeness. Upon completion of field work, logbooks will be placed in the project files. Field reports will be verified with field log books to ensure correct reporting of information. Review will be conducted prior to completion of each report.	Internal	Christian LeJune (Tetra Tech), Jeremy Bekis (Tetra Tech), TBD (Tetra Tech)
Chain of custody record	COC forms will be reviewed against the samples packed in the each cooler/sample package prior to shipment. COCs will be sent with the samples to the laboratory, while copies are retained for the Sampling Trip Report and the project files. They will be internally reviewed upon completion of activities and verified against field logs, and laboratory report. Review will be conducted with completion of each data usability assessment/measurement report.	Internal	Christian LeJune (Tetra Tech), Jeremy Bekis (Tetra Tech) Laboratory Sample (IML), Deborah Kutsal (Tetra Tech)
Laboratory results	Results will be reviewed/verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal	External	Eric Brandjord (IML)
EDDs	The EDDs will be reviewed to confirm whether required fields and formats were provided.	Internal	Randy Dorian (Tetra Tech)
Laboratory analytical data package	Data packages will be reviewed/verified internally by IML for completeness and technical accuracy prior to submittal. All laboratory data will be verified by IML for completeness and technical accuracy prior to submittal to Tetra Tech. Data packages will be reviewed as to content and sample information upon receipt by Tetra Tech. Tetra Tech or its validation contractor will evaluate the data packages for completeness and compliance.	Internal	Eric Brandjord (IML), Deborah Kutsal (Tetra Tech), Sophia Serda (USEPA)
Deliverables	The project results will be compiled in a summary report. Entries will be reviewed and verified against hard copy information. Data validation reports and the QAPP will be used to prepare a project data quality and usability report for the final quarterly report. The data will be evaluated against project DQOs and measurement performance criteria.	Internal	Christian LeJune (Tetra Tech), Eric Brandjord (IML), Randy Dorian (Tetra Tech)

QAPP Worksheet #35: Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Name, Organization)
IIa	SOPs	Ensure that the sampling methods/procedures outlined in QAPP were followed, and that any deviations were noted/approved.	Christian LeJune (Tetra Tech), Mike Ferrif (Tetra Tech)
IIb	SOPs	Determine potential impacts from noted/approved deviations, in regard to PQOs.	Deborah Kutsal (Tetra Tech), Mike Ferrif (Tetra Tech)
IIa	Chains of custody	Examine COC forms against QAPP and laboratory contract requirements (e.g., analytical methods, sample identification, etc.).	Deborah Kutsal (Tetra Tech), Christian LeJune (Tetra Tech)
IIa	Laboratory data package	Examine packages against QAPP and laboratory contract requirements, and against COC forms (e.g., holding times, sample handling, analytical methods, sample identification, data qualifiers, QC samples, etc.).	Deborah Kutsal (Tetra Tech), Randy Dorian (Tetra Tech)
IIa	Field/Lab Transcription	Check the accuracy of information transferred from field notes and laboratory testing report to report	Christian LeJune (Tetra Tech), Mike Ferrif (Tetra Tech)
IIb	Laboratory data package	Qualify data based on QC deficiencies	Deborah Kutsal (Tetra Tech)
IIb	Laboratory data package	Qualify data based on QC deficiencies	Deborah Kutsal (Tetra Tech)

QAPP Worksheet #36: Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (title and organizational affiliation)
IIb	Air	Metals	Low	USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (USEPA 2017b)	Tetra Tech QC Chemist
IIb	Air	Gross Alpha/Beta/Gamma	Low	Multi-Agency Radiological Laboratory Analytical Protocols Manual (USEPA 2004b)	Tetra Tech QC Chemist

☑ Worksheet Not Applicable (State Reason) EPA Region 9 will be responsible for assessing the usability of the data.

QAPP Worksheet #37: Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: NA
Describe the evaluative procedures used to assess overall measurement error associated with the project: NA
Identify the personnel responsible for performing the usability assessment: USEPA Region 9
Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies: NA

NA Not Applicable

EXHIBIT A1-1

LABORATORY QUALITY ASSURANCE PLAN

INTER-MOUNTAIN LABS

QUALITY ASSURANCE MANUAL

QUALITY ASSURANCE MANUAL
for
INTER-MOUNTAIN LABORATORIES, INC.

555 Absaraka
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(307) 674 – 7506
(307) 672 -9845 FAX

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Revision 8.20

Approvals:

Kevin Chartier Date President	Lisa Balstad Date Water Lab Supervisor
Tom Patten Date Laboratory Manager	Karen Secor Date Soils Lab Supervisor
Michelle LaGory Date Quality Assurance Manager	Matt DeDeo Date Kinetics Lab Supervisor
Wade Nieuwsma Date Radiochemistry Lab Supervisor	Steve Kasa Date Organics Lab Supervisor
Mary Slipp Date Trace Metals Lab Supervisor	Mary Hininger Date Gravimetric Labs Supervisor

INTER-MOUNTAIN LABORATORIES, INC.

QUALITY ASSURANCE MANUAL
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Quality Management System Procedures

Attachments

1.0 HISTORY

Inter-Mountain Labs was incorporated in the State of Wyoming in 1979 as an environmental analytical laboratory serving the energy development industries. To meet changing needs, Inter-Mountain Labs has expanded and diversified to provide analytical services for agriculture, municipalities, mining, remediation, and a wide variety of industries throughout the nation and the world. Inter-Mountain Labs also created a technical services group to offer environmental consulting services that currently include water sampling, soil sampling, and air quality services that include ambient air monitoring and regulatory permitting. In 2003, Inter-Mountain Labs expanded to include analysis of radionuclides. Further expansion of services provided included the development of a Kinetics lab in 2008. With corporate offices in Sheridan, Wyoming, and laboratories in Sheridan and Gillette, Wyoming, Inter-Mountain Labs provides comprehensive analytical and assessment services in the Rocky Mountain corridor, across the nation, and internationally.

Inter-Mountain Labs analytical division is a multidisciplinary organization specializing in the chemical analyses of air, water, soil, and waste. The staff of professional and technical employees includes diverse educational backgrounds including chemistry, soil science, geology, microbiology, physics, and engineering to meet the client's analytical requirements.

Inter-Mountain Labs conducts organic, inorganic, microbiological, radiochemical, and gravimetric analyses of water, air, and soil matrices in compliance with requirements for the Safe Drinking Water Act (SDWA), Clean Water Act (CWA), Clean Air Act (CAA), National Pollution Discharge Elimination System (NPDES), Resource Conservation Recovery Act (RCRA), United States Nuclear Regulatory Commission (USNRC), United States Department of Agriculture Health Inspection Service Plant Protection and Quarantine Program (PPQ), and other regulatory programs.

2.0 QUALITY POLICY

Inter-Mountain Labs is committed to using good professional practice in providing high quality service that meets or exceeds client needs and expectations. Our reputation is built on the value of that service and our commitment to the continual improvement of our quality management system.

The Management of Inter-Mountain Labs is committed to compliance with the EPA Manual for the Certification of Laboratories Analyzing Drinking Water, ISO/IEC 17025:2005, and the 2009 TNI Standard. Compliance dictates that all personnel comprehend and implement the objectives of the quality assurance manual and the quality system as a whole. Adherence to the quality management system ensures the delivery of a consistent standard of quality in services provided by the laboratory that meet or exceed compliance requirements.

3.0 QUALITY OBJECTIVES

Inter-Mountain Labs is committed to expanding quality system certifications and capabilities in response to clients' needs. Certifications expand marketability and reputation.

Inter-Mountain Labs is committed to improving response time. Improved response times increase customer satisfaction, reduce holding times, and raise productivity.

Inter-Mountain Labs is committed to maintaining consistency of reporting and documentation within the organization. Consistency increases customer satisfaction.

Inter-Mountain Labs is committed to improving the training and expertise of laboratory staff. Training and experience equate to expertise. Improved expertise increases the reputation and credibility of an organization.

4.0 ETHICS AND VALUES

Inter-Mountain Labs relies on and takes pride in the professionalism of its employees. Among other things, professionalism consists of the manner and character by which employees conduct themselves as well as their interaction with co-workers and clients. Inter-Mountain Labs believes that our personnel are and will continue to be responsible employees and solid community members, and will not act in a manner that is contrary to their best interest or the interest of Inter-Mountain Labs, other employees, clients, or the community.

Inter-Mountain Labs employees are obligated to not only act in an ethical manner but to report unacceptable activities by other employees, clients, or suppliers. Individuals in the employ of Inter-Mountain Labs found to be acting in an unacceptable or unethical manner will be subject to discipline up to, and including, dismissal from Inter-Mountain Labs.

Analysts will be expected to subscribe to and fully conform to the following Quality Assurance Code of Ethics:[1]

1. Acquire a full understanding in every area of analytical chemistry in which services are offered.
2. Understand any limitations on the data and discuss them with clients as appropriate.
3. Use validated methodology exclusively.
4. Demonstrate statistical control of the measurement system before definitive measurements are made.
5. Calibrate to the extent necessary and possible.
6. Utilize Good Laboratory Practices and Good Measurement Practices throughout all aspects of the sampling and measurement process.
7. Utilize documented procedures and record all significant details in such a way that all measurements can be reproduced by a competent analyst.
8. Determine limits of uncertainty for all data produced.
9. Confirm the qualitative identification of all parameters measured.
10. Retain all samples, data, and documentation as necessary.

[1] Taylor, John K., "Quality Assurance of Chemical Measurements", Lewis Publishers Inc., 1987

Inter-Mountain Labs is a progressive, technical, service organization comprised of individuals instilling the following values:

- Commitment to excellence through application of the most current and innovative methods using state of the art instrumentation.
- Service to the client at every stage of our relationship: enthusiasm at first communication, application of expertise to assist in pre-sampling determinations, efficiency in application of methods, and commitment to quality throughout the analytical process.
- Commitment to the organization through open communication, flexibility, enthusiasm, courtesy, and unity.
- Personal commitment by all Inter-Mountain Labs. employees to basic values of honesty, integrity, reliability, and accountability.

Policies and procedures have been implemented to ensure that high ethical standards are maintained by all laboratory personnel.

Inter-Mountain Labs has an “A2LA Name and Logo Use Procedure” to ensure that the use of the “A2LA Accredited” symbol, allowed by our accreditation, is appropriate and conforms to A2LA Document R105, governing its use.

Inter-Mountain Labs has “Data Handling Procedures” to provide ethical guidance relative to handling of data.

It is the policy of Inter-Mountain Labs that all personnel hold client information, including proprietary rights, in confidence. Additional information related to handling of client confidentiality is described in the Client and Data Confidentiality Procedure.

It is the policy of Inter-Mountain Labs that personnel are held to a high standard of conduct, avoiding participation in any activities that would diminish clients’ confidence in the lab’s competence, impartiality, judgment or integrity. Specific guidance regarding participation in outside activities is described in the Handling of Outside Activities Procedure.

It is the policy of Inter-Mountain Labs that laboratory personnel are protected from internal and external pressures that might compromise the quality of analytical data produced. Further guidance regarding protection of personnel from undue pressures is provided in the Elimination of Undue Pressure Procedure.

It is the policy of Inter-Mountain Labs that electronic signatures may be used on laboratory documents and procedures, provided that they are administered only by their genuine owner.

Employees shall immediately report observed ethics violations to senior management. Reports are handled confidentially from initiation, through investigation, corrective action, and resolution.

5.0 SAFETY AND ENVIRONMENT

Inter-Mountain Labs has a high commitment to safety and the environment. Inter-Mountain Labs maintains a Chemical Hygiene Plan within the Laboratory Safety Plan, for safety of employees and protection of the environment. Inter-Mountain Labs reclaims or recycles waste products whenever possible for the protection of the environment. Samples are disposed of per the Sample Disposal Procedure.

6.0 ORGANIZATION

Inter-Mountain Labs employs highly skilled, motivated professionals qualified in accordance to this Quality Assurance Manual at every level of operation. Attached to this Quality Assurance Manual are organizational charts, an Organizational Relationships description, and resumes of key personnel. A Training Procedure has been developed to ensure that qualified people perform functions that are quality critical activities. Job descriptions are maintained according to the Training Procedure to ensure personnel understand quality procedures and expectations. All personnel must comply with the Quality Assurance Program and initiate corrective actions when needed.

It is the policy of Inter-Mountain Labs to continually assess training needs of laboratory personnel, and to provide training as needs are identified.

Each discipline within the laboratory (Organics, Water, Soils, Metals, Kinetics, Radiochemistry, and Particulate Matter in Air Gravimetric Analysis) is under the review of a laboratory supervisor. An experienced professional guides each analytical technique area and maintenance involved with the specific type of instrumentation.

The Laboratory Supervisors have the overall responsibility for the activities of their laboratory section. Each laboratory supervisor must have, at minimum, a bachelor's degree in chemistry or other appropriate science degree, and at least one year of relative analytical experience. The Radiochemistry Lab Supervisor must have two years of experience in radiochemical analyses. The Supervisor manages the laboratory personnel, reviews contracts, completes job descriptions, evaluates employees, manages training, and authorizes work on methodology and instruments. The supervisor has the responsibility to stop work in any area where quality may be compromised. Supervisors are responsible for ensuring work gets performed in a timely fashion. Supervisors are responsible for ensuring the laboratory has the information, equipment, supplies, and qualified personnel to get work reported in as timely a fashion as possible. The laboratory supervisors report to the Laboratory Manager.

The Quality Assurance Manager is responsible for the coordination and implementation of the Quality Assurance Manual. The Quality Assurance Manager must have a bachelor's degree in science, appropriate training, a year of quality assurance experience, a working knowledge of statistics involved in laboratory quality control, and a basic understanding of laboratory methods. The Quality Assurance Manager trains and authorizes work on quality procedures. The quality assurance manager controls training records, annual internal audits, preventive actions, and corrective actions. The Quality Assurance Manager is authorized and responsible for stopping work in any laboratory where quality may be compromised. The Quality Assurance Manager

reports to the Laboratory Manager and has access to the upper levels of management at which laboratory policy decisions are made.

Technical Managers are responsible for day-to-day oversight of performance of analytical methods and reporting of results for their laboratory section. Duties include monitoring of data quality and validity. The technical manager may serve as the laboratory supervisor and/or as an analyst. Education and experience requirements for each laboratory section may vary based on type of analysis performed in that section. Personnel who lack the requisite educational requirements, but possess appropriate experience may serve as Technical Manager if they have previously been granted a qualification exception for that position while working in a NELAC accredited lab. When a Technical Manager is absent for >15 consecutive calendar days, their deputy (who must meet the qualifications of Technical Manager for that lab section as described below) will fulfill their duties during the period. If the absence extends beyond 35 consecutive calendar days, the primary accrediting body must be notified. Similarly, the primary accrediting body must be notified when a Technical Manager is terminated or hired.

The Technical Manager of the Radiochemistry Lab must have, at minimum, a Bachelor's Degree in chemistry or a related science, 24 college semester credit hours in chemistry, and two years experience performing related analyses. An advanced degree in chemistry or a related science may be substituted for one year of experience.

The Technical Manager of the Organics or Metals Lab must have, at minimum, a Bachelor's Degree in chemistry or a related science, 24 college semester credit hours in chemistry, and two years of experience performing related analyses. An advanced degree in chemistry or a related science may be substituted for one year of experience.

The Technical Manager of the Water, Soils, Kinetics, or Particulate Matter in Air Gravimetric Labs must have, at minimum, an Associate's Degree in chemistry or a related science, 16 semester credit hours in chemistry, and two years of experience in performing related analyses.

Bench Analysts are the employees, degreed and technicians, who perform the day-to-day routine tests and data acquisition in the laboratory. Analysts are encouraged to make any suggestions that may improve quality and productivity in the laboratory.

Support Personnel are those persons, other than analysts, who support the efforts of the laboratory. Support personnel include secretaries, office managers, computer specialists, etc.

7.0 QUALITY SYSTEM

Inter-Mountain Labs relies on a multi-tiered approach to documentation of the Quality System. The top tier document is the Quality Assurance Manual. The Quality Assurance Manual is updated at least annually, or more frequently if needed. The Quality Assurance Manual refers to the second tier of documents. The second tier of documents is presented as system documents relating to the Quality Assurance Manual. This second tier of documents includes: system procedures, resumes, organizational relationships, organizational charts, and laboratory certification/accreditations/licenses. The second tier of documents references forms, lists, and location-specific documents. Second tier documents are reviewed during the course of annual internal audits, and revised as needed. The third tier of documents includes: analytical

procedures, calibration procedures, equipment procedures, and location specific lists, forms and schedules. Analytical procedures are reviewed annually; other third tier documents are reviewed during the course of annual internal audits. All third tier documents are revised as needed. All documents are inventoried in the Master Document List.

The Quality Assurance Manual has procedures for maintenance of the Quality System. The Document Control Procedure is used to control document creation, revision and elimination. The Control of Records Procedure contains policies for records. The Audit Procedure defines the procedure for verification of the Quality System. The Management Review Procedure is used to continuously improve the Quality Assurance Manual.

8.0 CUSTOMER FOCUS

Inter-Mountain Labs promotes a customer focus.

It is the policy of Inter-Mountain Labs to assess the capability and resources required to perform requested work prior to acceptance. The laboratory has established a Contract Review Procedure to facilitate the determination of customer requirements, and to assess the ability of the laboratory to meet these requirements.

Complaints may originate from customers, or other parties, including employees. Complaints are resolved through the Corrective Action Procedure and the Preventive Action Procedure.

The Sample Receiving Procedures are used to improve customer interactions.

Inter-Mountain Labs has established a NIST Traceability Procedure to establish traceability to national and international standards.

Inter-Mountain Labs has established a Measurement Uncertainty Procedure and a Method Detection Limit Procedure to deliver highly informative quality data.

It is the policy of Inter-Mountain Labs that corrective action is taken to resolve significant complaints, and when laboratory personnel or external auditors detect non-conforming work or quality system non-conformities. Non-conformities are managed by appropriate personnel, their significance is assessed and correction is made in a timely manner, the client is notified or work recalled when necessary, and work is resumed after review and authorization by laboratory management. Further detail regarding the handling of different types of non-conformities is given in the Corrective Action Procedure.

The Proficiency Testing Procedure is used to assess laboratory competence by analysis of a sample of an unknown value, analyzed by normal laboratory procedures and compared against values verified by the Proficiency Test provider.

The IT Procedures ensure protection and subsequent recovery of data, and describe the development and validation of software.

The Report Generation Procedure ensures quality data is reviewed then reported in a manner that increases value to the customer.

The Director of Business Development solicits feedback through frequent client contacts, communicates this information during regular management meetings, and initiates related preventive and corrective actions as necessary. Additionally, a customer satisfaction survey is distributed each year, to solicit customer feedback. Customer feedback from all sources is discussed during annual management review.

9.0 MATERIALS, EQUIPMENT, AND SERVICE

It is the policy of Inter-Mountain Labs to use high quality materials, equipment, and services that meet or exceed customer and regulatory requirements. Inter-Mountain Labs uses a Purchasing/Subcontracting Procedure and Equipment Procedure to ensure consistent quality products and services are used in the laboratories. The Equipment Procedure ensures environmental, calibration, and traceability requirements are maintained. The Equipment Procedure details how to find equipment and determine the procedure used to confirm the equipment's acceptability.

10.0 METHODOLOGY

Inter-Mountain Labs provides a high quality service, employing a variety of methodologies. Inter-Mountain Labs provides high quality service by following handling procedures, methodology procedures, and reporting procedures. Inter-Mountain Labs provides a high quality sample handling. Inter-Mountain Labs uses a Field Services Sampling Procedure, Sample Receiving Procedures and Report Generation Procedures to ensure consistent high quality service. Guidelines for authorizing, documenting, and reporting departures from standard methodology procedures are given in the Report Generation Procedures. Inter-Mountain Labs. maintains a high level of expertise in a variety of methodologies. The approved methodologies include:

1. Standard Methods for the Examination of Water and Wastewater, approved editions.
2. EPA SW-846 online, Test Methods for Evaluating Solid Waste Physical/Chemical Methods.
3. Methods of Soil Analysis – Chemical and Microbiological Properties, American Society of Agronomy.
4. EPA – 40 Code of Federal Regulations, Part 50 (air); Part 136 (wastewater); Parts 141 and 142 (drinking water) and updates.
5. Annual Book of ASTM Standards.
6. EPA 600/2-78-054.

List of Methods

40 CFR Part 50 Appendix B
40 CFR Part 50 Appendix J
40 CFR Part 50 Appendix L
40 CFR Part 50 Appendix O
ACW10
ASA 9 25 1
ASA 9 33-3.2
ASA 9 73-74
ASA 9 74-2.3
ASA 9 BSE
ASTM D 422
ASTM C1308-08
ASTM D 1498-08
ASTM D 2492-84
ASTM D 2972-88
ASTM D 3859-93
ASTM D5072-09
ASTM D 5744-13
ASTM D 7237-06
ASTM D7511-09
ASTM D 7572-09
ASTM E 1915-11
ASTM E 2242-13
EPA 1311
EPA 1312
EPA 200.2
EPA 200.7
EPA 200.8
EPA 245.1
EPA 245.6
EPA 300.0
EPA 335.4
EPA 350.1
EPA 351.2
EPA 353.2

EPA 420.4
EPA 504.1/8011
EPA 552.2
EPA 600/2-78-054 section 3.2.2
EPA 600/2-78-054 section 3.2.3
EPA 600/2-78-054 section 3.2.4
EPA 600/2-78-054 section 3.2.6
EPA 624
EPA Ra-05
EPA1631E
EPA 1669
EPA 1664A
EQL-0310-189 (IML 2009)
Georgia Tech Method
HACH 8131
HACH 10218
HACH 10360
MWMP BMRR, NDEP
IO-3.1
IO 3.4
IO-3.5
NIOSH 1501
OTW01
OIA-1677 09
SM1030E
SM2120B
SM2130B SM2150B
SM2310B
SM2320B
SM2340B
SM2510B
SM2540B
SM2540C
SM2540D
SM2540F
SM2550B
SM3500-Cr B
SM4500-Cl B

SM4500-Cl G
SM4500-CN I
SM4500-CO2 D
SM4500-F^- C
SM4500-H^+ B
SM4500-N C
SM4500-O G
SM5210B Modified
SM5220D
SM5310B
SM7110B
SM7500-Ra B
SM9215 B
SM9215 E
SM9221E
SM9222D
SM9222G
SM9223B
SW-846 3010A
SW-846 3020A
SW-846 3050B
SW-846 3510B
SW-846 3511 Modified
SW-846 3550B
SW-846 5035
SW-846 6010C
SW-846 6020A
SW-846 7470A
SW-846 7471A
SW-846 8015C
SW-846 8021B
SW-846 8081A
SW-846 8082
SW-846 8260B
SW-846 8270C SIM
SW-846 9020
SW-846 9076
SW-846 9095B

USDA Handbook 60 Methods
USDA 60 19
USDA 60 21a
USDA 60 22a
USDA 60 22b
USDA 60 24
USDA 60 6(27a)

AUDIT PROCEDURE

Scope:
This procedure describes policies and procedures for audits that are performed to provide verification, accreditation, and maintenance of the quality management system.

Application:
This procedure identifies two types of audits – external audits and internal audits.

External Audits:
External audits may be performed by outside regulatory agencies or their representatives, independent accreditation bodies, existing clients, or potential clients, to qualify service or verify compliance to a standard. External audits include certification-related audits, customer-initiated audits, and third party audits.

A representative of IML management will be assigned to external auditors as a guide. The guide assists the auditor in location changes, record and document retrieval, and introductions to staff. External auditors are treated in a professional manner at all times. Guides must be familiar with this document.

In order to ensure confidentiality, an immediate verbal communication is made to inform the Laboratory Supervisor of a customer audit. It is the guide's responsibility to inform Laboratory Supervisors that a customer audit requires special considerations for confidentiality. Sensitive records belonging to other customers will be protected from view of the auditor. The guide will call ahead as the auditor passes from one area to another, alerting the Laboratory Supervisors to the changes of locations.

Third party auditors are allowed to view all documents and records necessary for the conduction of the audit. Where appropriate, third party auditors are required to sign a confidentiality agreement before the conduction of the audit.

Internal Audits:
Internal audits are audits performed by IML personnel at IML facilities on a scheduled basis to verify that IML lab operations comply with its own quality management system, and with requirements of lab accreditation standards. The Quality Manager is responsible for planning and organizing internal audits. The Quality Manager uses an internal audit schedule to arrange audits throughout the year. An internal audit schedule is prepared annually, prior to the start of each calendar year; the schedule may be amended during the course of the year to incorporate audits requested by management, audits scheduled as follow-up to an internal or external audit, or to allow some flexibility related to circumstances within the laboratory.

An internal audit of any newly-developed method for use in the lab will be conducted prior to analysis of customer samples. The audit will include review of lab SOP, comparison of SOP to reference method requirements, appropriateness of Training and Authorization record, and compliance to related regulatory programs.

During the course of the year, the laboratory will be audited to each section of ISO/IEC 17025:2005, the added requirements of the A2LA Wyoming Storage Tank Program, and applicable sections of the 2009 TNI Standard. In addition, an audit of drinking water analyses and associated requirements of the EPA Manual for the Certification of Laboratories Analyzing Drinking Water will be scheduled and performed annually.

The schedule will contain auditable sections of ISO/IEC 17025:2005, quality manual procedures, and test procedures. Typically the schedule will ask an internal auditor to audit two or three sections per audit. The auditor will follow the steps indicated below:

1) Read the requirements in ISO/IEC 17025:2005 for each section assigned.
2) Read the requirements of A2LA for environmental programs for each section listed.
3) Read the requirements of A2LA general requirements for each section assigned.
4) Read applicable requirements of the 2009 TNI Standard Volume 1, Modules 1, 2, 4, or 6.
5) Read applicable requirements of the EPA Manual for the Certification of Laboratories Analyzing Drinking Water, Fifth Edition.
6) Read the requirements of relative quality or analytical procedures.
7) Compare SOP requirements to those of analytical reference methods.
8) Make a list of requirements.
9) Compare your list of requirements to the Quality Manual or procedures.
10) From this comparison, add to your list whom to interview and what documents or records to view.
11) Audits of analytical procedures should include review of QC Failure logbooks.
12) Conduct the audit by interviewing as many people as possible on your list and inspecting as many documents and records as possible. For two or three sections or procedures, eight hours should be sufficient to complete an internal audit.
13) Describe briefly how each requirement was met, who was interviewed, and what documents or records were viewed.
14) If objective evidence clearly indicates that a requirement was not met or that a deviation from the quality system occurred, a finding should be written and a Non-conformance Corrective Action Request (NCAR) should be initiated. The internal auditor will complete the “Non-Conformity” portion of the NCAR

form, noting the requirement not met (including section of the guidance document) or the deviation found. The NCAR form is then delivered to the Quality Manager. The Quality Manager will assign Root Cause Analysis to appropriate personnel and the NCAR will be completed following the IML Corrective Action Procedure. IML will immediately begin an investigation when audit findings cast doubt on the validity of data. At the conclusion of the investigation, if it is determined that reported data are in error or must be qualified, the lab will prepare a detailed written explanation for presentation to the customer; this detailed explanation will be delivered to the affected customer(s) within 90 days of the conclusion of the investigation. It is the responsibility of the Quality Manager, Lab Manager, or Technical Manager to ensure that the explanation is presented to the customer within the 90-day time frame. Corrective action taken must be recorded following the IML Corrective Action Procedure.

15) Recommendations may be written to suggest improvements.
16) A final report is submitted to the Quality Manager.
17) The final report will contain the following information:

    1) The name of the person making the report.
    2) The sections or procedures being audited.
    3) A summary of events of the internal audit.
    4) All NCARs arising from audit findings.
    5) Any recommendation(s) for improvement.
    6) A review of status of corrective actions and recommendations from previous audit of area.
    7) All descriptions of how requirements are met.
    8) All people interviewed, and documents and records viewed.
    9) A copy of the list used in the audit.

If the audit findings cast doubt on the effectiveness of the quality system, an additional audit of the area or section of the standard is scheduled.

Internal auditors are required to conduct themselves in a professional manner at all times. Internal Auditors must be trained as per the Training Procedure and this document. Internal audits must be conducted by trained personnel who are independent of the area to be audited. Audit reports are reviewed following completion to ensure implementation of any related NCARs.

Approvals:

_____

Michelle LaGory Date
Quality Manager

_____

Tom Patten Date
Laboratory Manager

Standard Operating Procedure for Client and Data Confidentiality

1.0 Scope and Application.

1.1 The information provided to Inter-Mountain Laboratories (IML) by clients or potential clients is confidential and shall be protected from release to any other entity or to the public.

1.2 The analytical data and all associated information and conclusions are paid for by IML clients, and belongs to the client. All such information will be protected from accidental or purposeful release to any other entity or to the public unless specifically directed to by the owner of the information, the client.

2.0 Summary.

2.1 IML is committed to maintaining clients' confidence in IML's competence and integrity by maintaining the confidentiality of records and information. IML will accomplish this by limiting access to records, confirming electronic delivery of reports, and requiring authorization to release information to other entities.

3.0 Definitions.

3.1 Information relating to a client's operation, including (but not limited to) staff contacts, project locations, holdings, assets, etc. that are released to IML as part of an analytical project are confidential.

3.2 Results of analyses (field and lab) and all related information including (but not limited to) sample identification, project locations, observations, raw data, reports, conclusions, and interpretations belong to the client and are considered confidential.

4.0 Considerations.

4.1 Ultimate submission of a report to a regulatory body which then becomes public record does not relieve the burden of confidentiality.

5.0 Procedure.

5.1 As part of establishing business relationships with IML for analysis, clients will provide sensitive company information to IML. Examples of this information include staff contacts, project locations, holdings, assets, etc. This information shall be considered confidential. .Information regarding a client shall not be disclosed to any third party or to the public without prior written authorization from the client.

5.1.1 In discussions with a third party (e.g. regulatory agencies) reference to a specific client must be generic. Refer to them as "a client in the industry".

5.1.2 Requests from third parties to contact a client must be denied or the third party information may be given to the client to allow them to initiate the contact.

5.2 As part of sending samples to IML for analysis, clients will provide sensitive project information to IML. Examples of this information include staff contacts, sample identification, project locations, field observations, etc. This information shall be considered confidential.

5.2.1 Information regarding sample information shall not be disclosed to any third party (including regulatory agencies) or to the public without prior written authorization from the client.

5.2.2 In discussions with a third party (e.g. regulatory agencies) reference to specific project must be generic. Refer to general areas and applications.

5.3 As part of analyzing samples for clients, IML will acquire sensitive information. Examples of this information include observations, raw data, reports, conclusions, interpretations, etc. This information shall be considered confidential.

5.3.1 Information regarding sample analyses shall not be disclosed to any third party (including regulatory agencies) or to the public without prior written authorization from the client.

5.3.2 In discussions with a third party (e.g. regulatory agencies) reference to analytical results must be generic. Refer to general issues. Do not name the client.

5.4 Access to confidential client information and records will be limited to IML employees. All information and records will be kept in locked file cabinets, locked offices, or areas isolated from general traffic.

5.5 Clients who visit IML facilities must log in using a Visitor's Log and an IML employee must accompany them at all times. They will not be given access to file cabinets, raw data, or areas where other client information is immediately available. Information related to their operation will be retrieved and brought to them in a non-sensitive area.

5.6 Auditors must sign a non-disclosure agreement prior to review of documents for auditing purposes.

5.7 Employees shall immediately report violations to senior management. Violations may result in disciplinary action ranging from oral reprimand to termination. In addition to disciplinary action taken by IML, some violations may require restitution and may lead to legal action against the person(s) involved.

6.0 References.

6.1 ISO/IEC17025:2005, "General Requirements for the Competence of Testing and Calibration Laboratories".

Quality Assurance Official:_____

Lab Official:_____

Date:_____

CONTRACT REVIEW PROCEDURE

Scope:

This procedure describes the contract submission, review, and approval procedure.

Application:

Formal Contracts:

Formal contracts are typically initiated by companies, organizations, or government entities with a “Request for Proposal.” The “Request for Proposal” is routed to the appropriate qualified technical reviewer for comments and pricing. A response is prepared either positive or negative as to ability to perform, pricing, and other items. Where appropriate, a positive response is prepared according to the guidelines in the “Request for Proposal.” A positive response defines the methods as well as the parameters analyzed. The methodology chosen are appropriate, up to date international, national, or regional standard methodology. The methods applied to each parameter are detailed. Data Quality Objectives are communicated by the client to the laboratory. The level of Quality Assurance and Quality Control required by the project are determined. Inter-Mountain Laboratories, Inc. response is then sent to the company, organization, or entity which initiated the “Request for Proposal.”

If the response is accepted, a contract is sent to Inter-Mountain Laboratories, Inc. The contract is reviewed by a designee of the company. Designees permitted to review and sign contracts for the company are designated by the Board of Directors for Inter-Mountain Laboratories, Inc. A list is maintained by the Secretary/Treasurer. The contract is compared to the “Request for Proposal” and the Inter-Mountain Laboratories, Inc. response. Any discrepancies are investigated. A contract will not be signed, and work will not commence, until the discrepancies have been resolved. A technical review is performed by the qualified reviewer. All contracts must be reviewed by an officer of the company prior to final approval. The designee’s signature indicates that each provision of the contract has been reviewed and approved.

If a revision to the contract is required, Inter-Mountain Laboratories, Inc. receives or generates an amendment or additional contract. The amendment or additional contract is compared against the “Request for Proposal”, the Inter-Mountain

Laboratories, Inc. response, and relevant contracts. Once the amendment or additional contract has been reviewed and all discrepancies and provisions are resolved and agreed upon, the amendment or contract is signed by the designee of the company. The designee's signature indicates that each provision of the amendment or contract has been reviewed and approved.

Once contracts are approved, copies of the approved contracts are sent to the Laboratory Manager. Copies of approved contracts as well as all relevant documentation pertaining to approved contracts are sent to the Secretary/Treasurer. The Laboratory Manager is responsible for ensuring the laboratories remain within the scope of contracts. Records of the "Request for Proposal", responses, contracts, and amendments are retained by the Secretary/Treasurer.

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Informal Contracts:

Many proposals are not formalized as written contracts. Companies, organizations, or government entities typically initiate informal contracts with a "Request for Proposal" for small and sometimes large informal jobs. The Laboratory Manager, Laboratory Supervisors, or Business Development personnel prepares a bid or price quote in response. The job is assessed by determining the client's Data Quality Objectives for the type of sample/s (i.e. waste, drinking water, soil, ground water, or other), the appropriate test method for each individual parameter, detection limits, the appropriate units of measure, the required level of quality control, reporting requirements and prices. The preparer must conclude if the laboratory has the capability to fulfill the order. If the laboratory does not have the capability, the laboratory communicates to the customer and does not accept the samples. The laboratory may accept the sample/s and sub-contract part or all of the work for the customer. If this is the case, the client is asked for permission to sub-contract the work. An acceptable turnaround time for the customer is determined. Next, the laboratory determines the availability of labor and instrumentation. Typically, asking the Laboratory Supervisor is sufficient. If the laboratory has the capacity and capability a second qualified person may review the proposal before the proposal is sent to the client. The client often verbally accepts the proposal or simply sends samples. Samples are received through normal sample receiving.

Proposals are delivered in PDF files and stored electronically on a common drive in the bids directory by the Clients names. The same format is used for each

proposal with a proposal ID. The COCs for Home Series and Hay Samples predetermine the appropriate methods for capability and capacity to do the work.

Approvals:

_____

Michelle LaGory Date
Quality Assurance Manager

_____

Tom Patten Date
Laboratory Manager

CONTROL OF RECORDS PROCEDURE

Scope:

This procedure identifies the procedures and policies for the protection, security, confidentiality, identification, collection, maintenance, storage, retention, and disposition of quality and technical records.

Application:

This procedure applies to the quality and technical records associated with the organics, water, trace metals, radiochemistry, gravimetric, kinetics, and soils laboratories. In the lab, a record is considered to be a register of an observation. Records may be made electronically or may be handwritten. Records are useful in establishing conditions that enable historical reconstruction and repeatability of analyses.

Protection and Security:

Protection is accomplished by storing paper and electronic records in secure facilities. These facilities are protected from weather and theft.

The facilities are secured with locks. A current list of key holders is maintained at each facility. For the 555 Absaraka address, the Accounts Manager manages the keys and the list. The key list includes the name, signature, and initials of lab personnel. The key list also serves as a means to identify the signature and initials of lab personnel who sign or initial lab records; a separate signature list is maintained for personnel who are not issued keys. For the 1673 Terra Avenue address, the Quality Manager manages the keys and the list. If a key is not returned after an employee is dismissed or resigns, the person managing the keys arranges for the locks to be changed and new keys are issued.

Electronic data are protected by electronic backups to tape or other computers. Backups are required for all electronic records such as file servers, lab data systems, and email systems. Backups shall be stored in a location separate from the original unless the back-up is protected by use of a fireproof safe. Since electronic records can contain data in an organized manner these records are protected with passwords. The programmers/database managers control passwords and access. The entire electronic network is protected from outside intruders with a firewall.

When customers, vendors, or other persons visit the laboratory the office manager will ask them if they need assistance. The person they have come to visit will meet them and accompany them through the laboratory. The laboratory assigns laboratory identification numbers to associate with data. This protects clients from unauthorized viewing of their data. Laboratory identification numbers are associated with sampling events by the Chain of Custody forms, LIMS, and final reports. It is the responsibility of the person accompanying the visitor to ensure that client files are not stolen, copied, or examined by the visitor.

Identification:

Records are identified by identifiers, forms, content, and location. Procedures detail record identifiers, forms, and content. Location identifies many records. Examples of locations and types of records contained at each location are shown below:

Location	Area	Type of record
555 Absaraka	Organics Laboratory	Client files Instrument Logs MDL studies Work sheets Performance Evaluations Certificates Purchase orders Sample Logs Refrigerator Logs Balance Logs Calibration Logs Instrument files Server files Vendors list
	Finance Office	Contracts Bids Requests for proposals
	Accounts Office	Purchase Orders Packing lists Vendors list
	Lower Level	Gravimetric filters Client files Contracts Login session reviews

		Weigh session reviews Certificates
555 Absaraka	Indoor Tennis Court	Long term storage for records of Organics laboratory Finance Office Accounts Office Gravimetric Labs

Location	Area	Type of record
1673 Terra Avenue (New building)	Soils, Water, & Trace Metals Laboratory	Client files Instrument Logs MDL studies Work sheets Performance Evaluations Certificates Purchase orders Sample Logs Refrigerator Logs Balance Logs Calibration Logs Instrument files Server files Vendors list
	Quality Office	Quality lists Job descriptions Training records Internal Audit records External Audit records Corrective action records Preventive action records Management review records Proficiency Testing Records Obsolete procedures
1818 Terra Avenue	Units 605&503	Off-site long term storage for records of Quality, Soils, Water, RadChem and Trace Metals Laboratory
RadChem/Soils Lab (Original building)		Client files Calibration Logs Reports

MDL Studies
Control Charts
Certificates
Balance Logs
Oven Logs
Pipette Logs
Radiation Monitoring Log
pH and EC meter logs
Maintenance Log
Shot Log

Collection and Maintenance of Records:

Inter-Mountain Laboratories Incorporated uses “client files” to organize data. Chain of custody, condition upon receipt forms, final reports, and copies of original observations are placed in “client files”. In addition to records listed below, other records relative to analysis that must be retained include the date of analysis; time of analysis if ≤72 hrs, or when time critical steps such as extraction or incubation are included in analysis; manual calculations; ID of analyst; sample prep and cleanup; results; standard and reagent traceability; data and quality control review and assessment; software verification; and records of changes to automated data entry. Sufficient standard and reagent information must be included in client files to allow for adequate traceability and reconstruction of analysis. These files are put together in either a labeled folder or stapled together with a cover sheet. These files move throughout the laboratories until final reports are completed and invoiced. After invoicing they are stored.

Laboratory logbooks are assigned unique identifiers by the Quality Manager, or appropriate representative, at the time they are issued.

Record integrity is maintained. In order to protect the integrity of hand written records, records are made with ink. When hand written records are made in error, a single strikeout of the original record is made and the correct value is written next to the error value; this correction is accompanied by initials of person making the correction and the date on which the correction was made. When the capability exists, data files will be saved to the network on a monthly basis by the person controlling the technology. Otherwise a paper record system is maintained.

Records are collected in files, notebooks, worksheets, printouts, and electronic files. Collection is performed by an employee as needed. Records are maintained in the area of collection as long as space allows. Records are then moved to long term storage areas. Records are maintained in chronological, alphabetical, and numeric order. Records relative to laboratory accreditations

must be made available to the accreditation body as needed. Examples of how records are maintained are shown:

Type of Record	Maintenance System
Client files	Alphabetical per client for each calendar year
Instrument logs	Chronological for each instrument
MDL studies	Chronological for each instrument
Work sheets	Chronological for each work sheet
Performance Evaluations	Chronological for each type
Certificates	Chronological for each type
Sample Logs	Chronological for each type
Refrigerator Logs	Chronological for each unit
Balance Logs	Chronological for each unit
Calibration Logs	Chronological for each area
Instrument files	Chronological for each instrument
Server files	Chronological for each server
Contracts	Alphabetical per client
Bids	Alphabetical per client
Requests for proposals	Alphabetical per client
Purchase Orders	Numeric order
Packing slips/Accounts Payable	Alphabetical per vendor for each calendar year
Quality lists	Chronological for each type
Job descriptions	Alphabetical per employee
Training records	Alphabetical per employee
Audit records	Chronological
Corrective action records	Chronological
Preventive action records	Chronological
Management review records	Chronological
Gravimetric Filters	Alphabetical per vendor for each calendar year
Weigh session reviews	Chronological
Login session reviews	Chronological
Logs	Chronological

Storage:

Long term storage of paper records is necessary for some types of records. The long term storage areas are the indoor tennis court, the 1673 Terra Avenue lab building, and 1818 Terra Avenue. Paper records are stored in these areas in cardboard boxes and/or file cabinets. The boxes are labeled with owner, type, and chronology.

The accounts office places purchase orders and accounts payables files in boxes and stores them in the tennis court area. The organics laboratory and gravimetric labs places client files, instrument files and other quality records in boxes and stores them in the tennis court area. The water, soils, radchem and

trace metals laboratories place client files, instrument files and other quality records in boxes and store them at 1818 Terra Avenue; long term storage of Quality Office records is also at this location. The financial office currently does not use long term storage.

Access logs are available to record retrieval from and return to storage at long term storage locations. Records include Work Order number or record ID, Date Removed and Returned, and Initials of person removing record.

Retention and Disposition:

Records are retained for a minimum of ten years by Inter-Mountain Laboratories, Inc. If the generating laboratory moves to another location, the records will move with the generating laboratory. During the retention period, the lab must maintain the means for the retrieval of records that are retained solely in electronic form. To dispose of records which are older than ten years, shred records with mechanical shredder. After shredding, place shredded material in a trash/landfill dumpster.

Clients will be contacted in the event that the laboratory changes ownership or goes out of business, so that arrangements may be made for collection or transfer of client records. Additionally, regulatory protocols will be followed.

Approvals:

_____

Laboratory Official Date

_____

Quality Assurance Official Date

CORRECTIVE ACTION PROCEDURE

Scope:
This procedure identifies the procedures, policies, and authorities for completing corrective actions in the laboratory.

Application:
Laboratory Corrective Actions are taken to eliminate the cause of a nonconformity, preventing it from recurring. Corrective actions are initiated from a variety of sources. Inter-Mountain Labs has identified complaints, internal audits, external audits, and nonconforming work as the sources for initiation of corrective action. Corrective actions require cause analysis, corrective actions, reviews, monitoring, and closure. This procedure provides guidance for conducting root cause analysis and establishes authorities for completion of each stage of the corrective action process.

Complaints:
Complaints can originate from customers, employees, service providers, government regulators, or other parties. Complaints are communicated to project managers, Laboratory Supervisors, the Quality Manager, or the Laboratory Manager. The manager who receives the complaint determines whether the handling of the complaint requires that a corrective action be completed (i.e., whether the complaint represents a departure from the lab's quality system requirements). Complaints that do not represent a departure from the lab's quality systems may be handled through the Preventive Action process, or through other means relating to customer service.

If the complaint warrants completion of a corrective action, the manager immediately initiates the corrective action process.

Nonconforming Work Production:
Nonconforming work production includes any inability to meet customer or methodology requirements. Examples of nonconforming work are:

* Lost samples.

* Holding time failures.

* LCS outside of limits, or other criteria that causes a batch or data to be rejected. This situation is special and is handled differently than other NCARs. The analyst fills out the "Quality Control Failure Log" sheet. These logs are not routed to the quality manager but are maintained in each laboratory section. A cause is identified and corrective action is initiated. The resolution of the problem must be approved by the section supervisor, or his deputy. Approval is indicated by a signature on the

"Quality Control Failure Log" sheets. It is the responsibility of each section supervisor, or their deputy, to ensure the appropriate use of the Quality Control Failure Log in their section.

* Unacceptable results on performance evaluation audits.

* Unacceptable results on inter/intra-laboratory comparison studies.

* Abnormal performance of instrumentation.

* Ethics violations.

Nonconforming work production may be detected by analysts, data reviewers, internal auditors, or managers. When nonconforming is detected, it is communicated to Laboratory Supervisors, the Quality Manager, or the Laboratory Manager. The manager who receives the corrective action request immediately initiates the corrective action process.

Quality System Nonconformities:
Quality system nonconformities are generally discovered during internal audits, customer audits, or third party audits.

In the case of a system nonconformity identified during an internal audit, the internal auditor initiates the nonconformity process by recording the relevant data on a Nonconformance Corrective Action Request form ("NCAR"). The internal auditor presents these to the Quality Manager in an internal audit report.

In the case of customer audits or third party audits, the Quality Manager initiates the NCAR.

Corrective Action Procedure:
Timeliness is of extreme importance when reacting to quality system nonconformities from all sources. It is the responsibility of the Quality Manager and Laboratory Manager to ensure timely responses, taking into account severity and magnitude.

When it is determined that a Corrective Action is necessary, the process is recorded on a Nonconformance Corrective Action Request form. The record identifies who detected the non-conformity, the nature of non-conformity, the date of discovery and any immediate corrective actions taken. The form is immediately sent to the Quality Manager. The Quality Manager assigns a completion date for the NCAR.

Any immediate corrective action taken is reviewed and approved by the Quality Manager. Root Cause Analysis, with a due date of completion, is assigned to appropriate Inter-Mountain Labs personnel by the Quality Manager.

Cause analysis will consist of following steps:

1) Typically, a meeting is scheduled of the team to whom root cause analysis is assigned.
2) The team may use the Five Whys or 4-Ms (Man, Method, Machine, Materials) to identify a list of potential causes. Care is taken not to blame individuals and an effort is made to reach the core of the problem.
3) Potential causes identified are reviewed, and then ranked in order of importance.
4) Objective evidence in support of the identified causes is gathered.
5) Believed cause(s), those believed to be at the core of the problem, are identified and recorded.
6) Corrective Actions (and necessary corrections) most likely most likely to prevent a recurrence of the problem are identified.
7) The NCAR form is returned to the Quality Manager for review of the cause analysis. The Quality Manager reviews the cause analysis, adding signature and date to that portion of the form when it is determined that the cause analysis is appropriate.

An assessment of the significance of the nonconformity is made, along with a determination of whether it is necessary to stop work, contact the customer, reissue a report, or recall data. In the case where work needs to be recalled, senior management will be notified. In the case where work has been halted, work will not resume until the Quality Manager, Laboratory Supervisor or Laboratory Manager has authorized a resumption of work.

Where corrective action involves a change to laboratory procedure, this change must also be incorporated into the document that describes the procedure. Dates of implementation of the corrective actions are recorded. The NCAR form is returned to the Quality Manager on or before the assigned due date.

A review of root cause analysis and the corrective actions taken is performed by the Quality Manager. The Quality Manager signs the form after confirming that corrective actions have been implemented and are appropriate to the significance of the problem.

The form is submitted to the Laboratory Manager for final review and approval. A date is assigned for monitoring of corrective action for effectiveness. The NCAR is considered closed when monitoring demonstrates that the corrective actions have been fully implemented. Completed NCARs are retained by the Quality Manager.

NCARs are posted in the Quality section of the Intranet, where they are edited and tracked through completion.

Summary of revisions from Corrective Action Procedure 2.9, revised 9/30/14.

Reorganized procedure to more clearly describe how corrective action is conducted in response to quality system nonconformities from all sources: complaints, internal audits, external audits, and work production (including Proficiency test failures).

Changed “non-conformance” to “nonconformance” throughout document.

Redundancy within the procedure was eliminated by describing one procedure for conducting quality system corrective action including root cause analysis. Use of QC Failure logs for tracking failed QC remains within the procedure.

Language added to “Complaints” to facilitate determination of instances in which Corrective Action is not necessary.

Revised portion of the procedure describing root cause analysis.

Added statement that a date is assigned for completion of root cause analysis.

Added statement that NCARs are tracked through completion on Intranet.

Added statement that dates of implementation of corrective action are recorded on NCAR form.

Eliminated “Authorities” section because authorities are established within each section of the procedure.

Approvals:

_____ _____

Laboratory Manager Date

_____ _____

Quality Manager Date

DATA HANDLING PROCEDURES

1.0 SCOPE AND APPLICATION

1.1 This standard operating procedure applies to any computerized data set which can be manipulated and re-processed to produce a change from the original data set. This procedure covers manual integrations employed by analysts to integrate peak area/height manually using chromatographic software. These procedures also cover the appropriate handling of replicate, internal standards, and calibration run data. These procedures are used by individuals involved with instrumental systems.

2.0 DEFINITIONS and USE

2.1 Manual Integration is defined as the process by which an analyst can reset the two points to calculate the area/height under the curve of a peak during processing of data such that the peak area/height is different from the original automated process set by the run parameters. The data system might identify the wrong peak; this situation must be corrected by manual integration. Manual integration is used to provide accurate measurement of peak area/height where the original integration provided by the data system is in error.

3.0 ACCEPTED REASONS FOR MANUAL DATA HANDLING

3.1 Peaks are split by chromatography software
3.2 There are shoulder peaks
3.3 Baseline noise
3.4 There are negative spikes in the baseline
3.5 There are rising or falling baselines
3.6 The wrong peak is identified by the chromatographic software
3.7 Instrument calibration is not linear either on the high or low end of the curve.
3.8 Instrument internal standard reassignment to improve accuracy of data.

4.0 CAUTION

4.1 Manual integration is not used to change peak size in order to pass QC criteria.
4.2 Manual integration is never used to misrepresent data.
4.3 Removal of replicate data must have a statistical basis for removal.
4.4 Removal of calibration data points must be done carefully. The data curve must be a better representative of true or linear, usually only the lowest calibration or the highest calibration points are removed.
4.5 Assigning internal standards must be done in an unbiased manner.

5.0 PROCEDURE

5.1 Perform data handling in an unbiased manner.
5.2 Record with initials and date in the “customer file” that a manual data handling was performed.
5.3 Records shall clearly indicate use of manual data handling.

Approval:

_____
Laboratory Official Date

_____
Quality Assurance Official Date

DOCUMENT CONTROL PROCEDURE

Scope:
This procedure applies to the control of documents for the Quality Assurance Plan at Inter-Mountain Laboratories, Inc. (IML) laboratory locations. This procedure recognizes the existence of both internal documents and external documents and the need to control these documents. This procedure describes how to locate, identify, create, revise, review, eliminate, and archive documents described in the Quality Assurance Manual.

Application:
Quality system documents include policies, procedures, and instructions; this includes any writing that describes what to do and/or how to do it. It is essential that these documents be controlled and authorized for use, to ensure that a consistent quality of service is provided by the laboratory that meets or exceeds accreditation requirements. Documents are controlled by format, creation, review, approvals, location, and removal of obsolete documents. IML has separate procedures for internal documents and external documents. Internal documents include but are not limited to analytical procedures, quality system documents, calibration procedures, forms and checklists that contain instruction for performing a task and other documents created by IML personnel. All internal analytical procedures must include calibration procedures where applicable. External documents are analytical procedures, calibration procedures, and other procedures defined in reference texts. IML maintains an electronic Master Document List that is controlled by the Quality Manager. The list tracks document name, revision, revision date, location and number of distributed hard copies, and controls availability of electronic copies. The Master Document List may be viewed in LIMS and on the intranet. From the list, official versions of internal documents are available as "Read Only" documents, and official versions of forms may be printed for use in the lab. IML supervisory personnel are kept apprised of creation, revision, and elimination of both internal and external controlled documents during regular management meetings and through email. This information is then communicated by supervisors to their staff; in addition, notes from the management meetings are posted on the intranet.

Internal Documents:

General:

Controlled internal quality documents must be signed by a minimum of two Inter-Mountain Laboratories, Inc. representatives. The signatures indicate a review of the documentation and approval by the signatories. One of the signatures must be from senior management, lab management, or quality assurance management. The other signature may be any other appropriate Inter-Mountain Labs representative. Each page of a controlled internal quality document contains the revision status, revision date, page number, total number of pages, and the identifier. Internal documents other than forms are distributed on green paper.

Analytical Standard Operating Procedures (SOPs) shall have three descriptors to identify each document. The first descriptor consists of one or two letters that identifies the laboratory section to which it applies; e.g., “W” for Water Lab, “R” for Radiochemistry Lab, “O” for Organics Lab, “M” for Metals Lab, ”S” for Soils Lab, "ML" for Micro-Gravimetric Lab, and "GL" for Gravimetric Lab. The second descriptor denotes the method, where applicable; e.g. “8015GRO” indicates the analytical method for gasoline range organics by SW-846 method 8015. Additionally, a number ID may be assigned sequentially, based on category or type, e. g., 300-399 for "Routine Procedures "; e.g., "ML-AppLO301-1.0" indicates a routine procedure used in the Micro-Gravimetric Lab in performing work in support of analysis by the methods described at 40 CFR Part 50 Appendices L and O. The last descriptor indicates the version of the document. All procedures shall originate with “1.0”. Small changes shall be denoted with an incremental increase of one to the number to the right of the decimal; an example is from “1.0” to “1.1”. When major changes occur, see “Revisions” section, changes shall be denoted with an incremental increase of one to the number on the left and the number on the right will become zero, e.g., a change from “1.1” to “2.0”. An example of a complete identifier is “O-8015GRO-1.2”, for version 1.2 of the organics laboratory’s procedure for the analysis of gasoline range organics by SW-846 method 8015B.

Revisions:

When it is determined that a revision to an existing controlled internal quality document is needed, the revision is made electronically. Hand amendments to controlled internal documents are not allowed.

When revisions are made to internal analytical procedures, a review is made of associated internal supporting documents including but not limited to method “Quick Notes” or “Posted Notes”, prep procedures, logbooks, forms, or checklists that may require revision to reflect changes made to the analytical procedure.

In the case of simple or minor changes to a document, where practicable (feasible and usable), the use of strikethrough, ~~strikethrough,~~ for amended text and italic, *italic*, for additional text will be practiced. Alternatively, the use of “Track Changes” in Word is allowed as well.

When a major revision is made to an internal document, as described in “General” section, where tracking major changes would impact the readability of the document, a detailed summary of revisions from the previous version may be added as an attachment to the procedure.

The revised document is reviewed by two IML representatives. Following review, the representatives will approve the revised document by signing

the document. The previous revision is then removed from all locations. A copy of the previous revision is marked “obsolete” and retained for reference. The remaining copies of the previous revision are marked “obsolete” and destroyed. The Master Document List is then updated and the revised document is put into service at all necessary locations.

Creation:

When it is determined that an additional controlled internal quality document is needed, the new document is created and saved as an electronic file. Controlled internal quality documents that may need to contain references to the new document are reviewed by two IML representatives. If the creation of the new document requires the revision of related existing documents, the revisions will be performed as described in this procedure. After review, the representatives will approve the new document by signing the document. The signatures indicate the review of the new document as well as review of other documents which may need a reference to the new document. The Master Document List is then updated and the new document is put into service at all necessary locations.

New analytical SOPs are created using the most current approved analytical SOP template. The lab must use the most current approved version of the reference method that meets the needs of the customer. Laboratory SOPs must adopt the most stringent Quality Control requirements given in the related reference method or regulation.

Eliminations:

Controlled internal documents can be eliminated by senior management, lab management, or quality assurance management. When it is determined that a controlled internal quality document needs to be eliminated, a review is performed. Documents which may contain references to the eliminated document are reviewed by an IML representative. If revisions to existing documents are determined, the revisions will be performed as described in this procedure for revisions. After review, the document is removed from all locations. A copy of the eliminated document is marked obsolete, signed, and filed. The remaining copies of the eliminated document are marked obsolete and destroyed. The signature indicates the review of the eliminated document as well as review of other documents which may contain a reference to the eliminated document. The Master Document List is then updated.

Review:

Controlled internal documents will be reviewed annually and revised as needed to ensure relevance and compliance with requirements. Quality Manual documents will be reviewed annually during the course of internal audits; record of their review will be made in the corresponding internal audit report. Review of analytical procedures will be performed annually

and will be managed by section supervisors. Record of analytical procedure review will be made on a sheet placed at the front of each SOP manual; record will include document identifier, signature of reviewer, date of review, and note indicating whether revision is required. Internal documents may be reviewed by senior management, lab management, or quality management. Records of review will be retained according to the Control of Records Procedure.

Forms:

Because forms are primarily used to facilitate recording quality critical information related to laboratory analysis, it is important that forms are standardized, approved, and controlled. Though considered documents when they contain instruction, forms are controlled a bit differently than analytical or quality procedures within the laboratories.

As with other internal documents, a new form is created as an electronic document when a need is identified. Each controlled form must contain the name of the form, the revision date, and revision number. When a form consists of more than one page, the page number and total number of pages must be included on each page. Forms do not require signatures of approval, and changes between revisions are not identified on the current version.

A form is considered "approved" after it has been thoroughly reviewed, distributed for use in the lab, and added to the Master Document List. Blank obsolete forms are removed from points of use. Completed forms are considered records (an account of something that has been observed) and are managed per the Control of Records Procedure.

Electronic Files:

The Quality System is a paper system, but electronic files are stored and retained for practical purposes. The electronic files of current approved procedures and forms are maintained in the Quality Assurance Manager's partition on the network server. Only the Quality Manager and the Database Manager have access to this partition through the network login. These files are protected so that when a revision is required the paper original does not need to be reproduced. The following procedure is performed by the Quality Assurance Manager when an electronic file revision is required:

1) Save the file with a new file name.
2) Accept all previous changes.
3) Electronically transfer the file to the person who will make the changes.
4) When the changes are approved, obtain the file.
5) Protect the new document by placing the file in the Quality Assurance Managers partition, the "V" drive. The obsolete version of the

document is then archived in the appropriate “Obsolete” file in the Quality Manager’s partition.

6) A “Read Only” copy of the document is then placed on the Intranet and in LIMS for common access. The obsolete version of this document is removed from this common directory, and archived in the Quality Manager’s “V” drive.

The contents of the Quality Assurance Manager’s partition will be considered part of the Master Document List.

External Documents:

External Documents are documents not produced by Inter-Mountain Laboratories, Inc. personnel. Examples of external documents are software, instrument manuals, regulations, and analytical methods produced by another entity. External documents are reviewed for appropriateness as acquired, by members of laboratory management. Review and approval are signified by placing on the Master Document List. External documents are controlled by location and listing. Analytical methods are found in “external document areas.”

External documents are reviewed periodically during internal audits and when changes are made to internal documents that reference them.

Some external documents are updated frequently and at irregular intervals, such as regulations, accreditation requirements, and guidance documents. Reasonable efforts are made to ensure that the laboratory is kept abreast of these updates by subscribing to available notification services such as email updates, RSS feeds, and newsletters.

External documents found to be invalid or obsolete will be marked obsolete. They may remain in the laboratory for historical purposes if they are clearly marked as being “obsolete”. Otherwise, they must be removed from the laboratory immediately. A copy of the valid external document will be obtained and added to the laboratory. The Master Document List will then be updated.

Approvals:

_____

Laboratory Official Date

_____

Quality Assurance Official Date

EQUIPMENT PROCEDURE

Scope:
This procedure describes the procedures and policies for equipment.

Application:
This procedure details how to identify, locate, determine status, and confirm equipment acceptability in the laboratory. This procedure also details the procedures for handling non-conforming equipment.

Support Equipment:
Support equipment includes equipment that does not directly produce analytical results, but its performance is critical to production of accurate quantitative results. Support equipment includes but is not limited to ovens, incubators, balances, automatic pipettors, thermometers, refrigerators and freezers. Additional detail about appropriate monitoring and maintenance of this type of equipment is found in Thermometers and Monitoring Procedure, Pipette Delivery Check Procedure, and Balance Calibration Procedure.

Analytical Equipment:
Analytical Equipment includes instruments and components of measurement systems that are used for the direct production of analytical data.

Environment:
Analytical instrumentation and equipment is continually updated, acquired and utilized in the laboratory. The Laboratory Supervisor is responsible for determining the appropriate laboratory environment for each piece of equipment. The Laboratory Supervisors examine owner's manuals, calls manufacturers, and uses experience to determine appropriate placement and environmental considerations for each piece of laboratory equipment.

New Equipment:
Prior to placing new equipment into service, the Laboratory Section Supervisor will review operating requirements and determine whether use will require that revisions be made to existing lab SOPs or to associated record forms. Careful consideration will be given to reference method requirements, and whether use of the equipment will require that a different analytical method be cited.

When the equipment is put into service, it is added to the Equipment List for the appropriate laboratory section. A description of the unit, make, model, serial number or laboratory-assigned unique identifier, associated software if applicable, performance measurement methods, location of owner's manual if applicable, location of unit, IML inventory number if applicable, and description of use are maintained in the Equipment List.

Conformance:
Acceptance criteria for system performance is established for all instrumentation and equipment. Fume hoods are placed appropriately to facilitate performance of lab activities and for safety considerations. Velocity flow of hoods are checked for

conformance annually, per the IML Safety Plan. When lab equipment is repaired, serviced, or goes outside of laboratory control for any reason, sufficient checks to ensure proper performance must be conducted prior to placing back into service. When analytical instruments go outside of laboratory control, a MDL study must be conducted prior to returning to service.

Non-Conforming Equipment:

When equipment is determined to be non-conforming, use of the equipment is immediately halted. Supervisors are immediately informed of the problem and records are made in instrument maintenance logs detailing the problem. The equipment is tagged as non-conforming by adhering an appropriate sign with signature and date to the equipment. Supervisors assist the analyst to determine the steps needed to repair and return the equipment to operational status. Supervisors re-examine the laboratory environment and supply materials (compressed gas pressures, electrical service, etc.) for suitability whenever equipment becomes non-conforming.

When lab environmental conditions (electrical supply, temperature, humidity, lighting, sterility, dust, etc.) interfere with proper performance of lab equipment, the lab supervisor should be contacted immediately and immediate action must be taken to return operating conditions to an acceptable level.

The data management system in the ambient air particulate gravimetric laboratories prevents further analyses from occurring when equipment is non-conforming. This includes the analytical balance and environmental control systems. Additionally, when environmental conditions fall outside limits, alerts are emailed to appropriate personnel.

Supervisors will conduct an investigation to determine if data obtained prior to the break down were compromised. Where appropriate, a record of the investigation will be recorded in the instrument log book. If samples need to be run again, where appropriate, a record of the samples will be noted in the instrument log book.

If data have been reported and need to be recalled, the Corrective Action Procedure will be used. Where appropriate, corrective action requests will be noted in the instrument log book. Equipment that remains non-conforming for a period of six months will be removed from the laboratory. At that time, the Equipment List is updated to reflect the change in status. Instrument log books and/or calibration logs will be kept as per the Control of Records Procedure.

Responsibilities

Lab Manager:

The Lab Manager determines the method of ensuring conformance of equipment. The Lab Manager is also responsible for ensuring equipment is uniquely identifiable and that measurements are traceable to national or international standards.

Quality Manager:

The Quality Manager maintains the Equipment Lists, placing new equipment on the lists, assigning unique equipment identifiers where needed, and updating lists as needed. The Quality Manager is also responsible for scheduling and arranging calibration services for quality-critical support equipment (e.g., balances and thermometers).

Safety Officer:
The Safety Officer performs annual checks of air flow velocity of lab fume hoods.

Laboratory Section Supervisor:
The Lab Section Supervisors' responsibilities related to this procedure include determining the proper operating environment for optimum performance of instrumentation and other lab equipment in their section, and informing the Quality Manager of addition of new equipment and of other changes to laboratory equipment inventory. Additionally, the Lab Section Supervisor is responsible for assessing whether use of new laboratory equipment will require updates to existing lab SOPs or other lab documents (forms, logbooks, etc.). The Lab Section Supervisor ensures that necessary records and procedures are located at the area of use. When equipment becomes nonconforming, the Section Supervisor conducts an investigation of the nonconformity, assists the analyst in assessing the need for repair to return equipment to operational status, and re-examines the operating environment and supply materials. The Laboratory Section Supervisors are responsible for ensuring calibration procedures, analytical procedures, and records are maintained and available at the locations of use.

Analyst/Technician:
The analyst is responsible for informing their supervisor of the detection of nonconforming equipment, and updates any associated maintenance log, detailing the problem and describing action taken to bring equipment back into conformance.

Summary of changes from previous version Equipment Procedure 1.3, revised 9/29/14:

Minor editorial changes for accuracy.
Added descriptions and definitions of Support Equipment and Analytical Equipment.
Reorganized to clarify responsibilities of lab personnel (Lab Manager, Quality Manager, Safety Officer, Lab Section Supervisors, and Analysts/Technicians) relative to this procedure.

Approvals:

_____
Michelle LaGory Date
Quality Assurance Manager

_____
Tom Patten Date
Laboratory Manager

FIELD SERVICES SAMPLING PROCEDURE

Scope:
This procedure describes the general procedures and policies for sampling in the field.

Application:
This procedure applies to the solid, liquid, and gaseous samples collected by the Field Services group.

Procedure:
The following is a list of requirements for each sampling event.

1) Obtain, understand, and adhere to any sampling plan, instructions, and/or guidelines from the customer associated with the sampling event.
2) Produce or obtain an IML sampling procedure for the project. Alternatively produce or use a checklist. The customer requirements shall be defined for every project.
3) Inspect instruments and equipment prior to leaving for the sampling event.
4) Record all calibrations of instruments with traceability to NIST.
5) Record any pertinent conditions that may impact the samples.
6) Record all field measurements immediately on field sheets.
7) Chain of Custody forms shall be completed at the time of collection.
8) At minimum, label each sample with identifier, sample date, and sample time for liquid and gaseous samples. At minimum, label with identifier for solids.
9) Preserve samples appropriately as per an approved edition of the Standard Methods for Water and Wastewater immediately upon collection.
10) Decontaminate equipment as per the sampling plan or customer guidelines.
11) Any customer-required deviation from this procedure shall be recorded with associated sample data, included with associated test results, and communicated to appropriate persons.
12) Deliver samples to laboratory in timely manner, using temperature preservation where appropriate, so testing will be completed within holding times.
13) Return instruments and equipment in clean, working, and ready condition.
14) File all customer records in file labeled by year, customer, and if necessary project.

Approvals:

_____
Field Services Supervisor Date

_____
Laboratory Manager Date

Inter-Mountain Labs, Inc. IT Procedures

Scope:
This document describes Information Technology (IT) procedures employed at IML locations.

Security and Traceability:
Control of the computer systems is accomplished by limited access by users according to the task performed. Computer access is tracked by using login names and passwords. Virus protection programs are installed on all computers to detect and remove viruses.

Software Validation Procedure:
Software is occasionally written to automate data transfers and other applications. This procedure applies to software that manipulates, transfers, routes, or otherwise processes analytical data.

Software Creation:
Software is created to perform specific tasks. When software programs are written, they will be appropriately commented.. The comments will be sufficient to understand the function of each section or line of code. If the code is or cannot be commented, an accompanying explanation of the code will be produced. This explanation will be kept with the programmer/database manager.

Software Validation:
Software needs to be validated before allowed into general use. Software is validated or acceptance tested by processing real data with the program, using a test environment. The output data are then reviewed. If the output is unsuccessful, software creation is continued. If the review is successful, a copy of input and output data are saved by the programmer/database manager. The software can be put into general use. During the period immediately following release for use in the laboratories, the program is beta tested or closely monitored for problems by the database manager and users.

Calculations programmed into computer software are verified initially, then periodically thereafter by manual calculations. These manual calculations are retained and made available for future inspection.

Backup / Restore Procedure:
The following serves as a general guideline with regards to data backup and recovery. Every effort should be taken to apply these procedures at each IML location. If any portion or instruction in this document cannot be implemented at your location, document what is being done to provide similar, if not equal capabilities.

Operating Environment:

The current network operating environment consists of Intel-based PC servers running Microsoft Windows Server 2008, Microsoft Windows Server 2003, and Microsoft Windows Server 2000. The Laboratory Information Management System (LIMS) at the Sheridan Terra Avenue Lab runs on a Windows 2000 server.

Each IML location uses Veritas/Symantec Backup Exec, version 8.5 or greater. Each office must have two individuals (primary and alternate) familiar with the operation of this software.

Backup Media:
The Windows 2008 server used at the Gillette Lab is backed up to an RD1000 removable disk unit. The Sheridan Terra Avenue Lab uses a single tape drive. An appointed operator is responsible for the daily changing of media. The Sheridan Absaraka Street location uses a robotic tape library and backup to disk.

Backup:
A nightly unattended backup of all network files will be scheduled using Backup Exec. The LIMS database backs up every night to the Windows 2003 server before the tape backup runs. (Contact the network administrator, or consult the Backup Exec documentation) Each day's full backup should fit on one tape. If all network files will not fit on one tape, a differential backup may be scheduled for Monday through Thursday, and a full backup scheduled for Friday. A differential backup backs up all files that have been modified since the last full backup. Additionally, End-of-Month tapes will be required for at least a three month rotation. The following is an example of a two-week tape rotation schedule:

May 2013, into April 2013…		1 Wednesday-1	2 Thursday-1	3 Friday-1
6 Monday-2	7 Tuesday-2	8 Wednesday-2	9 Thursday-2	10 Friday-2
13 Monday-1	14 Tuesday-1	15 Wednesday-1	16 Thursday-1	17 Friday-1
20 Monday-2	21 Tuesday-2	22 Wednesday-2	23 Thursday-2	24 Friday-2
27 Monday-1	28 Tuesday-1	29 Wednesday-1	30 Thursday-1	31 EOM-1
3 Monday-2	4 Tuesday-2	5 Wednesday-2	6 Thursday-2	7 Friday-1
…	…	…	…	…

Tape or other media will be labeled either manually or by a management system.

With the successful completion of each backup, the resulting tape should be moved off-site for the purposes of disaster recovery. This tape may return on-site only for data recovery, or following the successful completion of another full backup.

Use the tape-cleaning cartridge or cleaning kit as suggested by the tape drive manufacturer's documentation.

Restore:

The two-week tape rotation allows the recovery of data from any night of, the last two weeks, or from any end-of-month of the last three months.

Using the Backup Exec Administrator console on the server, the operator can locate the file or directory from a specific day or tape and choose to restore the chosen data to either the original or an alternate location. When restoring to the original location, it is prudent to make a temporary copy of the data that are about to be over-written. This can be done to another location on the server or to a local drive on a network-attached workstation.

Windows shadow copies provide yet another layer of data protection by its own version of file snapshots twice per day, once in the morning and once in the afternoon. Windows Server stores a copy of the all shared files on the server and stores them in a hidden location on the server. At any time a server administrator can restore a "previous version" of a file or folder dating as far back as several weeks. This is a simple file copy from the hidden location on the server to any location the server administrator chooses. Being a simple file copy makes the operation much quicker than restoring from tape.

IT Representative	Date
Laboratory Official	Date

MANAGEMENT REVIEW PROCEDURE

Scope:
This procedure describes management review.

Application:
This procedure identifies the procedure for frequency, attendance, review, actions, and records for management review of the Quality System.

Summary:
Meetings of the Lab Manager, the Quality Manager, Database Manager, and Laboratory Section Supervisors are held on an approximately weekly basis to provide general exchange of information among departments. Topics may include incoming work, instrument status, regulatory changes, staffing issues, proficiency testing, trouble-shooting, etc. New Non-conformance Corrective Action Requests (NCARs) are introduced and discussed; progress of open NCARs is discussed as well. Summaries of these meetings are compiled and distributed to personnel both electronically and as posted hard copies.

Senior management, the Quality Assurance Manager, laboratory management representatives, and other appropriate personnel will review the Quality System on an annual basis. Senior Management is defined as any officer of the company. The review includes, at minimum:

- Management review from previous year
- Quality Policy
- Management system policies and procedures, and their suitability
- Quality Objectives
- Corrective Actions
- Preventive Actions and opportunities for improvements
- Reports from managers and supervisors
- Changes in volume and type of work
- Results of external audits
- Results of internal audits
- Approved vendors
- Complaints
- Customer feedback
- Results of proficiency testing
- Internal analytical procedures and their suitability, including records of review
- Staffing
- Training needs
- Resource allocations

Procedure:
The Quality Assurance Manager will arrange for presentations on previous management reviews, responses from customer satisfaction surveys, customer complaints, audits, proficiency testing, corrective actions, preventive actions, and other items. Each presentation will include an accounting of incidents. Presentations may include grouping of similarities, graphical displays, trends, or other relevant data. After the presentation a discussion period is conducted. This is an opportunity for all participants to propose ideas and solutions for changes to the quality system. A list of proposed changes to the quality system will be collected by the Quality Assurance Manager. After all changes have been proposed to the quality system, senior management will make a decision as to which changes will be implemented, with any needed personnel training or resource allocations. A Preventive Action or Corrective Action is assigned with a due date for each action as appropriate. Each presentation is conducted in this manner until all presentations and actions are completed.

Finally a discussion period on the suitability of the Quality Policy, management system policies, and the Quality Objectives is conducted. This is an opportunity for all participants to propose changes to the quality policy, management system policies, and quality objectives. A list of proposed changes will be collected by the Quality Assurance Manager. After all changes have been proposed, senior management will make a decision as to actions to implement. A Preventive Action or Corrective Action will be assigned with a due date for each change as appropriate.

Additionally, annual review of laboratory analytical procedures for each laboratory section is assigned to the appropriate section supervisor. Record forms to be used to record review of analytical procedures during the coming year, by department, are distributed to section supervisors. Completed records from the course of the review year are submitted to the Quality Manager during the meeting. If department review of procedures has not yet been completed, forms may be retained until completion, but review records must be completed by the end of the calendar year.

Records:
A record of the meeting is produced which documents the individuals in attendance, place of meeting, start time of meeting, end time of meeting, items reviewed, actions agreed upon, and assignments of actions.

The Quality Assurance Manual is reviewed and revised annually, to reflect changes made as a result of annual Management Review.

Approvals:

_____
Michelle LaGory Date
Quality Assurance Manager

_____
Kevin Chartier Date
President/CEO

QUALITY ASSURANCE PROGRAM

IDENTIFICATION FORM

Document Title:

Standard Operating Procedure for Determination of Measurement Uncertainty

Location: Inter-Mountain Laboratories, Inc.
Address: 1673 Terra Avenue
Sheridan, WY 82801

Laboratory Official: **Tom Patten**
Title: **Lab Manager** *Phone:* **(307) 672-8945**

Quality Assurance Officer: Michelle LaGory

Telephone: (307) **672-8945**

Address: 1673 Terra Avenue
Sheridan, Wyoming 82801

Plan Coverage:

Standard Operating Procedure for estimating the uncertainty of measurements.

I have read and understand the following Standard Operating Procedure, and concede that the information contained therein is true and accurate to the best of my knowledge.

Quality Assurance Official: _____ *Date* _____

Lab Official: _____ *Date* _____

Standard Operating Procedure for Determination of Measurement Uncertainty

1.0 Scope and Application.

1.1 This procedure applies to all analyses of all sample types ranging from reagent water to wastewater to solid samples. The measurement uncertainty varies as a function of sample matrix and can be determined for all matrices to be analyzed.

1.2 The uncertainty value obtained by this procedure is used to judge the uncertainty related to a single measurement in a future sample. This procedure is applicable to estimating measurement uncertainty of Category III test methods, as identified by A2LA's Policy on Estimating Measurement Uncertainty for Life Sciences Testing Labs.

2.0 Summary of Method.

2.1 A quality control sample, typically a Laboratory Control Sample (LCS), is analyzed on a regular frequency. The results of the LCS analyses are normalized and charted. The measurement uncertainty will be calculated from this information for each analytical method.

3.0 Definitions.

3.1 The measurement uncertainty is defined as the 95% confidence interval statistically defined by a minimum of 20 normalized values of the Laboratory Control Sample. The Laboratory Control Sample has been subjected to the same preparation and analytical procedures as an actual sample.

3.2 Category III methods include quantitative chemical, environmental, or biological analyses developed as published regulatory or consensus methods. Major components of measurement uncertainty for quantitative laboratory analyses include sampling, transport, storage, subsampling, sample preparation, dilution when applicable, instrument variability, uncertainty of calibration standard, fluctuations of environmental conditions, and variability among individual analysts and technicians in making measurements. All laboratory SOPs for analytical methods used within the scope of the Wyoming Storage Tank Program must include identification of the test method's category of measurement uncertainty.

4.0 Interferences, Considerations.

4.1 The analytical method utilized must be referenced by number or title for each analyte.

4.2 Reference the sample matrix with the appropriate reporting units.

5.0 Safety.

5.1 See appropriate method

6.0 Apparatus and Materials.

6.1 See appropriate method

7.0 Reagents and Consumable Materials.

7.1 Reagent water – water in which the analyte and interferent concentrations are not detected at the method detection limit of each analyte of interest

7.2 Laboratory Control Sample (LCS) – reference sample acquired from an approved vendor independent from the supplier of the calibration standards. The LCS should contain the analyte(s) of interest at concentrations near the middle of the calibration range.

8.0 Calibration and Standardization.

8.1 See appropriate method

9.0 Quality Control.

9.1 The analyst can evaluate the measurement uncertainty whenever a new data point is acquired and entered into the LIMS system.

10.0 Procedure for Hand Calculations.

10.1 Prepare data for method uncertainty determination and control chart evaluation. Refer to example spreadsheet below.

10.1.1 Compile the most recent set of at least 20 Laboratory Control Sample (LCS) results. Enter the results in a Microsoft Excel® spreadsheet in the following format or similar.

10.1.2 Enter the date of data acquisition, the analytical result, and the true value as given by the manufacturer's certificate of analysis.

10.1.3 Enter the formula "= $\frac{result}{TrueValue} \times 100\%$ " in the cells under the heading "Recovery".

10.1.4 In the cells under "Average", enter the formula "*=average(cell1:cellxx)*" where cell1 is the first recovery value and *cellxx* is the xxth recovery value.

10.1.5 In the cells under "Standard Deviation", enter the Excel® formula "*=stdev(cell1:cellxx)*" where cell1 is the first recovery value and *cellxx* is the xxth recovery value.

10.2 The method uncertainty is calculated as plus or minus two times the standard deviation. In this example, the method uncertainty equals ± 2 x 5.3% = ± 10.6%.

10.3 Calculate the limits for a control chart.

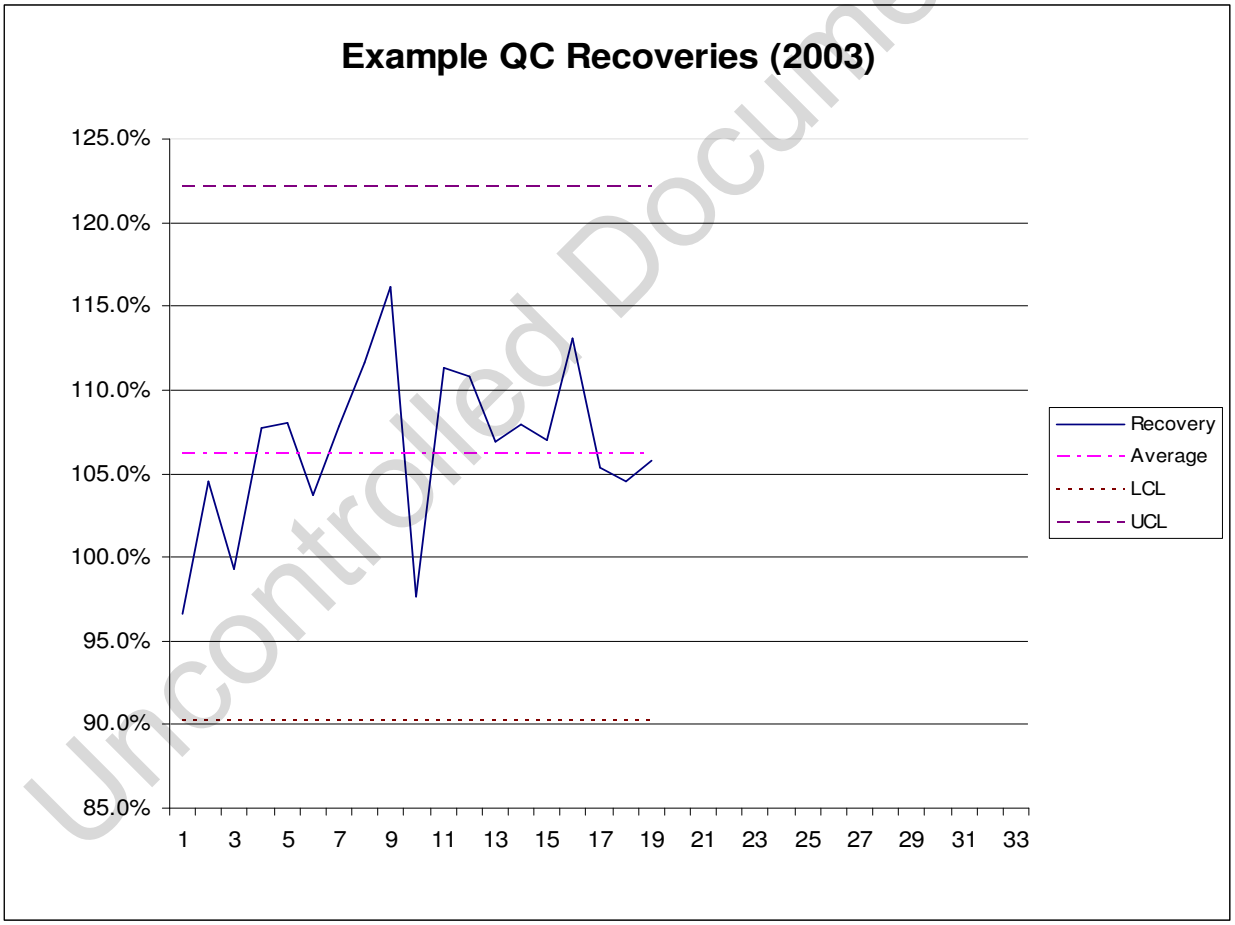
10.3.1 In the cells under "Lower C.L. (Control Limit)", enter the Excel® formula "$=cell_{avg}-(3*cell_{stdev})$" where $cell_{avg}$ is the cell containing the average recovery value and $cell_{stdev}$ is the cell containing the standard deviation value.

10.3.2 In the cells under "Upper C.L. (Control Limit)", enter the Excel® formula "$=cell_{avg}+(3*cell_{stdev})$" where $cell_{avg}$ is the cell holding the average recovery value and $cell_{stdev}$ is the cell containing the standard deviation value.

Date	Result	True Value	Standard Deviation	Recovery	Average	Lower C.L.	Upper C.L.
01/01/03	28.7	29.7	5.3%	96.6%	106.2%	90.3%	122.1%
01/02/03	31.05	29.7	5.3%	104.5%	106.2%	90.3%	122.1%
01/03/03	29.5	29.7	5.3%	99.3%	106.2%	90.3%	122.1%

01/04/03	32	29.7	5.3%	107.7%	106.2%	90.3%	122.1%
01/05/03	32.1	29.7	5.3%	108.1%	106.2%	90.3%	122.1%
01/06/03	30.8	29.7	5.3%	103.7%	106.2%	90.3%	122.1%
01/07/03	32.01	29.7	5.3%	107.8%	106.2%	90.3%	122.1%
etc	etc	Etc	5.3%	etc	106.2%	90.3%	122.1%

10.4 Use Excel® functions to create a line chart that contains the values for "Recovery", "Average", "Lower Control Limit", and "Upper Control Limit". See example.



11.0 Procedure for Using LIMS

11.1 An LCS (Laboratory Control Sample) should be merged with every run. Merge data as normal but the LCS must be labeled "LCS".

11.2 The LIMS will calculate a percent recovery for all LCS samples. The LIMS will also calculate the limits for a control chart.

11.3 Under the Quality Assurance category in the LIMS select the Control Charting option and run the ControlCharting form. There are three tab subforms; “RETRIEVE DATA”, “VIEW DATASET / GRAPH”, and “PLOT GRAPH / UPDATE CHART”.

11.4 In the Retrieve Data tab select the TestCode(s) and Sample Type(s) to be charted. Enter a minimum 20 in the “Num of Points” box, the default is 40 points.

11.5 Click the Get Data button to retrieve the data.

11.6 In the View Dataset / Graph tab select each analyte that needs to be checked. Calculated values for the Warning Limits (□ 2 standard deviations) and Control Limits (□ 3 standard deviations), Average, and Standard Deviation are displayed. To view a graph of the analyte data right-click on it in the analyte list.

11.7 In the Plot Graph / Update Chart tab select the analyte(s) and click the Plot Rec Graph(s) button to print a hardcopy data listing and graph.

12.0 Comments.

12.1 Use the control chart to evaluate the suitability of all LCS data acquired. A data point outside the control limits will be entered and described in the appropriate Quality Control failure logbook. See Corrective Action Procedure for appropriate use of Quality Control failure logbook.

12.2 A separate logbook will be used to record investigations of potential control chart anomalies or trends. Criteria for investigation may include any of the following:

12.2.1 Seven consecutive values above the mean, clearly increasing toward the upper warning limit.

12.2.2 Seven consecutive values below the mean, clearly decreasing toward the lower warning limit.

12.2.3 Two of three consecutive values outside the warning limits.

12.2.4 Nine of ten consecutive values at or outside warning limits on one side of the mean.

13.0 References.

13.1 ISO/IEC17025:2005, “General Requirements for the Competence of Testing and Calibration Laboratories”.

13.2 P103b – Annex: Policy on Estimating Measurement Uncertainty for Life Sciences Testing Labs. A2LA 2010.

Standard Operating Procedure for Determination of Method Detection Limits

1.0 Scope and Application.

1.1 This procedure applies to sample types ranging from reagent water to wastewater to solid samples. Not all analytical methods are amenable to determination of an method detection limit (MDL). The MDL varies as a function of sample matrix and shall be determined for all matrices to be analyzed. It is essential that all sample processing steps of the analytical method be included in the determination of the MDL.

1.2 The MDL obtained by this procedure is used to judge the significance of a single measurement in a future sample.

2.0 Summary.

2.1 A low level standard is processed and analyzed multiple times. The resultant concentrations are statistically evaluated to determine the method detection limit.

3.0 Definitions.

3.1 The method detection limit (MDL) is the minimum concentration of substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

3.2 Interferences are defined as systematic errors in the measured analytical signal of an established procedure caused by the presence of interfering species.

4.0 Considerations.

4.1 The analytical method utilized must be referenced by number or title with the MDL for each analyte.

4.2 Reference the sample matrix with the appropriate reporting units.

5.0 Reagents.

5.1 Reagent water – water in which the analyte and interferent concentrations are not detected at the method detection limit of each analyte of interest

6.0 Calibration and Standardization.

6.1 See appropriate method

7.0 Quality Control.

7.1 Perform a method detection limit study whenever significant changes or repairs are made to the instrumentation or preparation process.

7.2 Where appropriate, a method detection limit study should be performed at least annually on each instrument, or more frequently if required by the reference method followed. Additionally, a study should be performed prior to placing a new instrument into service, whenever a new analyst begins work, and when an instrument has been moved or has had significant repairs.

8.0 Procedure.

8.1 Estimate the detection limit by one of the following:

8.1.1 The concentration value that corresponds to an instrument signal to noise ratio in the range of 2.5 to 5.

8.1.2 The concentration equivalent to three times the standard deviation of replicate instrumental measurements of the analyte in reagent water.

8.1.3 That region of the standard curve where there is a significant change in sensitivity (i.e. a break in the slope of the standard curve).

8.1.4 Instrumental limitations.

8.1.5 Instrument and method knowledge.

8.2 Prepare a laboratory standard in the matrix of interest that is between 2 and 5 times the estimated detection limit.

8.3 Take a minimum of seven aliquots of the standard and process each through the entire analytical method.

8.4 Load the raw analytical result data file into the LIMS Data Input program. Use the method detection limit features by selecting the appropriate results and clicking on the "MDL button". Print and or review your data as needed.

Alternatively, an Excel format may be used to calculate MDLs. In either case, the original raw values obtained, with all significant figures, are used to calculate the MDL. Values for each replicate must not be truncated or rounded prior to calculating the MDL. The final calculated MDL value may be rounded.

Retain all records of MDLs, per IML Control of Records Procedure.

8.5 Enter the new MDL values into the LIMS Sysytem:

8.5.1 From the Main Page click on “Test Information”. From the “Test Information” click on “Tests”. This will bring up a list of tests. Select the appropriate test and then click on the “Limits” tab. Enter the new MDL value by typing the value into the “MDL” column row associated with the correct parameter and units.

8.5.2 This can also be accomplished by moving a spreadsheet of data by clicking the “Update” button on the “Limits” tab. This will bring up a screen asking for a filename and test. Click “Load”. Then review data for acceptability.

8.5.3 The MDLs must be updated to all of the active projects. On the “Limits” tab click on the “Updt Projects”. This will bring up a prompt screen. Click on the check boxes for “TestGroups”, “Projects”, and “MDL”. Then click the “Update” box on the prompt screen. This may take a while if there are many projects associated with a test. An “Update Complete” prompt should follow if this worked.

8.5.4 The new project MDLs must now be validated and checked for a PQL being greater than an MDL. Click on the “Check Projects” button. If a prompt of “Nothing to Report” appears then there are no problems and the process is complete. If a list of issues appears then print the list and show that to your supervisor. The list must not include active projects where the MDL is greater than the PQL.

9.0 Calculation.

8.1 Calculate the variance (S^2 or σ^2) of the replicate measurements as follows:

$$S^2 = \frac{1}{n-1}\left[\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}\right]$$

where x_i; i=1 to n, are the analytical results from the n sample aliquots

8.2 Calculate the standard deviation (S or σ) of the replicate measurements as follows:

$$S = \sqrt{S^2}$$

where S^2 is the variance calculated in Section 8.5

8.3 Calculate the method detection limit (MDL) as follows:

$$MDL = S * T_{(n-1,\ 1-\alpha=0.99)}$$

where :

S = standard deviation of the replicate analyses

$T_{(n-1,\ 1-\alpha=0.99)}$ = student's t-value appropriate for a 99% confidence interval with n-1 degrees of freedom. See Table 1.

10.0 Reporting Method Detection Limit.

10.1 The analytical method used to determine the MDL must be identified by the method name and/or reference number.

10.2 Units appropriate to the matrix must be included.

11.0 Comments.

11.1 The MDL determination may take place over several consecutive or non-consecutive days.

11.2 Individual replicate results may not be excluded.

12.0 References.

12.1 ISO/IEC17025:2005, "General Requirements for the Competence of Testing and Calibration Laboratories".

12.2 Code of Federal Regulations, Title 40, Appendix B to Part 136--Definition and Procedure for the Determination of the Method Detection Limit--Rev. 1.11.

TABLE 1: STUDENT'S T VALUES AT 99 PERCENT CONFIDENCE LEVEL

Number of Replicates	Degrees of Freedom *(n-1)*	t Value
7	6	3.143
8	7	2.998
9	8	2.896
10	9	2.821
11	10	2.764
16	15	2.602
21	20	2.528
26	25	2.485
31	30	2.457

Quality Assurance Official:_____

Lab Official:_____

Date:_____

NIST TRACEABILITY PROCEDURE

Scope:

This procedure describes the method of meeting National Institute of Standards and Technology (NIST) traceability.

Application:

This procedure covers chemicals, standardized and check solutions, standards log books, weights, timers, thermometers, and any other calibration standard or service.

General Requirement:

Whenever feasible, traceability to NIST and the use of an ISO 17025:2005 accredited provider for standards and/or service is required. The certificates for standards and providers shall state traceability to NIST and their accreditation.

Chemicals:

Chemicals that will be used for making standardizing solutions must be ordered from approved vendors (see Subcontracting and Purchasing Procedures). Materials used must be American Chemical Society (ACS) grade or better.

Standardized and Check Solutions:

Standardized and check solutions, must be ordered from a list of approved vendors (see Subcontracting and Purchasing Procedures). Certificates of traceability must be retained.

Expired Chemicals, Standards, and Check Solutions:

Any out of date chemicals, standards, and check solutions may be retained for an undetermined amount of time; however, containers must be clearly labeled with bright orange labels with the word “expired” visible.

Standards Log Books:

Standards Log Books shall be maintained for the purposes of tracking lot numbers, dates of use, and expiration dates for calibration and check solutions. Every time a calibrating solution or check solution is put into use, the lot number, date of preparation, initials of preparer, and solution expiration date must be recorded in the standards log book.

Weights:

Weights are used to establish NIST traceability. Weights must be handled with non-metal forceps or tweezers, and/or cotton or equivalent gloves. Skin or other substances must not be allowed to come in physical contact with weights. Weights should be gently cleaned with camel hair brushes or lint free wipes to remove dust particles. Every five years weights will be sent to a NIST traceable facility for recalibration, or new weights with NIST traceability will be obtained. The Quality Manager is responsible for scheduling and arranging for calibration (or replacement) of weights in the analytical labs; in the Gravimetric Labs, these duties are assumed by the Laboratory Supervisor. Certification records will be maintained in the laboratory of use by the Laboratory Supervisor.

Timers:

Timers for quality critical activities need to be NIST traceable. Where timing activity is determined to be critical, a NIST traceable timer will be used. If the Laboratory Supervisor determines that a timer needs to be traceable to NIST, a timer with a NIST traceable certificate will be obtained. Such timers need to be recertified every year. Because recertifying a timer is usually cost prohibitive, new timers with traceability certificates will be obtained on a yearly basis. Certificates of traceability will be kept at the laboratory of use by the Laboratory Supervisor.

Thermometers:

Thermometers are used to record temperatures. Thermometers need to be NIST traceable. Original NIST traceability certificates will be obtained and kept at the facility of use by the Laboratory Supervisor. If the traceability certificate does not include a calibration report that includes checks at temperatures that bracket the range of use in the laboratory, the thermometer must be checked against NIST traceable thermometers, which bracket the range of use, prior to placement in service. Each lab will have appropriate traceable thermometers. Dial thermometers, such as meat thermometers, will be tested quarterly against an appropriate traceable thermometer. Digital thermometers and thermocouples will be obtained with certificates of traceability and will be replaced prior to dates of expiration. Infrared thermometers will be verified semi-annually, using a NIST traceable thermometer, over the full range of use. Other types of thermometers, such as classic mercury thermometers, will be calibrated yearly against an appropriate traceable thermometer. These traceable reference thermometers used in annual calibrations must either be recalibrated, or purchased new, at least every five years. The Quality Manager is responsible for scheduling and arranging for annual calibration checks and purchasing of traceable reference thermometers in the analytical labs; in the Gravimetric Labs, these duties are assumed by the Laboratory Supervisor.

Traceability can be maintained on some thermometers by performing an ice point calibration. Logs of thermometers, certificates of traceability, and ice point calibration logs will be maintained under the direction of the Laboratory Supervisor.

Ice point calibrations are performed by immersing a classic mercury thermometer in a de-ionized ice water bath for fifteen minutes, then observing the reading. Forty-eight hours prior to testing, the thermometer should be rested at room temperature. Crushed ice is prepared from de-ionized water. A small amount of de-ionized water is added to the ice, to form a slush. The slush is allowed to sit for 15 minutes in an insulating container, such as a Styrofoam cup. Excess water is poured off and more ice is added, to make a thick slush. The thermometer is immersed to the level appropriate for the thermometer type for 15 minutes. Successive readings are obtained at one-minute intervals until the readings remain constant. When the readings remain constant, they are recorded in a calibration log book.

Approvals:

_____
Quality Assurance Official Date

_____
Laboratory Official Date

Standard Operating Procedure for Definition and Handling of Outside Activities

Scope and Application.

This procedure applies to all employees of Inter-Mountain Laboratories, their divisions, affiliates, and subsidiaries (collectively referred to herein as IML).

Summary.

IML is committed to the adherence to ethical, moral, and legal standards in the conduct of its business. Clients' confidence in IML's competence, impartiality, judgment, or integrity may be diminished by improper employee activities. The guidelines contained in this document serve to assist the individual in making decisions in the course of their everyday activities.

Definitions.

Activities that diminish clients' confidence in IML's competence, impartiality, judgment, or integrity are those to be avoided. The reputation and profitability of IML depend on the actions of each employee.

Procedure.

General guidance.

This document does not – and cannot – cover all situations. The guidelines should be interpreted in conjunction with specific IML policies and good common sense. Additionally, activities that **appear** to be improper must be avoided.

If there are any questions regarding a specific situation, employees are encouraged to discuss the matter with a member of senior management. Any suspected violations shall be reported to senior management. Every effort will be made to protect confidentiality, to insure questions are answered, and to address concerns promptly.

Employees shall avoid any situation where their objectivity may reasonably be questioned due to individual interests or personal or family relationships. At times, an employee may inadvertently find themselves in such a situation. In the event of such a situation, employees shall notify a member of senior management immediately.

Employees shall not give or release confidential data or information concerning IML to anyone not employed by IML without proper authorization.

IML acquires and keeps business because of the quality of its services and goods. IML does not give unethical or illegal rebates, kickbacks, or other improper favors to customers or their representatives.

Potential conflict of interest.

Employees who own, directly or indirectly, any interest in companies doing business with IML, must disclose such information promptly and in writing to IML's Vice President. Ownership of publicly traded securities is not reportable, unless the ownership interest could reasonably give rise to a conflict of interest.

An employee must report the fact that a family member is employed with an entity doing, or seeking to do business, with IML if the employee is in a position to recommend or determine if IML will do business with the family member's employer. This information shall be forwarded to IML's Vice President. The disclosure of such information will not preclude IML from doing business with such an outside entity, but may require that work assignments be shifted or additional approvals be obtained prior to doing business with the outside entity so as to avoid any conflict of interest or the appearances of impropriety.

Potential interference with performance of work.

Employees shall avoid outside employment or activities if the activity reduces work efficiency, interferes with the employee's ability to act conscientiously in the best interest of IML, requires the use of proprietary, confidential or other non-public information, procedures, plans or techniques of IML or otherwise creates the appearance of impropriety.

Personal use of company property.

Excessive, non-routine, and/or expensive use of IML property for purposes unrelated to IML business is not permitted. Employees may occasionally use IML property such as telephones, computers or photocopiers for personal reasons. IML's tools, equipment, or machines may not be used for personal purposes. IML property may be used to participate in legitimate charitable or non-profit purposes only with prior written approval of the President or Vice President.

Boundaries between work and outside activities.

Employees work for and are compensated by IML for their time. IML employees may not be asked or required to perform work not related to IML business during their working hours. IML employees may participate in legitimate charitable, non-profit, or educational activities with prior written approval of the President or Vice President.

Dealing with suppliers.

Clients who want to do business, or continue to do business, with IML must understand that all purchases by IML will be made on the basis of price, quality, service, and suitability to IML's needs.

Reciprocity will not be allowed. Suppliers will not be asked to buy goods or services from IML, an IML employee or his/her family, or to donate money, goods, or services to a school, charity or non-profit organization in order to become or continue to be a supplier.

Employees or their families must not seek nor accept any type of payment, kickback, or rebate related to or based upon IML's purchase or sale of goods or services.

Gifts and entertainment.

It is common business practice to offer or accept certain courtesies, usually meals and entertainment. Employees may not accept or offer any gift or entertainment if someone would believe that the gift or entertainment obligates the employee or IML to do business with that person or company. Questions regarding propriety of acceptance of a particular gift should be raised with senior management.

Gifts include merchandise, products, personal services, and tickets to sporting or cultural events. Employees must not solicit gifts, gratuities, or any type of personal benefit or favor. Employees are prohibited from accepting gifts of money. Employees may accept unsolicited gifts having a value less than $250.00. Gifts of greater value must be reported to senior management.

Employees are prohibited from soliciting entertainment from any company or person doing, or attempting to do, business with IML. IML will not do business with companies or persons soliciting entertainment from IML or its employees. Entertainment includes, but is not limited to, meals, golf outings, out of town trips, and sporting events. Entertainment involving recreational travel must be approved by the Vice President.

Participation in political affairs.

Employees are encouraged to be active in governmental and political affairs on their own behalf. Only a member of senior management or a designee may act or speak on behalf of IML.

Consequences of inappropriate activities.

Employees shall immediately report violations to senior management. Violations may result in disciplinary action ranging from oral reprimand to termination. In addition to disciplinary action taken by IML, some violations may require restitution and may lead to civil or criminal action against the person(s) involved.

References.

ISO/IEC17025:2005, "General Requirements for the Competence of Testing and Calibration Laboratories".

Quality Assurance Official:_____

Laboratory Official:_____

Date:_____

PREVENTIVE ACTION PROCEDURE

Scope:
This procedure identifies the procedures, policies, and authorities for preventive actions.

Application:
Preventive actions are initiated by strategic planning sessions, staff suggestions, review of laboratory activities, investigation of industry trends, changes in regulatory requirements, information from vendors, discussions with clients, internal and external audits, management reviews, and other sources. Although primarily addressed through the Corrective Action process, preventive actions may be initiated as a result of a complaint from customers, service providers, employees or other parties. Preventive actions require initiation, action, monitoring, and closure.

Definition:
Preventive actions are needed improvements in the technical or quality systems to eliminate potential nonconformances. Preventive actions are not responses to existing problems but rather positive actions to improve future performance. Preventive actions are initiated by management.

Procedure:
The "Preventive Action Request" form is used to assist in the development of action plans:

1) Initiate a preventive action by filling out the top section of the form. Describe how the actions were identified as being needed and what in general is planned.
2) Describe in more detail what is planned in the next section of the form. Detail each separate action and planned completion date
3) Monitoring and measurement of the preventive action may be needed to ensure that the preventive action was effective. These measurement and monitoring activities should list the planned activities and the dates of completion for these activities.
4) An evaluation of effectiveness should be recorded whenever a monitoring has been performed. This can be recorded in the "Effectiveness Evaluation" section.
5) A manager will review the form, the preventive actions, the monitoring, the measurement, and the effectiveness. This review is recorded by placing a signature and date on the form. The preventive action is then considered closed.
6) A manager may abandon a plan at any time by writing "abandoned" with initials, date and reason for abandonment.

Approvals:

_____

Tom Patten Date
Laboratory Manager

_____

Michelle LaGory Date
Quality Manager

Proficiency Testing Procedure

1.0 Scope and Application

1.1 This procedure is applicable to the analyzing, submitting, record keeping, and scheduling of proficiency testing. Laboratory sections participate in appropriate proficiency test studies when they are available, at intervals required by accreditation programs.

2.0 Scheduling

2.1 The Quality Manager will schedule proficiency testing to ensure compliance with the programs in which the laboratory is involved.

2.2 For most accreditation programs, successive Proficiency Test (PT) samples are analyzed at least five months apart and no more than seven months apart unless the PT is being used for corrective action to reestablish successful history to maintain or reinstate accreditation. In that case, the dates of successive PT samples for the same accreditation Field of Proficiency Testing must be at least fifteen days apart.

2.3 EPA certification requires successful analyses of accredited parameters on an annual basis.

3.0 Analyzing

3.1 Proficiency test samples are logged into LIMS and labeled with LIMS IDs following receipt, and sample handling is as close to that of customer samples as possible.

3.1.1 Samples may be received as full volume (ready to analyze, requiring no dilution), or as concentrate in vials or sealed ampoules. Due to the assortment of container types, PT samples are not "mainstreamed" with other lab samples, but stored together with other samples from the same study, in a manner to protect from breakage or loss.

3.1.1.1 Water Lab: Samples are held together at >0 to ≤6°C in a labeled container in the walk-in cooler until use.

3.2 An appropriately-trained and authorized analyst or backup analyst will perform the proficiency test or tests according to normal laboratory procedures.

3.3 The analyst or a backup analyst will follow the proficiency test provider's recommendations for performing the analytical test as applicable.

3.3.1 The analyst will acknowledge that they have read any preparation and handling instructions provided by manufacturer by signing and dating instructions. The signed instructions will be retained as a record of review.

3.3.2 If sample must be prepared from a concentrate, the analyst will follow prep instructions from manufacturer as written, recording the volume of concentrated sample used, the type of diluent used, and the final dilution volume, as well as any other relevant information related to sample handling. This record will be made on the instruction sheet provided by the manufacturer and will be retained with the data packet.

3.4 Any dilution factors that have been applied to proficiency test samples will be recorded on the original data worksheet.

3.5 The PT samples must be analyzed as regular samples in an analytical batch. It is allowable to run duplicates and matrix spikes on the PT samples. It is not allowable to run the PT samples as a statistical study in an analytical batch. Samples may be analyzed multiple times however, as part of an investigation related to corrective action.

3.6 PT sample analysis for accreditation purposes may not be subcontracted to another laboratory.

3.7 Lab personnel must not attempt to obtain values of PT samples from other laboratories or from the provider prior to the close of a study.

3.8 As with customer samples, occasionally a lab mishap (e.g., spills, error in prep from concentrate, etc.) may occur that would potentially compromise or call data quality into question. In these instances, the analyst should bring

the issue to the attention of their supervisor or Quality Manager. Additional sample may be requested if applicable.

4.0 Submitting Results

4.1 The Lab Manager, QA Officer, Assistant Lab Manager, Section Supervisor, or any appropriate manager will submit the proficiency test results to the provider.

4.2 The results of the proficiency test shall be reviewed by the person submitting the results.

4.3 Data review is completed following guidance in IML Report Generation Procedure.

4.3.1 As mentioned in the “Scheduling” section of this procedure, analysis dates for reported results must be separated by a minimum of five months and maximum of seven months between studies.

4.4 The individual or individuals submitting the proficiency test should follow the provider’s recommendations for submittal.

4.4.1 Though not a requirement, direct data upload from LIMS to the provider’s website (when available) is preferable, in order to prevent transcription errors.

4.5 Results are submitted directly to the accrediting/certification body by the provider, or by the laboratory in circumstances where this is permitted and appropriate.

5.0 Corrective Action

5.1 Unacceptable results will be followed promptly by a cause analysis and appropriate corrective action.

5.1.1 EPA SDWA regulated VOCs “80% Rule”:

5.1.1.1 The lab must successfully analyze Vinyl Chloride.

5.1.1.2 The lab must successfully analyze 80% of 20 other regulated VOCs.

5.1.1.3 The lab must successfully analyze 100% of the four regulated trihalomethanes.

5.1.1.4 The lab must successfully analyze 80% of the five regulated HAA5s.

5.2 Remedial action for analytes within the laboratory's scopes of accreditation or certification will include enrolling in the next available round of proficiency testing for the failed analyte(s).

5.3 The lab must maintain a history of at least two successful performances of the most recent three attempts for each accredited PT parameter analyzed.

5.4 Related corrective action responses, including cause analysis, for analytes within the Wyoming Storage Tank Remediation program will be forwarded to A2LA in a timely manner.

6.0 Record Keeping

6.1 The proficiency test submittal, data sheets and provider's final results should be filed together in the appropriate laboratory facility.

7.0 Summary of Changes from Previous Version 1.6, revised 6/9/16.

7.1 Section 2: Moved "Scheduling" Section (Sec. 2) from end of document. Changed "QA Officer" to "Quality Manager" at Section 2.1. New information added at Sections 2.2 and 2.3.

7.2 Section 3:

7.2.1 Added requirement to prep per manufacturer instruction at Section 3.3.2.

7.2.2 Section 3.5: Changed statement from "…samples will be analyzed as regular samples…" to "…samples must be…" Added statement

that sample may be analyzed multiple times as part of a corrective action investigation at Section 3.5.

7.2.3 Added requirements at Sections 3.6, and 3.7.

7.2.4 Added statement at Section 3.8 regarding lab mishaps.

7.3 Section 4:

7.3.1 Added statement at Section 4.3.1.

7.3.2 Added phrase “in circumstances…” at Section 4.5.

Approvals:

_____

Laboratory Manager Date

_____

Quality Manager Date

PURCHASING/SUBCONTRACTING PROCEDURE

Scope:
This procedure describes procedures for subcontracting of analytical testing and purchasing service and supplies.

Application:

This procedure identifies two procedures. One procedure is followed for subcontracting. Another procedure is followed for purchasing service and supplies.

Procedure:

Subcontracting:

Subcontracting is separated into three categories: general subcontracting, specified subcontracting, and certified subcontracting. The purchasing department maintains a list of preferred subcontractors. Subcontractors are chosen on the basis of logistics, performance, and ability. The Laboratory Manager or Quality Manager is responsible for review and approval of subcontracted laboratories. The Purchase Requisition form for all subcontracted analyses must be reviewed and signed ("Department Technical Review") by the Lab Manager, Quality Manager, or Technical Supervisor prior to subcontracting.

General Subcontracting:

General subcontracting is the procedure used when a customer or project requires analytical test work be subcontracted and the customer or project does not require the work be produced from a certified or specified laboratory. Whenever a laboratory subcontracts, the customer is informed of the intent to subcontract. This can be performed by facsimile, email, or letter. Permission is gained to ensure the work performed meets the requirements of the customer. (At this point the customer may designate specific laboratories or specific certification requirements. If either of these happens the appropriate procedure will be initiated.) When the laboratory gains approval from the customer for the subcontracted work, the laboratory sends the work to the subcontractor. The information from the subcontracted

laboratory is gathered and reported back to the customer as per the Report Generation Procedure.

Specified Subcontracting:

Specified subcontracting is the procedure used when a customer specifies subcontractors. Whenever a laboratory subcontracts, the customer is informed of the intent to subcontract to the specified subcontractor. This can be performed by facsimile, email, or letter. Permission is gained to ensure the work performed meets the requirements of the customer. When the laboratory gains approval from the customer for the subcontracted work, the laboratory sends the work to the subcontractor. The information from the subcontracted laboratory is gathered and reported back to the customer as per the Report Generation Procedure.

Certified Subcontracting:

Certified subcontracting is the procedure used when a customer or project requires accredited/certified/licensed analyses. The Quality Assurance Manager or Lab Manager investigates different laboratories to ensure they meet customer certification requirements. The Quality Assurance Manager or Lab Manager then confirms the certifications by obtaining certification documents from the subcontractor and reviewing these documents. Whenever certified subcontracting is necessary, the customer is informed of the intent to subcontract. This can be performed by facsimile, email, or letter. Permission is gained to ensure the work performed meets the requirements of the customer. When the laboratory gains approval from the customer for the subcontracted work, the laboratory sends the work to the subcontractor. The information from the subcontracted laboratory is gathered and reported back to the customer as per the Report Generation Procedure.

Service and Supplies:

IML uses approved vendors, certificates of analyses, and NIST Traceable certifications to control quality critical materials and service. Quality critical materials and service fall into three categories: chemicals, measurement devices, and services. Chemicals which are considered quality critical are reagents and standards used to make calibration standards. When possible, standards are purchased that conform to ISO Guide 34. Measurement devices which are quality critical include, pipettes, syringes, volumetric flasks, graduated cylinders, thermometers, timing devices, and other measurement devices. Services that are quality critical include gas supply, de-ionized water supply, instrument repair, and calibration service.

Vendors and service providers are selected based upon historically-provided quality of service or supply; new vendors are selected based on collection of sufficient evidence of ability to provide required quality of service or supply necessary. New vendors are approved by Lab Manager, Quality Manager or Section Supervisor following sufficient review of quality of goods and services has been performed. Records of this review are maintained on file in the Quality Manager's office.

Purchasing:

The laboratories maintain a list of approved suppliers. The laboratory supervisor can remove a vendor from approval.

1) Designated individuals in sections track inventory of supplies on an ongoing basis, identify needs to replenish inventory, and submit requests for purchase to the local purchasing agent.
2) The local purchasing agent will then generate a Purchase Requisition (PR). The PR must include:
    a) Vendor name
    b) Vendor address (if a new vendor)
    c) Vendor phone number (if a new vendor)
    d) Date (of purchase request)
    e) Date needed, if need is urgent. Note this in "Comments Section".
    f) Quantity needed
    g) Unit of measure (e.g., "cs" for case, "pk" for pack, or "ea" for each.
    h) Item number (Catalog/Part number)
    i) Item description, noting grade, type or class necessary
    j) Unit price and extended price
    k) Any special instructions/considerations are noted in the "Comments" section.
    l) If need is urgent, this should be noted in the "Comments" section; otherwise, shipment will be Ground.
    m) Department (Laboratory Section: Organics, Water, Admin, etc.).
    n) "Purchase Requested By" is for the person requesting the order.
3) Purchasing agent must submit the PR to the Section Supervisor for technical review related to quality of items or services ordered; the Section Supervisor indicates approval for technical content by signing. In addition, the purchasing agent must obtain signature approval for purchase from the Lab Manager or Deputy Lab Manager. At this time, a copy may be made for the Purchasing Agent's use.
4) Purchasing agent then emails or delivers a copy of the approved PR to Corporate Purchasing Agent.
5) Corporate Purchasing Agent reviews the PR for completeness and accuracy.

6) Any order over $1000 or unusual in nature must be submitted to a Corporate Officer for approval.
7) Corporate Purchasing Agent then prepares the Purchase Order (PO) and places the order.
8) If a problem arises during placement of the order, every attempt will be made to resolve the problem with the vendor. If the problem cannot be resolved, the PR will be returned to the purchasing agent for corrections.
9) The vendor will be asked to provide an order confirmation and delivery date.
10) After the order is placed, the PO will be sent back to the local purchasing agent.
11) Any changes that need to be made to the local data base (i.e. catalog numbers, prices, etc.) will be made at this time. It will also be noted if the order could not be placed, or if any corrections need to be made. Backorders will also be clearly noted on the PO.

Special Consideration for Purchase of Radioactive Standards and Sources

A separate Purchase Request form is used for the purchase of radioactive materials. This form requires the signature of a Radiation Safety Officer (RSO) in addition to the signature of the Laboratory Manager. The form also directs that the order be sent to the attention of an RSO. When ordering radioactive materials, the Radiation Safety Officer (RSO) must be given a copy of the purchase request in order to ensure that IML does not exceed NRC licensing limits.

Receipt of supplies:

1) As the items are received at the laboratories, personnel who sign for them perform a visual inspection of the shipping container.
2) If the shipping container is visibly damaged, it should be opened, and its contents inspected for damage prior to accepting delivery.
3) The individual requesting the supplies, or the appropriate section supervisor, will be contacted to inspect contents. Inspection includes comparing package contents against the packing slip and purchase order, and inspecting integrity of contents.
4) Any issues discovered must be communicated to the Corporate Purchasing Agent for resolution with the shipper or vendor.
5) If the items are satisfactory, the packing slip is signed, dated, and copied. Original packing slips are forwarded to HQ daily. The signature on the packing slip serves as an evaluation of the supplier, i.e., that the supplier has shipped the materials ordered, and that the materials are of the appropriate quality for use by the laboratory.

6) A copy of the packing slip is retained and attached to the PO at the location from which items were requested.
7) If no packing slip is found in the shipment, a copy of the PO should be signed, dated, and noted “No packing slip received.”, then forwarded to HQ in place of the packing slip.
8) Items are removed from the package, packing materials are discarded after ensuring that all items have been removed, then the shipping container is properly disposed of.
9) Once the packing slip, PO and invoice have been matched up, payment will be scheduled.
10) Payment will be made from the Accounting Department.

The Office Manager resolves problems as they arise. Inter-Mountain Laboratories, Inc. may demand corrective and preventive actions from suppliers when problems occur that could affect a laboratory’s ability to provide quality service.

Special Consideration for Receipt of Packages Containing Radioactive Standards and Sources:

If a package labeled as "Radioactive" appears to be damaged, immediately contact an RSO. Ask the carrier to remain at the facility until it can be determined that neither the carrier nor the vehicle is contaminated.

Any package containing radiochemistry standards or sources shall only be received by an RSO or an authorized user. After placing the item in the radiochemistry standards cabinet, the RSO will ensure that the inventory list is updated appropriately.

The RSO must retain a copy of the packing slip to document receipt of the radioactive material.

Quality Reception:

Where appropriate (e.g., standards, reagents, dry chemical), "Received" and the receipt date are written on the item prior to placing in storage.

Refrigerators, freezers, chemical storage areas, gas cylinder chains, flammable storage cabinets, and other storage areas are available for appropriate storage of supplies.

To assure quality of reagents, a method blank for every analytical method shall be performed whenever possible. To assure quality of sample containers, bottle blanks and LCSs are analyzed for possible negative or positive bias prior to placing a new type of sample container into service.

The laboratories require calibration certificates for calibration solutions. Whenever available these certificates shall contain NIST traceability. These and other certificates of traceability are retained in the laboratory area of use. Hence ICP standards certificates are kept in the same room as the ICP Standards. The laboratories shall use calibration and reagent logs to trace lot numbers to sample batches as detailed in the NIST Traceability Procedure.

Quality Storage:

In order to assure quality of storage, the manufacturer's recommendations on the containers and accompanying instructions are examined before storage. These recommendations are followed. In the event there is no guidance on storage with the shipment, the MSDS is examined for appropriate storage. As chemicals can be hazardous, the IML Safety Plan, which contains the Chemical Hygiene Plan, is used for guidance on safety.

Care should be taken to store standards in a location separate from samples. Two refrigerators are available for storage of standards in the water lab. For volatile organic standards in the organics lab, place these in the "Standards Only" refrigerator, "STD 1", except when this is contrary to manufacturer's recommendations.

Approvals:

_____

Michael Boint Date
Secretary/Treasurer

_____

Tom Patten Date
Laboratory Manager

REPORT GENERATION PROCEDURE

Scope:
This procedure describes the procedures and policies for reporting data generated by Water, Trace Metals, Soils, Radiochemistry, and Organics Labs.

Application:
This procedure identifies the steps necessary for reporting results. The steps are data generation, method deviation, data reduction and validation, report creation and review, report revision, report amendments, data review, and approval.

Data Generation:
Data are generated at instruments and measurement devices by Technicians, Analysts, Technical Supervisors, and Laboratory Supervisors. At the time of generation, data are reviewed for calibrations, dilutions, quality checks, instrument malfunctions, and method requirements. If an instrument fails on an LCS, a corrective action is taken and recorded in the QC failure log (see corrective action procedure). Each section supervisor or a management appointed representative shall review data from each section for quality control criteria specific to each method. This review will include checks for data integrity, ensuring proper form of error correction, using single strike-through, date, and initials of person making correction. A record of review will be indicated for every batch of data produced with at minimum initials and a date.

Data are approved for review by placing the data sheets in the “client file” or stapling data sheets to data packs. If data do not meet methodology requirements, the data approved for review will contain notes on deficiencies. Samples failing methodology requirements are sometimes reanalyzed. If a second analysis is acceptable, the analysis is approved for use. If the second analysis does not meet methodology requirements, the Laboratory Supervisor or Technical Supervisor is contacted and a decision on whether to continue is determined.

If it is determined that reportable data cannot be generated, the customer is contacted immediately. The customer is contacted by the Laboratory Supervisor, Laboratory Manager, or Technical Supervisor. Data that do not meet QC criteria may be reported with qualifiers if approved by the client. If it is determined that acceptable data can be generated, the samples are reanalyzed until reportable data have been generated.

Method Deviation:
Methods sometimes are deviated from due to particularities of samples or other reasons. If a method is deviated from this must be recorded in a systematic way. Before deviating from a method, the deviation must be technically justified. A Laboratory Supervisor must technically justify the deviation. The Laboratory

Supervisor must obtain objective evidence which technically justifies the method deviation. The Laboratory Supervisor must then attach the technical justification evidence to the client file. The method deviation must be approved by the customer. The Laboratory Supervisor contacts the customer and asks for permission to deviate from the method. The Laboratory Supervisor must obtain written approval from the customer to perform a method deviation. Typically, approval will be in the form of a fax, email, or letter. The Laboratory Supervisor approves the method deviation by writing “method deviation approved” with signature and date on the fax, email, or letter indicating customer approval. This approval is then attached to the customer file. The analyst records the deviation on original observation sheets, run printouts, or another appropriate log. The record will be a handwritten description labeled “Method Deviation”. To record the event, describe which samples were affected by the deviation, why a deviation occurred, how the deviation was conducted, also initial and date the description of the event. If there is not enough room to describe the event on the original observation sheet, attach a description to the original observation sheet with staples. The deviation can then be noted in the final report.

Modifications made to methods used in analysis of non-potable water compliance samples must follow guidance within 40 CFR Part 136.6 for establishing method equivalency. The underlying chemistry and the determinative technique must remain basically the same to be considered a modification rather than a deviation. Sufficient records must be maintained by the lab demonstrating that performance of the modified method is equivalent to that of the approved method. Necessary performance checks must be completed prior to the issuance of data obtained by the modified method. Records of the demonstration must be retained in a form that is readily available and easily retrievable. Details of the method modification must be included in the laboratory SOP.

Any change in the method chemistry or in the determinative step of analysis is considered a method deviation. A method modification or deviation may not be used in analysis of drinking water compliance samples without approval from the regulatory agency.

Data Reduction and Validation:
Data are entered into the LIMS system, either manually from bench sheets or by merging an electronic file directly from an instrument. All digits that will import from instrument measurements are merged directly into the LIMS. Data acquisition is automated as much as possible to avoid data transcription errors.

Data are reduced to reportable quantities and units by calculations performed by instrument software, by calculations programmed into the LIMS, and/or by trained technicians as prescribed by the appropriate approved methods. The use of calculations programmed into the LIMS minimizes error and ensures that calculations are performed consistently. Calculations used are given in the individual analytical lab SOPs.

Verified and locked Excel spreadsheets may be used in the laboratory. After creation of an Excel spreadsheet, review format for necessary information, verify calculations, and document verification. Select each cell or group of cells that you would like to remain unlocked for data entry. On the “Home” tab in the “Cells” group, click “Format”, then “Format Cells”. On “Protection” tab, clear the “Locked” checkbox, and then click “OK”. Do this for each cell or group of cells that require data entry. On “Review” tab, in “Changes” group, click “Protect Sheet”. In “Allow all users of this worksheet to” list, ensure that “Select unlocked cells” is checked, and “Select locked cells” is deselected. In “Password to Unprotect Sheet” box, type a password for sheet, then click “OK” button, and retype password to confirm. Verify Excel spreadsheet is locked by trying to enter data. Document locked status. Locked and validated spreadsheets are approved for use and controlled by the supervisor of each lab section. Send a copy of verified locked spreadsheet to Quality Manager for preservation of official version of spreadsheet, and addition to Master Document list.

Software creation and validation, as well as checks of calculations, are described in greater detail in the IT Procedures SOP.

Data entry is an important step in the data validation process because the data are reviewed at this point to determine compliance with acceptance criteria. After the data have been entered into LIMS, the technician reviews that the appropriate value is associated with the appropriate sample. This review is recorded in the LIMS system with a required electronic password signaling QA review.

Report Creation and Review:
A report is generated from LIMS. Each report is assigned a unique eleven-character ReportID. The reports contains a title; name and address of the laboratory; unique identifier of the report; the name and addresses of the customer; page numbering that indicates the place of each page in the whole, e.g., "Page 2 of 5"; unique sample identifiers; date of sample receipt; methods utilized to generate results; dates of analysis; identification of the parameters; analytical results with units of measure; and the name and function of the authorizer. The report may have attachments such as copies of the Chain of Custody, case narrative statements, cover sheets, or a Condition of Receipt form. The report flags deviations or non-conformities from standard methods. The report may contain references to sampling plans or other documents. Reports contain the statement “These results apply only to the samples tested”. After the report is prepared, the data are reviewed for appropriateness of the contents. Each section preparing reports has a series of review criteria they look at other than typical QC criteria. Below is a listing of some examples.

Section	Criteria
Metals	Dissolved value is less than Total value, or ±20% RPD of Total value, as if it were a duplicate

Organics Peaks with computer-generated flags are reviewed for appropriate identification of compounds

RadChem Positive Ra^{226} values are either historically or in-growth confirmed

Water BOD is less than COD
A cation-anion balance is performed as per SM1030E
The sum of Nitrate +Nitrite is more than Nitrite (NO_2)
WAD cyanide is less than total cyanide
Ammonia value is less than TKN
An automated QC check for correctness of results is performed in the LIMS.

Soil Carbonate valuesX10 is within +/- 20% of NP
Total carbon is larger than organic carbon
Total sulfur is larger than acid washed or water washed sulfur
SAR is similar in magnitude to ESP
CEC is less than the clay %
Sum of cations/10 is approximately equal to EC except when over 5
Lower pH should translate to a lower NP
Hot water Se is less than AB-DTPA Se, which is less than Total Se
Sum of exchangeable cations is approximately equal to CEC

All lab sections
When analytical results for a sample are available by more than one technology (e.g., toluene by GC and GC/MS), results may be compared as duplicate analyses; if results do not meet method criteria for duplicate analyses, samples should be reanalyzed to verify results.

Report review is critical for interpretation and accuracy of data. The reviewer of the report notes needed changes on the report. The changes are made and a new report is produced. The report is reviewed by two representatives when labor allocation makes this possible; otherwise there is one reviewer. A Report Review Checklist is used in the water lab, to ensure thoroughness of review and completeness of the final report, including the description of any anomalies in the Case Narrative. The report is approved by signing the final report. Personnel must be authorized to issue reports, as described in the Training Procedure.

Reporting:
Customers require reports in a variety of formats such as fax, email, electronic transmission, traditional mailing, or customer generated forms. Customers' reporting needs are met whenever possible. In some instances, IML may be instructed to send a customer's report directly to the regulatory agency. A list of these customers is maintained by the appropriate Project Manager. All electronic transmissions shall contain the following statement "The contents of this electronic transmission and any attachments may contain confidential and/or proprietary information, and is intended only for the person/entity to whom it was

originally addressed. Any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this electronic transmission in error please notify the sender immediately and destroy this message and any attachments from your system." or similar language. Reports are primarily generated in electronic form, unless the customer has specifically requested that a hardcopy be sent. Unless specified by the customer, electronic data shall be sent in a format that does not easily allow modifications; such as Adobe Acrobat PDF format. An email delivery receipt is requested when the report is emailed.

Analytical reports of data generated for clients from the state of Nevada must be issued from the main lab at 1673 Terra Avenue.

Amendments to Reports:

A supplemental report may be issued if a customer requests additional analyses of samples that have previously been analyzed and reported, particularly when a request is made awhile after the original report has been issued. A supplemental report may be issued if the report is not used to correct errors in an original report. When a report needs to be amended, the following procedure is performed. A new Work Order is created in the LIMS, logged with newly requested parameters. . The amended report is prepared as a supplement to the original report, with the statement "Supplement to (original ReportID)" added to the "Project" field in the LIMS. The amended report is then reported as detailed in this procedure under "Report Generation and Review" and "Reporting".

Revising Reports

If a report needs to be revised due to erroneous results, needed corrections, or amendments that require a complete new test report, the following procedure is performed. A revised report is created as detailed in this procedure under "Report Creation Review". The revised report is prepared with all amendments and corrections, and is issued a new ReportID. The revised report is prepared as a replacement report. The revised report is prepared with an acknowledgement of the previous report. A brief explanation of the reason for the reissue of the report is included in the Case Narrative, stating which analyses and samples are affected where applicable. The revised report is prepared with the statement "Replaces (previous ReportID)". A revised report differs from a supplemental report, or report amendment, in that the revision is a replacement for the original report; a supplemental report is issued in addition to the original report. A revised report is reported as detailed in this procedure under "Reporting".

Approvals:

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Quality Assurance Official Date

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Laboratory Official Date

REPORT GENERATION PROCEDURE FOR GRAVIMETRIC LABORATORY

Scope:
Gravimetric Laboratory procedures and policies for reporting results.

Application:
This procedure identifies the steps necessary for reporting results. The steps are data generation and review, report creation, report revision, report amendments, report review, and approval.

Data Generation:
In the Gravimetric Laboratory, management of data is handled primarily by a combination of a specialized laboratory information system and a custom (proprietary) Data Management System (DMS). Data are stored and tracked by an eight digit sample identification number taken from the PTFE filter to uniquely identify each filter. For the gravimetric laboratory all sample data are entered into the database electronically through serial interfaces and bar coded information. Data are generated at the analytical balances by Technicians, Analysts, and Laboratory Supervisors. At the time of generation, data are reviewed for quality checks, instrument malfunctions, and method requirements. Determination of mass collected on the filter (net mass) is calculated by subtracting the tare (initial) mass from the final mass in mg. No rounding occurs on the masses all three decimal places are reported. Data are printed out and reviewed once more for quality checks, method requirements and completeness. Data are approved by the technician initialing the first page of the printout. A second review from an independent technician must be performed. During the weigh session if a working mass standard fails the session is stopped and corrective action is taken and recorded in the QC failure log. (see corrective action procedure).

If it is determined that reportable data cannot be generated, the customer is contacted immediately. The customer is contacted by the Laboratory Supervisor, Laboratory Manager, or Technical Supervisor. Data that do not meet QC criteria may be reported with qualifiers if approved by the client. If it is determined that acceptable data can be generated, the samples are reanalyzed until reportable data have been generated.

Method Deviation:
Methods sometimes are deviated from due to particularities of samples or other reasons. If a method is deviated from this must be recorded in a systematic way. Before deviating from a method, the deviation must be technically justified. A Laboratory Supervisor must technically justify the deviation. The Laboratory Supervisor must obtain objective evidence which technically justifies the method deviation. The Laboratory Supervisor must then attach the technical justification evidence to the client data file. The method deviation must be approved by the customer. The Laboratory Supervisor contacts the customer and asks for

permission to deviate from the method. The Laboratory Supervisor must obtain written approval from the customer to perform a method deviation. Typically, approval will be in the form of a fax, email, or letter. The Laboratory Supervisor approves the method deviation by writing “method deviation approved” with signature and date on the fax, email, or letter indicating customer approval. This approval is then attached to the client file. The analyst records the deviation on original observation sheets, data printouts, or another appropriate log. The record will be a handwritten description labeled “Method Deviation”. To record the event, describe which samples were affected by the deviation, why a deviation occurred, how the deviation was conducted, also initial and date the description of the event. If there is not enough room to describe the event on the original observation sheet, attach a description to the original observation sheet with staples. The deviation can then be noted in the final report.

Reports Creation and Review:
A report is generated from the proprietary DMS. The report is a gravimetric report based on a date range of post-sampling (gross) weigh dates for each filter and client.

After the gravimetric report is generated compliance with acceptance criteria is determined. The laboratory supervisor or the technician reviews that the appropriate value is associated with the appropriate filter sample.

Supervisor or a management appointed representative shall review data from the gravimetric lab for quality control criteria specific to each method. A record of review will be indicated for every batch of data produced with at minimum initials and a date.

Each report is assigned a ReportID. The reports contains a title, the name and addresses of the customer, page numbering, name of the client, unique sample identifiers, methods utilized to generate results, identification of the parameters, units of measure, and the name and function of the authorizer. The report may have attachments such as copies of the Chain of Custody, case narrative statements, cover sheets, or a Condition of Receipt form. The report flags deviations or non-conformities from standard methods. The report may contain references to sampling plans or other documents. Reports contain the statement “These results apply only to the samples tested”. After the report is prepared, the data are reviewed for appropriateness of the contents. A series of review criteria is examined other than typical QC criteria. Some examples; the initial weight should be greater than the gross weight for the filter sample, the net mass a positive result. And the number of filter samples matches the number of filters listed on the Chain of Custody.

Report review is critical for interpretation and accuracy of data. The reviewer of the report notes needed changes to the report. The changes are made and a new report is produced. The report is reviewed by two representatives when labor allocation makes this possible; otherwise there is one reviewer A report checklist may be used to ensure thoroughness of review and completeness of the final report, including the description of any anomalies in the Case Narrative. The report is approved by signing the final report. Personnel must be authorized to issue reports, as described in the Training Procedure.

Reporting:
Clients require reports in a variety of formats such as fax, email, electronic transmission, traditional mailing, or client generated forms. Clients' reporting needs are met whenever possible. All electronic transmissions shall contain the following statement "The contents of this electronic transmission and any attachments may contain confidential and/or proprietary information, and is intended only for the person/entity to whom it was originally addressed. Any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this electronic transmission in error please notify the sender immediately and destroy this message and any attachments from your system." or similar language. Electronic reports are sent, a hard copy of the report can also be mailed to the client, if the client has specifically requested. Unless specified by the client, electronic data shall be sent in a format that does not easily allow modifications; such as a security protected Adobe Acrobat PDF format.

Amendments to Reports

If a report needs to be amended, the following procedure is performed. An amended report is created as detailed in this procedure under "Report Creation", and "Data Review". The amended report is prepared with all amendments and is issued a new ReportID. The amended report is prepared as a supplement report. The amended report is prepared with an acknowledgement of the previous report. The amended report is prepared with the statement "Supplement to (previous ReportID)". The amended report is then reported as detailed in this procedure under "Reporting".

Revising Reports

If a report needs to be revised due to erroneous results, needed corrections, or amendments that require a complete new test report, the following procedure is performed. A revised report is created as detailed in this procedure under "Report Creation", and "Data Review". The revised report is prepared with all

amendments and corrections, and is issued a new ReportID. The revised report is prepared as a replacement report. The revised report is prepared with an acknowledgement of the previous report. The revised report is prepared with the statement “Replaces (previous ReportID)”. A revised report is reported as detailed in this procedure under “Reporting”.

Approvals:

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Quality Assurance Official Date

_____
Laboratory Official Date

SAMPLE DISPOSAL PROCEDURE

Scope:
This procedure describes the procedures and policies for sample retention and disposal.

Application:
This procedure applies to soil, water, trace metals, gravimetric and organics laboratories.

Soil:
Samples in the soil laboratory are retained for one year from date received. They are retained in their processed 10 mesh state (see Standard Operating Procedure for Sample Processing and Coarse Fragments). Processors store samples in the "sample retention area" in a logical manner. Periodically sample processors need to go through these samples, check the dates, and dispose of samples that are more than one year old. To dispose of these samples, record the sample identification numbers, signature or initials of person disposing of samples, and the date of disposal in a sample disposition log. Complete the disposal by placing solid samples in the trash/landfill dumpster. Liquid extracts and sample digestates obtained from soil extraction procedures are disposed of by neutralizing and pouring down the laboratory sink with copious amounts of water. Containers are disposed of in the trash/landfill dumpster. Used sample containers may not be recycled. If data from any of the samples indicates the sample is waste, as described by EPA RCRA regulations, the sample cannot be disposed of in the landfill. The samples must be returned to the client. If the client will not accept the samples, see chemical hygiene plan for procedures on appropriate disposal.

Trace Metals:
Samples in the trace metals laboratory are retained for five months from date sampled. Samples are retained in their received or preserved state. Sample extracts or samples processed prior to analysis are not typically saved. Original preserved samples are saved. These are stored in the trace metals storage area in the warehouse. Periodically technicians need to go through these samples check the dates, and dispose of samples that are more than five months old. To dispose of samples, record the sample identification numbers, signature or initials of person disposing of samples, and the date of disposal in a sample disposition log. Water samples are neutralized then poured down the sink with copious amounts of water. Complete the disposal by placing the empty containers in the trash/landfill dumpster. Used sample containers may not be recycled. Waste samples are sent back to the client as appropriate. If data from any of the samples indicates the sample is waste, as described by EPA RCRA regulations, the sample cannot be disposed of in the landfill or municipal water treatment system. The

samples must be returned to the client. If the client will not accept the samples, see chemical hygiene plan for procedures on appropriate disposal.

Water*:*
Samples in the water laboratory are retained for three months from date sampled. Samples are retained in their received or preserved state. Samples that are processed prior to analysis are not typically saved. Original preserved samples are saved. These are stored in the water laboratory. Periodically technicians need to go through these samples, check the dates, and dispose of samples more than three months old. To dispose of these samples, record the sample identification numbers, signature or initials of person disposing of samples, and the date of disposal in the sample disposition log. Water samples are neutralized, then poured down the sink with copious amounts of water. Soil samples and containers from water samples are disposed of by placing in the trash/landfill dumpster. Used sample containers may not be recycled. If data from any of the samples indicates the sample is waste, as described by EPA RCRA regulations, the sample cannot be disposed of in the landfill or municipal water treatment system. The samples must be returned to the client. If the client will not accept the samples, see chemical hygiene plan for procedures on appropriate disposal.

Organics:
Samples in the organics laboratory are retained for three months from date sampled. They are retained in their received or preserved state throughout their holding times. Samples that are processed prior to analysis are not typically saved. Original preserved samples are saved throughout the holding times in the preserved state. Where practicable, samples are retained in their preserved state for three months. At times space can be a limiting factor in refrigerators. During times of storage space constraints, samples that have been processed and have exceeded their holding times will be taken out of the refrigerators and stored at room temperature until disposition. These are stored in the organics laboratory. Periodically technicians need to go through these samples, check the dates, and dispose of samples more than three months old. To dispose of these samples, record the sample identification numbers, signature or initials of person disposing of samples, and the date of disposal in the sample disposition log. Water samples are neutralized and poured down the sink along with copious amounts of water. Soil samples and containers from water samples are disposed of by placing in the trash/landfill dumpster. Used sample containers may not be recycled. If data from any of the samples indicates the sample is waste, as described by EPA RCRA regulations, the sample cannot be disposed of in the landfill or municipal water treatment system. The samples must be returned to the client. If the client will not accept the samples, see chemical hygiene plan for procedures on appropriate disposal.

RadChem:

Samples in the radiochemistry laboratory are retained for six months from date sampled. Samples are retained in their received or preserved state. Sample aliquots that are processed prior to analysis are not typically saved. Original samples are saved. These are stored in the RadChem laboratory. Periodically technicians need to go through these samples, check the dates, and dispose of samples more than six months old. To dispose of these samples, record the sample identification numbers, signature or initials of person disposing of samples, and the date of disposal in the sample disposition log. Water samples are neutralized, then poured down the sink with copious amounts of water. Soil samples and containers from water samples are disposed of by placing in the trash/landfill dumpster. Used sample containers may not be recycled. If the sample is from source material or by-product (i.e. yellow cake), the sample must be returned to the client via a reverse chain of custody.

Gravimetric Labs:

Samples in the gravimetric lab for EPA methods 40 CFR 50 Appendix L and O are retained for at least one year from date of collection, in cold storage at 4°C or cooler, unless the customer has made other arrangements for the samples. Filter samples for EPA Methods 40 CFR 50 Appendix B, J, and J modified are retained five years unless the customer has made other arrangements for the samples. Clients are contacted before disposal or returning the samples. Technicians will dispose of samples or return filter samples. These samples will be checked against dates of collection and client requests. A record of disposal will be recorded with filter sample dates, customer, signature or initials of person disposing of samples, and the date of disposal in a log. Air filter samples are disposed of by placing in the trash/landfill dumpster.

Approvals:

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Michelle LaGory Date
Quality Assurance Manager

_____

Tom Patten Date
Laboratory Manager

SAMPLE RECEIVING PROCEDURE

Scope*:*
This procedure describes the procedures and policies for sample receipt at Inter-Mountain Laboratories, Inc.

Application*:*
This procedure identifies the steps necessary for receiving samples that have been submitted for analysis in the Water, Soils, Radiochemistry, Kinetics and Organic labs in Sheridan WY, and the IML Gillette WY location. The guidelines are followed to ensure personnel safety, sample integrity, security and confidentiality. A separate procedure is followed in the Gravimetric Laboratories.

Related Laboratory Procedures:
IML provides sampling kits to customers with containers and preservatives of known quality, per analytical method guidance, following procedures outlined in the IML Sample Kit Preparation Procedure.

Receiving:
Sample receiving is performed by technicians, analysts, supervisors, or managers.

Sample shipment containers such as coolers, bags, or boxes are opened on the day they arrive in the laboratory, when appropriate personnel are available to receive them. Otherwise the Chain of Custody (COC) is signed and the samples are placed in a refrigerated environment. The Chain of Custody is always signed when the samples are received at the laboratory.

A Condition Upon Receipt form (CUR) is used by lab personnel to record observations related to sample receiving, to ensure that samples meet analytical method requirements (e.g., appropriate container type, adequate sample volume, etc.). The presence or absence of shipping seals and their physical condition are noted. The general condition of the samples is assessed and any leaking or broken containers are noted.

The COC is examined and compared against the contents of the shipment containers. The examination includes: accounting of samples, COC completeness, requested analyses, appropriate sample identification, preservation, holding times, and any rush indications. This information is recorded on the CUR form, along with any notes describing discrepancies or deficiencies.

Sample volume, container type, preservation, and matrix is examined for appropriateness to requested methodology. Space is included on the COC for the client to indicate whether samples are for regulatory compliance, and if so, for which compliance program. This information is used to ensure that samples are logged in and handled appropriately while in the lab, ensuring that the clients' data quality objectives (DQOs) are met. In addition, test groups and client-specific projects are maintained in the LIMS to ensure that client DQOs are met. If the samples meet the methodology and receiving criteria, the samples are logged and accepted.

Preservation:
Preservation is method dependent. Preservation techniques include temperature control, pH modification, and interferent elimination. The laboratories compare preservation technique against an approved edition of "Standard Methods for the Examination of Water and Waste Water" and/or against chapter 4 of SW-846. Preservation actions are taken and recorded as needed on the CUR form. The pH, temperature, or other measurements are performed in a manner which does not introduce contamination to the samples or compromise sample integrity

The temperature of the samples is measured with an infra-red or digital stem thermometer. The infra-red gun type thermometer is operated by depressing and holding the power button on the grip, then directing the spot towards the sample(s) at a distance of approximately six to ten inches; the temperature displayed is allowed to stabilize before the observed temperature is recorded. Stem thermometers are used by placing the stem adjacent to samples; the temperature displayed is allowed to stabilize before the observed reading is recorded. Measurements of sample temperatures are made immediately after a cooler is opened, or immediately at receipt for samples that are not received in a cooler. These measurements are recorded on the COC and CUR form. If multiple samples are received, a representative temperature is obtained by measuring a representative sample. If more than one cooler is received, a representative temperature is measured and recorded for each cooler. Both observed and corrected temperatures are recorded on the CUR.

Unless method guidance indicates otherwise, acceptable temperatures of samples are as follows:

a. Samples may be received at room temperature if they are returned to the lab within 15 minutes of sampling.
b. Samples that are received at the lab on the same day as sampled may not have had time to cool sufficiently. Samples may be received as Received on Ice (ROI) if ice is present and chilling has begun. A record of "ROI" and the temperature at receipt is made on the CUR.
c. Most water samples for inorganic and organic analyses that are received after one day post-sampling must be received at $>0^{o}C$ to $\leq 6^{o}C$.

d. Surface Water Treatment Rule (SWTR) samples for bacterial analysis should be received at >0° to ≤10°C; SWTR samples that are received frozen or partially frozen must be invalidated. SWTR samples received shortly after sampling may not have had adequate time to cool sufficiently; these are acceptable if received on ice within two hours of sampling or if they have been iced immediately after sampling. Temperature exceedances that would adversely affect analytical results must be flagged appropriately in the final analytical report.
e. Soil samples received for organic analyses must be received at >0° to ≤6°C. The temperature of routine soils samples received in the Soils Lab is not required to be measured at receipt.

The customer must be notified when regulatory compliance samples are received outside appropriate temperature criteria; permission from the client must be obtained whether to commence work or reject samples.

Samples requiring pH modification are checked for pH at receipt, and are adjusted by addition of method-appropriate preservative. A log of the preservative added will be created to trace lot numbers of preservative added to samples. A record of any preservative added to samples is made on the CUR. VOAs and Oil and Grease/TPH samples are not checked for pH at receipt.

Aqueous samples received for analysis of total metals that are received at a pH >2 must be adjusted to pH <2, and allowed to sit for a minimum of 24 hours prior to analysis; this will dissolve any metals that had adsorbed to the container wall. Sample Receiving staff will record the date and time of preservation. Every sample for the Wyoming Storage Tank Program, (LAUST), must be checked for preservation and the observations recorded appropriately.

Appropriate chemicals are added to samples as defined by approved methodologies to remove interferences (e.g., sodium thiosulfate to eliminate residual chlorine in samples submitted for bacteria analysis….)

<u>Special Considerations for Radiochemistry Samples:</u>
Samples containing radiological material, such as yellow cake, should be identified by the client at the time of receiving with a “Radioactive” label. The radiation safety officer (RSO) should be called to take possession of the material. (In the absence of the RSO, an Authorized User (AU) may take possession of radioactive material.) Source and by-product material must be listed on the licensed material inventory and stored as such. Source and by-product material is kept approximately 3 months, or until analyses and reports have been completed. Source and by-product material are then returned to client via reverse chain of custody.

Radiochemistry samples are screened at receipt, using a hand-held radioactivity detector or other suitable monitoring device. Samples with an emission rate > 0.5mR/hr will be stored in a separate area, to reduce the risk of contamination of

other samples. Radiochemistry samples are stored in the radiochemistry lab, away from other samples.

Sample Acceptance:
If the samples do not meet the requirements, the customer is notified, and sample rejection and re-sampling may be recommended. An Inter-Mountain Laboratories representative communicates the deficiencies of the samples to the customer. The customer decides on any modifications or whether to proceed with the analyses, and this decision is recorded on the CUR form. IML will reject samples that do not meet program requirements and will not have value to our customers. IML qualifies data that do not meet program requirements. IML will attempt to communicate the needs of each program, and documentation requirements, with respect to the following items:

- Sample ID
- Location
- Date
- Time
- Sampler ID
- Preservation
- Sample Type
- Labeling
- Packaging
- Containers
- Holding Times
- Volume Requirements

Holding Times:
The Water laboratories adhere to holding times by assigning samples and methodology to individuals who track hold times through sample backlogs in the LIMS. Holding times and preservation methods are compared against the methodology requirements in an approved edition of “Standard Methods for the Examination of Water and Wastewater”, or in the appropriate approved reference method. The Sample Custodian communicates verbally to the assigned analyst information regarding samples which require immediate attention including rush samples. A list of samples with short holding times is maintained by the Sample Custodian on a white board for easy reference.

The Organics laboratory adheres to holding times by tracking them through sample backlogs in the LIMS. Samples are analyzed based upon priority of holding time expirations. Holding times and preservations are compared against method guidance and SW-846, chapter 4 for volatile and semi-volatile organics.

Logging:
Sample information is entered into the Laboratory Information Management System (LIMS). Information entered includes client, project, customer sample

identification, matrix, sampler, parameters for analysis, methodology per parameter, specially-requested or program-required detection limits, date and time sampled, and date received. The COC is also examined for notes made by the client/sampler in the "Turn Around Times", "Compliance Information", "Remarks" and "Additional Remarks" sections; information such as field measurements or other comments are logged into LIMS where appropriate.

The LIMS then assigns a unique eight character laboratory identifier for each group of samples or sample set. The identifier is eight characters, the letter "S" followed by seven numbers, such as the example "S1706099". The two numbers following the letter indicate the year the sample set was logged. Where "17" would indicate that the sample set was logged in the year 2017. The two numbers following indicate the month the sample set was logged. Where "06" would indicate the sample set was logged in June. The last three numbers are sequentially generated; "099" would indicate the ninety ninth sample set logged in the month.

Each sample within the set is further identified by a three digit extension followed by a letter, as the example "S1706099-001B". The first three numbers in the extension are generated sequentially and are assigned to each sampling point. Where "001" would indicate the first sampling point in the set. The letter extension is generated alphabetically and is assigned to each container. Where "B" would indicate the second container of sampling point "001".

These identifiers are recorded on the Chain of Custody.

When samples listed on a single Chain of Custody must be logged into LIMS in more than one Work Order (e.g., when samples listed require different customer-specific groups of analyses), all LIMS-assigned sample IDs must be recorded on the original Chain of Custody. Additional copies are made from the original, to ensure that all Work Orders associated with each COC contain a copy of the original COC.

Labels are printed and attached to the samples. The laboratories create a packet of records for each sample set. These include a Work Order, the COC (including any additional instructions received from the client), the CUR Form, Report Review checklist, and analytical records and reports as they are completed.

Lab labels are compared against customer information on container labels as they are affixed, to ensure that they are placed on appropriate containers and that there are no discrepancies between COC and bottle labels. After labels are affixed to sample containers, containers are sorted by requested analysis, placed on trays in numeric order (by lab ID), and routed to the appropriate laboratory section for analysis. Samples that require temperature preservation are stored in a walk-in cooler or refrigerator. Samples are stored in the laboratory section in which they are to be analyzed. If space restrictions do not allow retention of all

samples in the lab section prior to disposal, samples may be moved to designated longer term storage if appropriate: soils samples on labeled shelves in steel building; metals samples on shelves in room in steel building; organics samples in boxes in corridor adjacent to extraction lab. Departures from these arrangements may be made if required by individual projects.

Additionally, samples likely to be the basis for enforcement action or to be used for evidentiary purposes will be subjected to more stringent tracking of movement within the laboratory. Drinking water samples likely to be the basis of enforcement action will be collected (where applicable), transported (where applicable), and handled by laboratory personnel per guidance in Appendix A of the EPA Manual for the Certification of Laboratories Analyzing Drinking Water Fifth Edition, which is attached to this procedure.

Special Considerations for Drinking Water Compliance Samples:
Test Groups have been created in the LIMS to ensure appropriate login of drinking water samples. These Test Groups should be used to log in drinking water compliance samples. The Test Groups include Report Limits and Maximum Contaminant Levels that reflect drinking water standards.

Radiochemistry drinking water samples must be logged in to the LIMS system using the following test codes "SDWA_GR_ALPHA", "SDWA_R226", and "SDWA_R228". The login personnel must alert the Radchem Lab that drinking water samples have arrived because they need to be stored and preserved in a manner separated from CWA and NRC samples.

Log Review:
Following sample login, a Report Review checklist form is attached to the customer record packet for each Work Order. This form includes a checklist for use in conducting log review to assist in ensuring that samples are appropriately logged into the LIMS. Log Review is preferably performed by someone other than the person who logged in the Work Order. The person performing the review must record their initials and date of review, in addition to recording checks that each listed item has been logged appropriately. Log Review is completed by authorizing the set in LIMS.

Receipt of Samples Originally Received at Another IML Location:

Samples may be received at any of three IML locations: corporate headquarters in Sheridan, Terra Avenue labs in Sheridan, or the Gillette laboratory. Samples may be received at any location, sometimes due to accessibility to clients, and are moved within the three locations to accommodate required analyses. Samples are moved in a timely manner to accommodate hold times and requested rush analyses. The receiving laboratory is responsible for identifying time sensitivity issues related to samples, and will alert the laboratory responsible for analysis

Samples are transported between locations by IML personnel or a commercial shipping service. Samples are transported in coolers or other secure containers, with adequate packing material to ensure safe transport. A copy of the original COC from the client, and a copy of the CUR form from the original receiving lab are placed in the shipping container with the samples. Samples are held in a refrigerated environment prior to transport. If samples will be in transit between locations for more than one hour, ice is added to the shipping container.

The COC is signed by each person relinquishing and receiving samples, with the date and time, at each stage of transfer. The temperature of samples is measured and recorded for each group of samples that are in transit for greater than one hour. Samples delivered after business hours are placed in a refrigerated environment. Notes of observations regarding discrepancies or deficiencies are added to the Condition Upon Receipt form as needed.

The receipt date logged into LIMS will be that of receipt at the original receiving lab. Analytical results generated at more than one IML location are consolidated into a single report that is reviewed and generated at the Terra Avenue Lab. If reported results are generated at more than one IML location, the location at which each value is generated will be indicated in the analytical report. The reporting lab will retain the original COC, and copies of the COC will be retained at each IML location where samples are received.

Sample Storage:
Samples that require thermal preservation are stored under refrigeration at >0° to ≤6°C.

A separate shelf is dedicated to storage of drinking water samples for radionuclide analysis in the Radiochemistry Lab.

Samples are stored in secure areas, separate from standards, food, or other potentially contaminating sources. Portions of samples including extracts, leachates, digestates must be stored according to same requirements as full samples.

Sub-Sampling:
Water: The sample container should be inverted several times to ensure thorough mixing, and a portion should immediately be poured into an appropriate container.

Soil: The sample should be stirred in the original container (if applicable), using a utensil that will not contaminate the target analysis, until the sample is as homogeneous as possible. A portion of the sample should then be removed using a utensil that will not contaminate the target analysis, and transferred to an appropriate container.

These sub-sampling procedures only apply when no other guidance is provided by the analytical methods scheduled.

Approvals:

_____
Quality Assurance Official Date

_____
Laboratory Official Date

Summary of revisions from Sample Receiving Procedure 2.13, revision date 3/5/15:

1. Minor editorial changes throughout document; some reorganization within document for clarity.
2. Added reference to Sample Kit Preparation Procedure under “Related Laboratory Procedures.”
3. Added comments about use of Condition Upon Receipt form under “Receiving” section.
4. Consolidated temperature preservation information under “Preservation” section, as a subsection of “Receiving”.
    a. Changed type of electronic thermometer used from “thermocouple” to “digital stem thermometer.”
    b. Added statement that method guidance takes priority over generic receipt guidance described in procedure.
    c. Added statement that a representative temperature is taken for each cooler received, and that the observed and corrected temperatures are recorded on the CUR.
    d. Changed acceptability of samples received at room temperature from one hour post-sampling to 15 minutes post-sampling.
    e. Clarified that a record of measured temperature is required in addition to record of “ROI” for samples received on ice within a day of sampling.
    f. Added statement that soil samples for organic analyses must also be received within >0 to ≤6°C range.
    g. Clarified acceptance criteria for bacteria samples, particularly surface water drinking water compliance samples.
    h. Added requirement for customer contact specific to instances of temperature exceedance at receipt for compliance samples.
5. Added requirement for record of preservative lot number on CUR when preservative is added to samples in lab.
6. Added statement that VOAs and Oil and Grease samples are not checked at receipt.
7. Added “Special Considerations for Radiochemistry Samples” subsection in “Receiving” section.

8. Placed information regarding sample acceptance into separate “Sample Acceptance” section.
9. Added “method guidance” as a source of hold time and preservation requirements used in the Organics Lab.
10. “Logging” section:
    a. Added entry of “specially-requested or program-required detection limits” in “Logging” section.
    b. Added examination of COC for information regarding “Turn Around Times” and “Compliance Information.”
    c. Removed references to separate LIMS that are no longer used in Organics and Gillette labs.
    d. Added “Report Review Checklist” as a form that is assembled into record packet assembled for the Work Order following login.
    e. Created a separate section for “Special Considerations for Drinking Water Compliance Samples”, moving login information from the “Receiving” section, and mentioning special Test Groups that assign drinking water specific Report Limits and MCLs.
11. Created a separate “Log Review” section that describes steps for review and authorization of Log Review in LIMS, including use of “Report Review Checklist” form in recording log review.
12. Created separate “Sample Storage” section.
    a. Moved statement regarding storage of drinking water samples for analysis of radionuclides from “Receiving” Section to “Special Considerations for Drinking Water Compliance Samples” section.
    b. Added statement about contamination considerations and storage of leachates, extracts, and digestates.

Appendix A
Chain-of-Custody Evaluations

A. Introduction

Written procedures for sample handling should be available and followed whenever samples are collected, transferred, stored, analyzed or destroyed. For the purposes of litigation, it is necessary to have an accurate written record to trace the possession and handling of samples from collection through reporting. The procedures defined here represent a means to satisfy this requirement.

A sample is in someone's "custody" if:

1. It is in one's actual physical possession;

2. It is in one's view, after being in one's physical possession;

3. It is one's physical possession and then locked up so that no one can tamper with it;

4. It is kept in a secured area, restricted to authorized personnel only.

B. Sample Collection, Handling and Identification

1. It is important that a minimum number of persons be involved in sample collection and handling. Guidelines established in standard manuals for sample collection preservation and handling should be used (e.g., EPA NPDES Compliance Sampling Inspection Manual, MCD 51, Standard Methods for Examination of Water and Wastewater). Field records should be completed at the time the sample is collected and should be signed or initialed, including the date and time, by the sample collector(s). Field records should contain the following information:

   a. Unique sample or log number;

   b. Date and time;

   c. Source of sample (including name, location and sample type);

   d. Preservative used;

   e. Analyses required;

   f. Name of collector(s);

   g. Pertinent field data (pH, DO, Cl residual, etc.);

   h. Serial number on seals and transportation cases;

   i. Comments.

2. Each sample is identified on a pressure sensitive gummed label or standardized tag affixed to the container(s). This label should contain the sample identifier, collection date, collection time, and preservative used, if applicable and the collector(s') initials. The analysis required

should be identified. Where a label is not available, the sample information should be written on the sample container with an indelible marking pen.

3. The closed sample container should then be placed in a transportation case along with the completed chain-of-custody record form, and any pertinent field records or list of requested analyses. The transportation case should then be sealed and labeled. All records should be filled out legibly in waterproof pen. The use of locked or sealed chests will eliminate the need for close control of individual sample containers. However, there will undoubtedly be occasions when the use of a chest will be inconvenient. On these occasions, the sampler should place a seal around the cap of the individual sample container which would indicate tampering if removed.

C. Transfer of Custody and Shipment

1. When transferring the possession of the samples, the transferee must sign and record the date and time on the chain-of-custody record. Custody transfers, if made to a sample custodian in the field, should account for each individual sample, although samples may be transferred as a group. Every person who takes custody must fill in the appropriate section of the chain-of-custody record.

2. The field custodian (or field sampler if a custodian has not been assigned) is responsible for properly packaging and dispatching samples to the appropriate laboratory for analysis. This responsibility includes filling out, dating, and signing the appropriate portion of the chain-of-custody record. A recommended chain-of-custody format is illustrated in Figure 1.

3. All packages sent to the laboratory should be accompanied by the chain-of-custody record and other pertinent forms. A copy of these forms should be retained by the field custodian (either carbon or photocopy).

4. Mailed packages can be registered with return receipt requested. If packages are sent by common carrier, receipts should be retained as part of the permanent chain-of-custody documentation.

5. Samples to be transported must be packed to prevent breakage. If samples are shipped by mail or by other common carrier, the shipper must comply with any applicable Department of Transportation regulations. (Most water samples are exempt unless quantities of preservatives used are greater than certain levels.) The package must be sealed or locked to prevent tampering. Any evidence of tampering should be readily detected if adequate sealing devices are used.

6. If the field sampler delivers samples to the laboratory, custody may be relinquished to laboratory personnel. If appropriate personnel are not present to receive the samples, they should be locked in a designated area of the laboratory to prevent tampering. The person delivering the samples should make a log entry stating where and how the samples were delivered and secured. Laboratory personnel may then receive custody by noting in a logbook, the absence of evidence of tampering, unlocking the secured area, and signing the custody sheet.

D. Laboratory Sample Control Procedures

Sample control procedures are necessary in the laboratory from the time of sample receipt to the time the sample is discarded. The following procedures are recommended for the laboratory:

1. A specific person must be designated as custodian and an alternate designated to act as custodian in the custodian's absence. All incoming samples must be received by the custodian, who must indicate receipt by signing the accompanying custody/control forms and who must retain the signed forms as permanent records.

2. The custodian must maintain a permanent logbook to record, for each sample, the person delivering the sample, the person receiving the sample, date and time received, source of sample, date the sample was taken, sample identification log number, how transmitted to the laboratory, and condition received (sealed, unsealed, broken container, or other pertinent remarks). This log should also show the movement of each sample within the laboratory; i.e., who removed the sample from the custody area, when it was removed, when it was returned, and when it was destroyed. A standardized format should be established for logbook entries.

3. A clean, dry, isolated room, building, and/or refrigerated space that can be securely locked from the outside must be designated as a "custody room."

4. The custodian must ensure that heat-sensitive samples, light-sensitive samples, radioactive samples, or other sample materials having unusual physical characteristics, or requiring special handling, are properly stored and maintained prior to analysis.

5. Distribution of samples to the analyst performing the analysis must be made by the custodian.

6. The laboratory area must be maintained as a secured area, restricted to authorized personnel only.

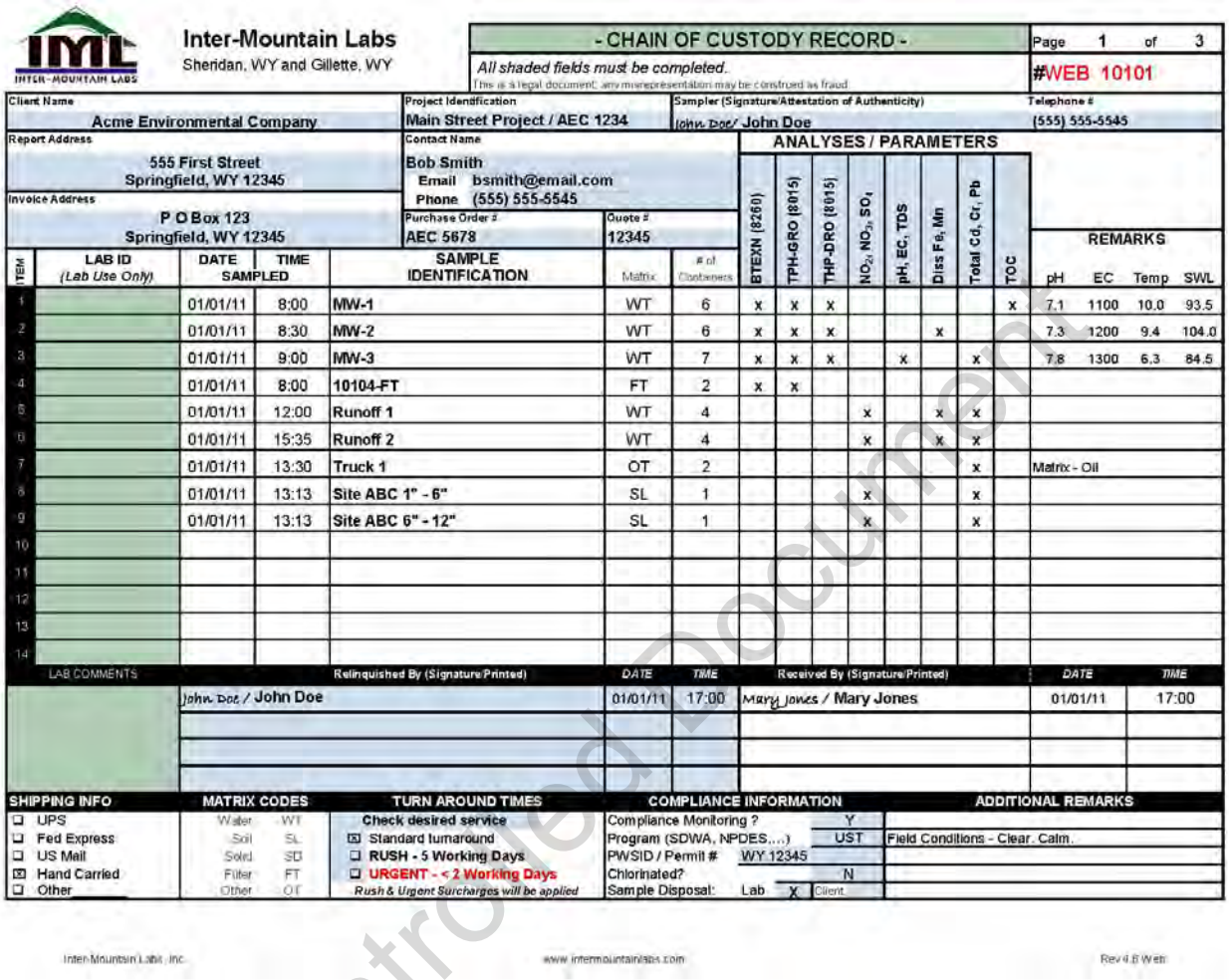
7. Laboratory personnel are responsible for the care and custody of the sample once it is received by them and must be prepared to testify that the sample was in their possession and view or secured in the laboratory at all times from the moment it was received from the custodian until the time that the analyses are completed.

8. Once the sample analyses are completed, the unused portion of the sample, together with all identifying labels, must be returned to the custodian. The returned tagged sample must be retained in the custody room until permission to destroy the sample is received by the custodian.

9. Samples will be destroyed only upon the order of the responsible laboratory official when it is certain that the information is no longer required or the samples have deteriorated. (For example, standard procedures should include discarding samples after the maximum holding time has elapsed.) The same procedure is true for sample tags. The logbook should show when each sample was discarded or if any sample tag was destroyed.

10. Procedures should be established for internal audits of sample control information. Records should be examined to determine traceability, completeness, and accuracy.

Figure 1.



Inter-Mountain Labs
Sheridan, WY and Gillette, WY

- CHAIN OF CUSTODY RECORD -

Page 1 of 3

All shaded fields must be completed.
This is a legal document; any misrepresentation may be construed as fraud.

#WEB 10101

Client Name	Project Identification	Sampler (Signature/Attestation of Authenticity)	Telephone #
Acme Environmental Company	Main Street Project / AEC 1234	John Doe / John Doe	(555) 555-5545

Report Address	Contact Name
555 First Street Springfield, WY 12345	Bob Smith Email bsmith@email.com Phone (555) 555-5545
Invoice Address	**Purchase Order #** / **Quote #**
P O Box 123 Springfield, WY 12345	AEC 5678 / 12345

ANALYSES / PARAMETERS

ITEM	LAB ID (Lab Use Only)	DATE SAMPLED	TIME SAMPLED	SAMPLE IDENTIFICATION	Matrix	# of Containers	BTEXN (8260)	TPH-GRO (8015)	THP-DRO (8015)	NO_2, NO_3, SO_4	pH, EC, TDS	Diss Fe, Mn	Total Cd, Cr, Pb	TOC	REMARKS pH	EC	Temp	SWL
1		01/01/11	8:00	MW-1	WT	6	x	x	x					x	7.1	1100	10.0	93.5
2		01/01/11	8:30	MW-2	WT	6	x	x	x			x			7.3	1200	9.4	104.0
3		01/01/11	9:00	MW-3	WT	7	x	x	x		x		x		7.8	1300	6.3	84.5
4		01/01/11	8:00	10104-FT	FT	2	x	x										
5		01/01/11	12:00	Runoff 1	WT	4				x		x	x					
6		01/01/11	15:35	Runoff 2	WT	4				x		x	x					
7		01/01/11	13:30	Truck 1	OT	2							x		Matrix - Oil			
8		01/01/11	13:13	Site ABC 1" - 6"	SL	1				x			x					
9		01/01/11	13:13	Site ABC 6" - 12"	SL	1				x			x					
10																		
11																		
12																		
13																		
14																		

LAB COMMENTS	Relinquished By (Signature/Printed)	DATE	TIME	Received By (Signature/Printed)	DATE	TIME
	John Doe / John Doe	01/01/11	17:00	Mary Jones / Mary Jones	01/01/11	17:00

SHIPPING INFO	MATRIX CODES		TURN AROUND TIMES	COMPLIANCE INFORMATION		ADDITIONAL REMARKS
☐ UPS	Water	WT	Check desired service	Compliance Monitoring ?	Y	
☐ Fed Express	Soil	SL	☒ Standard turnaround	Program (SDWA, NPDES,...)	UST	Field Conditions - Clear, Calm.
☐ US Mail	Solid	SD	☐ RUSH - 5 Working Days	PWSID / Permit #	WY 12345	
☒ Hand Carried	Filter	FT	☐ URGENT - < 2 Working Days	Chlorinated?	N	
☐ Other	Other	OT	*Rush & Urgent Surcharges will be applied*	Sample Disposal:	Lab X Client	

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SAMPLE RECEIVING PROCEDURE FOR GRAVIMETRIC LABORATORIES

Scope*:*
This procedure describes the procedures and policies for sample receipt at Inter-Mountain Laboratories, Inc. in the Gravimetric Laboratories.

Application*:*
This procedure identifies the steps necessary for receiving samples that have been submitted for analysis in the Gravimetric Laboratories. The guidelines are followed to ensure sample integrity, security and confidentiality.

Receiving:
Sample receiving is performed by technicians, analysts, supervisors, or managers.

Sample shipment containers such as coolers, bags, or boxes are opened on the day they arrive in the laboratory, when appropriate personnel are available to receive them. Otherwise the chain of custody (COC) is signed and the samples are placed in a refrigerated environment. The chain of custody is always signed when the samples are received at the laboratory.

The presence or absence of shipping seals and their physical condition are noted.

Open cooler and immediately determine the maximum shipping temperature of the cooler as indicated by the min/max thermometer within the shipping cooler. As quick as possible turn the min/max thermometer on and read the maximum temperature or if it's evident the thermometer was not reset immediately employ the infrared gun.

The infrared thermometer gun is used in its place of the min/max thermometer if the thermometer did not accompany the cooler by error, not functioning, or by client's choice. Turn on the infrared gun to verify operational. To obtain the temperature with the infrared thermometer gun, immediately point the gun into the cooler at the filter samples with the trigger held down watching the digital read out until it stabilizes, typically a few seconds. Retrieve the Chain of Custody form and record the temperature.

Enter the temperature in the exposed login form in the data management system. If the temperature exceeds 4ºC, the data management system will flag records for all samples included in that shipment.

Temperature preservation requirement is only for EPA methods 40 CFR 50 Appendix L and O. Filter samples are readied for conditioning as soon as possible and after analysis stored. Other methods do not require temperature to be measured at receipt or stored below 4ºC. Filter methods do not require preservation besides the temperature.

The COC is examined and compared against the filter samples of the shipment . The examination includes: accounting of samples, COC completeness, requested analyses, appropriate sample identification, and any rush indications. This information is recorded on the Condition Upon Receipt form if required, along with any notes describing discrepancies or deficiencies.

If the samples do not meet the requirements, the customer is immediately notified. An Inter-Mountain Laboratories representative communicates the deficiencies of the samples to the client. The client decides on whether to proceed with the analyses, and this decision is documented on the condition of receipt form.

Expiration Date:
Expiration date is a requirement for only EPA methods 40 CFR 50 Appendix L and O. The data management system will automatically flag filter samples past the expiration date by comparing the sample date and the tare weigh date. The filter should be used before 30 days of the tare date. Filter samples are flagged and analyzed as soon as conditioning requirements are complete.

Logging:
Filter sample information is entered into the Data Management System under the unique filter number. Record arrival date, time, and maximum temperature, Chain of Custody data and sampler run data. During login, enter the date and time the filter samples began equilibration in the data management system.

Approvals:

_____
Quality Assurance Official Date

_____
Laboratory Official Date

TRAINING PROCEDURE

Scope:
This procedure details how to identify training needs, what type of training is appropriate, how to demonstrate training, and how to authorize personnel to perform work.

Application:
This procedure applies to the Soils, Trace Metals, Water, Kinetics, Radiochemistry, Organics, and Air Science Gravimetric Laboratories. Training is divided into five areas. The areas include instrumentation and technology training, methodology training, report generation training, quality system training, software training, and chemical hygiene/safety training.

Identifying Training Needs:

New employees are assessed for training needs using a Training Needs Assessment form included in the New Employee packet. The appropriate lab section supervisor will use the form to assess initial training needs, signing the form with the date that the assessment was performed. This form will also be used to assess training needs when personnel transfer to new positions within the company.

Education and experience of new personnel, and those transferring to a new position or assuming additional responsibilities, are compared against education and experience requirements given in the IML Quality Manual. A brief resume that details education, experience, and affiliations or publications may be created for new employees, and updated to reflect intra-lab transfers or additional education.

A Job Description will be initiated for each new employee during the initial training needs assessment, and will be updated as needed for current employees by the immediate supervisor or Quality Assurance Manager, using a Job Description form. This job description will list technology responsibilities, methodology responsibilities, production responsibilities, identify the employee's title, and indicate whether they serve as a deputy for another laboratory section. Responsibilities will be compared against training requirements by the Quality Assurance Manager during preparation for annual Management review; identified training needs will be discussed during the annual Management Review meeting. A training needs list may be produced and presented to the Supervisor in charge, or to upper management, at any time that a critical need is identified. Job Descriptions are kept on file in the Quality Manager's office.

Instrumentation and Technology Training:

Every technology in the laboratory must have one person who is technology trained in the laboratory. A twelve month grace period will be allowed for new technologies introduced into the laboratory. Instrumentation and technology training requires material presentation under the direction of a skilled analyst, demonstrations of competence, experience, and authorization. Examples of technologies that need training are shown below:

Soils: C/S Analyzer and Automatic Titrator.
Trace Metals: AA, Hg analyzer, ICP-OES, and ICP-MS.
Water: Automatic Titrator, RFA, TOC analyzer, discrete analyzer, and IC.
Organics: GC and GC-MS.
Radchem: GPC, Gamma Spectrometer, and Alpha Spectrometer

Experience is technology training. To be considered trained on a technology; one year of experience performing work on a technology is required.

Analytical Methodology Training:

Analytical methods shall only be performed by appropriately trained and authorized persons. Analytical methodology training requires material presentation under the direction of a skilled analyst, demonstrations of competence, and an authorization to perform work. The listing of methods for each laboratory can be found in the Master Document List.

Material presentations are typically performed with two separate presentations. One of the material presentations typically will consist of the person being trained reading the method procedure and SOP, then discussing any questions concerning the method with an experienced analyst. Both the trainer and the trainee will then sign the SOP method training record at the end of the SOP, signifying that the SOP has been both read and understood by the trainee. The other material presentation typically will consist of a method demonstration performed by an experienced analyst for the employee in training.

A Training Checklist is used by both trainer and trainee to ensure that details pertaining to performance of method are addressed such as sample storage, program-required detection limits, interference mitigation, use of support equipment, use of the associated QC Failure Logbook and other forms, etc. The checklist is signed by both trainer and trainee, and maintained in the employee's training file in the Quality Manager's office.

Initial demonstrations of competence in the Trace Metals, Organics, Soils, and Water laboratories are performed by successfully analyzing a minimum of four Laboratory Control Samples (LCSs) prior to the analysis of actual customer samples. The performing of four LCSs prevents the new technician from making "first timers" mistakes to real samples. In the Air Science Gravimetric Laboratories, training includes four subsequent weighings of laboratory blanks

prior to the analysis of actual customer samples; additionally, an analyst comparison study is performed.

Ongoing demonstrations of competence in the Trace Metals, Organics, Soils, and Water laboratories may consist of successful participation in a proficiency Test study or successful analysis of four consecutive LCSs.

Initial demonstrations of competence in the Radiochemistry laboratory are performed by conducting an MDL study per the Method Detection Limit procedure, or by successfully analyzing a minimum of four Laboratory Reagent Blanks (LRBs) and four LCSs prior to the analysis of actual customer samples. For demonstration of competence with analysis of drinking water samples, the amount of analyte in the LCS should be between the radioanalyte's MCL and its required detection limit.

Ongoing demonstrations of competence in the radiochemistry laboratory are made annually per either of the two options described in the previous paragraph, or by compiling batch QC sample analysis data performed by the analyst during the year. Data for four LRBs, from four separate batches, analyzed on four non-consecutive days are assessed to verify sensitivity. Data from four LCSs, from four separate batches, analyzed on four non-consecutive days are assessed to verify accuracy and precision. For drinking water, the amount of analyte in the four LCSs should be between the radioanalyte's MCL and its required detection limit.

Authorization must exist for methodology training to be considered complete. To authorize methodology training, the Laboratory Supervisor or deputy must complete the "Training and Authorization" form. The form and attached demonstration of competence must be reviewed by the Section Supervisor, Quality Manager, and Lab Manager. Their signatures are affixed, authorizing the analyst to begin independent work in the lab. A copy of this form will be kept by the Quality Assurance Manager.

Each time an analytical SOP is revised, personnel authorized to perform the method are briefed on the revisions by either a supervisor or the person making the revision. Both the trainer and the trainee then sign the method training record at the end of the SOP.

Report Generation Training:

Typically, personnel authorized to issue reports include Laboratory Supervisors, Laboratory Managers, Project Managers, and Quality Managers or their deputies.

Training entails demonstration of the reporting process while working beside a Project Manager, discussion of data review and critical elements of reporting,

and review of the Report Generation Procedure. During the training period, prior to authorization, reports must be reviewed by both the trainee and the trainer. A Training and Authorization record is made as personnel are authorized to review and issue reports. A description of training, participants and their roles, the date of authorization, and the signature of laboratory supervisory personnel authorizing the trainee are recorded.

Quality System Training:

Every person who performs duties associated with the quality system procedures shall be trained and refreshed every year prior to performing the procedures. Examples of quality system procedures are shown below:

Sample Receiving Procedure
Sample Receiving Procedure for Gravimetric Laboratories
Report Generation Procedure
Report Generation Procedure for Gravimetric Laboratories
Sample Disposal Procedure
Contract Review Procedure
Equipment Procedure
Method Detection Limit Procedure
Measurement Uncertainty Procedure
Purchasing/Subcontracting Procedure

NIST Traceability Procedure
Quality Assurance Manual
Document Control Procedure
Control of Records Procedure
Corrective Action Procedure
Audit Procedure
Training Procedure
Client and Data Confidentiality Procedure
Elimination of Undue Pressure Procedure
Handling of Outside Activities Procedure
Management Review Procedure

IT Procedures
Field Services Sampling Procedure
Data Handling Procedures
Preventive Action Procedure
Proficiency Testing Procedure

Material presentations typically are performed by having a trainer explain the material in a verbal and/or graphical presentation. What is an appropriate material presentation is determined by the Quality Assurance Manager or deputy.

Annual Quality Training includes Data Integrity Training, at minimum, alternating with full Quality system training every other year.
Demonstrations of competence typically include a quiz. What is an appropriate demonstration of competence is determined by the Quality Assurance Manager or deputy.

Data Integrity Training consists of training on the quality system procedures of the Quality Assurance Manual, Elimination of Undue Pressure Procedure, Handling of Outside Activities Procedure, Client and Confidentiality Procedure, Data Handling Procedure, and a signed attestation of honest work production on the Inter-Mountain Laboratories Data Integrity Attestation Statement.

New Employee Orientation includes Data Integrity Training as well as appropriate general laboratory procedures, such as Balance Calibration, RO/DI Water Conductivity Check Procedure, Glass Cleaning Procedure, Thermometers and Monitoring Procedure, and Training Procedure.

Authorization must exist for training to be considered complete. To authorize training, the Quality Assurance Manager or deputy completes and signs the "Training Presentation and Authorization" form. This form shall be kept by the Quality Assurance Manager.

Software Training:
All software associated with LIMS, instruments, methodology, and production of work is considered informally trained.

The informal procedure is as follows:

1) A trained employee verbally explains how to perform a task on the software to the employee in training.
2) The trained employee then demonstrates the task to the employee in training.
3) The employee in training is then asked to perform the task to the trained employee.
4) If successful, the employee is considered trained. If not the procedure is repeated until successful.

Chemical Hygiene Training:

Currently monthly safety meetings are required attendance for all technical laboratory personnel. Chemical hygiene training is under the direction of Safety. This method only mentions this area in order to identify training needs.

Approvals:

_____
Laboratory Official Date

_____
Quality Assurance Official Date

Standard Operating Procedure for Elimination of Undue Pressure

Scope and Application:

This procedure applies to all activities within Inter-Mountain Laboratories which may be impacted by external expectations or demands.

Summary:

Managers, Supervisors, Analysts and Technicians will have avenues to relieve pressures that, left unchecked, may compromise the quality of analytical data.

Definitions:

Undue pressure is defined as demands from external or internal sources to modify methods or data in order to meet expectations for due dates or results. This definition does not – and cannot – cover all situations but it should be interpreted in connection with IML's Ethics Policy and good common sense. Undue pressure may include the following situations (plus others):

> Threat of loss of employment if analyses of a specific sample set is not completed "immediately".
>
> Threat of negative employee review if results do not match expected values.
>
> Supervisory direction to alter results.
>
> Insistence that analyses be completed without acceptable Quality Control parameter results.
>
> Client insistence that results are "wrong" and contract will be rescinded if results are not "right".

Turn times are defined as the time from sample receipt to submission of results to the client. Rush analyses are laboratory analysis packages that are prioritized to be performed in less time than the standard laboratory turn time. Rush status may only be assigned if shortened turn time allows for performance of all necessary analytical steps and associated quality control.

Quality Control:

All appropriate Quality Control parameters must meet acceptance criteria to qualify results to be reported.

Procedure:

Undue pressure may be exerted from a number of sources, including (but not limited to):

Due dates that do not account for all analytical steps.

Instrument downtime impacting turn times.

Management expectations.

Client expectations of results to meet their regulatory needs.

Instrument limitations.

The Contract Review Procedure incorporates realistic evaluation of laboratory capacity as part of the performance criteria review.

Client communications to discuss results will be taken by section supervisors or lab management to isolate analysts from client expectations. Managers or supervisors will request conformational analyses without defining client expectations.

Management may set fiscal or throughput goals for each operation but non-attainment of a single goal will not be the basis for continued employment of staff.

Clients may tour the laboratory with a guide but may not participate in the analysis of their own samples.

Analysts who feel that they are being pressured to produce data that is not of acceptable quality will initiate a Corrective Action Request form.

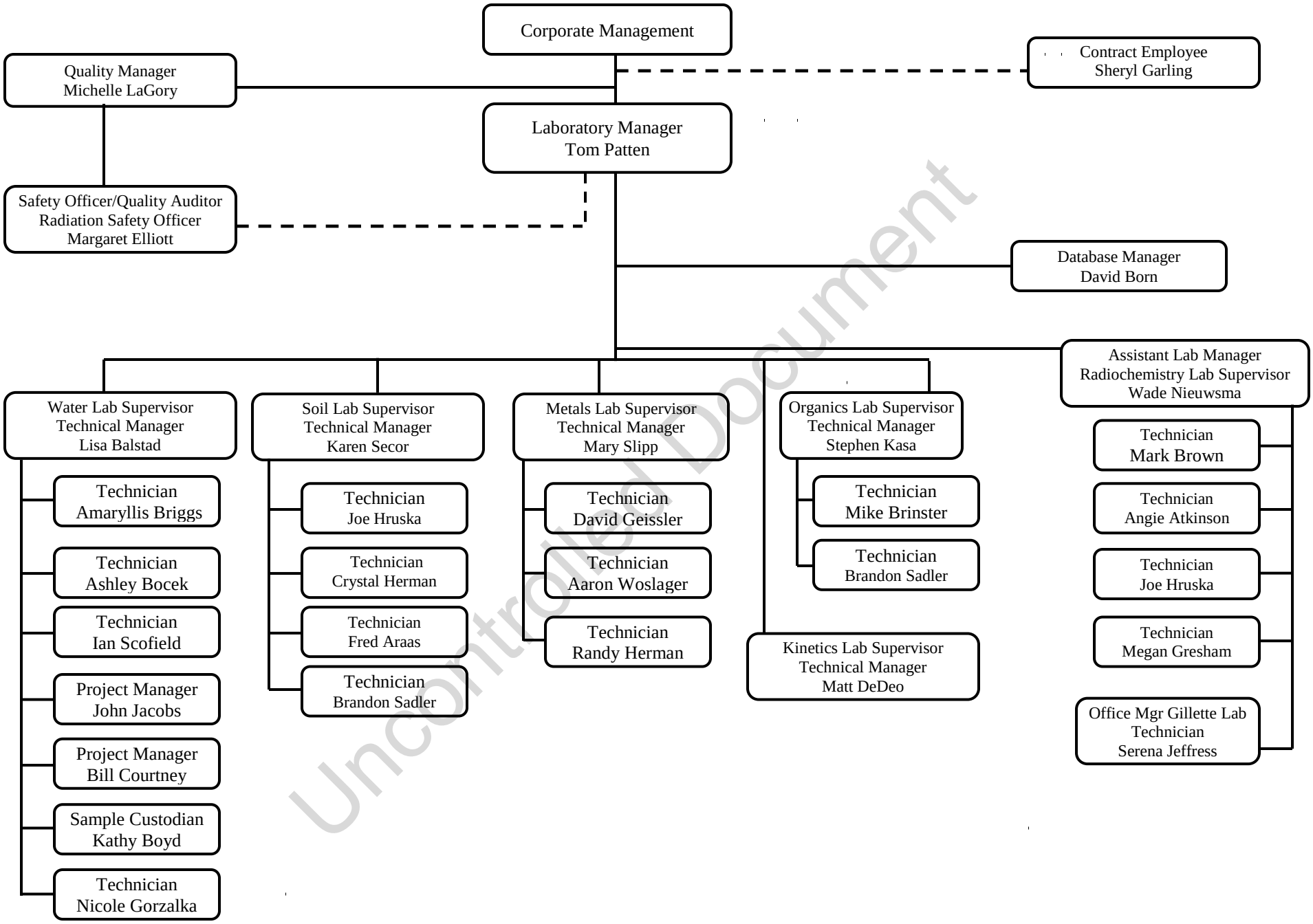
References:

ISO/IEC17025:2005, “General Requirements for the Competence of Testing and Calibration Laboratories”.

Quality Assurance Official:_____

Lab Official:_____

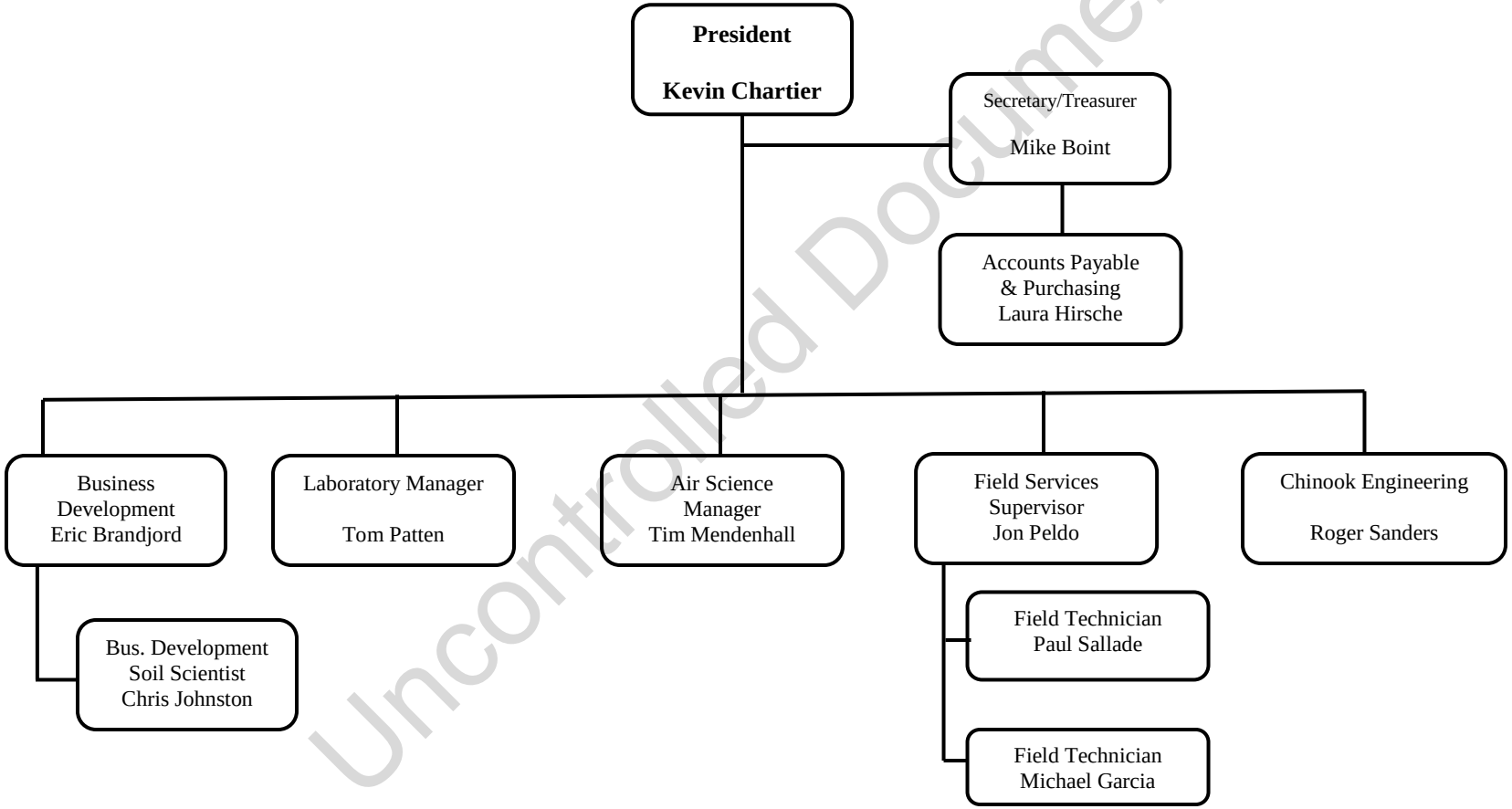
Date:_____



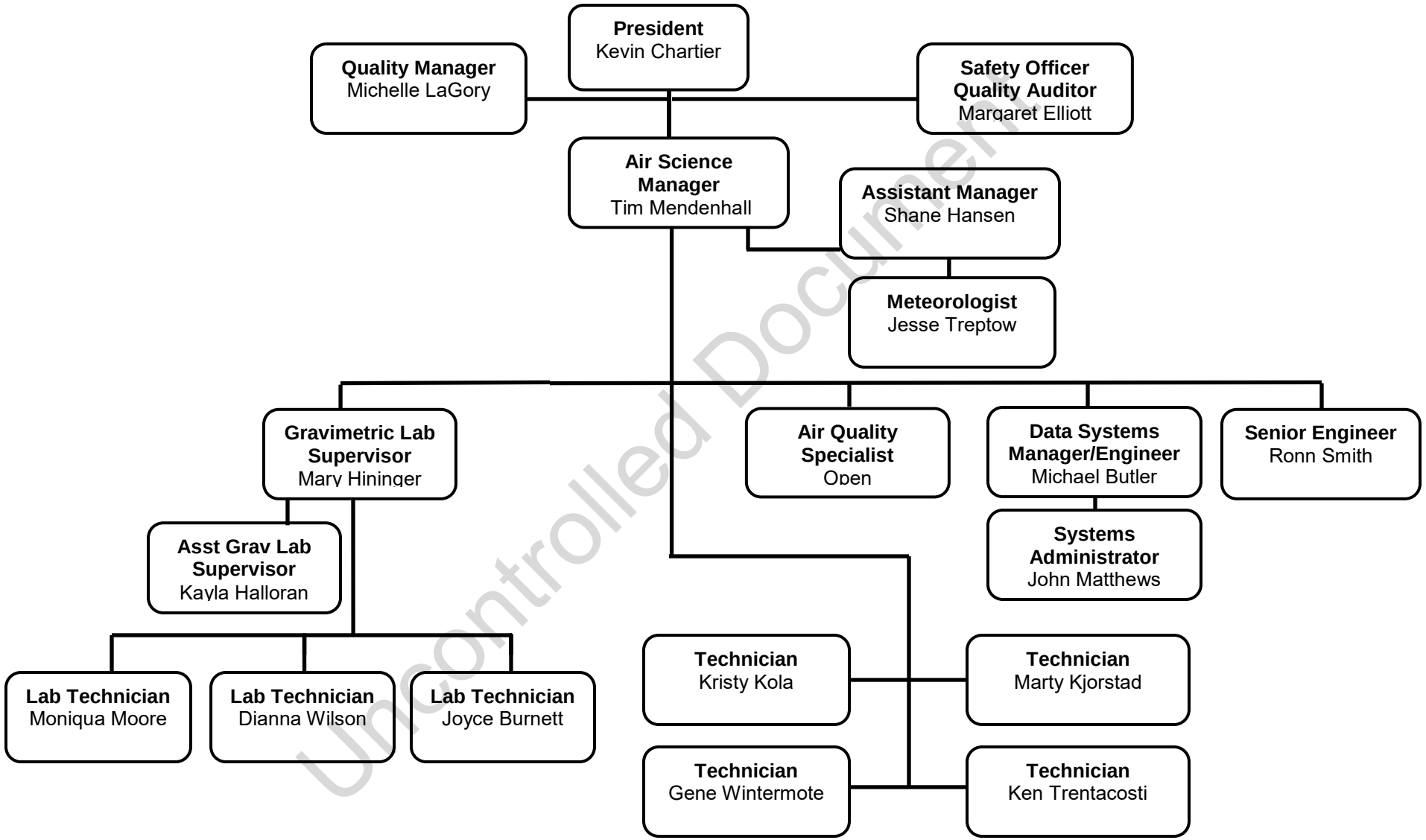
Lab Organizational Chart

Inter-Mountain Laboratories, Inc.
Organization Chart

Corporate Management



IML Air Science Organization
February 2017



ORGANIZATIONAL RELATIONSHIPS

Scope:
This document explains the organizational relationships of Inter-Mountain Laboratories Incorporated.

Operations:

Inter-Mountain Laboratories Incorporated operates analytical laboratories, field services, technical services, and air science services. Inter-Mountain Laboratories Incorporated conducts business as Chinook Engineering. Chinook Engineering manufactures measuring devices and provides metrology calibration services.

Senior Management:
Senior Management consists of the three officers of the company, Kevin Chartier, Tom Patten, and Mike Boint. Kevin is the president of the company and makes the important decisions for capital outlay. Mike Boint is Vice President and the financial officer. He maintains and provides the financial information concerning the company. Tom Patten is Vice President and is responsible for laboratory operations.

Support Services:
Certain positions within the company cross many boundaries; these positions are considered support service providers. Examples of support services are networking, database management, business development, and quality coordination.

Approvals:

_____
Michelle LaGory Date
Quality Assurance Manager

_____
Kevin Chartier Date
President of Company

Attachment 4

Accreditations, Certifications, Licenses, Approvals

Organization	Program	Certificate Number
Arizona Department of Health Services	PM in Air	AZ0773
Arizona Department of Health Services	Pb in Air	AZ0774
USEPA Region 8	SDWA	WY00005
Idaho Dept of Health & Welfare	SDWA	EPA ID: WY00005
Louisiana Dept of Env Qual	PM in Air	05062
Montana Dept of Public Health	SDWA	CERT00001
Nevada Dept of Conservation & Nat Res	CWA/RCRA/Mining	WY000052018-1
North Dakota State Dept of Health	SDWA	R-199
North Dakota State Dept of Health	CWA/RCRA	R-199A
North Dakota State Dept of Health	RCRA Organics	R-199B
Oklahoma Dept of Env Quality	CWA	2017-025
South Dakota Dept of Env & Nat Res	SDWA	WY00005
Texas Commission on Env Quality	Air/CWA/RCRA	T104704507-17-8
Railroad Commission of Texas	Surface Coal Mining & Rec	File Ref No: 1423801
USDA Animal & Plant Health Insp Serv	Permit to Receive Soil	P330-15-00304
USNRC	Materials License	49-29405-01
Utah Dept of Health	CWA	WY000052017-6

EXHIBIT A1-2

LABORATORY STANDARD OPERATING PROCEDURES

INTER-MOUNTAIN LABS

STANDARD OPERATING PROCEDURES

Standard Operating Procedures for Agilent Inductively Coupled Plasma Mass Spectrometer

Document Title: Standard Operating Procedures for Agilent ICPMS

Document Control Number: M-Agilent_ICPMS-2. 3

Location: Inter-Mountain Laboratories, Inc., Sheridan

Address: 1673 Terra Avenue
Sheridan, WY 82801

Edited by: Mary Slipp

Title: Metals Section Supervisor **Phone:** (307) 672-8945

Quality Manager: Michelle LaGory

Telephone: (307) 672-8945

Address: 1673 Terra Ave

Sheridan, WY 82801

Plan Coverage: Standard Operating Procedures for Analysis of Trace Metals using Agilent Inductively Coupled Plasma-Mass Spectrometer.

Lab Representative: _____

Lab Supervisor: _____

Standard Operating Procedure for Agilent ICPMS

1.0 Test Method.

1.1 Standard operating procedure for the analysis of elements in an aqueous solution using inductively coupled plasma mass spectrometry.

2.0 Sample Matrix.

2.1 Aqueous

3.0 Detection Limits.

3.1 Method Detection Limits (MDLs) are determined yearly for USEPA 200.8 and Method 6020A and every 6 months for IO-3.5 and IML2009, or more frequently if applicable per IML's Method Detection Limit procedure. A MDL study is performed by new operators, and whenever a significant change has been made to the instrument system that would affect instrument performance.

3.2 MDLs take any dilutions performed into consideration.

3.3 Report Limits may be predetermined by regulatory requirements, or by customer requirements; otherwise, report limits are established at 2 to 5 times the determined MDL.

3.4 Refer to the procedure described in 40 CFR Part 136 Appendix B for MDL acceptance and calculation criteria.

3.5 MDLs are matrix specific.

3.6 Data is available upon request.

4.0 Scope and Application.

4.1 This method details the procedure for analyzing various elements in aqueous solutions.

4.2 This method is appropriate for drinking water, surface water, ground water, waste water, aqueous extractions of solids, biosolids, filter extractions, and select biological fluids.

4.3 Performance of this procedure requires a working knowledge of the Agilent ICPMS.

4.4 Some elements commonly reported using this SOP are: Be, Al, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Ga, As, Se, Sr, Mo, Ag, Cd, Sn, Sb, Ba, La, Tl, Pb, Bi, and U.

5.0 Method Summary.

5.1 ICP-MS technology makes possible the simultaneous multi-element determination of trace elements. Sample material in solution is introduced by pneumatic nebulization into

a radio-frequency plasma, where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a quadrupole mass spectrometer having a minimum resolution capability of 1 amu peak width at 5% peak height. The ions transmitted through the quadrupole are detected by an electron multiplier, or Faraday detector, and the ion information processed by a data handling system. Interferences relating to the technique must be recognized and corrected for. Such corrections must include compensation for isobaric elemental interferences and interferences from polyatomic ions derived from the plasma gas, reagents, or sample matrix. Instrumental drift as well as suppressions or enhancements of instrument response caused by the sample matrix must be corrected for by the use of internal standards.

6.0 Definitions.

6.1 Calibration Blank: A volume of reagent water acidified with the same acid matrix as in the calibration standards.

6.2 Calibration Standard: A solution prepared from the dilution of stock standard solutions. The calibration solutions are used to calibrate the instrument response with respect to analyte concentrations.

6.3 Continuing Calibration Blanks (CCB): The CCB is a solution that is matrix –matched to the calibration solutions and does not contain the analyte of interest.

6.4 Continuing Calibration Verification (CCV): The CCV standard is prepared from the calibration standard stocks near the midpoint of the calibration curve and is used to verify the calibration.

6.5 Dissolved Analyte: The concentration of analyte in an aqueous sample that will pass through a 0.45µm membrane filter assembly prior to sample acidification.

6.6 Duplicate (DUP): A DUP is a replicate of an actual sample, analyzed to provide precision information about the analysis.

6.7 High Standard Verification (HSV): A quality control check that reanalyzes the highest standard used to demonstrate calibration linearity.

6.8 Initial Calibration Blank (ICB): The ICB is a solution that is matrix-matched to the calibration solutions and does not contain the analyte of interest.

6.9 Initial Calibration Verification (ICV): The ICV is a calibration standard at a concentration near the midpoint of the calibration curve and is used to verify the calibration.

6.10 Instrument Detection Limit (IDL): The concentration equivalent to the analyte signal, which is equal to three times the standard deviation of a series of seven replicate measurements of the calibration blank.

6.11 Interference Check Sample (ICS/ICSAB): A multi-element standard of known concentrations used to monitor and verify instrument performance as needed and depending upon the method being analyzed. The ICSAB contains elements of interest as well as interference elements.

6.12 Internal Standard Solution: A solution containing pure analytes added to a sample, extract, or standard solution in known amounts and used to measure the relative responses of other method analytes that are components of the same sample or solution. The internal standard must be an analyte that is not a sample component.

6.13 Laboratory Fortified Blank (LFB) or Laboratory Control Sample (LCS): A blank sample that has been fortified with the analyte of interest or a sample that has a known value for the analyte of interest and has been processed through the entire analytical method.

6.14 Laboratory Reagent Blank (LRB): An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and internal standards that are used with other samples. The LRB is used to determine if method analytes or other interferences are present in the laboratory environment, reagents, or apparatus.

6.15 Linear Dynamic Range (LDR): The concentration range over which the instrument response to an analyte is linear.

6.16 Low Level Initial Calibration Verification (LLICV), method 6020A: The calibration verification run after the calibration and represents a lower concentration near the reporting limit.

6.17 Low Level Calibration Verification (LLCCV), method 6020A: The calibration verification run as needed which represents a lower concentration near the reporting limit.

6.18 Lower Limit of Quantitation (LLOQ), methods 6020A and EQL-0310-189: The LLOQ is prepared from calibration standard stocks at or near the reporting limit and is used to verify reporting limit feasibility.

6.19 Matrix Spike (MS): The MS is a replicate of an actual sample that has been laboratory-fortified with analyte to provide information about the effect of the sample matrix on the analysis.

6.20 Matrix Spike Duplicate (MSD): The MSD is an additional replicate of the same sample as the MS, laboratory-fortified at the same concentration, used to demonstrate precision and bias.

6.21 Method Blank (MB): A solution that is matrix-matched to samples and calibration standards that does not contain the analytes of interest. The MB is processed through all of the same procedural steps as actual samples.

6.22 Method Detection Limit (MDL): The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration

is greater than zero. Refer to the procedure described at 40 CFR Part 136 Appendix B and the IML Method Detection Limit Procedure for further details.

6.23 Quality Control Sample (QCS): A solution of method analytes of known concentrations, which is used to fortify an aliquot of LRB or sample matrix. The QCS is obtained from a source external to the laboratory and different from the source of calibration standards. It is used to check either laboratory or instrument performance.

6.24 Stock Standard Solution: A concentrated solution containing one or more method analytes prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source.

6.25 Total Recoverable Analytes: The concentration of analyte determined either by "direct analysis" of an unfiltered, acid-preserved drinking water sample with turbidity of < 1 NTU, or by analysis of the solution extract of a solid sample or an unfiltered aqueous sample following digestion by refluxing with hot dilute mineral acid(s).

6.26 Tuning Solution: A solution which is used to determine acceptable instrument performance prior to calibration and sample analysis.

7.0 Interferences, Considerations.

7.1 Several types of interference effects may contribute to inaccuracies in the determination of trace elements. They can be summarized as follows:

7.1.1 Isobaric elemental interferences: These are caused by isotopes of different elements which form singly or doubly-charged ions of the same nominal mass-to-charge ratio and which cannot be resolved by the mass spectrophotometer. All elements determined by this method have, at a minimum, one isotope free of isobaric elemental interference. Of the analytical isotopes recommended for use with this method, only molybdenum-98 (ruthenium) and selenium-82 (krypton) have isobaric elemental interferences. If alternative analytical isotopes having higher natural abundance are selected in order to achieve greater sensitivity, an isobaric interference may occur. All data obtained under such conditions must be corrected by measuring the signal from another isotope of the interfering element and subtracting the appropriate signal ratio from the isotope of interest.

7.1.2 Abundance sensitivity: This is a property defining the degree to which the wings of a mass peak contribute to adjacent masses. The abundance sensitivity is affected by ion energy and quadrupole operation pressure. Wing overlap interferences may result when a small ion peak is being measured adjacent to a large one. The potential for these interferences should be recognized and the spectrometer resolution adjusted to minimize them.

7.1.3 Isobaric polyatomic ion interferences: These are caused by ions consisting of more than one atom which have the same nominal mass-to-charge ratio as the isotope of interest, and which cannot be resolved by the mass spectrometer. These ions are

commonly formed in the plasma or interface system from support gasses or sample components. Most of the common interferences have been identified, and these are listed in Table 5. Such interferences must be recognized, and when they cannot be avoided by the selection of alternative analytical isotopes, appropriate corrections must be made to the data. Equations for the correction of data should be established at the time of the analytical run sequence, because the polyatomic ion interferences will be highly dependent on the sample matrix and chosen instrument conditions. In particular, the common 82Kr interference that affects the determination of both arsenic and selenium can be greatly reduced with the use of high purity krypton-free argon.

7.1.4 Physical interferences: These are associated with the physical processes that govern the transportation of sample into the plasma, sample conversion process in the plasma, and the transmission of ions through the plasma-mass spectrometer interface. These interferences may result in differences between instrument responses for the sample and the calibration standards. Physical interferences may occur in the transfer of solution to the nebulizer (e.g., viscosity effects), at the point of aerosol formation and transport to the plasma (e.g., surface tension), or during excitation and ionization processes within the plasma itself. High levels of dissolved solids in the sample may contribute deposits of material on the extraction and /or skimmer cones reducing the effective diameter of the orifices and therefore ion transmission. Dissolved solids levels not exceeding 0.2% (w/v) are recommended. Internal standards may be used effectively to compensate for many physical interference effects.

7.1.5 Memory interferences: These result when isotopes of elements in the previous sample contribute to the signals measured in a new sample. Memory effects can be a result of sample deposits on sampler and skimmer cones, plasma torch, and spray chamber. These interferences can be minimized by flushing with a rinse blank between samples.

8.0 Safety.

8.1 Each chemical compound used should be treated as a potential health hazard. Standards are all to be considered toxic and handled accordingly. Personnel should follow guidance in the IML Safety Plan. SDSs are available for reference. Should spills occur, contact the safety officer.

8.2 ICP-MS instruments operate at high currents of electricity and care should be taken to avoid placement of liquids upon the instrument.

9.0 Apparatus and Materials.

9.1 Inductively coupled plasma mass spectrometer

9.2 Appropriate data handling system

9.3 An instrument-compatible chiller

9.4 Analytical balance

9.5 Centrifuge with guard bowl

9.6 Air displacement pipettes (a variety of volumes)

9.7 Class A volumetric flasks, graduated cylinders

9.8 Argon, hydrogen and helium gas supply

10.0 Reagents and Consumable Materials.

10.1 All standard stock solutions and quality control solutions, either single element or multi-element, are purchased from approved commercial suppliers.

10.2 Reagent water: IML lab-produced deionized (DI) water

10.3 Nitric acid (HNO_3): concentrated, trace metals grade

10.4 Hydrochloric acid (HCl): concentrated, trace metals grade

10.5 Rinse Blank: 2% HNO_3

10.6 Tuning Solution: See IML Standards Preparation Procedure

10.7 Internal Standards Solution: See IML Standards Preparation Procedure

10.8 Interference Check Solutions: See IML Standards Preparation Procedure

10.9 Test tubes: Plastic, single-use

10.10 Disposable pipette tips: various capacities

10.11 Various sizes of metals-free plastic containers

11.0 Sample Collection, Preservation, Handling.

11.1 Aqueous samples received by the laboratory must be sampled in glass, fluoropolymer, or polyethylene containers.

11.2 If water samples for total metals analysis are received unpreserved at the laboratory, 1+1 nitric acid is added to pH<2 at receipt. Samples are then held for a minimum of 24 hours prior to analysis, to dissolve any metals that have adsorbed to the container walls.

11.3 Samples for analysis as dissolved metals are filtered in the laboratory if they have not been filtered prior to receipt. After filtering with a 0.45 µm filter, the samples are acidified with 1+1 nitric acid to a pH<2. When samples are filtered in the lab, the

technician records the date and time of filtering, as well as their initials on the bottle label.

11.4 The pH of all aqueous samples (dissolved, total, and total recoverable) must be checked immediately before subsampling for analysis or digestion to assure that the sample pH is <2. The pH will be documented in LIMS recording the date and time of the pH check, sample ID, pH strip lot number, analyst performing analysis, pH result, lot number of preservative if available. If pH is >2, additional HNO3 must be added to the sample, and it must be held for an additional 24 hours prior to processing. This procedure may be repeated as many times as needed until the desired pH <2 is reached.

11.5

11.6 Sample preparation and digestion (if applicable) are detailed in IML SOPs for digestion by EPA methods 200.2, 3020A, IO-3.1, and FEM IML 2009 Appendix A.

11.7 The lab provides plastic 250 mL bottles with red label and a small vial with red cap containing 2 mL of 1+1 nitric acid for preservative.

11.8 Sample Hold Times:

11.8.1 If properly preserved, aqueous samples can be held up to 6 months before analysis.

11.8.2 For air filters, the maximum sample holding time is usually 180 days from collection.

12.0 Quality Control.

12.1 Instrument log and standards preparation logs are documented electronically in the LIMS.

12.2 Initial calibration blank (ICB) and continuing calibration blank (CCB) are analyzed initially and every 10 samples.

12.3 DUP soil samples are designated by the soils department, duplicate water samples are randomly selected by the metals technician at a frequency of 10%.

12.4 Supplier-certified calibration verification (second source) must be analyzed after every calibration to verify calibration standards.

12.5 Data quality objectives for the analysis of QA/QC samples for each ICPMS method are summarized in Tables 1, 2, 3, and 4.

12.6 Internal standards may be changed from initial instrument settings due to presence in the sample or internal standard drift.

12.7 Bioassay samples that are greater than the reporting limit will be verified by repeat analysis.

12.8 Dissolved spiked (MS, MSD, and dissolved LCS) samples are prepared by diluting the original sample as needed then adding 0.1 mL of 10ppm ICPMS spiking solution to 10 mL of the diluted sample.

13.0 Calibration and Standardization.

13.1 Calibration standards are handled in accordance with the appropriate method being run. The standards are diluted to working solutions from stock supply. Preservation is to match normal sample acid concentrations for analysis. Multi-element solutions are used and obtained from reputable commercial sources. Details about calibration concentrations and requirements for each method are listed in Tables 1, 2, 3, and 4.

13.2 The instrument must be calibrated at the beginning of each run.

13.3 Calibration data are accepted based upon acceptance criteria outlined in the appropriate method being used as detailed in Tables 1, 2, 3, and 4.

13.4 IML routinely uses an external calibration (as opposed to a standard additions calibration). This can be checked by viewing the settings in the Online ICPMS Mass Hunter software and choosing the Batch section → Data Analysis Method tab → Full Quant tab → Basic Calibration Parameters → Calibration Method → External Calibration.

14.0 Procedure.

14.1 See Appendix 1 for detailed instrument operation instructions and screen shots of software operations.

14.2 Maintenance procedures are followed as recommended by the instrument's manufacturer and outlined in the appropriate method. Peristaltic pump tubing and 2% HNO_3 rinse water are changed daily, or as needed. Pump oil is changed according to instrument manufacturer's recommendation. Chiller fluid level must be monitored periodically and changed as needed. The ICPMS sampler and skimmer cones, and Extraction Lens-Omega Lens assembly are cleaned or replaced as needed. Periodic cleaning or changing of the nebulizer, spray chamber, auto-sampler tubing, torch, and instrument tubing will be necessary. Any time the operator feels that the instrument is not operating properly; the problem will be found and rectified before processing samples.

14.3 Initiation of the ICPMS begins with checking for adequate argon, helium and hydrogen gas, changing and engaging peristaltic pump tubing, emptying waste, and filling 2% HNO_3 water and 2% HNO_3 + 2% HCl rinse reservoirs. Uncap all tuning solutions and the P/A solution. Place the internal standard line in a solution of 2% HNO_3 DI. Turn on the computer monitor and computer if not already on. Open the Agilent operating

software labeled ICPMS Instrument Control. Create the day's working batch file by copying the previous day's batch using "Save Batch As…" function under "File" and give it the current date as a file name saving it to the D drive. Delete previous data from the queue and any samples in the Sample List tab in the Unknown Samples table. Check to make sure Start Up has tests checked that you want to have run at the end of the warm-up period. Put the auto-sampler probe in the 1ppb Tuning Solution by going to the auto-sampler section of the task bar and telling the auto-sampler the location of the 1ppb Tuning Solution. Press the "Plasma On" icon. At this point you can choose to let the software start the preset Performance Test after a 30 minute instrument warm-up, or you can manually start the Performance Test if needed. Allow the instrument to warm-up for at least 30 minutes.

14.4 After warm-up, the Start-Up program will run automatically, or must be started manually depending on the operator's choice to optimize, align and check instrument performance. The normal start-up sequence includes: Torch Axis, EM, Plasma Correction, Standard Lens Tune, Resolution/Axis, Performance Report, and P/A factor. When this is finished, check to assure all operations are successful and check the Performance Report to check sensitivity and cone condition. Put the auto-sampler probe in the 10ppb Tune Solution. Ensure that the instrument is in the "no gas" mode, and perform a "Signal Monitor" to detect when the instrument is in steady state and is ready for the instrument tune. Click the "Stop" icon. To start the instrument tune, click the "Start Auto Tune" green arrow icon. When this is complete click the "Save" icon. Then perform the USEPA tune check by clicking the "Generate Tune Report" icon in the Report section of the operations bar. The report will print automatically and save a pdf in the day's batch as well. Next tune the gas modes by clicking on the appropriate tab (no gas, He, or H2) and "Send to ICPMS" in the tool bar. Then time scan to equilibrate and when in a steady state click the "Start Auto Tune" green arrow icon. When complete, save settings. Continue to the next mode until all modes have been tuned. When finished, put the auto-sampler in the 2% HNO_3 rinse solution and the internal standard line in the internal standard. Start the "Signal Monitor" program in the Tune tab and monitor the reading until a steady state is achieved.

14.5 Enter a sample run table by going to the Batch section, then the Sample list tab, and highlight in the Sequence Flow table the Unknown Samples option and fill in the Unknown Samples table appropriately. Place prepared samples in the appropriate racks and then onto the auto-sampler. To start the run, click "Add to Queue" in the Batch (Queued) bar.

14.6 The auto-sampler table should be established following procedures according to EPA 200.8 (or appropriate method) and IML standard analysis procedures.

14.7 In the Online/Offline Data Analysis Mode, which auto initiates, run progress may be monitored in this mode.

14.8 Evaluate all data according to standards presented in all methods being run in that day's batch. Table 6 contains valuable guidance for isotope selection of select sample types and methods being utilized.

14.9 After the run is completed, export the data file by going to "File", "Export Table". Name the file and change the XLSX type to XLS to be compatible with Excel 97-2003 Workbook. Save the file in the day's batch and also export onto a flash drive to transfer the data to a LIMS enabled system.

14.10 The Agilent ICPMS can be set to auto-shut off by clicking the "Plasma Off at End" icon in the Queue. It can be manually shut down by clicking the "Plasma Off" icon in the task bar.

14.11 After the instrument has shut off, release the peristaltic pump tubing, send the auto-sampler home, and cap all solutions and rinses.

15.0 Data Analysis and Calculations.

15.1 ICPMS data is generated in µg/L.

15.2 Dilution factors, which are multiplied by the instrument software, must be reviewed to take instrument detection limits into account.

15.3 MS percent recovery calculation:

$$R = ((C[s] – C)/S)*100$$

Where:

R = percent recovery

C[s] = fortified sample concentration

C = sample background concentration

S = concentration equivalent of analyte added to fortify the sample

15.4 Relative percent difference (RPD):

$$RPD = ((D1-D2)/[(D1 + D2)/2]) * 100$$

Where:

RPD = relative percent difference

D1 = first sample value

D2 = second sample value

15.5 Air Filter Calculations:

Air filter conversion from µg/L to ng/filter for PM Teflon style filter using IO-3.1 digestion:

ng/filter = µg/L * 0.02 L/filter * 1000 ng/µg

Air filter conversion from µg/L to ng/filter for TSP/PM10 style filter using IO-3.1 digestion:

ng/filter = µg/L * 0.02 L/strip * 12 strips/filter * 1000 ng/µg

Air filter conversion from µg/L to µg/filter for TSP/PM 10 style filter using 40 CFR Appendix G Secion 50 digestion:

µg/filter = µg/L * 0.1 L/strip * 12 strips/filter

15.6 Percent solid calculation: % solid = (Sample Dry Weight/Sample Wet Weight) * 100

15.7 Conversion of µg/L to mg/kg using a 3050 digestion with 100mL final volume:

mg/kg = µg/g = µg/L * 0.1 L/1 g sample

16.0 Precision and Accuracy.

16.1 Precision is assessed by analysis of DUP samples.

16.2 Accuracy is assessed by analysis of LCS/QCS and MS samples.

17.0 Pollution Prevention

17.1 There is a low potential of pollution attributed to performance of this method.

18.0 Data Assessment and Acceptance Criteria.

18.1 The reporting limit is typically defined as 2-5 times the MDL.

18.2 If the method allows the use of an LDR, use the most recent acceptable LDR level. An acceptable LDR is one that, when run, read at ± 10% of the solution concentration used. The acceptable LDR level is then 10% less than the solution concentration used.

18.3 See Table 1-4 for a summary of acceptable QC criteria.

19.0 Contingencies and Corrective Action for Out of Control or Unacceptable Data.

19.1 For samples using method USEPA 200.8, IO-3.5, and EQL-0310-189, internal standards should read between 60-125%. If they do not, dilute problematic samples or find the causative problem and reanalyze affected samples.

19.2 For samples using method 6020A: If internal standard intensity < 70% , ensure that the instrument has not drifted by looking at internal standard in nearest clean matrix (CCB). If low internal standard intensities are observed in the CCB, correct the problem, recalibrate and reanalyze affected samples.

19.3 For samples using method 6020A: If drift hasn't occurred, matrix effects should be removed by diluting the affected sample fivefold (1+4) and reanalyze with internal standard. If this dilution does not remove matrix effect, repeat dilution until internal standard intensities rise to ≥70%.

19.4 If a quality control sample is out of acceptance, take corrective actions and repeat analysis.

19.5 Flag all quality control sample failures that cannot be resolved by repeating the analysis, such as a matrix spike recovery, in the final report.

20.0 Waste Management.

20.1 Sample disposal is conducted per IML Sample Disposal Procedure and IML Safety Plan.

21.0 References.

21.1 USEPA. May 1994. Determination of Trace Elements in Waters and Waste by Inductively Coupled Plasma Mass Spectrometry, Method 200.8, Revision 5.4.

21.2 Agilent 7700 Series ICPMS Mass Hunter Workstation User Guide, Manual Part Number G7201-90200, Rev. A, September 2010

21.3 Federal Register Vol. 72, No. 47. Monday March 12, 2007. Rules and Regulations, Table II

21.4 USEPA. February 2007. SW-846. Chapter Three, Inorganic Analytes, Revision 4.

21.5 USEPA. February 2007. Inductively Coupled Plasma-Mass Spectrometry, Method 6020A, Revision 1.

21.6 USEPA. June 1999. Compendium Method IO-3.5 Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS).

21.7 Inter-Mountain Labs. 2009. IML 2009 Procedure for the Determination of Lead in Ambient Air TSP by Hot Plate Acid Extraction and ICP-MS Analysis, EQL-0310-189.

21.8 40 CFR Part 136 Appendix B. Definition and Procedure for the Determination of the Method Detection Limit, Revision 1.11.

22.0 Tables, Diagrams, Comments.

22.1 Table 1. EPA 200.8 QC Acceptance Criteria

	USEPA 200.8	
QC Procedure	Criteria	Frequency
Performance Test	RSD< 5%	Daily
Initial Calibration	Min. Correlation Coefficient > 0.995	Beginning of each run
Calibration Standards	Min of one concentration with 3 replicates in ascending order (e.g.: blank, 1ppb, 10ppb, 20ppb, 100ppb, and 200ppb) starting with a calibration blank	
Internal Standard Recovery	60-125%	
QCS- Second Source QC	90-110%	Beginning of each run
ICV- Initial Calibration Verification	90-110%	Beginning of each run
ICB- Initial Calibration Blank	Less than project detection limits	Beginning of each run
CCV- Continuing Calibration Verification	90-110%	Every 10 samples and end of run
CCB- Continuing Calibration Blank	Less than project detection limits	Every 10 samples and end of run
Method Blank	Less than project detection limits	Once per batch of 20 samples
LCS- Laboratory Fortified Blank	85-115% or on-going QC charts	Once per batch of 20 samples
Duplicate (DUP)	≤20% RPD	Every 10 samples
Matrix Spike (MS)	70-130%	Every 10 samples
Matrix Spike Duplicate (MSD)	70-130% & ≤20% RPD	Every 10 samples
Sample Dilution		Needed if concentration > LDR
MDL- Method Detection Limit	7 fortified blanks @ 2-5x conc of mdl	Yearly
LDR- Linear Dynamic Range	10% of true value	Yearly

22.2 Table 2. SW-846 EPA 6020A QC Acceptance Criteria

	6020A

QC Procedure	Criteria	Frequency
Performance Test	RSD< 5%	Daily
Initial Calibration	Min. Correlation Coefficient > 0.998	Beginning of each run
Calibration Standards	Concentrations must contain a minimum of a blank and three non-zero standards in increasing concentration (e.g.: blank, 1ppb, 10ppb, 20ppb, 100ppb, and 200ppb)	
Internal Standard Recovery	≥70%	
QCS- Second Source QC (6020 ICV)	90-110%	Beginning of each run
ICV- Initial Calibration Verification (Second Source)	ICV = QCS = 90-110%	Beginning of each run
ICB- Initial Calibration Blank	Less than project detection limits	Beginning of each run
LL ICV- Low Level ICV	±30% at lowest reporting limit conc.	Beginning of each run
CCV- Continuing Calibration Verification	90-110%	Every 10 samples and end of run
CCB- Continuing Calibration Blank	Less than project detection limits	Every 10 samples and end of run
LL CCV- Low Level CCV	±30%	End of run
ICS/ICSAB- Interference Check Solution		Beginning of each run
Method Blank	Less than project detection limits	Once per digestion batch of 20 samples or less
LLQC	±30% of true value	Following establishment of lower RLs, and as needed
LCS- Laboratory Fortified Blank	80-120% or on-going QC charts. For solids, use manufacturer's established limits.	Once per batch of 20 samples
Duplicate (DUP)	≤20% (RPD)	Every 20 samples
Matrix Spike (MS)	75-125% (±20% for post-dig spikes) If the digested spike fails, a post digestion spike should have recoveries of ± 20%. If this spike fails, a dilution test should be run on this sample. If both digested and post digestion spikes fail, matrix effects are confirmed.	Every 20 samples
Matrix Spike Duplicate (MSD)	75-125% & ≤20% RPD If the digested spike fails, a post digestion spike should have recoveries of ±20%. If this spike fails, a dilution test should be run on this sample. If both digested and post digested spikes fail, matrix effects are confirmed.	Every 20 samples
Serial Dilution/Dilution Test	90-110%	Run if digested spike fails ±25%, then post-digest MS/MSD fails ±20%
Sample Dilution		Needed if concentration > LDR
MDL- Method Detection Limit	7 fortified blanks @ 3-5x conc of mdl	Yearly
IDL- Instrument Detection Limit	(Blanks x7) x3	Quarterly, non-consecutive days
LDR- Linear Dynamic Range	10% of true value	6 months

22.3Table 3. Method IO-3.5 QC Acceptance Criteria

	IO-3.5

QC Procedure	Criteria	Frequency
Performance Test and Mass Cal	RSD< 5%	Daily
Initial Calibration	Min. Correlation Coefficient > 0.995	Beginning of each run
Calibration Standards	Min of one concentration with 3 replicates in ascending order (e.g.: blank, 1ppb, 10ppb, 20ppb, 100ppb, and 200ppb) starting with a calibration blank	
Internal Standard Recovery	60-125%	
QCS- Second Source QC	90-110%	Beginning of each run
ICV- Initial Calibration Verification	ICV = QCS=90-110%	Beginning of each run
ICB- Initial Calibration Blank	Less than project detection limits	Beginning of each run
CCV- Continuing Calibration Verification	90-110%	Every 10 samples and end of run
CCB- Continuing Calibration Blank	Less than project detection limits	Every 10 samples and end of run
HSV- High Standard Verification	95-105%	Beginning of each run
ICS- Interference Check Solution (ICSAB)	80-120%	Beginning & end of each run
Reagent Blank		
Filter Blank=Method Blank	Values greater than the reporting limit should be flagged on the report.	
LCS- Laboratory Fortified Blank	80-120% or on-going QC charts	Once per batch of 20 samples
Duplicate (DUP)	<20% RPD	Once per batch of 20 samples
Matrix Spike (MS)	75-125%	Once per batch of 20 samples
Serial Dilution	90-110%	Once per batch of 20 samples
Sample Dilution		Needed if concentration > LDR
MDL- Method Detection Limit	7 fortified blks w/ filter @ 2-5x conc of mdl	Every 6 months
LDR- Linear Dynamic Range	10% of true value	Every 6 months

22.4 Table 4. FEM IML 2009 (EQL-0310-189) QC Acceptance Criteria

	FEM IML 2009	
QC Procedure	Criteria	Frequency
Performance Test and Mass Cal	RSD< 5%	Daily
Initial Calibration	Min. Correlation Coefficient 0.995	Beginning of each run
Calibration Standards	A minimum of three standards and a blank in ascending order (e.g.: blank, 1ppb, 10ppb, 20ppb, 100ppb, and 200ppb)	
Calibration Read-back Error	±30% lowest stds; ±10% other stds	Beginning of each run
Internal Standard Recovery	60-125%	
QCS- Second Source QC	90-110%	Beginning of each run
ICV- Initial Calibration Verification	90-110%	Beginning of each run
ICB- Initial Calibration Blank	Less than project detection limits	Beginning of each run
LLOQ	±50% at lowest reporting limit conc.	Beginning of each run
CCV- Continuing Calibration Verification	90-110%	Every 10 samples and end of run
CCB- Continuing Calibration Blank	Less than project detection limits	Every 10 samples and end of run
HSV- High Standard Verification	95-105%	Beginning of each run
ICS- Interference Check Solution	80-120%	Beginning & end of each run
Reagent Blank	Less than project detection limits	Once per batch of 20 samples
Filter Blank=Method Blank	Less than project detection limits	Once per batch of 20 samples
LCS- Laboratory Fortified Blank	80-120% or on-going QC charts	Once per batch of 20 samples
Duplicate (DUP)	≤20% RPD	Once per batch of 20 samples
Matrix Spike (MS)	75-125%	Once per batch of 20 samples
Serial Dilution	90-110%	Once per day
Sample Dilution		Needed if concentration > high std
MDL- Method Detection Limit	7 fortified blks w/ filter @ 2-5x conc of mdl	Every 6 months

22.5 Table 5. Common Polyatomic Ion Interferences in ICP-MS

Background Molecular Ions		
Molecular Ion	Mass	Element Interference
NH^+	15	
OH^+	17	
OH_2^+	18	
C_2^+	24	
CN^+	26	
CO^+	28	
N_2^+	28	
N_2H^+	29	
NO^+	30	
NOH^+	31	
O_2^+	32	
O_2H^+	33	
$^{36}ArH^+$	37	
$^{38}ArH^+$	39	
$^{40}ArH^+$	41	
CO_2^+	44	
CO_2H^+	45	Sc
ArC^+, ArO^+	52	Cr
ArN^+	54	Cr
$ArNH^+$	55	Mn
ArO^+	56	
$ArOH^+$	57	
$^{40}Ar^{36}Ar^+$	76	Se
$^{40}Ar^{38}Ar^+$	78	Se
$^{40}Ar_2^+$	80	Se

22.6 Table 6. Recommended Isotopes.

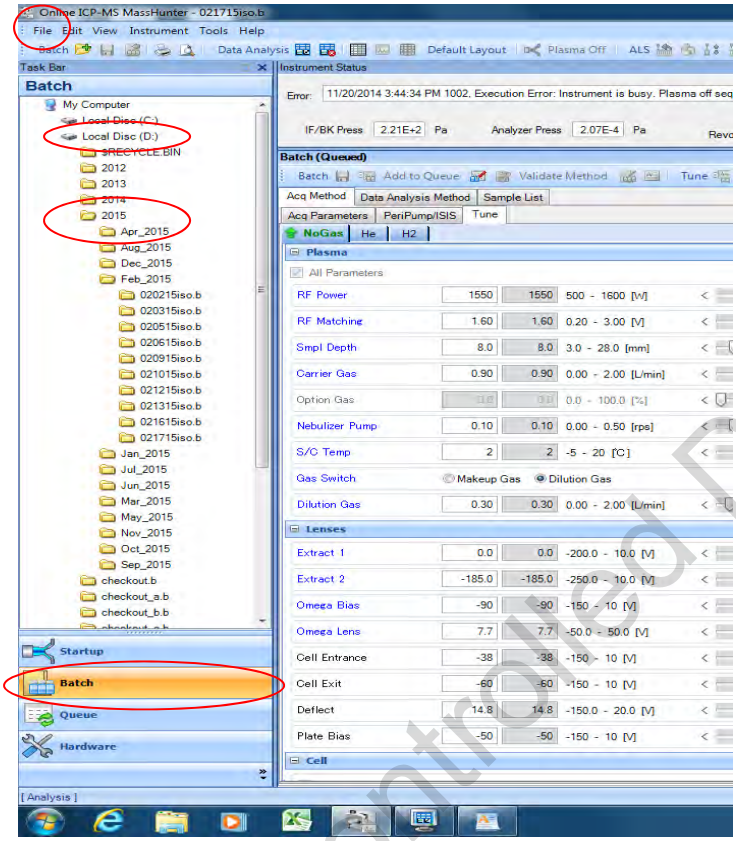
Recommended Analytical Isotopes*				
Element	EPA 200.8 Mass(es)	6020A Mass(es)	IO-3.5 Mass(es)	FEM IML 2009
Aluminum	27	27	27	
Antimony	121, 123	121, 123	121, 123	
Arsenic	75	75	75	
Barium	135, 137	138, 137, 136, 135, 134	135, 137	
Beryllium	9	9	9	
Bismuth		209		
Cadmium	106, 108, 111, 114	114, 112, 111, 110, 113, 116, 106	106, 108, 111, 114	
Chromium	52, 53	52, 53, 50, 54	52, 53	
Cobalt	59	59	59	
Copper	63, 65	63, 65	63, 65	
Lead	206, 207, 208	206, 207, 208, 204	206, 207, 208	206, 207, 208
Manganese	55	55	55	
Molybdenum	95, 97, 98	98, 96, 92, 97, 94	95, 97, 98	
Nickel	60, 62	58, 60, 62, 61, 64	60, 62	
Selenium	77, 82	80, 78, 82, 76, 77, 74	77, 82	
Silver	107, 109	107, 109	107, 109	
Thallium	203, 205	205, 203	203, 205	
Thorium	232		232	
Tin	118	120, 118	118	
Uranium	238		238	
Vanadium	51	51, 50	51	
Zinc	66, 67, 68	64, 66, 68, 67, 70	66, 67, 68	
Krypton	83			
*Isotopes recommended for analytical determination are underlined.				
*Drinking water analysis does not allow the use of gas mode determinations.				
*Certain matrices may require the use of alternative isotopes.				
*A recommendation is not a limitation.				

Appendix 1

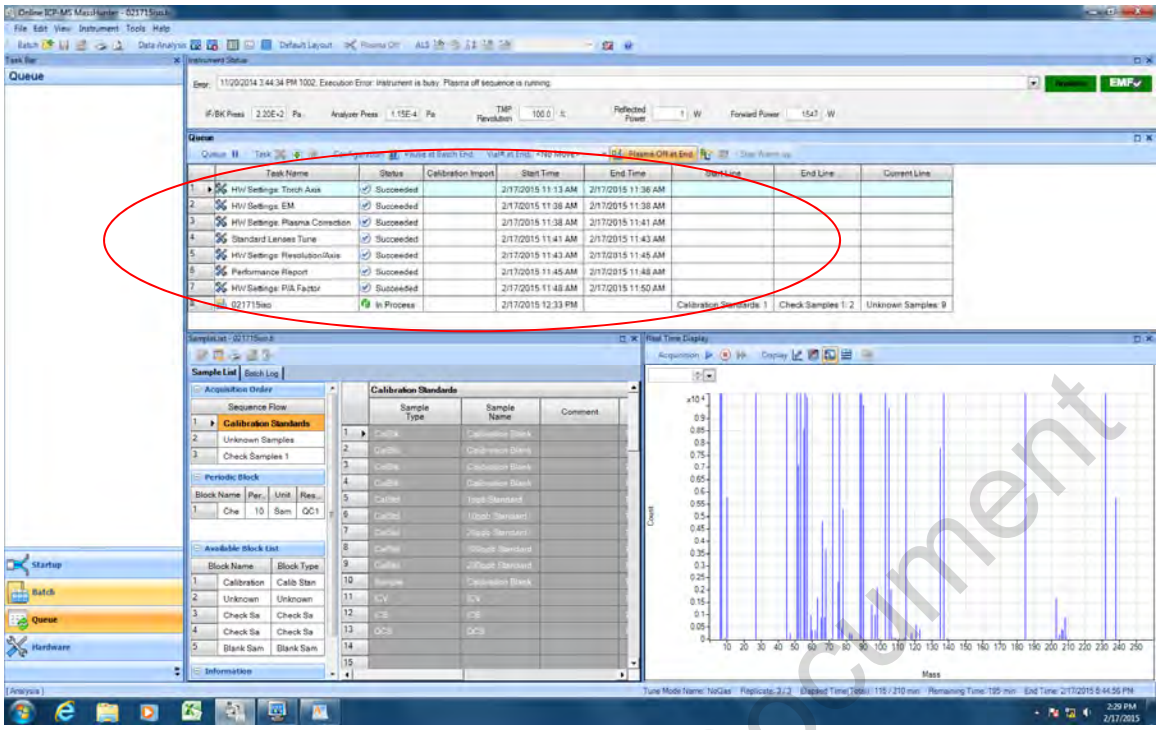
Step by Step Detailed Operation Instructions:

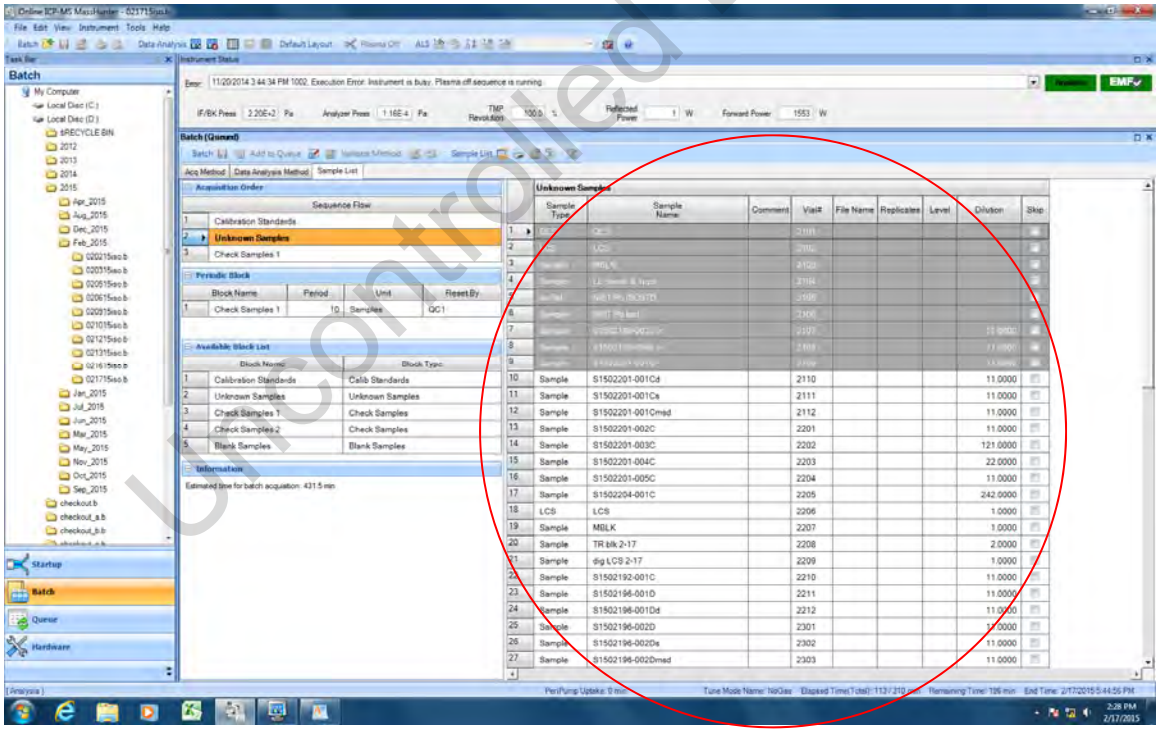
1. Open “ICP-MS Instrument” icon.

2. Create an operating file for the day. Open the last existing batch file. Go to “File”, “Save Batch As”, save new batch in the “D:” drive in the appropriate year and month giving it the current date followed by the letters “iso” (file that has Pb isotopes enabled).

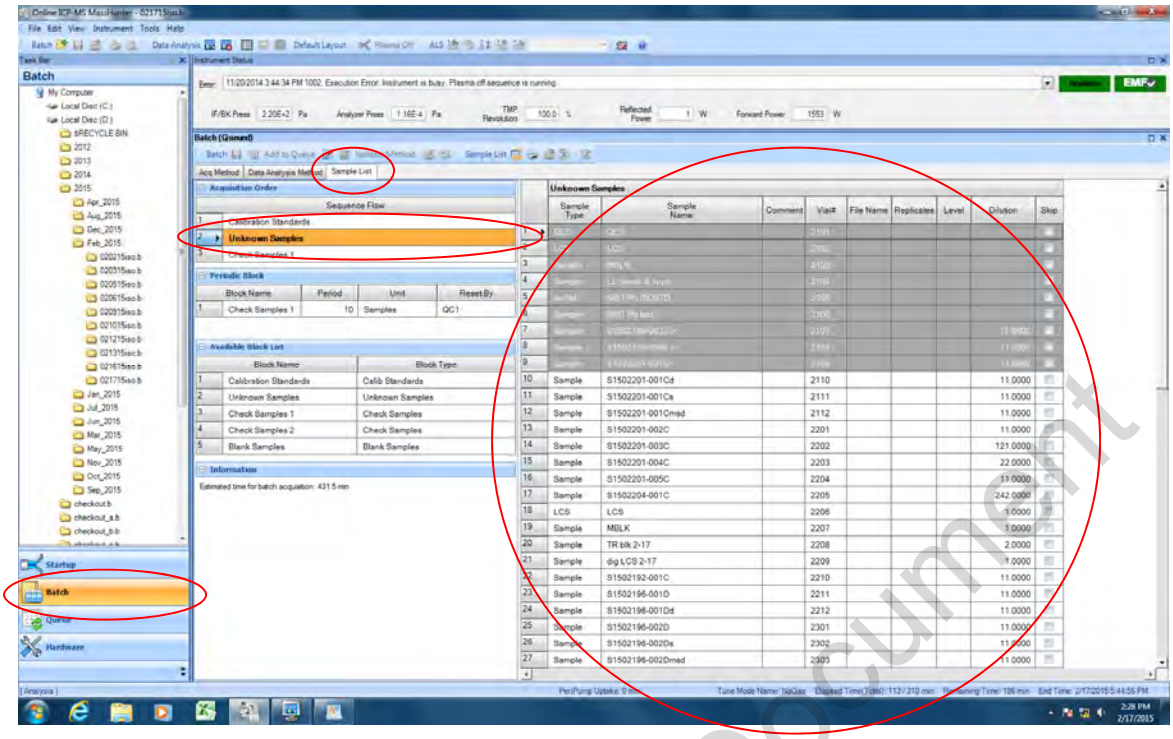


3. Highlight and delete the data from the queue and the sample list to create an empty template for the day’s use.



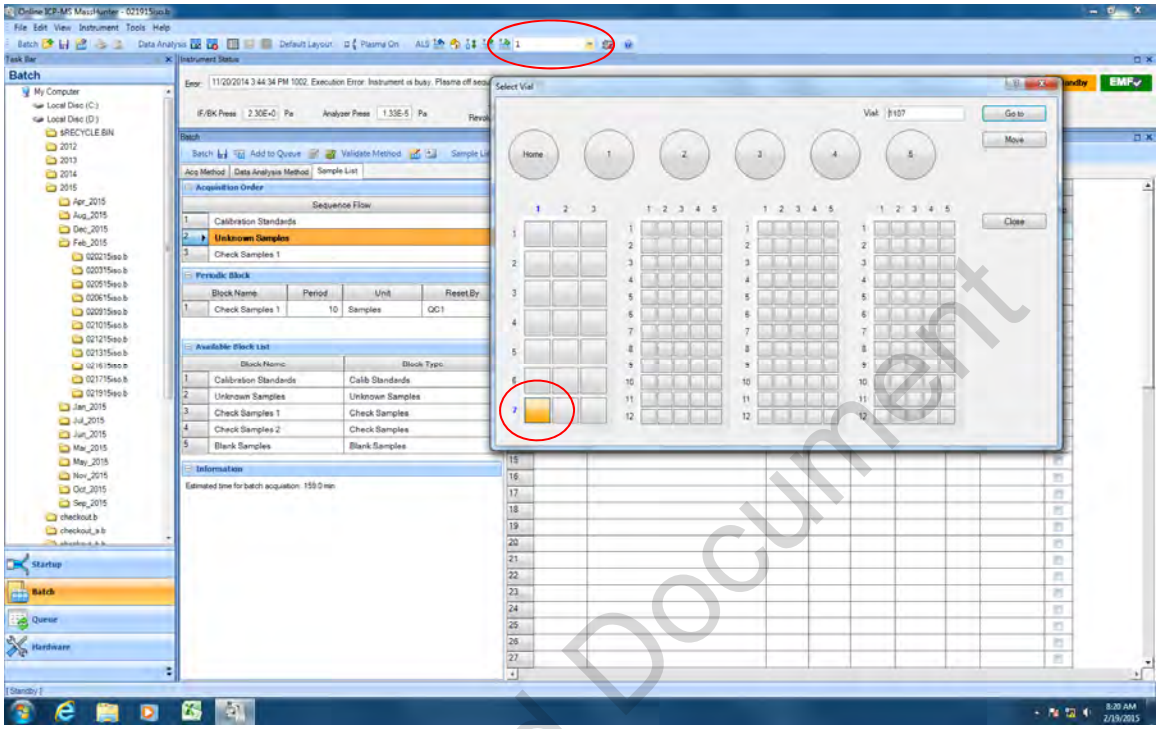


4. Enter the runs sequence and sample numbers in the sample table.

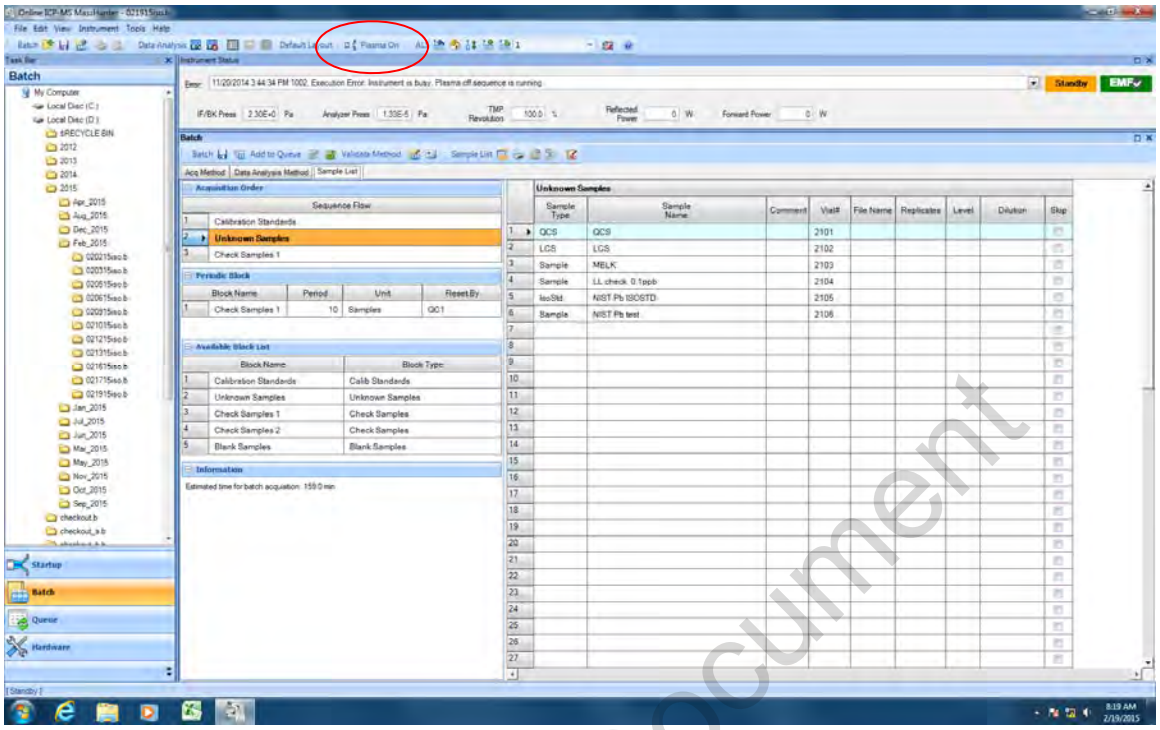


5. Prepare the instrument for startup and warm-up. Put new pump tubing on daily. Fill all rinse solutions, internal standard solution container, and empty waste. Pour fresh blank and 20ppb standards daily and all standards are poured fresh weekly. Open the 1ppb

tuning solution, 10ppb tuning solution, and the PA solution vials. Direct the auto-sampler probe to go to the 1ppb tuning solution by using the drop down box in the “Select ALS Vial #” box. Put the internal standard tubing in the DI H_2O bottle.

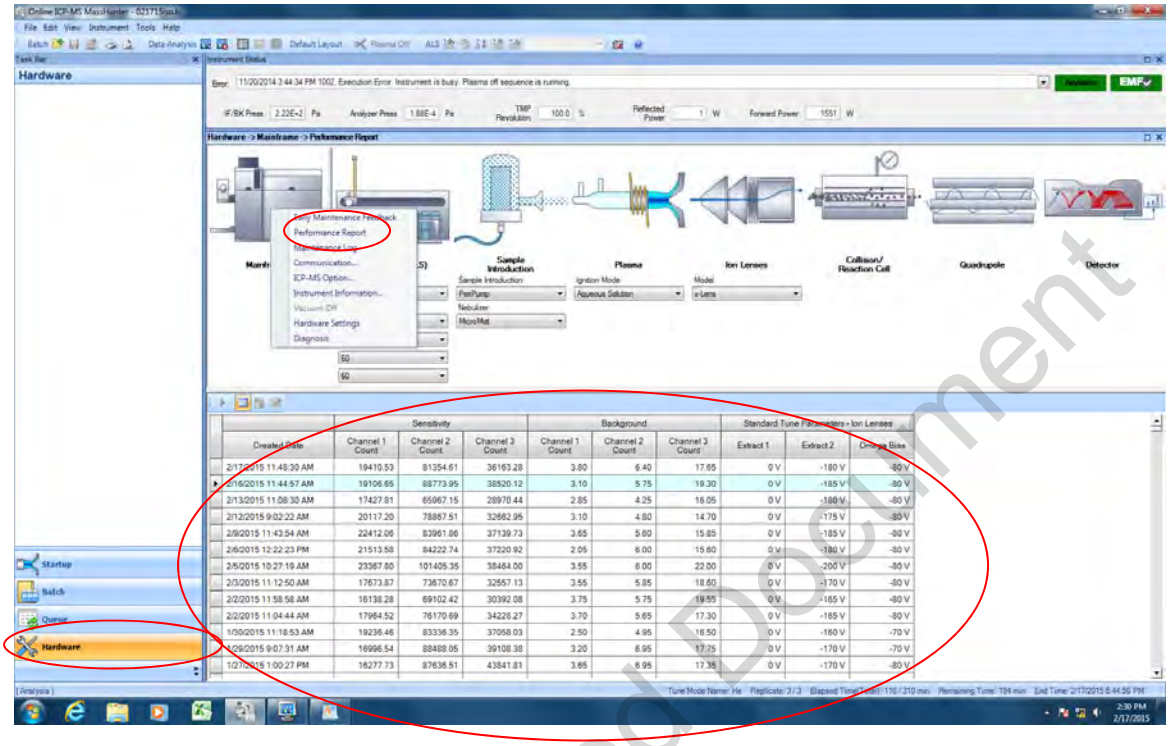


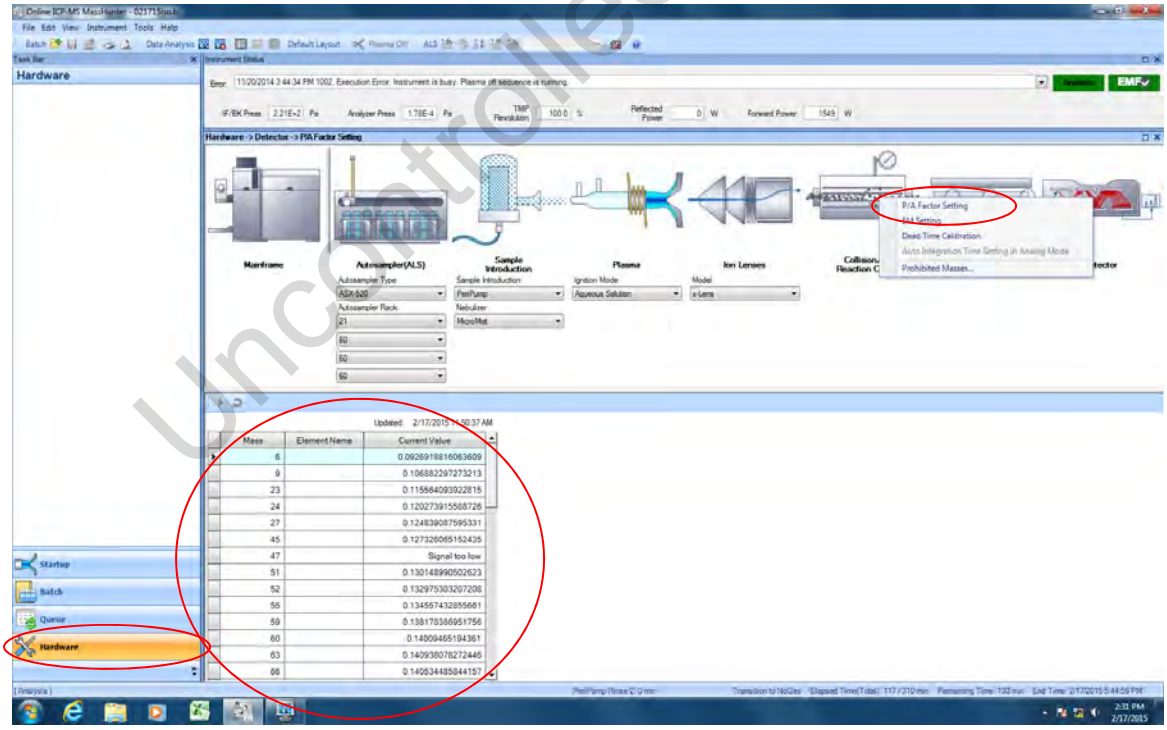
6. Click the “Plasma On” icon. The instrument software will warm up the instrument, and afterwards, perform a series of operations to alignment and tuning to optimize the instrument.



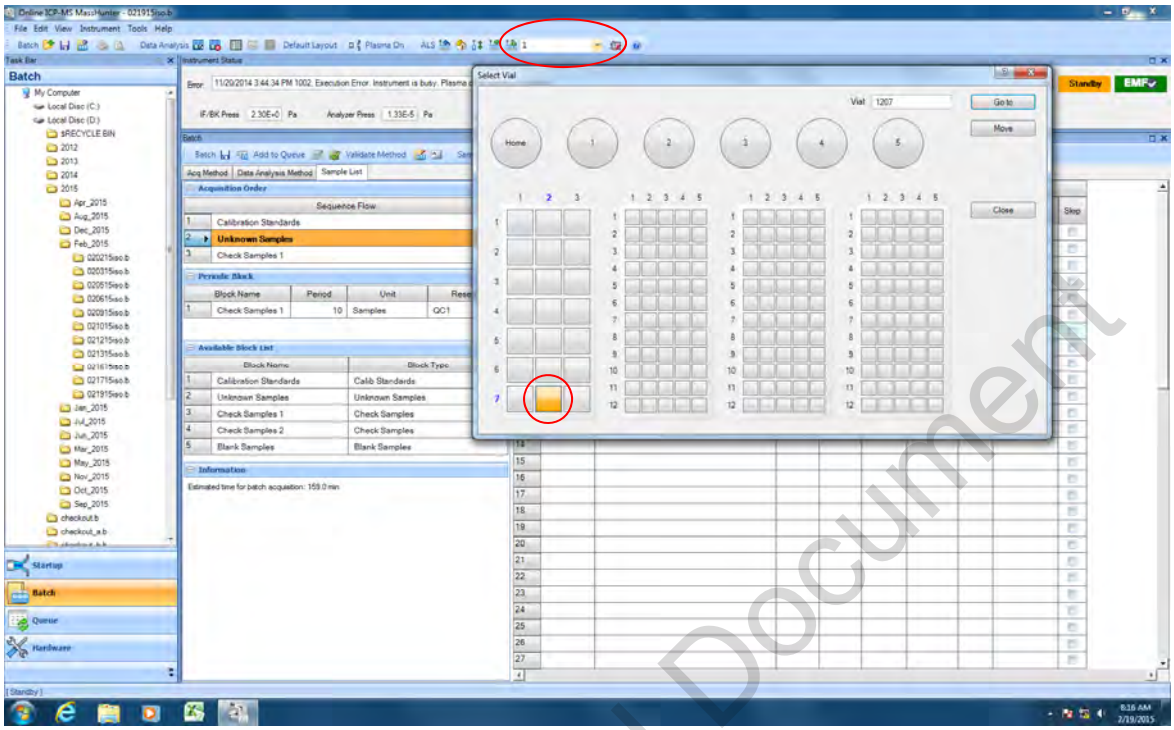
7. Check the “Performance Report” to make sure the sensitivity looks appropriate and similar to previous determinations. To access this report, go to the “Hardware” section and right click on the “Mainframe”. A list will appear so that you may select

"Performance Report". Check the P/A Report. To access this report, go to the "Hardware" section and right click on the "Detector". A list will appear so that you may select "P/A Factor Setting". Ensure that most masses have a P/A factor.

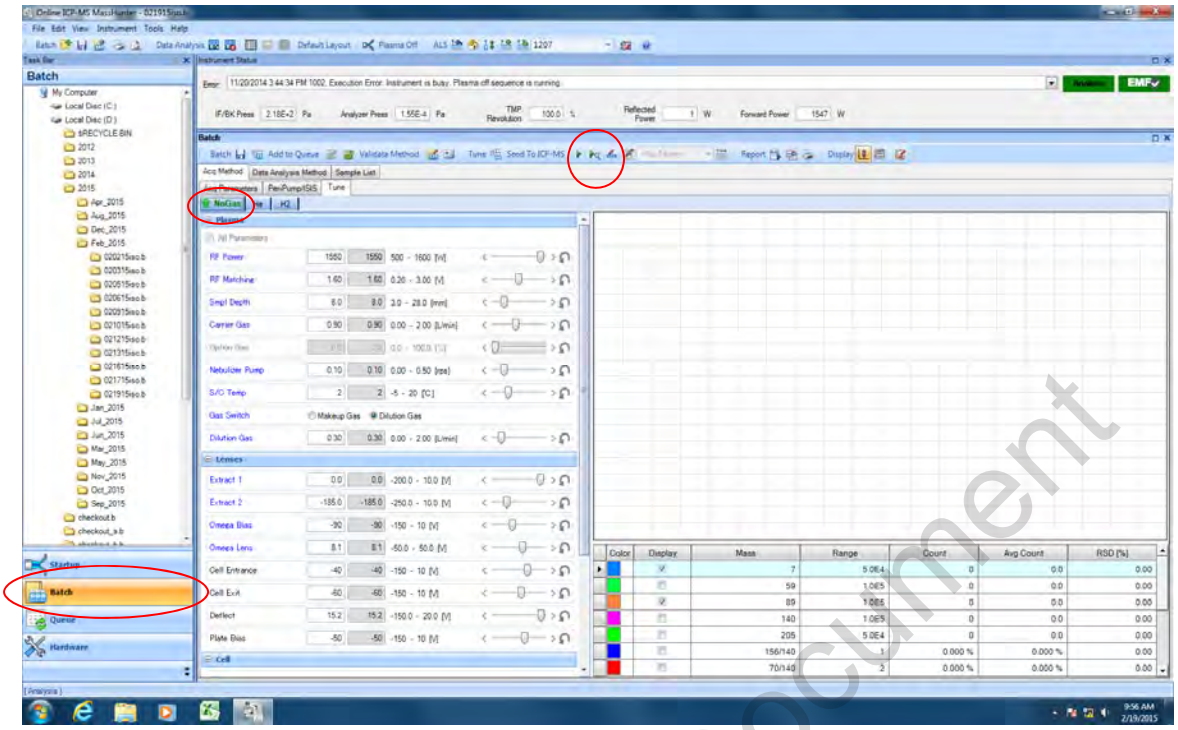


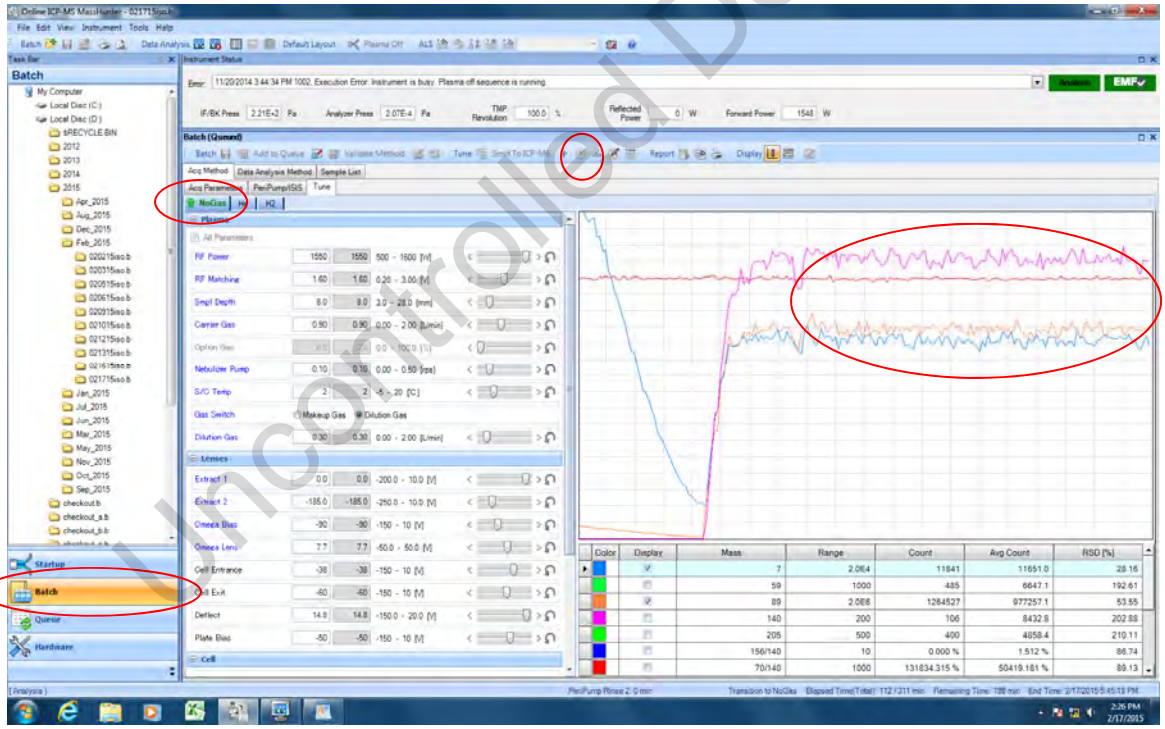


8. Direct the auto-sampler to the 10ppb tuning solution.

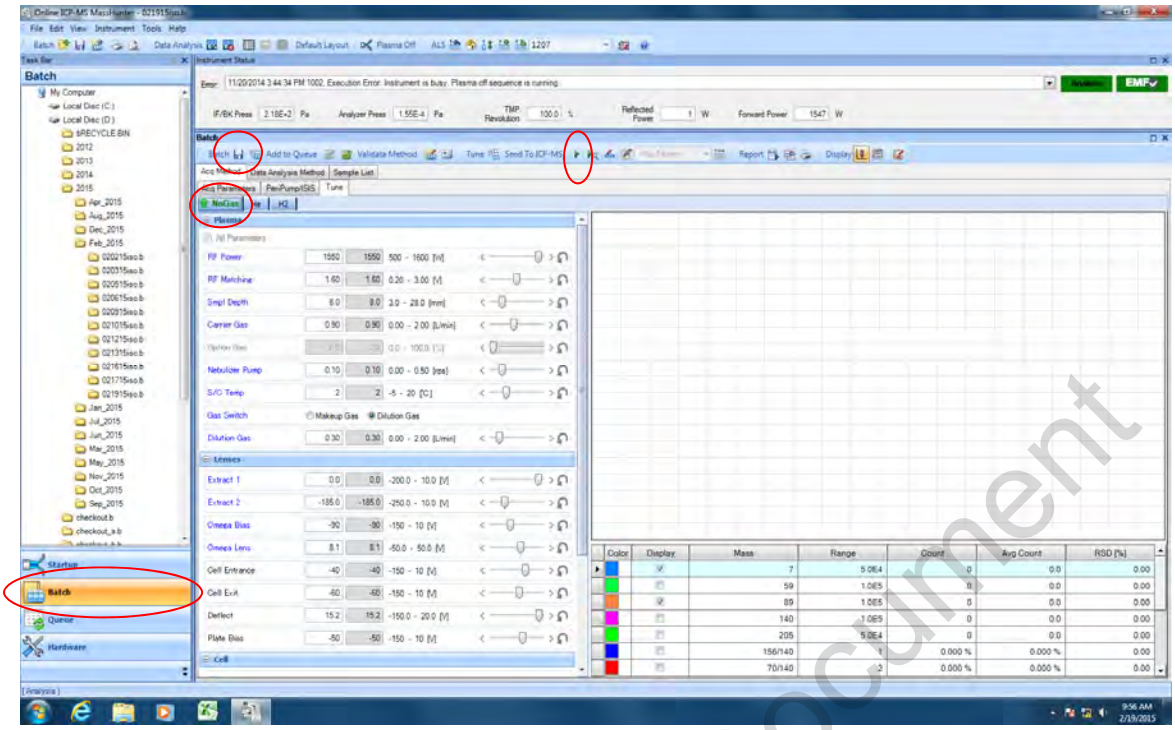


9. While in the “No Gas Mode”, enter the “Signal Monitor” mode to check for a steady state.

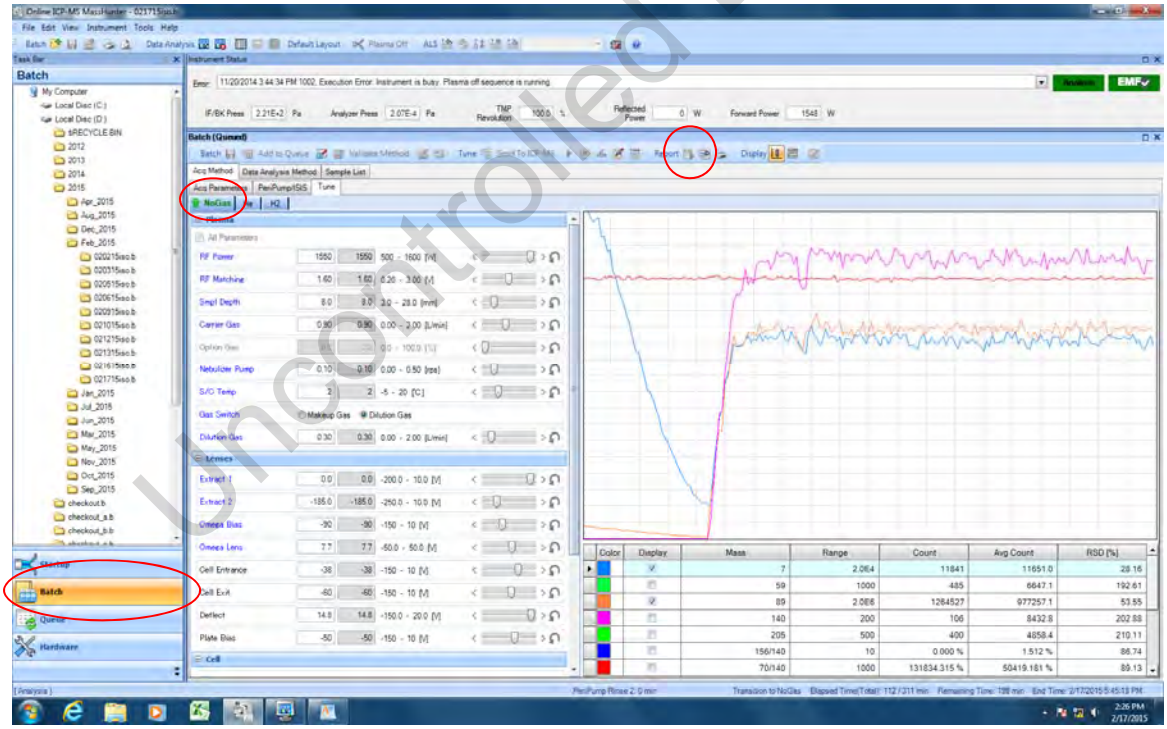




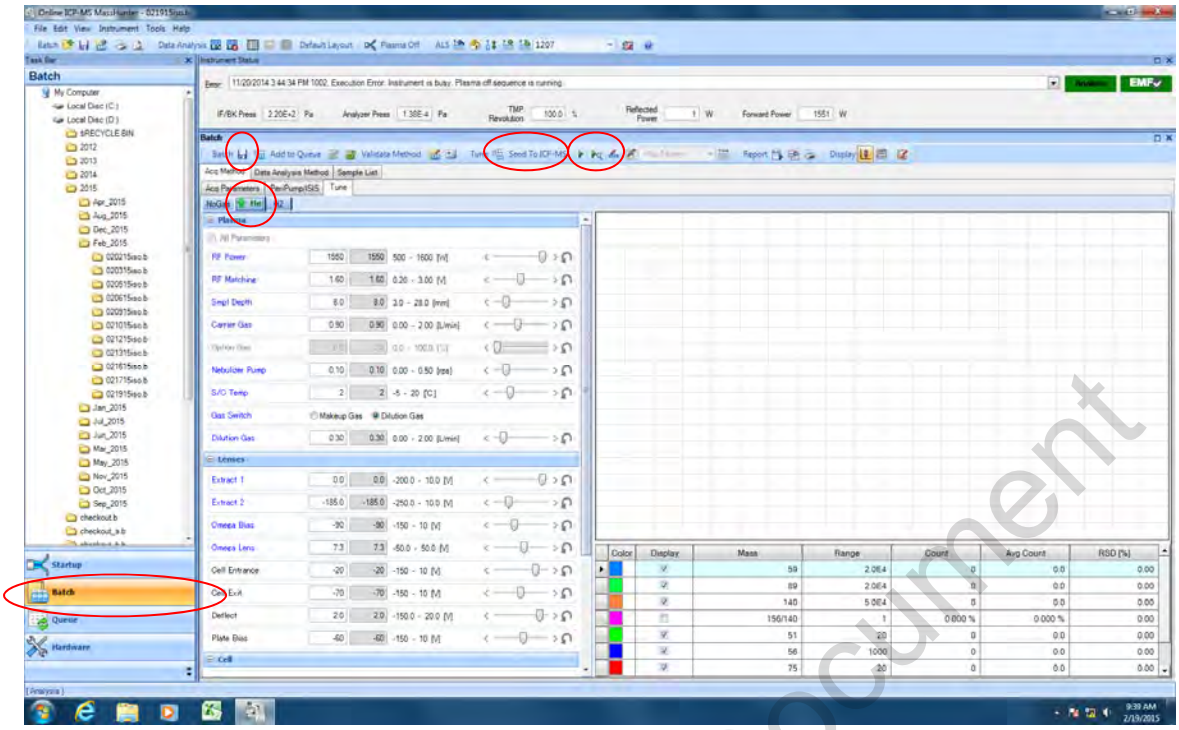
10. Perform an Auto Tune for the “No Gas Mode”. Click the green arrow icon to “Start Auto Tune”. When it is finished, click “OK”. Save by clicking on the “Save” icon.



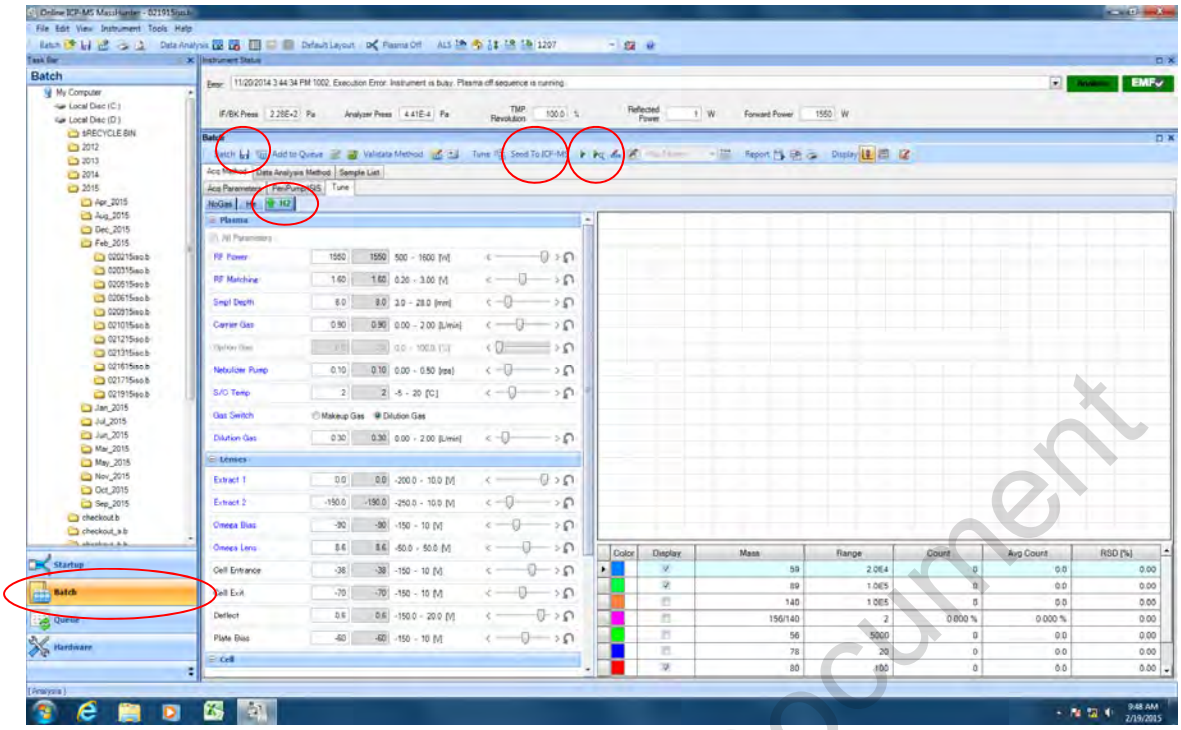
11. Perform a 200.8 Tune and Report by clicking on the “Generate Tune Report” icon.



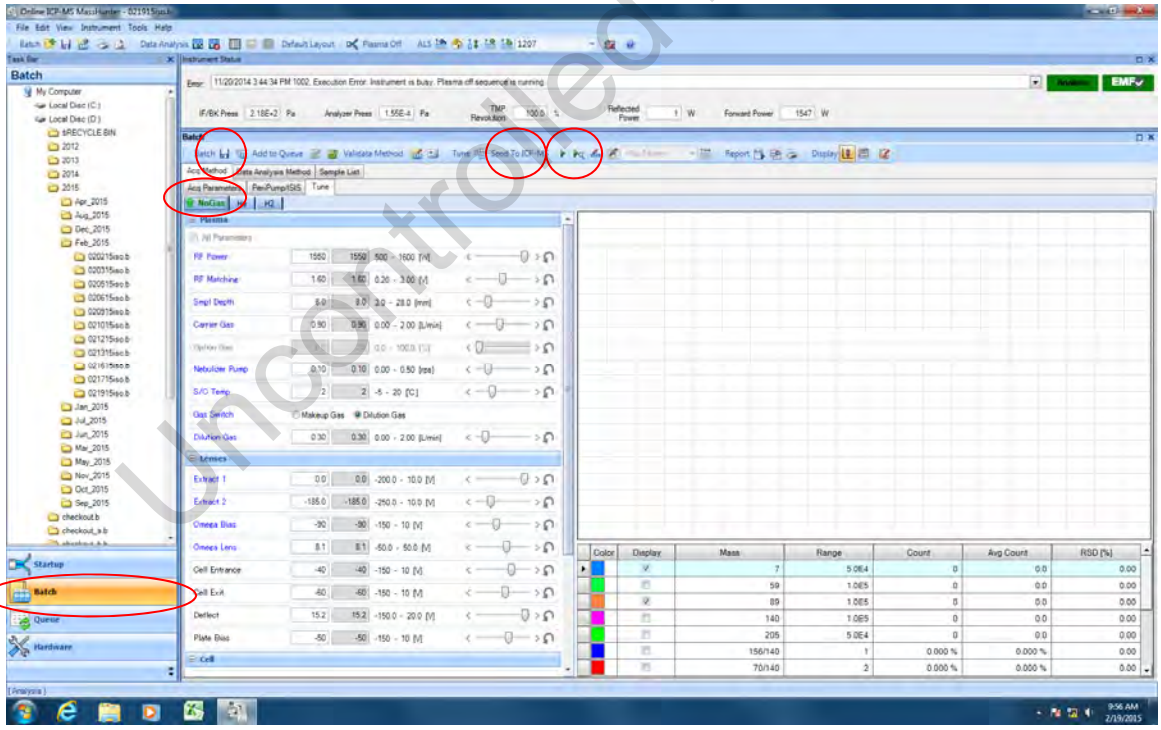
12. Click on the He tab. Click “Send to ICPMS”. Click “Signal Monitor” to let the He mode come to equilibrium. Perform an Auto Tune for the He mode (green arrow). Save settings.



13. Click the H2 tab. Click “Send to ICPMS.” Click “Signal Monitor” to let the H2 mode come to equilibrium. Perform an Auto Tune for the H2 mode (green arrow). Save settings.

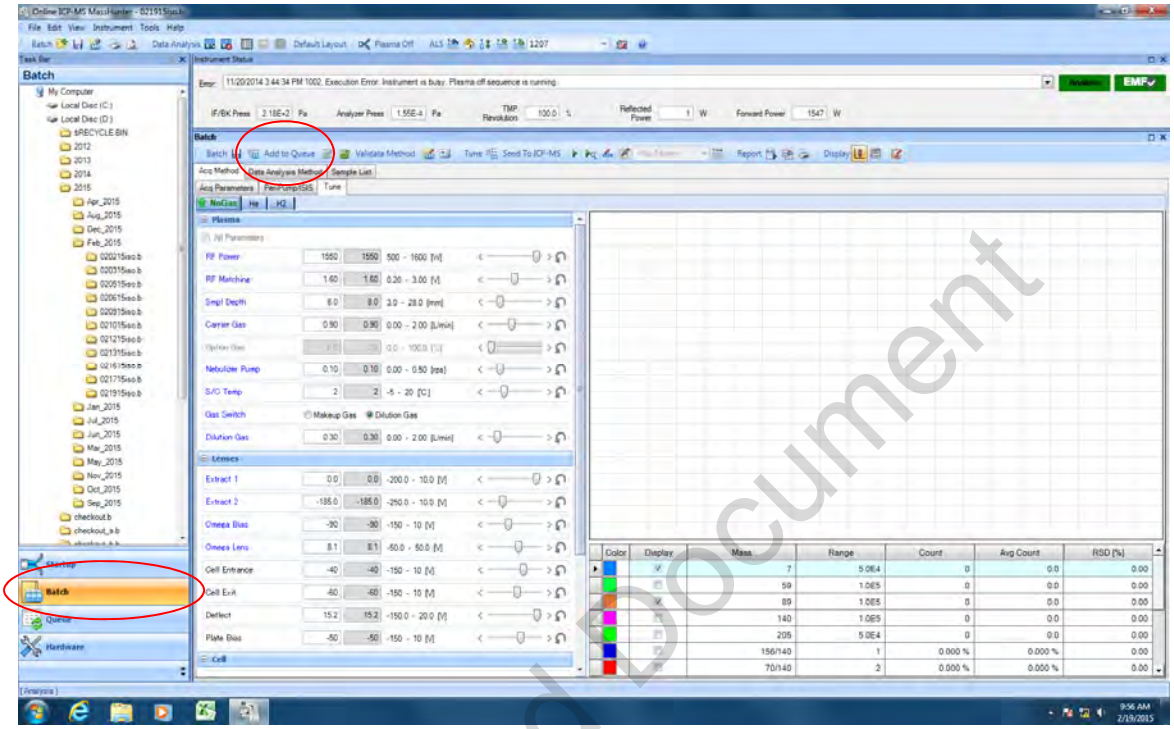


14. Click the No Gas mode. Click “Send to ICPMS”. Redo the Auto Tune for the No Gas mode. Save settings.



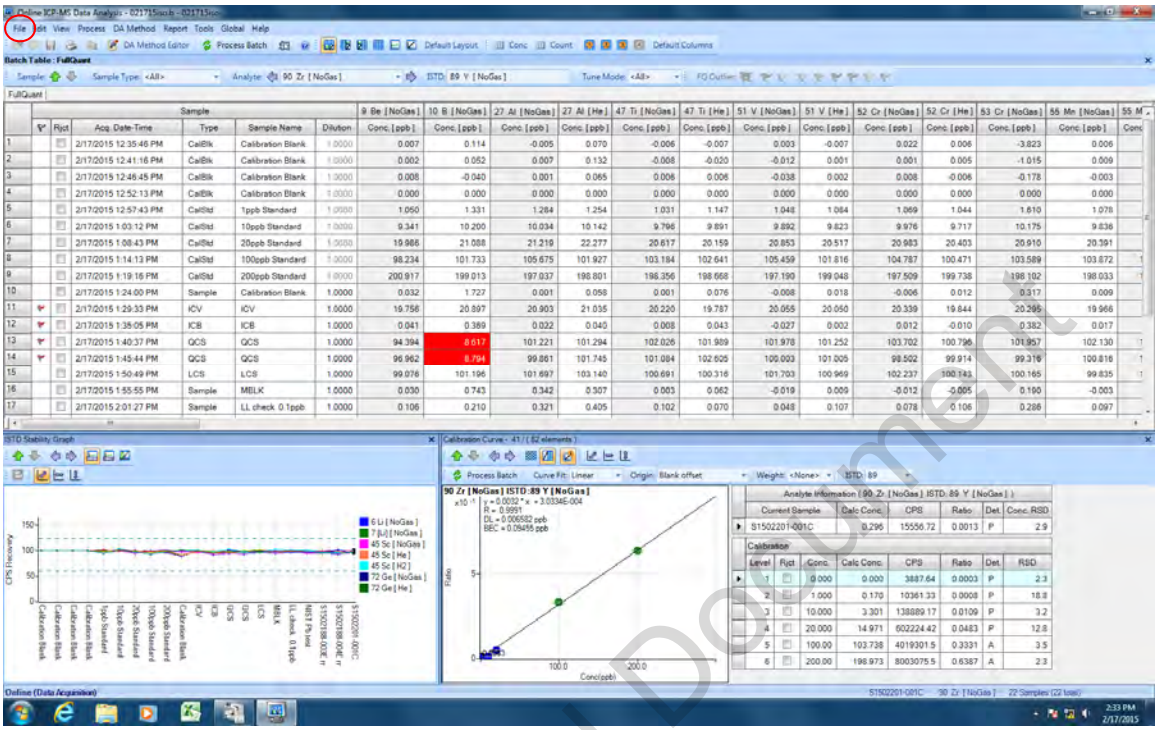
15. Direct the auto-sampler probe to the rinse position 1. Put the internal standard tubing into the internal standard. Click “Signal Monitor” and watch graph for a stable signal.

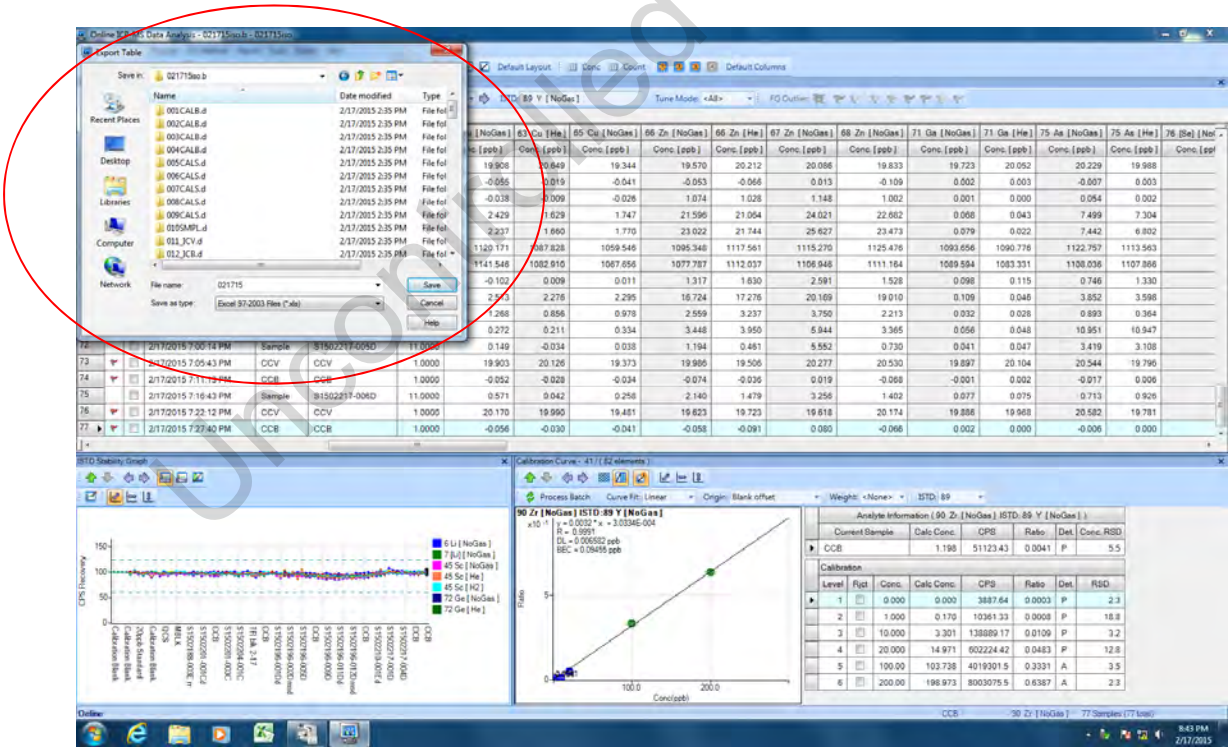
Uncap all standards and QC. When a stable signal is achieved, click “Add to Queue” to begin the run.



16. After the run is complete, check all QC for acceptability. Export the data by going to “File” then “Export Table”. Name the file and change the XLSX file default to XLS. Save

the file in the day's batch and export onto a flash drive to transfer the data to a LIMS enabled system.





ATTACHMENT #1

STANDARD OPERATING PROCEDURE FOR THE AGILENT ICPMS

METHOD TRAINING RECORD

Document Title: **Standard Operating Procedures for the Agilent ICPMS**

Document Control Number: M-Agilent_ICPMS-2.3

Location: Inter-Mountain Laboratories, Inc.

I have read the preceding document and understand all sections.

I have been trained in the performance of the methods and any recent revisions to this procedure.

ANALYST	SIGNATURE	DATE	TRAINER

Standard Operating Procedures for Digestion By Method IO3.1

Document Title: Standard Operating Procedures for Digestion By Method IO3.1

Document Control Number: M-IO3.1-2.0

Location: Inter-Mountain Laboratories, Inc., Sheridan

Address: 1673 Terra Avenue
Sheridan, WY 82801

Edited by: Mary Slipp

Title: Metals Section Supervisor **Phone:** (307) 672-8945

Quality Manager: Michelle LaGory

Telephone: (800) 828-1407

Address: 1673 Terra Ave

Sheridan, WY 82801

Plan Coverage: Standard Operating Procedures for Hot Acid Extraction of Air Filters in Preparation for Metals Analysis by Inductively Coupled Plasma (ICP) Spectroscopy and ICPMS.

Lab Representative: _____

Lab Supervisor: _____

Standard Operating Procedure for Digestion by Method IO3.1

1.0 Test Method.

1.1 The sample preparation procedure of air filter samples for analysis by spectrochemical determination of metals.

2.0 Sample Matrix.

2.1 Air filter.

3.0 Detection Limits.

3.1 Not applicable.

4.0 Scope and Application.

4.1 This digestion procedure is used for the preparation of air filter samples for analysis by Inductively Coupled Plasma (ICP) spectroscopy and ICPMS for metals. This procedure is used to determine the total amount of metals in the sample.

5.0 Method Summary.

5.1 A mixture of trace metals grade nitric acid, trace metals grade hydrochloric acid, DI water, and the filter to be digested and analyzed are refluxed in a covered digestion vial in a block digester. If the sample contains suspended solids, it must be centrifuged, filtered or allowed to settle prior to analysis.

6.0 Definitions.

6.1 Duplicate (DUP): A replicate of an actual sample that is analyzed to provide precision information about the analysis.

6.2 Laboratory Control Sample (LCS): A blank sample that has been fortified with the analyte of interest or a sample that has a known value for the analyte of interest and has been processed through the entire analytical method.

6.3 Matrix Spike (MS): Two replicates of an actual sample that have been laboratory-fortified with analyte, analyzed to determine precision of analysis and provide information about the effect of the sample matrix on the analysis.

6.4 Method Blank (MB): An aliquot of reagent and an appropriate portion of an unexposed filter is placed in a sample container and carried through the entire digestion and analytical process.

6.5 Reagent Blank (RB): An aliquot of reagent placed in a sample container and carried through the entire digestion and analytical process.

6.6 Reflux: The process of heating a sample until vapors form and recondense.

6.7 LIMS: Laboratory Information Management System.

7.0 Interferences, Considerations.

7.1 Interferences are discussed in the referring analytical method.

8.0 Safety.

8.1 Concentrated acids should be handled inside an approved fume hood. Protective clothing, gloves, and safety glasses should be worn.

9.0 Apparatus and Materials.

9.1 Hinged cap polypropylene disposable digestion vials, 70 mL

9.2 Ribbed watch glasses, polypropylene

9.3 Qualitative filter paper or centrifugation equipment

9.4 Fume hood

9.5 Protective clothing

9.6 Gloves and safety glasses

9.7 CPI Mod Block digester

9.8 Filtering apparatus

9.9 Die (Cutter)

9.10 Template (Board) and Hammer

9.11 Analytical Balance, top loader

9.12 Eppendorf air displacement pipettor or similar dispensing device

9.12.1 Disposable pipette tips, 10 mL capacity

9.13 ISO 17025 Traceable waterproof thermometer

10.0 Reagents and Consumable Materials.

10.1 IML DI Water: (Reagent Water) Water should be monitored for impurities.

10.2 Concentrated Nitric Acid, trace metals grade (HNO_3): Acid should be analyzed to determine level of impurities. If the method blank is < RL, the acid can be used.

10.3 Concentrated Hydrochloric Acid, trace metals grade (HCl): Acid should be analyzed to determine level of impurities. If the method blank is < RL, the acid can be used.

10.4 IO-3.1 Extraction Solution, (5.55% HNO_3 / 16.75% HCl). Prepare by adding in ~ 500 mL of IML DI water, 55.5 mL of concentrated HNO_3 and 167.5 mL of concentrated HCl, dilute to one liter with IML DI water.

11.0 Sample Collection, Preservation, Handling.

11.1 Refer to appropriate SOP for filter collection. Ambient large fiber filters should be received folded in half lengthwise with the particulate material inward and enclosed in protective envelopes. Store these protective envelopes at approximately 15-30°C until analysis. Handle filters using latex gloves while cutting and transferring to a digestion vial. Maximum holding time is 180 days.

11.2 Other filters should be contained in a protective casing.

12.0 Quality Control.

12.1 Digestion information is recorded in LIMS and printed out or recorded in the digestion log book.

12.2 For each analysis batch of 20 samples or fewer processed, a RB, MB, and LCS must be processed.

12.3 RBs, MBs, and LCSs are carried through the entire sample preparation and analytical process. These blanks will be useful in determining if samples are being contaminated.

12.4 A duplicate sample is processed with each analytical batch of 20 or fewer samples or fewer. DUPs are used to determine precision. DUP analysis may not be possible if the entire filter is consumed in the digestion process.

12.5 Spiked samples or standard reference materials are processed with each analytical batch of 20 samples or fewer. The MS is used to determine accuracy. MS analysis may not be possible if the entire filter is consumed in the digestion process.

12.6 If a sample is entirely consumed in the digestion process, if a collocated filter is provided, and if the client desires, a collocated filter may be used for duplicate analysis or spiking purposes. The duplicate and/or spiked filter will be identified in LIMS or in the logbook.

13.0 Calibration and Standardization.

13.1 Not applicable.

14.0 Procedure.

14.1 Prior to use, wash with IML DI water all non-consumable laboratory equipment that will come in contact with the filter samples to prevent contamination.

14.2 Using gloves, wipe the template base and cutting blade with a clean, dry Kimwipe to prevent sample cross-contamination.

14.3 Unfold the 8" x 10" filter to be sectioned and carefully place exposed side up on the cutting surface. Use a die cutting blade and hammer to cut ¾" X 8" strip.

14.4 Label the digestion vial with the lab ID. Carefully cut with ceramic scissors or otherwise non-contaminating implements and place (without disturbing sampled area of filter) the filter pieces down into the lower portion of the digestion vial to ensure the IO-3.1 Extraction Solution will cover the entire filter.

14.5 In the event that a smaller filter is used, use the entire filter in the digestion process. If needed, cut the smaller filter so that the pieces placed in the digestion vial will be submerged in the IO-3.1 Extraction Solution.

14.6 If the filter is a Teflon filter, snip the outer supporting plastic ring with ceramic scissors in a few places so that the filter will fit into a digestion vial and be submerged in IO-3.1 Extraction Solution**.**

14.7 Add spiking solution to appropriate vessels. Using a repeating Eppendorf pipetter or similar device, add 10 mL of IO-3.1 Extraction Solution. The IO-3.1 Extraction Solution should cover the filter material completely.

14.8 Place the digestion vial in the MOD Block, contained in a fume hood, and reflux gently while covered with a ribbed watch glass for 30 minutes. At least twice during the digestion process check to ensure that the filter is submerged. Do not allow samples to go dry. Remove vials from the digester and allow the sample to cool.

14.9 Rinse the vial walls and watch glass with IML DI water. Decant the solution from the filter into a clean screw top vial that has been weighed and labeled with the filter sample identification.

14.10 Add approximately 10 mL IML DI water to the remaining filter material in the digestion vial and allow it to stand for at least 30 minutes. This critical step must not be deleted. It allows the acid to diffuse from the filter into the rinse.

14.11 Transfer the extraction fluid from the digestion vial to the second screw top vial. Rinse the digestion vial and any remaining solid material with IML DI water and add the rinses to the second screw top vial. Dilute to 20 mL on a top loading balance and mix well.

14.12 The final extraction volume is 20 mL based on the above procedure. The final extraction solution concentration is 3% HNO_3/8% HCl. The sample must be allowed to settle. Centrifuge or filter the sample prior to analysis.

14.13 Detailed digestion data is logged in LIMS including sample IDs; identification of person performing procedure; date and time at start and end of digestion; sample

weights; beginning and ending temperatures; solutions used; and IDs of pipettes, thermometer, and balance used.

15.0 Data Analysis and Calculations.

15.1 Samples dilutions must be taken into account when reporting data.

16.0 Precision and Accuracy.

16.1 Precision is assessed by analysis of duplicate samples.

16.2 Accuracy is assessed by analysis of spiked samples.

17.0 Pollution Prevention

17.1 There is a low potential of pollution attributed to performance of this method.

18.0 Data Assessment and Acceptance Criteria.

18.1 Refer to the analysis method for determination of acceptance criteria.

19.0 Contingencies and Corrective Action for Out of Control or Unacceptable Data.

19.1 If analytical method criteria are not met, the sample batch may be re-digested if needed and if possible.

20.0 Waste Management.

20.1 Sample disposal is conducted per IML Sample Disposal Procedure and IML Safety Plan.

21.0 References.

21.1 Methods for the Analysis of Water and Waste Water, Method 200.7 USEPA 600.

21.2 (1999) Compendium Method IO-3.1 Selection, Preparation, and Extraction of Filter Material, Available: http://www.epa.gov/ttn/amtic/files/ambient/inorganic/mthd-3-1.pdf

21.3 (2003) 40CFR Chapter 1 Part 50—Environmental Protection Agency –National Primary and Secondary Ambient Air Quality Standards, Appendix G to Part 50 –Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air, Available: http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr50_00.html

22.0 Tables, Diagrams, Comments.

22.1 Summary of changes made from previous version M-IO3.1-1.7 August 2011:

22.1.1 Editorial changes necessary to implement TNI-compliant format. New SOP sections include 1.0, 2.0, 17.0, 18.0, 19.0, 20.0, and 22.0.

22.1.2 Section 4.0 Scope and Application was the previous Section 1.0. The previous section 1.2 was deleted due to redundancy.

22.1.3 Section 5.0 Minor editorial changes made for clarity.

22.1.4 Section 6.0 Definitions was expanded to include Quality Control Samples and abbreviations used in the document.

22.1.5 Section 9.0 Apparatus and Material: references to EPA methods IO 3.1 and EPA 200.8 were removed from this section.

22.1.6 Section 12.0 Quality Control: redundancies were removed and the section was streamlined for clarity.

22.1.7 Section 14.0 This section was expanded for clarity and added detail regarding filter type and how to ensure filter remains submerged.

22.1.8 Section 15.0 Statement added regarding accounting for sample dilution.

22.1.9 Section 16.0 Information at 16.1 and 16.2 added.

ATTACHMENT #1

STANDARD OPERATING PROCEDURE

METHOD TRAINING RECORD

Document Title: **Standard Operating Procedures for Digestion by Method IO-3.1**

Document Control Number: M-IO3.1-2.0

Location: Inter-Mountain Laboratories, Inc.

I have read the preceding document and understand all sections.

I have been trained in the performance of the methods and any recent revisions to this procedure.

ANALYST	SIGNATURE	DATE	TRAINER

Standard Operating Procedure for Analysis of Gross Alpha-Beta

Document Title: Standard Operating Procedure for Analysis of Gross Alpha-Beta (SM 7110 B)

Document Control Number: R-GAB-4.3

Location: Sheridan Lab

Address: 1633 Terra Avenue
Sheridan, WY 82801

Edited by: Tom Patten

Title: Quality Officer **Phone:** (307) 672-8945

Quality Manager: Michelle LaGory

Telephone: (307) 672-8945

Address: 1673 Terra Avenue
Sheridan, WY 82801

Plan Coverage:

Standard Operating Procedure for Analysis of Gross Alpha-Beta (SM7110 B)

Original: 11/17/03

Lab Representative: _____

Lab Supervisor: _____

Standard Operating Procedure for Gross Alpha-Beta

1.0 Test Method.

1.1 Standard Operating Procedure for the determination of Gross Alpha/Beta emissions in water and wastewater.

2.0 Sample Matrix

2.1 This method is applicable to drinking water, surface water, and wastewater. Suspended solids in water and soils can be evaluated by this same method if these are put into a soluble form by acid digestion before analysis.

3.0 Detection Limits.

3.1 The determination of method detection limits shall be done annually using the procedure as outlined in the Inter-Mountain Labs Method Detection Limit Procedure.

4.0 Scope and Application.

4.1 This method is applicable to drinking water for compliance with the Safe Drinking Water Act, and for water and waste water for compliance with the Clean Water Act.

5.0 Method Summary.

5.1 A sample is evaporated in a glass beaker to a volume suitable for transfer and drying onto a stainless steel planchet.

5.2 The planchet is presented to a gas flow proportional counter for a count time appropriate to the detection limit and volume of sample. The values are adjusted for sample absorption efficiency and background subtraction.

5.3 Gross Alpha and Beta are reported in pCi/L.

6.0 Definitions

6.1 De-Ionized (DI) Water: Laboratory-produced reagent water.

6.2 Method Blank (MB) – An aliquot of reagent water that is treated exactly as a sample, exposed to the same glassware, equipment and reagents as samples. The MB is used to determine whether interferences are present in the lab environment, reagents, or equipment.

6.3 Laboratory Control Sample (LCS) – A sample of known value that is treated exactly as a sample, exposed to the same analytical steps as samples, used to determine whether the methodology is in control, and as a measure of precision and accuracy. The LCS is from a source different than that of the calibration standards.

6.4 Duplicate (DUP): A DUP is a replicate of an actual sample, analyzed to provide precision information about the analysis.

6.5 Matrix Spike (MS) – A duplicate sample aliquot to which a known quantity of analyte is added. The MS is analyzed exactly the same as an unfortified sample. Analysis of the MS measures interferences caused by the sample matrix.

6.6 Matrix Spike Dup (MSD) – An additional sample aliquot to which a known quantity of analyte, at the same concentration added to the MS, is added. Analysis of the MSD measures interferences caused by the sample matrix and reproducibility or precision.

6.7 Method Detection Limit (MDL) - The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater. See IML Method Detection Limit Procedure.

6.8 Minimum Detectable Activity (MDA) – An estimate of the smallest true activity (or activity concentration) of analyte in a sample that ensures a 95% probability of detection, given a detection criterion that ensures only a 5% probability of detection in analyte-free samples.

7.0 Interferences, Considerations.

7.1 Radionuclides that can be volatilized during the sample preparation will not be measured by this method.

7.2 Nitrated water solids (sample evaporated with nitric acid present) will not remain at a constant weight after drying and desiccation, then being exposed to atmosphere before and during counting. Heat these samples to a dull red for a few minutes to convert these salts to oxides. This stabilizes the weights sufficiently to allow for a consistent count.

7.3 Interferences can occur with samples containing chlorides. These chlorides react with the metal planchets forming metal chlorides which contribute to the sample absorption of radiation. The total efficiency curves do not compensate for this type of sample absorption. Samples can be digested in the presence of nitric acid, thereby volatizing chloride as the acid.

8.0 Safety.

8.1 Radionuclide sources will be kept in a cabinet with at least 1/4 inch of carbonaceous material for shielding. Low level and low activity sources are considered safe to handle, however, all sources shall be handled with appropriate personal protective equipment employed.

8.2 The laboratory will monitor background radiation in strategic locations with a radiation badge program through an off-site, independent company. The monitoring will include gamma in all sites, and radon in select sites.

8.3 Swipes of laboratory surfaces are performed monthly, using 47 mm paper filters that are analyzed to determine the removable alpha radiation present on surfaces. Lower levels should be kept at background; however maximum levels should not exceed 200 dpm/100 cm^2.

8.4 The RadChem laboratory will maintain supplies of detergents and other agents that remove radioactive substances from clothes, hair, and skin, as well as laboratory equipment.

8.5 See SDS sheets for information on all chemicals. See Inter-Mountain Labs Safety Plan for any other related safety information.

9.0 Apparatus and Materials.

9.1 Tennelec LB 4110 Gas flow proportional counter with 2 in. detectors or equivalent

9.2 Accumet AB-30 Conductivity meter or equivalent

9.3 Stainless steel planchets 2 inches in diameter by 3/32 inches deep (20.3 cm^2 area)

9.4 Glass beakers: 30 and 100 mL capacities

9.5 Transfer pipettes, plastic, 3 mL

9.6 Glass graduated cylinders: 25, 50, and 100mL capacities

9.7 Teflon coated electric griddle with adjustable heat settings (Warm - 400ºF)

9.8 Hot plate or equivalent, capable of holding, at least, 9-250 mL beakers

9.9 Desiccator with charged drying agent

9.10 Eppendorf pipettor with Combitips and adaptors for 10 mL or equivalent

9.11 Eppendorf pipettor, 0.1-1.0 mL adjustable with tips, or equivalent

9.12 Oxford pipettors, 5.0 – 10.0 mL adjustable with tips, or equivalent

9.13 Disposable plastic cups: 25 and 100 mL capacities

9.14 Glass stirring rods and rubber policeman

10.0 Reagents and Consumable Materials.

10.1 Reagent water: De-ionized water (DI-water), free of radioactive materials.

10.2 Methyl orange indicator, dissolve 0.5 grams of methyl orange indicator in 800 mL DI-water and dilute to 1 liter.

10.3 Nitric Acid, 16 M HNO_3, Reagent grade (70%).

10.4 Nitric acid, 1 M: Dilute 63 mL of 16 M nitric acid to 1-L with DI-water.

10.5 Standard for Gross Alpha, Natural Uranium composed of isotopes 238, 235, and 234. The activity of this standard should be prepared at a level consistent with compliance requirements. All stock standards shall be NIST traceable sources. Prepared standards shall have an expiration date of one year from preparation date, with unique RadChem identification label, and are stored in the controlled RadChem standards cabinet.

10.6 Standard for Gross Beta, Strontium-90. The activity of this standard should be prepared at a level consistent with compliance requirements. All stock standards shall be NIST traceable sources.

10.7 P-10 gas for instrument, 90% argon and 10% methane.

10.8 Ethyl alcohol, 95%

11.0 Sample Collection, Preservation, and Handling.

11.1 Samples should be collected in plastic or glass bottles of sufficient quantity to do complete analysis and requisite quality control samples.

11.2 Samples should arrive in a raw state or preserved with nitric acid to pH 2.

11.2.1 In the case of drinking water samples, when a sample arrives unpreserved, acid will be added to the sample container within 5 days of sampling, and analysis will be delayed for 16 hours. The acid will be added in the RadChem laboratory, because the preservative must be analyzed to screen for radioactive contaminants.

11.2.2 The acid used to preserve the samples will be screened for radioactive contaminants prior to use and the results will be entered into the standards log book. The entire acid lot number will be considered acceptable, if the initial test is below the MRL or MDA of the aliquot tested. The aliquot tested will be equivalent to the average amount of acid necessary to preserve 2-L of sample to pH < 2.

11.2.3 For drinking water, composite samples, and any other compliance sample that is preserved by an acid not supplied by the laboratory, a field blank must accompany the sample. A field blank is considered a sample of radioactive free water that has been preserved in the field with the same acid preservative, at the same time, as the submitted compliance sample.

11.2.3.1 If a preserved sample is sent to the laboratory for the laboratory to composite, a field blank must accompany each aliquot of the total composite, unless it can be proven that the same preservative is used for each aliquot. This is important to note for composites done for each quarter of the year.

11.3 Drinking water samples will be stored on a separate shelf in the RadChem laboratory, to reduce the chance of cross-contamination from other samples.

12.0 Quality Control. (See Tables 1 and 2 for summaries of Quality Control requirements)

12.1 Batch requirements

12.1.1 Each batch will consist of no more than twenty samples.

12.1.1.1 If possible, drinking water samples shall be prepared and analyzed in batches separated from all other laboratory samples.

12.1.2 Each batch will contain a MB, a (LCS for both alpha and beta, a DUP or MSD, and a sample/matrix spike (MS) for both alpha and beta.

12.1.3 If enough sample is not provided to allow for all quality control samples, a sample of tap water and either a DUP or a MS can be analyzed to take the place of client sample quality control.

12.1.4 Since the laboratory must protect the client samples, enough volume of sample must be saved to repeat the analysis.

13.0 Calibration and Standardization.

13.1 Determination of efficiency: The plateaus, ROIs, dead band, and efficiencies are all determined according to manufacturer's specifications and instructions within the Operator's Manual and current software operating package. All these functions are performed through the instrument software, and graphed, printed or stored electronically, and archived. These operations are performed annually.

13.1.1 Efficiency of each detector is determined by dividing the counts per minute by the disintegrations per minute of known Alpha and Beta producing plated sources. All sources are traceable to NIST-certified sources.

13.2 Determination of total efficiency: Two sets are prepared, one for alpha, one for beta. In each set, eight samples are prepared one with de-ionized water and seven with an appropriate volume of a solution containing solids similar in composition to samples. The spike amount is fixed for all. The samples are prepared as per the method, and dried onto planchets. For counting, each planchet is counted for 120 minutes in each detector. The results are averaged and a total efficiency graph is produced for the alpha side and beta side for each detector. The total efficiency curves will be re-verified or established annually. Calculations are then made for each weight range, so total efficiency can be determined. NOTE: Care must be taken to ensure a uniform distribution of solids on the planchet.

13.2.1 Total efficiency preparation from Protocol for EPA Evaluation of Alternate Test Procedures for Analyzing Radioactive Contaminants in Drinking Water

13.2.1.1 Prepare the following solutions-

13.2.1.1.1 Aluminum chloride hexahydrate, 4 mg/mL: Dissolve 1.0 g of $AlCl_3 \cdot 6H_2O$ and dilute to 250 mL with reagent water.

13.2.1.1.2 Barium chloride dihydrate, 4 mg/mL: Dissolve 1.0 g of $BaCl_2 \cdot 2H_2O$ and dilute to 250 mL with reagent water.

13.2.1.1.3 Calcium nitrate tetrahydrate, 40 mg/mL: Dissolve 10.0 g of $Ca(NO_3)_2 \cdot 4H_2O$ and dilute to 250 mL reagent water.

13.2.1.1.4 Iron (III) chloride, 4 mg/mL: Dissolve 1.0 g of $FeCl_3$ and dilute to 250 mL with reagent water.

13.2.1.1.5 Magnesium sulfate heptahydrate, 100.0 mg/mL: Dissolve 25.0 g of $MgSO_4 \cdot 7H_2O$ and dilute to 250 mL with reagent water.

13.2.1.1.6 Sodium bicarbonate, 80 mg/mL: Dissolve 20.0 g of $NaHCO_3$ and dilute to 250 mL with reagent water.

13.2.1.1.7 Sodium phosphate dibasic anhydrous, 14 mg/mL: Dissolve 3.5 g of Na_2HPO_4 and dilute to 250 mL with reagent water.

13.2.1.1.8 Sodium sulfate anhydrous, 60 mg/mL: Dissolve 15.0 g of $NaSO_4$ and dilute to 250 mL with reagent water.

13.2.1.2 For preparing 1-L of matrix, 5 mL of each solution is added to a 1-L volumetric flask and taken to volume with reagent water.

13.2.1.3 An appropriate volume of this matrix is used for each of 7 total efficiency preparations (the first being a blank with spike only) in a range up to the calculated maximum sample mg limit to create the total efficiency curve.

13.3 Background determination: For each new purchase of planchets, a specific RadChem lot number will be assigned to the entire batch. The batch background is determined for each individual detector by performing six consecutive 120 minute counts on planchets. An

average for each detector is obtained from its data and used for background subtraction. This is done through the instrument software, which is graphed, printed or stored electronically, and archived.

13.3.1 These planchets become a part of the system background which is performed daily.

13.3.2 When a new tank of P-10 gas is put into service a blank analysis shall be run on planchets to verify the background of the system.

13.4 Daily calibration of the system

13.4.1 Background of the instrument

13.4.1.1 Each day of use, the instrument shall have a background run of at least 2 hours. For each detector, the puck, planchet holder, and a clean planchet shall be in place.

13.4.1.2 Backgrounds shall be control charted and limits set at ± 3 times the standard deviation of the sample set. If a background fails this criterion it will be re-run before samples are run on the instrument. Background check reports are stored electronically at the instrument. Backgrounds outside control limits for individual windows are recorded in the laboratory notebook for the analysis and this window is not used until potential contamination can be addressed. Review of background for individual windows is indicated by initialing lab notebook.

13.4.2 Instrument Contamination Monitoring Procedure

13.4.2.1 If an instrument background will not pass and it is suspected that the planchet may be contaminated, it will be cleaned or replaced. The replacement will be noted with the drawer and detector indicated, along with a note as to why the planchet is being cleaned or replaced. Another background will be run to see if this corrects the background failure issue.

13.4.2.2 If the background still does not pass, further investigation must be done to determine if the raised background is caused by actual contamination or if it is caused by instrument malfunction.

13.4.3 Calibration check

13.4.3.1 Each day of use, the instrument shall have a calibration check run with alpha and beta sources and these shall be within ±10% of the calculated value. A second calibration can be run if these criteria are not met.

13.4.3.2 Each detector shall have an alpha and a beta run performed.

13.4.4 Assessing instrument drift

13.4.4.1 For drinking water samples and any other samples that fall under compliance standards, the efficiency and background of the instrument will be measured either following the measurement of the samples or within 24 hours of initiation of analysis.

13.4.4.2 To assess instrument efficiency, the calibration check from Section 13.4.3 will be re-run. The results must be within the same parameters as the initial calibration.

13.4.4.3 The background will be run after this efficiency and done as per Section 13.4.1. The results must be within the same parameters as the initial background.

13.5 The LCS standard solution is prepared from NIST traceable stock standard. A validated and locked spreadsheet is used to calculate the activity of the LCS standard solution in pCi/mL. The date, weight of stock standard used, the stock standard activity and the final volume of the LCS standard solution are entered into the spreadsheet. The spreadsheet automatically calculates the activity of the LCS standard solution. The spreadsheet is located on the server, under Radchem Results. The prep of the LCS standard solution is recorded in the Standards logbook.

13.5.1 See IML Report Generation Procedure for instruction on protection and control of spreadsheets.

14.0 Procedure.

14.1 An electrical conductivity for each sample needs to be performed to estimate the amount of dissolved solids and therefore approximate weight per volume. This needs to be performed on raw sample, as acid preservation will make this step impossible.

14.1.1 Calibrate the electrical conductivity (EC) meter per instruction manual. Pour approximately 20 mL of sample into a plastic disposable cup. Set the EC electrode into its stand, and lower into the sample. Allow the reading to stabilize and record this number on the sample bottle. If an EC is run for the sample as part of the project sampling plan, this number can be looked up from the LIMS system and used.

14.1.2 This number reflects the weight per liter. The working volume for this method is 100 mL, so divide this number by 10 to give the approximate weight in solids for 100 mL. For example, an EC reading of 500 µmhos/L would mean that there are approximately 500 mg/L. This would be a total of 50 mg in 100 mL, safely below the limit.

14.1.3 Weak alpha-emitters will be stopped if covered by sample solids of only 4 mg/cm^2. On a 2-inch planchet this calculates to a total weight of 81.07 mg/cm^2. This is the upper level for sample weight of any sample requiring alpha analysis. Beta analysis should be done with sample solids less than 10 mg/cm^2 or a calculated weight of 202.68 mg/cm^2 on a 2-inch planchet. Since the majority of samples are run simultaneously for alpha and beta, the lower limit of alpha is used as the weight limit for this analysis.

14.2 Temperature settings vary from hot plate to hot plate. A setting which keeps water temperatures at the point of evaporation without boiling should be used. A lower temperature setting can be used if volatile radionuclides are suspected to be present.

14.2.1 Ground water or monitoring wells that are being analyzed for polonium-210 may benefit from a lower evaporation temperature.

14.3 Measure an appropriate amount of sample into a graduated cylinder and pour into 250 mL glass beaker. If a volume of 25 mL or less is used, the sample is poured into a 30 mL beaker and taken through the rest of the procedure as normal.

14.3.1 If a small enough volume is taken, this can be dried directly on the planchet.

14.3.1.1 The smaller volume is measured into a small beaker or solo cup, nitric acid is added, and the sample is poured directly onto the planchet.

14.4 Add 1-2 drops of Methyl orange indicator per 100 mL of volume.

14.5 Add 1:1 nitric acid drop-wise if samples are not pink. Additional acid may be necessary if there are excess salts or potential chloride present. Stir sample. Add spike to the appropriate samples.

14.6 Heat beaker to just below boiling point and evaporate to about 5-10 mL, swirling occasionally. Do not let sample dry completely.

14.7 While samples are evaporating, record initial weights of planchets.

14.8 Transfer to a tared planchet in small increments. If the beaker has residue, at the discretion of the technician/analyst, rinse the beaker with 2 mL 1 M nitric acid and add to the planchet. NOTE: Some raw samples and filtered samples have fine particles that need to be rinsed onto the planchet. This may require more than 2 mL acid. If this residue seems to be at an excess, a smaller sample aliquot should be used.

14.9 Dry planchet on an electric griddle set to 'Warm' or approximately 150-200°F until dry. (It is important to make sure that the contents in the planchets do not come to a boil while drying. This will result in a loss of sample and can cross-contaminate other samples.) Record date and time planchets are removed from heat.

14.10 Place on a tray in a desiccator, covered with another tray, until ready to count. Weigh planchets just before counting.

14.11 If hydrophilic, nitrated water solids are suspected to be present, the weight of the planchet may need to be checked before and after counting (additional water weight will attenuate counts.) If the weight increases, the planchet is heated to a dull red heat for several minutes to convert the nitrates to oxides and the planchet is recounted. Volatile radionuclides such as cesium and polonium may be lost during this process and demonstrate the limitations of this analysis.

14.12 Count samples on a gas-proportional counter. Calculate results and error. Report with error.

14.12.1 If short-lived radionuclides are suspected or are required for analysis, a time study for decay will be conducted and executed depending on the half-life of the analyte in question.

15.0 Data Analysis and Calculations.

15.1 Standardization: Calculate the Total Efficiency (TE) of the detector.

TE = CPM(mass)/DPM

Where:

CPM (mass) = Counts per minute as a function of mass.
DPM=Disintegrations per minute

15.2 Alpha activity in pCi/L is calculated as shown:

Alpha = $((C_\alpha - B)*1000)/(2.22*TE*V)$

C_α = Counts per minute, alpha
B = Background Disintegrations per minute
TE = Total Efficiency
V = Volume of sample in mL

15.3 Beta activity in pCi/L is calculated as shown:

Beta = $(((C_\beta - B*1000))/(2.22*TE*V)$

C_β = Counts per minute, beta
B = Background Disintegrations per minute.
TE = Total Efficiency
V = Volume of sample in mL.

15.4 Beta activity in pCi/L, calculated for cross-talk correction:

Beta = $(\beta - \alpha M)*1000 / 2.22 * TE * V$

Where:
β = net beta counts at the beta plateau
α = net alpha counts at the alpha plateau
M = alpha amplification factor (from ratio plot)
TE = Efficiency
V = volume of sample in mL

15.5 Error at the 95% confidence level is calculated as shown below:
Error = $((1.96\ S(r))*1000)/(2.22*\ TE*V)$

Where:

$S(r) = ((Ri/Ti)+(C_B/TB))^{0.5}$
And
Ri = Count rate due to sample in CPM
Ti = Time in minutes measured sample
C_B = Count rate of background in CPM.
TB = Time in minutes measured on the background
CPM = Counts per minute.
TE= Total Efficiency.
V = Volume of sample in mL.

15.6 Error for Beta at the 95% confidence level, cross-talk corrected.

$Error_{Cross\text{-}talk} = (Error_\alpha^2 + Error_\beta^2)^{1/2}$
Where:
$Error_\alpha$ = Beta counting error at 95% confidence level

$Error_{\beta}$ = Alpha counting error at 95% confidence level

15.7 Lower limit of detection (LLD) calculation

LLD = ((4.66*(((B/Ti)+(B/TB))^0.5))*1000/(2.22*E*V*A))+(3*1000/(2.22*TE*V*TB))

15.8 Calculations in software are verified manually whenever the efficiency of the system is recalculated.

16.0 Precision and Accuracy.

16.1 Relative percent difference, RPD

RPD = |(A-B) / ((A+B)/2)|

Where:
A = Net activity of the first measurement
B = Net activity of the second measurement

16.2 Replicate error ratio, RER

$RER = |A-B| / SQRT(s_a^2 + s_b^2)$

Where:
A = Net activity of the first measurement
B = Net activity of the second measurement
s_a = The uncertainty of the first measurement (See Section 15.6, S(r))
s_b = The uncertainty of the second measurement

17.0 Pollution Prevention.

17.1 This procedure by definition is used on radioactive materials. All use of these materials is minimized as much as possible, for safety and waste containment.

18.0 Data Assessment and Acceptance Criteria.

18.1 MB
18.1.1 The MB results shall be below the reporting limit or MDA.

18.2 LCS

18.2.1 The LCS shall be within acceptance limits.

18.2.2 Drinking water compliance sample limits – The LCS shall be within ±20% of the true standard value for batches containing drinking water samples.

18.3 DUPs shall be within the acceptance criteria. Using either relative percent difference or replicate error ratio.

18.4 MS

18.4.1 The MS should be within acceptance limits. If MS exceeds acceptance limits, sample may be recounted or flagged.

18.5 MSD

18.5.1 The Relative Percent Difference should be within acceptance limits. If MSD is greater than acceptance limits and less than 5 times the MDA, the MSD will be evaluated using the replicate error ratio (RER). If this is less than 2, MSD will be accepted.

18.5.2 Drinking water compliance sample limits – The MS shall be within ±30% of the true standard value for batches containing drinking water samples.

19.0 Contingencies and Corrective Action for Out of Control or Unacceptable Data.

19.1 MB - the method blank recovery should be below the reporting limit. If the recovery is over this limit, the blank may be re-counted. If the recovery is still over limit, data may be reported if data are flagged and qualified appropriately.

19.2 LCS - If the LCS is outside of the acceptance limits, the LCS may be re-counted. If the LCS is still out of limits, the samples should be repeated.

19.2.1 Drinking water limits – If drinking water is in a batch with LCS outside of acceptance criteria, the LCS must be re-counted. If the LCS is still out of limits, the drinking water samples must be repeated from new aliquots.

19.3 DUP or MSD samples – If a duplicate sample fails both acceptance criteria, it will be re-counted. If the sample is still out of these criteria, the samples may be re-analyzed, however, the batch may be reported if the remaining quality control samples all meet acceptance criteria.

19.3.1 Drinking water compliance samples - Samples must be re-analyzed using new aliquots of sample, or resampled.

19.4 MS – If a sample falls out of acceptance criteria, and all other criteria are acceptable, the data may be accepted and poor spike recovery attributed to sample matrix. The data are flagged and this information will be placed in the case narrative in the report package.

19.4.1 Drinking water limits – If drinking water is in a batch with the matrix spike outside of acceptance criteria, the matrix spike must be re-counted. If the matrix spike is still out of limits, the drinking water samples must be re-analyzed.

20.0 Waste Management.

20.1 The RadChem department follows the policies and procedures in the Inter-Mountain Labs Sample Disposal Procedure and Safety Plan, and also adheres to the requirements inherent within the licensing requirements of the Nuclear Regulatory Committee (NRC).

21.0 References.

21.1 APHA AWWA WEF. 2011. Standard Methods for the Examination of Water and Wastewater. Method 7110B, Evaporation Method for Gross Alpha-Beta.

21.2 USEPA. 1980. Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA/600/4-80-032, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

21.3 Canberra Industries, Inc. 2010. Apex-Alpha/Beta™ Counting Productivity Software, User's Manual, V1.0.1, Canberra Industries, Inc., Meriden, CT.

21.4 USEPA. 2009. Protocol for EPA Evaluation of Alternate Test Procedures for Analyzing Radioactive Contaminants in Drinking Water, EPA 815-R-09-018, Office of Water (MS-140), Cincinnati, OH.

22.0 Tables, Diagrams, Comments.

22.1 Table 1

Table 1		
Ground water and monitoring samples/Clean Water Act samples		
QC Procedure	Criteria	Frequency
Instrument calibration-plateaus, efficiencies		Yearly
System background		Yearly
Stability check-efficiencies	90-110%	Day of use
Stability check-background	3 sigma control limit	Day of use
Method blank	Less than method detection limit	Every batch
LCS-Laboratory control sample	Ongoing QC charts at 3 sigma	Every batch
LCSD-Laboratory control sample duplicate	Ongoing QC charts at 3 sigma AND ± 20% RPD or RER <2	If requested
Duplicate	±20% RPD or RER <2	Every 10 samples
Matrix spike	Ongoing QC charts at 3 sigma	Every 10 samples
Matrix spike duplicate	Ongoing QC charts at 3 sigma AND ± 20% RPD or RER <2	If requested
MDL-Method detection limit	7 method blanks and 7 fortified blanks spiked between MCL and required detection limit	Yearly

22.2 Table 2

Table 2		
Safe Drinking Water Act compliance samples		
QC Procedure	Criteria	Frequency
Instrument calibration-plateaus, efficiencies		Yearly
System background		Yearly
Stability check-efficiencies	90-110%	Day of use
Stability check-background	3 sigma control limit	Day of use
Method blank	Less than method detection limit	Every batch
LCS-Laboratory control sample	80-120%	Every batch
LCSD-Laboratory control sample duplicate	80-120% AND ± 20% RPD or RER <2	If requested
Duplicate	±20% RPD or RER <2	Every 10 samples
Matrix spike	70-130%	Every 10 samples
Matrix spike duplicate	70-130% AND ± 20% RPD or RER <2	If requested
MDL-Method detection limit	7 method blanks and 7 fortified blanks spiked between MCL and required detection limit	Yearly

ATTACHMENT #1
STANDARD OPERATING PROCEDURE FOR GROSS ALPHA-BETA
METHOD TRAINING RECORD

Document Title: **Standard Operating Procedure for Analysis of Gross Alpha-Beta**

Document Control Number: R-GAB-4.3

Location: Inter-Mountain Laboratories, Inc.

I have read the preceding document and understand all sections.
I have been trained in the performance of the methods and any recent revisions to this procedure.

ANALYST	SIGNATURE	DATE	TRAINER

ATTACHMENT A2

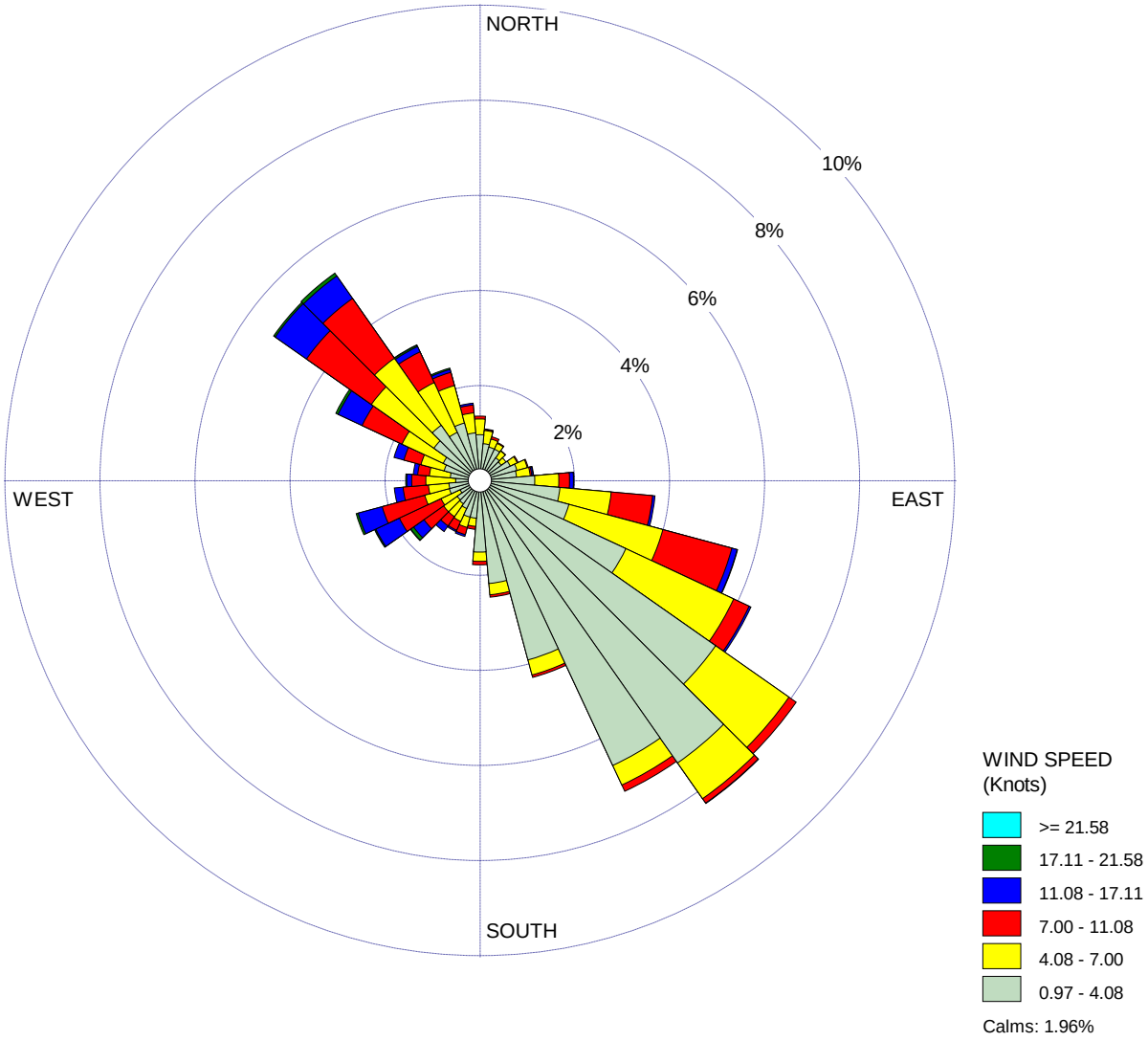
SHIPROCK, AZ, WIND ROSE

WIND ROSE PLOT:

Station # 1233 - NNEPA Shiprock Met Station , NM

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: **Start Date: 3/3/2016 - 00:00** **End Date: 4/12/2017 - 14:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **1.96%**	TOTAL COUNT: **9733 hrs.**	
	AVG. WIND SPEED: **4.43 Knots**	DATE: **4/17/2017**	PROJECT NO.: **TO 0021**

ATTACHMENT A3

STANDARD OPERATING PROCEDURES

Tetra Tech SOP 004: Field-Portable X-Ray Fluorescence Analyzer Measurement
Tetra Tech SOP 019: Packaging and Shipping Samples
Tetra Tech SOP 024: Recording Notes in Field Logbooks
Tetra Tech SOP 064: Calibration of Air Sampling Pump
Tetra Tech and ERG RPP SOP 001: Calibration of a Radiological Survey Detector
Tetra Tech and ERG RPP SOP 002: Calibration of a Radiological Survey Meter
Tetra Tech and ERG RPP SOP 006: Personnel, Environmental, and Work Area Air Sampling
SERAS SOP #2008: General Air Sampling Guidelines
SERAS SOP #2101: Retrieving Meteorological Information
SERAS SOP #2119: Air Sampling for Metals [NIOSH Method 7300, Elements]
SERAS SOP #2130: Operation of the DryCal DC-Lite Primary Flow Calibrator

Standard Operating Procedure

SOP No. 004
Field-Portable X-Ray Fluorescence Analyzer Measurement

March 2018

CONTENTS

1.0 BACKGROUND

The purpose of this Standard Operating Procedure (SOP) is to support the XRF measurements, sample collection and analysis, and visual survey activities. In the field, the locations of the in-situ XRF measurements will be determined with based on GPS coordinates included in site-specific Field Sampling Plans. The measurement location identifier and GPS coordinates will be entered into the XRF datalogger before making a field analysis. Photographs will also be taken at the measurement locations at the discretion of the field personnel to document the measurement locations and the general conditions of the surface materials.

As described in the Sampling and Analysis Plan (SAP), a visual survey will be performed to define the overall physical condition of the area. The visual survey will document surface conditions for color and texture, presence of defined stormwater drainage paths, and vegetative conditions. The presence of tailing and waste rock materials will also be visually identified, where possible. The visual survey information will be recorded in the field logbook or electronic form on tablet computer.

At each measurement location, the following information will be recorded in the field logbook or on a designated electronic field form:

- Names of field personnel
- Date/time of measurement
- Measurement location identifier
- General weather conditions (e.g. hot, windy, no precipitation)
- Surface material description, including color and texture (e.g. red-brown, sandy silt with occasional gravel) and relative moisture content (e.g., dry, moist, wet)
- Description and location of any tailing and waste rock materials, if visually present
- Description and location of nearby features (e.g., building foundations)
- Description and location of stormwater drainage paths, if present near the measurement location
- General description of vegetation conditions
- Sample identification, sample collection location, and collection time, if sample is collected
- Any problems encountered or deviations in XRF operation or sample collection methods
- Description of any unusual circumstances
- Photo documentation details, if necessary.

In addition, the following information will be recorded in the field logbook at least on a daily basis to document the field in-situ XRF measurements:

- XRF make and model number
- Documentation and results of instrument performance checks

- Certified reference materials (NIST standards) and blanks used for calibration purposes
- Site-specific calibration standards used
- Any problems encountered with instrument setup and operation.

2.0 FIELD PORTABLE X-RAY FLUORESCENCE (XRF) PROCEDURES FOR MEASUREMENT OF METAL CONCENTRATIONS IN SOILS

2.1 SCOPE AND APPLICABILITY

The following procedures describe the protocol for performing in-situ and ex-situ analysis of soil using a field-portable, NITON Corporation X-Ray Fluorescence (XRF) Spectrometer, in accordance with EPA Method 6200, Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment, Revision 0, January 1998. These procedures will also be used in conjunction with the XRF manufacturer's operation manual. Any changes or modifications to these procedures will be documented by the field technician and approved by the project manager.

2.1.1 Principles of Operation

XRF analyzers use either a radioisotope source or X-ray tube for the analysis of inorganic metal concentrations. Principles of operation are defined in the XRF operation manual and EPA Method 6200.

2.1.2 Health and Safety Issues

Proper training for safe use of the instrument and radiation training will be completed by the user prior to use of the instrument. The user will also refer to the operation manual for the XRF instrument for proper operation of that instrument. The instrument user should also be aware of local, state and national regulations that pertain to the use and storage of radiation producing equipment and radioactive materials. Compliance with all applicable regulations is required.

Safety precautions for use of the XRF instrument are as follows:

- Never point the XRF at yourself or anybody else with the shutter open.
- Stand to the rear or side of the XRF when the shutter is open. Do not operate the instrument in a seated position; this may expose your lower body to radiation.
- Do not fix the shutter in an open position (except in provided test stands).
- Do not leave the XRF unattended.
- Only trained people will operate an XRF.
- Open the shutter only with the sample in place.
- Never open the probe.

- Store the XRF in a safe place. Do not drop the machine (or put the instrument in a position where it will be likely to be dropped).
- Wear a dosimeter ring (if required by regulations).
- Perform wipe tests, per manufacturer's instructions.
- Women of child bearing age should be aware of the potential damage to a developing fetus from radiation exposure.
- Transport XRF in a shock-proof case.
- Follow all manufacturer's training and instructions.

OSHA exposure limits are presented below.

Whole body exposure:	5,000 mrem/yr	1,250 mrem/quarter
Extremities:	50,000 mrem/yr	18,750 mrem/quarter

Some states have specified lower limits for public exposure. The lowest exposure limits were found to be 100 mrem/yr and 1 mrem/day.

More detailed information and procedures are contained in EPA Method 6200, Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment, Revision 0, January 1998.

2.2 PROCEDURES

This section provides procedures for two types of measurement of metal concentrations with the portable XRF instrument according to procedures recommended in EPA Method 6200–field and laboratory measurements. The field in-situ XRF measurements are performed directly on the soil surface in the field to provide real-time analysis of metal concentrations. The intrusive XRF measurements are performed on samples collected from the field and analyzed either in the field or in a controlled, interior environment.

2.2.1 Field XRF Procedures

The following procedures outline the steps for in-situ XRF analysis of undisturbed soils in the field.

2.2.1.1 XRF Daily Calibration and Preparation

See instructions in Section 2.2.2.3, for XRF Calibration that follows general manufacturer procedures and calibration checks with certified reference materials (CRM), field blanks, etc.

2.2.1.2 Field In-Situ XRF Measurement

Follow manufacturer instructions to prepare the XRF for in situ measurement. Determine and prepare the location to be sampled. Measure an approximately 6-inch by 6-inch area for measurement. Remove any debris on the soil surface consisting of rocks, pebbles, leaves, vegetation, twigs or roots. Thoroughly homogenize soil within the measurement area to a depth

of approximately 3 inches below ground surface (bgs) using a stainless steel or plastic trowel. Level and smooth the soil surface with a stainless-steel or plastic trowel so that the probe window is in direct contact with the soil surface. Lightly tamp the soil surface with the trowel to increase soil density and compactness. The soil should not be saturated or have a moisture content exceeding approximately 20 percent.

When ready for analysis, press the XRF down on the soil surface, thus opening the XRF shutter. Maintain the XRF shutter open for the specified count time (60 seconds is recommended) then remove/release the XRF from the sample to stop the analysis. The measured metal concentrations are recorded by the XRF datalogger.

2.2.1.3 Decontamination

After every test the XRF detector shutter and any measurement guards will be wiped clean with tissue or wipes. If a stainless-steel trowel or other non-disposable equipment is used for the XRF in-situ measurements, decontamination procedures that are provided in Section 2.2.2.9 will be followed.

2.2.2 Intrusive XRF Analysis

The following method outlines procedures for preparing soil samples collected in the field for ex-situ XRF measurements under laboratory conditions, according to procedures recommended in EPA Method 6200.

2.2.2.1 Supplies

General Sample Supplies:
Stainless steel bowls
Stainless steel trowel or spoon
Disposable plastic spoons
Paper towels
Toaster oven
Deionized water
Alconox detergent (or similar)
Scrub brushes
Sample bags/containers

XRF Equipment and Supplies (obtained from the XRF manufacturer):
XRF instrument and mini lab kit
Sieves
Mortar and pestle (ceramic)
Polyethylene sample cups, collar, and bottom
X-ray window film (Mylar, or similar)

2.2.2.2 Sample Collection and Preparation

Soil samples will be collected in such a manner that the sample is representative of the soil matrix analyzed at the field in-situ XRF measurement location. Sample collection procedures are described in Section 3.0. Typically, the soil sample will be collected from a 6-inch by 6-inch square area to a depth of 3 inches. However, a larger soil volume may be required to provide a sufficient sample for drying and sieving depending on the soil texture and moisture content, and if necessary splitting for QC testing or laboratory analysis. Rocks, pebbles, vegetation matter, and other foreign debris will be removed from the sample. The minimum soil sample volume will be sufficient to fill a 4-ounce plastic sample bag after sieving. The sample will be placed in a clean

sample container suitable for thorough mixing of the sample, such as a Ziploc® bag or stainless steel bowl.

2.2.2.3 XRF Daily Calibration and Preparation

Turn the XRF detector on and allow it to warm up for at least 15 minutes, or as recommended by manufacturer. Perform a calibration check (i.e., instrument performance check) of the XRF detector according to manufacturer specifications. Quality control (QC) samples will also be analyzed prior to sample analysis, as described in Section 2.4.

2.2.2.4 Homogenize the Sample

The sample will be mixed by kneading within the Ziploc® bag or mixing in a stainless steel bowl using a clean stainless steel or plastic spoon. The sample will be mixed until the analyst is confident the sample has been completely homogenized.

2.2.2.5 Drying the Sample

If the sample is visibly wet, the sample will be air-dried or dried in a conventional or toaster oven at a temperature no greater than 150 degrees Celsius. A microwave oven will not be used to dry the sample. If the sample is air-dried, it will be allowed to dry in a protected environment to prevent contamination by dust deposition. The sample will be inspected for any remaining foreign debris (rocks, metal, wood, etc.); any such debris will be removed.

2.2.2.8 XRF Measurement

Place the Ziploc sample bag on a flat, stable surface. Next place the XRF detector on the surface, so that the shutter is directly in contact with the sample bag. When ready for measurement, depress the XRF into the sample bag, opening the shutter. Keep the XRF shutter open for a specified count time (60 seconds is recommended) then remove/release the XRF from the sample to stop the measurement. Count times are the seconds the sample is analyzed. The same count time will be used for calibration standards and samples for the same matrix. Count times may vary depending on the required results and may range from 20 seconds to over 600 seconds. The longer the count time the lower the detection limit obtained. The measured metal concentrations are recorded by the XRF datalogger. A single plastic bag may be analyzed multiple times to account for heterogeneity within the sample material. If multiple analyses are performed, measurements should be performed in different locations on the sample bag (for example, one measurement at the center of the bag, and four additional measurements at the approximate midpoint between the center and each corner of the sample bag).

2.2.2.9 Decontamination

Equipment, including stainless steel bowls, mortar and pestle, sieves, reusable trowels or spoons, etc. will be decontaminated prior to reuse. Decontamination procedures will consist of wiping with a clean paper towel or dry brushing loose soil from each piece of equipment. Next, rinse and/or scrub equipment with a DI and Alconox mixture using a clean scrub brush. Rinse with DI or distilled water, and then wipe dry with clean paper towels or air dry. If air drying is used, ensure the area is clean and away from areas where recontamination by dust deposition is possible. Store equipment in plastic or other protective covering to keep clean. The XRF detector and soil test

platform may be wiped with a clean paper towel. The work area will be kept clean and clear of unnecessary equipment at all times. It is recommended that plastic be used to cover the work surface so that it may easily be replaced with new and clean plastic whenever necessary.

2.3 DOCUMENTATION

Information to be recorded in the field notebook or designated field form for the field XRF analysis is described in Section 1.0. The following information will be recorded in a notebook or logbook for laboratory XRF analysis:

- Site-specific calibration standards used, or field standards if any
- Instrument make and model number, supplier of instrument, radioactive source used
- Date of analyses
- Name of analyst
- Sample locations and identification numbers
- Documentation of instrument performance checks
- QC samples, their origin and type
- Sample preparation method, sieve size used, if any
- Samples submitted to the laboratory for analyses
- Any problems encountered in instrument set up and operation or sample preparation and analysis

2.4 QUALITY ASSURANCE/QUALITY CONTROL

Proper warm up times and calibration of the XRF detector will always be followed as recommended and specified by the manufacturer (Section 2.1.1).

Additional QA/QC measures may include analyses of sample duplicates, field standards, and soil blanks to describe precision, accuracy of field XRF data. Certified reference material (NIST standards) and soil blanks are typically provided by the XRF manufacturer, or will be obtained from the equipment vendor. The low, medium, and high NIST soil standards and soil blanks will be measured every time the instrument is calibrated to ensure the accuracy of the XRF. Calibration will be performed at least once per day.

Duplicate field XRF measurements and laboratory XRF measurements will be repeated at a minimum of one for every 20 measurements.

SOP APPROVAL FORM

TETRA TECH, INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

PACKAGING AND SHIPPING SAMPLES

SOP NO. 0 19

REVISION NO. 7

Last Reviewed: November 2014

Quality Assurance Approved

November 24, 2014

Date

1.0 BACKGROUND

In any sampling program, the integrity of a sample must be ensured from its point of collection to its final disposition. This standard operating procedure (SOP) describes procedures for packaging and shipping samples. Steps in the procedures should be followed to ensure sample integrity and to protect the welfare of persons involved in shipping and receiving samples.

1.1 PURPOSE

This SOP establishes the requirements and procedures for packaging and shipping samples. It has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) "Contract Laboratory Program Guidance for Field Samplers." Procedures described in this SOP should be followed for all routine sample packaging and shipping. If procedures are to be modified for particular contract- or laboratory-specific requirements, modified procedures should be clearly described in site-specific plans such as work plans, field sampling plans (FSPs), or quality assurance project plans (QAPPs). Deviations from the procedures in this SOP must be documented in a field logbook. This SOP assumes that samples are already in the appropriate sample jars and that the sample jars are labeled.

This SOP does not cover the packaging and shipment of Dangerous Goods or Hazardous Materials. The shipment of Dangerous Goods (by air) and Hazardous Materials (by ground) requires specialized training. If you have NOT received this training in the last two years, you are NOT qualified to package or ship these materials and may be personally liable for any damages or fines. Contact one of Tetra Tech's shipping experts for assistance. Instructions to access the training course, shipping experts and health and safety (H&S) contacts, and general information on packaging and shipping hazardous substances and dangerous goods can be obtained by checking the links provided in Section 1.4 (References).

1.2 SCOPE

This SOP applies to packaging and shipping of environmental and nonhazardous samples. This SOP does not address shipping dangerous goods or hazardous materials.

1.3 DEFINITIONS

Airbill: An airbill is a shipping form (such as a FedEx shipping form) acquired from the commercial shipper and is used to document shipment of the samples from the sampler to the designated analytical laboratory (see Figure 1).

Custody-of-Custody form: A chain-of-custody form is used to document the transfer of custody of samples from the field to the designated analytical laboratory (see Figure 2). The chain-of-custody form is critical to the chain-of-custody process and is used to identify the samples in each shipping container to be shipped or delivered to the laboratory for chemical or physical (geotechnical) analysis (see Figure 3).

Custody seal: A custody seal is a tape-like seal and is used to indicate that samples are intact and have not been disturbed during shipping or transport after the samples have been released from the sampler to the shipper (see Figure 4). The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been packaged for shipping (see Figure 5).

Environmental samples: Environmental samples include drinking water, most groundwater and surface water, soil, sediment, treated municipal and industrial wastewater effluent, indoor and ambient air, nonhazardous bulk materials, soil gas, dust, asbestos, and biological specimens. Environmental samples typically contain low concentrations of contaminants and, when handled, require only limited precautionary procedures.

Field Blank: A field blank is any blank sample that is packaged and shipped from the field. Each field blank is assigned its own unique sample number. Field blanks include trip blanks, rinse blanks, and equipment blanks, all intended to assess potential cross-contamination. For example, a trip blank checks for contamination during sample handling, storage, and shipment from the field to the laboratory.

Nonhazardous samples: Nonhazardous samples are those samples that do not meet the definition of a hazardous sample and do not need to be packaged and shipped in accordance with the International Air Travel Association's (IATA's) "Dangerous Goods Regulations" (DGR) or U.S. Department of Transportation's (U.S. DOT's) "Hazardous Materials Regulations" (HMR) defined in Title 49 Code of Federal Regulations (CFR).

The following definitions are provided to further distinguish environmental and nonhazardous samples from dangerous good and hazardous samples:

Dangerous goods: Dangerous goods are articles or substances that can pose a significant risk to health, safety, or property when transported by air; they are classified as defined in Section 3 of the DGR (IATA 2014).

Hazardous samples: Hazardous samples include dangerous goods and hazardous substances. Hazardous samples shipped by air should be packaged and labeled in accordance with procedures specified by the DGR; ground shipments should be packaged and labeled in accordance with the HMR.

Hazardous substance: A hazardous substance is any material, including its mixtures and solutions, that is listed in 49 CFR 172.101 and its quantity, in one package, equals or exceeds the reportable quantity (RQ) listed in Table 1 to Appendix A of 49 CFR 172.101.

1.4 REFERENCES

General Awareness, H&S contacts, and course training information" click here. (Tetra Tech, Inc., EMI Operating Unit. Intranet) Available on-line at: https://int.tetratech.com/sites/EMI/hs/Pages/Dangerous-Goods-Shipping.aspx

International Air Transport Association (IATA). 2014. "Dangerous Goods Regulations. 2014." For sale at: http://www.iata.org/publications/Pages/standards-manuals.aspx. Updated annually, with new edition available late in year.

U.S. Environmental Protection Agency (EPA). 40 CFR, 763 Subpart F, Asbestos Hazards Emergency Response Act (AHERA).

EPA. 2011. "Contract Laboratory Program Guidance for Field Samplers." EPA 540-R-09-03. Available on-line at: http://www.epa.gov/oerrpage/superfund/programs/clp/download/sampler/CLPSamp-01-2011.pdf. January.

1.5 REQUIREMENTS AND RESOURCES

The procedures for packaging and shipping samples require the following:

- Coolers (insulated ice chest) or other shipping containers appropriate to sample type
- Ice
- Bubble wrap or similar cushioning material
- Chain-of-custody forms and seals
- Airbills
- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)
- Large plastic garbage bags for lining the cooler
- Temperature blank sample bottle filled with distilled water can be included in the cooler if appropriate to sample type

- Trip blank samples used to check for volatile contamination during sample handling in the field and shipment from field to laboratory should be included in the cooler if volatile organic compounds are requested for analysis. Also see Field Blank under definitions.

2.0 PROCEDURES

The following procedures apply to packaging and shipping nonhazardous and environmental samples.

2.1 PACKAGING SAMPLES

After they have been appropriately containerized and labeled, environmental samples should be packaged as described in this section. This section covers procedures for packing samples for delivery by commercial carrier (air or ground) and hand delivery of environmental samples (by employee or courier), as well as shipping asbestos and air quality samples. Note that these instructions are general; samplers also should be aware of client-specific requirements concerning the placement of custody seals or other packaging provisions.

2.1.1 Packaging Samples for Delivery by Commercial Carrier (Air or Ground)

Samples shipped by commercial carriers should be packed for shipment using the following procedures and in compliance with all carrier requirements:

Preparing the sample:

1. Allow a small amount of headspace in all bottles, or as instructed by the laboratory (except volatile organic compound [VOC] containers with a septum seal) to compensate for any changes in pressure and temperature during transfer.
2. Be sure the lids on all bottles are tight (will not leak). Lids maybe taped or sealed with custody seals as added protection or as required.
3. Place sample containers in resealable plastic bags.

Preparing the cooler:

1. Secure and tape the drain plug of the cooler with fiber or duct tape.
2. It is recommended that the cooler be lined with a large plastic garbage bag before samples, ice, and absorbent packing material are placed in the cooler.
3. Wrap the sample containers in bubble wrap or line the cooler (bottom and sides) with a cushioning material to prevent breakage of bottles or jars during shipment.
4. Add a sufficient quantity of ice to the cooler to cool samples to 4 °C ($\pm$ 2 °C). Ice should be double bagged in resealable plastic bags to prevent the melted ice from leaking out. If required, include one temperature blank (a sample bottle filled with distilled water) per cooler.

5. For volatile organic analysis (VOA) samples only, include one trip blank for VOA analysis per shipment matrix in each cooler.
6. Fill all remaining space between the bottles or jars with bubble wrap.
7. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).
8. If more than one cooler is being shipped, mark each cooler as "1 of 2," "2 of 2," and so forth.
9. Place the chain-of-custody forms (see Figure 2) into a resealable plastic bag, and tape the bag to the inner side of the cooler lid (see Figure 3). If you are shipping more than one cooler, copy the chain-of-custody form so that there is one copy of all forms in each cooler. The samples listed on the chain-of-custody form must match exactly with the contents of the cooler. Tape any instructions for returning the cooler to the inside of the lid.
10. Close the lid of the cooler and tape it shut by wrapping strapping tape around both ends and hinges of the cooler at least once.
11. Place two signed custody seals (see Figure 4) on opposite sides of the cooler, ensuring that each one covers the cooler lid and side of the cooler (see Figure 5; note that in contrast to the figure, the seals should be placed on the opposite sides of the cooler and offset from each other, rather than directly across from each other as shown in Figure 5). Place clear plastic tape over the custody seals so that the cooler cannot be opened without breaking the seal.
12. Shipping containers must be marked "THIS END UP." Arrow labels, which indicate the proper upward position of the container, may also be affixed to the container (see Figures 3 and 5). A label containing the name, phone number, and address of the shipper should be placed on the outside of the container (Federal Express [FedEx] label) (see Figure 1).
13. Ship samples overnight using a commercial carrier such as FedEx.

2.1.2 Hand Delivery of Environmental Samples (by Employee or Courier)

Samples hand-delivered to the laboratory should be packed for shipment using the following procedures:

Preparing the sample:

1. Bottles can be filled completely with sample (required for VOC containers with a septum seal).
2. Be sure the lids on all bottles are tight (will not leak).

Preparing the cooler:

1. Secure and tape the drain plug of the cooler with fiber or duct tape.
2. Wrap the sample containers in bubble wrap and/or line the cooler (bottom and sides).
3. Add a sufficient quantity of ice to the cooler to cool samples to 4 °C. Ice should be double bagged in resealable plastic bags to prevent the melted ice from leaking out. If required, include one temperature blank (a sample bottle filled with distilled water) per cooler.
4. For VOA samples only, include one trip blank for VOA analysis per shipment matrix in each cooler.
5. If more than one cooler is being shipped, mark each cooler as "1 of 2," "2 of 2,"and so forth.

6. Place chain-of-custody form (see Figure 2) in a resealable plastic bag and tape to the inside of the cooler lid, close the lid, seal with custody seals, and transfer the cooler to the courier (see Figure 3). Alternatively, when samples will be delivered directly to the laboratory, close the cooler and hand-deliver it with the chain-of-custody form. The samples listed on the chain-of-custody form must match exactly with the contents of the cooler.
7. Include any instructions for returning the cooler to the inside of the lid.
8. Place two signed custody seals (see Figure 4) on opposite sides of the cooler, ensuring that each one covers the cooler lid and side of the cooler (see Figure 5, note that the seals should be placed on the opposite sides of the cooler and offset from each other, rather than directly across from each other as shown in Figure 5). Place clear plastic tape over the custody seals so that the cooler cannot be opened without breaking the seal.
9. Shipping containers must be marked "THIS END UP," and arrow labels, which indicate the proper upward position of the container should be affixed to the container (see Figures 3 and 5).

2.1.3 Shipping Asbestos Samples

Asbestos samples shipped by commercial carriers should be packed for shipment using the following procedures and in compliance with all carrier requirements:

1.` Place each asbestos sample in a small resealable plastic bag. Place the bags of asbestos samples in a large resealable plastic bag.
2. Select a rigid shipping container (FedEx box) and pack the cassettes upright in a noncontaminating, nonfibrous medium such as a bubble pack to prevent excessive movement during shipping.
3. Avoid using expanded polystyrene because of its static charge potential. Also avoid using particle-based packaging materials because of possible contamination.
4. Affix custody seals to the top of the cassettes or outer sample bag so that the bags cannot be opened without breaking the seal.
5. Insert the chain-of-custody form in the box. Include a shipping bill and a detailed listing of samples shipped, their descriptions and all identifying numbers or marks, sampling data, shipper's name, and contact information.
6. Ship bulk samples in a separate container from air samples. Bulk samples and air samples delivered to the analytical laboratory in the same container will be rejected.
7. For each sample set, designate which are the ambient samples, which are the abatement area samples, which are the field blanks, and which is the sealed blank if sequential analysis is to be performed.
8. Hand-carry samples to the laboratory in an upright position if possible; otherwise, choose that mode of transportation least likely to jar the samples in transit.
9. Address the package to the laboratory sample coordinator by name when known and alert him or her of the package description, shipment mode, and anticipated arrival as part of the chain-of-custody and sample tracking procedures. This information will also help the laboratory schedule timely analysis for the samples when they are received.

2.1.4 Shipping Air Samples

Packaging and shipping requirements for air samples vary depending on the media used to collect the samples and the analyses required. Sampling media typically include Summa canisters and Tedlar bags for whole air samples, filters for metals and particulate matter, and sorbent tubes for organic contaminants. This section of the SOP provides general guidelines for packaging and shipping air samples collected using these media. The project FSP or QAPP should also be reviewed for any additional project-specific requirements or instructions.

Summa Canister Samples

1. Close the canister valve by tightening the knob clockwise or flipping the toggle switch. Replace the brass cap on the canister inlet.
2. If a flow controller was used to collect the air sample over a specified time interval, the flow controller should be removed before replacing the brass cap.
3. Fill out the sample tag on the canister with the sample number and the date and time of collection. Include the identification number of the flow controller on the sample tag if one was used. Make sure the information on the sample tag matches the chain-of-custody form.
4. Complete the chain-of-custody form. In addition to the information normally included, the form should include the following data: sample start and stop dates and times; initial and final Summa canister vacuum readings; Summa canister identification number; and flow controller identification number.
5. Package the Summa canister (and flow controller) in its original shipping box with the original packaging material. Tape the box shut and apply custody seals if required. Note: Summa canisters should never be packaged with ice.
6. Summa canister shipments typically include several canisters, and may include more than one shipping box. The chain-of-custody form for the shipment should be sealed within one of the shipping boxes.
7. Ship the samples by a method that will meet the holding time. Summa canister samples should be analyzed within 30 days of sample collection.

Tedlar Bag Samples

1. Close the Tedlar bag by tightening the valve clockwise.
2. Fill out the label on the bag with the sample number and the date and time of sample collection. Make sure the information on the label matches the chain-of-custody form.
3. Complete the chain-of-custody form.
4. Package the Tedlar bag in a shipping box with appropriate packing material. Multiple bags can be packaged in the same box. Tape the box shut and apply custody seals if required. Note: Tedlar bag samples should not be cooled or packaged with ice.
5. Tedlar bag shipments may include more than one shipping box. The chain-of-custody form for the shipment should be sealed within one of the shipping boxes.

6. Ship the samples using priority overnight delivery. Tedlar bag samples should be analyzed within 3 days of sample collection.

Filter Cassette Samples

1. Disconnect the filter cassette from the air sampling pump and replace the plastic caps on the inlet and outlet openings.
2. Attach a label to the sample that includes the sample number and the date and time of sample collection. Make sure the information on the label matches the chain-of-custody form.
3. Complete the chain-of-custody form. In addition to the information normally included, the form should include the following data: sample start and stop dates and times; initial and final air flow rates (or average flow rate); volume of air sampled; and sampling pump identification number.
4. Package the filter cassettes in a shipping box (such as a FedEx box). Use an appropriate packing material (such as bubble wrap) to separate the samples and prevent damage.
5. Place the chain-of-custody form within the box, seal the box, and apply custody seals if required. Filter cassette samples typically do not need to be cooled, but check the FSP or QAPP for project-specific requirements.
6. Ship the samples by a method that will meet the holding time.

Sorbent Tube Samples

1. Disconnect the sample tube from the air sampling pump and seal both ends of the tube with plastic caps.
2. Complete a sample label that includes the sample number and the date and time of sample collection. Make sure the information on the label matches the chain-of-custody form.
3. If the tube is small and the label cannot be attached to the tube, the tube can be placed in a small sealable plastic bag and the label can be attached to the bag or placed inside the bag with the tube.
4. Complete the chain-of-custody form. In addition to the information normally included, the form should include the following data: sample start and stop dates and times; initial and final air flow rates (or average flow rate); volume of air sampled; and sampling pump identification number.
5. Packaging requirements for the sample tubes will depend on the analysis required, and the sampler should check the FSP or QAPP for project-specific requirements (for example, tubes may need to be wrapped in aluminum foil to prevent exposure to light). Packaging containers and methods include (1) shipping boxes (as described under filter cassette samples), (2) small sample coolers filled with double-bagged ice, and (3) small sample coolers filled with blue ice.
6. Place the chain-of-custody form within the box or container, seal the box or container, and apply a custody seal if required.
7. If coolers are used for shipping, tape instructions for returning the cooler to the inside of the lid.
8. Ship the samples by a method that will meet the holding time.

Polyurethane Foam (PUF) Tube Samples

1. Disconnect the PUF tube from the air sampling pump and wrap the tube in aluminum foil.
2. Attach a label to the wrapped sample tube that includes the sample number and the date and time of sample collection. Make sure the information on the label matches the chain-of-custody form.
3. Wrap the PUF tube in bubble wrap and place the tube in a glass shipping jar.
4. Complete the chain-of-custody form. In addition to the information normally included, the form should include the following data: sample start and stop dates and times; initial and final air flow rates (or average flow rate); volume of air sampled; and sampling pump identification number.
5. Package the PUF tube jars in a cooler that is filled with double-bagged ice. Use bubble wrap or other cushioning material to separate the samples and prevent breakage.
6. Place the chain-of-custody form within the cooler, seal the cooler, and apply a custody seal if required.
7. If coolers are used for shipping, tape instructions for returning the cooler to the inside of the lid.
8. Ship the samples by a method that will meet the holding time. Samples collected in PUF tubes typically must be extracted within 7 days of collection.

2.2 SHIPPING DOCUMENTATION FOR SAMPLES

Airbills, chain-of-custody forms, and custody seals must be completed for each shipment of nonhazardous environmental samples. Figures 1, 2, and 4 provide examples of these forms and instructions for completing them.

Field staff collecting samples should also review their field work plans to confirm what documentation must be completed during each sampling event, including client-specific requirements. For example, some EPA programs have a specific requirement to use Scribe software, an environmental data management system, to create sample documentation, electronically input information into Traffic Report or chain-of-custody forms, and enter other data.

- The Scribe software can be accessed from the EPA Environmental Response Team (ERT) at the following address: http://www.ertsupport.org/scribe_home.htm
- The ERT User Manual for Scribe, reference, and training materials can be accessed from the Scribe Support Web site at the following address: http://www.epaosc.org/scribe

Note that some laboratories must routinely return sample shipping coolers within 14 calendar days after the shipment has been received. Therefore, the sampler should also include instructions for returning the cooler with each shipment, when possible. The sampler (not the laboratory) is responsible for paying for return of the cooler and should include shipping airbills bearing the sampler's shipping account number,

as well as a return address to allow for return of the cooler (see Figure 1). Samplers should use the least expensive option possible for returning coolers.

2.3 SHIPMENT DELIVERY AND NOTIFICATION

A member of the field sampling team must contact the laboratory to confirm it accepts deliveries on any given day, especially Saturdays. In addition, samplers should ensure the laboratory has been notified in advance of the pending shipment and notify any additional parties as required. The sampler needs to know the laboratory's contact name, address, and telephone number and be aware of the laboratory's requirements for receiving samples.

The sampler needs to know the shipping company's name, address, and telephone number (see Figure 1). In addition, samplers should be aware of the sample holding times, shipping company's hours of operation, shipping schedule, and pick-up and drop-off requirements to avoid delays in analytical testing.

Priority Overnight Delivery

Priority overnight delivery is typically the best method for shipment. Delays caused by longer shipment times may cause the sample temperature to rise above the acceptable range of 4° C (± 2 ° C) and technical holding may expire, which in turn may compromise sample integrity and require recollection of samples for analysis. If sample delivery procedures are to be modified for particular contract- or laboratory-specific requirements, the procedures should be clearly described in site-specific plans such as work plans, FSPs, or QAPPs.

Saturday Delivery

If planning to ship samples for Saturday delivery, the laboratory must be contacted in advance to confirm it will accept deliveries on Saturdays or arrange for them to be accepted. In addition, samplers should ensure the laboratory has been notified in advance of the pending shipment and notify any additional parties as required.

2.4 HEALTH AND SAFETY CONSIDERATIONS

In addition to the procedures outlined in this SOP, all field staff must be aware of and follow the health and safety practices that result from the Activity Hazard Analyses (AHA) for the project. The AHAs include critical safety procedures, required controls, and minimum personal protective equipment (PPE) necessary to address potential hazards. The hazards specific to project tasks must be identified and

controlled to the extent practicable and communicated to all project personnel via the approved, project-specific Health and Safety Plan (HASP).

3.0 POTENTIAL PROBLEMS

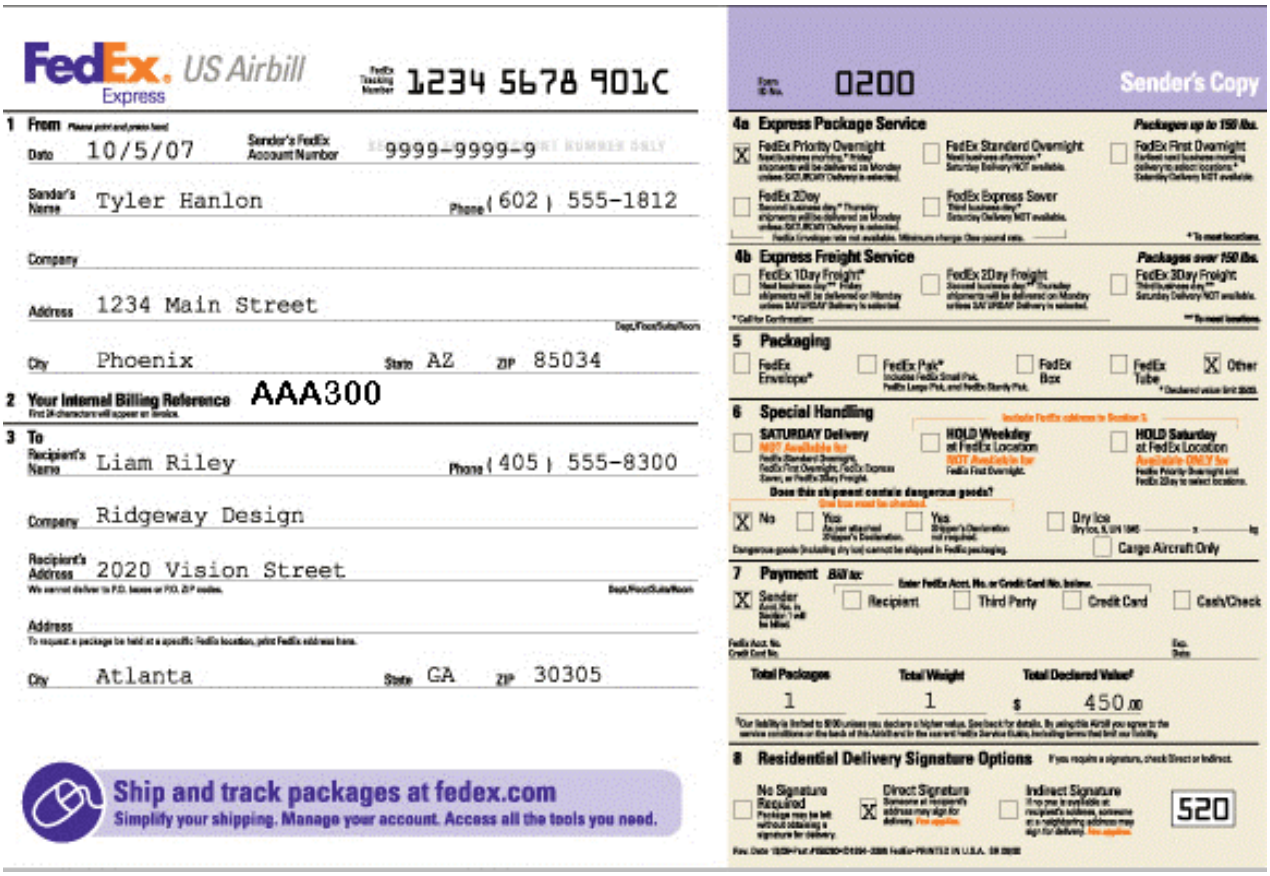
The following potential problems may occur during sample shipment:

- Leaking package. If a package leaks, the carrier may open the package and return the package. Special care should be taken during sample packaging to minimize potential leaks.
- Improper labeling and marking of package. If mistakes are made in labeling and marking the package, the carrier will most likely notice the mistakes and return the package to the shipper, thus delaying sample shipment. A good practice is to have labels, forms, and container markings double checked by a member of the field team.
- Bulk samples and air samples delivered to the analytical laboratory in the same container. If samples are combined in this way, they will be rejected. Always ship bulk samples in separate containers from air samples.
- Issues in packing asbestos samples. When asbestos samples are shipped, avoid using expanded polystyrene because of its static charge potential. Also avoid using particle-based packaging materials with asbestos samples because of possible contamination.
- Improper, misspelled, or missing information on the shipper's declaration. The carrier will most likely notice these errors as well and return the package to the shipper. A good practice is to have another field tram member double check this information.
- Missed drop off time or wrong location. Missing the drop off time or having the wrong location identified for drop off will delay delivery to the laboratory and may cause technical holding times to expire. Establish the time requirements in advance of completing the field effort and be sure and provide some contingency time for potential delays such as traffic or checking and redoing paperwork.
- Incorrectly packaging samples for analysis at multiple laboratories. For example, inorganic samples may be shipped to one laboratory for analysis, while organic samples may need to be shipped to another laboratory. All field staff should be aware which samples are to be shipped to which laboratory they package samples for multiple types of analysis.
- Holidays or weather-related delays. Be aware of holidays and weather forecasts that could cause delays in delivery. Delays caused by longer shipping times may cause technical holding times to expire, which in turn may compromise sample integrity or require recollection of samples for analysis.
- Not noting field variances in field log book. Field variances should be noted in the field log book and the project manager notified. Common field variances include:
  - Less sample volume collected than planned. Notify appropriate staff and the laboratory to ensure there is an adequate amount for analysis.

- Sample collected into incorrect jar because of broken or missing bottle-ware. Notify appropriate laboratory staff to ensure there is no confusion regarding the analysis of the sample.

FIGURE 1

EXAMPLE OF A FEDEX US AIRBILL FOR LOW LEVEL ENVIRONMENTAL SAMPLES

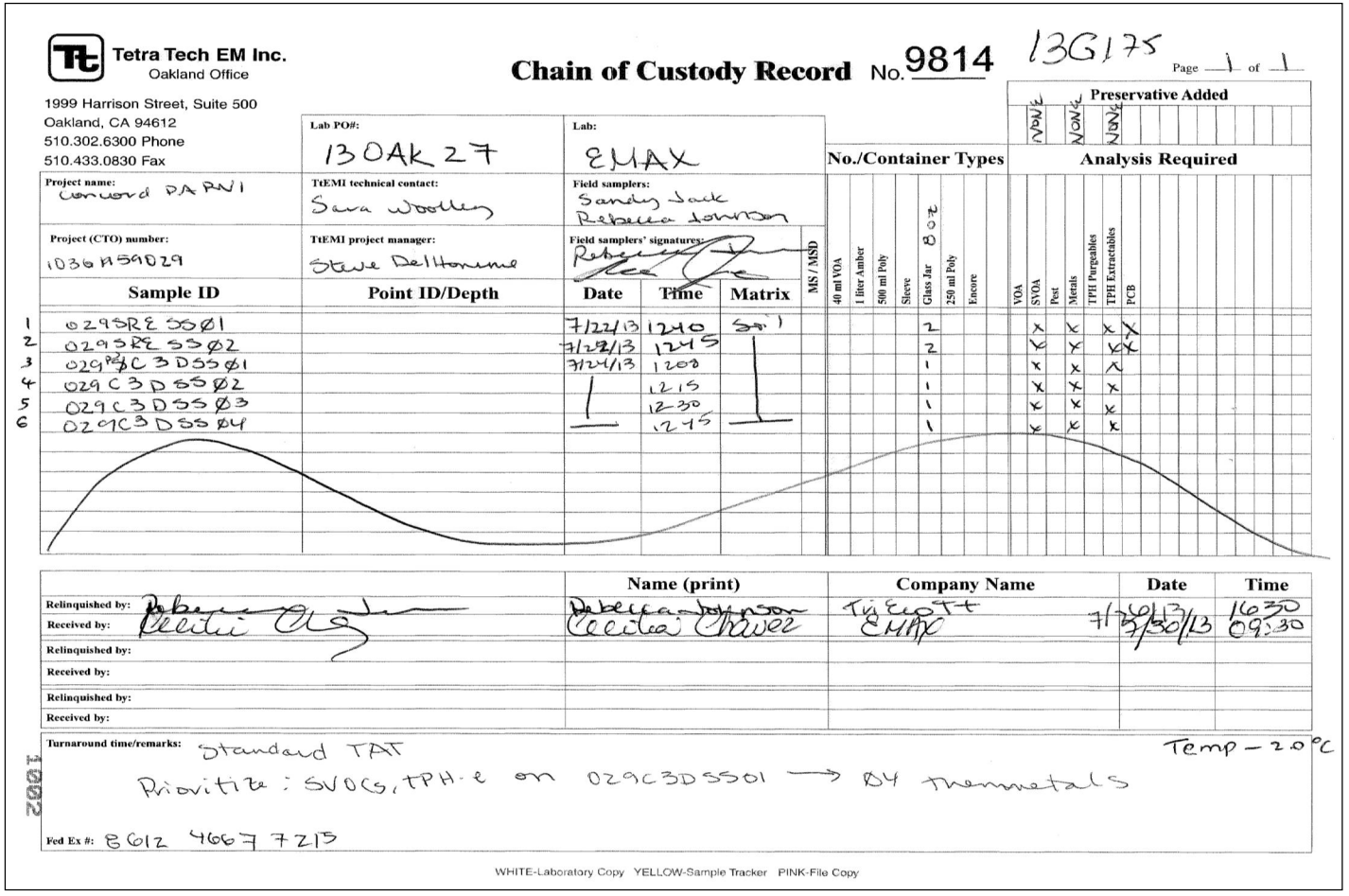


Filling Ou t the FedEx U S Airbill

- The sender must complete the following fields on the pre-printed airbill:
  - Section 1: Date
  - Section 1: Sender's FedEx Account Number
  - Section 1: Sender's Name, Company, Address, and Phone Number
  - Section 2: Internal Billing Reference (Project Number)
  - Section 3: Recipient's Name, Company, Address, and Phone Number
  - Section 4: Express Package or Freight Services (Priority Overnight)
  - Section 5: Packaging (usually "Other," your own packaging)
  - Section 6: Special Handling (Saturday delivery if prearranged with receiving laboratory; "No" dangerous goods contained in shipment)
  - Section 7: Payment ("Bill to Sender")
  - Section 7: Total Number of Packages
  - Section 7: Total Weight (completed by FedEx employee)
  - Section 8: Delivery Signature Options ("No Signature Required")

FIGURE 2

EXAMPLE OF A CHA IN-OF-CUSTODY FORM (WHI TE COPY)



Tetra Tech EM Inc.
Oakland Office
1999 Harrison Street, Suite 500
Oakland, CA 94612
510.302.6300 Phone
510.433.0830 Fax

Chain of Custody Record No. 9814 13G175 Page 1 of 1

Lab PO#: 130Ak27
Lab: EMAX
Project name: Concord DA RM1
TtEMI technical contact: Sara Woolley
Field samplers: Sandy Jack, Rebecca Johnson
Project (CTO) number: 103GA59029
TtEMI project manager: Steve DeHomme
Field samplers' signatures:

	Sample ID	Point ID/Depth	Date	Time	Matrix	MS / MSD	No./Container Types: 40 ml VOA	1 liter Amber	500 ml Poly	Sleeve	Glass Jar 8oz	250 ml Poly	Encore	Preservative Added: NONE	NONE	NONE	Analysis Required: VOA	SVOA	Pest	Metals	TPH Purgeables	TPH Extractables	PCB
1	029SRE55Ø1		7/22/13	1240	Soil						2						X	X	X		X	X	
2	029SRE55Ø2		7/22/13	1245							2						X	X	X		X	X	
3	029DUPC3D55Ø1		7/24/13	1200							1						X	X	X		X		
4	029C3D55Ø2			1215							1						X	X	X		X		
5	029C3D55Ø3			1230							1						X	X	X		X		
6	029C3D55Ø4			1245							1						X	X	X		X		

	Name (print)	Company Name	Date	Time
Relinquished by:	Rebecca Johnson	TtEMI	7/30/13	1630
Received by:	Cecilia Chavez	EMAX	7/30/13	09:30
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				

Turnaround time/remarks: Standard TAT
Temp – 20°C
Prioritize: SVOCs, TPH-e on 029C3D5501 → B4 thenmetals

Fed Ex #: 8612 4667 7215

WHITE-Laboratory Copy YELLOW-Sample Tracker PINK-File Copy

Completing a Sample Chain-of-Custody Form

After samples have been collected, they will be maintained under chain-of-custody procedures. These procedures are used to document the transfer of custody of the samples from the field to the designated analytical laboratory. The same chain-of-custody procedures will be used for the transfer of samples from one laboratory to another, if required.

The field sampling personnel will complete a Chain-of-Custody and Request for Analysis (CC/RA) Form (Figure 1, Chain of Custody Record) for each separate container of samples to be shipped or delivered to the laboratory for chemical or physical (geotechnical) analysis. Information contained on the triplicate, carbonless form will include:

1. Project identification (ID) (for example, contract and task order number);
2. Project Contract Task Order (CTO) number;
3. Laboratory Project Order (PO) number;
4. Tetra Tech Technical Contact;
5. Tetra Tech Project Manager
6. Laboratory name;
7. Field sampler names;
8. Field sampler signature;
9. Sample ID;
10. Point ID and Depth (Do NOT include this information on the laboratory copy of the chain-of-custody (top white copy);
11. Date and time of sampling;
12. Sample matrix type;
13. Sample preservation method; note "NONE" if no preservatives;
14. Number and types of sample containers and container capacity;
15. Sample hazards (if any);
16. Requested analysis;
17. Requested sample turnaround time or any special remarks;
18. Page __ of __;
19. Method of shipment;
20. Carrier/waybill number (if any);
21. Signature, name, and company of the person relinquishing the samples and the person receiving the samples when custody is transferred;
22. Date and time of sample custody transfer;

23. Condition of samples when they are received by the laboratory.

The sample collector will cross out any blank space on the CC/RA Form below the last sample number listed on the part of the form where samples are listed.

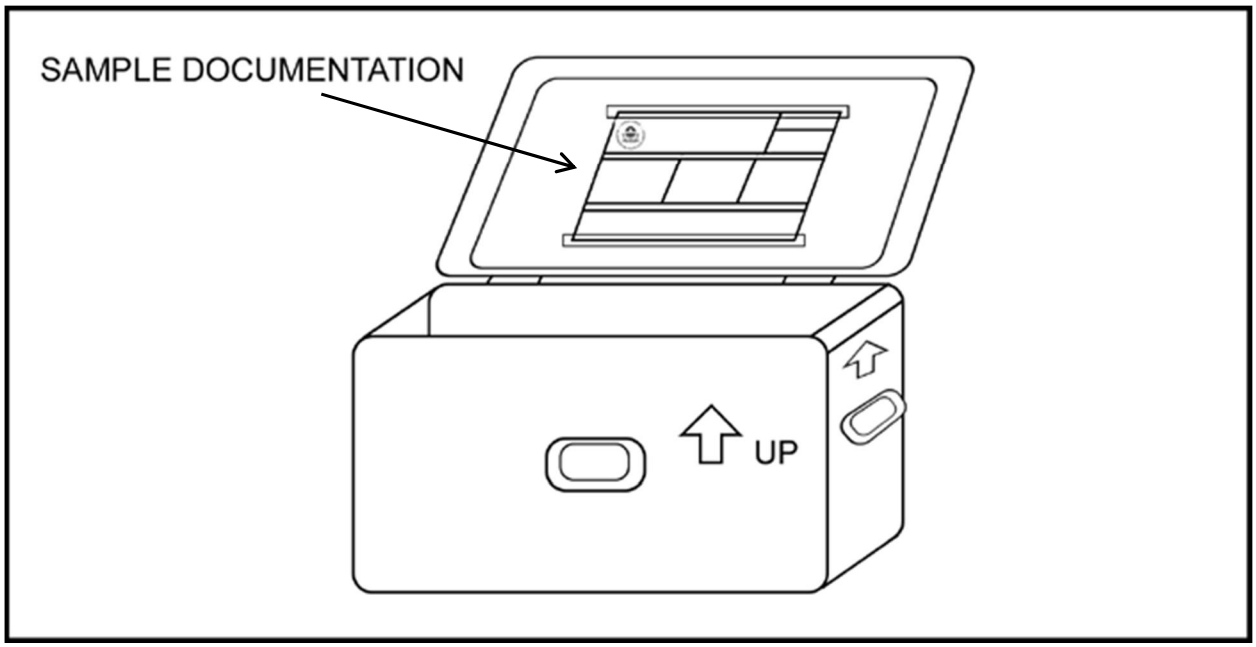
The sampling personnel whose signature appears on the CC/RA Form is responsible for the custody of a sample from time the sample is collected until the custody of the sample is transferred to a designated laboratory, a courier, or to another Tetra Tech employee for transporting a sample to the designated laboratory. A sample is considered to be in custody when the custodian: (1) has direct possession of it; (2) has plain view of it; or (3) has securely locked it in a restricted access area.

Custody is transferred when both parties to the transfer complete the portion of the CC/RA Form under "Relinquished by" and "Received by" or a sample is left at a FedEx facility pending shipment. Signatures, printed names, company names, and date and time of custody transfer are required. When custody is transferred, the Tetra Tech sampling personnel who relinquished the samples will retain the third sheet (pink copy) of the CC/RA Form. When the samples are shipped by a common carrier, a Bill of Lading supplied by the carrier will be used to document the sample custody, and its identification number will be entered on the CC/RA Form. Receipts of Bills of Lading will be retained as part of the permanent documentation in the Tetra Tech project file.

FIGURE 3

EXAMPLE OF A SAMPLE COOLER WITH ATTACHED DOCUMENTATION

Place the necessary paperwork (chain-of-custody form, cooler return instructions, and associated paperwork) in the shipping cooler or acceptable container. All paperwork must be placed in a plastic bag or pouch and then secured to the underside of the shipping container lid.



Source: U.S. Environmental Protection Agency. 2011.

FIGURE 4

EXAMP LE OF A CUSTODY SEAL

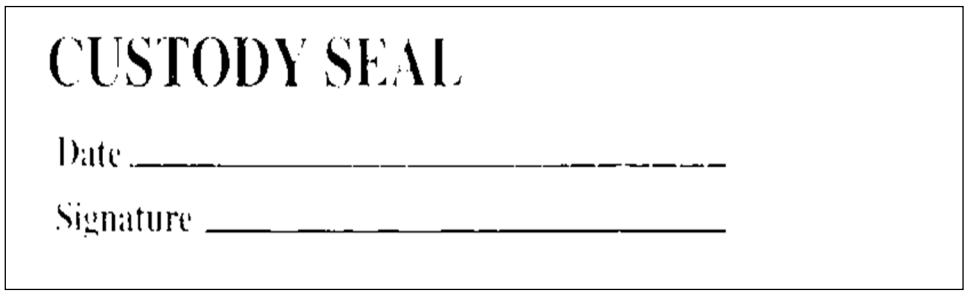
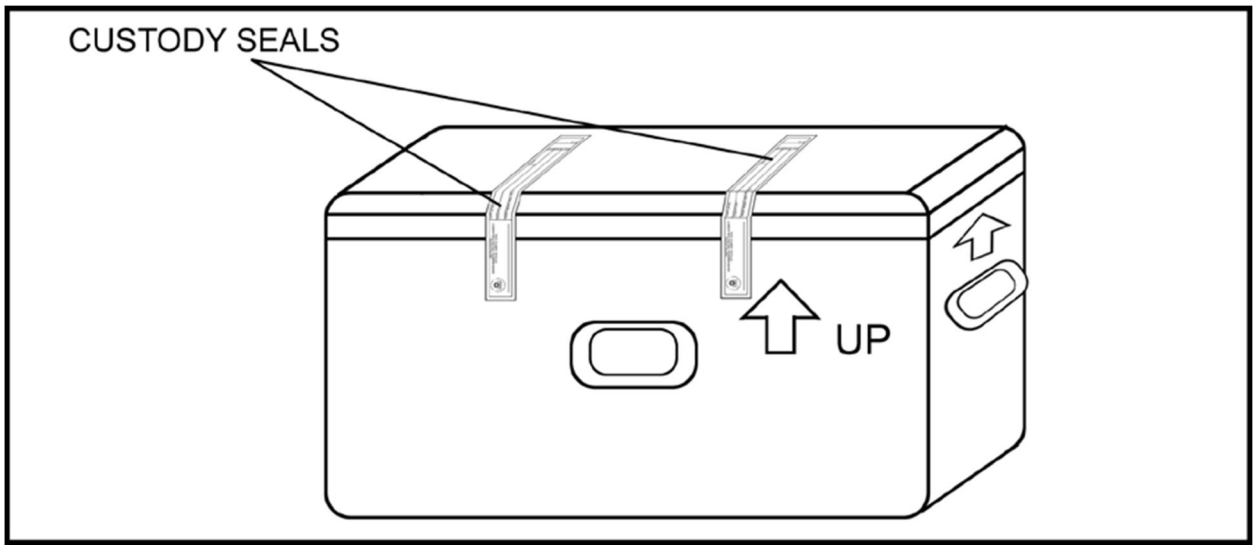


FIGURE 5

EXAMP LE OF SHIPP ING COOLER WITH C USTODY SEALS



Source: U.S. Environmental Protection Agency. 2011.

Please note that the two seals typically are affixed to opposite sides of the cooler and offset from each other, although the offset is not depicted on the EPA figure above.

SOP APPROVAL FORM

TETRA TECH, INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

RECORDING NOTES IN FIELD LOG BOOKS

SOP NO. 024

REVISION NO. 2

Last Reviewed: November 2014

Carla J Bunk

Quality Assurance Approved

November 24, 2014

Date

1.0 BACKGROUN D

Complete and accurate field documentation is critical to a successful project and the field log book is an important tool to support field documentation needs. The field logbook should include detailed records of all field activities, document interviews with people, and record observations of conditions at a site. Entries should be described in a level of detail to allow personnel to reconstruct, after the fact, activities and events that occurred during their field assignments. Furthermore, entries should be limited to facts. Avoid speculation related to field events and do not record hearsay or unfounded information that may be presented by other parties during field activities. For example, do not record theories regarding the presence or absence of contamination when you are collecting field screening data or speculation regarding the reasons for a property owner's refusal to grant access for sampling.

Field logbooks are considered accountable documents in enforcement proceedings and may be subject to review. Therefore, the entries in the logbook must be accurate and detailed, but should not contain speculative information that could conflict with information presented in subsequent project deliverables and correspondence. Also be aware that the field logbooks for a site may be a primary source of information for depositions and other legal proceedings that may occur months or years after field work is complete and long after our memories have faded. The accuracy, neatness, and completeness of field logbooks are essential for recreating a meaningful account of events.

1.1 PUR PO SE

The purpose of this standard operating procedure (SOP) is to provide guidance to ensure that field logbook documentation collected during field activities meets all requirements for its later use. Among other things, field logbooks may be used for:

- Identifying, locating, labeling, and tracking samples
- Recording site activities and the whereabouts of field personnel throughout the day
- Documenting any deviations from the project approach, work plans, quality assurance project plans, health and safety plans, sampling plans, and any changes in project personnel
- Recording arrival and departure times for field personnel each morning and evening and weather conditions each day
- Describing photographs taken during the project.

In addition, the data recorded in the field logbook may later assist in the interpretation of analytical results. A complete and accurate logbook also aids in maintaining quality control, because it can verify adherence to project scope and requirements.

1.2 SCOPE

This SOP establishes the general requirements and procedures for documenting site activities in the field logbook.

1.3 DEFINITIONS

None.

1.4 REFERENCES

Compton, R.R. 1985. Geology in the Field. John Wiley and Sons. New York, NY.

1.5 REQUIREMENTS AND RESOURCES

The following items are required for field notation:

- Field logbooks
- Ballpoint pens or Sharpies with permanent waterproof ink
- 6-inch ruler (optional)

Field logbooks should be bound (sewn) with water-resistant and acid-proof covers, and each page should have preprinted lines, numbered pages, and a single column. They should be approximately $7^1/_2$ by $4^1/_2$ inches or $8^1/_2$ by 11 inches in size. Loose-leaf sheets are not acceptable for use as field notes.* If notes are written on loose paper, they must be transcribed as soon as possible into a bound field logbook by the same person who recorded the notes originally. *Note: Data collection logs and field forms used to record field measurements and data are acceptable as loose-leaf sheets maintained in a three-ring binder with numbered pages.

Ideally, distribution of logbooks should be controlled by a designated person in each office. This person assigns a document control number to each logbook, and records the assignment of each logbook distributed (name of person, date distributed, and project number). The purpose of this procedure is to ensure the integrity of the logbook before its use in the field, and to document each logbook assigned to a

project. In the event that more than one logbook is assigned to a project, this process will ensure that all logbooks are accounted for at project closeout.

2.0 PROCEDUR ES

The following subsections provide general guidelines and formatting requirements for field logbooks, and detailed procedures for completing field logbooks.

2.1 GEN ERA L GUIDEL INES

- A separate field logbook must be maintained for each project. If a site consists of multiple subsites (or operable units), designate a separate field logbook for each subsite. Similarly, if multiple activities are occurring simultaneously requiring more than one task leader (well installation, private well sampling, or geophysical survey.), each task leader should maintain a separate field logbook to ensure that each activity is documented in sufficient detail.
- At larger sites, a general field log may be kept at the site trailer or designated field office to track site visitors, document daily safety meetings, and record overall site issues or occurrences.
- Data from multiple subsites may be entered into one logbook that contains only one type of information for special tasks, such as periodic well water-level measurements.
- All logbooks must be bound and contain consecutively numbered pages.
- No pages can be removed from the logbook for any purpose.
- All information must be entered using permanent, waterproof ink. Do not use pens with "wet ink," because the ink may wash out if the paper gets wet. Pencils are not permissible for field notes because information can be erased. The entries should be written dark enough so that the logbook can be easily photocopied.
- Be sure that all entries are legible. Use print rather than cursive and keep the logbook pages free of dirt and moisture to the extent possible.
- Do not enter information in the logbook that is not related to the project. The language used in the logbook should be factual and objective. Avoid speculation that could conflict with information presented in subsequent project deliverables and correspondence (see Section 1.0 above).
- Use military time, unless otherwise specified by the client.
- Include site sketches, as appropriate.
- Begin a new page for each day's notes.
- Include the date at the top of each page.
- At the end of a day, draw a single diagonal line through any unused lines on the page, and sign at the bottom of the page. Note and implement any client specific requirements (for example, some U.S. Environmental Protection Agency (EPA) programs require each logbook page to be signed).

- Write notes on every line of the logbook. Do not skip any pages or parts of pages unless a day's activity ends in the middle of a page.
- If a line is left blank for some reason, cross out (with a single line) and initial to prevent unauthorized entries.
- Cross out (with a single line) and initial any edits to the logbook entries. Edits should only be made if the initial entry is illegible or erroneous. Do not make corrections for grammar or style.

2.2 LOGBOO K FORMA T

The layout and organization of each field logbook should be consistent and generally follow the format guidelines presented below. Some clients or contracts may have specific formatting guidelines that differ somewhat from this SOP; review client requirements at the start of the project to help ensure any client-specific guidelines are integrated.

2.2.1 Logbook C over

Write the following information on the front cover of each logbook using a Sharpie or similar type permanent ink marker:

- Logbook document control number (assigned by issuer)
- "Book # of #" (determined by the project manager if there is more than one logbook for the project)
- Contract and task order numbers
- Name of the site and site location (city and state)
- Name of subsite (or operable unit), if applicable
- Type of activity (if logbook is for specific activity, such as well installation or indoor air sampling)
- Beginning and ending dates of activities entered into the logbook

2.2.2 Inside Cover or F irst Page

Spaces are usually provided on the inside front cover (or the opening page in some logbooks) for the company name, address, contact names, and telephone numbers. If preprinted spaces for this information are not provided in the logbook, write the information on the first available page. Information to be included on the inside front cover or first page includes:

- Tetra Tech project manager and site manager and phone numbers
- Tetra Tech office address

- Client contact and phone number
- Site safety officer and phone number
- Emergency contact phone number (911, if applicable, or nearest hospital)
- Subcontractor contacts and phone numbers
- Site property owner or property manager contact information

2.3 ENTERING INFORMATION IN THE LOG BOOK

The following lists provide guidance on the type of information to be included in a typical field logbook. This guidance is general and is not intended to be all-inclusive. Certain projects or clients may specify logbook requirements that are beyond the elements presented in this SOP.

General Daily Entries:

- Document what time field personnel depart the Tetra Tech office and arrive at the hotel or site. If permitted by the client to charge travel time for site work, document what time personnel leave and arrive at the hotel each day. (This information may be needed at remote sites where hotel accommodations are not near the site.)
- Indicate when all subcontractors arrive and depart the site.
- Note weather conditions.
- Include the date at the top of each page.
- Document that a site safety meeting was held and include the basic contents of the meeting.
- List the level of protection to be used for health and safety.
- Summarize the day's planned activities.
- Summarize which activities each field team member will be doing.

Field Activity Entries:

- Refer to field data collection forms for details about field data collection activities (for example time, date, depth of samples, field measurements). If separate field sampling sheets are not used, see section below regarding logbook entries for sampling activities.
- Refer to well purge forms, well construction logs, and other activity-specific forms as applicable rather than including this type of information in the field logbook. These other forms allow the information to be more accessible at a later date.
- List any air monitoring instrumentation used, with readings and locations.
- Refer to instrument field logs for equipment calibration information.
- Summarize pertinent conversations with site visitors (agency representatives, property owners, client contacts, and local citizens).
- Summarize any problems or deviations from the quality assurance project plan (QAPP) or field sampling plan.
- Document the activities and whereabouts of each team member. (As indicated in Section 2.1, multiple logbooks may be required to ensure sufficient detail for contemporaneous activities).
- Indicate when utility clearances are completed, including which companies participated.
- Indicate when verbal access to a property is obtained.
- Include names, addresses, and phone numbers of any pertinent site contacts, property owners, and any other relevant personnel.
- Document when lunch breaks or other work stoppages occur.
- Include approximate scale for all diagrams. If a scale is not available, write "not to scale" on the diagram. Indicate the north direction on all maps and cross-sections, and label features on each diagram.

Sampling Activity Entries: The following information should typically be on a sample collection log and referenced in the log book. If the project does not use sample sheets as a result of project-specific requirements, this information should be included in the logbook.

- Location description
- Names of samplers
- Collection time
- Designation of sample as a grab or composite sample
- Type of sample (water, sediment, soil gas, or other medium)
- On-site measurement data (pH, temperature, and specific conductivity)

- Field observations (odors, colors, weather)
- Preliminary sample description
- Type of preservative used.
- Instrument readings, if applicable

Closing Dai ly Entr ies:

- Describe decontamination procedures (personnel and equipment).
- Describe handling and disposition of any investigation-derived wastes.
- Summarize which planned activities were completed and which ones were not.
- Note the times that personnel depart site for the day.
- Summarize any activities conducted after departing the site (paperwork, sample packaging, etc.). This may be required to document billable time incurred after field activities were completed for the day.

Photo graph ic Log Entries :

- For digital photographs, indicate in the text that photographs were taken and the location where the photographs can be found (for example, in the project file).
- Camera and serial #
- Photographer
- Date and time of photograph
- Sequential number of the photograph and the film roll number or disposable camera used (if applicable)
- Direction of photograph
- Description of photograph

2.4 LOGBOO K ST ORAGE

Custody of logbooks must be maintained at all times. During field activities, field personnel must keep the logbooks in a secure place (locked car, trailer, or field office) when the logbook is not in personal possession. When the field work is over, the logbook should be included in the project file, which should be in a secured file cabinet. The logbook may be referenced in preparing subsequent reports and may also be scanned for inclusion as an appendix to a report. However, it is advisable to obtain direction directly from the client before including the logbook as a report appendix, because its inclusion may not be appropriate in all cases.

2.5 HEALTH AND SAFETY CONSIDERATIONS

In addition to the procedures outlined in this SOP, all field staff must be aware of and follow the health and safety practices that result from the Activity Hazard Analyses (AHAs) for a project. The AHAs include critical safety procedures, required controls, and minimum personal protective equipment (PPE) necessary to address potential hazards. The hazards specific to project tasks must be identified and controlled to the extent practicable and communicated to all project personnel via the approved, project-specific Health and Safety Plan (HASP).

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

CALIBRATION OF AIR SAMPLING PUMP

SOP NO. 064

REVISION NO. 0

Last Reviewed: November 1999

Quality Assurance Approved

May 24, 1993

Date

1.0 BACKGROUND

Several instruments are available to calibrate low air flow rate. The soap bubble meter method is one example. An air sampling pump and bubble meter calibrator are used to calibrate sample collecting devices including filters, impingers, sampling tubes, and color detector tubes. It is important to note that if a sampling pump uses a variable area flow meter (rotameter) for flow rate indication, the calibrated flow rate often must be adjusted for the actual air pressure and temperature during sampling. A formula for determining the corrected flow rate is provided.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for calibrating a rotameter sampler using an SKC® digital calibrator (calibrator).

1.2 SCOPE

This SOP provides instruction on calibration of a rotameter sampler by comparing a known airflow through the rotameter sampler and through the SKC® soap bubble meter calibrator.

1.3 DEFINITIONS

None

1.4 REFERENCES

SKC Inc. "Universal Flow Sample Pump Model 224-PCXR7 Operating Instructions." Form #3764-REV 706.

SKC Inc. "Electronic Calibrator Model 712 Operating Instructions." Form #3792-Rev 8 11.

1.5 REQUIREMENTS AND RESOURCES

To calibrate an air sampling pump the following equipment is needed:

- Air sampling pump
- SKC® digital calibrator (soap bubble meter)
- Soap solution
- Temperature and pressure gauge

2.0 PROCEDURES

The following procedures are used to calibrate an sampling pump with an SKC® digital calibrator:

1. The air sampling pump calibration should be checked at the beginning, middle, and end of the sampling event to determine the original loss in calibration.

2. Place the glass bubble meter in the digital calibrator (Figure 1). In general, if the flow rate is 2 liters/minute (L/min) or greater, slide the glass bubble meter to its lowest position on the stand. For flow rates of 500 milliliters (mL) or less, slide the glass bubble meter to its highest position on the stand. For intermediate flow rates, a bubble meter position between the extremes may be best.

3. Through the lower gas inlet tube, fill the liquid chamber with soap solution to a level just below the inner glass tubing.

4. Attach the flexible tubing to the upper gas inlet tube. Make this connection with the shortest tubing length possible, and avoid kinks and bends for the most accurate measurements.

5. Test the sampler battery pack for full charge by turning the sampler on using the ON/OFF switch (Figure 1). Press the START/HOLD key then the Flow and Battery Check key. Adjust the flow to 2 L/min using the flow adjustment control. The display should indicate “battery OK” in the upper left-hand corner.

6. While in the battery test mode, connect the flexible tubing to the filter housing intake. Set the sampler to the desired flow rate using the flow adjustment control.

7. Moisten the entire inner surface of the gas bubble meter with the soap solution. To do this, draw bubbles upward by squeezing the latex bulb until the bubbles travel the entire length of the bubble meter without breaking.

8. Press the ON/RESET button on the digital calibrator to turn on the instrument. Wait until a "0" is displayed, indicating the instrument is ready. There should be no bubbles in the area of the sensor block when the instrument is first turned on or when reset is pushed.

9. Squeeze the latex bulb gently to generate soap film bubbles. While the bubbles are being timed through the sensor block, the bulb should not be touched or erroneous flow rates may result. When bubbles pass through the lower sensor in the sensor block, the "TIMING IN PROGRESS" symbol (" + ") should be displayed.

10. For flow rates above 2 L/min the auto-bubbler clamp should be used. After the bubble meter has been moistened place the clamp on the large part of the latex bulb with the open end up. With the gas flowing, lightly tighten the clamp until the bubbles begin to form. Adjust the clamp so that the bubbles are going through the tube one at a time. When adjusted properly, hands off operation is possible and will continue for a period of time. When the bubbles stop forming, tighten the clamp.

11. After the bubble passes the upper sensor in the sensor block, the display will read out the gas flow rate. The gas flow rates measured by the digital calibrator should be within 0.7 L/min of the flow rate on the sampler.

12. Repeat the determination at least twice more and average the three results.

13. Measure the air temperature.

14. Record the following data on a calibration sheet:

    - Flow rate
    - Pressure of air sampled
    - Air temperature
    - Atmospheric pressure
    - Serial number of the pump
    - Pump number
    - Date and name of sampler

15. The expression for the corrected flow rate is:

$$Q_l = Q_2(P_C T_S / P_S T_C)^{0.5}$$

where

Q_l = Corrected flow rate (L/min)

Q_2 = Calibrator flow rate (L/min)

P_C = Atmospheric pressure (kiloPascals or other pressure units)

P_S = Pressure of air sampled (same units as P_C)

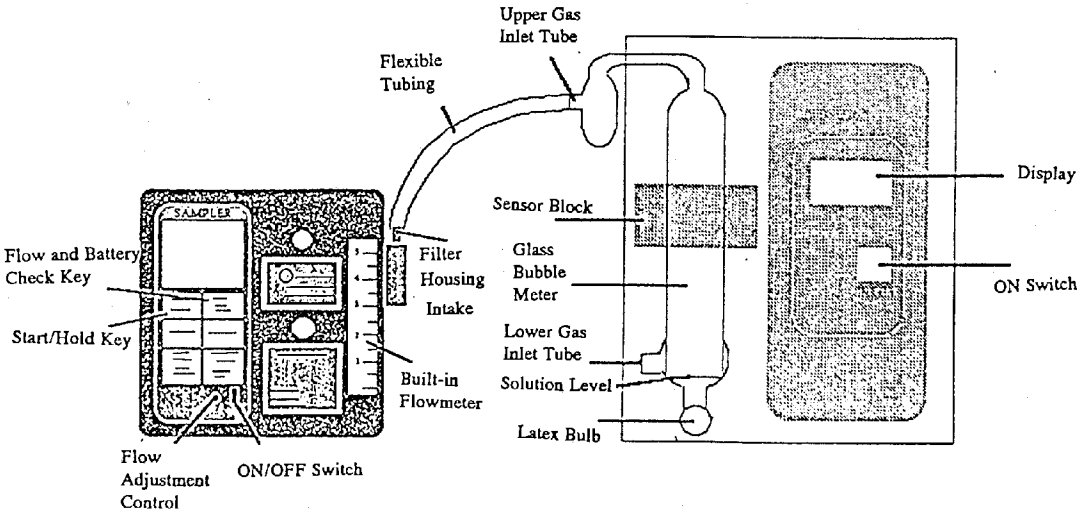
T_C = Temperature during calibration of sampling pump (Kelvin: EC + 273.16)

T_S = Temperature of air sampled (Kelvin: EC + 273.16)

The corrected flow rate is important to determine when sampling at high elevations or when temperatures are very low. The formula provided will help to determine the correct flow rate under such conditions.

FIGURE 1

AIR SAMPLING PUMP CALIBRATION APPARATUS



Environmental
Standard Operating Procedure

SOP No. 001
Calibration of a Radiological Survey Detector

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for the calibration of general purpose radiological survey detectors in a manner that meets the applicable sections of the ANSI N323A-1997 American National Standard Radiation Protection Instrumentation Test and Calibration.

A radiological survey detector (detector) is used with a compatible radiological survey meter (meter) to measure radiation in integrated scaler count and/or ratemeter modes. There are several types of detectors including single channel alpha, beta, high-energy gamma, and low-energy gamma; dual channel alpha/beta; Geiger-Mueller which detects gross combined alpha/beta/gamma, and others. *NOTE: Environmental Restoration Group, Inc. (ERG) does not calibrate exposure rate, dose rate, or very high range detectors/meters.* These are sent to a calibration facility having the National Institute of Standards and Technology (NIST)-traceable radiological check sources necessary to perform such a calibration. Even with their differences most detectors operate and are calibrated in a similar manner. A detector is calibrated using an appropriate meter and NIST-traceable check source of known activity. Typically, if a single-channel detector is calibrated then a single-channel meter is required, and similarly if a dual-channel detector is calibrated then a dual-channel meter is required. The type of detector also dictates the check source(s) used. During the calibration process the detector is also inspected for any physical damage that might affect its functionality; e.g., a punctured mylar, cracked housing. Calibration of any survey detector is required prior to initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect instrument operation.

To calibrate a radiological survey detector the Instrument Technician must show proficiency on the detector, the accompanying meter, and be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 EQUIPMENT AND MATERIALS

The following equipment is required to calibrate a radiological survey detector:

- Radiological survey detector – Ludlum Model 43-5 (zinc-sulfide, alpha), Model 43-68 (gas proportional, alpha/beta), Model 43-93 (zinc sulfide + plastic, alpha/beta), Model 44-9 (GM "Pancake", alpha/beta/gamma), Model 44-10 (sodium iodide, high-energy gamma), Field Instrument for Detecting Low Energy Radiation (FIDLER, sodium iodide, low-energy gamma), or similar.
- Calibrated meter appropriate for use with the detector to be calibrated
- NIST-traceable calibration check source with known activity. Use a thorium 230 (Th-230) source for typical calibration of an alpha detector. Use a technetium 99 (Tc-99) or strontium-yttrium 90 (Sr/Y-90) source for typical beta detector calibration. Use a cesium 137 (Cs-137) for typical gamma detector calibration. Check sources used depend on the goal of the survey. While the sources listed above are for typical calibrations, they are not definitive.
- Calibration jig; used to ensure consistent detector position relative to check source.
- Cable to connect detector and meter.
- Flathead precision screwdriver.
- ERG Certificate of Calibration form or access to ERG equipment rental database.

3.0 PROCEDURE

The following procedures will be used for the general detector calibration process. Not all detectors have the same features or calibration needs. When unsure, check the manufacturer's Technical Manual for confirmation and/or assistance. *NOTE: If detector calibration is in conjunction with a meter calibration then some of the initial calibration steps may be performed as part of the initial meter calibration.*

1. **PHYSICAL INSPECTION** – Check detector for damaged tube (e.g., GM detector), punctured or dirty mylar window, cracked welds or other damage to detector housing, and/or loose cable connector or screws, as applicable to detector type and model. *NOTE: Punctured mylar window or cracked welds may be difficult to assess visually.* Turn instrument audio on and rotate detector to/from a light source, such as a bright lamp or sunlight, to assist in identifying any possible light leaks. Repair or replace detector components as necessary.
2. Open up the ERG Equipment Rental database and locate the appropriate meter/detector specific form. If access to the database is not possible then record calibration data on a printed form.
3. Input the Manufacturer, Model Number, and Serial Number for the meter and/or detector being calibrated on the form.
4. Input the atmospheric pressure of the calibration location; barometric pressure, temperature, and relative humidity.
5. Prior to connecting the meter to the detector set meter to appropriate starting high voltage (HV). If unsure, then start at around 500 volts.
6. Connect the meter to the detector being calibrated and turn on.
7. Note condition of battery as indicated by display. If the indicated battery power is not within BATT OK range on analog meter or not greater than 5.0 in digital LCD display then replace.
8. **GM DETECTOR TYPE** – The calibration of a GM Pancake detector or other GM detector is simply a confirmation of functionality. All GM type detectors are set at a model-specific single operating HV. For example, the Ludlum Model 44-9 GM Pancake detector operates at 900 V. Check the model-specific operating HV if other than a Model 44-9 and set the meter HV to this value. GM Pancake detectors typically operate at an input sensitivity, or threshold (THR), setting of 30 mV to 40 mV. Confirm the detector model THR in the Technical Manual if unsure of value, and set the meter THR to this value.
9. **SCINTILLATION AND GAS PROPRTIONAL DETECTOR TYPES** – With the exception of the GM detectors, the operating voltage for most detectors is determined based on the its response to changes in the operating high voltage (HV) as observed in a plateau curve, instrument efficiency, cross-talk, and background counts.
    a. Single-channel scintillation detectors typically operate at a THR setting of 10 mV. Dual-channel scintillation detectors typically operate at an alpha THR setting of 120 mV, and beta THR and WIN settings of 3.5 mV and 35.0 mV, respectively. Gas proportional detectors typically operate in a THR range of 2 to 5 mV if in single-channel use, and at an alpha THR setting of 100 mV, and beta THR and WIN settings of 3.5 mV and 35.0 mV, respectively if in dual-channel use. Confirm the model THR and WIN settings in the Technical Manual if unsure of value, and set the meter THR and WIN to these values.
    b. If using a Model 2221 confirm that the window (WIN) switch is turned OUT.

c. Place the detector and the appropriate check source in the calibration jig such that they are in the appropriate and repeatable detector-to-source geometry. For alpha and/or beta sources this is directly underneath the detector face. For gamma sources this is typically 3 to 6 inches away from the detector.

d. With the HV already set at an appropriate beginning HV gradually increase the voltage until the meter begins to register counts, then increase to the next higher 50 V increment (i.e., if you begin to get audible counts at 620 V then continue to increase HV to 650 V). *NOTE: Use of the meter audio is helpful here. After the initial starting HV is identified the audio volume may be turned down/off.*

e. If the meter has only analog ratemeter function then record the count rate for this HV setting. If the meter has scaler function then perform a 1-minute scaler count and record the scaler count result for this HV setting instead.

f. Remove the source and repeat measurement at this HV, and record as the background count result for this HV setting.

g. Replace the check source, increase HV to next incremental setting, and repeat the previous step until the source or background count rate begins to increase rapidly with increased voltage. *NOTE: Under no circumstances should the operating voltage exceed 1200 V for scintillation detectors or 1800 V for gas proportional detectors.* HV incremental increases vary by model number. *NOTE: In some cases it might be 25 V increments, and others it might be 100 V increments.* Choose the appropriate increments to generate an acceptable plateau curve.

10. **EVALUATE PLATEAU CURVE –** Prepare a graph of count rate versus HV setting. *NOTE: If using the ERG Rental database the calibration forms generate this graph automatically as data are entered.* The graph should consist of a curve showing a rise in count rate as the HV is increased, which then flattens out to a relatively flat section where there is little increase in count rate over a voltage range of up to several hundred volts, and then possibly a very sharp increase in count rate. This initial curve is known as the “knee”, which then transitions into the flatter region known as the “plateau”, and then into the “region of continuous discharge”. An example HV voltage plateau curve is shown in Figure 1 below.

11. **SET OPERATING HV –** The detector operating HV should be set somewhere above the knee and below the region of continuous discharge, preferably 50 to 100 volts above the knee. *NOTE: Operating HV setting depends on several variables, including desired background counts, detector efficiency, and condition of detector crystal and photomultiplier tube.*

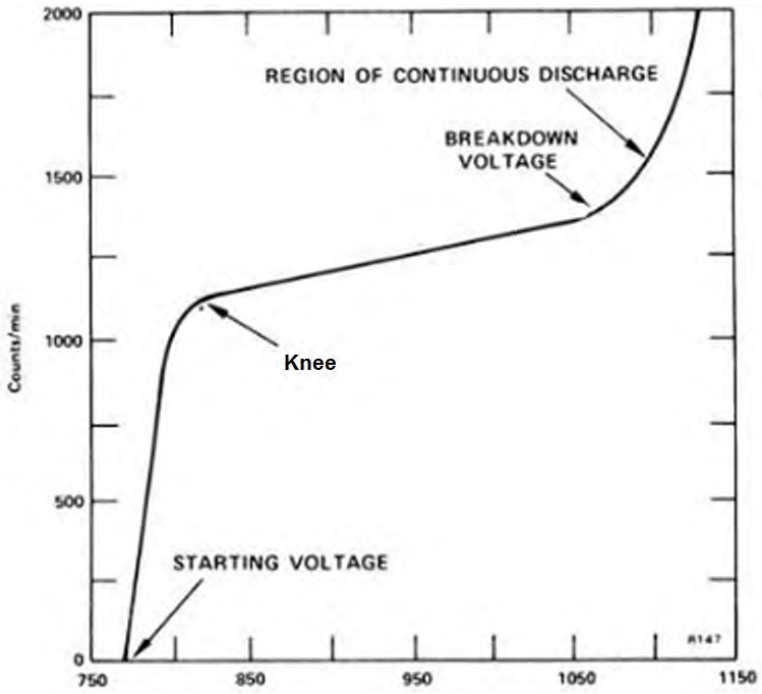


Figure 1 – Example of a High Voltage Plateau Curve

4.0 RECORDS

A detector calibration is documented using the appropriate meter/detector-specific Certificate of Calibration form (form) found in the ERG Equipment Rental database. If access to the database is not available, then a blank Certificate of Calibration form for the appropriate meter/detector specific calibration may be completed manually. When a calibration is completed the Certificate of Calibration form must be printed, protected, and retained per the ERG Document Retention Schedule and ANSI N323A-1997.

Environmental
Standard Operating Procedure

SOP No. 002
Calibration of a Radiological Survey Meter

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

January 2018

CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for the calibration of general purpose radiological survey meters in a manner that meets the applicable sections of the ANSI N323A-1997 American National Standard Radiation Protection Instrumentation Test and Calibration.

A general purpose radiological survey meter (meter) is used with a compatible detector to measure radiation in integrated scaler count and/or rate modes. A meter is calibrated using a pulse generator, also known as a pulser. The pulser allows for the high voltage, threshold, window setting, and analog/digital count rate to be tested. During the calibration process the meter is also inspected for damaged buttons, switches, etc., or any physical damage that might affect functionality. Calibration of any survey meter is required prior to initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect instrument operation.

To calibrate a radiological survey meter the Instrument Technician must show proficiency on the meter, and be recognized on their ERG Training Qualification Form as qualified to perform this procedure

2.0 EQUIPMENT AND MATERIALS

The following equipment is required for the calibration of a radiological survey meter:

- Radiological survey meter – Ludlum Model 12, 177, 2000, 2221, 2241, 2360, 2929, or similar.
- Calibrated pulse generator – Ludlum Model 500 pulser, or similar.
- Calibrated Fluke multimeter, or similar.
- Cable to connect meter and pulser.
- Flathead precision screwdriver.
- ERG Certificate of Calibration form, or access to ERG Equipment Rental database.

3.0 PROCEDURE

The following procedures will be used for general meter calibration. Not all meters have the same features or calibration needs. When unsure check the manufacturer's Technical Manual for confirmation and/or assistance.

1. Open up the ERG Equipment Rental database and locate the appropriate meter/detector specific form.
2. Input the Manufacturer, Model Number, and Serial Number for the meter and/or detector being calibrated on the form.
3. Input the atmospheric pressure of the calibration location; the barometric pressure, the temperature, and the relative humidity.
4. **PHYSICAL INSPECTION** – Check meter for broken components that may affect operation (e.g., broken parts including latches, knobs, buttons, switches; misaligned knobs; and loose screws). When everything is found to be in proper working order check the Mechanical Check box on the form.

5. **AUDIO CHECK** – Check that the meter audio feature is in proper working order. If so, then check the Audio Check box on the form.
6. **RESET CHECK** – Check that the Reset button is in proper working order. If so, then check the Reset Check box on the form.
7. **BATTERY CHECK** – Check that the battery level is of sufficient (minimum of 4.4 VDC, or within "BAT TEST" range on meter dial). If so, then check the Battery Check box on the form.
8. Connect the pulser to the meter being calibrated.
9. **HV CHECK** – Check the high voltage level at 500, 1000, 1500 volts to see if the meter readings matches the pulser readings (± 2.5%). If so, then check the 500 V, 1000 V, and 1500 V boxes on the calibration form. If the readings do not match, then refer to the Technical Manual on how to adjust the meter HV to match the pulser output, and recheck.
10. **THR/WIN OPERATION** – If applicable to the meter being calibrated, determine if the input sensitivity, or threshold (THR), and window (WIN) features are operating correctly. Not all meters will have an adjustable THR or a WIN feature. Determine what the THR and WIN settings are on the meter. Use the THR and WIN buttons that display the settings when pressed. The THR setting is typically detector specific, and the WIN setting is use/project specific. By adjusting the amplitude on the pulser, check to see if the set displayed THR and WIN settings correspond to actual. If so, then check the THR/WIN Operation box on the form. If the readings do not match, then refer to the Technical Manual on how to adjust the meter THR and WIN to match the pulser output, and recheck. For dual channel alpha/beta meters repeat the THR check for both channels. Only the beta channel (lower channel) will have a WIN.
11. **FAST/SLOW RESPONSE CHECK** – With the pulser providing a count rate of less than 500 counts per minute (CPM) and the pulse multiplier in the X1 position switch the pulser multiplier to the X100 or X1000 range. With the RESP switch in the F (fast) position the meter should indicate a count rate in the set range within 4 ± 1 seconds. With the RESP switch in the S (slow) position the meter should indicate a count rate in the set range in 22 ± 2 seconds. If so, then check the F/S Response Check box on the form.
12. **GEOTROPISM** – If applicable to the meter being calibrated, determine if the unit is experiencing geotropism, or a change in the analog meter reading due to gravity. Check the needle position by holding the meter in three different orientations (meter face flat, meter face up, and meter face on its side). If the meter reads the same in all three orientations then the meter successfully passes the geotropism check, check the Geotropism box on the form.
13. **METER ZEROED** – Press the ZERO button and release. The meter should zero out. If so, then check the Meter Zeroed box on the form.
14. **RANGE TEST** – Set the scale multiplier on the meter and check the ranges indicated on the appropriate calibration sheet. Set the count rate on the pulse generator to its highest reference setting indicated on the calibration sheet. Set the meter to the proper ratemeter range scale, observe, and record the instrument analog reading. Record this value in the "As Found Reading" column on form. If the reading is not ± 10% of what the pulser reads then use a precision flathead screwdriver to adjust the appropriate internal meter potentiometer so the meter reading matches the pulser output. If unfamiliar with this process then refer to Technical Manual. If /when the reading is within ± 10% then record in the Meter Reading column on form. If applicable to the meter being calibrated, switch the ratemeter range scale to LOG and record value in the Log Scale Count column on form. Repeat this for the remaining reference settings. NOTE: As the count rate

and range setting are changed on the pulser, allow time for the analog meter movement to respond, as this may take several seconds to happen if in slow response mode.

15. **INTEGRATED COUNT** – If applicable to the meter being calibrated check the integrated counts feature (i.e., check the ability to collect counts for a set time span), for example: one minute; then perform a one-minute integrated count. For dual channel alpha/beta meters repeat the integrated count process for both channels. Do this for each scale range of counts specified on form.
16. **INSTRUMENT WITHIN TOLERANCE** – If the instrument passes all checks above then check the Instrument found within tolerance check box.
17. At the bottom of the form check the appropriate pulser serial number box, and Fluke multimeter box if used.
18. If no detector is to be calibrated with the meter then print out form, sign and date form enter a calibration due on form (no more than one year from calibration date), and submit for review to someone else qualified to perform a radiological survey meter calibration. If a detector is to be calibrated with the meter then continue on to that procedure.

4.0 RECORDS

A meter calibration is documented using the appropriate meter/detector specific Certificate of Calibration form (form) found in the ERG Equipment Rental database. If access to the database is not available then a blank Certificate of Calibration form for the appropriate meter/detector specific calibration may be manually completed. When a calibration is completed the Certificate of Calibration form must be printed, protected, and retained per the ERG Document Retention Schedule and ANSI N323A-1997.

Environmental
Standard Operating Procedure

SOP No. 006
Personnel, Environmental, and Work Area Air Sampling

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

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CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes three techniques for determining the concentration of airborne radioactive particulates. The techniques differ only in sample collection; the analytical technique for determining the concentration from the filter media is the same for each sample collection method.

2.0 PRECAUTIONS

- N/A

3.0 EQUIPMENT AND MATERIALS

The following equipment is required for the collection of air samples:

- Air Sampler: Either Area, Breathing Zone, or High Volume
- Particulate Filters GFA (25mm or 47mm, to fit air sampler). Envelopes for filter storage or petri dishes.
- Timing Device
- Counting Instruments: Ludlum 2929 or equivalent
- Air Particulate Sampling Survey Forms

4.0 PROCEDURE

The following procedures will be used for air sampling, depending on the sample being taken.

4.1 WORK AREA SAMPLES

1. Select a calibrated Regulated Air Sampler (RAS-1) and install the appropriate size filter in the filter head.
2. Select a suitable location for sampling. The location chosen is based on an evaluation of the operation being performed. The ideal location for personnel monitoring in a work area would approximate the breathing zone of a worker and would be between the source of the potential airborne material and the location of the worker(s).
3. Determine the time and flow rate necessary to sample a volume sufficient to ensure an adequate Lower Limit of Detection (LLD).
4. Turn on the air sampling unit, adjust the flow rate to a calibrated value, and record the serial number, starting time, flow rate, vacuum and initials of the technician.
5. Record the exact location of the air sampling unit and the nature of the work being performed.
6. Periodically check air sampler unit for proper operation.

7. After the minimum collection time to meet the LLD requirement, record ending flow rate, vacuum and time, and turn off the air sampling unit. Remove the air filter and place in sample envelope or petri dish and label it.

4.2 EVIRONMENTAL SAMPLES

1. Select a calibrated Regulated Air Sampler (RAS-1) and install the appropriate size filter in the filter head.
2. Select a suitable location to place the sampler. Ideally, a series of samplers should be deployed at the perimeter of the worksite with a greater number of samplers placed down wind of the prevailing winds.
3. Turn on the air sampling unit, adjust the flow rate to a calibrated value, and record the serial number, starting time, flow rate, vacuum and initials of the technician.
4. Continuous Air Monitoring

    a. If the deployed sampler(s) is for continuous air monitoring, the filter will need to be changed periodically. The filter change interval should be determined on factors such as flow rate and filter loading.

    b. When a filter needs to be changed, record the ending flow rate, vacuum and time and turn off the sampling unit. Remove the filter from the filter head and place it in a marked envelope.

    c. Place a new filter into the filter head and turn on the sampler unit. Record the start flow rate, vacuum and time.

5. If continuous air monitoring is not required, record the ending flow rate, vacuum and time and turn off the air sampler if there is no work activity.

4.3 LAPEL SAMPLES

1. Select a calibrated lapel air sampler and install a 25 mm diameter filter in the filter cassette head. Install the cassette into the cyclone.
2. Determine the time and flow rate necessary to sample a volume sufficient to ensure that an adequate LLD is obtained. When used with Gillian Part Number 800061 cyclones, limit the flow rate to 2.0 liters per minute. Due to the low flow rate of lapel air sampling pumps, it is usually necessary to operate the pump for a longer period of time than the RAS-1 pumps. A four (4) to eight (8) hour sample, if possible, is preferable.
3. Select a worker with the highest potential for exposure to airborne radioactive materials. Instruct the worker regarding the wearing of the lapel sampler. Position the filter head in the breathing zone.
4. Record the name of the worker and the nature of the work being performed. Record any other pertinent information.
5. Turn on the air sampling pump, adjust the flow rate to a calibrated value, and record the start time, start flow rate, sample identifier, and initials of the issuing technician.
6. Periodically, check the work area and air sampling unit for proper monitoring and operation.

7. Record the ending flow rate and ending time, and turn off the air sampling unit. Remove the air filter and place it in the sample envelope or petri dish and label.

   NOTE: Any period of time which the sampler is left running outside work area (e.g., during lunch break) shall be deducted from the total run time used in calculating airborne concentrations.

5.0 COUNTING INSTRUCTIONS

1. An initial 24 hour decayed count may be performed for informational purposes. Allow a minimum of 72 hours from the end of sample collection before counting sample (to allow for decay of interfering short-lived radon-222 daughters) as appropriate. If Th-232 is a site contaminant, a minimum of 7 days must be allowed for the decay of Ra-220 decay products. The LLD should be at least 10% of the MPC for the final counting of the sample.
2. After waiting at least 24 hours (or 72 hours for thoron decay) from the end of the sample collection, place the sample in the detector and make a count of a time that has been prescribed in the project work plan, radiation protection plan, or equivalent. Record the start time and the result on the appropriate forms. (NOTE: Count time must be increased if LLD is greater than 10% of the limit.)
3. Use the following formula to calculate the long-lived alpha or beta concentration:

$$C = \frac{(S - B)(FA)}{(2.22x10^6)(E)(V)}$$

where:

C = concentration in air, µCi/ml

S = Sample alpha count rate (cpm) = gross sample counts / sample count time (min)

B = Background count rate (cpm) = background counts / background count time (min)

E = Detector efficiency, cpm/dpm

V = Volume sampled (mL) = Average actual flow rate (Lpm) x sample collecting time (min) x 1000 mL/L

FA = Filter absorption factor, 1.25 for glass fiber filter, 1.00 for beta counting

2.22×10^6 = Conversion factor, dpm to µCi

4. Compare the concentration in the sample to the most restrictive limit for the radionuclides present at the site. If the limit is exceeded, the sample must be stored for at least 72 hours and a sample count repeated. This is to allow any radon or thoron daughters collected on the filter to decay. If the result still exceeds the applicable limit, notify the site Radiation Safety Officer or Health and Safety Officer.

GENERAL AIR SAMPLING GUIDELINES

CONTENTS

CONTENTS (Cont'd)

GENERAL AIR SAMPLING GUIDELINES

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous waste sites on ambient air. It presents the United States Environmental Protection Agency/Environmental Response Team's (U.S. EPA/ERT's) approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy. This SOP does not address indoor air sampling.

Two basic approaches can be used to assess ambient air (also referred to as air pathway assessments): modeling and measurements. The modeling approach initially estimates or measures the overall site emission rate(s) and pattern(s). These data are input into an appropriate air dispersion model, which predicts either the maximum or average air concentrations at selected locations or distances during the time period of concern. This overall modeling strategy is presented in the first three volumes of the Air Superfund National Technical Guidance Series on Air Pathway Assessments[1,2,3]. Specific applications of this strategy are presented in several additional Air Superfund Technical Guidance documents[4].

The measurement approach involves actually measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the probable "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with this second assessment strategy. This SOP also discusses the U.S. EPA/ERT's monitoring instruments, air sampling kits, and approach to air sampling and monitoring at hazardous waste sites.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. The U.S. EPA/ERT maintains numerous monitors for real-time measurements. Examples of air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and remote optical sensors.

Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis and therefore do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

In the Superfund Removal Program, On-Scene Coordinators (OSCs) may request the U.S. EPA/ERT to conduct air monitoring and sampling during the following situations: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

- Emergency Response

  Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in a controlled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

- Removal Site Assessment

  Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

- Removal Actions

  Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and Disease Registry (ATSDR).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., U.S. EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (i.e., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (i.e., whirl bags, resealable bags or culture tubes) which are then placed into a shipping container.

Use bubble wrap or Styrofoam peanuts when packing air samples for shipment. DO NOT USE VERMICULITE.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentration. Natural sources, such as biological waste, can produce hydrogen sulfide and methane which may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (i.e., burning of fossil fuels; emissions from vehicular traffic, especially diesel; and volatile compounds) from petrochemical facilities; effluvium from smoke stacks) may also contribute. Air sampling stations should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters of concern may occur with nonrelated compounds [i.e., nitrogen compounds and polyaromatic hydrocarbons (PAHs)]. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (i.e., PAHs).

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the detection limits are adequate for the intended use of the final results.

Some equipment may be sensitive to humidity and temperature extremes.

5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. None of these instruments acquires true time-weighted average concentrations. In addition, these instruments are not capable of acquiring simultaneous concentration readings at multiple locations, although several are able to sequentially analyze samples taken remotely from different locations. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites[5]," provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices and analytical instruments are described in Appendix A.

5.2 Air Sampling Equipment and Media/Devices

The U.S. EPA/ERT uses the following analytical methods for sampling: *NIOSH Manual of Analytical Methods*[6], *American Society for Testing and Materials (ASTM) Methods*[7], *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*[8,9], and *OSHA Methods*[10].

Additional air sampling references include *Industrial Hygiene and Toxicology* (3rd Ed.)[11] and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*[12]. These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Camera
- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Glass cracker
- Multiple plug outlet
- Whirl bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container

Use the following additional equipment when decontaminating glassware on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Appropriate solvent(s)
- Spray bottles
- Liquinox (soap)
- Paper towels
- Distilled/deionized water
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1% sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in ERT/REAC SOP #2006, Sampling Equipment Decontamination.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.

Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An organic vapor analyzer (OVA) is typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels

of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument-

dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's detection limit.

7.2 Air Sampling Design

7.2.1 Sampling Plan Design

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling plan.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling plan.
A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical detection limit to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of QA/QC samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by

placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the sampling plan. Does the sampling plan verify adequate levels of protection for on-site personnel, or address potential off-site impacts associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case", or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, then quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.

- Worst case: sampling conducted under the worst meteorological and/or site conditions which would result in elevated ambient concentrations.

- One-time: only one chance is given to collect a sample without regard to time or conditions. Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the detection limits. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit. A sufficient amount of sample must be collected to achieve the desired detection limit without interference from other contaminants. In addition, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the sampling and analytical methods being utilized, the variability of contaminant concentration over time at the site, the level of precision required and cost limitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.

- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.

- Topographic features that affect the dispersion and transport of airborne toxic constituents. Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.

- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.

- Roadways (dirt or paved), which may generate dust that could mask site contaminants.

- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples would typically be adequate, especially around major emission sources.

A short-term monitoring program ranges from several days to a few weeks and generally includes gathering data for site assessments, removal actions, and source determination data (for further modeling). Activities involved in a short-term sampling strategy must make the most of the limited possibilities for data collection. Consider moving upwind/downwind locations daily based on National Oceanic and Atmospheric Administration (NOAA) weather forecasts. Weather monitoring becomes critical where complex terrain and local meteorological effects frequently change wind direction. Often, a number of alternatives can fulfill the same objective.

Prevailing winds running the length of a valley usually require a minimum number of sampler locations; however, a complex valley may require more sampler locations to account for the wide variety of winds. Ocean/lake effects may require a radical plan to collect enough samples to reach a low detection limit. Two sets of samplers may be placed next to each other: one set would be activated during the sea breeze while the other set is turned off, and vice versa when there is no sea breeze. After the sampling event, the respective upwind and downwind samples would be combined. Another alternative for sampling near a large body of water may be to use automatic, wind-vector-operated samplers, which turn the sampler on only when the wind comes from a specified vector. At sites located on hillsides, wind will move down a valley and produce an upward fetch at the same time. Sampling locations may have to ring the site to measure

the wind's impact.

Off-site sources may affect on-site monitoring. In this case, on-site meteorological data, concurrent with sampling data, is essential to interpreting the acquired data. Also, additional upwind sampling sites may be needed to fully characterize ambient background contaminant levels. Multiple off-site sources may require several monitoring locations, but if the sources are at a sufficient distance, only one monitoring location is needed.

Topography and weather are not the only factors in sampler location; the sampling sites must be secure from vandals and mishap. Secure all sampling locations to maintain chain of custody, and to prevent tampering with samples or loss of sampling units. High-volume sampling methods often require the use of 110 VAC electric power. When portable generators are used, the power quality may affect sampler operation. Also, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered.

Air quality dispersion models can be used to place samplers. The models incorporate source information, surrounding topography, and meteorological data to predict the general distance and directions of maximum ambient concentrations. Modeling results should be used to select sampling locations in areas of maximum pollutant concentrations.

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion
- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- If defined, the degree of confidence needed for either the mean or maximum downwind concentrations observed
- The precision requirements for single measurements
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air sampling may be warranted. However, if the site activities will be conducted for only eight hours a day, and there are no emissions likely to occur during the remaining 16 hours, then sampling would be appropriate prior to the start of daily activities, would continue during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting

after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the detection limit. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples and are usually collected in less than five minutes and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

Air quality dispersion models can predict the maximum air contaminant concentration expected from a source. The meteorological and site conditions expected to cause the highest concentration are known as worst-case conditions and can be identified by analyzing the modeling results. Depending upon the objective, one may sample when the model predicts worst-case conditions will exist.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. This data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to be monitored are, at a minimum, wind speed, wind direction, and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). The remaining parameters primarily affect the amount of a contaminant available in the air.

- Wind Speed

  When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.

- Wind Direction

Wind direction highly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

- Atmospheric Stability

  Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

- Temperature

  Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semivolatiles occurs at the hottest time of day, or on the hottest day.

- Humidity

  High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample, or limit the volume of air sampled and thereby increase the detection limit.

- Atmospheric Pressure

  Migration of landfill gases through the landfill surface and through surrounding soils are governed by changes in atmospheric pressure. Atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements of overlying structures.

  In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

  The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affects its behavior and can influence the method used to sample and analyze it.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are usually provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter

(mg/m^3) or micrograms per cubic meter ($\mu g/m^3$).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The manufacturer's instructions should be reviewed prior to instrument use. Instruments must be utilized in accordance with manufacturer's instructions. Equipment checkout and calibration activities must occur prior to and after monitoring and sampling and must be documented.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies; then a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and matrix spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives. Refer to ERT/REAC SOP #2005, Quality Assurance/Quality Control Samples, for further details, and suggested frequencies for submittal of QA/QC samples.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly, in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples. Refer to ERT/REAC SOP #2002, Sample Documentation, for further information.

10.0 DATA VALIDATION

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.

11.0 HEALTH AND SAFETY

Personal protection equipment (PPE) requirements identified in federal and/or state regulations and 29 Code of Federal Regulations (CFR) 1910.120 for hazardous waste site work must be followed.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

12.0 REFERENCES

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APPENDIX A
Portable Screening Devices and Specialized Analytical Instruments
SOP #2008
November 1994

PORTABLE SCREENING DEVICES

Where possible, a datalogger should be used to minimize the length of time required for site personnel to be in a potentially contaminated area. Datalogger cable is available from manufacturers for linear output instruments and some nonlinear output instruments. U.S. EPA ERT/REAC has output cables for organic vapor analyzers (i.e., HNU and OVA), toxic gas analyzers (i.e., monitox) and real-time aerosol monitors (i.e., RAM and miniram).

- Total Hydrocarbon Analyzers

  Total hydrocarbon analyzers used to detect a variety of volatile organic compounds (VOCs) at hazardous waste sites principally employ either a photoionization detector (PID) or a flame ionization detector (FID). Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps. The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene. They respond poorly to organic compounds lacking hydrocarbon characteristics.

- Oxygen and Combustible Gas Indicators

  Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the lower explosive limit (LEL). The measurements are temperature-dependent. The property of the calibration gas determines sensitivity. LELs for individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

  CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e, O_2 content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

- Toxic Atmosphere Analyzers

  The toxic atmosphere analyzer is a compound-specific instrument, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may be lead to erroneous results.

  U.S. EPA/ERT has the following toxic atmosphere analyzers: carbon monoxide, phosgene, nitrous oxide, hydrogen cyanide, sulfur dioxide, hydrogen sulfide, and chlorine gas.

- Aerosol/Particulate Monitors

  A Real-Time Aerosol/Particulate Monitor (RAM) displays readings for total particulates. The instrument employs a pulse light emitting diode which generates a narrow band emission in conjunction with a photovoltaic cell to detect light scattered from particulates.

  The U.S. EPA/ERT uses the RAM when the contaminant of concern is associated with particulates, and when responding to fires involving hazardous materials, to identify plume levels. The instrument is very useful in determining the presence of a plume when it is not visible. The U.S. EPA/ERT typically uses RAMs on tripods to obtain particulate concentrations at the breathing zone level. Personal dataloggers are used with the RAMs to document minimum, average and maximum concentrations. This provides real-time data without requiring those in personal protective equipment to be constantly present in the plume.

- Chemical Detector Tubes (Colorimetric Tubes)

  A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant present, producing a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

- Radiation Meters

  Radiation meters determine the presence and level of radiation. The meters use a gas or solid ion detection media which becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

- Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors

  Hydrogen sulfide (H_2S) and Mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S and Hg concentration. The monitors provide rapid and relatively low detection limits for H_2S and Hg in air. After extensive sampling periods or high concentrations of H_2S and Hg, the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

- Infrared Detectors

  Infrared detectors such as the Miniature Infrared Analyzer (MIRAN) use infrared (IR) absorption as a function of specific compounds. MIRAN instruments apply to situations where the contaminants are identified but concentrations are not. MIRAN instruments generally require AC power.

SPECIALIZED ANALYTICAL INSTRUMENTS

The continuous monitors described above provide qualitative measurement of air contaminants. Quantitative measurements in the field can be obtained using more sophisticated instruments, such as portable Gas Chromatographs, to analyze grab samples.

- Direct Air Sampling Portable Gas Chromatographs (GCs)

  Portable GCs use gas chromatography to identify and quantify compounds. The time it takes for a compound to move through a chromatographic column is a function of that specific compound or group of compounds. A trained technician with knowledge of the range of expected concentrations of compounds can utilize a portable GC in the field to analyze grab samples. GCs generally require AC power and shelter to operate. This method is limited by its reliance on a short-term grab sample to be representative of the air quality at a site.

- Remote Optical Sensing

  This technique, also referred to as long-path or open-path monitoring, involves transmitting either an infrared or ultraviolet light beam across a long open path and measuring the absorbance at specific wavelengths. The technique is capable of analyzing any preselected organic or inorganic volatile compound that can be resolved from compounds naturally occurring in ambient air. Current projected removal applications include perimeter monitoring during site cleanups and measurement of emission source strengths during site assessments.

- TAGA Direct Air Sampling Mass Spectrometer/Mass Spectrometer

  The Trace Atmospheric Gas Analyzer (TAGA), which is operated by the U.S. EPA/ERT, is capable of real-time detection of preselected organic compounds at low parts-per-billion concentrations. The instrument has been successfully used by the U.S. EPA/ERT for isolating individual emission plumes and tracking those plumes back to their sources.

APPENDIX B
Air Sampling Equipment and Media/Devices
SOP #2008
November 1994

AIR SAMPLING EQUIPMENT

- High-Volume, Total Suspended Particulate (TSP) Samplers

  High-volume TSP samplers collect all suspended particles by drawing air across an 8- by 10-inch glass-quartz filter. The sample rate is adjusted to 40 cubic feet per minute (CFM), or 1134 liters per minute (L/min), and it is held constant by a flow controller over the sample period. The mass of TSPs can be determined by weighing the filter before and after sampling. The composition of the filter varies according to the analytical method and the detection limit required.

- PM-10 Samplers

  PM-10 samplers collect particulates with a diameter of 10 microns or less from ambient air. Particulates of this size represent the respirable fraction, and thus are of special significance. PM-10 samplers can be high-volume or low-volume. The high-volume sampler operates in the same manner as the TSP sampler at a constant flow rate of 40 CFM; it draws the sample through a special impactor head which collects particulates of 10 microns or less. The particulate is collected on an 8- by 10-inch filter. The low-volume sampler operates at a rate of approximately 17 L/min. The flow must remain constant through the impactor head to maintain the 10-micron cut-off point. The low-volume PM-10 collects the sample on 37-mm Teflon® filters.

- High-Volume PS-1 Samplers

  High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 CFM (144 to 282 L/min). This system is excellent for measuring low concentrations of semivolatiles, PCBs, pesticides, or chlorinated dioxins in ambient air.

- Area Sampling Pumps

  These pumps provide flow-rate ranges of 2-20 L/min and have a telescopic sampling mast with the sampling train. Because of the higher volume, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used for metals, pesticides and PAH sampling which require large sample volumes.

- Personal Sampling Pumps

  Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 0.1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an AC charger/converter.

- Canister Samplers

  Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over

the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control device until the canister is near atmospheric pressure.

Pressure canister sampling systems use a pump to push air into the canister. To maintain a higher, more controlled flow, the pump typically controls the pressure differential across a critical orifice at the inlet of the canister, resulting in a pressurized canister at the completion of sampling.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide better results or a wider range of results.

- Summa Canisters

  Summa canisters are highly polished passivated stainless steel cylinders. The Summa polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. At the site, the canister is either placed in a sampler to control sample collection rate, or opened to collect a grab sample. Samples can be collected by allowing air to bleed into or be pumped into the canister. U.S. EPA/ERT uses 6-liter Summa canisters for VOC and permanent gas analysis.

- Passive Dosimeters

  Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are absorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

- Polyurethane Foam (PUF)

  PUF is a sorbent used with a glass filter for the collection of semivolatile organic compounds such as pesticides, PCBs, chlorinated dioxins and furans, and PAHs. Fewer artifacts (chemical changes that occur to collected compounds) are produced than with some other solid sorbents. PUF is used with the PS-1 sampler and U.S. EPA Method TO13. PUF can also be used with personal sampling pumps when sampling for PAHs using the Lewis/McCloud method. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.

- Sampling Bags (Tedlar)

  Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally pumped into the bags, but sometimes a lung system is used, in which a pump creates a vacuum around the bag in a vacuum box. Then the sample flows from a source into the bag. This method is used for VOCs, fixed gases (CO_2 , O_2 and N_2) and methane.

- Impingers

  An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

- Sorbent Tubes/Cartridges

GENERAL AIR SAMPLING GUIDELINES

A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes and tube containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a GC, for compound analysis:

- Tenax Tubes

  Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO1 and VOST for volatile nonpolar organic , some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 mm Hg).

- Carbonized Polymers

  The carbonized molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes pumped. These are used in U.S. EPA Method TO2 for highly volatile nonpolar compounds which have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

- Mixed Sorbent Tubes

  Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

- Chemically Treated Silica Gel

Silica gel is a sorbent which can be treated with various chemicals. The chemically treated silica gel can then be used to sample for specific compounds in air. Examples include the DNPH-coated silica gel cartridge used with U.S. EPA Method TO11.

- XAD-2 Polymers

  XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with U.S. EPA Method TO13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

- Charcoal Cartridges

  Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. Ambient air is drawn through them so that the backup section verifies that breakthrough of the analytes on the first section did not occur, and the sample collection was therefore quantitative. Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence on the second section. Next, the adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).

- Tenax Tubes

  Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

- Particulate Filters

  Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air and is then analyzed for particulate mass or chemical or radiological composition. Particulate filters are made from different materials which are described below.

- Mixed Cellulose Ester (MCE)

  MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are used often for particulate sampling.

- Glass Fiber

  Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and high, solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

  Particulate filters with polyvinyl chloride are resistant to concentrated acids and alkalis. Their low moisture pickup and light tare weight make them ideal for gravimetric analysis.

- Teflon

  Teflon is manufactured from polytetrafluorethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. Teflon filters are used for metal collection.

- Silver

  Particulate filters manufactured from pure silver have high collection efficiency and uniform pore size. These filters are used for mercury collection and analysis.

- Cellulose

  Particulate filters with cellulose contain less than 0.01% ash. These filters are used to collect particulates.

RETRIEVING METEOROLOGICAL INFORMATION

CONTENTS

SUPERCEDES: SOP #2048; Revision 0.0; 08/11/92; U.S. EPA Contract EP-W-09-031.

RETRIEVING METEOROLOGICAL INFORMATION

1.0 SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to define the protocol for retrieving meteorological information to be used as inputs to categorize on-site field conditions in "real-time."

This SOP is applicable to all field activities which involve the collection of environmental data or which include activities that expose workers to climate related stresses.

This SOP is not intended to cover all possible meteorological data retrieval venues, but to describe several of those which are readily available to ERT/SERAS personnel.

These are standard (i.e., typically applicable) operating procedures, which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

There are several sources of meteorological data available. In practice, more than one source should be accessed to ensure (a degree of) reliability in the data. Sources of meteorological data include:

- On-Site Meteorological Data Acquisition Systems (OMDAS)
- National Weather Service (NWS) and Other Governmental Services
- Airports
- Neighboring Industrial Facilities
- Public Bulletin Boards

Prior to site activities, field personnel are expected to contact and to be familiar with the avenues of obtaining meteorological information. A more detailed description is provided in Section 7.0 of this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There is no chemical interferences for this procedure; however, the instrumentation is fragile and there is a chance of breakage.

5.0 EQUIPMENT/APPARATUS

Necessary equipment for the OMDAS is discussed in ERT/SERAS SOP #2120, Remote Meteorological Station. Computers connected to phone modems are required to access public bulletin boards.

6.0 REAGENTS

This section is not applicable to this SOP.

7.0 PROCEDURE

This section discusses the methods of retrieving meteorological data. This SOP does not list all of the methods of meteorological data retrieval, but it does provide sufficient information to obtain data from various sources. These information sources should be checked prior to the site operations.

An excellent source of meteorological data is provided by an OMDAS. An OMDAS provides the site personnel with easy access to meteorological information and informs site workers of local conditions when the site environment differs from surrounding areas. In addition to on-site measurements, meteorological conditions should be obtained by an outside, reliable source. These sources may include:

- National Weather Service (NWS)
- National Climatic Data Center (NCDC)
- Accu-Weather's Accu-Access
- Weather-Brief
- Major City/Airport Data
- Neighboring Industrial Facilities

7.1 National Weather Service

The local NWS offices are listed in the "Blue Pages" (Government Agencies) in the phone book. If they are not listed separately, the number can be found under the Department of Commerce. The NWS headquarters is in Kansas City and can be reached at 1510 East Bannister Road, Building, 1 Kansas City, MO 64131 (816-926-7993). They will provide telephone numbers for other local or regional NWS offices.

Typical data which should be obtained includes surface temperature, barometric pressure, wind speed and wind direction. At times it may be necessary to obtain upper air information which includes ceiling height, cloud cover, and upper level wind speed and direction. The NWS also has access to radar data which may provide useful information.

7.2 National Climatic Data Center

The NCDC, in Asheville NC, offers historical meteorological data. The hourly data is provided in one year segments, and is similar to that provided by the NWS (barring the radar). The data is encoded differently than that from the NWS, but a separate file including their format is provided. See the SERAS meteorologists for more information.

7.3 Accu-Weather's Accu-Data/Weather-Brief

ERT/SERAS currently subscribes to a communication software link to Weather-Brief, Inc. The

link attaches users to a direct access or menu driven bulletin board that provides several types of meteorological data, including: hourly observations, short-range forecasts, long-range forecasts, radar information, and satellite data. To access data for a specific location, the user must provide a three-letter station identifier. The hourly observation data (preferred for modeling) is updated continuously. Seventy-two hours of archived hourly data is available. Other software links are available. One such software, Accu-Weather's Accu-Data may be subscribed to on a bi-annual basis.

7.4 Major City/Airport Weather (Weather-Brief)

Current weather conditions, as well as forecast information can be accessed by dialing 1-800-WX-BRIEF. Identify yourself as a U.S. EPA contractor and tell the operator the city(ies)/area(s) for which you want information.

7.5 Neighboring Industrial Facilities

Some facilities have their own OMDAS which are checked monthly for statistical errors. These sites offer good data for dispersion models which may require a meteorological history. To receive copies of their weather data, interested parties should contact the plant's facility manager or the local air management agency. Many facility managers will provide copies of the data at no charge. Local air management agencies may be able to provide information regarding the quality of meteorological data available at facilities within their district. See the SERAS meteorologists for more information.

7.6 Data Storage

Preservation, handling and storage of the OMDAS data is discussed in ERT/SERAS SOP #2120, Remote Meteorological Station. Meteorological data obtained during, or for, field activities should be stored on magnetic media which is labeled to include:

- Name of site
- Date(s) data were collected
- Specific information collected

A copy of this information should be provided to the SERAS meteorological and modeling staff for future use.

8.0 CALCULATIONS

The OMDAS is a direct reading device which provides wind flow parameters (such as wind speed, wind direction and temperature). Specific OMDAS calibration and calculations are available in ERT/SERAS SOP #2120, Remote Meteorological Station.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

Before beginning site activities, Task Leaders are responsible for accessing the meteorological service closest to the planned site. In addition, Task Leaders should familiarize themselves with the proper use and acquisition of data from the OMDAS. Periodic checks should be made every two hours with the local

weather service to ensure instrument reliability and worker safety.

In addition, the following general quality assurance procedures apply:

1. All data must be documented on field data sheets or within site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

10.0 DATA VALIDATION

Data validation is made possible by checks through several sources. See the SERAS meteorologists for further information and assistance.

11.0 HEALTH AND SAFETY

Physical hazards of the OMDAS may be avoided by securing the cables from the probes and the antenna with a velcro tie as described in ERT/SERAS SOP #2120, Remote Meteorological Station.

When working with potential hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

12.0 REFERENCES

This section is not applicable to this SOP.

AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

CONTENTS

* These sections affected by Revision 0.0.

SUPERCEDES: SOP #2119; Revision 0.0; 10/07/94; U.S. EPA Contract EP-W-09-031.

AIR SAMPLING FOR METALS [NIOSH METHOD 7300, ELEMENTS]

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to define the proper sample collection technique for air sampling of elemental metals, as well as delineate the typical working range of the method and indicate potential interferences. Elements covered by this method include the metals listed in Table 1 (Appendix A).

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air sampling for elemental metals involves passing a known quantity of air across a mixed cellulose ester (MCE) filter. The particulate phase of the air, with a nominal size of greater than or equal to 0.8 microns (µm) is trapped in the filter.

This method requires air sampling using 37-millimeter (mm), 3-stage cassettes loaded with 0.8 µm MCE filters and support pads. The approximate minimum and maximum sample volumes required for detection of the metals of interest are listed in Table 1 (Appendix A).

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

No preservatives or special storage conditions are required. However, the samples should be stored with the filter upright and transported at or near ambient conditions to prevent significant deterioration of the samples. When transporting and handling the samples, prevent impact and vibrations which would dislodge particulates from the filters.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

A potential problem with the sampling method is overloading of the filter. This can disrupt flow, consequently producing analytical results that may be biased low. Periodic checking of the filter and pump during sampling can reduce this error and sample cassettes can be changed during the sampling period. In the event of heavy sample loading, multiple filters would be submitted and analyzed in the laboratory as a single sample. The total volume must be indicated on the Chain of Custody record.

5.0 EQUIPMENT/APPARATUS

The following equipment is required for air sampling for elements:

- Air pumps, low or medium volume
- Tygon tubing
- 0.8:m MCE filters with support pads
- 37-mm 3-stage cassettes

- Hose-barb filter adapters
- Calibrated rotameter or bubble meter
- Screwdriver set
- Sample collection documentation (air sampling worksheets, sample labels, logbooks, chain of custody records)
- Particulate monitoring equipment (Real-time Aerosol Monitor [RAM])
- Personal protection gear
- Whirlpack bags

6.0 REAGENTS

This section is not applicable to this SOP.

7.0 PROCEDURE

7.1 Field Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain and organize the necessary sampling and monitoring equipment.

3. Decontaminate or pre-clean equipment, and ensure that it is in working order. Precalibrate sampling equipment, if possible.

4. Prepare scheduling and coordinate with staff, client, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific Health and Safety Plan.

6. Use stakes, flagging tape, or other appropriate means to mark all sampling locations. If necessary, the proposed locations may be adjusted based on site access, property boundaries, surface obstructions and/or on-site activity.

7. Make an estimate of the airborne concentrations of the elements of concern. It may be possible to extrapolate the concentration of particulates by assuming similar percentages of metals are present in the airborne particulates as in the soils. However, it should be noted that this is only a rough estimate. If estimation of the airborne concentration of metals is not possible, then sample volumes should remain within the limits recommended in Table 1 (Appendix A).

8. Arrange for sample analysis by an appropriately certified laboratory and check with the laboratory for any special requirements (e.g., additional lot blanks).

7.2 Calibration

Calibrate the sampling pumps in the following manner:

1. Assemble the calibration train as shown in Figure 1 (Appendix A) using a representative 37-mm, 3-stage filter cassette loaded with a 0.8 µm MCE filter and support pad (outlet plug removed), Tygon tubing, hose-barb filter adapter, rotameter, and air sampling pump. Depending on the required flow rate, a low volume or a medium volume sampling pump may be required. Refer to Figure 2 (Appendix A) for an illustration of the components of the filter cassette.

2. Turn on the pump, allow to warm up, and adjust the flow using the flow adjust mechanism, until the float ball on the rotameter is aligned with the pre-calibrated flow rate value. A sticker on the rotameter should indicate this value. Refer to SERAS SOP #2118, Rotameter Calibration, for calibration procedures. NOTE: Depending on the project's objectives, calibration of the rotameter to a higher flow rate may be required.

3. Affix a sticker to the pump indicating flow rate and media.

7.3 Sampling

1. Assemble the sampling trains with clean filter cassettes (Figures 3 and 4, Appendix A).

2. Verify the pump calibration by removing the inlet plug from the cassette, attaching a rotameter with Tygon tubing and turning on the sampling pump. Ensure that all connections are tight. Record the actual flow rate on the Air Sampling Worksheet. Replace the inlet plug until ready to sample.

3. Set the sampling pump timer (low volume pumps) for the appropriate sampling time as determined by the Work Assignment Manager (WAM), or record the elapsed timer readings (medium volume pumps) on the Air Sampling Worksheet. This will be dictated by the type of sampling pump being utilized.

4. Deploy the sampling pumps as indicated in the sampling plan, following site health and safety procedures.

5. Remove the cassette cap or inlet plug from the cassette. Sampling for elemental metals can be conducted with the cassettes open-faced (cassette cap removed) or closed-faced (only inlet port plug removed). Open-faced is preferred because it permits an even loading of the filter cassette and should be used whenever high particulate concentrations are expected. This allows greater particulate loading of the filter. However, either method is acceptable since the entire filter is used during sample analysis. Closed-faced sampling is typically performed when there is a possibility that the sample may be shaken and particulates may be lost.

6. Turn on the sampling pump and allow it to run for the sampling period determined by the WAM.

7.4 Post Sampling

1. Verify the sampling period by reading the sample run time (low volume pumps) or by

checking the elapsed time on the counter (medium volume pumps). Record the sampling time on the Air Sampling Worksheet and turn off the pump.

2. Verify the pump calibration by attaching a rotameter with Tygon tubing and turning on the sampling pump. Record the final flow rate on the Air Sampling Worksheet. Insert the inlet plug.

3. Remove the sampling cassette from the sampling train and insert the outlet plug.

4. Complete the Air Sampling Worksheet and calculate the sample volume (see Section 8.0 for calculations.)

5. Label the sample and place it in a Whirlpack bag for transport to the laboratory for analysis.

6. Prepare the samples (including QC samples) for transport by packing them in a shipping container with bubble wrap or styrofoam pieces. Complete a Chain of Custody record in accordance with SERAS SOP #4005, Chain of Custody Procedures.

8.0 CALCULATIONS

The total volume of a sample is calculated by multiplying the total sample time by the average flow rate. The total volume for each sample must be indicated on the Chain of Custody Record.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 General QA Procedures

- All data must be documented on Air Sampling Worksheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

9.2 Field Blanks

Provide one field blank per sampling event or per 20 samples, whichever is greater. The field blank should be handled in the same manner as the sampling cassette (remove/replace cap and plug, and transport) except that no air is drawn through it.

9.3 Collocated Sample

Collect one collocated sample per sampling event or per 20 samples, whichever is greater. Collocated samples are two samples collected from two adjacent pumps during the same time period at the same flow rates.

9.4 Lot Blank

Include a minimum of three lot blanks per lot of sampling cassettes utilized for a sampling event. Consult with the analytical laboratory to determine if additional lot blanks are required.

10.0 DATA VALIDATION

Results of the QA/QC samples will be evaluated for contamination during the data validation process. This information will be utilized to qualify the environmental sample results accordingly with the data quality objectives of the project.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health Administration (OSHA), or corporate health and safety procedures.

12.0 REFERENCES

National Institute for Occupational Safety and Health. 1994. *NIOSH Manual of Analytical Methods*. Method 7300. 4th ed.

United States Environmental Protection Agency. 1995. *Superfund Program Representative Sampling Guidance. Volume 2: Air (Short-Term Monitoring).* EPA 540-R-95/140. Interim Final.

SKC, Inc. Universal Sample Pump, Operating Instructions. Form #37711. Rev. 9912.

Gilian. HFS-513 Air Sampling System Operating Manual. Document No. F-PRO-2105. Rev. C.

13.0 APPENDICES

A - Table
B - Figures

APPENDIX A
Table
SOP #2119
August 2001

TABLE 1. Sampling Volumes

Element (Symbol)	Minimum Air Volume to be collected - Liters	Maximum Air Volume to be collected - Liters
Silver (Ag)	250	2000
Aluminum (Al)	5(1)	100(1)
Arsenic (As)	5	2000
Beryllium (Be)	1250	2000
Calcium (Ca)	5	200
Cadmium (Cd)	13	2000
Cobalt (Co)	25	2000
Chromium (Cr)	5	1000
Copper (Cu)	5	1000
Iron (Fe)	5	100
Lithium (Li) (2)	100	2000
Magnesium (Mg)	5	67
Manganese (Mn)	5	200
Molybdenum (Mo)(2)	5	67
Sodium (Na)	13	2000
Nickel (Ni)	5	1000
Phosphorus (P)(2)	25(1)	2000(1)
Lead (Pb)	50	2000
Platinum (Pt)(2)	1250	2000
Selenium (Se)	13	2000
Tin (Sn)(2)	5	500
Tellurium (Te)(2)	25	2000
Titanium (Ti)(2)	5	100
Thallium (TI)	25	2000
Vanadium (V)	5	2000
Tungsten (W)(2)	5(1)	200(1)
Yttrium (Y)(2)	5	200
Zinc (Zn)	5	200
Zirconium (Zr)(2)	5	200

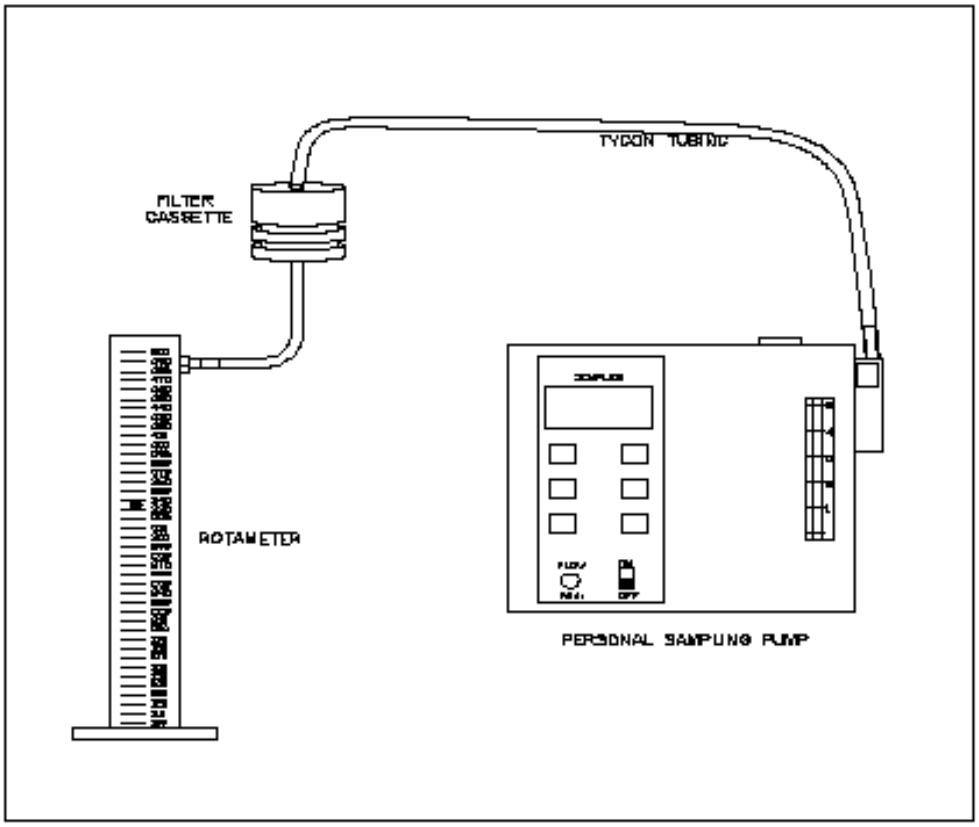
NOTE: Do not exceed a filter loading of approximately 2mg total dust.

(1) Larger volumes may be required if the anticipated concentration is less than the ACGIH Threshold Limit Value (TLV).

(2) Compound not on standard U.S. EPA Environmental Response Team analyte list.

APPENDIX B
Figures
SOP #2119
August 2001

FIGURE 1. Calibration Train with Low Volume Sampling Pump



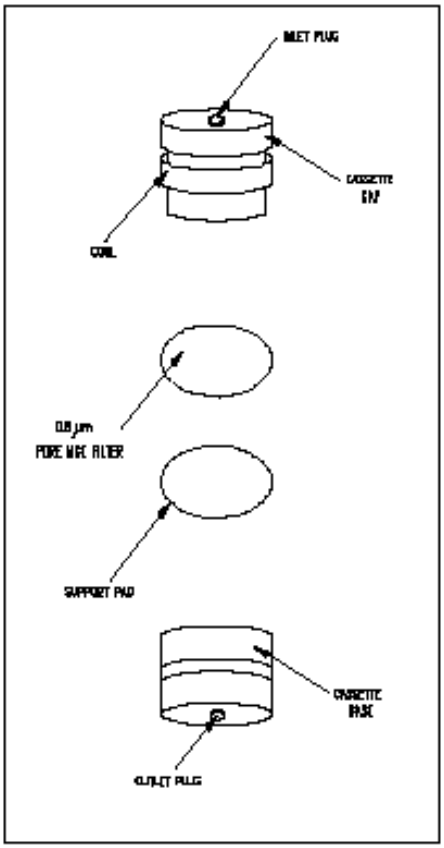

INLET PLUG
CASSETTE BODY
COIL
0.8 µm
PORE MCE FILTER
SUPPORT PAD
CASSETTE BASE
OUTLET PLUG

FIGURE 3. Aircon Sampling Train

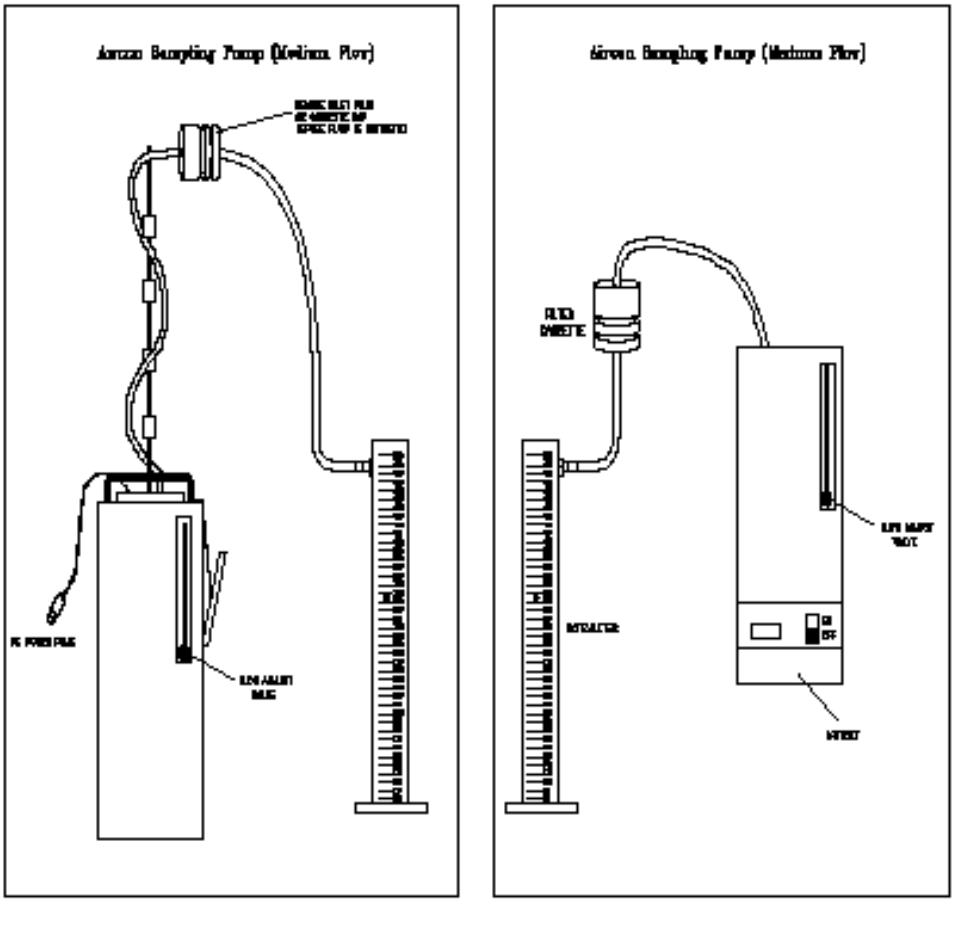
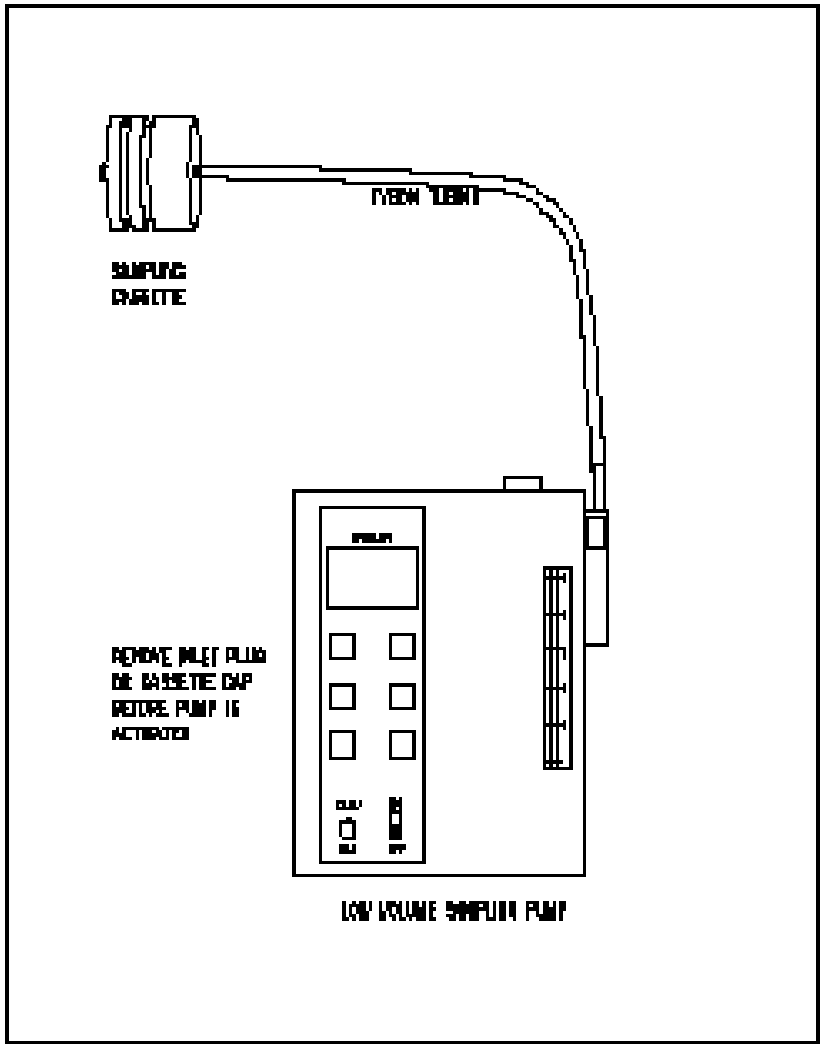


FIGURE 4. Sampling Train with Low Volume Sampling Pump



STANDARD OPERATING PROCEDURE APPROVAL AND CHANGE FORM

Scientific, Engineering, Response and Analytical Services
2890 Woodbridge Avenue Building 209 Annex
Edison New Jersey 08837-3679

STANDARD OPERATING PROCEDURE

Title: Operation of the DryCal DC-Lite Primary Flow Calibrator

Approval Date: 12/17/2015

Effective Date: 12/17/2015 | SERAS SOP Number: 2130, Rev 0.0

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The top row of this table shows the most recent changes to the controlled document. For previous revision history information, archived versions of this document are maintained by the SERAS QA/QC Officer on the SERAS local area network (LAN).

History	Effective Date
New SOP	12/17/15

OPERATION OF DRYCAL DC-LITE PRIMARY FLOW CALIBRATOR

CONTENTS

CONTENTS (Cont'd)

NEW SOP: SOP #2130, Rev. 0.0, 12/17/15, US EPA Contract EP-W-09-031

OPERATION OF DRYCAL DC-LITE PRIMARY FLOW CALIBRATOR

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the start-up, operation and routine use of the Bios International Corporation DryCal® DC-Lite Primary Flow Calibrator. The procedures and figures contained in this SOP are taken from the ***DryCal® DC-Lite Manual*** (2004) with the written consent (11/19/2015) of Bios International Corporation and Mesa Labs.

The DryCal DC-Lite is a field portable primary flow calibrator that is used for industrial hygiene, environmental and laboratory measurement applications. The DryCal DC-Lite is a National Institute of Standards and Technology (NIST) primary calibration standard that uses dry piston technology and infrared sensors to obtain volumetric flow rates. The DryCal DC-Lite can be used to measure gas flow for either a vacuum flow source or a pressure flow source. Applications include precise calibration of secondary standard calibration equipment, such as rotameters, and industrial hygiene and environmental air sampling pumps. Rapid calibrations are accomplished without the use of a soap solution thus reducing the uncertainty associated with other flow meters or rotameters.

A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure that the methods used are adequate to satisfy the data quality objectives listed in the QAPP for a particular site.

The procedures in this SOP may be varied or changed as required, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the QAPP. These changes must be documented in the final deliverable.

2.0 METHOD SUMMARY

The DryCal DC-Lite is a primary flow standard. The time required for a graphite composite piston to traverse a known distance within a glass flow cell is precisely measured, and an internal computer calculates the flow. The time the piston takes to move the known distance and implied volume yields the volumetric flow as:

$$q = \frac{v}{t} = \pi r^2 h/t$$

Where

q = volumetric flow rate
v = measurement volume
t = measurement time
r = radius
h = measurement path length

When a flow reading begins, an internal valve closes, diverting gas into the glass flow cell for measurement. The piston rises at the rate of gas flow between two collimated light beams at a known distance apart. After a suitable acceleration period, the rate of piston travel between the beams is timed. As the piston passes the second beam, the flow reading ends, the valve opens, the gas is released, and the piston drops. The volumetric flow measurement, based upon the parameters of length and time, is instantly displayed on the LCD in milliliters per minute (ml/minute) or liters per minute (LPM).

OPERATION OF DRYCAL DC-LITE PRIMARY FLOW CALIBRATOR

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

- Air samples require no preservation or special handling.
- DryCal DC-Lite calibrators can remain on charge until needed without causing damage to the battery.
- If the calibrator is stored for long periods of time the battery should be charged at least once every three months.
- Always store calibrators in a clean, dry environment and recharge the unit prior to use after long-term storage.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- Flow reading error sources include:
  - When the DryCal DC-Lite is used with pump models that pulsate (small shifts in flow rate during pulsation) the readings are affected accordingly.
  - Closure of the calibrator valve at the beginning of each flow reading results in a small pressure spike in the flow stream that can impact flow rate reading.
- Air containing cigarette smoke, excessive dust, or other particulates interferes will readings.
- Potential safety problems are presented in ***Section 11.0 Health and Safety***.

5.0 EQUIPMENT/APPARATUS

The following equipment is provided for the operation and transport of the DryCal DC-Lite Primary Flow Calibrator:

- DryCal DC-Lite Flow Calibrator

Model	Optimum Flow Range (±1%)	Extended Flow Range
L	10 ml/min–500 ml/min	1 ml/min–500 ml/min
ML	50 ml/min–2 L/min	5 ml/min–5 L/min
M	100 ml/min–7 L/min	10 ml/min–12 L/min
MH	200 ml/min–20 L/min	20 ml/min–20 L/min
H	500 ml/min–30 L/min	50 ml/min–30 L/min

- Single-Station Battery Charger
- Tubing Kit
- Leak-test Accessory
- Additional High Flow Tubing with ML, M, MH, and H models
- Certificate of Calibration
- Instruction Manual

6.0 REAGENTS

This section is not applicable to this SOP.

OPERATION OF DRYCAL DC-LITE PRIMARY FLOW CALIBRATOR

7.0 PROCEDURES

7.1 Air Flow Train Setup

7.1.1 Isolation

An isolation device is recommended to smooth the pulsation input and calibrator valve pressure spikes. To smooth flow, install a 25 millimeter (mm), 0.8 micrometer (µm) filter cassette in the flow train to create a suitable backpressure as needed.

7.1.2 Particulate Filter

The DryCal DC-Lite includes either a 5µmor 30µm inlet filter inside the inlet fitting depending on model. However, air containing cigarette smoke, excessive dust, or other particulates should be additionally pre-filtered by installing a 25mm, 0.8µmfilter cassette in the flow train on the inlet side as necessary.

7.2 Panel Buttons

7.3 Power ON

1. Press the **ON** button to turn the calibrator on.
2. An initializing screen will be displayed first showing the computer revision number and then the standard flow display screen.

Note: A Reset button is located on the lower back panel. If pressed, this button will quickly reset the unit to the initializing screen.

Note: The DC-Lite has an "energy saving" 5 minute inactivity shut-off feature.

7.4 Disable 5 Minute Shut Off

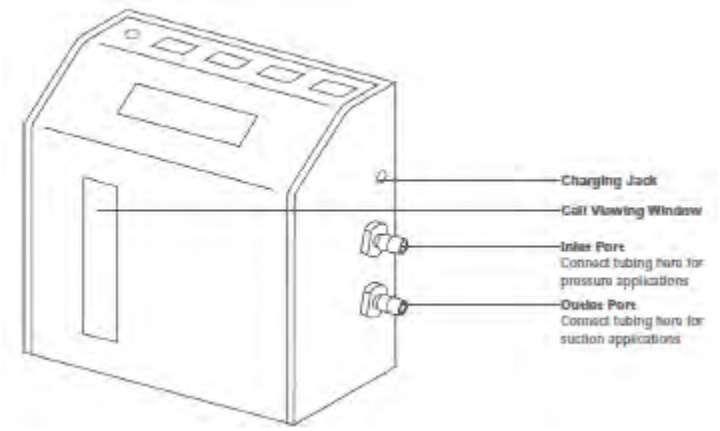
1. Press and hold the **Read** button, then press the **On** button or the **Reset** button if the unit is on.
2. The display will read, "Auto-Off Disabled" until the **Read** button is released.
3. To **Re-enable**, push the **Reset** button.

7.5 Take Readings

7.5.1 Single Flow Reading

1. Connect tubing between the calibrator and the flow source with both instruments **ON**.

Note: The calibrator connecting air flow ports are located on the right side of the unit. The lower port is for suction (outlet) and the upper port is for pressure (inlet).



Note: For industrial hygiene or environmental applications, the sampling medium should also be connected in-line.

2. Press the **READ** button **once** to obtain a single flow measurement display on the LCD.
3. A reading begins when the valve clicks shut, the green LEDs light, and the piston rises within the flow cell.
4. Continue the procedure to obtain the required number of flow readings.

Note: All successive readings in an averaging sequence will be used to calculate the average flow. The unit will automatically clear the average after ten readings and begin a new averaging sequence.

7.5.2 Auto Mode Reading

1. Press and **hold** the READ button until a reading starts then release.
2. To stop the continuous read session, press the **STOP** button once.

The display will indicate the current flow reading (FLOW), the average flow value (AVERAGE) and the number of readings in the average (NUMBER IN AVERAGE) with a maximum of 10 readings as the average flow rate.

Note: The number of readings in an averaging sequence can be reset to (00) at any time by pressing and holding the Stop button for 2 full seconds.

7.6 Printing

7.6.1 Print Setup

1. Turn the calibrator on before connecting the printer cable to avoid "Nexus Control."
2. Turn the flow source on and connect the tubing to either the inlet or outlet port of the calibrator.
3. Connect the printer cable to the parallel port on the back of the calibrator and turn the printer on.

7.6.2 Print Mode Selection

The PRINT button will toggle between three print settings OFF, 10 or ALL with the default setting OFF.

1. To engage the printer, press the **PRINT** button once for the print "10" setting allowing the printer to print 10 readings and stop.
2. Press the **PRINT** button 2 times for the print "ALL" position allowing the printer to print continuously.
3. After the printer setting selection has been made, press the **READ** button as appropriate for single or auto mode selection to initiate the flow measurement process.

7.7 Stop and Reset

1. To stop a flow reading at any time, press and release **Stop** button.
2. To reset, press and hold the **Stop** button for two full seconds.

Note: During a reset, the display is cleared and the number of readings in an averaging sequence is reset to zero.

3. For a **Hard Reset** when the calibrator does not respond to push-button commands, press the white recessed button on lower right side of the back panel near the parallel printer port.

Note: The Hard Reset button resets the unit back to the initializing screen and the printer setting will revert to the Off position.

8.0 CALCULATIONS

The DryCal DC-Lite Primary Flow Calibrator is a direct reading instrument requiring no calculations.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 General QA/QC Procedures

- All data must be documented on field data sheets or in site logbooks.
- The instrument must be operated according to this SOP and the operating instructions supplied by the manufacturer, unless otherwise specified in the QAPP.
- Records will be maintained, documenting the field level of personnel's competency in performing method and handling equipment

9.2 Annual Calibration

The DryCal DC-Lite must be calibrated annually by an accredited vendor.

10.0 DATA VALIDATION

The operator will ensure that the DryCal® DC-Lite Primary Flow Calibrator was operated in accordance with this SOP within instrument specifications and all operational checks have been completed and are within the criteria specified in the site-specific UFP-QAPP. The SERAS Task Leader is responsible for completing the UFP-QAPP verification checklist for each project.

Records will be maintained, documenting the level of personnel's competency in performing method and handling equipment.

11.0 HEALTH AND SAFETY

When working with potential hazardous materials, follow U.S. EPA, Occupational Safety and Health Administration (OSHA) and corporate health and safety procedures.

Safety concerns specific to the operation of the DryCal DC-Lite include:

- The DC-Lite is not rated intrinsically safe and is not for use with explosive gases or for use in explosive environments.
- The DC-Lite is not designed for pressurization above 0.35 bar (5 PSI) or gas flows above the rated specifications of the flow cell in use. Consult ***Appendix A: Specifications*** for acceptable gas flow ranges.
- For battery maintenance issues consult ***Appendix B: Maintenance***.
- Use only with clean laboratory air or other inert, non-corrosive gasses only.

12.0 REFERENCES

Bios International Corporation. 2004. ***DryCal® DC-Lite Manual.***

13.0 APPENDICES

A - Specifications
B - Maintenance

APPENDIX A
Specifications
SOP #2130
December 2015

(Source: Bios International Corporation. 2004. ***DryCal® DC-Lite Manual)***

OPERATION OF DRYCAL DC-LITE PRIMARY FLOW CALIBRATOR

Product Specifications

Size: 5" x 5" x 2.75" / 127 mm x 127 mm x 70 mm

Weight: 42 oz. / 1200 g

Flow Ranges/ Air Flow Accuracy:

Model	*Optimum Flow Range (1%)*	*Extended Flow Range**
L	15-500 ml/min. 1 ml/min	500 ml/min
ML	50 ml/min.- 2 L/min.	1 ml/min - 5 L/min
M	100 ml/min.-7 L/min.	10 ml/min - 12 L/min
MH	200 ml/min.-17 L/min	10 ml/min - 20 L/min
H	500 ml/min. - 30 L/min.**	30 ml/min - 30 L/min

Specifications based on averaged readings: lower limit is based on self-tested max. leakage.
**Contact BIOS for application assistance. ** 1.25% accuracy 17-30L/min*

Battery System: 6V rechargeable, sealed lead acid, 6-8 hours typical operation

AC Battery Charger/ Power Adapter: Wall- mounted, single station charger. Input: 100 to 120 VAC, 60 Hz., Output: 12 VDC (Optional; Input: 200 to 240 VAC, 50 Hz., Output 12 VDC)

Operating Modes: Single cycle, 10-readings, or auto-mode.

Temperature Range: 0-55 °C

Humidity Range: 0-70% non-condensing

Printer Port: Standard parallel (IBM Centronics, compatible with most printers)
Note: Not compatible with printers that require Microsoft® Windows™

Warranty: 2 Year

Note: The recertification program offered by BIOS is elective and is not included as a warranty item.

All specifications are subject to change. Please contact BIOS or visit our web site at: www.biosint.com, for the most current information.

APPENDIX B
Maintenance
SOP #2130
December 2015

(Source: Bios International Corporation. 2004. ***DryCal® DC-Lite Manual)***

OPERATION OF DRYCAL DC-LITE PRIMARY FLOW CALIBRATOR

The Battery System

The DryCal® DC-Lite is powered by an internal lead-acid battery. The battery will power the instrument for 6-8 hours of continuous use and has a typical service life of approximately 3-5 years. The DC-Lite provides a convenient 5 minute automatic shut-off feature for extended battery life. Use of a printer does not affect the battery life.

The DC-Lite can be charged and/or powered by the BIOS single-station charger when plugged into a standard 115V AC power source outlet (220V AC optional). Please read all setup and charging instructions indicated in this manual before using equipment.

Charging the Battery

Before using your DryCal® DC-Lite, be sure that the battery system has been fully charged to ensure that unit will perform to specification and maintain proper operation for the required time period.

The DC-Lite is equipped with a smart battery indicator that provides battery charge indication at three levels. When the battery indicator on the display is empty the unit will continue to operate for a short period of time before shutting itself off.

To Charge the DC-Lite:

1. Connect only the appropriate BIOS 12VDC charger, provided with the DC-Lite flow meter, into a standard wall outlet.

2. Insert the charger barrel plug into the charging jack located on the right side of the DC-Lite housing above the inlet and outlet air bosses. A green "CHARGE" LED will illuminate while the unit is charging. Full charge takes 8 to 12 hours, and the DryCal® can charge while being used.

2. To view the actual charging status during the charging period, disconnect the battery charger and wait 3-5 minutes. When the indicator is solid black the battery is fully charged.

- The unit may be charged for an indefinite time period without causing battery damage.

Battery Maintenance & Storage

Lead-acid batteries will not exhibit the "memory effect" common to nickel-cadmium batteries. A lead acid battery may be charged for an indefinite time period without damage.

Long-Term Storage:

Long-term storage without charging can damage the battery pack, therefore if the DC-Lite cannot be left charging continuously, it should be charged at least every three months.

ATTACHMENT A4

ALPHA AIR PARTICULATE SAMPLING SURVEY FORM

ALPHA AIR PARTICULATE SAMPLING SURVEY FORM

Reviewed by _____

Sample No. _____ Date _____
RWP or SOP _____ Field Tech _____
Location/Assigned To _____

Sampler Used _____ Filter Used _____
Sampler Serial # _____ Vac./Roto. Rdg.(start) _____
Sampling Rate (SR)_____ LPM Vac./Roto. Rdg.(stop) _____

Time Start _____ Time Stop _____ Elapsed Recorded Time (E) _____
Time Start _____ Time Stop _____ Elapsed Recorded Time (E) _____
Total Elapsed Time _____ *(All time counts in minutes)

Volume of Air Sampled (SR × E × 1000) _____ (ml)

COUNT

LAB TECH _____

Alpha Counter _____ Efficiency _____ Bkg. _____

Count Date and Time _____
Alpha Counts _____ Count Time _____
Bkg. Counts _____ Count Time _____
Gross Alpha _____ µCi/ml MDC _____µCi/ml
%DAC _____

$$Gross\ Alpha\ Acitvity, \mu Ci / ml = \frac{\left[Gross cpm - Bkg cpm\right](FA)}{2.22 \times 10^6 (dpm / \mu Ci) \times Eff.(cpm / dpm) \times Volume(ml)}$$

$$Estimated\ Error\ (95\%CL), \mu Ci / ml = 2 \times (FA) \frac{\sqrt{\frac{Gross cpm}{t(gross)} + \frac{Bkg cpm}{t_B}}}{2.22 \times 10^6 (dpm / \mu Ci) \times Eff.(cpm / dpm) \times Volume(ml)}$$

$$MDC, \mu Ci / ml = \frac{2.71 + 3.29 \times (FA)\sqrt{\frac{Bkg counts}{t_B} * t_S\left(1 + \frac{t_S}{t_B}\right)}}{2.22 \times 10^6 (dpm / \mu Ci) \times Eff.(cpm / dpm) \times Volume(ml)\ x\ t_S}$$

FA=Filter Absorption Factor
1.25 For Glass Fiber Filters
1.00 For all others

APPENDIX B

SITE-SPECIFIC DATA MANAGEMENT PLAN

Cove Mesa II Erosion and Removal Time-Critical Action

FINAL

Appendix B

Air Monitoring and Soil Scanning Site-Specific Data Management Plan

Response, Assessment, and Evaluation Services (RAES)

Contract No. EP-S9-17-03

Task Order 0021

August 26, 2019

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612

ACRONYMS AND ABBREVIATIONS

AWS	Amazon Web Services
COC	Chain of custody
CSV	Comma-separated values
DMP	Data management plan
EDD	Electronic data deliverable
ER	Emergency response
ERT	Environmental Response Team
FedRAMP	Federal Risk and Authorization Management Program
GIS	Geographic information system
PM2.5	Particulate matter less than 2.5 micrometers in diameter
QC	Quality control
RAES	Response, Assessment, and Evaluations Services
SCRIBE	Sampling and Laboratory Results Data Management Architecture
SERAS	Scientific, Engineering, Response & Analytical Services
SOP	Standard operating procedure
Tetra Tech	Tetra Tech, Inc.
TO 0021	Task Order 0021
TOCOR	Task order contracting officer representative
USEPA	U.S. Environmental Protection Agency

Tetra Tech, Inc. (Tetra Tech) prepared this site-specific data management plan (DMP) as an appendix to the Air Monitoring and Soil Scanning Work Plan prepared under the U.S. Environmental Protection Agency (USEPA) Response, Assessment, and Evaluations Services (RAES) contract (EP-S9-17-03). This site-specific DMP is prepared for Task Order 0021 (TO 0021) of the contract, the Cove Mesa II Erosion and Removal Time-Critical Action. Tetra Tech anticipates a subsequent USEPA task order to develop a programmatic DMP for the RAES contract, which may update elements of this site-specific DMP.

This site-specific DMP, in conjunction with the work plan (and appendices), supports the orderly collection, identification, processing, storage, retrieval, and assessment of information generated by the project field and laboratory activities. Overall project goals can be met only if the data obtained in the field and from analytical laboratories can be demonstrated and documented to meet data quality goals; therefore, this site-specific DMP presents contacts, data processing, data analysis, and data management methods to support the project's data quality objectives.

Any geographic information system (GIS) viewers created for this task order will be created and managed using USEPA-approved commercial-off-the-shelf applications. At the direction of the USEPA task order contracting officer representative (TOCOR), web-based visualization geospatial data could be stored on the USEPA Region 9 Emergency Response (ER) Cloud, which is a cloud-based platform hosted in Amazon Web Services (AWS), and procured by USEPA's Environmental Response Team (ERT) or on Tetra Tech's Federal Risk and Authorization Management Program (FedRAMP) system running on Microsoft Azure Government and certified at the high impact level.

The project data will be published to SCRIBE.NET at least once per day, but only when new project records have been added. This ensures that a copy of the most recent version of the database is securely stored on USEPA's SCRIBE.NET servers. Access to SCRIBE.NET data must be requested through USEPA's ERT and approved by the USEPA project manager. USEPA, Navajo partner agencies, and other contractors would be able to download the data at any time using SCRIBE software and appropriate credentials.

The remainder of this site-specific DMP provides a series of tables that identify data gathering, storage, and analysis processes related to project-specific data management activities. These tables are intended for use by field, data, and management staff for the task order. These tables are as follows:

- Table B-1. Site-Specific Data Management Plan Overview — Provides the project name, site-specific DMP author, initiation, and update dates, location to view data, and notes on the purpose of the site-specific DMP.
- Table B-2. Project Contacts — Provides key contact information, including the (1) USEPA TO 0021 Contracting Officer Representative and Region 9 Data Manager, and (2) Tetra Tech Project Manager, Data Manager, and Quality Control (QC) contacts.

- Table B-3. Data Processing — Identifies data items to be collected, data sources, target database for management of the data, data verification approaches, and standard operating procedures (SOP) for field data collection and documentation. Referenced SOPs are included as attachments to the Sampling and Analysis Plan/Quality Assurance Project Plan (Appendix A to this work plan).
- Table B-4. Data Analysis — Identifies analyses planned for the data collected, methods for the analysis, data storage software, frequency, responsible party (firm or agency), and deliverables to be generated using the data.
- Table B-5. Electronic Data Deliverable Format Specifications — Provides a draft electronic data deliverable (EDD) format that shows the structure envisioned for laboratory data to be incorporated into SCRIBE. This EDD specification will be included in the laboratory statement of work. The laboratory EDD files should be provided in a comma delimited (comma-separated value [CSV]) file and should include analytical information for all field samples, including field QC samples. The EDD column headers should match the field names listed in Table B-5. It is acceptable to add new fields if additional data need to be included.
- Table B-6. Analytical Suite Specifications — Groups analytes into analytical suite names that will be printed on the chain of custody (COC) alongside the field sample information. The analytical suites table specifies the analytes, methods, and containers for each analytical suite. This information provides key information to the laboratory to ensure that each sample is analyzed for the correct analytical suite.

Table B-1. Site-Specific Data Management Plan Overview

		Site-Specific Data Management Plan			
		Project Name:	Cove Mesa II Erosion and Removal Time-Critical Action Air Monitoring and Soil Scanning Work Plan	**Task Order:**	0021
		Author:	Randy Dorian	**Company:**	Tetra Tech, Inc.
		Date Initiated:	August 9, 2019	**Last Updated:**	August 9, 2019
Viewer:	The viewers allow users to view and search documents, web maps, mine site data, sampling information, analytical data, and other Navajo abandoned uranium mines information. https://r9.ercloud.org/TLCPortal/ https://tlc.ert.org *(On-Scene Coordinator [OSC] interface)*				
Notes:	This Site-Specific Data Management Plan (DMP) provides guidance for data collection by field personnel and subsequent data management activities. The data collection and the management practices presented in this plan help ensure data integrity and consistency for all data collection personnel and from one operational period to the next. This document should be used in conjunction with the Cove Mesa II Erosion and Removal Time-Critical Action Air Monitoring and Soil Scanning Work Plan and appendices (this Site-Specific DMP is Appendix B to the work plan). The data processing and analyses listed in this site-specific DMP are designed to support the project's data quality objectives. This Site-Specific DMP is a "living" document that will change as response activities evolve, workflows change, and new field data collection processes, forms, and tools become available. This site-specific DMP will be updated as needed and new versions will be distributed to the necessary partners.				

The following table lists project staff in key roles related to data management and oversight and their primary contact information.

Table B-2. Project Contacts

Role (Affiliation)	Name	Email	Phone Number
Task Order Contracting Officer Representative (USEPA)	Edwin “Chip” Poalinelli	poalinelli.edwin@epa.gov	415-972-3390 (office)
Region 9 Data Manager (USEPA)	Freyja Knapp	knapp.freyja@epa.gov	415-972-3025 (office)
Project Manager (Tetra Tech)	Mike Ferrif	mike.ferrif@tetratech.com	510-302-6320 (office) 808-498-5092 (cell)
Data Manager (Tetra Tech)	Randy Dorian	randy.dorian@tetratech.com	303-919-3084 (cell)
GIS Specialist (Tetra Tech)	Jim Herning	jim.herning@tetratech.com	805-637-0624 (cell)
Quality Control Coordinator (Tetra Tech)	Katie Henry	katie.henry@tetratech.com	510-302-6298 (office)

Notes:
Tetra Tech Tetra Tech, Inc.
USEPA U.S. Environmental Protection Agency

The following table outlines the data gathering and storage processes for various data types collected during the project.

Table B-3. Data Processing

Item	Data Input (Input Device)	Study (File Type)	Data Type (Data Source)	Target Database	Site-Specific Data Elements	Data QA/QC	Site-Specific Source or SOP
1	XRF Field Survey (Niton XL5 model or equivalent)	Screening Level (csv)	Instrument (Tetra Tech Field Team)	None	Yes	Geospatial QC	Work Plan, SAP/QAPP, SOP 004
2	Air/Personal Sampling (field form)	Summary Reports (csv, paper, PDF)	Sampling (Tetra Tech Field Team)	Scribe / SQL Server	Yes	Data Entry Rules, Scribe Auditor Rules	Work Plan, SAP/QAPP
3	Particulate and Metals Sampler and Pump Performance (GilAir Plus Sampling Pump, export and/or field form)	Summary Reports (csv, paper, PDF)	Instrument (Tetra Tech Field Team)	Scribe / SQL Server	Yes	Data Entry Rules, Scribe Auditor Rules	Work Plan, SAP/QAPP, SERAS SOPs 2119, 2008, 064, 073
4	Radiological Samples Field Analysis (Ludlum 2929 with 43-10-1 tray counter, or equivalent, exports and/or field form)	Summary Reports (csv)	Instrument (Tetra Tech Field Team)	Scribe / SQL Server	Yes	Data Entry Rules, Scribe Auditor Rules	Work Plan, SAP/QAPP, SERAS SOP No. 2201 and Radiation Protection Program (RPP) SOP 006
5	Analytical Data (Laboratory EDDs)	Summary Reports (csv)	Analytical (Analytical Laboratory)	Scribe / SQL Server	Yes	Scribe Auditor Rules, Chemist Data Verification	Work Plan, SAP/QAPP
6	Analytical Data (Validated EDDs)	Summary Reports (csv)	Analytical (Validator)	Scribe / SQL Server	Yes	Scribe Auditor Rules, Chemist Data Verification	Work Plan, SAP/QAPP, SERAS SOP 1017

Table B-3. Data Processing

Item	Data Input (Input Device)	Study (File Type)	Data Type (Data Source)	Target Database	Site-Specific Data Elements	Data QA/QC	Site-Specific Source or SOP
7	Logbook (hard copy notebook)	Summary Report (paper, PDF)	Field Observations (Tetra Tech Field Team)	None	No	Field team leader review and QA/QC	Work Plan, SAP, SOP 024
8	Gamma Radiation Survey (Mobile Device – Ludlum 44-10 probe, Ludlum 2221-1 meter, sub-meter GPS receiver; or equivalent)	Summary Reports (shapefile, csv)	Instrument (Tetra Tech Field Team)	Geodatabase	Yes	Post-processing QC, Geospatial QC	Work Plan, SAP/QAPP SOP 002 and RPP SOP 001 and 002
9	PM2.5 Monitoring (TSI DustTrak II Aerosol Monitor, sub-meter GPS receiver; or equivalent)	Summary Reports (PDF)	Instrument (Tetra Tech Field Team)	Scribe / SQL Server	Yes	Post-processing QC	Work Plan, SAP/QAPP

Notes:

CSV	Comma-separated values
EDD	Electronic data deliverable
PDF	Portable document format
PM2.5	Particulate matter less than 2.5 micrometers in diameter
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
SAP	Sampling and analysis plan
SERAS	Scientific,
SOP	Standard operating procedure
SQL	Structured Query Language
Tetra Tech	Tetra Tech, Inc.

The following table summarizes the planned data storage and deliverables associated with the various data analyses tasks that will be performed for this project.

Table B-4. Data Analysis

Item	Analysis Task	Method	Data Storage Software	Frequency	Responsibility	Deliverable
1	Weekly Data Reports	Data review	Excel, Access, Word	Weekly	Tetra Tech	Weekly Data and Analysis Summary Report
2	Results Summary	Database Query, Data review	Excel, Access, Word	One-time event	Tetra Tech	Validated Analytical Results Summary and Summary Report

Notes:
Tetra Tech Tetra Tech, Inc.

The following table shows elements of the EDD that will be used for laboratory data to support its integration into SCRIBE.

Table B-5. Electronic Data Deliverable Format Specifications

Table Name	Field Name	Required	Type	Size	Description
LabResults	Samp_No	Yes	Text	50	Scribe/Field Sample Number. May need to populate with Lab_Samp_No for lab QC (Required Primary and Foreign Keys).
LabResults	Lab_Location_ID	--	Text	50	Sample Location ID reported by the lab.
LabResults	Matrix_ID	Yes	Text	20	Matrix ID reported by Lab. (i.e., Soil, Water, Air, etc.).
LabResults	Sample_Type_Code	--	Text	50	Code which distinguishes between different types of samples. For example, normal samples must be distinguished from lab method blank samples (SAMP, LABQC).
LabResults	Lab_Coc_No	--	Text	50	Lab Work Order, or Sample Delivery Group, or Chain of Custody Number as reported by the Lab.
LabResults	Date_Collected	Yes	Date/time	8	Date Sample Collected as reported by the Lab.
LabResults	Date_Received	--	Date/time	8	Date Samples Received by Lab.
LabResults	Date_Extracted	--	Date/time	8	Date Samples Extracted by Lab.
LabResults	Date_Analyzed	--	Date/time	8	Date Analysis was performed by Lab.
LabResults	Lab_Name	Yes	Text	50	Laboratory that performed the analysis.
LabResults	Lab_Samp_No	Yes	Text	25	Lab Sample Number.
LabResults	Lab_Batch_No	--	Text	30	Lab Batch Number.
LabResults	Analysis	Yes	Text	100	Lab Analysis (i.e., METALS, “RAD” for radiation) (Required Primary Key).
LabResults	Analytical_Method	Yes	Text	100	Lab Analytical Method (i.e., 8270M).
LabResults	Extraction_Method	--	Text	100	Lab Extraction Method (i.e., “MEP” for Multiple Extraction Procedure, “TCLP” for Toxicity Characteristic Leaching Procedure, “SPLP” for Synthetic Precipitation Leaching Procedure, “EP” for Extraction Procedure Toxicity Test Method).
LabResults	CAS_NO	Yes	Text	50	Chemical Abstract Number (CAS).
LabResults	Analyte	Yes	Text	60	Analyte/Parameter name (i.e., Lead, Arsenic, etc.) (Required Primary and Foreign Keys)

Table B-5. Electronic Data Deliverable Format Specifications

Table Name	Field Name	Required	Type	Size	Description
LabResults	Detected	--	Text	20	Detected or Not Detected (i.e., "Y" for detected analytes or "N" for non-detects).
LabResults	Result	Yes	Double decimal	8	Result (number) returned from lab.
LabResults	Result_Qualifier	--	Text	10	Final/Validated Result qualifier/flag (i.e., J, U, ND, <, >).
LabResults	Lab_Result_Qualifier	Yes	Text	10	Result Qualifier as Reported by the Lab; leave blank if not qualified.
LabResults	Result_Units	Yes	Text	20	Result Unit of measurement (Required Primary Key).
LabResults	MDL	Yes	Double decimal	8	Method Detection Limit (MDL) or Minimum Detectable Concentration (MDC).
LabResults	MDL_Units	--	Text	20	MDL/MDC Units.
LabResults	Quantitation_Limit	--	Double decimal	8	Quantitation Limits as determined by the lab.
LabResults	Quantitation_Limit_Units	--	Text	20	Quantitation Limit Units.
LabResults	Reporting_Limit	Yes	Double decimal	8	Reporting Limits as determined by the lab.
LabResults	Reporting_Limit_Units	--	Text	20	Reporting Limit Units.
LabResults	Reportable_Result	--	Text	5	"Yes" for results that are considered to be reportable, or "No" for other results.
LabResults	Result_Type_Code	Yes	Text	50	"TRG" for a target or regular result, "TIC" for tentatively identified compounds, "SUR" for surrogates, "IS" for internal standards, or "SC" for spiked compounds.
LabResults	QC_Type	--	Text	40	Laboratory_Control_Sample, Method_Blank.
LabResults	Percent_Solids	--	Double decimal	8	Percent Solids.
LabResults	Percent_Lipids	--	Double decimal	8	Percent Lipids.
LabResults	Percent_Moisture	--	Double decimal	8	Percent Moisture of the sample portion used in the test.
LabResults	Total_Or_Disolved	--	Text	30	"D" for dissolved or filtered (metal) concentration, or "T" for everything else.

Table B-5. Electronic Data Deliverable Format Specifications

Table Name	Field Name	Required	Type	Size	Description
LabResults	Test_Type	--	Text	30	Type of test (i.e., "initial", "reextract1", "reextract2", "reextract3", "reanalysis", "dilution1", "dilution2", and "dilution3").
LabResults	Basis	--	Text	10	"Wet" for wet weight basis reporting, "Dry" for dry weight reporting.
LabResults	Dilution_Factor	Yes	Double decimal	8	Effective test dilution factor. Use 1 if not diluted.
LabResults	Percent_Recovery	--	Double decimal	8	Percent Recovery.
LabResults	SubSample_Amount	--	Double decimal	8	Amount of sample used for test.
LabResults	SubSample_Amount_Unit	--	Text	20	Unit of measurement for subsample amount.
LabResults	Final_Volume	--	Double decimal	8	The final volume of the sample after sample preparation. Include all dilution factors.
LabResults	Final_Volume_Unit	--	Text	20	The unit of measurement that corresponds to the final_amount.
LabResults	Comments	--	Text	250	Result Comments.
LabResults	QAFlag	--	Long Integer	4	QAFlag (Values: 0 = Not QAed 1=QAed).
LabResults	QA_Date	--	Date/time	8	QA Date.
LabResults	QA_Comment	--	Text	250	QA Comment.
LabResults	QA_UserName	--	Text	50	QA Username.
LabResults	Validation_Level	Yes	Text	30	Validation Level/Stage (EDD from Lab: Prelim; EDD from Validator: 2B, 3, etc).
LabResults	Activity	--	Double decimal	8	RAES: rad activity.
LabResults	CU	--	Double decimal	8	RAES: Counting Uncertainty.
LabResults	TPU	--	Double decimal	8	RAES: Total Propagated Uncertainty.

Table B-5. Electronic Data Deliverable Format Specifications

Table Name	Field Name	Required	Type	Size	Description
LabResults	CritVal	--	Double decimal	8	RAES: Critical Value.
LabResults	SigVal	--	Double decimal	8	RAES: Sigma Value.
LabResults	DER	--	Double decimal	8	RAES: Duplicate Error Ratio.
LabResults	DERLIM	--	Double decimal	8	RAES: Duplicate Error Ratio Limit.
LabResults	VAL_Result	--	Double decimal	8	RAES: Validation Result (number) returned from validator (not required); Lab should leave blank.
LabResults	VAL_Qual	--	Text	10	RAES: Validation Qualifier (not required); Lab should leave blank.
LabResults	Validator	--	Text	100	RAES: Validation Company. Validator company name (required for Validated EDD). Example: CheckInc. Lab should leave blank.

Notes:
EDD Electronic data deliverable
ID Identification
QA Quality assurance
QC Quality control
RAES Response, Assessment, and Evaluations Services

The following table specifies the analytical suites that will be assigned to each sample sent to the laboratory. This table will be used as a link to the COC to ensure that each analytical suite (represented as Analyses on the COC) is analyzed for the correct analytes and methods by the laboratory.

Table B-6. Analytical Suite Specifications

Analyses	Analyte	Method	Media	Container	Number of Containers
AirMet	Metals {arsenic (As), barium (Ba), lead (Pb), molybdenum (Mo), selenium (Se), uranium (U), and vanadium (V)}	USEPA IO-3.1 (preparation) and IO-3.5 analysis	Bulk	Filter in bottle or bag	1
AirRAD	Gross Alpha, Gross Beta	900	Bulk	Filter in bottle or bag	1

APPENDIX C

HEALTH AND SAFETY PLAN

Cove Mesa II Erosion and Removal Time-Critical Action

FINAL

Appendix C

Air Monitoring and Soil Scanning Health and Safety Plan

Response, Assessment, and Evaluation Services (RAES)

Contract No. EP-S9-17-03

Task Orders 0021

August 26, 2019

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612

TETRA TECH

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ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AHA	Activity hazard analysis
ALARA	As low as is reasonably achievable
AMS	Acute Mountain Sickness
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AUM	Abandoned uranium mine
Bi	Bismuth
CARC	Potential occupational carcinogen
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	Contaminant of concern
CPR	Cardiopulmonary resuscitation
DCN	Document control number
DOE	U.S. Department of Energy
GFCI	Ground fault circuit interrupter
GIS	Geographic information system
GPS	Global positioning system
H&S	Health and safety
HAPE	High Altitude Pulmonary Edema
HASP	Health and safety plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPS	Hantavirus pulmonary syndrome
HSR	Health and Safety Representative
IDLH	Immediately dangerous to life or health
mg	Milligrams
mg/m^3	Milligrams per cubic meter
mmHg	Millimeters of mercury
mrem	Millirem
NAMLRP	Navajo Abandoned Mine Lands Reclamation Program
NIOSH	National Institute for Occupational Safety and Health
NNEPA	Navajo Nation Environmental Protection Agency
NRC	U.S. Nuclear Regulatory Commission

ACRONYMS AND ABBREVIATIONS (CONTINUED)

OSHA	Occupational Safety and Health Administration
Pb	Lead
PEL	Permissible exposure limit
PM	Project Manager
PPE	Personal protective equipment
Ra	Radium
$RaSO_4$	Radium sulfate
RAES	Response, Assessment, and Evaluation Services
REL	Recommended exposure limit
rem/year	Roentgen equivalent man per year
RSE	Removal site evaluation
SDS	Safety data sheet
SMCRA	Surface Mining Control and Reclamation Act
SOW	Statement of work
SSC	Site Safety Coordinator
SWP	Safe work practice
TEDE	Total effective dose equivalent
Tetra Tech	Tetra Tech, Inc.
TLV	Threshold limit value
TO	Task Order
TOTAL	Tracking and Optimizing Tool for Analyzing Losses
TWA	Time-weighted average
U	Uranium
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound

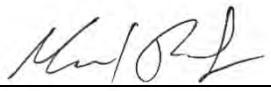
REVIEWS AND APPROVALS

CLIENT NAME: **U.S. Environmental Protection Agency Region 9**

CONTRACT NO.: EP-S9-17-03: **Response, Assessment, and Evaluation Services (RAES)**

Task Order 0021, Mesa II Erosion and Removal Time Critical Action, Cove, AZ

We the undersigned have read and approved of the health and safety guidelines presented in this health and safety plan for on-site work activities at the Eastern Agency Removal Site Evaluations for the Task Orders described above performed on the Navajo Nation, New Mexico.

Name	Signature	Date
Dave Brown Tetra Tech Health and Safety Manager		08/07/2019
Mike Ferrif Tetra Tech Project Manager		08/05/2019

This statement certifies that Tetra Tech has assessed the type, risk level, and severity of hazards for the project, and has selected appropriate personal protective equipment for site personnel in accordance with Occupational Safety and Health Administration regulations at Title 29 of the *Code of Federal Regulations*, Part 1910.132.

EMERGENCY INFORMATION

POST THIS PAGE ON SITE

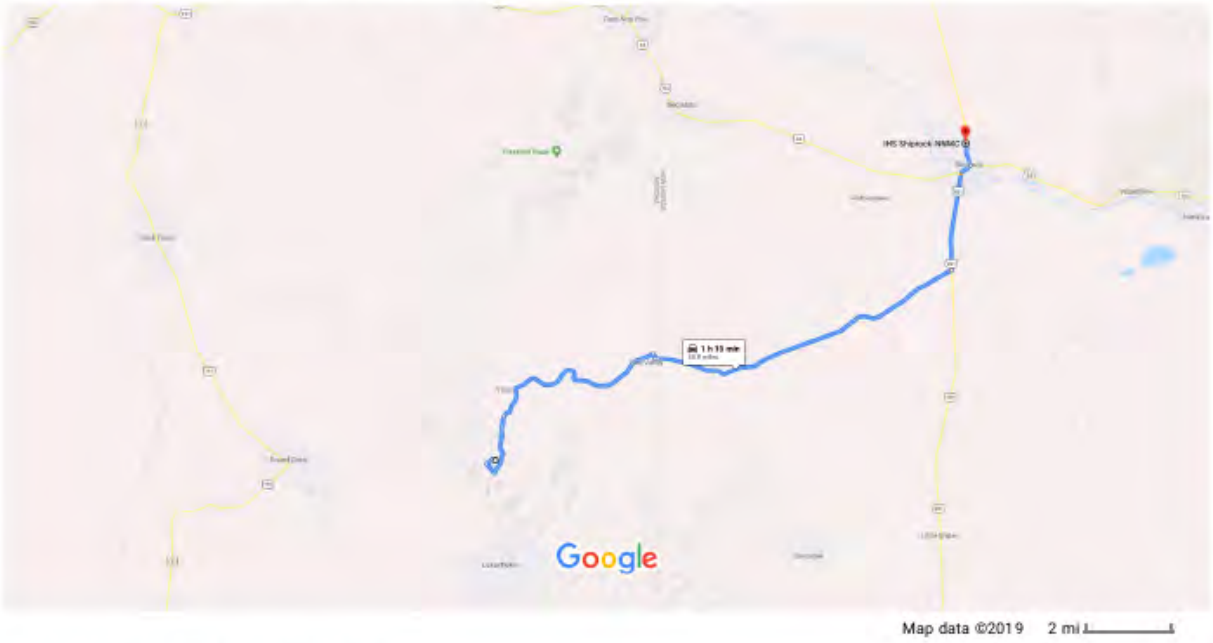
EMERGENCY CONTACTS AND ROUTE TO HOSPITAL

Emergency Contact	Telephone No.
InfoTrac Chemical Monitoring System	(800) 535-5053
WorkCare	(800) 455-6155
Farmington Fire Department –Farmington, NM	(505) 599-1430
Navajo Nation Fire Department No.100 – Window Rock, AZ	(928) 871-6111
Navajo Nation Police Department – Shiprock, NM	(505) 368-1351
Tetra Tech Personnel:	
Human Resource Development: Amy Clark	(626) 470-2516 (Office)
Health and Safety Manager: David Brown	(619) 446-7261 (Cell)
Health and Safety Manager: Denny Cox	(816) 668-7464 (Cell)
Project Manager: Mike Ferrif	(541) 912-8796 (Cell)
RAES Contract Program Manager: Kenyon Larsen	(510) 302-6459 (Office)
Client Contact:	
Edwin “Chip” Poalinelli USEPA Region IX	(415) 301-1573 (Cell)
NNEPA Criminal Enforcement Division:	
Anderson Harvey, Sgt.	(575) 571-3735 (Cell) (928) 871-7393 (Desk) (928) 871-7602 (Office)
Hospital Name: Hospital Address: **Hospital Telephone No.:**	IHS Shiprock – Northern Navajo Medical Center Highway 491 Shiprock, NM 87420 **(505) 368-6001**
Hospital Name: Hospital Address: **Hospital Telephone No.:**	San Juan Regional Medical Center 801 West Maple Farmington, NM 87401 **(505) 609-2000**
Hospital Name: Hospital Address: **Hospital Telephone No.:**	Chinle Comprehensive Health Care US 191 & Hospital Drive Chinle, AZ 86503 **(928) 674-7001**
Hospital Name: Hospital Address: **Hospital Telephone No.:** **Air Ambulance (Guardian Air, Flagstaff, AZ) Telephone No.:**	Flagstaff Medical Center 1200 N Beaver Street Flagstaff, AZ 86001 **(928) 773-2113** **(800) 523-9391**
Life Flight	**(888) 238-1428**

Figure C-1. Hospital Evacuation Routes

Mesa II to HIS Shiprock-Northern Navajo Medical Center (full emergency services available)

Google Maps 36.5130390, -109.2349832 to IHS Shiprock-NNMC, Shiprock, NM Drive 48.8 miles, 1 h 10 min



36.5130390, -109.2349832

Follow Indian Rte 33 to Indian Rte 13 in Red Valley

37 min (19.0 mi)

1. Head southwest

0.5 mi

2. Turn left

0.8 mi

3. Sharp left onto Indian Rte 33

3.6 mi

4. Turn right to stay on Indian Rte 33

0.8 mi

5. Turn right to stay on Indian Rte 33

13.0 mi

6. Turn right to stay on Indian Rte 33

0.4 mi

Follow Indian Service Rte 13 and US-491 N to Shiprock

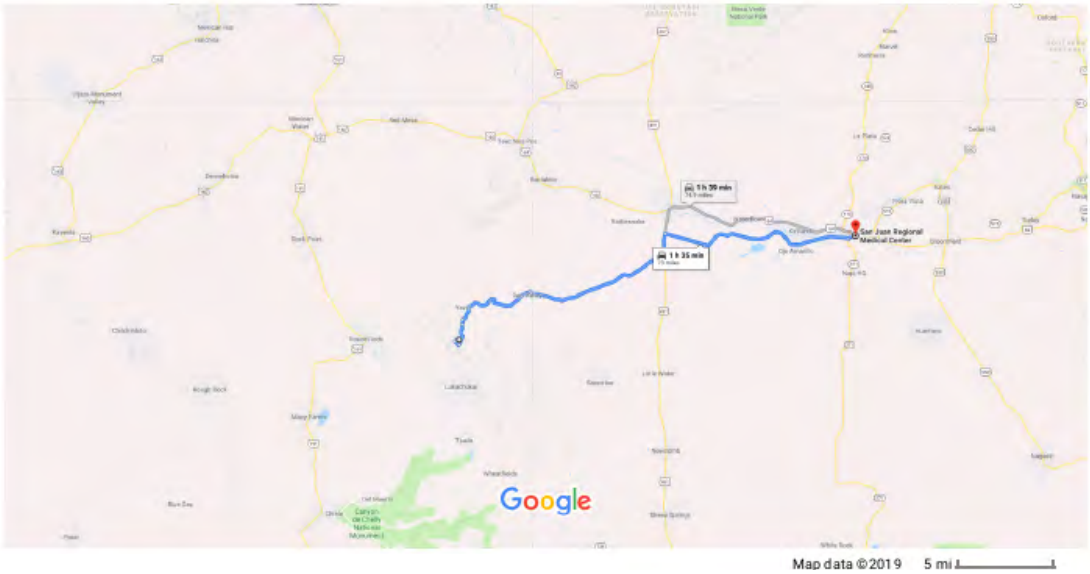
32 min (29.6 mi)

7. Turn left onto Indian Rte 13

295 ft

Mesa II to San Juan Regional Medical Center
(Level III trauma center, full emergency services available)

Google Maps 36.5130390, -109.2349832 to San Juan Regional Medical Center Drive 73.0 miles, 1 h 35 min



36.5130390, -109.2349832

Follow Indian Rte 33 to Indian Rte 13 in Red Valley

37 min (19.0 mi)

1. Head southwest

0.5 mi

2. Turn left

0.8 mi

3. Sharp left onto Indian Rte 33

3.6 mi

4. Turn right to stay on Indian Rte 33

0.8 mi

5. Turn right to stay on Indian Rte 33

13.0 mi

6. Turn right to stay on Indian Rte 33

0.4 mi

Follow Indian Service Rte 13 and Indian Rte 36 to W Maple St in San Juan County

57 min (53.9 mi)

7. Turn left onto Indian Rte 13

295 ft

8. Continue onto Indian Rte 33
   Entering New Mexico

0.1 mi

9. Continue onto Indian Service Rte 13

20.8 mi

10. Turn left onto US-491 N

3.0 mi

11. Turn right onto Indian Rte 36

28.7 mi

12. Turn left onto NM-371 N

0.8 mi

13. Continue straight onto W Pinon St

0.2 mi

14. Turn left onto S Lake St

0.1 mi

15. Turn right onto W Maple St
    Destination will be on the right

44 s (0.1 mi)

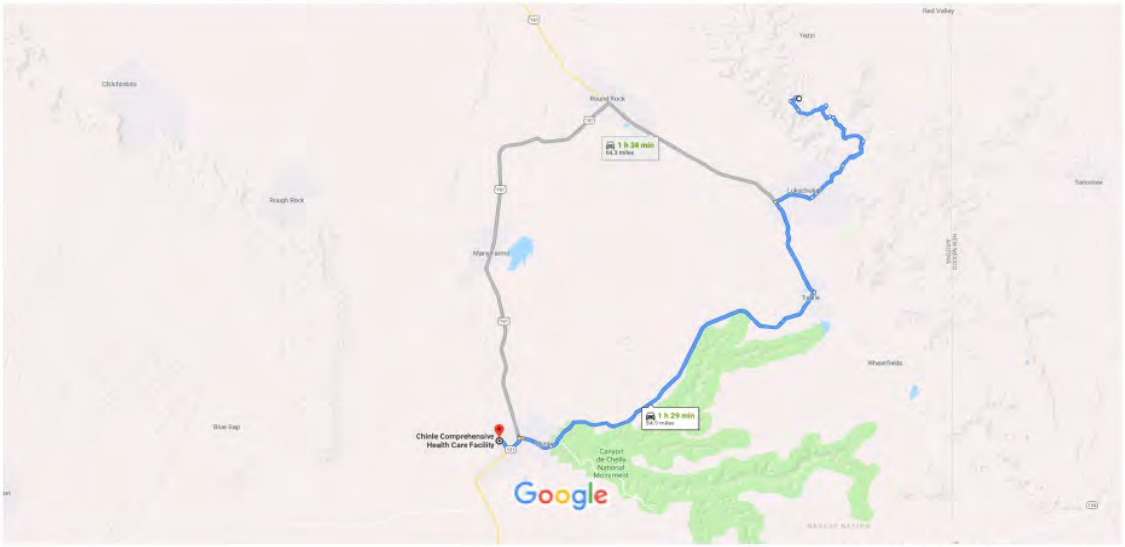
San Juan Regional Medical Center
801 W Maple St, Farmington, NM 87401

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Mesa II to Chinle Comprehensive Health Care Facility
(level IV trauma center, full emergency services available)

Google Maps 36.5130390, -109.2349832 to Chinle Comprehensive Health Care Facility

Drive 54.9 miles, 1 h 29 min



Map data ©2019 2 mi

36.5130390, -109.2349832

Take Indian Rte 33 to Indian Rte 13

32 min (9.1 mi)

1. Head southwest — 0.5 mi
2. Turn left — 0.8 mi
3. Slight right onto Indian Rte 33 — 2.5 mi
4. Turn right — 1.5 mi
5. Turn right — 0.3 mi
6. Turn right — 3.5 mi
7. Continue straight — 125 ft

Take Indian Rte 12 and Indian Rte 64 to Indian Rte 102 in Chinle

55 min (44.7 mi)

8. Turn right onto Indian Rte 13 — 2.9 mi
9. Indian Rte 13 turns slightly left and becomes N-13 — 2.9 mi
10. Continue onto Rte 13 — 0.4 mi
11. Continue onto Indian Rte 13 — 2.7 mi
12. Turn left onto Indian Rte 12 — 7.3 mi
13. Turn right onto Indian Rte 64 — 16.9 mi
14. Continue onto Indian Rte 64 — 7.9 mi
15. Continue onto Indian Rte 7 — 2.4 mi
16. Use the left 2 lanes to turn left onto US-191 S — 1.2 mi

Continue on Indian Rte 102 to your destination

3 min (1.1 mi)

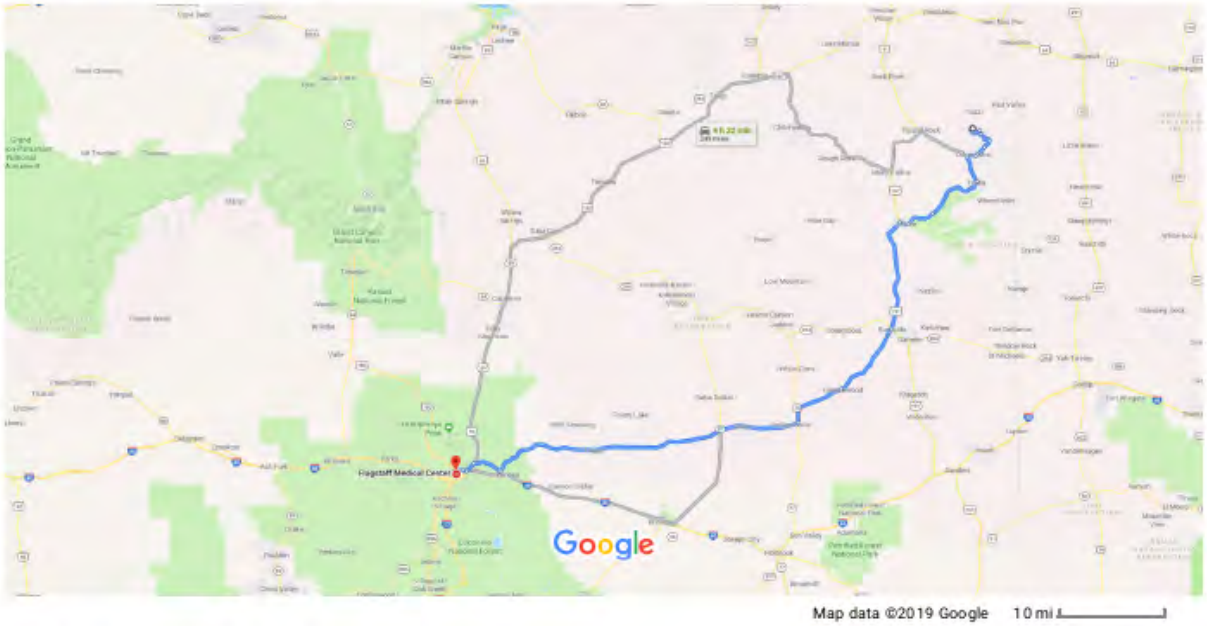
17. Turn right onto Indian Rte 102 — 0.9 mi
18. Turn left — 0.2 mi
19. Turn right
    Destination will be on the right — 276 ft

Chinle Comprehensive Health Care Facility
U.S. 191 & Hospital Drive, Chinle, AZ 86503

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Mesa II to Flagstaff Medical Center
(Level 1 trauma center, full emergency services available)

Google Maps 36.5130390, -109.2349832 to Flagstaff Medical Center Drive 218 miles, 4 h 17 min



36.5130390, -109.2349832

Take Indian Rte 33 to Indian Rte 13 — 32 min (9.1 mi)

1. Head southwest — 0.5 mi
2. Turn left — 0.8 mi
3. Slight right onto Indian Rte 33 — 2.5 mi
4. Turn right — 1.5 mi
5. Turn right — 0.3 mi
6. Turn right — 3.5 mi
7. Continue straight — 125 ft

Take Indian Rte 64, US-191 S, Indian Rte 15, Rte 15, ... and Leupp Rd to N Beaver St in Flagstaff — 3 h 44 min (209 mi)

8. Turn right onto Indian Rte 13 — 2.9 mi
9. Indian Rte 13 turns slightly left and becomes N-13 — 2.9 mi
10. Continue onto Rte 13 — 0.4 mi
11. Continue onto Indian Rte 13 — 2.7 mi
12. Turn left onto Indian Rte 12 — 7.3 mi
13. Turn right onto Indian Rte 64 — 16.9 mi
14. Continue onto Indian Rte 64 — 7.9 mi
15. Continue onto Indian Rte 7 — 2.4 mi
16. Use the left 2 lanes to turn left onto US-191 S — 30.4 mi
17. At the traffic circle, take the 2nd exit onto Indian Rte 15 — 21.8 mi
18. Continue onto Rte 15 — 11.8 mi
19. Continue onto Indian Rte 15 — 0.8 mi
20. Turn left onto State Hwy 77 — 3.3 mi
21. Turn right onto Indian Rte 15 — 69.1 mi
22. Continue onto Leupp Rd — 14.2 mi
23. Turn right onto Townsend Winona Rd — 8.0 mi
24. Use the left 2 lanes to turn left onto US-89 S (signs for Flagstaff) — 2.6 mi
25. Turn right onto E Lockett Rd — 1.2 mi
26. Continue onto E Cedar Ave — 1.2 mi
27. Continue onto E Forest Ave — 0.9 mi

Continue on N Beaver St to your destination — 1 min (0.2 mi)

28. Turn left onto N Beaver St — 312 ft
29. Turn left — 92 ft
30. Turn right — 351 ft
31. Turn left
    Destination will be on the right — 46 ft

Flagstaff Medical Center
1200 N Beaver St, Flagstaff, AZ 86001

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

1.0 INTRODUCTION

Tetra Tech Inc. (Tetra Tech) has prepared this health and safety plan (HASP) to support the U.S. Environmental Protection Agency (USEPA) by providing technical oversight of firms conducting removal site evaluations (RSE) within the Navajo Nation. The USEPA is the Lead Agency and the Navajo Nation Environmental Protection Agency (NNEPA) is the Supporting Agency and will be referred to as the "Agencies." The Northern Abandoned Uranium Mine (AUM) region where this work will be conducted is located in the northern portion of the Navajo Nation. The region includes twenty Navajo Nation Chapters: the Aneth, Beclabito, Burnham/T'iis Toh Sikaad, Cove, Gadii ahi/To'Koi, Hogback/Tse'Daa Kaan, Mexican Water, Nenahnezad, Newcomb/Tiis Nideeshgish, Red Mesa, Red Valley, San Juan, Sanostee/Tsealnaozt'ii, Sheepsprings/Toohaltsooi, Shiprock, Sweetwater/Tolikan, Teecnospos, Toadlena/TwoGreyHills and Upper Fruitland Chapters.

The Mesa II Mine site is in the Cove Chapter in the Northern AUM Region of the Navajo Nation.

This work was assigned under Task Orders 0021 (TO 0021) of the Response, Assessment, and Evaluation Services (RAES) contract (EP-S9-17-03). Field activities will include providing air monitoring and soil scanning support during erosion repair and road repair work. Air monitoring will include setting up perimeter air monitoring stations and collecting personal air samples for the first week of work. Gamma scanning equipment and a handheld XRF scanner will also be used to screen surface soils along the road and at borrow source locations. Further description of planned activities appears in Section 3.3. The Mesa II erosion repair/removal time critical action (Mesa II TCRA) will start in September 2019.

This document addresses items specified under Occupational Safety and Health Administration (OSHA) Title 29 of the *Code of Federal Regulations* (CFR), Part 1910.120 (b), "Final Rule." Pertinent regulatory and internal safety program areas covering employee and community protection from radiological hazards are addressed in more detail in this HASP. This HASP will be available to all on-site personnel who may be exposed to hazardous on-site conditions.

The purpose of this HASP is to define requirements and designate protocols to be followed in all air and soil monitoring activities at the Mesa II TCRA. All personnel on site, including Tetra Tech and site visitors, must be informed of site emergency response procedures and any potential fire, explosion, health, or safety hazards associated with on-site activities. This HASP summarizes potential hazards and defines protective measures planned for site activities.

This plan must be reviewed and approved by the Tetra Tech Health and Safety Representative (HSR) or a designee and the Tetra Tech Project Manager (PM) (see Reviews and Approvals). The Compliance Agreement form in Attachment C1 must be signed by all personnel before they enter the site. Protocols established in this HASP are based on available site data and on-site conditions and health and safety (H&S) hazards known or anticipated to be present at the site. Specifications in this HASP are subject to review and revision based on actual conditions encountered in the field during site activities. Significant revisions to this plan must be approved by the Tetra Tech HSR and PM.

2.0 HEALTH AND SAFETY PERSONNEL AND PLAN ENFORCEMENT

This section describes responsibilities of project personnel, summarizes requirements for subcontractors and visitors who want to enter the abandoned uranium mine (AUM) sites, and discusses HASP enforcement.

2.1 PROJECT PERSONNEL

Table C-1 lists personnel and organizations associated with planned activities at the site. The organizational structure will be reviewed and updated as necessary during the project.

Table C-1. Mesa II Erosion and Removal Time Critical Action

Project Health and Safety Personnel

Name/Title	Responsibility	Telephone No.
U.S. Environmental Protection Agency (USEPA) Client Representative		
Tana Alert	Project Officer	(415) 972-3090
Edwin "Chip" Poalinelli	Task Order (TO) Representative	(415) 972-3390 (Office) (415) 301-1573 (Cell)
Tetra Tech, Inc. (Tetra Tech) Personnel		
Kenyon Larsen	Program Manager	(510) 821-4795 (Cell)
Mike Ferrif	Project Manager (PM)	(808) 498-5092 (Cell)
Christian LeJeune	Site Safety Coordinator (SSC)	(505) 235-2966 (Cell)
Denny Cox	Health and Safety Representative (HSR) (Central Region)	(816) 668-7464 (Cell)
Dave Brown	HSR (West Region)	(619) 446-7261 (Cell)
iina' ba' Personnel		
TBD	Field Technicians	TBD

The Tetra Tech PM, Site Safety Coordinator (SSC), and HSR will be responsible for implementation and enforcement of the provisions of this HASP. Their duties and expectations of Tetra Tech are described in the following sections.

2.1.1 Project Manager

The Tetra Tech Program Manager, Kenyon Larsen, and PM, Mike Ferrif, have ultimate responsibility for ensuring implementation of the requirements set forth in this HASP. Some of this responsibility may be achieved through delegation to site-dedicated personnel who report directly to the PM. The PM will regularly confer with site personnel regarding safety and health compliance.

2.1.2 Site Safety Coordinator

SSCs are assigned by the PM and approved by the HSR to provide H&S oversight for a specific project. SSCs must be assigned for all Hazardous Waste Operations and Emergency Response (HAZWOPER) work, construction work, and whenever contractually required. HSRs may also require a SSC on non-HAZWOPER projects if warranted by site hazards or non-routine operations. If qualified by experience and training, the SSC may also serve as the "competent person" as required by federal or state H&S regulations and by the corporate H&S program. A competent person is required for activities such as excavations and fall protection. However, it is not anticipated that any field activities will require excavating or fall protection. Determinations of appropriate qualifications shall be made by the HSR in coordination with the PM on a project-by-project basis. The HSR has the right and responsibility to review the scope of work and site hazards to ensure that the SSC selected is adequately trained and experienced to manage site safety for a specific project. The SSC is responsible for the following:

- Being on site during all work activities or designating a qualified alternate SSC in his or her absence.
- Overseeing H&S issues for Tetra Tech employees and visitors at the site where he or she is assigned.
- Implementing hazard communication, respiratory protection, personal protective equipment (PPE), and other associated safety and health programs.
- Implementing the site-specific HASP.
- Verifying that on-site personnel read and understand site H&S documents, such as HASPs, project-specific safety data sheets (SDS), and activity hazard analyses (AHA).
- Verifying that the HASP accurately reflects all site hazards and is revised or amended as new tasks are assigned or new hazards are recognized.
- Verifying on-site personnel undergo all necessary training as specified by the HASP.
- Advising the PM and/or client of any field practices or conditions that may endanger the H&S of field personnel or visitors.
- Recommending corrective actions to any conditions that may endanger the H&S of field personnel or visitors.
- Selecting, inspecting, maintaining, and enforcing proper use, cleaning, and maintenance of protective clothing and equipment.
- Monitoring on-site hazards and conditions.
- Maintaining visual or verbal communication with all site workers. If site workers are in different groups working in different areas, each group will need a SSC.
- Stopping work if any worker feels that a work site condition, practice, or operation causes or presents a hazard that can reasonably be expected to result in immediate death, serious physical harm, or severe damage to the environment.

- Working closely with the project-specific PM to determine appropriate corrective action and/or prompt resolution to all hazards.
- Conducting daily H&S briefings for site personnel and initial site training for new personnel.
- Arranging for work area and personal or ambient hazard monitoring (for occupational exposure assessments related to heat/cold stress and other potential exposure hazards).
- Creating and maintaining records of employee exposure and monitoring results for all on-site personnel.
- Monitoring workers for signs of occupational health exposures, such as chemical exposure, heat stress, and fatigue.
- Coordinating and supervising emergency response and providing emergency first aid and cardiopulmonary resuscitation (CPR) to team members, if required.
- Reporting all occupational illness, injuries, incidents, and near-misses to the HSR and PM immediately after stabilization of the incident.
- Assisting in preparing reports of illnesses, injuries, motor vehicle accidents, or property damage.

2.1.3 Health and Safety Representatives

The Tetra Tech HSRs (Dave Brown and Denny Cox) are responsible for administration of the company H&S program. The HSR will act in an advisory capacity to the PM, SSC, and site personnel regarding project-specific H&S issues. The Tetra Tech PM will establish a liaison between officers and representatives of USEPA and the HSR on matters relating to H&S.

2.1.4 Tetra Tech and Project Team Employees

Tetra Tech employees are expected to fully participate in implementing the site HASP by obtaining necessary training, attending site safety meetings, always wearing designated PPE, complying with site safety and health rules, and advising the Tetra Tech SSC of H&S concerns at the site. Additionally, all Tetra Tech and iina' ba' employees have the following rights and responsibilities:

- Tetra Tech and iina' ba' employees are expected to report safety hazards they face while performing their work. As such, employee reports of safety hazards are viewed as positive interactions and ***no employee of Tetra Tech will retaliate against any other employee who reports a safety hazard***.
- Tetra Tech and iina' ba' employees have the right to refuse to perform work involving significant safety hazards they feel have not been addressed.
- Every Tetra Tech and iina' ba' employee has the right to stop work if he or she feels any work site condition, practice, or operation causes or presents a hazard that can reasonably be expected to result in immediate death, serious physical harm, or severe damage to the environment.

- Tetra Tech and iina' ba' employees are expected to maintain their exposures to levels that are as low as is reasonably achievable (ALARA). ALARA procedures are discussed in detail in Section 4.1.

2.1.5 Subcontractors

Subcontractor personnel directly contracted by Tetra Tech or iina' ba' at air sampling station site areas will be required to read and comply with all sections of this plan. All subcontractor personnel entering the site must sign the Compliance Agreement form (Form HSP-4) (see Attachment C1). Subcontractor personnel must comply with all applicable 29 CFR Section (§) 1910.120 training and site-specific radiological training, fit testing, and medical surveillance requirements as specified in the subcontractor's site-specific HASP and associated task hazard analysis. Subcontractors are responsible for providing PPE required by this plan for their personnel (see Section 7.1) and are directly responsible for the H&S of their employees.

2.1.6 Visitors

All site visitors will be required to read the HASP and sign the Compliance Agreement form (Form HSP-4) (see Attachment C1). Visitors will be expected to comply with relevant OSHA requirements. The SSC may also provide visitors with site-specific radiological overview, as required. Visitors will also be expected to provide their own PPE required by the HASP. Visitors who have not met PPE requirements are not permitted to enter areas where exposure to hazardous materials is possible.

2.2 HEALTH AND SAFETY PLAN ENFORCEMENT

HASP enforcement at the Mesa II site will be rigorous. Violators of the HASP will be verbally notified on first violation, and the violation will be noted by the Tetra Tech SSC in a field logbook. On second violation, the violator will be notified in writing, and the Tetra Tech PM and the violator's supervisor will be notified. A third violation will result in a written notification and eviction of the violator from the site. The written notification will be sent to human resources development and the HSR.

Personnel will be encouraged to report to the SSC any conditions or practices that they consider detrimental to their health or safety or other personnel whom they believe are in violation of applicable H&S standards. These reports may be made orally or in writing. Personnel who believe that an imminent danger threatens human health or the environment are encouraged to stop work and bring the matter to the immediate attention of the SSC for resolution.

At least one copy of this HASP will be available continuously to all site personnel. The SSC will discuss minor changes in HASP procedures at the beginning of each work day at the daily tailgate safety meeting. Significant plan revisions must be reviewed and approved by the HSR and discussed with the PM.

3.0 ABANDONED URANIUM MINE BACKGROUND INFORMATION

The primary potential hazardous substances on the Mesa II site are associated with mine-related waste, including radiological and chemical constituents; therefore, knowledge of radiological material exposure protection will be required to perform the activities identified in the USEPA statement of work (SOW) (USEPA 2018). The AUM sites are within the Colorado Plateau physiographic province, typically characterized by high desert. The plateau has some large changes in relief, with incised drainages, canyons, cliffs, buttes, arroyos, and other features consistent with a regionally uplifted, eroded, semi-arid plateau.

Summer site conditions are hot and dry; in winter, elevations of site locations render them subject to severe cold and high winds. Quick changes in weather pose danger of flash flooding. While this danger is greatest during the summer monsoon season (July through September), flash floods can occur at any time of the year.

The following sections further describe the AUM sites, history, and activities planned for this project.

3.1 ABANDONED URANIUM MINE SITE HISTORY

The Navajo Nation encompasses more than 27,000 square miles. The unique geology of the region renders the Navajo Nation rich in uranium, a radioactive ore in high demand after development of atomic power and weapons at the close of World War II in the 1940s. Approximately four million tons of uranium ore was extracted during mining operations within the Navajo Nation from 1944 to 1986. Many Navajo people worked in the mines, often living and raising families in close proximity to the mines and mills.

Uranium mining and milling activities no longer occur on Navajo lands, but the legacy of these activities remains, including more than 500 AUM claims and thousands of mine features such as pits, trenches, and holes. Structures and water sources in the area contain elevated levels of uranium, radium, and other radionuclides. Uranium and other elements (selenium, arsenic, etc.) associated with the mine and mill sites also occur naturally at elevated levels in rock, soil, surface water, and groundwater across the Navajo Nation and the broader Four Corners region (Arizona, Colorado, New Mexico, and Utah). Health effects as a result of exposure to these elements can include lung cancer, bone cancer, and impaired kidney functions.

In congressional hearings on November 4, 1993, regarding AUMs on the Navajo Nation, the Navajo Nation presented testimony regarding concerns about the mines before the Subcommittee on Oversight and Investigations and the Subcommittee on Native American Affairs. The Navajo Nation requested assistance to determine if the uranium mines posed a health risk to Navajo residents. USEPA presented testimony to describe its federal authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, and how USEPA could assist the Navajo Nation.

Risk of human and ecological exposure to uranium (and associated heavy metals) stems from the following three sources:

- Naturally occurring radioactive material,
- Uranium mines, including AUMs, and
- Uranium milling sites.

CERCLA addresses only wastes resulting from manmade activities, such as mining, milling, and related features (e.g., waste piles). The U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC) have authority under the Uranium Mill Tailings Radiation Control Act of 1978 to investigate and address certain former uranium mill sites, including those near Shiprock, New Mexico; Mexican Hat, Utah; Tuba City, Arizona; and Monument Valley, Arizona.

On April 21, 1995, the Navajo Nation Council established NNEPA, a regulatory agency within the Executive Branch of the Navajo Nation government. In April 2000, NNEPA, the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP), and USEPA Region 9 mapped all AUMs on the Navajo Nation, and NNEPA and USEPA Region 9 screened all AUMs on the Navajo Nation for possible remedial actions.

NAMLRP began in August 1988 as a program under the Navajo Nation's Division of Natural Resources. The purpose of the program is to fulfill the abandoned mine reclamation requirements of Public Law 95-87 "Surface Mining Control and Reclamation Act (SMCRA) of 1977, amended in 2016." SMCRA focused primarily on coal mines. NAMLRP activities were conducted to understand site conditions related to mining, both coal and other mining (i.e., uranium) throughout the Navajo Nation. NAMLRP completed an inventory, prioritized abandoned mine sites, and determined which sites to reclaim based on factors such as physical environmental problems and overall safety for reclamation employees.

In accordance with USEPA's 1984 Indian Policy (USEPA 1994) and the 2011 USEPA Policy on Consultation and Coordination with Indian Tribes (USEPA 2011), USEPA Region 9 consults with the Navajo Nation on a government-to-government basis when USEPA actions and decisions may affect tribal interests. In response to concerns raised by the Navajo Nation during the 1993 congressional hearing referenced above, the USEPA Region 9 Superfund Program initiated an investigation aimed at assessing human exposure to radiation and heavy metals from AUMs on Navajo Nation. USEPA conducted field sampling at AUMs, water sources, and homes beginning in the 1990s.

In 2002, with provision of records and logistical involvement by NAMLRP, USEPA developed the AUM Project Management Plan in partnership with NNEPA to create a screening assessment mechanism, with close involvement of NAMLRP. The U.S. Army Corps of Engineers (USACE) produced a geographic information system (GIS) database for USEPA in support of AUM screening assessments on the Navajo Nation. The GIS database identifies locations of known AUMs and uranium mining-related areas on the Navajo Nation and their proximities to structures, water sources, and surface water drainages.

3.2 FORMER SITE INVESTIGATIONS

Several investigations have been performed to investigate and characterize the nature and extent of abandoned uranium mining-related environmental contamination across the Navajo Nation. The reader is referred to the Work Plan (Tetra Tech 2019) for further discussion of previous investigations.

3.3 PLANNED ACTIVITIES

This section summarizes field activities to occur during the Mesa II TCRA. The field activities are scheduled to begin in September 2019 and continue weekly for approximately eight weeks and will be conducted by Tetra Tech and/or iina' ba' personnel. Additional details regarding implementation of these tasks appear in the SAP and QAPP in Appendices A and B, respectively, of the MESA II TCRA Work Plan.

The field activities will include the following tasks:

- Driving and hiking to the Mesa II TCRA work area
- Setting up and taking down perimeter air monitoring stations
- Non-intrusive gamma radiation surveys and X-ray fluorescence field surveys of the road and borrow source areas
- Documenting site features with cameras and applicable field forms
- Using gamma scanning equipment to perform decontamination scanning of boots, clothing and equipment before entering vehicles to leave the site

Furthermore, travel to sites may require use of all-terrain vehicles (ATV) or utility vehicles (UTV). Tetra Tech and iina' ba' personnel will receive appropriate safety training instructions for proper and safe usage of ATV and UTVs prior to their use. Given the remote locations of AUM sites, Tetra Tech, and iina' ba' will utilize two-way radios, long-distance radios, satellite phones, etc., to communicate, because cell phone service is expected to be limited or absent at the majority of AUM site investigation areas.

The desert climate produces weather that is often extreme and variable, and the site locations can be remote. Because of these factors, and the general safety protocol Tetra Tech employs, a minimum of two Tetra Tech team staff are required during each field event.

4.0 SITE-SPECIFIC HAZARD EVALUATION

Field activities and physical features of the sites may expose field personnel to a variety of hazards. This section provides information on potential hazards related to site activities and the nature of hazardous material impacts. Potential radiological, chemical, and physical hazards related to site activities are discussed below.

4.1 RADIOLOGICAL HAZARDS

The primary contaminants of concern (COCs) identified at the sites are uranium and its decay products. One of the uranium decay products, radium-226 (Ra-226), is the primary risk driver associated with uranium ore. Based on historical information regarding the radium contamination throughout the AUM sites, most radium likely is in the form of relatively insoluble radium sulfate ($RaSO_4$).

Uranium ore and its decay products present potential for exposure because of internal radiation hazards from alpha-emitting radionuclides and external radiation hazards from gamma-emitting radionuclides (primarily bismuth-214 [Bi-214] and lead-214 [Pb-214]). Respirable dust that may contain these radionuclides is considered the primary internal exposure pathway.

Uranium-238 (U-238) and Ra-226 are both part of the natural uranium decay series. Isotopes of the decay series decay by emitting alpha or beta radiation. Each of the beta emitters emits gamma radiation during decay (see Table C-2).

Tetra Tech is committed to protecting workers, the public, and the environment from radiation during field activities. The framework of protections from radiological hazards described in this HASP accords with NRC regulations specified in 10 CFR Part 20. While 10 CFR Part 20 is not strictly applicable to AUM sites because the sites are not covered under the Atomic Energy Act, 10 CFR 20 regulations are applicable or relevant and appropriate requirements (ARARs). The 10 CFR Part 20 regulations for radiation protection, at a minimum, conform to the applicable requirements set forth in OSHA regulations 29 CFR Part 1910.1096.

The Tetra Tech SSC will work with field personnel to limit their exposures to levels that are ALARA and below the maximum acceptable dose rate for workers—a total effective dose equivalent (TEDE) of 5 Roentgen equivalent man per year (rem/year). Tetra Tech will implement the principles of time, distance, and shielding, to the extent practicable, to protect workers from direct exposure to radiation. Administrative controls will be implemented to the extent practicable to protect workers from internal exposures to radiation.

ERG and Tetra Tech have prepared an RPP (Attachment C4). The RPP describes radiation hazards and controls in detail, in accordance with 10 CFR §20.1101. Tetra Tech personnel and all contractors will comply with the RPP. A summary of information conveyed within the RPP is discussed in this section.

The Tetra Tech SSC will ensure provision of adequate radiation training to all on-site Tetra Tech team personnel prior to start of work. The Tetra Tech SSC will work with field personnel to limit their exposures to levels ALARA and below the maximum acceptable dose rate for workers—a

total effective dose equivalent (TEDE) of 5 Roentgen equivalent man (rem) per year (rem/year). Tetra Tech will implement the principles of time, distance, and shielding, to the extent practicable, to protect workers from direct exposure to radiation. Administrative and/or engineering controls will be implemented to the extent practicable to protect workers from internal exposures to radiation. The reader is referred to the RPP for additional information regarding radiation training (see Attachment C4).

In accordance with the RPP, air monitoring will be conducted for one representative worker on field teams collecting surface or subsurface soil samples. Field personnel who are soil sampling or overseeing soil boring will start work in modified Level D PPE. Each person shall have readily available (e.g., in vehicle or carried on his/her person) a full-faced or half-faced respirator equipped with particulate filters for which the person is properly fit-tested and medically approved. Tetra Tech's respiratory protection program will be followed by all field personnel. The respiratory protection program is presented in Attachment C4.

Table C-2 lists the radioactive decay series at AUM sites.

Table C-2. Abandoned Uranium Mine Site Radioactive Decay Series

Symbol	Element	Radiation	Half-Life	Decay Product
U-238	Uranium-238	Alpha	4,460,000,000 years	Th-234
Th-234	Thorium-234	Beta	24.1 days	Pa-234
Pa-234	Protactinium-234	Beta	1.17 minutes	U-234
U-234	Uranium-234	Alpha	247,000 years	Th-230
Th-230	Thorium-230	Alpha	80,000 years	Ra-226
Ra-226	Radium-226	Alpha	1,602 years	Rn-222
Rn-222	Radon-222	Alpha	3.82 days	Po-218
Po-218	Polonium-218	Alpha	3.05 minutes	Pb-214
Pb-214	Lead-214	Beta	27 minutes	Bi-214
Bi-214	Bismuth-214	Beta	19.7 minutes	Po-214
Po-214	Polonium-214	Alpha	1 microsecond	Pb-210
Pb-210	Lead-210	Beta	22.3 years	Bi-210
Bi-210	Bismuth-210	Beta	5.01 days	Po-210
Po-210	Polonium-210	Alpha	138.4 days	Pb-206
Pb-206	Lead-206	None	stable	(none)

Specific information on the primary potential radiological hazard at AUM sites is presented in Table C-3, including exposure limits, anticipated exposure routes, and toxic characteristics.

Table C-3. Abandoned Uranium Mine Site Potential Radiological Hazard

Radiological Contaminant	Exposure Limits		Exposure Routes	Toxic Characteristics[1]
Uranium-238 and decay progeny (uranium series)	Worker Whole Body TEDE[2]	5 rem/year	Inhalation of suspended particulates and radon progeny, direct exposure to gamma-emitting radionuclides, and ingestion of contamination	Long-term exposure to low levels of this contaminant increases risk of developing several types of diseases. Inhaled or ingested radionuclides in the uranium series increases risk of developing such diseases as lymphoma, bone cancer, and diseases that affect formation of blood, such as leukemia and aplastic anemia. These effects usually take years to develop. External exposure to gamma radiation increases risk of cancer to varying degrees in all tissues and organs.
	Worker Lens of Eye	15 rem/year		
	Worker Individual Organ[3]	50 rem/year		
	Worker Skin or Extremity	50 rem/year		
	Public Whole Body TEDE[2]	100 mrem/year		

Notes:
[1] Source: USEPA 2011.
[2] TEDE is calculated as the sum of the external dose equivalent and the CEDE.
[3] Organ doses are external dose equivalent and CEDE.

CEDE Committed effective dose equivalent
mrem Millirem
rem/year Roentgen equivalent man per year
TEDE Total effective dose equivalent

4.1.1 X-Ray Fluorescence Measurements

Measurements of X-ray fluorescence (XRF) will proceed by use of a Thermo Scientific NITON XL5 Analyzer. The Thermo Scientific NITON XL5 Analyzer XRF 700 uses a silver anode X-ray tube. Trained personnel will wear whole body dosimeters while operating the portable XRF unit. The XRF unit will be transported in a shock-proof case.

Proper training for safe use of the instrument and radiation protection training will be completed by Tetra Tech and iina' ba' personnel prior to use of the instrument. Additional information on safely operating the XRF instrument is provided in the RPP and the SOP 004 in the SAP/QAPP (Appendix B of the Air Monitoring and Soil Scanning).

4.2 CHEMICAL HAZARDS

Previous investigations identified the following non-radiological contaminants of potential concern: arsenic, molybdenum, selenium, uranium, and vanadium. Notably, uranium can be more of a chemical toxicity concern than radiation depending on its solubility. Tetra Tech will limit exposure to these potential chemical hazards through administrative controls, such as limiting access to contamination areas. Also, Tetra Tech will limit exposure to chemical hazards by requiring use of appropriate PPE, such as gloves and wet wipes. Specific information on potential chemical hazards at AUM sites appears in Table C-4, including exposure limits, anticipated exposure routes, and toxic characteristics. SDSs and Agency for Toxic Substances

and Disease Registry (ATSDR) fact sheets are included in Attachment C2 to this HASP and summarize H&S information regarding hazardous materials. All site personnel will be informed of the hazards associated with the COCs and any chemicals necessary to complete the project. Attachment C2 includes the following information:

- Arsenic toxicological fact sheet
- Molybdenum hazard substance fact sheet
- Selenium toxicological fact sheet
- Uranium toxicological fact sheet
- Vanadium toxicological fact sheet

Table C-4. Abandoned Uranium Mine Site Potential Chemical Hazards

Chemical	Exposure Limits and IDLH Level	Exposure Routes	Symptoms of Exposure
Arsenic	PEL = TWA 0.01 mg/m^3 REL = CARC; C = 0.002 mg/m^3 [15-minute] TLV = TWA 0.01 mg/m^3 IDLH = CARC; 5.0 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Ulceration of nasal septum, dermatitis, gastrointestinal disturbances, peripheral neuropathy, respiratory irritation, hyperpigmentation of skin, potential occupational carcinogen
Molybdenum	PEL = TWA 0.005 mg/m^3 REL = CARC TLV = TWA 0.05 mg/m^3 IDLH = 100 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Lassitude (weakness, exhaustion), insomnia; facial pallor; anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis wrist, ankles; encephalopathy; kidney disease; irritation eyes; hypertension
Selenium	PEL = TWA 0.2 mg/m^3 REL = 0.2 mg/m^3 TLV = 0.2 mg/m^3 IDLH = 1 mg/m^3	Inhalation, ingestion, skin	Irritates eyes, skin, nose, throat; headache, chills, irritates gastrointestinal (GI) tract
Uranium	PEL = TWA 0.25 mg/m^3 REL = 0.2 mg/m^3 IDLH = 10 mg/m^3	Inhalation, ingestion, skin, and/or eye contact	Kidney damage, blood changes
Vanadium	PEL = 0.5 mg/m^3 REL = 0.5 mg/m^3 TLV = 0.5 mg/m^3 IDLH = 35 mg/m^3	Inhalation, ingestion, skin	Irritates eyes, skin, nose, throat; headache, chills, irritates GI tract; green tongue; wheezing, shortness of breath.

Sources: National Institute for Occupational Safety and Health (NIOSH) 2005; American Conference of Governmental Industrial Hygienists (ACGIH) 2018.

Notes:

CARC	Potential occupational carcinogen	PEL	Permissible exposure limit
C	Ceiling	REL	Recommended exposure limit
IDLH	Immediately dangerous to life or health	TLV	Threshold limit value
mg/m^3	Milligrams per cubic meter	TWA	Time weighted average

4.3 PHYSICAL HAZARDS

Physical hazards associated with site activities present potential threats to on-site personnel. Dangers are posed by, but not limited to, utility and power lines, slippery surfaces, exhaustion, uneven terrain, unseen obstacles, noise, heat, cold, and poor illumination.

Injuries resulting from physical hazards can be avoided by using safe work practices (SWPs) and exercising caution when working with machinery. Specific SWPs applicable to AUM sites are presented in Attachment C3 to this HASP. To ensure a safe workplace, the SSC will conduct and document regular safety inspections and will ensure that all Tetra Tech workers and visitors are informed of any potential physical hazards related to the site. Physical hazards identified at AUM sites include the following:

- Slips, trips, and falls
- Fires/wildfires
- Heavy equipment and open excavations
- Severe weather
- Heat/cold stress
- Historical mining explosive devices

4.3.1 Slip/Trip/Fall

During this project, personnel will frequently hike on steep ground and in arroyos that have uneven footing and historical mine workings. Slips, trips, and falls are likely the greatest continuous hazard to field team members during the planned activities. Field team members are to be vigilant in providing clear footing; clearly identifying obstructions, holes, or other tripping hazards; and maintaining awareness of uneven terrain and slippery surfaces.

Field staff will not climb rock faces or try to access locations where any climbing would be required.

4.3.2 Fires/Wildfires

Field activities or natural causes could result in a fire. Cigarette smoking is expressly forbidden except in a designated area. Field personnel will be observant of vegetation while parking and driving vehicles to preclude initiating fires from hot components. At least one ABC class dry chemical fire extinguisher will be available for use in each field vehicle.

Wildfires are a danger especially in areas of the southwestern United States with open spaces of natural brush that facilitate combustion of dry grasses and brush. The SSC will check with local fire departments as needed during the months when occurrences of wildfires are most frequent (July through November). If a wildfire threatens a site, the SSC will watch for changing conditions and, if necessary, ensure evacuation and security of the site in accordance with local fire department instructions.

4.3.3 Heavy Equipment and Open Excavations

Tetra Tech and iina' ba' personnel may be working in close proximity to heavy equipment operated by Clawson Excavation, an EPA contractor. This may include excavators and other heavy equipment. Work procedures specific to these activities are in Safe Work Practices presented in Attachment C3. Daily safety tailgate meetings will discuss work areas, haul patterns, and expected locations and activities of personnel on the ground. Personnel working in the vicinity of heavy equipment will wear required PPE including high-visibility vests. Personnel will maintain visual contact or radio communication with equipment operators. Personnel will not approach a piece of equipment until ground engaging equipment is lowered to the ground surface, the equipment park break is set, and the operator indicates that is safe to approach the equipment. At no time will anyone approach a piece of equipment from a direction disallowing maintenance of visual contact with the operator. Only trained and authorized equipment operators are permitted to operate backhoes, drill rigs, and other similar equipment. All personnel will adhere to the following safety precautions when working around heavy equipment:

- Equipment inspections must be conducted by a competent person prior to use. Inspections must accord with manufacturer's recommendations.
- Underground and overhead utilities must be identified prior to work. If an unanticipated underground utility is discovered, work shall stop and the PM and Safety Manager will be notified.
- Never stand beneath a suspended load.
- All belts, gears, shafts, pulleys, sprockets, spindles, drums, flywheels, chains, or other rotating or moving equipment parts must be guarded to prevent contact with persons working around the equipment.

Excavations, including pre-existing excavations, will not be entered by any personnel without approval of a Safety Manager. Excavations intended for entry by personnel minimally must meet OSHA requirements for shoring and sloping. All personnel will adhere to the following safety precautions when working near an excavation:

- No one will be permitted to enter a trench or excavation (1) before an inspection by a named Competent Person, and (2) without procedures for that entry having been specified.
- No trench or excavation will be left unattended or open without adequate barricades, caution tape, and signage.
- Personnel and equipment will maintain a minimum 3-foot clearance from the edge of the excavation.
- The spoil pile will be kept at least 3 feet back from edges of the excavation. The spoil pile shall be sloped to prevent soil from sliding back into the excavation

- Any water in the excavation shall be evaluated with respect to integrity of the excavation sidewall. If danger of collapse is indicated, minimum clearance shall be extended and/or sidewalls will be adequately braced.
- A competent person will be assigned/designated to be responsible for inspection and oversight of all excavation or trenching activities.
- Excavations deeper than 4 feet shall be equipped with stairs, ramps, or ladders so the employee can safely enter and exit the excavation area.

4.3.4 Severe Weather

AUM sites on the Colorado Plateau undergo frequent occurrences of severe weather, including thunderstorms and blizzards. Weather conditions at high elevations can change rapidly.

If a storm that includes lightning is suspected or observed, all activities must be stopped and equipment must be evaluated for its potential to act as a lightning rod. Drill rig masts provide conduits for lightning to strike and injure workers. Personnel should wait indoors or inside a vehicle (with the windows up) for the storm or lightning event to end. If a strike of lightning occurs and personnel are not in close proximity to a vehicle, the response should be to disband and lay low to ground by dropping to one's knees and bending forward with hands wrapped around knees away from any poles or trees.

Summertime monsoon flash floods are common during heavy downpours that may occur during the summer and fall seasons. Flash flooding is a common occurrence within dry desert washes. Travel in or across dry riverbeds, washes, or diversion channels may be required. Before vehicles enter ephemeral streams, drivers must be cognizant of forecasted potential for flash floods and time required to evacuate these areas. Never enter or cross when a riverbed is flooded.

4.3.5 Heat/Cold Stress

AUM sites on the Colorado Plateau can be extremely hot and cold, depending on the season and time of day. During this project, personnel will frequently be exposed to extreme temperatures for extended periods of time. Temperature extremes and dehydration are of great concern and will be a continuous hazard to field team members during the planned activities. Field team members are to be vigilant in drinking fluids and taking breaks when needed to avoid heat-related illnesses and dehydration. Proper layering of clothing, diet, and breaks will offset many aspects of cold stress as well. The SSC is responsible in the monitoring and implementation of SWPs 5-15 (heat illness prevention and monitoring) and 5-16 (cold stress), identified in Attachment C3, for providing clear guidance in heat- and cold-related illness prevention.

As a reminder, heat illness conditions and treatments are summarized in Table C-5.

Table C-5. Heat Illness Conditions and Treatments

Condition	Causes	Signs and Symptoms	Treatment
Heat cramps	Fluid loss and electrolyte imbalance from dehydration	• Painful muscle cramps, especially in legs and abdomen • Faintness • Profuse perspiration	• Move affected worker to cool location • Provide sips of liquid such as Gatorade® • Stretch cramped muscles • Transport affected worker to hospital if condition worsens
Heat exhaustion	Blood transport to skin to dissipate excessive body heat, resulting in blood pooling in the skin with inadequate return to the heart	• Weak pulse • Rapid and shallow breathing • General weakness • Pale, clamming skin • Profuse perspiration • Dizziness • Unconsciousness	• Move affected worker to cool area • Remove as much clothing as possible • Provide sips of cool liquid or Gatorade® (only if conscious) • Fan the person but do not overcool or chill • Treat for shock • Transport to hospital if condition worsens
Heat stroke[1]	Life-threatening condition from profound disturbance of body's heat-regulating mechanism	• Dry, hot, and flushed skin • Constricted pupils • Early loss of consciousness • Rapid pulse • Deep breathing at first, and then shallow breathing • Muscle twitching leading to convulsions • Body temperature reaching 105 or 106 degrees Fahrenheit or higher	• Immediately transport victim to medical facility • Move victim to cool area • Remove as much clothing as possible • Reduce body heat promptly by dousing with water or wrapping in wet cloth • Place ice packs under arms, around neck, at ankles, and wherever blood vessels are close to skin surface • Protect patient during convulsions

Note:
[1] Any of these symptoms require immediate attention. If heat stroke is suspected, emergency medical personnel should be immediately contacted and on-site first aid provided.

The SSC must understand and agree to the responsibility for implementing these SWPs in the field and implement the necessary monitoring requirements for worker safety during outdoor activities and temperature extremes.

4.3.6 Historical Mining Explosive Devices

Remnant mining-related explosive devices, such as dynamite sticks and blasting caps, may be encountered during the field activities. These devices can be extremely dangerous and can explode if disturbed or handled. Personal protection requires that the following three "R"s of explosives safety be utilized: Recognize, Retreat, and Report.

Recognize

Recognizing when you may have encountered a mining-related explosive device is one of the most important steps in reducing the risk of injury or death. If you encounter or even suspect that you have encountered such a device, you should consider it extremely dangerous.

Such devices should never be touched, moved, or disturbed. If they explode, anyone in the vicinity can be injured or killed. Regardless of size or shape and whether complete or in pieces, such devices should be considered extremely dangerous.

NEVER TOUCH, MOVE, OR DISTURB A SUSPECT EXPLOSIVE DEVICE.

These devices may be:

- Found almost anywhere in the project areas,
- Clearly visible on the surface,
- Buried at depths of inches to feet, or
- Partially or completely hidden by vegetation or dirt.

Warning signs may or may not mark areas where these devices have been used.

Collecting or keeping these devices as souvenirs is not allowed and could be dangerous and even deadly.

Retreat

If you encounter or suspect you may have encountered a mining-related explosive device, do not touch, move, or disturb it, but carefully retreat from the area by retracing your steps.

Never:

- Touch, move, or disturb a mining-related explosive device.
- Throw anything at a munition as it may detonate with the slightest touch.

If you encounter or suspect you may have encountered a mining-related explosive device, immediately and carefully leave the area. Retrace your steps out of the area by the same path that you entered. Once safely away, mark the path and get a fix on your position. A minimum distance of 50 feet should be reached before operating handheld radios.

Report

If you encounter or suspect you have encountered a mining-related explosive device, immediately report it to the SSO and PM, who will contact the following entities to clear the area:

- USEPA Program Manager
- Navajo Nation Criminal Investigation Department
- Farmington Bomb Squad

Also, advise your project team members to increase awareness until the area is cleared.

Provide as much information as possible about what you saw and where you saw it. This will help the appropriate project team members and explosives disposal personnel find, evaluate, and address the situation.

When you report the encounter, provide:

- The area where you encountered it.
- A general description of the device that includes its size and shape.
- Any readily visible markings (but do not approach or handle the device to see markings).

5.0 BIOLOGICAL HAZARDS

AUM sites are within open range and mountainous areas. Encountering biological hazards, primarily biting and stinging insects, is possible during work activities. Because of the diverse locations of the sites, field team personnel may be exposed to several biological hazards including but not limited to:

- Microbial (mold, bacterial, and viral)
- Snakes
- Bees, wasps, and yellow jackets
- Spiders (black widows and tarantulas) and scorpions
- Animal bites/animal-borne diseases (rabies, plague, etc.)
- Bird and rodent droppings (Hantavirus, etc.)
- Mountain lions and coyotes
- Bears
- Cattle
- Dogs

5.1 MICROBIAL

Microbial-related project risks are generally associated with exposure to untreated water and soils. If these media are contaminated with animal fecal matter or animal remains, they can present a risk of infection to unprotected workers and where personal hygiene is difficult. Microbial-related risks associated with the project may include:

- ***Escherichia coli* O157**. The most common type of *E. coli* infection that causes illness in people is called *E. coli* O157. Symptoms of *E. coli* O157 include watery or bloody diarrhea, fever, abdominal cramps, nausea, and vomiting. Illness may be mild or severe.
- **Cryptosporidium** infection (cryptosporidiosis) (krip-toe-spo-rid-ee-oh-sis) is a parasitic disease caused by Cryptosporidium parvum. It usually causes a mild to severe infection of the gastrointestinal system, including watery diarrhea, fever, abdominal cramps, nausea, and vomiting.
- **Giardia** is a microscopic parasite that causes the diarrheal illness known as giardiasis. Giardia is found on surfaces or in soil, food, or water that has been contaminated with feces from infected humans or animals.
- **Leptospirosis**, also known as Weil's Disease, is a bacterial infection that can be caused by exposure to wastewater. The infection causes flu-like symptoms with a persistent and severe headache and can lead to vomiting and muscle pain.

5.2 SNAKES

Snakes inhabit every part of the United States and are known to be present at the sites. Rattlesnakes and other snakes may be encountered in the field. Controls for snake hazards are the same as for every species.

Western Diamondback Rattlesnake

Precautions to lower the risk of being bitten by any snake include:

- Leave snakes alone; many people are bitten trying to kill a snake or get a closer look. In areas where snakes are known to be present, or when walking in tall grass, wear snake chaps to protect the lower legs from bites. Snake chaps are optional, and the decision regarding this will occur in the field, but snake chaps should be used when surveying and walking in undisturbed areas.
- Remain on paths as much as possible.
- Keep hands and feet out of areas that you can't see.
- Use caution when picking up or moving debris or equipment that has been sitting on the ground.
- If you encounter a snake, walk around it, giving it a berth of at least 6 feet.
- If you are bitten by a snake, immediately seek medical help, whether the snake is believed to be venomous or not.

For a venomous snakebite victim, the following first aid should be administered:

- Wash the bite with soap and water.
- Immobilize the bitten area and keep it lower than the heart.
- Immediately seek medical help.
- Do not ice or cool the bite, do not apply a tourniquet, and do not cut into the wound.

5.3 BEES, WASPS, AND YELLOW JACKETS

Most encounters with bees and yellow jackets occur when nests are disturbed. Before entering an area or opening an enclosure that is not frequently disturbed, take a few moments to observe whether insects are entering or exiting. If insects are flying to or from the area, avoid it if possible. If you must be in an area where disturbing a nest is likely, be sure to wear long pants and a long-sleeved shirt. Stinging insects fly around the top of their target, so if you get into trouble, cover your head (if possible) and run away.

If you get stung, look for a stinger and, if present, remove it. Several over-the-counter products or a simple cold compress can be used to alleviate the pain of the sting. If the sting is followed by severe symptoms, or if it occurs in the neck or the mouth, seek medical attention immediately because swelling could cause suffocation.

If you need to destroy a nest, consult with the SSC first. Commercially available stinging insect control aerosols are very effective, but could contaminate the area. Once the nest is destroyed, fine mesh may be applied over the exit and entry points of an enclosure to prevent re-infestation.

Employees with a known bee sting allergy should carry an EpiPen® prescribed by each employee's personal physician. These employees shall let the SSC, PM, and all other field staff know about this allergy and where the EpiPen will be kept while that employee is at the sites. EpiPens will be used only by appropriately trained personnel.

5.4 SPIDERS AND SCORPIONS

The most dangerous spiders to humans in North America are black widows and brown spiders (also known as brown recluse or fiddleback spiders). Encounter with brown spiders is not anticipated during this field program, but controls are the same for every species. A guide to identifying the black widow spider is presented below.

Black Widow Spider

The abdomen of the black widow spider usually shows an hourglass marking, and the female is 3 to 4 centimeters in diameter. Black widow spiders have been found in well casings and flush mount well covers. They are not aggressive, but are more likely to bite if guarding eggs. Light, local swelling and reddening of a bite are early signs of a black widow bite, which is followed by intense muscular pain, rigidity of the abdomen and legs, difficulty breathing, and nausea. If bitten, immediately seek medical attention.

Scorpions range across the southern and southwestern United States. Scorpions usually hide during the day and are active at night. They may hide under rocks, wood, or anything else lying on the ground. Some species may also burrow into the ground. Most scorpions live in dry, desert areas. However, some species can be found in grasslands, forests, and inside caves.

Symptoms of a scorpion sting may include:

- A stinging or burning sensation at the injection site (very little swelling or inflammation)
- Positive "tap test" (i.e., extreme pain when the sting site is tapped with a finger)
- Restlessness, convulsions, roving eyes, or a staggering gait
- Thick tongue sensation, slurred speech, or drooling
- Muscle twitches
- Abdominal pain and cramps
- Respiratory depression

These symptoms usually subside within 48 hours, although stings from a bark scorpion can be life-threatening.

Workers should take the following steps to prevent spider bites and scorpion stings:

- Wear long sleeves, long pants, and leather gloves.
- Shake out clothing or shoes before donning them.
- Workers with a history of severe allergic reactions to insect bites or stings should carry an EpiPen prescribed by their respective personnel physicians, and should wear a medical identification bracelet or necklace stating their allergy.

Workers should take the following steps if a coworker is bitten by a spider or stung by a scorpion:

- Immediately transport the victim to a medical facility or contact a qualified health care provider or poison control center for advice and medical instructions.
- Ice may be applied near the sting site (never submerge the affected limb in ice water).
- Remain relaxed and calm.
- The victim should not take any sedatives.
- Capture the scorpion or spider for identification if possible to do so safely.

5.5 ANIMAL BITES/ANIMAL-BORNE DISEASE

Potential physical injury, bites, and contact with feral dogs or wild animals can present significant health issues. Infection can result from the penetrating bite wound, and diseases from animals can be transmitted to humans.

5.5.1 Rabies

Rabies is a disease caused by the rabies virus. It may take several weeks or even a few years for people to show symptoms after getting infected with rabies, but usually people start to show signs of the disease 1 to 3 months after infection. Early signs of rabies can include fever or headache, but change quickly to nervous system signs such as confusion, sleepiness, or agitation. Once these symptoms begin in someone with rabies infection, that person usually does not survive. It is very important to talk to a doctor or health care provider right away if any animal bites you, especially a wild animal. Many kinds of animals can pass rabies to people. Wild animals are much more likely to carry rabies, especially raccoons, skunks, bats, foxes, and coyotes. However, dogs, cats, cattle (cows), or any warm-blooded animal can pass rabies to people. People usually get rabies from the bite of an infected animal. Many animals, such as dogs, cats, and horses, are vaccinated against rabies, but you should always wash any bite thoroughly and check with your health care provider about what to do if any animal bites you.

5.5.2 Plague

Plague is a rare bacterial disease caused by *Yersinia pestis* (yer-SIN-ee-ah PEST-iss). People usually show symptoms 2 to 6 days after infection. Symptoms include fever, chills, weakness, and swollen and painful lymph nodes. A few people get pneumonia (infection of the lungs) as a first symptom of plague. The infection then spreads to other parts of the body. Many people who do not receive treatment soon after infection do not survive. People can get plague from an infected animal, but this is rare. Rodents (for example, mice, rats, and squirrels) and cats are animals that can carry plague. This disease most often occurs in the southwestern United States. Usually, people get plague from the bite of an infected flea. Because fleas bite both people and animals, especially cats and rodents, an infected flea can pass plague to animals or people. People also can get infected by breathing in tiny droplets of water contaminated with *Yersinia pestis*.

5.5.3 Tularemia

Tularemia is caused by the bacteria *Francisella tularensis* and is characterized by sudden onset of high fever and chills, joint and muscle pain, and prostration. Slow-healing sores or lesions develop at the site of entry of the bacteria (or arthropod bite). Inflammation and swelling of nearby lymph nodes follow. The bacteria is maintained in rabbits, hares, rodents, and birds via tick transmission.

The natural reservoir for the bacteria includes infected ticks and animal species that are less susceptible and thus survive acute infections.

Hard ticks, primarily *D. andersoni*, *D. variabilis*, and *Haemaphysalis leporispalustris*, and some flies, especially the deerfly (*Chrysops discalis*), can subsequently transmit the disease to humans. Other transmission routes include drinking contaminated water; eating contaminated food or improperly cooked game meat; inhaling aerosols contaminated with rodent urine, feces, or dust; cuts from contaminated knives or other instruments; and scratches or bites from infected animals.

5.5.4 Bird and Rodent Droppings

Large populations of roosting birds may present a disease risk. The most serious health risks arise from disease organisms that grow in the accumulations of bird droppings, feathers, and debris under a roost, especially if roosts have been active for years. Among the fungal diseases associated with bird droppings, the two most common are Histoplasmosis and Cryptococcosis. In the United States, deer mice are the predominant carriers of Hantavirus, which causes Hantavirus pulmonary syndrome (HPS) in humans. This virus occurs in rodent urine, feces, or saliva and is transported via aerosol particles, which can cause the fatal respiratory disease when inhaled.

The deer mouse has big eyes and big ears. Its head and body are normally about 2 to 3 inches long, and the tail adds another 2 to 3 inches in length. It has been observed in a variety of colors, from gray to reddish brown, depending on its age. The underbelly is always white, and the tail has sharply defined white sides.

There is no specific treatment, cure, or vaccine for Hantavirus infection. However, it is known that if infection is recognized early and medical care in an intensive care unit is provided, recovery is possible. HPS will manifest symptoms within 1 to 5 weeks after exposure to mice or rats carrying Hantavirus. Initially, symptoms of HPS are:

- Fever,
- Severe muscle aches in the large muscle groups—thighs, hips, back, and sometimes shoulders (these symptoms are universal),
- Fatigue, and
- Difficulty in breathing (after a few days).

Symptoms can also include headaches, dizziness, chills, nausea, vomiting, diarrhea, and stomach pain. Site workers must eliminate or minimize contact with rodents and any areas of bird or rodent infestation. Site workers should avoid actions (such as sweeping) that raise dust in closed structures because infection occurs through inhalation. If a large quantity of droppings is present in a work area, work will be stopped until the area can be cleaned, PPE levels can be increased to include a respirator, or other engineering controls or work methods can be prepared to mitigate the hazard.

5.6 MOUNTAIN LIONS

Mountain lions are native to some of the sites and surrounding areas. Mountain lions are typically shy and will attempt to avoid human contact. To avoid encounters with mountain lions at the sites, observe the following procedures:

- Avoid working by yourself in an isolated area at either dawn or dusk, as mountain lions are most active at this time.
- Do not approach a mountain lion.
- If you are in a group, gather together noisily.

- If you are alone, remain calm. If you are wearing a jacket, raise it above your head to make yourself appear larger; find anything to hold or rise above yourself to make yourself look as big as possible. Speak calmly and firmly or attempt to yell for help while remaining calm. Do not make threatening gestures. Try to stay still until the mountain lion leaves or back away slowly until the mountain lion is out of sight. Do not turn and run.
- DO NOT CLIMB A TREE. Mountain lions are good climbers and by attempting to climb a tree, you can effectively trap yourself.
- DO NOT RUN. If you run, a mountain lion may identify you as prey and it may actually encourage an attack.

If a mountain lion attacks you or a coworker, take the following steps:

- Fight back and use anything you can, such as rocks, tree branches, and tools. Try to remain standing.
- Render first aid and call for professional medical care.

5.7 BEARS

Seeing a bear in the wild is a special treat. While it is an exciting moment, it is important to remember that bears are wild and can be dangerous. Their behavior is sometimes unpredictable. Although rare, attacks on humans have occurred, inflicting serious injuries and death. Each bear and each experience is unique; there is no single strategy that will work in all situations and that guarantees safety. Most bear encounters end without injury. Following some basic guidelines may help to lessen the threat of danger. Your safety can depend on your ability to calm the bear.

When you are in a remote location known to have bears, always remember to check with the nearest visitor center or backcountry office for the latest bear safety information.

Avoiding an Encounter

Following viewing etiquette is the first step to avoiding an encounter with a bear that could escalate into an attack. Keeping your distance and not surprising bears are some of the most important things you can do. Most bears will avoid humans if they hear them coming. Pay attention to your surroundings and make a special effort to be noticeable if you are in an area with known bear activity or a good food source, such as berry bushes.

Bear Encounters

Once a bear has noticed you and is paying attention to you, additional strategies can help prevent the situation from escalating.

- Identify yourself by talking calmly so the bear knows you are a human and not a prey animal. Remain still; stand your ground, but slowly wave your arms. Help the bear recognize you as a human. It may come closer or stand on its hind legs to get a better look or smell. A standing bear is usually curious, not threatening.

- Stay calm and remember that most bears do not want to attack you; they usually just want to be left alone. Bears may bluff their way out of an encounter by charging and then turning away at the last second. Bears may also react defensively by woofing, yawning, salivating, growling, snapping their jaws, and laying their ears back. Continue to talk to the bear in low tones; this will help you stay calmer, and it won't be threatening to the bear. A scream or sudden movement may trigger an attack. Never imitate bear sounds or make a high-pitched squeal.
- Use the buddy system—hike and travel in groups. Groups of people are usually noisier and smellier than a single person. Therefore, bears often become aware of groups of people at greater distances, and because of their cumulative size, groups are also intimidating to bears.
- Make yourselves look as large as possible (for example, move to higher ground).
- Do NOT allow the bear access to your food. Getting your food will only encourage the bear and make the problem worse for others.
- Do NOT drop your pack as it can provide protection for your back and prevent a bear from accessing your food.
- If the bear is stationary, move away slowly and sideways; this allows you to keep an eye on the bear and avoid tripping. Moving sideways is also non-threatening to bears. Do NOT run, but if the bear follows, stop and hold your ground. Bears can run as fast as a racehorse both uphill and down. Like dogs, they will chase fleeing animals. Do NOT climb a tree. Both grizzlies and black bears can climb trees.
- Leave the area or take a detour. If this is impossible, wait until the bear moves away. Always leave the bear an escape route.
- Be especially cautious if you see a female with cubs; never place yourself between a mother and her cub and never attempt to approach them. The chances of an attack escalate greatly if she perceives you as a danger to her cubs.

Bear Attacks

Bear attacks are rare; most bears are only interested in protecting food, cubs, or their space. However, being mentally prepared can help you have the most effective reaction. Every situation is different, but below are guidelines on how brown bear attacks can differ from black bear attacks. Help protect others by reporting all bear incidents immediately. Above all, keep your distance from bears.

- Brown/Grizzly Bears: If you are attacked by a brown/grizzly bear, leave your pack on and PLAY DEAD. Lay flat on your stomach with your hands clasped behind your neck. Spread your legs to make it harder for the bear to turn you over. Remain still until the bear leaves the area. Fighting back usually increases the intensity of such attacks. However, if the attack persists, fight back vigorously. Use whatever you have at hand to hit the bear in the face.

- Black Bears: If you are attacked by a black bear, DO NOT PLAY DEAD. Try to escape to a secure place such as a car or building. If escape is not possible, try to fight back using any object available. Concentrate your kicks and blows on the bear's face and muzzle.
- If any bear attacks you in your tent or stalks you and then attacks, DO NOT PLAY DEAD—fight back! This kind of attack is very rare, but can be serious because it often means the bear is looking for food and sees you as prey.

Bear Pepper Spray

Bear pepper spray can be an important thing to carry. It is used defensively to stop an aggressive, charging, or attacking bear. Although it's used in the same manner you would use mace on an attacking person, bear pepper spray and human pepper spray are not the same. Make sure you select a USEPA-approved product that is specifically designed to stop aggressive bears. It is not a repellent, so do not apply to your body or equipment.

5.8 CATTLE

Animals sense their surrounding differently than humans. They have difficulty accurately judging distances, so one quick movement can easily spook them.

Livestock have extremely sensitive hearing and can hear sound pitches that humans often cannot hear. This is why loud noises scare animals, and high frequencies can hurt their ears. When paired with unknown surroundings, loud noises will cause animals to be edgy and uneasy.

Animals can sense when someone is scared or nervous around them. Because of their size and weight, they can be dangerous without intending to be. When working with animals, move slowly and lightly touch them to encourage them to move, instead of shoving or hitting them. Never prod an animal when it has nowhere to run. If you are working in close proximity with animals, plan an escape route in case the animals get aggressive.

Use Extreme Caution Around Male Animals and Mothers with Offspring

It is a natural instinct for animals to be extremely territorial. They are determined to protect the area they feel belongs to them, including offspring, other animals in their herd, and the pasture where they live. Take extra caution during feeding times and stay out of the way as much as possible. If you cannot avoid the animals, watch for signs of aggression or fear for possible danger. Always leave yourself an escape route when animals get aggressive.

Warning signs include:

- Raised or pinned ears
- Raised tail or hair on the back
- Bared teeth
- Snorting
- Pawing at the ground

5.9 DOGS

One of the most common animals encountered in domestic areas and during project activities is the canine. “Dog mace,” or pepper spray for canines, may be an appropriate form of protection for areas with known sightings of aggressive dogs. Always exercise caution when approaching any dog because all dogs have the potential to bite. Initial observations can be misleading. Telltale signs, such as growling ears drawn back or tails tucked between the hind legs, may be absent, yet this does not guarantee that a dog will not act aggressively. For example, some dogs express nervousness by wagging their tail, which typically signifies a non-aggressive posture. If a dog displays unusual or awkward behavior, the worker should leave the area to avoid a negative encounter. Employees should request that residents and property owners restrain their animals while activities are under way. If a dog attempts to strike, the employee should try to block the dog using a backpack, stick, or other object for the dog to bite instead of the body. The employee should then immediately flee the area.

General safety tips for aggressive dog encounters:

- Employees should not approach any unfamiliar dog.
- Do not run from a dog or scream.
- Remain motionless (“be still like a tree”) when approached by an unfamiliar dog and avoid eye contact.
- If the dog continues to be aggressive, slowly back away from the dog until you can reach safe area.
- If knocked over by a dog, roll into a ball and be still.
- Do not attempt to pet or play with any dog that you are unfamiliar with, even if the owner is present and tells you that you can do so.
- Immediately report stray dogs or dogs displaying unusual behavior to your team leader and site safety officer.
- Avoid direct eye contact with a dog.
- Do not disturb a dog that is sleeping, eating, or caring for puppies.
- If bitten, clean the wound and seek medical direction from WorkCare. Report the incident to your supervisor, PM, and in Tracking and Optimizing Tool for Analyzing Losses (TOTAL) (see Section 11.12 for reporting).

6.0 TRAINING REQUIREMENTS

All on-site personnel who may be exposed to hazardous conditions, including Tetra Tech and subcontractor personnel and site visitors who will participate in on-site activities, will be required to meet training requirements outlined in 29 CFR Part 1910.120, "Hazardous Waste Operations and Emergency Response." All personnel and visitors entering the site will be required to review this HASP and sign the Compliance Agreement form (Form HSP-4), and site workers will be required to sign the Daily Tailgate Safety Meeting form (Form HST-2) (see Attachment C1).

Before on-site activities begin, the Tetra Tech SSC for each team will present a briefing for all personnel who will participate in on-site activities. The following topics will be addressed during the pre-work briefing:

- Names of the SSC and the designated alternate
- Site history
- Work tasks
- Hazardous chemicals that may be encountered on site
- Physical and radiological hazards that may be encountered on site
- PPE
- Training requirements
- Action levels and situations requiring upgrade or downgrade of level of protection
- Site control measures, including site communications, and SWPs
- Emergency communication signals and codes
- Personnel exposure and accident emergency procedures (exposure to hazardous substances, and other hazardous situations)
- Fire and explosion emergency procedures
- Emergency telephone numbers
- Emergency routes

The Tetra Tech SSC representative will present training on radiation hazards associated with the site for all personnel who participate in on-site activities. The SSC will present basic information at the sight in regard to the nature of activities to be performed and the types and levels of radiological hazards involved. This information will be presented to all personnel prior to commencement of their activities at the site.

Issues that arise during implementation of on-site activities will be addressed during tailgate safety meetings to be held daily before the workday or shift begins and will be documented in the Daily Tailgate Safety Meeting form (Attachment C1). Any changes in procedures or site-specific H&S-related matters will be addressed during these meetings.

6.1 RADIATION SAFETY TRAINING

Radiation Safety Training is not required for all site workers and visitors, but is recommended. A minimum of two participants should be trained in radiation safety. The training is outlined in SWP 6-21, Radiation Safety Practices, (see Attachment C3).

Women of child-bearing age who visit or work at the site during this project require supplemental radiation safety training with respect to potential exposures to the fetus. All unescorted visitors will receive training commensurate with the level of potential exposure to radioactive materials. The extent of the training required will be determined by the SCC, but at a minimum, will include radiation safety awareness training.

The site visit is short enough in duration not to require dosimeters. Site workers and visitors must follow all radiation safety rules and ALARA practices while conducting on-site activities.

6.2 CONTROL OF RADIOACTIVE MATERIALS

The radioactive materials present at AUM sites are limited in general to low activity uranium mining materials. However, elevated levels of natural uranium are known to exist in these materials. The field tasks covered under this HASP will not include collection of samples and will not involve possession/transportation of low activity mining materials.

6.2.1 Personal Protective Equipment

From a radiation protection perspective, full-length standard durable work clothing, and boots will be protective for and should be worn during the site visit. Skin surfaces other than the face should be covered as much as possible at all times with durable materials to help prevent cuts and abrasions that may provide routes of intake of radionuclides. A supply of moist towelettes should be carried when conducting activities around the site to clean hands and face as necessary.

6.2.2 Respiratory Protection

ALARA protocols will be followed to minimize potential inhalation risks. Although the potential for related doses is very small (i.e., well below occupational limits for radiation workers), personnel are expected to minimize the time needed to perform work in known or suspected areas of potentially high radon concentrations (e.g., near mine portals or other enclosed areas) in accordance with the ALARA policy.

Significant generation of dust under dry windy conditions is believed likely in this desert region of southwestern United States. The SSC has authority to stop work if such conditions generate readily visible airborne dust and this becomes a concern. Dust masks do not provide respiratory protection against inhalation hazards, but may provide a degree of worker comfort under moderately dusty conditions.

7.0 PERSONAL PROTECTION REQUIREMENTS

Levels of personal protection to be implemented for work tasks at AUM sites have been selected based on known or anticipated physical hazards; types and concentrations of contaminants that may be encountered on site; and contaminant properties, toxicity, exposure routes, and matrixes. The following sections describe protective equipment and clothing; reassessment of protection levels; limitations of protective clothing; and respirator selection, use, and maintenance.

7.1 PROTECTIVE EQUIPMENT AND CLOTHING

Personnel will wear protective equipment when (1) site activities involve known or suspected atmospheric contamination, (2) site activities may generate particulates, or (3) direct contact with hazardous materials may occur. Based on the anticipated hazard level, personnel will initially perform field tasks in Level D protection. If site conditions or results of air monitoring during on-site activities warrant a higher level of protection, all field personnel will withdraw from the site, immediately notify the Tetra Tech SSC, and wait for further instructions. Descriptions of equipment and clothing required for Level D protection are as follows:

- Coveralls or work clothes, if applicable
- Class II or better, high-visibility safety vests
- Outer gloves (neoprene, nitrile, or other), if applicable
- Disposable inner gloves (such as latex or vinyl) (optional)
- Rugged hiking boots or boots with steel-toe protection and steel shanks
- Hard hat (face shield optional)
- Safety glasses or goggles
- Hearing protection (for areas with a noise level exceeding 85 decibels on the A-weighted scale)

7.2 REASSESSMENT OF PROTECTION LEVELS

PPE levels may be downgraded or upgraded based on a change in site conditions or investigation findings, and only after approval by the Tetra Tech HSR. When a significant change in site conditions occurs, hazards will be reassessed. Some indicators of need for reassessment are as follows:

- Commencement of a new work phase, such as the start of a significantly different activity or work that begins at a different portion of the site.
- A change in job tasks during a work phase.
- A change of season or weather.
- Temperature extremes or individual medical considerations limiting effectiveness of PPE.
- Discovery of contaminants other than those previously identified.

- Readily visible airborne dust or a change in work scope that affects the degree of contact with contaminated media.

7.3 LIMITATIONS OF PROTECTIVE CLOTHING

PPE clothing ensembles designated for use during site activities have been selected to provide protection against contaminants at known or anticipated on-site concentrations and physical states. However, no protective garment, glove, or boot is entirely chemical-resistant; nor does any protective clothing provide protection against all types of chemicals or radioactivity. Permeation of a given chemical through PPE depends on contaminant concentration, environmental conditions, physical condition of the protective garment, and resistance of the garment to the specific contaminant. Chemical permeation may continue even after the source of contamination has been removed from the garment.

All site personnel will follow the procedures below to achieve optimum performance from PPE:

- When chemical-protective coveralls become contaminated, don a new, clean garment after each rest break or at the beginning of each shift.
- Inspect all clothing, gloves, and boots both before and during use for the following:
    - Imperfect seams
    - Non-uniform coatings
    - Tears
    - Poorly functioning closures
- Inspect reusable garments, boots, and gloves both before and during use for visible signs of chemical permeation, such as the following:
    - Swelling
    - Discoloration
    - Stiffness
    - Brittleness
    - Cracks
    - Any sign of puncture
    - Any sign of abrasion

7.4 RESPIRATOR SELECTION, USE, AND MAINTENANCE

Tetra Tech and subcontractor personnel will be informed of proper use, maintenance, and limitations of respirators during annual H&S refresher training and the pre-work briefing. Any on-site personnel who will use a tight-fitting respirator must pass a qualitative fit test for the respirator that follows the fit testing protocol conveyed in Appendix A of the OSHA respirator standard, and applicable NRC requirements (29 CFR §1910.134 and 10 CFR 20.1703). Fit testing must be repeated annually or when a new type of respirator is used.

Respirator selection is based on an assessment of the nature and extent of hazardous atmospheres anticipated during field activities. This assessment includes a reasonable estimate of employee exposure to respiratory hazards, and identification of each contaminant's anticipated chemical form and physical state.

Respiratory protection will include P-100 (high-efficiency) respirator cartridges, which are changed out either when breathing becomes noticeably difficult or at the end of each workday, whichever occurs first. Amendments to this HASP will be discussed during daily tailgate safety meetings.

Approved respirators for protection against particulate contaminants can include the following:

- A respirator equipped with a filter certified by NIOSH under 32 CFR Part 11 or 42 CFR Part 84 as a P100 filter (formerly known as a high-efficiency particulate air [HEPA] filter).

8.0 PERSONEL AND ENVIRONMENTAL MONITORING

Environmental monitoring or sampling will occur to assess personnel exposure levels, as well as site or ambient conditions, and to determine appropriate levels of PPE for work tasks. The following sections discuss personal air monitoring, thermal stress monitoring, and noise monitoring.

8.1 PERSONAL AIR MONITORING

Employees working closest to a source of contamination have the highest likelihood of exposure to airborne contaminant concentrations that may exceed established exposure limits. Therefore, selective monitoring of the workers closest to a source of contaminant generation will be conducted during site activities. Personal monitoring will occur in the breathing zone and the RPP provides specific guidance on the use of lapel air sampling.

8.2 THERMAL STRESS MONITORING

Heat stress and cold stress are common and serious threats for projects in remote locations. SWPs 5-15 and 5-16 discuss heat and cold stress and include monitoring methods appropriate for the season and location of work (see Attachment C3).

8.3 NOISE MONITORING

Most high noise levels at a work site are caused by heavy equipment such as drill rigs and backhoes, or sources associated with the work site, such as generators and vehicles. When noise levels at AUM sites are suspected to equal or exceed an 8-hour TWA of 85 decibels (dBA) on an A-weighted scale in slow response mode, the Tetra Tech SSC will evaluate the work area to characterize the noise source and exposure levels. A sound level meter may be used for the evaluation, but a noise dosimeter is recommended for documenting full-shift noise exposures. If neither instrument is available, the SSC may use a simple rule-of-thumb test to determine whether noise levels exceed 85 dBA. The test requires the SSC to determine how loud he or she must speak to be heard at an arm's length from another person. If the SSC must raise his or her voice to be heard, the average noise level likely exceeds 85 dBA.

Hearing protection must be worn if employees are exposed to noise levels that exceed the action level of 85 dBA. The protectors will be ear plugs or muffs that must provide sufficient attenuation to limit noise exposure to less than 85 dBA. The SSC will supervise use of hearing protectors at the work site as necessary.

9.0 SITE CONTROL

Site control is an essential component of HASP implementation. The following sections discuss measures and procedures for site control, such as on-site communications, site control zones, site access control, site safety inspections, and SWPs.

9.1 ON-SITE COMMUNICATIONS

Successful communication among field teams and personnel in the support zone is essential. The following communication systems will be available during site activities:

- Cellular telephones (service limited at most AUM sites)
- Satellite telephones
- Two-way radios

No cellular telephone service will be available at most AUM sites. Therefore, communication via radio will be important. In addition to radio communication, the hand signals shown in

Table C-6 will be used by site personnel in emergency situations, in combustible atmospheres, or when verbal communication is difficult:

Table C-6. Emergency Hand Signals

Signal	Definition
Hands clutching throat	Out of air or cannot breathe
Hands on top of head	Need assistance
Thumbs up	Okay, I am all right, or I understand
Thumbs down No or negative	No or negative
Arms waving upright	Send backup support
Gripping partner's wrist	Exit area immediately

9.2 SITE CONTROL ZONES

On-site work areas will be divided into an exclusion zone, a contamination reduction zone (CRZ), and a support zone to control spread of contamination and employee exposures to chemical and physical hazards.

Access to the exclusion zone and CRZ will be restricted to authorized personnel. Any visitors to these areas must present proper identification and be authorized to be on site, and must meet training requirements for the site, including site-specific training. The SSC will identify work areas that visitors or personnel are authorized to enter and will enforce site control measures.

The following sections describe the exclusion zone, the CRZ, and the support zone, as well as procedures to be followed within each. Locations of the site control zones may be adjusted in the field. Site control zones are also discussed in the radiation SWP 101 in Attachment C3.

Radiation surveys will occur in each area in accordance with radiation SWP 104 (Attachment C3).

9.2.1 Zone 1: Exclusion Zone

An exclusion zone includes areas where contamination is either known or likely to be present, or could cause harm to personnel because of work activity. The perimeter of the exclusion zone and an appropriate radius around work task areas will be demarcated verbally or by a physical barrier. During intrusive activities, a daily roster with the date of each person's entrance into the exclusion zone; the person's name, signature, and organization; and time of entry and exit will be kept for all personnel working in the zone. Visitors will not be permitted to enter the exclusion zone without proper qualifications, equipment, and Tetra Tech SSC and ERG subcontractor RSO authorization. Work tasks that require establishment of an exclusion zone include the following:

- Subsurface drilling with drill rig
- Tasks associated with heavy equipment.

9.2.2 Zone 2: Contamination Reduction Zone

An established CRZ is required for AUM sites. The CRZ will contain facilities to decontaminate personnel and portable equipment. A steam-cleaning or small portable pressure washer area for decontamination of heavy equipment and vehicles may be established at a location readily accessible from work areas. Equipment decontamination procedures are described in Section 10.2. Visitors will not be permitted to enter the decontamination zone without proper qualifications and Tetra Tech SSC and ERG subcontractor RSO authorization.

9.2.3 Zone 3: Support Zone

A support zone may be established at any uncontaminated and nonhazardous part of the site. The support zone shall be situated in an area generally upwind of any exclusion zone whenever possible. Site visitors not meeting training, medical surveillance, and PPE requirements must stay in the support zone.

9.3 SITE SAFETY INSPECTIONS

The Tetra Tech SSC and will conduct periodic site safety inspections to ensure safe work areas and compliance with this HASP. Tetra Tech will not be operating or providing oversight for the operation of heavy equipment and as such will not be conducting heavy equipment inspections. Results of the formal site safety inspections will be recorded on a Field Audit Checklist (Form AF-1 in Attachment C1).

9.4 SAFE WORK PRACTICES AND RADIATION SAFE WORK PRACTICES

Following is a list of various SWPs and H&S programs applicable to AUM sites. Copies of these SWPs and programs (designated by DCN) are included in Attachment C3 to this HASP:

☒	DCN 2-4	Hearing Conservation Program
☒	DCN 4-5	Excavation and Trenching
☒	DCN 4-9	Safe Haulage and Earth Moving
☒	DCN 4-10	Lead Protection Program
☒	SWP 5-1	General Safe Work Practices for Field Work
☒	SWP 5-2	General Safe Work Practices for Hazardous Work Site Activities
☒	SWP 5-07	Heavy Equipment
☒	SWP 5-15	General Safe Work Practice for Heat Illness Prevention and Monitoring
☒	SWP 5-16	General Safe Work Practice for Cold Stress
☒	SWP 5-17	Biohazard Safety
☒	SWP 05-19	Manual Lifting
☒	SWP 5-26	Prevention of Sun Exposure
☒	SWP 5-27	Respirator Cleaning Procedures
☒	SWP 5-28	General Safe Work Practices for Use of Air Purifying Respirators
☒	SWP 5-29	Respirator Qualitative Fit Test Procedures
☒	SWP 5-30	Encountering Dangerous or Aggressive Animals
☒	SWP 6-21	Radiation Safety Practices

10.0 DECONTAMINATION

Decontamination is the process of removing or neutralizing contaminants on personnel or equipment. When properly conducted, decontamination procedures protect workers from contaminants that may have accumulated on PPE, tools, and other equipment. Proper decontamination also prevents transport of potentially harmful materials to uncontaminated areas. Personnel and equipment decontamination procedures are described in the following sections.

10.1 PERSONNEL DECONTAMINATION

Personnel decontamination procedures will follow guidance in the *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH and others 1985).

All workers are instructed to wash their hands and faces prior to eating and drinking on a routine basis. Handy wipes are distributed to personnel when eating and drinking during breaks, lunchtime, and prior to departure from the site. Pancake probes are used to verify that safe levels of decontamination have been reached prior to eating or drinking.

Exit scanning will be conducted by personnel qualified through training and experience to use a pancake probe for detecting contamination. If contamination is found, personnel and PPE will be decontaminated with potable water or a mixture of detergent and water. Liquid and solid wastes generated during decontamination will be collected, scanned, and disposed of with other contaminated waste.

10.2 EQUIPMENT DECONTAMINATION

Decontamination of all excavation, sampling, and field monitoring equipment used during site activities will be required.

Heavy equipment, such as drilling and excavating vehicles, will be decontaminated at a designated location in the decontamination zone. Decontamination of on-site heavy equipment and sampling equipment will follow the procedures defined in the RPP.

11.0 EMERGENCY RESPONSE PLANNING

This section describes emergency response planning procedures to be implemented for AUM sites. These procedures are consistent with local, state, and federal disaster and emergency management plans, and are designed to comply with applicable provisions of 29 CFR Part 1910.38. The following sections discuss pre-emergency planning, personnel roles and lines of authority, emergency recognition and prevention, evacuation routes and procedures, emergency contacts and notifications, hospital route directions, emergency medical treatment procedures, protective equipment failure, fire or explosion, weather-related emergencies, spills or leaks, emergency equipment and facilities, and reporting.

11.1 PRE-EMERGENCY PLANNING

During the pre-work briefing and daily tailgate safety meetings, all on-site employees will be trained in and reminded of the provisions of Section 9.0, site communication systems, and site evacuation routes. The emergency response provisions will be reviewed on a regular basis by the Tetra Tech SSC and will be revised, if necessary, to ensure that they are adequate and consistent with prevailing site conditions. Because of the remote location of many of the sites, in the event of serious illness or injury, Life Flight air transport services may be necessary for transportation of the affected personnel. **The Life Flight contact for the region is 888-238-1428**.

11.2 PERSONNEL ROLES AND LINES OF AUTHORITY

The Tetra Tech SSC has primary responsibility for responding to and correcting emergences and for taking appropriate measures to ensure the safety of site personnel and the public. Possible actions may include evacuation of personnel from the site area. The SSC is also responsible for ensuring that corrective measures have been implemented, appropriate authorities have been notified, and follow-up reports have been completed.

In addition to internally required emergency communications, for work at AUM sites, the Tetra Tech PM will communicate directly with Jacob Phipps, USEPA Remedial Project Manager, 415-654-2512 (cell) in the case of emergency.

Personnel are required to report all injuries, illnesses, spills, fires, and property damage to the SSC. The SSC must be notified of any on-site emergencies and is responsible for ensuring that the appropriate emergency procedures described in this section are followed.

11.3 EMERGENCY RECOGNITION AND PREVENTION

Table C-3 and Table C-4 list potential on-site radiological and chemical hazards, respectively. On-site personnel will be made familiar with this information and with techniques of hazard recognition through pre-work training and site-specific briefings.

11.4 EVACUATION ROUTES AND PROCEDURES

In the event of an emergency that necessitates evacuation of a work task area or the site, the Tetra Tech SSC will contact all nearby personnel using the on-site communications discussed in Section 9.1 to advise the personnel of the emergency. The personnel will proceed along site roads to a safe distance upwind from the hazard source. The personnel will remain in that area until the SSC or an authorized individual provides further instructions. Evacuation routes will be discussed on site with field personnel during daily tailgate meetings, at least once per site before the start of field activities.

11.5 EMERGENCY CONTACTS AND NOTIFICATIONS

The emergency information before the introduction of this HASP provides names and telephone numbers of emergency contact personnel. ***THIS PAGE MUST BE POSTED ON SITE OR MUST BE READILY AVAILABLE AT ALL TIMES IN THE SUPPORT ZONE***. In the event of a medical emergency, personnel will notify the appropriate emergency organization and will take direction from the Tetra Tech SSC. In the event of a fire, explosion, or spill at the site, the SSC will notify the appropriate emergency contact, as well as follow proper internal notification procedures

11.6 HOSPITAL ROUTE DIRECTIONS

Maps showing hospital routes are provided in Figure C-1. Hospital routes will be discussed on site with field personnel during daily tailgate meetings and at least once per site before the start of field activities.

11.7 EMERGENCY MEDICAL TREATMENT PROCEDURES

A person who becomes ill or injured during work tasks may require decontamination. If the illness or injury is minor, any decontamination necessary will be completed, and first aid should be administered before the patient is transported. If the patient's condition is serious, partial decontamination will be completed, if feasible and without harming the patient (such as complete disrobing of the person and redressing of the person in clean coveralls or wrapping in a blanket). First aid should be administered until an ambulance or paramedics arrive. All injuries and illnesses must be reported immediately to the Tetra Tech PM and HSR.

Any person transported to a clinic or hospital for radiological exposure treatment will be accompanied by information on the radiological hazard to which he or she has been exposed at the site, if possible. Table C-3 lists this information.

11.8 PROTECTIVE EQUIPMENT FAILURE

If any worker in the exclusion zone experiences a failure of PPE that affects his or her personal protection, the worker and all coworkers will immediately leave the exclusion zone. Re-entry to the exclusion zone will not be permitted until (1) the protective equipment has been repaired or replaced, (2) the cause of the equipment failure has been determined, and (3) the equipment failure is no longer considered a threat.

11.9 FIRE OR EXPLOSION

In the event of a fire or explosion on site, the local fire department will be immediately summoned. The Tetra Tech SSC or a site representative will advise the fire department of the location and nature of any hazardous materials involved.

11.10 WEATHER-RELATED EMERGENCIES

Site work will not be conducted during severe weather conditions, including high-speed winds or lightning. In the event of severe weather, field personnel will stop work and leave the site.

Thermal stress caused by excessive heat or cold may occur as a result of extreme temperatures, workload, or the PPE used. Heat and cold stress treatment will be administered as described in SWPs 5-15 and 5-16 (see Attachment C3).

11.11 EMERGENCY EQUIPMENT AND FACILITIES

The following emergency equipment will be available on site:

- First aid kit (located in support zone)
- Cellular telephone
- Sateillite phone

11.12 REPORTING

All emergency situations require follow-up and reporting. An employee involved in an incident will immediately report the incident to the local Tetra Tech Office H&S Representative, Regional Safety Officer, or HSR via telephone. Attachment C1 includes the Tetra Tech Incident Report (Form IR). This report must be completed by the Tetra Tech PM and submitted to the Tetra Tech HSR within 24 hours of an emergency and the incident entered into the Tetra Tech web based TOTAL reporting system at the link provided below:

- https://my.tetratech.com/go3/index.php?option=com_content&view=article&id=337&Itemid=659

The report must include proposed actions to prevent similar incidents from occurring. The HSR must be fully informed of the corrective action process so that he may implement applicable elements of the process at other sites.

12.0 REFERENCES

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ATTACHMENT C1

TETRA TECH, INC. FORMS

Compliance Agreement (Form HSP-4)

Daily Tailgate Safety Meeting (Form HST-2)

Daily Site Log (Form SSC-1)

Accident and Illness Investigation Report (Form IR)

Field Audit Checklist (Form AF-1)

TETRA TECH, INC.

HEALTH AND SAFETY PLAN COMPLIANCE AGREEMENT

Project Name: _____

Project Number: _____

I have read and understand the health and safety plan indicated above and agree to comply with all of its provisions. I understand that I could be prohibited from working on the project for violating any of the safety requirements specified in the plan.

Name	Signature	Employer	Date

TETRA TECH, INC.

DAILY TAILGATE SAFETY MEETING FORM

Date: _____ Time: _____ Project No.: _____

Client:_____ Site Location: _____

Site Activities Planned for Today: _____

Weather Conditions: _____

Safety Topics Discussed	
Protective clothing and equipment:	
Chemical and physical hazards:	
Emergency procedures:	
Equipment hazards:	
Other:	
Attendees	
Printed Name	**Signature**

Meeting Conducted by:

_____ _____

Name Signature

	TETRA TECH, INC. DAILY SITE LOG	Revision Date: 10/1/2008 Document Control Number: FORM SSC-1 Page 1 of 1

Site Name: _____ Date: _____

Site Safety Coordinator:_____ Project Number:_____

Name (print)	Company	I have received site-specific training	Time	
			In	Out

Comments:

_____

_____

TETRA TECH, INC.
Safety Excellence

TETRA TECH, INC.
INCIDENT REPORT

Report Date	Report Prepared By	Incident Report Number

INSTRUCTIONS:

All incidents (including those involving subcontractors under direct supervision of Tetra Tech personnel) must be documented on the IR Form.

Complete any additional parts to this form as indicated below for the type of incident selected.

TYPE OF INCIDENT (Check all that apply)	Additional Form(s) Required for this type of incident
Near Miss (No losses, but could have resulted in injury, illness, or damage)	☐ Complete IR Form Only
Injury or Illness	☐ Complete Form IR-A; Injury or Illness
Property or Equipment Damage, Fire, Spill or Release	☐ Complete Form IR-B; Damage, Fire, Spill or Release
Motor Vehicle	☐ Complete Form IR-C; Motor Vehicle

INFORMATION ABOUT THE INCIDENT

Name of Affected Employee

Description of Incident

Note: If no employee was directly affected, enter the employee that witnessed the event or who would have been impacted. If the individual involved is a subcontractor directly supervised by a Tetra Tech employee, check below and enter the supervisor or project manager above.

Subcontractor ☐

Date of Incident	Time of Incident
	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐
Weather conditions at the time of the incident	**Was there adequate lighting?**
	_____ Yes ☐ No ☐

Location of Incident

_____ Was location of incident within the employer's work environment? Yes ☐ No ☐

Street Address	City, State, Zip Code and Country
Operating Unit	**Office Location**
Project Name / Project#	**Client**
Tt Supervisor or Project Manager	**Was supervisor on the scene?**
	Yes ☐ No ☐

WITNESS INFORMATION (attach additional sheets if necessary)	
Name	**Company**
Street Address	**City, State and Zip Code**
Telephone Number(s)	

RESPONSE ACTIONS

Response action(s) immediately taken by unit reporting the incident:

NOTIFICATIONS

Title				
Project Manager or Supervisor	**Printed Name**	**Signature**	**Telephone Number**	**Date**
Site Safety Coordinator or Office H&S Representative				
Operating Unit H&S Representative				
Other: _____				

The signatures provided above indicate that appropriate personnel have been notified of the incident.

TETRA TECH, INC.

FIELD AUDIT CHECKLIST

Project Name: _____ Project No.: _____

Field Location: _____ Completed by: _____

Project Manager: _____ Site Safety Coordinator: _____

General Items		In Compliance?		
Health and Safety Plan Requirements		Yes	No	NA
1	Approved health and safety plan (HASP) on site or available			
2	Names of on-site personnel recorded in field logbook or daily log			
3	HASP compliance agreement form signed by all on-site personnel			
4	Material Safety Data Sheets on site or available			
5	Designated site safety coordinator present			
6	Daily tailgate safety meetings conducted and documented			
7	On-site personnel meet HASP requirements for medical examinations, fit testing, and training (including subcontractors)			
8	Compliance with specified safe work practices			
9	Documentation of training, medical examinations, and fit tests available from employer			
10	Exclusion, decontamination, and support zones delineated and enforced			
11	Windsock or ribbons in place to indicate wind direction			
12	Illness and injury prevention program reports completed (California only)			
Emergency Planning				
13	Emergency telephone numbers posted			
14	Emergency route to hospital posted			
15	Local emergency providers notified of site activities			
16	Adequate safety equipment inventory available			
17	First aid provider and supplies available			
18	Eyewash stations in place			
Air Monitoring				
19	Monitoring equipment specified in HASP available and in working order			
20	Monitoring equipment calibrated and calibration records available			
21	Personnel know how to operate monitoring equipment and equipment manuals available on site			
23	Environmental and personnel monitoring performed as specified in HASP			

TETRA TECH, INC.

FIELD AUDIT CHECKLIST (Continued)

Safety Items		In Compliance?		
Personal Protection		Yes	No	NA
1	Splash suit			
2	Chemical protective clothing			
3	Safety glasses or goggles			
4	Gloves			
5	Overboots			
6	Hard hat			
7	Dust mask			
8	Hearing protection			
9	Respirator			
Instrumentation				
10	Combustible gas meter			
11	Oxygen meter			
12	Organic vapor analyzer			
Supplies				
13	Decontamination equipment and supplies			
14	Fire extinguishers			
15	Spill cleanup supplies			
Corrective Action Taken During Audit:				
Corrective Action Still Needed:				

Note: NA = Not applicable

_____ _____

Auditor's Signature Site Safety Coordinator's Signature

_____

Date

ATTACHMENT C2

SAFETY DATA SHEETS

Arsenic Toxicological Fact Sheet

Molybdenum Toxicological Fact Sheet

Selenium Toxicological Fact Sheet

Uranium Toxicological Fact Sheet

Vanadium Toxicological Fact Sheet

Arsenic - ToxFAQs™

CAS # 7440-38-2

This fact sheet answers the most frequently asked health questions (FAQs) about arsenic. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to higher than average levels of arsenic occur mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. At high levels, inorganic arsenic can cause death. Exposure to lower levels for a long time can cause a discoloration of the skin and the appearance of small corns or warts. Arsenic has been found in at least 1,149 of the 1,684 National Priority List (NPL) sites identified by the Environmental Protection Agency (EPA).

What is arsenic?

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds.

Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenate (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards.

What happens to arsenic when it enters the environment?

- Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching.
- Arsenic cannot be destroyed in the environment. It can only change its form.
- Rain and snow remove arsenic dust particles from the air.
- Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment.
- Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine that is much less harmful.

How might I be exposed to arsenic?

- Ingesting small amounts present in your food and water or breathing air containing arsenic.
- Breathing sawdust or burning smoke from wood treated with arsenic.
- Living in areas with unusually high natural levels of arsenic in rock.
- Working in a job that involves arsenic production or use, such as copper or lead smelting, wood treating, or pesticide application.

How can arsenic affect my health?

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs.

Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.

Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.

Skin contact with inorganic arsenic may cause redness and swelling.

Almost nothing is known regarding health effects of organic arsenic compounds in humans. Studies in animals show that some simple organic arsenic

CAS # 7440-38-2

compounds are less toxic than inorganic forms. Ingestion of methyl and dimethyl compounds can cause diarrhea and damage to the kidneys.

How likely is arsenic to cause cancer?

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans.

How can arsenic affect children?

There is some evidence that long-term exposure to arsenic in children may result in lower IQ scores. There is also some evidence that exposure to arsenic in the womb and early childhood may increase mortality in young adults.

There is some evidence that inhaled or ingested arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of arsenic that cause illness in pregnant females, can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

How can families reduce the risks of exposure to arsenic?

- If you use arsenic-treated wood in home projects, you should wear dust masks, gloves, and protective clothing to decrease exposure to sawdust.
- If you live in an area with high levels of arsenic in water or soil, you should use cleaner sources of water and limit contact with soil.
- If you work in a job that may expose you to arsenic, be aware that you may carry arsenic home on your clothing, skin, hair, or tools. Be sure to shower and change clothes before going home.

Is there a medical test to determine whether I've been exposed to arsenic?

There are tests available to measure arsenic in your blood, urine, hair, and fingernails. The urine test is the most reliable test for arsenic exposure within the last few days. Tests on hair and fingernails can measure exposure to high levels of arsenic over the past 6-12 months. These tests can determine if you have been exposed to above-average levels of arsenic. They cannot predict whether the arsenic levels in your body will affect your health.

Has the federal government made recommendations to protect human health?

The EPA has set limits on the amount of arsenic that industrial sources can release to the environment and has restricted or cancelled many of the uses of arsenic in pesticides. EPA has set a limit of 0.01 parts per million (ppm) for arsenic in drinking water.

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) of 10 micrograms of arsenic per cubic meter of workplace air (10 $\mu g/m^3$) for 8 hour shifts and 40 hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Arsenic (Update). Atlanta, GA: U.S. Department of Health and Human Services. Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30329-4027.

Phone: 1-800-232-4636

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Right to Know Hazardous Substance Fact Sheet

Common Name: **MOLYBDENUM**

Synonyms: None

Chemical Name: Molybdenum

Date: November 1999 Revision: February 2011

CAS Number: 7439-98-7

RTK Substance Number: 1309

DOT Number: UN 3089 (Powder)

EMERGENCY RESPONDERS >>>> SEE LAST PAGE

Description and Use

Molybdenum is a silver-white metal or a dark gray or black powder. It is used to make structural alloys and as a catalyst.

Hazard Summary

Hazard Rating	NJDOH	NFPA
HEALTH	1	-
FLAMMABILITY	0 (Solid) *3 (Powder or Dust)	-
REACTIVITY	0	-
*POWDER OR DUST MAY BE FLAMMABLE OR EXPLOSIVE POISONOUS GASES ARE PRODUCED IN FIRE CONTAINERS MAY EXPLODE IN FIRE		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

Reasons for Citation

- **Molybdenum** is on the Right to Know Hazardous Substance List because it is cited by OSHA, ACGIH, NIOSH and IRIS.

- **Molybdenum** can affect you when inhaled.
- Contact can irritate the skin and eyes.
- Inhaling **Molybdenum** can irritate the nose and throat.
- Exposure **to Molybdenum** can cause headache, fatigue, loss of appetite, and muscle and joint pain.
- **Molybdenum** may damage the liver and kidneys.
- Repeated exposure may cause low blood count (anemia).
- **Molybdenum** *powder* or *dust* is a fire and explosion hazard when mixed in air.

SEE GLOSSARY ON PAGE 5.

FIRST AID

Eye Contact

- Immediately flush with large amounts of water for at least 15 minutes, lifting upper and lower lids. Remove contact lenses, if worn, while rinsing.

Skin Contact

- Remove contaminated clothing and wash contaminated skin with soap and water.

Inhalation

- Remove the person from exposure.
- Begin rescue breathing (using universal precautions) if breathing has stopped and CPR if heart action has stopped.
- Transfer promptly to a medical facility.

EMERGENCY NUMBERS

Poison Control: 1-800-222-1222

CHEMTREC: 1-800-424-9300

NJDEP Hotline: 1-877-927-6337

National Response Center: 1-800-424-8802

Workplace Exposure Limits

OSHA: The legal airborne permissible exposure limit (PEL) is **15 mg/m^3** (as *total dust*) averaged over an 8-hour workshift.

ACGIH: The threshold limit value (TLV) is **3 mg/m^3** (as the *respirable fraction*) and **10 mg/m^3** (as the *inhalable fraction*) for **Molybdenum** *metal* and *insoluble compounds* averaged over an 8-hour workshift.

Determining Your Exposure

- Read the product manufacturer's Material Safety Data Sheet (MSDS) and the label to determine product ingredients and important safety and health information about the product mixture.
- For each individual hazardous ingredient, read the New Jersey Department of Health Hazardous Substance Fact Sheet, available on the RTK website (www.nj.gov/health/eoh/rtkweb) or in your facility's RTK Central File or Hazard Communication Standard file.
- You have a right to this information under the New Jersey Worker and Community Right to Know Act, the Public Employees Occupational Safety and Health (PEOSH) Act if you are a public worker in New Jersey, and under the federal Occupational Safety and Health Act (OSHA) if you are a private worker.
- The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard (29 CFR 1910.1200) and the PEOSH Hazard Communication Standard (N.J.A.C. 12:100-7) require employers to provide similar information and training to their employees.

This Fact Sheet is a summary of available information regarding the health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

Health Hazard Information

Acute Health Effects
The following acute (short-term) health effects may occur immediately or shortly after exposure to **Molybdenum**:

- Contact can irritate the skin and eyes.
- Inhaling **Molybdenum** can irritate the nose and throat causing coughing and wheezing.

Chronic Health Effects
The following chronic (long-term) health effects can occur at some time after exposure to **Molybdenum** and can last for months or years:

Cancer Hazard
- According to the information presently available to the New Jersey Department of Health, **Molybdenum** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard
- According to the information presently available to the New Jersey Department of Health, **Molybdenum** has not been tested for its ability to affect reproduction.

Other Effects
- Exposure to **Molybdenum** can cause headache, fatigue, loss of appetite, and muscle and joint pain. Repeated exposure may raise the *Uric Acid* level in the body, which can lead to gout.
- **Molybdenum** may damage the liver and kidneys.
- Repeated exposure may cause low blood count (anemia).

Medical

Medical Testing
For frequent or potentially high exposure (half the TLV or greater), the following are recommended before beginning work and at regular times after that:

- Liver and kidney function tests

If symptoms develop or overexposure is suspected, the following are recommended:

- Complete blood count
- Uric acid level

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under the OSHA Access to Employee Exposure and Medical Records Standard (29 CFR 1910.1020).

Mixed Exposures
- More than light alcohol consumption can cause liver damage. Drinking alcohol may increase the liver damage caused by **Molybdenum**.

Workplace Controls and Practices

Very toxic chemicals, or those that are reproductive hazards or sensitizers, require expert advice on control measures if a less toxic chemical cannot be substituted. Control measures include: (1) enclosing chemical processes for severely irritating and corrosive chemicals, (2) using local exhaust ventilation for chemicals that may be harmful with a single exposure, and (3) using general ventilation to control exposures to skin and eye irritants. For further information on workplace controls, consult the NIOSH document on Control Banding at www.cdc.gov/niosh/topics/ctrlbanding/.

The following work practices are also recommended:

- Label process containers.
- Provide employees with hazard information and training.
- Monitor airborne chemical concentrations.
- Use engineering controls if concentrations exceed recommended exposure levels.
- Provide eye wash fountains and emergency showers.
- Wash or shower if skin comes in contact with a hazardous material.
- Always wash at the end of the workshift.
- Change into clean clothing if clothing becomes contaminated.
- Do not take contaminated clothing home.
- Get special training to wash contaminated clothing.
- Do not eat, smoke, or drink in areas where chemicals are being handled, processed or stored.
- Wash hands carefully before eating, smoking, drinking, applying cosmetics or using the toilet.

In addition, the following may be useful or required:

- Before entering a confined space where **Molybdenum** *powder* or *dust* may be present, check to make sure that an explosive concentration does not exist.
- Use a vacuum or a wet method to reduce dust during clean-up. DO NOT DRY SWEEP.

Personal Protective Equipment

The OSHA Personal Protective Equipment Standard (29 CFR 1910.132) requires employers to determine the appropriate personal protective equipment for each hazard and to train employees on how and when to use protective equipment.

The following recommendations are only guidelines and may not apply to every situation.

Gloves and Clothing

- Avoid skin contact with **Molybdenum**. Wear personal protective equipment made from material that can not be permeated or degraded by this substance. Safety equipment suppliers and manufacturers can provide recommendations on the most protective glove and clothing material for your operation.
- The recommended glove materials for **Molybdenum** are Nitrile and Natural Rubber.
- The recommended protective clothing material for **Molybdenum** is Tyvek®, or the equivalent.
- All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Eye Protection

- Wear eye protection with side shields or goggles.
- If additional protection is needed for the entire face, use in combination with a face shield. A face shield should not be used without another type of eye protection.

Respiratory Protection

Improper use of respirators is dangerous. Respirators should only be used if the employer has implemented a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing, and medical exams, as described in the OSHA Respiratory Protection Standard (29 CFR 1910.134).

- Where the potential exists for exposure over **3 mg/m^3**, use a NIOSH approved negative pressure, air-purifying, particulate filter respirator with an N, R or P95 filter. More protection is provided by a full facepiece respirator than by a half-mask respirator, and even greater protection is provided by a powered-air purifying respirator.
- Leave the area immediately if (1) while wearing a filter or cartridge respirator you can smell, taste, or otherwise detect **Molybdenum**, (2) while wearing particulate filters abnormal resistance to breathing is experienced, or (3) eye irritation occurs while wearing a full facepiece respirator. Check to make sure the respirator-to-face seal is still good. If it is, replace the filter or cartridge. If the seal is no longer good, you may need a new respirator.
- Consider all potential sources of exposure in your workplace. You may need a combination of filters, prefilters or cartridges to protect against different forms of a chemical (such as vapor and mist) or against a mixture of chemicals.
- Where the potential exists for exposure over **30 mg/m^3**, use a NIOSH approved supplied-air respirator with a full facepiece operated in a pressure-demand or other positive-pressure mode. For increased protection use in combination with an auxiliary self-contained breathing apparatus or an emergency escape air cylinder.
- Exposure to **5,000 mg/m^3** is immediately dangerous to life and health. If the possibility of exposure above **5,000 mg/m^3** exists, use a NIOSH approved self-contained breathing apparatus with a full facepiece operated in a pressure-demand or other positive-pressure mode equipped with an emergency escape air cylinder.

Fire Hazards

If employees are expected to fight fires, they must be trained and equipped as stated in the OSHA Fire Brigades Standard (29 CFR 1910.156).

- **Molybdenum** *powder* or *dust* may be FLAMMABLE.
- **Molybdenum** *powder* or *dust* is an explosion hazard when mixed in air.
- For *solid* **Molybdenum**, extinguish fire using an agent suitable for type of surrounding fire. **Molybdenum** itself does not burn.
- POISONOUS GASES ARE PRODUCED IN FIRE, including *Molybdenum Oxides*.
- CONTAINERS MAY EXPLODE IN FIRE.
- Use water spray to keep fire-exposed containers cool.

Spills and Emergencies

If employees are required to clean-up spills, they must be properly trained and equipped. The OSHA Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120) may apply.

If **Molybdenum** is spilled, take the following steps:

- Evacuate personnel and secure and control entrance to the area.
- Eliminate all ignition sources.
- Collect powdered material in the most convenient and safe manner and place into sealed containers for disposal.
- Keep **Molybdenum** *powder* and *dust* out of confined spaces, such as sewers, because of the possibility of an explosion.
- Ventilate and wash area after clean-up is complete.
- DO NOT wash into sewer as **Molybdenum** is toxic to aquatic life.
- It may be necessary to contain and dispose of **Molybdenum** as a HAZARDOUS WASTE. Contact your state Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.

Handling and Storage

Prior to working with **Molybdenum** you should be trained on its proper handling and storage.

- **Molybdenum** reacts violently with OXIDIZING AGENTS (such as PERCHLORATES, PEROXIDES, PERMANGANATES, CHLORATES, NITRATES, CHLORINE, BROMINE and FLUORINE) and STRONG ACIDS (such as HYDROCHLORIC, SULFURIC and NITRIC).
- Store in tightly closed containers in a cool, well-ventilated area.
- Sources of ignition, such as smoking and open flames, are prohibited where **Molybdenum** *powder* is used, handled, or stored.
- Metal containers involving the transfer of **Molybdenum** *powder* should be grounded and bonded.
- Use explosion-proof electrical equipment and fittings wherever **Molybdenum** *powder* is used, handled, manufactured, or stored.
- Use only non-sparking tools and equipment, especially when opening and closing containers of **Molybdenum** *powder*.

Occupational Health Information Resources

The New Jersey Department of Health offers multiple services in occupational health. These services include providing informational resources, educational materials, public presentations, and industrial hygiene and medical investigations and evaluations.

For more information, please contact:

New Jersey Department of Health
Right to Know
PO Box 368
Trenton, NJ 08625-0368
Phone: 609-984-2202
Fax: 609-984-7407
E-mail: rtk@doh.state.nj.us
Web address: http://www.nj.gov/health/eoh/rtkweb

GLOSSARY

ACGIH is the American Conference of Governmental Industrial Hygienists. They publish guidelines called Threshold Limit Values (TLVs) for exposure to workplace chemicals.

Acute Exposure Guideline Levels (AEGLs) are established by the EPA. They describe the risk to humans resulting from once-in-a lifetime, or rare, exposure to airborne chemicals.

Boiling point is the temperature at which a substance can change its physical state from a liquid to a gas.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is unique, identifying number, assigned by the Chemical Abstracts Service, to a specific chemical.

CFR is the Code of Federal Regulations, which are the regulations of the United States government.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes destruction of human skin or severe corrosion of containers.

The **critical temperature** is the temperature above which a gas cannot be liquefied, regardless of the pressure applied.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

ERG is the Emergency Response Guidebook. It is a guide for emergency responders for transportation emergencies involving hazardous substances.

Emergency Response Planning Guideline (ERPG) values provide estimates of concentration ranges where one reasonably might anticipate observing adverse effects.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

IARC is the International Agency for Research on Cancer, a scientific group.

Ionization Potential is the amount of energy needed to remove an electron from an atom or molecule. It is measured in electron volts.

IRIS is the Integrated Risk Information System database on human health effects that may result from exposure to various chemicals, maintained by federal EPA.

LEL or **Lower Explosive Limit**, is the lowest concentration of a combustible substance (gas or vapor) in the air capable of continuing an explosion.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the federal Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the New Jersey Public Employees Occupational Safety and Health Act, which adopts and enforces health and safety standards in public workplaces.

Permeated is the movement of chemicals through protective materials.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

Protective Action Criteria (PAC) are values established by the Department of Energy and are based on AEGLs and ERPGs. They are used for emergency planning of chemical release events.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

STEL is a Short Term Exposure Limit which is usually a 15-minute exposure that should not be exceeded at any time during a work day.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

UEL or **Upper Explosive Limit** is the highest concentration in air above which there is too much fuel (gas or vapor) to begin a reaction or explosion.

Vapor Density is the ratio of the weight of a given volume of one gas to the weight of another (usually *Air*), at the same temperature and pressure.

The **vapor pressure** is a force exerted by the vapor in equilibrium with the solid or liquid phase of the same substance. The higher the vapor pressure the higher concentration of the substance in air.

NJ Health New Jersey Department of Health

Right to Know Hazardous Substance Fact Sheet

Emergency Responders Quick Reference

Common Name: **MOLYBDENUM**

Synonyms: None
CAS No: 7439-98-7
Molecular Formula: Mo
RTK Substance No: 1309
Description: Silver-white metal or a dark gray or black powder

HAZARD DATA

Hazard Rating	Firefighting	Reactivity
1 - Health **0 - Fire (Solid)** **3 - Fire (Powder or Dust)** **0 - Reactivity** **DOT#:** UN 3089 (Powder) **ERG Guide #:** 170 **Hazard Class:** 4.1 (Flammable solids)	**Molybdenum** *powder* or *dust* may be FLAMMABLE. **Molybdenum** *powder* or *dust* is an explosion hazard when mixed in air. For *solid* **Molybdenum**, extinguish fire using an agent suitable for type of surrounding fire as **Molybdenum** itself does not burn. POISONOUS GASES ARE PRODUCED IN FIRE, including *Molybdenum Oxides*. CONTAINERS MAY EXPLODE IN FIRE. Use water spray to keep fire-exposed containers cool.	**Molybdenum** reacts violently with OXIDIZING AGENTS (such as PERCHLORATES, PEROXIDES, PERMANGANATES, CHLORATES, NITRATES, CHLORINE, BROMINE and FLUORINE) and STRONG ACIDS (such as HYDROCHLORIC, SULFURIC and NITRIC).

SPILL/LEAKS

Isolation Distance:

Spill: 25 meters (75 feet)

Fire: 800 meters (1/2 mile)

Collect powdered material in the most convenient and safe manner and place into sealed containers for disposal.

For **Molybdenum** *powder* use only non-sparking tools and equipment,

Keep **Molybdenum** *powder* and *dust* out of confined spaces, such as sewers, because of the possibility of an explosion.

DO NOT wash into sewer as **Molybdenum** is toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment.

PHYSICAL PROPERTIES

Flash Point:	Nonflammable solid, Flammable *powder* or *dust*
Vapor Pressure:	~0 mm Hg at 68°F (20°C)
Specific Gravity:	10.28 (water = 1)
Water Solubility:	Insoluble
Boiling Point:	8,717°F (4,825°C)
Melting Point:	4,752°F (2,622°C)
Molecular Weight:	95.9

EXPOSURE LIMITS

OSHA:	15 mg/m^3, 8-hr TWA (as *total dust*)
ACGIH:	3 mg/m^3, 8-hr TWA (as the *respirable fraction*)
IDLH:	5,000 mg/m^3

PROTECTIVE EQUIPMENT

Gloves:	Nitrile and Natural Rubber
Coveralls:	Tyvek®
Respirator:	>3 mg/m^3 - full facepiece APR with *High efficiency filters* >30 mg/m^3 - SCBA

HEALTH EFFECTS

Eyes:	Irritation
Skin:	Irritation
Inhalation:	Nose and throat irritation with coughing and wheezing

FIRST AID AND DECONTAMINATION

Remove the person from exposure.

Flush eyes with large amounts of water for at least 15 minutes. Remove contact lenses if worn.

Remove contaminated clothing and wash contaminated skin with soap and water.

Begin artificial respiration if breathing has stopped and CPR if necessary.

Transfer promptly to a medical facility.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

SELENIUM

CAS # 7782-49-2

Division of Toxicology ToxFAQs™ **September 2003**

This fact sheet answers the most frequently asked health questions (FAQs) about selenium. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: People may be exposed to low levels of selenium daily through food and water. Selenium is a trace mineral needed in small amounts for good health, but exposure to much higher levels can result in neurological effects and brittle hair and deformed nails. Occupational inhalation exposure to selenium vapors may cause dizziness, fatigue, irritation of mucous membranes, and respiratory effects. This substance has been found in at least 508 of the 1,636 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is selenium?

Selenium is a naturally occurring mineral element that is distributed widely in nature in most rocks and soils. In its pure form, it exists as metallic gray to black hexagonal crystals, but in nature it is usually combined with sulfide or with silver, copper, lead, and nickel minerals. Most processed selenium is used in the electronics industry, but it is also used: as a nutritional supplement; in the glass industry; as a component of pigments in plastics, paints, enamels, inks, and rubber; in the preparation of pharmaceuticals; as a nutritional feed additive for poultry and livestock; in pesticide formulations; in rubber production; as an ingredient in antidandruff shampoos; and as a constituent of fungicides. Radioactive selenium is used in diagnostic medicine.

What happens to selenium when it enters the environment?

❏ Selenium occurs naturally in the environment and can be released by both natural and manufacturing processes.
❏ Selenium dust can enter the air from burning coal and oil. This selenium dust will eventually settle over the land and water.
❏ It also enters water from rocks and soil, and from agricultural and industrial waste. Some selenium compounds will dissolve in water, and some will settle to the bottom as particles.
❏ Insoluble forms of selenium will remain in soil, but soluble forms are very mobile and may enter surface water from soils.
❏ Selenium may accumulate up the food chain.

How might I be exposed to selenium?

❏ The general population is exposed to very low levels of selenium in air, food, and water. The majority of the daily intake comes from food.
❏ People working in or living near industries where selenium is produced, processed, or converted into commercial products may be exposed to higher levels of selenium in the air.
❏ People living in the vicinity of hazardous waste sites or coal burning plants may also be exposed to higher levels of selenium.

How can selenium affect my health?

Selenium has both beneficial and harmful effects. Low doses of selenium are needed to maintain good health. However, exposure to high levels can cause adverse health effects. Short-term oral exposure to high concentrations of selenium may cause nausea, vomiting, and diarrhea. Chronic oral exposure to high concentrations of selenium compounds can produce a disease called selenosis. The major signs of selenosis are hair loss, nail brittleness, and neurological abnormalities (such as numbness and other odd sensations

in the extremities).
Brief exposures to high levels of elemental selenium or selenium dioxide in air can result in respiratory tract irritation, bronchitis, difficulty breathing, and stomach pains. Longer-term exposure to either of these air-borne forms can cause respiratory irritation, bronchial spasms, and coughing.
Levels of these forms of selenium that would be necessary to produce such effects are normally not seen outside of the workplace.
Animal studies have shown that very high amounts of selenium can affect sperm production and the female reproductive cycle. We do not know if similar effects would occur in humans.

How likely is selenium to cause cancer?

Studies of laboratory animals and people show that most selenium compounds probably do not cause cancer. In fact, studies in humans suggest that lower-than-normal selenium levels in the diet might increase the risk of cancer.
The International Agency for Research on Cancer (IARC) has determined that selenium and selenium compounds are not classifiable as to their carcinogenicity to humans.
The EPA has determined that one specific form of selenium, selenium sulfide, is a probable human carcinogen. Selenium sulfide is not present in foods and is a very different chemical from the organic and inorganic selenium compounds found in foods and in the environment.

How can selenium affect children?

It is likely that the health effects seen in children exposed to selenium will be similar to the effects seen in adults.
However, one study found that children may be less susceptible to the health effects of selenium than adults.
Selenium compounds have not been shown to cause birth defects in humans or in other mammals.

How can families reduce the risk of exposure to selenium?

❑ Certain dietary supplements and shampoos contain selenium; these should be used according to the manufacturer's directions.
❑ Children living near waste sites that contain selenium or coal burning plants should be encouraged to wash their hands before eating and to avoid putting their unwashed hands in their mouths.

Is there a medical test to show whether I've been exposed to selenium?

Low levels of selenium are normally found in body tissues and urine. Blood and urine tests for selenium are most useful for people who have recently been exposed to high levels. Toenail clippings can be used to determine longer-term exposure. These tests are not usually available at your doctor's office, but your doctor can send the samples to a laboratory that can perform the tests. None of these tests, however, can predict whether you will experience any health effects.

Has the federal government made recommendations to protect human health?

The EPA restricts the amount of selenium allowed in public water supplies to 50 parts total selenium per billion parts of water (50 ppb).
The Occupational Safety and Health Administration (OSHA) sets a limit of 0.2 mg selenium/m^3 of workroom air for an 8-hour work shift.
ATSDR and the EPA have determined that 5 micrograms of selenium per kilogram of body weight taken daily would not be expected to cause any adverse health effects over a lifetime of such intake.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Toxicological Profile for Selenium (Update) Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Natural & Depleted Uranium - ToxFAQs™

CAS # 7440-61-1

This fact sheet answers the most frequently asked health questions (FAQs) about natural and depleted uranium. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Natural uranium is a naturally occurring chemical substance that is mildly radioactive. Depleted uranium is an adjusted mixture of natural uranium isotopes that is less radioactive. Everyone is exposed to low amounts of uranium through food, water, and air. Exposure to high levels of natural or depleted uranium can cause kidney disease. Uranium has been found in at least 67 of 1,699 National Priorities List (NPL) sites identified by the Environmental Protection Agency (EPA).

What is uranium?

Uranium is a naturally occurring radioactive element. It is naturally present in nearly all rocks, soils, and air; can be redistributed in the environment through wind and water erosion; and more can be released into the environment through volcanic eruptions. Natural uranium is a mixture of three isotopes: ^{234}U,235U, and ^{238}U. The most common isotope is ^{238}U; it makes up over 99% of natural uranium. All three isotopes behave the same chemically, but they have different radioactive properties. The half-lives of uranium isotopes (the amount of time needed for half of the isotope to give off its radiation and change into a different element) is very long. The least radioactive isotope is ^{238}U with a half life of 4.5 billion years. Depleted uranium is a mixture of the same three uranium isotopes except that it has very little ^{234}U and ^{235}U. It is less radioactive than natural uranium. Enriched uranium is another mixture of isotopes that has more ^{234}U and ^{235}U than natural uranium. Enriched uranium is more radioactive than natural uranium.

Uranium is almost as hard as steel and much denser than lead. Natural uranium is used to make enriched uranium; depleted uranium is the leftover product. Enriched uranium is used to make fuel for nuclear power plants. Depleted uranium is used as a counterbalance on helicopters rotors and airplane control surfaces, as a shield to protect against ionizing radiation, as a component of munitions to help them penetrate enemy armored vehicles, and as armor in some parts of military vehicles.

What happens to uranium when it enters the environment?

- Natural and depleted uranium that exist in the dust in the air settle onto water, land, and plants. Uranium deposited on land can be reincorporated into soil, washed into surface water, or stick to plant roots. Uranium in air, surface water, or groundwater can be transported large distances.

How might I be exposed to uranium?

- Food and drinking water are the primary sources of intake for the general public. Very low levels of uranium are found in the air.
- Root crops such as potatoes, parsnips, turnips, and sweet potatoes contribute the highest amounts of uranium to the diet. Because uranium in soil can stick to these vegetables, the concentrations in these foods are directly related to the concentrations of uranium in the soil where the foods are grown.
- In most areas of the United States, low levels of uranium are found in the drinking water. Higher levels may be found in areas with elevated levels of naturally occurring uranium in rocks and soil.
- People may be exposed to higher levels of uranium if they live near uranium mining, processing, and manufacturing facilities. People may also be exposed if they live near areas where depleted uranium weapons are used.

How can uranium enter and leave my body?

Most of the uranium you breathe or ingest is not absorbed and leaves the body in the feces. Absorbed uranium is deposited throughout the body. The highest levels are found in the bones, liver, and kidneys; 66% of the uranium in the body is found in your bones. It can remain in the bones for a long time; the half-life of uranium in bones is 70–200 days. Most of the uranium that is not in bones leaves the body in the urine in 1–2 weeks.

How can uranium affect my health?

Natural uranium and depleted uranium have the identical chemical effect on your body. Kidney damage has been seen in humans and animals after inhaling or ingesting

Natural and Depleted Uranium

CAS # 7440-61-1

uranium compounds. However, kidney damage has not been consistently found in soldiers who have had uranium metal fragments in their bodies for several years. Ingesting water-soluble uranium compounds will result in kidney effects at lower doses than following exposure to insoluble uranium compounds.

Studies in animals have shown that inhalation exposure to insoluble uranium compounds can result in lung damage. In male rats and mice, exposure to uranium has been shown to decrease fertility. Uranium compounds on the skin caused skin irritation and mild skin damage in animals.

Health effects of natural and depleted uranium are due to chemical effects and not to radiation.

How likely is uranium to cause cancer?

Neither the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC) nor the EPA have classified natural uranium or depleted uranium with respect to carcinogenicity.

How can uranium affect children?

The health effects seen in children from exposure to toxic levels of uranium are expected to be similar to the effects seen in adults.

Exposure of animals to high levels of uranium during pregnancy, which caused toxicity in the mothers, has induced early deaths and birth defects in the young. It is not clear if this can happen in the absence of effects on the mother. We do not know whether uranium can cause birth defects in people. There are some studies that suggest that exposure to depleted uranium increased the frequency of birth defects, but the studies are deficient to allow valid conclusions.

How can families reduce the risk of exposure to uranium?

- Avoid eating root vegetables grown in soils with high levels of uranium. Consider washing fruits and vegetables grown in that soil and discard the outside portion of root vegetables.
- Consider having your water tested if you suspect that your drinking water might have elevated levels of uranium; if elevated levels are found, consider using bottled water.

Is there a medical test to determine whether I've been exposed to uranium?

Natural uranium is in your normal diet, so there will always be some level of uranium in all parts of your body. If depleted uranium is present, it adds to the total uranium level. Uranium can be measured in blood, urine, hair, and body tissues. Most tests are for total uranium; however, expensive tests are available to estimate the amounts of both natural and depleted uranium that are present.

Has the federal government made recommendations to protect human health?

The government has made recommendations for uranium which apply to natural and depleted uranium combined.

The EPA established a maximum drinking water contaminant level of 0.03 mg/L.

The Occupational Safety and Health Administration (OSHA) has limited workers' exposure in air to an average of 0.05 mg U/m^3 for soluble uranium and 0.25 mg U/m^3 for insoluble uranium over an 8-hour workday.

The National Institute for Occupational Safety and Health (NIOSH) recommends workers exposure be limited to 0.05 mg U/m^3 of air for soluble uranium and 0.2 mg U/m^3 for insoluble uranium averaged over a 10-hour workday and recommends that exposure to soluble uranium not exceed 0.6 mg U/m^3 for more than 15 minutes.

The Nuclear Regulatory Commission (NRC) has established air concentration limits for uranium and its individual isotopes that apply to occupational exposure and releases from facilities.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2013. Toxicological Profile for Uranium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30329-4027.

Phone: 1-800-232-4636.

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Vanadium - ToxFAQs™

CAS # 7440-62-2

This fact sheet answers the most frequently asked health questions (FAQs) about vanadium. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Everyone is exposed to low levels of vanadium in air, water, and food; however, most people are exposed mainly from food. Breathing high levels of vanadium pentoxide may cause lung damage. Ingesting vanadium can cause nausea and vomiting. In animals, ingesting vanadium can cause decreased red blood cells and increased blood pressure. Vanadium has been found in at least 319 of 1,699 National Priorities List (NPL) sites identified by the Environmental Protection Agency (EPA).

What is vanadium?

Vanadium is an element that occurs in nature as a white-to-gray metal compounds, and is often found as crystals. Pure vanadium has no smell. It usually combines with other elements such as oxygen, sodium, sulfur, or chloride. Vanadium and vanadium compounds can be found in the earth's crust and in rocks, some iron ores, and crude petroleum deposits.

Vanadium is used in producing rust-resistant, spring, and high-speed tool steels.

Vanadium pentoxide is used in ceramics, as a catalyst, and in the production of superconductive magnets.

Vanadyl sulfate and sodium metavanadate have been used as dietary supplements.

What happens to vanadium when it enters the environment?

- Vanadium mainly enters the environment from natural sources and from the burning of fuel oils.
- It does not dissolve well in water.
- It combines with other elements and particles.
- Vanadium binds strongly to soil and sediments.
- Low levels have been found in plants, but it is not likely to build up in the tissues of animals.

How might I be exposed to vanadium?

- Eating foods containing vanadium, higher levels are found in seafoods. Vanadium is found in some nutritional supplements.
- Breathing air near an industry that burns fuel oil or coal; these industries release vanadium oxide into the air.
- Working in industries that process vanadium or make products containing vanadium.
- Breathing contaminated air or drinking contaminated water near waste sites or landfills containing vanadium.
- Breathing cigarette smoke.
- Vanadium is not readily absorbed by the body from the stomach, gut, or contact with the skin.

How can vanadium affect my health?

Exposure to high levels of vanadium pentoxide in air can result in lung damage.

Nausea, mild diarrhea, and stomach cramps have been reported in people some vanadium compounds. A number of effects have been found in animals ingesting vanadium compounds including decreases in the number of red blood cells, increased blood pressure, and mild neurological effects. The amounts of vanadium given in these animal studies that resulted in harmful effects are much higher than those likely to occur in the environment.

Vanadium

CAS # 7440-62-2

How likely is vanadium to cause cancer?

The International Agency for Research on Cancer (IARC) has classified vanadium pentoxide as possibly carcinogenic to humans based on evidence of lung cancer in exposed mice.

The Department of Health and Human Services (DHHS) and EPA have not classified vanadium as to its human carcinogenicity.

How can vanadium affect children?

The health effects in children are expected to be similar to the effects seen in adults.

Studies in animals exposed during pregnancy have shown that vanadium can cause decreases in growth and increases in the occurrence of birth defects. These effects are usually observed at levels which cause effects in the mother. Effects have also been observed at vanadium doses which did not cause effects in the mother.

How can families reduce the risk of exposure to vanadium?

- Vanadium is present in some supplements. Consult with your doctor before taking supplements containing vanadium to determine if they are appropriate for you. Supplements should be kept out of reach of children.
- Vanadium is a component of tobacco smoke. Avoid smoking in enclosed spaces like inside the home or car in order to limit exposure to children and other family members.

Is there a medical test to determine whether I've been exposed to vanadium?

Vanadium can be measured in blood and urine. These tests cannot determine if harmful health effects will occur from the exposure to vanadium.

Has the federal government made recommendations to protect human health?

The Occupational Safety and Health Administration (OSHA) has set a legal limit of 0.5 milligrams per cubic meter (0.5 mg/m^3) for vanadium pentoxide dust as a ceiling limit not to be exceeded during the workday. A ceiling limit of 0.1 mg/m^3 for vanadium pentoxide fumes has also been established.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for Vanadium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30329-4027.

Phone: 1-800-232-4636.

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATTACHMENT C3

SAFE WORK PRACTICES

DCN 2-4	Hearing Conservation Program
DCN 4-5	Excavation and Trenching
DCN 4-9	Safe Haulage and Earth Moving
DCN 4-10	Lead Protection Program
SWP 5-1	General Safe Work Practices for Field Work
SWP 5-2	General Safe Work Practices for Hazardous Work Site Activities
SWP 5-07	Heavy Equipment
SWP 5-15	General Safe Work Practice for Heat Illness Prevention and Monitoring
SWP 5-16	General Safe Work Practice for Cold Stress
SWP 5-17	Biohazard Safety
SWP 05-19	Manual Lifting
SWP 5-26	Prevention of Sun Exposure
SWP 5-27	Respirator Cleaning Procedures
SWP 5-28	General Safe Work Practices for Use of Air Purifying Respirators
SWP 5-29	Respirator Qualitative Fit Test Procedures
SWP 5-30	Encountering Dangerous or Aggressive Animals
SWP 6-21	Radiation Safety Practices

This hearing conservation program has been established by Tetra Tech to protect employees from the harmful effects of noise exposure. This program is designed to comply with the Occupational Safety and Health Administration (OSHA) occupational noise exposure standard in Title 29 of the *Code of Federal Regulations* (CFR), Part 1910.95, as well as federal, state, local, and contractual requirements.

The hearing conservation program elements describe how the criteria specified by the OSHA standard shall be implemented, reviewed and maintained. Program elements include responsibilities, action levels, monitoring, employee notification, audiometric testing, hearing protection, warning signs and information, and training. This hearing conservation program shall be made available upon request to employees and their representatives.

1.0 SCOPE

An action level for noise has been established by OSHA based on an 8-hour, time-weighted average (TWA) of 85 decibels measured on the A-weighted scale (dBA) in the slow response mode. When employees are exposed to sound that exceeds this action level, employers must implement a hearing conservation program. All employees exposed to sound levels exceeding the action level of 85 dBA fall under the scope of this Hearing Conversation Program.

2.0 RESPONSIBILITIES

Operating unit health and safety managers (HSMs) are responsible for application and oversight of the hearing conservation program within their respective organizations. Each HSM will maintain records of all noise exposure measurements for at least two (2) years, in accordance with Tetra Tech Recordkeeping and Reporting Requirements (Document Control Number (DCN) 1-4). The HSM is also responsible for identifying employees to be included in the audiometric testing program and for scheduling audiometric exams through the Tetra Tech corporate medical surveillance provider.

Project managers are responsible for ensuring compliance with hearing conservation controls and protection at their project sites. Site safety coordinators (SSCs) are responsible for identifying noise control areas or operations and implementing the program on a site-specific basis. The HSM will assist project managers and SSCs with assessing the need for and implementing hearing conservation programs at individual sites. Employees are responsible for wearing appropriate hearing protection devices and following hearing conservation procedures in noise control areas.

3.0 PROGRAM ELEMENTS

Permissible Exposure Limits

The following table identifies OSHA permissible exposure limits for noise exposures. Whenever possible, administrative or engineering controls will be used to reduce sound levels. If controls are not feasible or fail to reduce sound levels to below 85 dBA, hearing protection will be provided to employees to reduce sound exposures to below the 85 dBA limit. This Tetra Tech hearing conservation program ***mandates*** the use of hearing protection for 8-hour, TWA exposures of 85 dBA or greater.

TABLE 1 - PERMISSIBLE NOISE EXPOSURES*

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
½	110
¼ or less	115

* When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C(1)/T(1) + C(2)/T(2) C(n)/T(n) exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

Monitoring

In most instances, high noise levels at a project site are generated by heavy equipment, such as drill rigs and backhoes, or sources associated with the work site operations such as operating equipment and vehicles. Most common high-noise-level sources have been measured, and instances where hearing protection is required shall be indicated in the site-specific hazard assessment documents such as a health and safety plan (HASP), construction health and safety plan (C-HASP), job hazard analysis (JHA), job safety analysis (JSA), or permit. When noise

exposures at a work site are suspected to equal or exceed an 8-hour, TWA of 85 dBA resulting from noise sources not previously measured, the SSC will conduct an evaluation to characterize the noise sources and exposure levels.

A portable sound-level meter is recommended for surveying general work areas and for estimating noise exposure when the noise levels are relatively constant. Noise dosimeters are recommended for documenting full-shift noise exposures when noise sources fluctuate, are intermittent, or otherwise difficult to document with the sound-level meter. Monitoring for occupational noise exposure will be conducted for each representative task or job position that the SSC deems necessary. The HSM shall assist with sound level monitoring and reporting as necessary.

All noise measurements will be taken in the hearing zone of the affected employee. The hearing zone is an area within a radius not to exceed 12 inches from the ear closest or in most direct proximity to the noise source.

Monitoring equipment must be in factory calibration and will be checked in the field with an appropriate field calibration check standard according to the equipment manufacturer's recommendation before and after each set of measurements. Documentation of test field calibration checks will be kept with the field data collected.

In some cases, such as on short-term projects, the SSC may forgo actual noise level measurements and use a simple rule-of-thumb test to determine if noise levels are in excess of 85 dBA. The test requires the SSC to determine how loud he or she must speak to be heard at arm's length from another person. If the SSC must raise his or her voice to be heard, average noise levels likely exceed 85 dBA.

Employee Notification

The SSC is responsible for informing employees exposed at or above an 8-hour, TWA of 85 dBA of the results of the monitoring.

Audiometric testing

Audiometric testing shall be conducted for all Tetra Tech employees potentially exposed to sounds levels greater than 85 dBA TWA. The audiometric testing program consists of baseline audiograms, annual audiograms, and termination audiograms. Employees will be informed of the results of these tests at the time of their examination. Audiometric test results will be retained for Tetra Tech by the corporate medical advisor and will become a part of each employee's permanent

medical record. Exposure and audiometric records will be made available to employees upon request.

Hearing Protection

Tetra Tech will provide hearing protection to all personnel that may experience noise exposures at or greater than 85 dBA. Hearing protection must provide sufficient attenuation to limit employee noise exposure to an 8-hour, TWA of less than 85 dBA. Hearing protection will be replaced as necessary. The SSC will supervise the correct use of hearing protection at a work site. Personnel will receive instruction in proper fitting during initial and refresher hearing conservation training classes.

Warning Signs and Information

The SSC will post "Hearing Protection Required" signs in areas where noise levels have been measured and determined to exceed the 85-dBA, TWA action level. Signs may also be posted in areas where monitoring has not been conducted but noise levels are expected to exceed the 85-dBA, TWA level based on similarity to past activities or on the judgment of the SSC.

For short-duration projects or where personnel exposure in the high-noise area is limited and controlled, the SSC may provide verbal notice of the need for hearing protection in place of the signs described above.

4.0 Training

Hearing conservation training may be conducted as a stand-alone course or may be included in HAZWOPER, construction safety, or other health and safety training. Hearing Conservation training will include the following:

- Effects of noise on hearing;
- The purpose of hearing protectors;
- The advantages, disadvantages, and attenuation of various types of hearing protection;
- Instruction on selection, fitting, use, and care of hearing protectors; and
- The purpose of audiometric testing and an explanation of the test procedure.

Documentation of initial and refresher training will be through class attendance records and course agendas.

Revision Date	Document Authorizer	Revision Details
10/1/2008	Chris McClain	Update from 1998 format

1.0 PURPOSE

This program provides the requirements for activities involving excavations in accordance with 29 CFR 1926, Subpart P - Excavations.

2.0 SCOPE

These requirements are applicable to all Tetra Tech operations.

3.0 MAINTENANCE

The VP, Corporate Health and Safety or designee is responsible for updating this procedure. Approval authority rests with Tetra Tech's Senior VP, Corporate Administration. Suggestions for revision shall be submitted to the Corporate Administration department.

4.0 DEFINITIONS

4.1 Benching

A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

4.2 Competent Person

A competent person is one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

4.3 Excavation

Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

4.4 Hazardous Atmosphere

An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

4.5 Protective Systems

A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

4.6 Sloping

A method of protecting employees from cave-ins by forming sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

4.7 Support System

A structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

4.8 Trench

A narrow excavation made below the surface of the ground. In general the depth is greater than the width, but the width of a trench measured at the bottom is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less, the excavation is also considered to be a trench.

5.0 DISCUSSION

5.1 Responsibilities

5.1.1 Competent Person

The competent person(s) shall be responsible for:

- Day-to-day oversight of open excavations and trenches
- Conducting soil classifications
- Selection of protective systems
- Conducting daily inspections of open excavations and trenches; and
- Providing the PM and or Supervisor with all required documentation on a daily basis.

5.1.2 Line Management

The Project Manager (PM) shall be responsible for:

- Ensuring compliance with this procedure
- Providing the necessary resources for compliance with this procedure; and
- Designating competent personnel in consultation with the Site Safety Coordinator (SSC)

5.1.3 Site Safety Coordinator Personnel

The SSC shall be responsible for:

- Providing oversight on the implementation of the requirements contained in this procedure
- Conducting periodic reviews of open trenches and excavations
- Consulting with the project manager and competent person on excavation issues; and

- Maintaining required records.

5.2 Designation of Competent Personnel

Prior to the start of any excavation work the project manager shall designate a competent person to fulfill the requirements of this procedure.

5.3 General Requirements

The following section provides general requirements governing activities in and around excavation and trenches, as well as the requirements for the selection and use of protective systems.

- Surfaces surrounding open trenches and excavations shall have all surface hazards removed.
- All utilities shall be located and cleared prior to initiating digging. Public or facility utility groups shall be utilized where possible for this purpose. In the absence of either, the SSC shall specify the procedures to be used to clear utilities in consultation with the project manager. When the excavation is open, utilities shall be supported and protected from damage. Clearance and support methods shall be documented on the daily inspection checklist.
- No person may enter a trench or work at the foot of the face of an excavation until a qualified, competent person has inspected the excavation and determined whether sloping or shoring is required to protect against cave-in or subsidence and the appropriate protection has subsequently been installed.
- Trenches and excavations must be assessed by a qualified, competent person, even in the absence of working personnel, whenever heavy equipment will be operating nearby in order to ensure that the trench or excavation will support the weight of the equipment without subsistence or causing the accidental overturning of machinery.
- Access to trenching areas must be controlled and limited to authorized personnel. Prior to entering a trench or excavation, workers must notify the project manager, SSC, and nearby equipment operators whose activities could affect the trench or excavation.
- Trenches and excavations must be inspected regularly (daily at a minimum) to ensure that changes in temperature, precipitation, shallow groundwater, overburden, nearby building

weight, vibration, or nearby equipment operation have not caused weakening of the sides, faces, and floors and to ensure that personnel protection is being maintained.

- Where structural ramps are used for egress they shall be installed in accordance with 29 CFR 1926.651(c)(1).
- Stairways, ladders, or ramps shall be provided as means of egress in all trenches 4 feet or more in depth. Travel distance shall be no more than 25 feet between means of exit.
- Ladders if used must be secured from shifting, and must extend at least 3 feet above the top of the trench or excavation.
- Where necessary to prevent falls, crosswalks or walkways will be constructed. Structural ramps, walkway, and cross walks must be designed by a qualified competent person.
- Employees exposed to vehicular traffic shall wear traffic vests.
- No employee shall be permitted under loads being lifted or under loads being unloaded from vehicles.
- When vehicles and machinery are operating adjacent to excavations warning systems such as stop logs or shall be utilized to prevent vehicles from entering the excavation or trench.
- Scaling or barricades shall be used to prevent rock and soils from falling on employees.
- Excavated and loose materials should be kept at least 3 feet from the edge of excavations, but at a minimum 2 feet from the edge of the excavation in accordance with OSHA requirements.
- Walkways or bridges with standard railing shall be provided at points employees are to cross over excavations or trenches.
- Barriers shall be provided to prevent personnel from inadvertently falling into an excavation.
- Comply with any regulatory or contract required permitting and notification processes. For example, in California, a Cal-OSHA excavation permit and notification is required. Clients may classify excavations and trenches as permitted confined spaces, in these cases, DCN 2-5 Confines Space Entry shall be followed. These requirements shall be outlined in the site specific Health and Safety Plan

- When subsidence or tension cracks are apparent anywhere in an excavation, all work should be stopped until the problem is corrected.

- The competent person must inspect trenches or excavations after any precipitation event to ensure integrity has been maintained.

- If trenches or excavations are near walkways or roadways, guards or warning barriers must be placed to alert pedestrians and drivers of the presence of the trench or excavation.

- If possible, trenches or excavations should be covered or filled in when unattended. Otherwise, strong barriers must be placed around the trench or excavation and lighting must be provided at night if the trench or excavation is near a walkway or roadway.

- When a hazardous atmosphere could exist, the excavation must be tested for appropriate hazardous substances and oxygen level before personnel entry. Excavation where hazardous atmospheres exist must be treated as a confined space. Entry must follow procedures outlined in "Confined Spaced Entry Program," Document Control No. 2 5.

- Entry is not allowed into excavations where water has accumulated.

5.4 Hazardous Atmospheres

Where atmospheres containing less than 19.5 percent oxygen or other types of hazardous atmospheres may exist the following requirements shall be implemented.

- Atmospheric testing shall be done prior to employees entering excavations 4 feet or greater in depth.

- Testing methods shall be listed on the daily inspection checklist and results documented daily in field logs.

- Control measures such as ventilation and personal protective equipment (PPE) shall be used to control employee exposure to hazardous atmospheres below published exposure limits.

- Ventilation shall be used to control flammable and combustible vapors to below 10 percent of their lower explosive limit.

- Testing shall be repeated as often as necessary to ensure safe levels of airborne contaminants.
- Emergency equipment shall be provided and attended when the potential for a hazardous atmosphere exists. This equipment shall include but not be limited to emergency breathing apparatus, harnesses, lifelines, and basket stretchers. Required equipment will be listed on the daily inspection checklist and reviewed daily.

5.5 Protection From Water Hazards

When water has collected or is collected in excavations and trenches the following requirements shall be applied.

- Employees shall not work in excavations in which water has, or is, accumulating without the use of additional protection such as special support systems or water removal.
- Water removal shall be monitored by a competent person.
- Barriers such as ditches and dikes shall be used to divert runoff from excavations and trenches.
- Trenches shall be re-inspected prior to re-entry after water accumulation due to heavy rainfall or seepage.

5.6 Stability of Adjacent Structures

When excavating or trenching near an adjacent structure the following practices shall be implemented.

- Support systems such as shoring, bracing, or underpinning shall be provided where the stability of buildings, walls, or other structures is endangered by excavation.
- Excavation bases or footings of foundations shall be prohibited unless support systems are used, the excavation is in stable rock, a professional engineer has determined the structure is sufficiently removed from the site as to not pose a hazard, or the PE determines that the excavation shall not pose a hazard to employees due to the structure.

- Support systems shall be used when it is necessary to undermine sidewalks, pavements, and appurtenant structures.
- Surcharge load sources and adjacent encumbrances shall be listed with their evaluation date on the daily inspection checklist.

5.7 Daily Inspections

Inspections shall be performed daily on all excavations, adjacent areas, and protective systems before personnel enter the trench. The checklist provided in Attachment A or equivalent shall be used.

5.8 Soil Classification

To perform soil classification, the competent person shall use a thumb test, pocket penetrometer, or shear vane to determine the unconfined compressive strength of the soils being excavated. In soils with properties that change (i.e., one soil type mixed with another within a given area) several tests may be necessary. When different soil types are present the overall classification shall be that of the type with the lowest unconfined compressive strength. Classifications shall result in a soil rating of Stable Rock, Type A, Type B, or Type C in accordance with 29 CFR 1926.652, Appendix A. Soil classifications shall be listed on the daily inspection checklist. The soils analysis checklist provided in Attachment B or equivalent shall be used for soil classifications.

5.9 Sloping and Benching

All sloping and benching shall be done in accordance with 29 CFR 1926.652, Appendix B. Selection of the sloping method and evaluation of surface surcharge loads shall be made by a competent person familiar with the requirements contained therein. Sloping and benching methods and specifications shall be listed on the daily inspection checklist.

5.10 Protective Systems

Protective systems are required on all excavations over 5 feet in depth or in excavations less than 5 feet when examination of the ground by a competent person reveals conditions that may result in cave-ins.

Selection and installation of protective systems shall be done in accordance with 29 CFR 1926.652, Appendices C & D, or manufacturers data for shoring and shielding systems. Selection of a protective system shall be made based upon soil classification and job requirements by a competent person.

Protective systems and specifications shall be listed on the daily inspection checklist.

5.11 Training

Competent persons shall have an adequate combination of experience and training to classify soil types and select protective systems as outlined in 29 CFR 1926.652. Training and experience pertaining to qualification as a competent person shall be documented and include the following:

- General safety practices related to working in or near open excavations;
- Inspection requirements and techniques;
- Classification of soils in accordance with 29 CFR 1926.652, Appendix A; and
- Uses, limitations, and specifications of protective systems in accordance with 29 CFR 1926.652.

Training records shall be maintained in accordance with DCN 1-4 Recordkeeping and Reporting Requirements..

6.0 REFERENCES

29 CFR 1926, Subpart P, Excavations. Environmental, Health & Safety - Programs Procedure EHS 1-9, Recordkeeping OSHA (U.S. Department of Labor, Occupational Safety and Health Administration),

DAILY EXCAVATION INSPECTION CHECKLIST To be completed by a "Competent Person"

Indicate for each item by circling: Y (Yes), N (No), - Address in Comments, Not Applicable (N/A.)

I. General Inspection of Job Site

A. Surface encumbrances removed or supported Y N N/A
B. Employees protected from loose rock or soil that could pose a hazard by falling or rolling into the excavation Y N N/A
C. Hard hats worn by all employees Y N N/A
D. Spoils, materials, and equipment set back at least 2 feet from the edge of the excavation Y N N/A
E. Barriers provided at all remotely located excavations, wells, pits, shafts, etc. Y N N/A
F. Walkways and bridges over excavations 4 feet or more in depth are equipped with standard guardrails Y N N/A
G. Warning vests or other highly visible clothing provided and worn by all employees exposed to public vehicular traffic Y N N/A
H. Warning system established and utilized when mobile equipment is operated near the edge of the excavation Y N N/A
I. Employees prohibited from working on the faces of sloped or benched excavations above other employees Y N N/A

II. Utilities

A. Utility companies contacted and/or utilities located Y N N/A
B. Exact location of utilities marked when approaching the utilities Y N N/A
C. Underground installations protected, supported or removed when excavation is open Y N N/A

III. Means of Access and Egress

A. Lateral travel to means of egress no greater than 25 feet in excavations 4 feet or more in depth Y N N/A
B. Ladders used in excavations secured and extended 3 feet above the edge of the trench Y N N/A
C. Structural ramps used by employees designed by a competent person Y N N/A
D. Structural ramps used for equipment designed by a registered professional engineer (RPE) Y N N/A
E. Ramps constructed of materials of uniform thickness, cleated together on the bottom, equipped with a no-slip surface Y N N/A
F. Employees protected from cave-ins when entering or exiting the excavation Y N N/A

IV. Wet Conditions

A. Precautions taken to protect employees from the accumulation of water Y N N/A

B. Water removal equipment monitored by a competent person Y N N/A
C. Surface water or runoff diverted or controlled to prevent accumulation in the excavation Y N N/A
D. Inspections made after every rainstorm or other hazard increasing occurrence Y N N/A

V. Hazardous Atmospheres

A. Atmosphere within the excavation tested where there is a reasonable possibility of an oxygen deficiency, combustible or other harmful contaminant exposing employees to a hazard Y N N/A
B. Ventilation Y N N/A
C. Testing conducted often to ensure that the atmosphere remains safe Y N N/A
D. Emergency equipment, such as breathing apparatus, safety harness and line, and basket stretcher readily available where hazardous atmospheres could or do exist Y N N/A
E. Safety harness and life line used and individually attended when entering deep confined excavations Y N N/A

VI. Support Systems

A. Materials and/or equipment for support systems selected based on soil analysis, trench depth and expected loads Y N N/A
B. Materials and equipment used for protective systems inspected and in good condition Y N N/A
C. Materials and equipment not in good condition have been removed from service Y N N/A
D. Damaged materials and equipment used for protective systems inspected by a RPE after repairs and before being placed back into service Y N N/A
E. Protective systems installed without exposing employees to the hazards of cave-ins, collapses or from being struck by materials or equipment Y N N/A
F. Members of support system securely fastened to prevent failure Y N N/A
G. Support systems provided to insure stability of adjacent structures, buildings, roadways, sidewalks, walls, etc. Y N N/A
H. Excavations below the level of the base or footing approved by an RPE Y N N/A
I. Removal of support systems progresses from the bottom and members are released slowly as to note any indication of possible failure Y N N/A
J. Backfilling progresses with removal of support system Y N N/A
K. Excavation of material to a level no greater than 2 feet below the bottom of the support system and only if the system is designed to support the loads calculated for the full depth Y N N/A
L. Shield system placed to prevent lateral movement Y N N/A
M. Employees are prohibited from remaining in shield system during vertical movement Y N N/A

VII. Comments

Site location

Date Time Competent Person

Soil Type(s)

Soil Classification(s)
Excavation depth
Excavation width

Type of protective system used

SOILS ANALYSIS CHECKLIST

This checklist must be completed when soil analysis is made to determine the soil type(s) present in the excavation. A separate analysis must be performed on each layer of soil in excavation walls. A separate analysis must also be performed if the excavation (trench) is stretched over a distance where soil type may change.

Site location:

Date:

Time:

Competent Person

Where was the sample taken from?

Excavation:

Depth:

Width:

Length:

VISUAL TEST

Particle type: Fine Grained (cohesive) Course grained (sand or gravel)

Water conditions: Wet Dry Surface water present Submerged

Previously disturbed soils? Yes No

Underground utilities? Yes No

Layered soils? Yes No

Layered soil dipping into excavation? Yes No

Excavation exposed to vibrations: Yes No

Crack-like openings or spallings observed? Yes No
Conditions that may create hazardous atmosphere? Yes No

If yes, identify condition and source:

Surface encumbrances: Yes No

Work to be performed near public vehicular traffic? Yes No

Possible confined space exposure? Yes No

MANUAL TEST

Plasticity: Cohesive Non-cohesive

Dry Strength: Granular (crumbles easily) Cohesive (broken with difficulty)

NOTE: The following unconfined compressive strength tests should be performed on undisturbed soils.

THUMB TEST (used to estimate unconfined compressive strength of cohesive soil)
Test performed: Yes No

Type A (soil indented by thumb with very great effort)

Type B (soil indented by thumb with some effort)

Type C (soil easily penetrated several inches by thumb with little or no effort).If soil is submerged, seeping water, subjected to surface water, runoff, exposed to wetting.

PENETROMETER OR SHEARVANE (used to estimate unconfined compressive strength of cohesive soils)
Test performed: Yes No

Type A (soil with unconfined compressive strength of 1.5 tsf or greater)

Type B (soil with unconfined compressive strength of 0.5 tsf to 1.5 tsf)

Type C (soil with unconfined compressive strength of 1.5 tsf or less). If soil is submerged, seeping water,

subjected to surface water, runoff, exposed to wetting.

WET SHAKING TEST (used to determined percentage of granular and cohesive materials). Compare results to soil textural classification chart to determine soil type. Test performed Yes No

Type A (clay, silty clay, sandy clay, clay loam, and in some cases silty clay, loam and sandy clay loam)
Type B [angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and in some cases, silty clay loam and sandy clay loam
Type C(granular soil including gravel, sand and loamy sand)

% granular

% cohesive

% silt

NOTE: Type A – no soil is Type "A" if soil is fissured; subject to vibration; previously disturbed; layered dipping into the excavation on a slope of 4H:1V.

SOIL CLASSIFICATION

Type A

Type B

Type C

SELECTION OF PROTECTIVE SYSTEM

Sloping, Specify angle:

Timber Shoring

Aluminum Hydraulic Shoring

NOTE: Although OSHA will accept the above tests in most cases, some states will not. Check your state safety requirements for trenching regulations.

Revision Date	Document Authorizer Name	Revision Details
10/1/2011	Chris McClain	Update

This safe work practice (SWP) has been prepared to address health and safety issues associated with haulage and earth moving at construction work sites. This SWP has been prepared to supplement a construction site health and safety plan (C-HASP).

1.0 APPLICABILITY

This SWP shall apply to all projects which involve hauling and earth moving activities. The project manager (PM) shall ensure application and adherence to this SWP. This SWP may be used as an attachment to a Tetra Tech Construction Health and Safety Plan (C-HASP).

2.0 HAULAGE AND EARTH MOVING

Haulage and earth moving requirements provided in this section are based on Article 10 of the California Construction Safety Orders. General, construction and maintenance, warning methods, operation, fueling, repair, and rollover protective structure requirements are defined in the following sections.

2.1. General Requirements

The following sections describe general requirements for haulage and earth moving on private roadways and off-highway conditions, dust control, equipment control, exhaust, and heat shields in the State of California. These requirements are based on CCR Title 8 Section 1590.

2.1.1 Private Roads and Off-Highway Condition

On single-lane private roads with two-way traffic shall be provided with turnouts. Where turnouts are not practicable, a control system shall be provided to prevent vehicles from meeting on such single-lane roads.

On private roads used for two-way traffic, arrangements shall be such that vehicles travel on the right side as much as possible. Signs shall be posted to clearly indicate variations from this system. Where practicable, separate haulage roads shall be provided between loaded and empty units. Haulage roads shall be wide enough to allow for safe passage. Safe distances between moving units shall be maintained.

NOTE: Left hand traffic patterns are permitted provided that vehicle operators are advised of the pattern and job site conditions warrant that the procedure is safe.

Private roads shall be maintained free from holes and ruts that affect the safe control of the vehicle. Emergency access ramps and berms used by an employer shall be constructed to restrain and control runaway vehicles.

Where a hazard exists to employees because of traffic or haulage conditions, a system of traffic controls shall be required so as to abate the hazard.

NOTE: Nothing in this SWP shall preclude the use of additional signs that are not included in the "Manual of Traffic Controls for Construction and Maintenance Work Zones". Examples include the following: "Haul Road," "Left Hand Pattern," "Scraper Crossing," etc.

Employees, such as grade-checkers, surveyors and others exposed to vehicular traffic, shall wear flagging garments, or equivalent, as required for flaggers in Document Control Number (DCN) 4-4 "Vehicle Use, Traffic Control, and Flaggers".

2.1.2 Dust Control

Action shall be taken to prevent dust from seriously reducing visibility. In dusty operations, equipment operators shall use adequate respiratory protection in accordance with the Tetra Tech Respiratory Protection Program (DCN 2-6).

2.1.3 Equipment Control.

Equipment shall be under control at all times and shall be kept in gear when descending grades.

No vehicle shall be driven at a speed greater than is reasonable and proper. Vehicles shall be operated with due regard for weather, traffic, intersections, width and character of the roadway, type of motor vehicle, and any other existing conditions.

2.1.4 Exhaust

Arrangements shall be made to direct exhaust gases away from the operator's breathing zone.

2.1.5 Heat Shields

When push-tractors are working in tandem, heat shields, or equivalent protection, shall be provided for operators.

2.2 Construction and Maintenance Requirements

The construction and maintenance requirements for haulage vehicles and equipment are listed below:

Windshields: Windshields complying with the applicable provisions of the state vehicle code shall be provided and maintained on haulage vehicles and scrapers.

Equipment and Accessories: Equipment and accessories installed on haulage vehicles shall be arranged so as to avoid impairing the driver's operational vision to the front or sides.

Brakes: Service brake systems for self-propelled, rubber-tired, off-highway equipment manufactured before January 1, 1972 (for scrapers January 1, 1971) shall meet minimum performance criteria for service brake systems as set forth in the Society of Automotive Engineers Recommended Practices listed below. Service, emergency and parking brake systems for self-propelled, rubber-tired, off-highway equipment manufactured after January 1, 1972 (for scrapers January 1, 1971) shall meet the applicable minimum performance criteria for each system as set forth in the same Society of Automotive Engineers Recommended Practices:

Self-Propelled Graders	SAE J236-1971
Trucks and Wagons	SAE J166-1971
Front-End Loaders and Dozers	SAE J237-1971
Self-Propelled Scrapers	SAE J319b-1971

Note: Equipment that meets the performance criteria of SAE Recommended Practice J1152-APR 1980, Braking Performance—Rubber-Tired Construction

Machines, satisfies the requirements of this Section.

Air Tank Service: Liquids should be drained automatically from vehicle's compressed air tanks, but if such automatic equipment is not provided, the tanks shall be drained manually at least once each operating shift.

Cab Shield: Haulage vehicles, whose pay load is loaded by means of cranes, power shovels, loaders, or similar equipment, shall have a cab shield and/or canopy adequate to protect the operator from shifting or falling materials.

Fenders complying with the following standards from SAE Recommended Practice J321, November, 1967 or J321b April, 1978, shall be provided on new scrapers, carryalls, related power units, and trailed hauling units manufactured and placed into service after January 1, 1971.

Lights: Whenever visibility conditions warrant additional light, all vehicles, or combinations of vehicles, in use shall be equipped with at least two headlights and two taillights in operable condition.

Canopy: Crawler tractors, bulldozers, carryalls and similar equipment manufactured and used prior to April 1, 1971, except for scrapers, front-end loaders and new equipment covered by 1596, shall have canopy protection and seat belts for the operator when used where there is exposure to falling or rolling objects.

Operating Levers: Operating levers controlling hoisting or dumping devices on haulage bodies shall be equipped with a latch or other device which will prevent accidental starting or tripping of the mechanism.

Trip Handles: Trip handles for tailgates of dump trucks shall be so arranged that in dumping, the operator will not be exposed either to the hazard of being struck by failing material or any part of the truck.

Dump Bodies: Haulage vehicles equipped with dump bodies that tilt to release their load by gravity through an opening at the rear or side shall be provided with a device that gives the operator a clearly audible or visible warning when sufficient force is applied by the elevating

mechanism to cause or sustain dump body elevation.

Hazard Signals: Tractor-scrapers (self-propelled) pushed by other equipment during loading operations shall be provided with a clearly audible or visible warning device that can be activated by the operator of the tractor-scraper to communicate an "ALL STOP" warning to the pushing equipment in event of an emergency.

2.3 Warning Methods

Every vehicle with a haulage capacity of 2 ½ cubic yards or more used to haul dirt, rock, concrete, or other construction material shall be equipped with a warning device that operates automatically while the vehicle is backing. The warning sound shall be of such magnitude that it will normally be audible from a distance of 200 feet and will sound immediately on backing. In congested areas or areas with high ambient noise which obscures the audible alarm, a signaler, in clear view of the operator, shall direct the backing operation.

Those vehicles not subject to the above circumstances and operating in areas where their backward movement would constitute a hazard to employees working in the area on foot, and where the operator's vision is obstructed to the rear of the vehicle shall be equipped with an effective device or method to safeguard employees such as:

- An automatic back-up audible alarm which would sound immediately on backing, or
- An automatic braking device at the rear of the vehicle that will apply the service brake immediately on contact with any obstruction to the rear, or In lieu of the above, administrative controls shall be established such as:
- A spotter or flagger in clear view of the operator who shall direct the backing operation, or
- Other procedures which will require the operator to dismount and circle the vehicle immediately prior to starting a back-up operation, or
- Prohibiting all foot traffic in the work area.

Other means shall be provided that will furnish safety equivalent to the foregoing for personnel working in the area.

All vehicles shall be equipped with a manually operated warning device which can be clearly heard from a distance of 200 feet.

The operator of all vehicles shall not leave the controls of the vehicle while it is moving under its own engine power.

Hauling or earth moving operations shall be controlled in such a manner as to ensure that equipment or vehicle operators know of the presence of rootpickers, spotters, lab technicians, surveyors, or other workers on foot in the areas of their operations.

2.4 Haulage Vehicle Operation

Vehicles shall not be operated at speeds which will endanger the driver or traffic.

Haulage vehicles shall be under positive control during all periods of operation. When descending grades, the vehicles shall be kept in gear.

When wire rope is being wound on a power-driven drum, a mechanical threading device shall be used, where practicable, to guide the cable. When this operation must be done manually, the feet shall not be used and the hands shall be kept at least 3 feet from the drum.

All vehicles in use shall be checked at the beginning of each shift to assure that the following parts, equipment, and accessories are in safe operating condition and free of apparent damage that could cause failure while in use:

- Service brakes, including trailer brake connections;
- Parking system (hand brake);
- Emergency stopping system (brake);

- Tires;
- Horn;
- Steering mechanism;
- Coupling devices;
- Seat belts;
- Operating controls; and
- Safety devices.

All defects affecting safe operation shall be corrected before the vehicle is placed in service. These requirements also apply to equipment such as lights, reflectors, windshield wipers, defrosters, fire extinguishers, and such where such equipment is necessary.

Exhaust Gases: Vehicle engines shall not be allowed to run in closed garages or other enclosed places, unless vents are provided which effectively remove the exhaust gases from the building.

Unstable Loads: Loads on vehicles shall be secured against displacement.

Tire Repair: Except for emergency field repairs, a safety tire rack, cage, or equivalent protection shall be used when inflating truck or equipment tires after mounting on a rim, if such tires depend upon a locking ring or similar device to hold them on the rim.

Parking Brakes: Whenever the equipment is parked, the parking brake shall be set. Equipment parked on inclines shall have the wheels chocked and the parking brake set or be otherwise prevented from moving by effective mechanical means.

Scissor points on all front-end loaders which constitute a hazard to the operator shall be adequately guarded.

A loader shall not travel without adequate visibility for the driver and stability of the equipment.

No loading device shall be left unattended until the load or bucket is lowered to the ground, unless proper precautions such as blocking are taken to prevent accidental lowering.

All high lift trucks (e.g., forklifts), industrial trucks, and rider trucks used on a construction site shall conform with the applicable orders in Article 25 of the General Industry Safety Orders and shall meet the following requirements:

- If a load is lifted by two or more trucks working in unison, the proportion of the total load carried by any one truck shall not exceed its capacity.

- Steering or spinner knobs shall not be attached to the steering wheel unless the steering mechanism is of a type that prevents road reactions from causing the steering hand wheel to spin. The steering knob shall be mounted within the periphery of the wheel.

- Loading buckets, scoops, blades or similar attachments on haulage vehicles shall not be used as work platforms or to elevate or transport employees.

2.5 Fueling

No internal combustion engine fuel tank shall be refilled with a flammable liquid while the engine is running. Fueling shall be done in such a manner that the likelihood of spillage is minimal. *If a spill occurs it shall be washed away completely, evaporated, or equivalent action taken to control vapors before restarting the engine.* Fuel tank caps shall be replaced before starting the engine.

A good metal-to-metal contact shall be kept between fuel supply tank or nozzle of supply hose and the fuel tank.

No open lights, welding, or sparking equipment shall be used near internal combustion equipment being fueled or near storage tanks.

No smoking shall be permitted at or near the gasoline storage area or on equipment being fueled. Post a conspicuous sign in each fuel storage and fueling area stating: "**NO SMOKING WITHIN 25 FEET**."

Class I liquids shall not be dispensed by pressure from drums, barrels, and similar containers. Approved pumps taking suction through the top of the container or approved self-closing faucets shall be used.

No repairs shall be made to equipment while it is being fueled.

Each fuel storage tank or drum shall have the word "Flammable" conspicuously marked thereon and should also have a similarly sized word indicating the contents of the container.

A dry chemical or carbon dioxide fire extinguisher rated 6:BC or larger shall be in a location accessible to the fueling area.

2.6 Repair of Haulage Vehicles, Tractors, Bulldozers and Similar Equipment

No repairs shall be attempted on power equipment until arrangements are made to eliminate possibility of injury, caused by sudden movements or operation of the equipment or its parts. When the equipment being repaired is a bulldozer, carryall, ripper, or other machine having sharp or heavy moving parts such as blades, beds, or gates, such parts shall be lowered to the ground or securely and positively blocked in an inoperative position.

All controls shall be in a neutral position, with the engine(s) stopped and brakes set, unless work being performed requires otherwise.

Trucks with dump bodies shall be equipped with positive means of support, permanently attached, and capable of being locked in position to prevent accidental lowering of the body while maintenance or inspection work is being done. In all cases where the body is raised for any work, the locking device shall be used.

2.7 Roll-Over Protective Structures (ROPS)

Requirements for ROPS are based on CCR Title 8 Section 1596 and are described in the following subsections.

2.7.1 General Requirements

ROPS and seat belts shall be installed and used on all equipment listed below:

- Scrapers, tractors, front-end loaders, bulldozers, motor graders and water wagon prime movers having brake horsepower ratings above 20. The provisions of this section do not apply to non-rider equipment.

Exceptions to this section include the following:

- Side boom, pipe-laying tractors.
- An operator restraining system, acceptable to the Division, shall be permitted to be used in lieu of the required seat belts on motor graders not designed for seated operations.
- ROPS or seat belts shall not be required for the equipment identified in above when loading/unloading from transportation vehicles on relatively flat surfaces.
- Rollers and compactors having a weight greater than 5,950 pounds.
- Rollers or compactors having segmented and/or sheepsfoot-type wheels or drums.

All rollers and compactors when operating under any of the following conditions:

- Parallel to and within 3 feet of a down slope steeper than 3 feet horizontal to 1 foot vertical, or
- Within 3 feet of a vertical or nearly vertical drop-off exceeding 1 foot in height, or
- On any grade exceeding 15 percent (10 feet horizontal to 1½ feet vertical)

2.7.2 ROPS Design Criteria

ROPS shall be in compliance with or equivalent to SAE Recommended Practice J-1040-a,

February, 1975, for equipment manufactured on or after April 1, 1971, or J1040c, April, 1979.

2.7.3 Overhead Protection

ROPS shall provide operator protection against the hazard of falling objects.

2.7.4 Retrofit Design Criteria

The basic design criteria for retrofit ROPS used on scrapers, tractors, front-end loaders, bulldozers, motor graders and water wagon prime movers manufactured prior to April 1, 1971, and for rollers and compactors manufactured prior to July 1, 1977 must meet the requirements defined in Section 1596(d).

2.7.5 Seat Belts

Seat belts shall be adequate for the intended service and in good repair. Belts shall meet the following requirements, which parallel those of SAE Recommended Practice J-386-a, November, 1973, and the applicable provisions of SAE Recommended Practice, J-4-c, July, 1965. The following requirements apply:

Adjustment: The seat belts shall be capable of snug adjustment by the occupant by a means easily within his reach or shall be provided with an automatic locking or emergency locking retractor.

Marking: Each seat belt shall be permanently and legibly marked or labeled with year of manufacture, model or style number and name or trademark of manufacturer or distributor, or of the importer if manufactured outside of the United States. Marking should also include indication of compliance with SAE Recommended Practice J-386-a, November, 1973.

Stiffness: To minimize "roping," the seat belt webbing shall be woven and/or treated to produce a stiffness in the transverse direction equal to or greater than that obtained with a weave of double plain with one up, one down binder, without stuffers. This stiffness shall be effective for the usable life of the webbing. The webbing shall be flexible in the longitudinal direction to permit adjustment to -40°F.

Material: The seat belt webbing material shall have a resistance to acids, alkalis, mildew,

aging, moisture and sunlight equal to or better than that of untreated polyester fiber. The webbing shall not be less than three (3) inches in width; its ends shall be protected or treated to prevent unraveling and the breaking strength shall be at least 6,000 pounds.

Release: The seat belt buckle shall be designed so that it can be easily released with a single motion. It shall also be capable of being released with either available mittened hand.

Closure: The seat belt buckle shall be designed so that it can be easily closed with mittened hands.

Location: When a two-piece belt is used, the adjustment means shall be on each half of the belt to allow for the centering of the buckle on the operator.

Operation: Each adjustment shall be capable of being made with the use of one mittened hand.

Tests: A typical complete seat belt assembly, including webbing, straps, buckles, adjustment and attachment hardware, and retractors, shall be capable of passing the following destructive tests:

- The assembly loop shall withstand, without failure, a force of not less than 5,000 pounds and each structural component of the assembly a force of not less than 2,500 pounds.
- The length of the assembly loop between anchorages shall not increase more than 14 inches and each half of the assembly loop shall not increase more than 7 inches when subjected to a force of 5,000 pounds.
- Any webbing cut by the hardware during testing shall have a breaking strength at the cut of not less than 4,200 pounds.
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10/1/2008	Chris McClain	Update from 1998 format

Tetra Tech, Inc. (Tetra Tech) has established the lead protection program based on requirements outlined in 29 CFR Part 1926.62, Lead. This program applies to all employees who may be occupationally exposed to lead during construction activities. Situations in which the lead standard may apply during Tetra Tech work tasks include the following:

- Removal and encapsulation of materials containing lead
- Releases of lead during an emergency clean up
- Transportation, disposal, storage, or on-site containment of lead or materials containing lead where construction activities are performed
- Maintenance operations associated with the activities above

Tetra Tech will implement engineering and work practice controls, including administrative controls, to reduce or minimize employee exposure to lead whenever feasible. A written compliance plan that describes how Tetra Tech will comply with the lead standard will be included with the project's health and safety plan (HASP) whenever applicable. The compliance plan will detail activities, controls, air monitoring results, and other information relevant to the work that involves exposure to lead.

The sections below describe Tetra Tech's (1) lead protection policy, (2) field procedures to prevent or minimize exposure to lead, (3) medical surveillance procedures, (4) employee information and training, and (5) recordkeeping requirements.

1.0 LEAD PROTECTION POLICY

Tetra Tech, Inc. will ensure that no employee is exposed to lead at concentrations greater than 50 micrograms per cubic meter ($\mu g/m^3$) of air averaged over an 8-hour period. This level is the Occupational Safety and Health Administration's permissible exposure limit (PEL) for lead. Short exposures to lead above the PEL are permitted as long as the average exposure does not

exceed the PEL in an 8-hour workday. Daily exposure to lead can extend beyond a typical 8-hour workday as the result of overtime or other alternations in an employee's work schedule. If an employee is exposed to lead for more than 8 hours, the allowable time weighted average (TWA) concentration for that day will be reduced as calculated using the following formula:

$$\frac{400}{\text{Hours worked in the day}} = \text{Allowable employee exposure (in } \mu\text{g/ m}^3\text{)}$$

For example, for an employee exposed to lead during a 10-hour shift, the allowable exposure is 40 µg/m^3.

$$\frac{400}{10 \text{ hours}} = 40\ \mu\text{g/ m}^3$$

Tetra Tech will not calculate an employee's lead exposure by averaging the exposure level with and without respiratory protection as allowed under Paragraph (c)(3) of the lead standard.

The action level for airborne lead is 30 µg/m^3 as an 8-hour TWA. This value does not consider the use of respirators.

2.0 FIELD PROCEDURES

Field procedures that Tetra Tech will use to prevent or minimize employee exposure to lead include exposure assessment and observation, use of personal protective equipment (PPE), including respiratory protection and protective work clothing, housekeeping procedures, hygiene, and sign posting.

2.1 Exposure Assessment and Observation

If lead is present at a work site in any form, the Tetra Tech site safety coordinator (SSC) will make an initial determination of whether the action level may be exceeded. This initial determination includes instrumental monitoring of the air for lead and must indicate exposure of

a representative number of employees reasonably believed to be exposed to the highest levels. The sampling results may be used to make decisions about appropriate controls and PPE use. If any employee complains of symptoms that may be attributable to lead exposure or if any other information or observations indicate employee exposure to lead, this information must also be considered as part of the initial determination. If an initial determination shows that a reasonable possibility exists that any employee may be exposed to lead above the action level (without regard to the use of respirators), an air monitoring program to determine the exposure level of every employee will be conducted.

When air monitoring for lead is performed, Tetra Tech will allow the employee or a designee to act as an observer of the monitoring. Observers are entitled to an explanation of the measurement procedure and a record of the results obtained. Because results will not normally be available at the time of the monitoring, observers are entitled to an explanation of the measurement procedure and to record the results obtained. Tetra Tech will provide the observer with any PPE required by employees working in the area being monitored. Tetra Tech also requires any observer to wear all such equipment and to comply with all applicable health and safety procedures.

2.2 Respiratory Protection

When engineering and work practice controls are not feasible or sufficient to reduce exposures to or below the lead PEL, Tetra Tech will require employees to use respiratory protective equipment. Tetra Tech has established a Respiratory Protection Program to provide and ensure safe and appropriate use of respirators when exposure to airborne contaminates is not controlled below the PEL by other means. The cost of respirators is paid for by Tetra Tech. Tetra Tech may also be required to provide on-site employees with respirators even if air exposure levels do not exceed the PEL. An employee may request a respirator when, for example, medical advice

suggests that lead absorption should be decreased. Employees who intend to have children in the near future can also request a respirator to minimize adverse reproductive effects. During the preparation of the HASP, Tetra Tech will ensure that respirators are chosen, fitted, worn, cleaned, and maintained properly during use, and replaced when they stop providing adequate protection.

Tetra Tech will select respirators that have been approved by the National Institute for Occupational Safety and Health (NIOSH). The respirator selected will provide a proper amount of protection based on the anticipated concentration of airborne lead at each site. Selection will also be based on information provided in Table 1 of 29 CFR Part 1926.62. A respirator that provides a greater level of protection than required may be chosen by the employee.

Air purifying respirators will use P-100 or equivalent filters. Employees should change the filters whenever breathing becomes difficult. Respirator wearers are permitted to periodically leave the work area to wash their faces and respirator face pieces whenever necessary to prevent skin irritation. Medical surveillance must be conducted prior to respirator usage. Results of the medical surveillance examination may indicate that an alternative means of respiratory protection is needed.

The Tetra Tech Respiratory Protection Program ensures that the respirator face piece fits properly. Tetra Tech employees receive proper training in the use of respirators during an initial 40-hour health and safety training course and through subsequent annual, in-house, 8-hour refresher training courses. Tetra Tech instructs employees in how to wear a respirator, why it is needed, and its limitations.

2.3 Protective Work Clothing and Equipment

If an employee is exposed to lead above the PEL or if exposure can cause skin and eye irritation, Tetra Tech will provide appropriate protective work clothing and equipment for the hazard. Appropriate protective work clothing and equipment may include cotton coveralls or similar full-body work clothing, gloves, hats, shoes or disposable shoe covers, and face shields or vented goggles. All equipment is provided to staff at no cost.

Tetra Tech is responsible for repairing and replacing clothing and equipment when necessary and for cleaning, laundering, and disposing of protective clothing and equipment. Contaminated work clothing or equipment must be removed in changing rooms and must not be worn home. Contaminated clothing to be cleaned, laundered, and disposed of must be placed in a closed, impermeable container in a changing room. At no time may contaminants be removed from protective clothing or equipment by means that may disperse the lead contamination into the air.

2.4 Housekeeping

The Tetra Tech SSC will ensure that all surfaces are maintained so that they are as free as practicable of accumulations of lead. Floors and other surfaces where lead accumulates will be cleaned by vacuuming or other methods that minimize the likelihood of lead becoming airborne. Vacuums will be equipped with high efficiency particulate air (HEPA) filters.

2.5 Personal Hygiene

Changing rooms, showers, and filtered or fresh air lunch areas will be made available to workers exposed to airborne lead above its PEL. Changing rooms, showers, and lunch areas that are free of lead contamination must be provided to workers exposed to lead in excess of the PEL. After showering, no work clothing (including shoes and underwear) or work equipment may be worn home. Clothing used during the shift should be carefully separated from street clothes so that

cross contamination does not occur. Employees may not enter the lunch area while wearing protective clothing or equipment unless dust on the clothing has been removed by HEPA vacuuming, downdraft decontamination booths, or other methods. Finally, workers exposed to lead must wash their hands and face prior to eating, drinking, smoking, or applying cosmetics. In areas where the PEL is exceeded, the Tetra Tech SSC will ensure that food and beverages are not present or consumed, tobacco products are not present or used, and cosmetics are not applied. If Tetra Tech is unable to provide showers, the SSC will ensure that employees wash their hands and face at the end of each work shift.

2.6 Sign Posting

The Tetra Tech SSC will post appropriate warning signs in each work area where employee exposure to lead is above the PEL. The signs will read as follows:

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR
EATING

The Tetra Tech SSC will ensure that the signs remain legible.

3.0 MEDICAL SURVEILLANCE

Medical surveillance can determine if personnel have been effectively protected. Effective implementation of the exposure controls defined in this program will protect most workers from the adverse effects of exposure but may not satisfactorily protect individual workers who (1) have high body burdens acquired over the past years, (2) have additional uncontrolled sources of

of nonoccupational exposure, (3) exhibit unusual lead absorption rates, or (4) have specific, nonwork-related medical conditions that could be aggravated by exposure (for example, renal disease and anemia). In addition, control systems may fail or hygiene and respirator programs may be inadequate. Periodic medical surveillance of individual workers will help detect potential failures of protective measures.

All required medical surveillance must be performed by or under the supervision of a licensed physician. Medical surveillance is provided without cost to employees at a reasonable time and place. The medical surveillance program provides biological monitoring of lead and provides special medical examinations based on a case-by-case need.

Tetra Tech shall make an initial medical surveillance examination available to any employee exposed to lead on any day at or above the action level of 30 µg/m^3 (8-hour TWA) for more than 30 days in any consecutive 12-month period. The initial medical surveillance will consist of a full examination and blood sampling for lead and zinc protoporphyrin (ZPP) levels to establish a baseline level to which subsequent data may be compared. The blood lead and ZPP tests are known as biological monitoring. The full examination is discussed in the Tetra Tech, Inc. Health and Safety Manual, Document 3-2, Medical Surveillance.
Tetra Tech shall notify each employee in writing of the results of his or her blood lead level within 5 working days of the receipt of the biological monitoring results.

The biological monitoring will be conducted at least every 2 months for the first 6 months and every 6 months thereafter. If a worker's blood lead level is at or above 40 µg per 100 milliliters (mL), the monitoring frequency must be increased from every 6 months to at least every 2 months and must not be reduced until two consecutive blood lead level tests indicate a lead level

below 40 µg per 100 mL. An employee whose blood lead level exceeds 40 µg per 100 mL will be temporarily removed from the work area with medical removal protection benefits.

Medical examinations will also be conducted annually on employees exposed to lead above the action level and on an employee whose blood lead level exceeded 40 µg per 100 mL at any time during the preceding year. A medical examination or consultation will also be conducted as soon as possible after an employee notifies Tetra Tech that he or she is experiencing signs or symptoms commonly associated with acute lead poisoning or that he or she has difficulty breathing while wearing a respirator or during a respirator fit test. Employees will also be offered a medical examination or medical advice concerning the effects of current and past exposure and their ability to bear healthy offspring.

If a need for multiple physician reviews arises, Tetra Tech will consult 29 CFR Part 1926.62(j)(iii) of the lead standard for proper procedures.

Employees are not permitted to engage in prophylactic chelation unless under the direct supervision of a licensed physician in a clinical setting and the knowledge of Tetra Tech.

Tetra Tech will remove an employee from work who has an exposure to lead at or above the action level and who exhibits a blood lead level at or above 50 µg per 100 mL. This removal will be
conducted in accordance with the requirements of 29 CFR Part 1926 (k), Medical Removal Protection, of the lead standard.

4.0 EMPLOYEE INFORMATION AND TRAINING

Tetra Tech will communicate the hazards of lead in accordance with the Hazard Communication standards for both general and construction industries, 29 CFR 1910. 1200 and 29 CFR 1926.59, respectively. Tetra Tech will train affected employees on the following topics:

- Contents of the lead standard
- Work operations involved
- Purpose of respiratory protection
- Medical surveillance requirements
- Engineering and work practice controls
- Contents of the compliance plan
- Restriction of chelation agents
- Rights to medical records

5.0 RECORDKEEPING

As required by the lead standard, Tetra Tech will establish and maintain an accurate record of the following:

- Exposure assessments
- Medical surveillance records for each individual
- Medical removal records for each individual

Records will be made available for review or copying to affected employees, former employees and their designated representatives, and the Assistant Secretary of OSHA and Director of NIOSH when requested in writing. Records will be properly transferred if Tetra Tech ceases to do business.

To prevent injuries and adverse health effects, the following general safe work practices (SWP) are to be followed when conducting work involving known and unknown site hazards. These SWPs establish a pattern of general precautions and measures for reducing risks associated with field operations not conducted on hazardous waste sites. This list is not inclusive and may be amended as necessary.

- Be familiar with and knowledgeable of and adhere to all instructions in the construction health and safety plan (C-HASP), job safety analysis, job hazard analysis, work permit or other health and safety documentation.
- At a minimum, a safety meeting will be held at the start of each project to discuss the hazards of the site and site work. Additional meetings will be held, as necessary, to address new or continuing safety and health concerns.
- Be aware of the location of the nearest telephone and all emergency telephone numbers.
- Attend a briefing on the anticipated hazards, equipment requirements, SWPs, emergency procedures, and communication methods before going on site.
- Plan and delineate entrance, exit, and emergency escape routes.
- Rehearse unfamiliar operations prior to implementation.
- Use the “buddy system” whenever respiratory protection, fall protection, or other protective equipment is in use. Buddies should establish hand signals or other means of emergency communication in case radios break down or are unavailable.
- In order to assist each other in the event of an emergency, buddies should maintain visual contact with each other and with other on-site team members by remaining in close proximity.
- Do not bring nonessential vehicles and equipment onto the site.
- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the site safety coordinator (SSC).
- Maintain a portion of the site field logbook as a project safety log. The project safety log will be used to record the names, entry and exit dates, and times on site of all Tetra Tech personnel, subcontractor personnel, and project site visitors; and other information related to safety matters.

- A portable eyewash station should be located in the support zone if corrosive materials are used or stored on the site.
- Smoking is not allowed on Tetra Tech projects sites, except in designated smoking areas.
- Do not bring matches and lighters in the exclusion zone or contamination reduction zone.
- Observe coworkers for signs of toxic exposure and heat or cold stress.
- Inform coworkers of nonvisual effects of illness if you experience them, such as headaches, dizziness, nausea, or blurred vision.
- Anyone known to be under the influence of drugs or intoxicating substances that impair the employee's ability to safely perform assigned duties shall not be allowed on the job while in that condition.
- Horseplay, scuffling, and other acts that tend to have an adverse influence on the safety or well-being of the employees is prohibited.
- Work shall be well planned to prevent injuries in the handling of materials and when working with equipment.
- No one shall knowingly be permitted or required to work while the employee's ability or alertness is so impaired by fatigue, illness, or other causes that might unnecessarily expose the employee or others to injury.
- Use proper lifting techniques. Heavy objects will be lifted using the large muscles of the leg instead of the smaller muscles of the back.
- Wear appropriate footwear and all other protective equipment required for work.
- Cleanse thoroughly after handling hazardous substances.
- Maintain all tools and equipment in good condition.
- First aid kits shall be located in a prominent location and stocked with basic first aid supplies.

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	TETRA TECH, INC. GENERAL SAFE WORK PRACTICES for HAZARDOUS WASTE SITE ACTIVITIES	Revision Date: 10/1/2008 Document Control Number: SWP 5-2 Page 1 of 3

To prevent injuries and adverse health effects, the following general safe work practices (SWP) are to be followed when conducting work involving known and unknown site hazards on hazardous waste sites. These SWPs establish a pattern of general precautions and measures for reducing risks associated with hazardous site operations. This list is not inclusive and may be amended as necessary.

- Do not eat, drink, chew gum or tobacco, take medication, or smoke in contaminated or potentially contaminated areas or where the possibility for contact with site contamination exists.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. If a source of potable water is not available at the work site that can be used for hands-washing, the use of waterless hand cleaning products will be used, followed by actual hand-washing as soon as practicable upon exiting the site. A thorough shower and wash must be conducted as soon as possible if excessive skin contamination occurs.
- Avoid contact with potentially contaminated substances. Do not walk through puddles, pools, mud, or other such areas. Avoid, whenever possible, kneeling on the ground or leaning or sitting on drums, equipment, or the ground. Do not place monitoring equipment on potentially contaminated surfaces.
- Remove beards or facial hair that interferes with a satisfactory qualitative respirator fit test or routine pre-entry positive and negative pressure checks.
- Be familiar with and knowledgeable of and adhere to all instructions in the site-specific health and safety plan (HASP). At a minimum, a safety meeting will be held at the start of each project to discuss the HASP. Additional meetings will be held, as necessary, to address new or continuing safety and health concerns.
- Be aware of the location of the nearest telephone and all emergency telephone numbers.
- Attend a briefing on the anticipated hazards, equipment requirements, SWPs, emergency procedures, and communication methods before going on site.
- Plan and delineate entrance, exit, and emergency escape routes.
- Rehearse unfamiliar operations prior to implementation.

- Use the "buddy system" whenever respiratory protection equipment is in use. Buddies should establish hand signals or other means of emergency communication in case radios break down or are unavailable.
- Buddies should maintain visual contact with each other and with other on-site team members by remaining in close proximity in order to assist each other in case of emergency.
- Minimize the number of personnel and equipment in contaminated areas (such as the exclusion zone). Nonessential vehicles and equipment should remain within the support zone.
- Establish appropriate support, contamination reduction, and exclusion zones.
- Establish appropriate decontamination procedures for leaving the site.
- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the site safety coordinator (SSC).
- Maintain a portion of the site field logbook as a project safety log. The project safety log will be used to record the names, entry and exit dates, and times on site of all Tetra Tech personnel, subcontractor personnel, and project site visitors; air quality and personal exposure monitoring data; and other information related to safety matters. Form SSC-1, Daily Site Log, may be used to record names of on-site personnel.
- A portable eyewash station should be located in the support zone if chemical splashes to eyes are possible.
- Do not bring matches and lighters in the exclusion zone or contamination reduction zone. Flames and open fires are not permitted on site.
- Observe coworkers for signs of toxic exposure and heat or cold stress.
- Inform coworkers of nonvisual effects of illness if you experience them, such as headaches, dizziness, nausea, or blurred vision.

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10/1/2008	Chris McClain		Update from 1998 format
	Rick Lemmon		

1.0 PURPOSE

The purpose of this procedure is to identify minimum requirements, and to provide guidance to Tetra Tech Inc. (Tetra Tech) project personnel concerning the management of construction tools and equipment on construction projects.

2.0 SCOPE

This procedure applies to all Tetra Tech projects that include a construction, O&M, and/or UXO component, including remediation construction.

3.0 MINIMUM REQUIREMENTS

3.1 Definitions

3.1.1 Construction Equipment

For the purposes of this procedure, construction equipment shall mean heavy equipment, such as excavators, scrapers, off-road trucks, dozers, road graders, compactors, dredges, and cranes; light equipment, such as skid-steers, forklifts, generators, and light plants; and operating systems such as screens, crushers, conveyors, pugmills, mobile treatment plants, and pumps. Any discussion of construction equipment shall be understood not to include cars, pickup trucks, flatbed trucks, etc. registered for use on public roadways, which shall be called vehicles hereinafter. Also for the purposes of this procedure, construction equipment shall be synonymous with Contractor's Equipment, a term also commonly used in the construction industry to designate the types of equipment described above.

3.1.2 Terms

The terms "should, may, and might" as used in statements in this procedure are intended to denote a discretionary consideration; the terms "shall & must" are intended to impose a mandatory requirement. The terms "is, are, & will" as used in statements in this procedure are intended to denote discretionary or mandatory requirements that are addressed in other department/disciplines' procedures. However, nothing contained herein should be interpreted as to prohibit development and approval of project-specific procedures or plans that take exception to mandatory direction presented in this procedure provided that the appropriate level of approval, (Executive Vice President of Construction, Business Line Executive Vice President, or the Vice President ESQ Services as appropriate) is obtained for deviations from such requirements.

3.1.3 Tools of the Trade

Specific hand tools and or equipment (e.g., manlifts, trucks, trenchers, and pumps) normally provided by or to workers for the performance of their particular work activity.

3.2 Roles & Responsibilities

3.2.1 Equipment Supervisor

Depending on the project's equipment needs, an individual may be designated as the Equipment Supervisor. Responsibilities of the Equipment Supervisor include:

- Determination of the equipment needs for the project;
- Providing input to the Work Plan concerning equipment;
- Identification of Contract and legal/regulatory requirements for mobilization of equipment on client facilities;
- Submit required certifications, inspection reports, and test reports for equipment;
- Arranging for the mobilization/demobilization of equipment in support of the project's schedule, providing required notices, such as mobilization details and dates, and obtaining Contractual or legally required approvals for mobilization;
- Receipt inspection of equipment arriving at the site, including coordination of any client or third party inspection;
- Coordination with equipment yard personnel or vendors regarding equipment maintenance;
- Ensuring implementation of safe work practices for equipment utilization; and
- Assuring that the return of demobilized equipment is performed in accordance with the terms of the rental/lease/PO agreement and documented correctly, or, for Tetra Tech owned equipment, that the equipment transfer form is completed and coordinated with the Equipment Manager; and
- All other responsibilities as assigned by the Project Manager or Site Supervisor

3.3 Safe Operation Requirements for Tools

3.3.1 Manual T-Post Drivers

There shall be no use of manual fence post drivers, such as those typically used to drive T-posts, without prior approval from the Site Safety Coordinator or the Vice President of Construction. Any approval of the use of such a tool shall require the implementation of an Activity Hazard Analysis (AHA) to identify and control the hazards presented by the tool. The AHA shall address appropriate PPE and position for the task in order to avoid injury to the worker.

3.3.2 Tools

The Site Supervisor shall determine the nature and quantity of tools required for the construction effort and shall ensure that adequate tools are provided in support of the schedule.

Tools may be assigned to workers or crews for the duration of their activities and shall be stored in gang boxes or other secured storage areas when not in use.

The Site Supervisor may designate certain tools to be issued from a tool control area on a daily basis. These tools should be signed out at the beginning of the work, returned to the tool control area at the end of the work, and signed back in.

3.3.3 Worker Provided Personal Tools

Workers may be required to provide personal tools of the trade for their particular work. Master mechanics, for example, may be required to provide tools required for repairs and maintenance of construction equipment and vehicles. Requirements for workers to provide their own tools shall be established based on the project requirements and shall be discussed at the Pre-Job Conference to be held in accordance with the requirements of the Labor Relations Guidelines LR-8, Pre-Job Conferences.

Any worker required or offering to provide personal tools shall be required to present a list of personal tools being provided upon reporting to the project site. The Site Supervisor shall inventory the tools against this list for verification that all listed tools have been provided. The list shall then be maintained for use in performing an inventory of the tools when the worker is to leave the site at the end of the worker's assignment and shall be the basis for any claims for loss or damage.

The Site Supervisor shall ensure that any personal tools brought onto the project site receive a safety inspection. The safety inspection shall include as a minimum, the items addressed in Section 3.3.4 of this procedure.

The Site Supervisor should ensure that secure, lockable facilities are provided for the storage of worker provided personal tools.

The worker shall be responsible for notification of lost or damaged tools immediately on discovery of the loss. The limits of the project's liability (if any) for loss or damage to personal tools provided by the workers should be established at the Pre-Job Conference.

Use of personal tools, other than addressed above, either by manual or by Tetra Tech nonmanual personnel, should not be allowed except as specifically authorized by the Project Manager or Site Supervisor. Project personnel should be notified that Tetra Tech will not be liable for any theft, loss, or damage of unauthorized personal tools on the project site.

3.3.4 Tool Safety Inspection

OSHA 29 CFR Part 1926 Subpart I Tools – Hand and Power provides guidance for tool safety. All tools shall be inspected for the following minimum features by the person using the tool prior to starting the work:

- Proper general condition of tools, electrical cords, and air hoses;
- Presence and serviceability of guards and safety devices;
- Proper electrical grounding or double insulation protection;
- Power tools properly equipped with constant pressure switches;
- Tool retainers installed on pneumatic tools;
- Proper adjustment of the tool; and
- Confirming that the load rating of the tool is sufficient for the work to be performed.

Unsafe tools shall be removed from service and the Site Supervisor advised of the condition for corrective action. An Out of Service tag should be placed on all unsafe or defective tools to prevent their inadvertent use by others. These tools should be physically segregated from the acceptable tools.

3.3.5 Environmental Safety and Quality Policy Implementation

Proper selection of construction equipment can impact employee health, consideration should be given to ergonomic design when selecting construction equipment.

Selection of construction equipment and vehicles may have significant impacts on the environment, either adverse or beneficial. Proper selection of the size and type of equipment and vehicles can reduce the adverse impacts from their operation.

Project procurement practices for construction equipment, parts, supplies, lubricants, and fuel shall be consistent with the principles of pollution prevention. For example, consideration should be given to such factors as rent versus buy options, disposable versus reusable filters, recycled versus virgin oils/fluids, recycling versus disposal of spent fluids and used parts, and fuel efficiency and economy of operation.

Spent fluids, filters, and used parts shall be recycled to the extent practical, or otherwise disposed of in accordance with the environmental compliance elements of the Work Plan or EHS plan.

Proper utilization of construction equipment and vehicles can also reduce adverse impacts on the environment. (For example, it is Tetra Tech's policy to not allow unattended equipment and vehicles to be left with motors running. This is not only a safety consideration; it reduces adverse environmental impacts and is generally cost effective due to reduced fuel consumption.)

3.3.6 Insurance

The Project Manager shall ensure that all construction equipment, including Tetra Tech-owned or rental/lease equipment, is covered by appropriate insurance policies for the intended use of the equipment. Property insurance on construction equipment is normally arranged by Tetra Tech if Tetra Tech bears the risk of loss or if Tetra Tech is required to arrange such insurance. However, all rented/leased construction equipment valued in excess of $100,000, and all cranes regardless of their value shall be reported to the Administration and Compliance Department via the 'Insurance Request for Leased Equipment' (Attachement 5, and available in Tetra Links and from procurement) for specific inclusion under the Tetra Tech property insurance policy. The procurement representative should be contacted to ensure that this

occurs in each case. Notification is not required for equipment valued under $100,000 except when the construction equipment provider requests a certificate of insurance be provided, or the equipment is a crane.

The Project Manager, usually through the designated procurement representative, should ensure that duplicate insurance coverage is not provided through the equipment provider since this will increase the rental rates. In those cases where the provider requires insurance certificates to verify coverage by Tetra Tech, the procurement representative should be contacted to obtain the appropriate documentation.

A Vehicle Insurance Form (available from the Vehicle Insurance Coordinator, Tetra Links or procurement) shall be processed and sent to the Vehicle Insurance Coordinator for all vehicles (leased, rented, or owned) which are registered and operated off jobsites on public highways.

3.3.7 Receipt and Inspection

All construction equipment shall be subject to a receipt inspection by a competent person and any Contract or otherwise required additional person(s) prior to acceptance at the project site. The inspections and tests shall be in accordance with the manufacturer's recommendations. Most vendors provide a form for notation of any existing damage to the equipment to be filled out on receipt. The equipment should be inspected carefully to determine its condition, including any damage, missing or non-functional equipment. The agreement should be used as a basis to determine that everything required (e.g., the equipment, its condition, manuals, spares, documentation of inspections, and certifications) has been provided. All discrepancies should be noted on the form. A pre-inspection of the equipment prior to transport to the Project site should be considered. Particular attention shall be given to the following items:

- All safety equipment and its condition;
- Operator (when provided) certification for the equipment;
- Posted operating and safety instructions;
- All pollution control devices and their condition;
- Safe entry and egress, with steps, ladders, handholds, and platforms provided as required, including safe access to perform routine checks, maintenance, and refueling operations;
- Leaking fluids, such as hydraulic oil, engine oil, transmission fluid, and coolant;

- Deteriorated or cracked hydraulic and coolant hoses which could result in leaks or spills;
- Guard belts, gears, shafts, pulleys, fly wheels and other reciprocating, rotating or moving parts shall be guarded to protect workers from becoming caught on, in or between machinery; and
- Presence of the manufacturer operation and maintenance manual.

Equipment or vehicles with deficient conditions relating to safety or protection of the environment shall not be placed into service until the deficiencies have been corrected and documented.

All construction equipment shall be subject to an operational check prior to acceptance at the project site. The operational check should verify that the equipment has the capability to function as intended or as required through the full range of its intended use.

Receipt of construction equipment shall be documented; with a copy of the receipt inspection report provided to the Equipment Supervisor and to the equipment purchase order file. Documentation should include entries for date and time of receipt, condition of equipment, mileage or engine hours at time of receipt, information on next scheduled maintenance, and a record of operating and maintenance manuals received with the equipment. Photographs or a video record of the equipment on receipt should be taken if conditions are noted that would warrant further documentation.

Construction equipment providers will often include terms and conditions on receipt documentation to be signed when construction equipment is delivered to the project site. **Project personnel requested to sign this receipt documentation shall not sign any delivery forms unless authorized to do so by Legal of the Project Manager. Further, if they are required to sign delivery forms, they shall be instructed to cross out all terms and conditions, on both the front and back of the forms, before signing.** Alternately, the person receiving the construction equipment should enter the following statement in the immediate vicinity of their signature: “In lieu of the terms and conditions set forth on this document, the Original Purchase Order (or appropriate form of agreement) terms and conditions apply to the receipt of this item(s).” These actions are necessary to avoid acceptance of additional or different terms and conditions.

Construction equipment delivered to the project site should be accompanied with operating and maintenance manuals. Cranes and lifting equipment shall include certification of satisfactory completion of annual inspection and have load charts posted in the cab. Additionally, some

construction equipment may be supplied with common replacement parts, such as filters and belts, and any specialized tools required for routine operation or maintenance. (i.e. forks, buckets, lift arms, and tool carries) These items should be carefully inventoried upon receipt, and documented on the receipt inspection report. Responsibility for protection and maintenance of the construction equipment shall be verified, and all measures necessary to protect the construction equipment from damage or loss will be instituted in accordance with the agreement, operating, and maintenance manuals or other instructions as appropriate.

Disposition requirements for construction equipment found to not be in accordance with the rental/lease/sale agreement when received shall be confirmed with the vendor immediately.

A sample Equipment/Vehicle Inspection Report is included as Attachment 1 to this procedure.

3.3.8 Protection from Environmental Extremes

Consideration shall be given to the environmental conditions to which the construction equipment will be exposed to during its time at the project site or during transportation. The manufacturer's instructions shall be reviewed and followed to ensure adequate protection from damage due to environmental conditions.

Adequate protection to the construction equipment's cooling system shall be verified by ensuring that the appropriate coolant/antifreeze mixture, as recommended by the manufacturer, has been used.

Appropriate procedures for operating or storing construction equipment, such as water treatment systems, shall be developed in accordance with the manufacturer's instructions. Measures such as draining and venting the system, providing auxiliary heat sources (e.g., heat tape), dry storage, shaft rotation, fluid levels, shall be taken to protect construction equipment subject to damage from environmental conditions.

Manufacturer's instructions concerning periodic operation of construction equipment shall be followed.

A means of ensuring that appropriate protective measures are instituted and performed as required should be implemented through the establishment of site procedures, logs, and/or checklists.

3.3.9 Equipment Inspections

All construction equipment shall be inspected daily (when in use) for safety and operability, including manufacturer's recommended daily inspections. The inspection form/checklist should note any deficiencies for correction and serve as documentation of the inspection performance. The Equipment Supervisor shall be notified of any deficiency immediately. A Daily Equipment Inspection form, a sample of which is included as Attachment 2 to this procedure, should be filled out at the start of the shift and provided to the Equipment Supervisor. Other supplemental forms which may be used in conjunction with Attachment 2 are the equipment specific "Pre-operation Inspection" and/or "Function Tests" forms, which are normally supplied by the equipment manufacturer. This information is usually found in the equipment's Operation Manual.

Government property control procedures usually require the implementation of a vehicle utilization log for vehicles when used on government projects; other projects should also implement a similar system for logging use of these vehicles. The log should be kept in the vehicle and an entry made for each use, including name of the driver, purpose of the trip, starting mileage, ending mileage, fuel purchased, maintenance performed, and any damage incurred. The log sheets should be transmiTetra Teched as required in the contract documents and the project's documentation plan. Copies of the log sheets will be maintained and filed as discussed in Section 3.3.12 of this procedure.

A separate Daily Equipment Inspection Report should be filled out for each shift if construction equipment is utilized on multiple shifts.

The Equipment Supervisor should use the information on Daily Equipment Inspection forms to schedule any repairs or preventive maintenance required for the equipment. Equipment with missing or defective safety features should not be put in service until repairs have been performed to bring the equipment into compliance with any applicable Tetra Tech H&S Program and/or regulatory requirements.

Implementation of the daily equipment inspections should be the subject of periodic verification inspections performed by the Project Manager, Site Supervisor, and/or the Site Safety Coordinator (SSC). These periodic inspections should include verification that the required maintenance is being performed in a timely manner to ensure that unsafe conditions or impacts to the environment (e.g., spills, releases, and discharges) are not created by delays in correcting deficiencies noted on the Daily Equipment Inspection Forms.

Rigging equipment, wire rope, nylon or KEVLAR slings and chokers shall be inspected by a competent person prior to use each shift; particular attention shall be paid to the rigging condition and presence of load/certification tags.

Cranes (weight handling equipment) shall be subjected to annual and certification inspections per OSHA guidelines. Mobile and crawler cranes shall be inspected on a monthly basis; a sample checklist form is included as Attachment 3 to this procedure.

Construction equipment to be demobilized shall be given a final inspection, similar to the receipt inspection, to identify and document, by means of written description and pictures, the condition of the equipment as it leaves the project site. Where possible, a concurrent inspection by the vendor is preferred. Additionally, some projects, particularly USACE projects, require a certificate of decontamination prior to the equipment leaving the site.

3.3.10 Operator Qualifications

Tetra Tech employees operating vehicles or construction equipment on public rights of way shall be required to have in their possession a valid driver's license appropriate to the location where the item is being operated and containing the appropriate endorsement for the type of vehicle or construction equipment being operated. A Commercial Driver's License (CDL) may be required for operation of some construction equipment on public rights of way, or as a specific requirement of a client's safety program. In addition, individual states may require specific licenses or certifications for operators of certain equipment, such as forklifts, and hoisting equipment. Additionally, the client's safety program may include license or certification requirements for personnel operating equipment on their property. The contract documents should be reviewed carefully to ensure that any such requirements are incorporated into the project's Work Plan or HASP. The Site Supervisor shall verify that the operator possesses the required license(s). Copies of licenses should be maintained in the on-site project employee file.

Any agreements for the rental or lease of vehicles or equipment should be reviewed for any provider's requirements for licensing or certification of operators to ensure that any such requirements are incorporated into the project's Work Plan or HASP.

Operators shall be required to demonstrate their proficiency in operating the construction equipment to be assigned to them prior to being allowed to work. Crane operators shall have qualifications for the type of crane to be operated.

Operator proficiency may be demonstrated through a performance test such as those

developed by the International Union of Operating Engineers, or by equipment manufacturers such as Caterpillar. These performance tests include exercises developed to demonstrate operator proficiency in various aspects of equipment operation, including daily operator inspections, ability to follow directions, ability to understand equipment limitations and operating guidelines, safety, and productivity. Also included are checklists that assist an observer in evaluating all of the various aspects of equipment operation. Attachment 4 is an example of Operator/Driver Observation Checklist.

Where it is not possible or practical to demonstrate operator proficiency through a performance test as described above, there should be a period of observation of the operator during the initial period of performance, whether the operator is a new employee or a current employee who is being assigned to a different type of equipment than previously operated on the project site. This observation may be performed by a knowledgeable member of the management team or a designated craft employee such as a foreman or steward. The above referenced checklists could be used for this observation in lieu of the performance test.

Operators shall be physically fit to perform their duties and may be required to participate in the Tetra Tech Medical Surveillance program.

3.3.11 Refresher Training and Evaluation

Refresher training in relevant topics shall be provided to Crane (as defined by OSHA 1910.180(a) operators, and Powered Industrial Truck (PIT) as defined by OSHA 1910.178(a)(1) operators prior to be allowed to continue operating when:

- The operator has been observed to operate the PIT/Crane in an unsafe manner.
- The operator has been involved in an accident or near-miss incident.
- The operator has received an evaluation that reveals that the operator is not operating the PIT/Crane safely.
- The operator is assigned to operate a different type of PIT/Crane; or
- A condition in the workplace changes in a manner that could affect safe operation of the PIT/Crane.

An evaluation of each PIT/Crane operator's performance shall be conducted at least once every three years.

Refresher training in relevant topics shall be provided to all other construction equipment operators when:

- The operator has been observed to operate the equipment in an unsafe manner.
- The operator has been involved in an accident or near-miss incident.
- The operator has received an evaluation that reveals that the operator is not operating the equipment safely.
- The operator is assigned to drive a different type of equipment; or
- A condition in the workplace changes in a manner that could affect safe operation of the equipment.

The employer shall certify that each operator has been trained and evaluated. The certification shall include the name of the operator, the type of equipment, the date of the training, the date of the evaluation, and the identity of the person(s) performing the training or evaluation.

3.3.12 Repairs

All construction equipment shall be repaired as necessary and maintained in good working order. Repairs to rented/leased construction equipment shall be in accordance with the terms of the rental/lease agreement. Repairs to rented/leased and Tetra Tech's construction equipment shall be documented and a record of the repairs maintained in the project files. Copies of the repair records are to be forwarded to the equipment yard for Tetra Tech-owned equipment.

Construction equipment with deficiencies noted on the Daily Inspection Report should be repaired promptly. The Equipment Supervisor, with input from the Environmental and Safety Supervisor as appropriate, should evaluate if a piece of equipment or a vehicle should be removed from service until the deficiency is corrected.

Construction equipment that develops a fluid leak such as engine oil, hydraulic oil, transmission fluid, or coolant shall be removed from service until the deficient condition has been corrected.

Construction equipment with missing or inoperable exhaust systems, including spark or flame arrestors, mufflers, and catalytic converters, shall be removed from service until the deficient

condition has been corrected.

Tampering with, removal, modification, or otherwise rendering inoperable any pollution control device on construction equipment shall not be allowed except as specifically authorized by the equipment manufacturer or appropriate authority and the Project Manager or Supervisor's concurrence

Only trained, qualified personnel shall be allowed to repair equipment. The project's Work Plan should address repairs to equipment by designating required actions in the event of an equipment failure.

An Authorization for Capital Expenditure or Lease (AFCEL) is to be completed for all major repair work (i.e., $1500.00 and over) performed on Tetra Tech-owned construction equipment in accordance with Accounting/Finance Procedure AF-8, Fixed Assets. (Note that on some construction equipment, the cost of a specific item, a replacement tire for example, may require the processing of an AFCEL due to the item cost.)

Costs for major repairs, as well as repairs for deficiencies, to Tetra Tech-owned construction equipment shall be charged back to the project releasing the equipment if the need for repairs is identified within 30 days of the equipment's release and removal from a project and there are indications that the repairs are needed as the result of lack of maintenance or failure of the releasing project to otherwise keep the equipment in good working order.

No repair shall be undertaken for damage covered by an insurance claim until the damage is reported to the Administration and Compliance Department and the insurer approves the repairs.

3.3.13 Documentation and Record Keeping

A file shall be established and maintained for each operator which contains documentation that the operator has the proper qualifications, licenses/certificates, and training to perform his/her job function. Records may include training identified in the HASP (e.g., OSHA, DOT, Waste Management training), vehicle operator licenses, results of site-administered proficiency testing, and any other special licenses/certificates required by state/local law or the client.

A file shall be established and maintained for each piece of construction equipment, and all records relating to that equipment shall be placed in the file, including the Receipt Inspection Report, annual inspections (for cranes), record of the date the equipment was first placed in

service, Daily Equipment Inspection records, maintenance records, repair records, record of the last date that the equipment was in service, demobilization inspection report, and the decontamination certificate, if applicable. For ease of retrieval, all records pertaining to pieces of equipment should be maintained in separate folders for each piece of equipment.

Additional copies of inspection reports and records may be required to be maintained in other project files, such as the procurement files and/or the Environmental Health and Safety files, based on the project's Documentation Plan.

The Equipment Supervisor should ensure that complete and accurate record of equipment utilization, including a list of idle equipment, is provided to the Quality Control Site Manager on a daily basis..

It may be useful to maintain equipment utilization information on a spreadsheet depending on the size of the project. Information such as equipment mobilization date, date of first use, utilization of equipment by rental period (for example, if rental rate is based on hourly usage and is billed on a monthly cycle, there should be an entry for the number of hours the equipment was used in each billing period), scheduled equipment release date, actual release date, and demobilization date. This information may be useful in verification of vendor invoices, in review of production rates, for preparation of requests for change orders or equitable adjustment, or for backup for use in support of (or defense against) claims.

Copies of all maintenance and repair records for Tetra Tech-owned construction equipment shall be forwarded to the Tetra Tech Equipment Manager at the regional equipment yard on a periodic basis. This period should be monthly, and in no circumstances should it exceed quarterly. An Equipment Service Form is available from the Equipment Manager. This form shall be used to report unscheduled and preventative maintenance on Tetra Tech-owned construction equipment.

The Equipment Manager produces a spreadsheet for Tetra Tech-owned construction equipment that is distributed to the projects on a monthly basis. The Equipment Supervisor shall ensure that reports of mileage or meter readings and routine maintenance for all Tetra Tech-owned construction equipment and vehicles assigned to the project are provided to the Equipment Manager for inclusion on the spreadsheet on a monthly basis. A Meter/Mileage Reading Update Form, available from the Equipment Manager, shall be used to report the required information.

The Equipment Supervisor should review the availability date included on the spreadsheet for Tetra Tech-owned equipment and vehicles assigned to the project and inform the Equipment

Manager of any required revisions to these dates.

The Equipment Supervisor shall complete an Equipment Transfer Report, available from the Equipment Manager, for all Tetra Tech-owned construction equipment and vehicles to be mobilized to, and demobilized from the project. Copies of the Equipment Transfer Reports shall be provided to the Equipment Manager at the regional equipment yard.

There shall be no equipment disposal action (junk or sale) for Tetra Tech-owned construction equipment or vehicles without prior notification and approval from the Tetra Tech President.

4.0 GUIDANCE

4.1 Additional Considerations

4.1.1 Control of Government Property

Activities involving the use of Government property are to be controlled by specific procedures negotiated with the Client in accordance with the contract's terms and conditions; such procedures shall be consulted where appropriate. Such activities may involve the handling or installation of Government property, whether furnished by the Government to Tetra Tech or acquired by Tetra Tech for use in the performance of work and for which the Government has retained title.

Government property may include construction tools and equipment purchased as a project cost, as well as permanent materials or equipment purchased for incorporation into the work. Project-specific procedures for control of Government property are to address issues relevant to the use, storage, inventory control, maintenance, and/or final disposition of the Government property.

4.1.2 Spill Control and Emergency Response Dedicated Tools and Equipment

The project's Emergency Response Plan, or Emergency Action Plan is to identify dedicated personal protective equipment and emergency response tools and equipment to be available for an emergency response to a spill or discharge of hazardous material.

Dedicated emergency response tools and equipment are to be segregated and identified for use in emergency response situations. The use of dedicated emergency response tools or equipment for any other activity is not to be permitted.

4.1.3 Inventory Control

An individual should be designated as the Material Control Supervisor and should be responsible for inventory control of all tools issued from the tool control area. A log should be maintained for all tools issued and should record, as a minimum, the identification by name and employee number of the individual signing out the tool, the date and time the tool was signed out, the intended use of the tool (by area or system), an indication of when the tool is to be returned, and the time and date when the tool is returned.
Inventory control of tools assigned to individuals or crews should be performed on a daily basis as the tools are returned to the gang box or storage area. The crew foreman should be responsible for inventory control of tools assigned to the foreman's crew.

The Site Supervisor should immediately be made aware of any missing tools and should take the appropriate action to investigate and/or replace the missing tools.

4.1.4 Disposition of Tools at Project Completion

The Project Manager should make a determination of the disposition of tools remaining at the end of the project. The project may not be reimbursed by the client for the purchase of tools on certain cost reimbursable and lump sum projects. On other projects, a dollar value for individual tools may establish whether or not the client provides any reimbursement. The terms and conditions of the contract should provide direction as to the required disposition of the tools. Tools for which the project has been reimbursed by the client are to be dispositioned in accordance with the client's preferences and the contract terms and conditions.

Tools purchased for the project as a project cost, and which are not to be turned over to the client, should be dispositioned by the Project Manager. Means of disposition may include, but not be limited to, declaring the tools surplus, sale of the tools, or providing the tools to another project. The Project Manager should consult with the appropriate Business Line Executive Vice Presidents, concerning disposition of project tools.

Tetra Tech owned tools (i.e., not purchased as a project cost) should be dispositioned by the Project Manager based on consultation with the appropriate Business Line Executive Vice Presidents. Means of disposition of Tetra Tech-owned tools may include, but not be limited to, declaring the tools surplus, sale of the tools, return of the tools to an equipment yard, or providing the tools to another project.

4.1.5 Company-Owned Equipment

Tetra Tech utilizes regional equipment yard(s) for the temporary storage and maintenance of Tetra Tech-owned construction equipment and vehicles when not currently assigned to a project. Available Tetra Tech-owned equipment should be considered for support of a project's construction effort based on an analysis of the benefits to the project and/or Tetra Tech. When evaluating Tetra Tech owned equipment the requirements discussed in 4.1.6 below should be considered when making the equipment selection.

4.1.6 Rental/Lease Equipment

Agreements for rental/lease of construction equipment should be coordinated through an authorized procurement representative to ensure that appropriate terms and conditions are included in the agreement. The Scope of Work for the agreement should be developed and reviewed carefully, including review by the Site Supervisor or Equipment Supervisor for inclusion of sufficient detail in order to clearly define the scope of work.

The Equipment Supervisor, or requisitioner if there is no designated Equipment Supervisor, should review the terms and conditions of all rental/lease agreements to determine that the following topics are adequately addressed:

- Receipt and return of the rental or leased equipment and any required accessories;
- Inspection and documentation of receipt and release;
- Provision of documentation required to be submitted, such as Occupational Safety and Health Administration (OSHA) accredited inspection reports, NDE reports, test reports (i.e. load test for cranes), typically annual inspections, and wire rope certification.
- Provision of all safety equipment and accessories, as required, such as fire extinguishers, seat belts, Roll Over Protection Structures (ROPS), Falling Object Protection Structures (FOPS), access steps, handholds, platforms, and anti two-block devices and load moment indicator (cranes);
- Provision of documentation demonstrating operator certification;
- Provision of Certificate of Compliance when required, for instance by NAVFAC P-307 Management of Weight Handling Equipment, Appendix P - Contractor Crane Requirements.

- Provision and requirements of routine and non-routine maintenance and repairs, including payment for labor, parts, filters, lubricants, and fluids;
- Documentation requirements for the above maintenance and repairs;
- Disposal/recycling requirements for used parts, filters, lubricants, and fluids;
- Items such as point of delivery, costs of delivery and return, rental charges during idle time, notification requirements for demobilization, and point of return;
- Appropriate rental rate provisions for straight time and overtime;
- Responsibility for damage to equipment;
- Insurance;
- Indemnification (if included);
- Payment for replacement of parts subject to normal wear and tear, such as tires, tracks, cuTetra Teching edges, and teeth; and
- Documentation requirements required in support of invoices for basic rental rates and overtime rates, as well as labor, parts, filters, lubricants, and fluids.

Rental agreements should be structured to include normal wear and tear on the equipment in the basic rental rate. In all cases, there should be mutual agreement with the equipment vendor as to the condition of the equipment as it is delivered. This should include items such as the life expectancy of the parts subject to wear and tear, their condition on receipt (i.e., percentage of usable life remaining), and the expected condition on return of the equipment. There should be agreement on minor versus major repairs and on what constitutes normal wear and tear. Mutual agreement is essential to mitigate potential claims from vendors for excessive wear and tear.

4.1.7 Mobilization of Equipment

Mobilization of construction equipment may be a long lead time item and may require client or third party involvement or approvals to gain site access, depending on the required equipment. The Site Supervisor or Equipment Supervisor should determine the lead time required, including Contract submitted and advance notice/approval requirements, and plan for the mobilization of equipment to support the project's schedule.

- Planning for mobilization of equipment should include a thorough review of Contract requirements for utilization of each equipment and site access requirements.
- Documentation of certification, and OSHA compliant annual inspection, load testing, safety devices (e.g., anti two-block) installed, wire rope certification, and operator's certification for cranes (weight handling equipment) should be reviewed prior to initiating mobilization of cranes.

4.1.8 Equipment Maintenance

The Equipment Supervisor should be responsible for administration of a construction equipment maintenance program for the project. A spreadsheet of all Tetra Tech-owned equipment, titled the Status of All Project Equipment, is maintained by the Construction Department providing notification of the scheduled maintenance requirements for each piece of equipment. Either this spreadsheet, or a project specific spreadsheet, should be maintained and statused on a periodic basis. Specific maintenance requirements may also be contained in specific contract negotiated property procedures or in other Tetra Tech corporate procedures.

As construction equipment is received on site, it should be added to the spreadsheet for tracking of the required maintenance.

A review of the scheduled maintenance should be performed for all construction equipment to be used in the Exclusion Zone to determine the desirability of performing any upcoming scheduled maintenance prior to placing the equipment in service. It may be difficult and expensive to perform the maintenance under the conditions required in the Exclusion Zone, or to decontaminate the construction equipment in order to perform the maintenance under clean conditions. When the maintenance of equipment in the Exclusion Zone is anticipated, the Site Supervisor should ensure that qualified personnel are available with the appropriate medical clearances and certifications to work in the Exclusion Zone.

4.1.9 Construction Equipment Safe Operation Requirements

Standards for safe operation of equipment are contained in the documents identified herein, inclusive and in particular of the requirements for safe operation of lifting and rigging equipment and weight handling equipment. The Contract typically will specify certain documents/codes to be followed for the project.

- The United States Army Corps of Engineers (USACE) Safety and Health Requirements Manual, EM 385-1-1, Chapters 16, 17, and 18, provide guidance concerning the safe operation of construction equipment.
- Safe operation of earth drilling equipment is addressed in SWP 5-36 Drill Rigs.
- Safe operation of hand and power tools is addressed in OSHA standard 29CFR Part 1926 Subpart I.
- Safe operation of cranes, derricks, hoists, elevators and conveyors is addressed in OSHA standard 29CFR Part 1926 Subpart N.
- Safe operation of motor vehicles, mechanized equipment and marine operations is addressed in 29CFR Part 1926 Subpart O.
- Rollover protective structures and overhead protection is addressed in 29CFR Part 1926 Subpart W.
- The American Society of Mechanical Engineers (ASME) provides guidance in the B30 commiTetra Techee volumes – Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings.
- The United States Department of Energy (DOE) provides guidance for safe lifting operations in Technical Standard DOE-STD-1090 – Hoisting and Rigging.
- The United States Navy publication NAVFAC P-307 – Management of Weight Handling Equipment includes requirements for Contractor Cranes (see appendix P). Navy facilities issue Instructions specific to particular facilities such as 'NAVSHIPYDPUGET INSTRUCTION 11262.4A' which provides requirements for weight handling equipment at all Navy facilities within the Puget Sound.

Construction Equipment safety requirements shall be met before any task can be safely and properly performed, including

- Equipment will be used only in the manner in which it was designed.

- Vehicles and equipment shall be kept in the appropriate gear or drive range when in motion, specifically when ascending or descending a grade. Freewheeling or coasting is prohibited.
- Steps, handrails and grab irons shall be used and equipment shall be faced when mounting or dismounting equipment. When climbing onto or from equipment a 3-point contact shall be maintained. Steps, handrails and grab rails shall be kept maintained, clean and free from slip, trip and fall hazards. Allow extra time in winter or rainy conditions to clean ice, snow and mud from equipment.
- Operators shall wear seat belts before starting and while in operation if the equipment is supplied with seat belts.
- Eye protection is mandatory if the equipment does not have an enclosed cab.
- Passengers shall not ride on equipment unless the equipment is designed to accommodate passengers.
- Before dismounting, the operator shall secure the equipment from movement by lowering all ground-engaging attachments, if so equipped (i.e., setting the parking brake, placing the transmission in park, disabling the hydraulics and activating any other elements of the equipment per the operator's manual).
- Wheeled equipment, without ground-engaging attachments, shall be chocked immediately following dismount with chock blocks that are adequate for the wheel size and equipment weight.
- Blades, buckets and other materials shall be in contact with the ground before the operator dismounts the equipment.
- Equipment should not be left unattended while the engine is running. If conditions exist that make it necessary for equipment to be left running in an unattended state (i.e., cold weather and certain start-ups), do not allow the general public entrance to the area unless the area can be clearly delineated. If the area cannot be clearly delineated to preclude casual entrance by the general public, unattended equipment shall not be left running.

- The work site around equipment shall be clear prior to moving equipment. The operator shall be attentive to people and any vehicles that may have entered the area during the walk-around inspection.
- All operations shall be in accordance with manufacturers Standard Operating Procedures (SOPs).
- All ground disturbance operations shall comply with the DCN 4-5 Trenching and Excavation Practices.
- Proper working distances shall be maintained when operating equipment that is near electrical lines, as defined in DCN 5-9 Safe Electrical Work Practices.
- Employees shall not get on or off a vehicle or piece of equipment while it is moving.

4.1.10. General Traffic Requirements

The traffic rules in this section shall be followed, at a minimum, when heavy equipment and haul trucks are operated on project sites. The PM or SSC shall implement new traffic rules as conditions or project changes dictate.

- All applicable local governing authority driving rules shall be followed when driving heavy equipment and haul trucks on public or project sites.
- Operators shall understand and adhere to the site traffic right-of-way rules and work zone configurations.
- Speed limits, dependent on the risk associated with the site, shall be posted for the location and shall always be observed. Violation of speed limits shall result in disciplinary actions, which shall be posted and discussed with the workforce. Appropriate signage shall adequately communicate haul roads and traffic hazards.
- Vehicles and equipment shall follow at a safe distance as determined by road conditions, the specific vehicle and loading. The site shall define a minimum following distance.

- Passing shall be limited to areas of adequate clearance, visibility and where marked accordingly. Passing may be prohibited completely on some sites or areas.

- Lights should be used to direct equipment at night; work zone lighting shall be sufficient for the work being performed.

- Adequate equipment spotters and ground employees should be deployed in conjunction with the job zone and traffic control plan. Spotters shall be not in the path of equipment travel while equipment is backing into a dump or loading area. Spotters shall wear bright, reflective clothing and be competent in directing and signaling equipment. Spotters and operators shall have a clear understanding of signal protocol for the site. When applicable, equipment will be equipped with a working signal alarm while backing up.

- A communications plan shall be developed by the site to allow the workforce to have communications with operators and spotters. A direct communication technique such as radio communication is preferred. If noise may impede operators to hear radios, then visual alerts (e.g., warning lights) inside the cab that are visible to the operator shall be considered.

4.1.11 Road Construction and Maintenance

For the safest and most efficient worksite, these construction and maintenance rules shall be followed when applicable:

- Elevated haul roads and roads, where risk is high from activities such as building dikes, shall have side berms or barriers that are axle height or greater to accommodate for the largest type of equipment that normally occupies the road. Drainage shall be allowed.

- All curves shall have open sight lines and have as large a radius as practical.

- Haul road/traffic changes shall be communicated to all affected personnel.

- Roadways shall be constructed with a slight crown to facilitate drainage.

- All roadways, including haul roads, shall be routinely maintained in a safe condition, including the elimination or control of dust, ice or similar hazards. Adequate dust control equipment shall be provided on the job site and shall be utilized to control the hazards.

4.1.12 Demobilization of Equipment

Construction equipment should be demobilized when no longer required for the work. The Executive Vice President of Construction should be provided with a status of Tetra Tech-owned construction equipment and scheduled release dates in order to coordinate availability of equipment with other projects.

The Project Manager or designee should request demobilization instructions from the Executive Vice President of Construction or designee to determine the location to receive Tetra Tech-owned equipment.

Construction equipment leaving the Exclusion Zone of a remediation construction project will be decontaminated in accordance with the requirements of DCN 3-9 Decontamination and the site specific HASP.

Individual state regulations may require cleaning of construction equipment leaving a site, not limited to remediation construction, in order to control the spread of microorganisms contained in the soil. Such requirements are to be identified in the project HASP plans.

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2/16/2012	Chris McClain	Content & Format Revision

1.0 INTRODUCTION

This safe work practice (SWP) addresses situations during which heat illness is likely to occur and provides procedures for preventing and treating heat-related injuries and illnesses. This SWP is applicable to all Tetra Tech employees performing outdoor activities at both domestic and international project locations. This SWP incorporates safety regulations of the States of California and Washington to protect outdoor workers from heat-related illness. An "outdoor place" is an open area such as an agricultural field, forest, park, equipment and storage yard, outdoor utility installation, tarmac, and road. An outdoor workplace also can include a construction site at which no building shell has been completed, and areas of a construction site outside of any building shells that may be present.

Many factors contribute to heat illness and UV exposure, including personal protective equipment (PPE), ambient temperature and humidity, workload, sun exposure, and the physical condition of the employee, as well as predisposing medical conditions. However, the primary factors of heat illness are elevated ambient temperatures in combination with fluid loss. Because heat illness is one of the more common health concerns during field activities, employees must be familiar with the signs, symptoms, and various treatment methods of each form of heat illness. Health effects from heat illness may range from transient heat fatigue or rashes to serious illness or death. Tracking the weather is imperative during outdoor field projects because heat-related illness and fatalities occur primarily during heat waves.

2.0 Definitions

The following are typical terms and definitions associated with heat illness prevention and monitoring activities:

Acclimatization – Gradual adaptation of the body to work under temperature conditions to which it is exposed. Acclimatization peaks in most people within 4 to 14 days of regular work taking up at least 2 hours per day in the heat.

Ambient Temperature – Temperature of the surroundings.

Electrolytic Sports Drink – A beverage containing sodium and potassium salts that replenish the body's water and electrolyte levels after dehydration caused by physical activity.

Environmental Risk Factors for Heat Illness – Working conditions under which heat illness could occur. Environmental risk factors include air temperature, relative humidity, radiant heat from the sun and other sources, conductive heat sources such as the ground, air movement (or lack of), workload severity and duration, and protective clothing and PPE worn by employees.

Heat Illness – A serious medical condition resulting from the body's inability to cope with a particular heat load. Symptoms include heat cramps, heat exhaustion, and heat stroke (see Table 1).

Heat Index – An index that combines air temperature and relative humidity to indicate the human-perceived equivalent temperature (i.e., how hot it feels outdoors).

Heavy Work – Digging/hand-auguring, heavy lifting, cutting trees, using heavy hand tools, and similar tasks.

Light Work – Walking, writing notes, handling samples, and similar tasks.

Medium Work – Bailing wells, moving light equipment, driving nails, and similar tasks.

Personal Risk Factors for Heat Illness – Factors such as an individual's age, degree of acclimatization, health, water consumption, alcohol consumption, caffeine consumption, and use of prescription medications that affect the body's water retention or other physiological responses to heat.

Preventive Recovery Period – Period of time needed to recover from the heat in order to prevent heat illness.

Relative Humidity – The amount of water vapor that exists in a gaseous mixture of air and water vapor.

Shade – Blockage of direct sunlight. Canopies, umbrellas, and other temporary structures or devices may be used to provide shade. One indicator that blockage is sufficient is absence of a shadow of an object within the area of blocked sunlight. Shade is not adequate when heat in the area of shade defeats the purpose of shade, which is to allow the body to cool. For example, a car sitting in the sun does not provide acceptable shade to a person inside it unless the car is running with air conditioning.

Wet Bulb Globe Temperature (WBGT) - a measurement used to indicate heat stress. WBGT takes into account the effects of humidity

3.0 Employee Duties and Responsibilities

Written procedures help Project Managers (PM), Site Safety Coordinators (SSC), and field team members reduce the risk of heat-related illnesses, and ensure that emergency assistance is provided without delay to all Tetra Tech employees. The following are the duties and responsibilities of the Project Team for implementing and managing the Heat Illness Prevention and Monitoring SWP.

3.1 Project Management

The PM must understand and agree to the responsibility for implementing this SWP for worker safety. The PM will assure that all employees at the work site comply with this SWP.

- The PM must designate an appropriate field team member to serve as the SSC who will implement this SWP and who will perform and document necessary monitoring requirements for worker safety.
- The PM will ensure necessary resources required to implement this SWP and necessary monitoring resources for worker safety are acquired and present at the work site prior to initiation of project activities in hot environments.
- The PM will work with the Director of Health and Safety and identify at risk employees.
- The PM will ensure all field team members are trained in heat illness management prior to working outdoors.
- The PM and SSC will modify working hours to schedule work during the cooler hours of the day, when possible. When a modified or shorter work-shift is not possible, more water and rest breaks shall be provided.
- The PM and SSC will verify that the elements of this SWP are documented in the Health and Safety Plan, as necessary.

3.2 Site Safety Coordinator

- The SSC must understand and agree to the responsibility for implementing this SWP in the field, and implement the necessary monitoring requirements for worker safety during outdoor activities.
- The SSC must have appropriate Occupational Safety and Health Administration (OSHA)-related training and experience to understand and implement this SWP, and to ensure required monitoring for worker safety during outdoor activities.
- The SSC must ensure that resources needed to implement this SWP and required monitoring for worker safety are acquired and present at the work site prior to initiation of project activities in hot environments.
- The SSC must maintain all necessary resources required under the SWP during project activities in hot environments.
- The SSC must ensure implementation and appropriate documentation of required monitoring for worker safety during site activities.
- The SSC must be familiar with and continuously monitor all employees, and must remain alert for onset of heat-related symptoms.
- The SSC and co-workers are encouraged never to discount any signs or symptoms of heat-related illness shown by one or more project team members, and to immediately report these signs or symptoms.
- The SSC will carry a cell phone or other means of communication to ensure that emergency services can be contacted, and will verify that these resources are functional at the worksite prior to each shift.

3.3 Field Team

- The field team will be able to recognize the hazards of working in warm environments.

- Co-workers will use a "buddy system" to monitor each other closely for discomfort or symptoms of heat illness.
- Every morning, workers must attend a daily tailgate safety meeting to be reminded of site-specific emergency procedures.
- A copy of site specific heat illness procedures shall be available for employee review.

4.0 Description and Requirements

4.1 Effects of Hot Weather

As the environment heats up, the body tends to warm up as well. The body's internal thermostat maintains a constant temperature by pumping more blood to the skin, which is cooled by evaporation from increasing perspiration production. In this way, the body increases the rate of heat loss to balance the heat burden created by a hot environment. Such situations generally do not cause harm, as long as the body is allowed to adjust to cope with the increasing heat.

In a very hot environment, however, the rate of heat gain exceeds the rate of heat loss. In this situation, the body's coping mechanisms can be overwhelmed, resulting in heat illness and leading to a range of serious and possibly fatal conditions.

4.2 Preparation for Hot Weather Work

The following list describes the process for preparing to work in hot weather conditions:

- Identify work that can pose a risk of heat stress and Ultraviolet (UV) exposure.
- Identify at-risk employees.
- Identify possible controls:
  - Establish controls for hot weather situations
  - Determine mandatory work and rest regimens based on current conditions, workload, clothing requirements, temperature and humidity for Threshold Limit Value (TLV).
  - Identify required fluid and food replacement schedules.

- Provide a location to cool down during breaks.
- Establish requirements to address UV exposure.
- Monitor workers in extreme heat conditions.

• Establish emergency response procedures to be followed for heat-related emergency situations.

• Provide for first aid and establish the requirement that first aid be administered immediately to employees displaying symptoms of heat-related illness.

• Provide training to employees and verify training records about site legal and regulatory requirements and about the characteristics and effects of heat stress and the recognition and prevention of heat-related injuries (See Table 1).

5.0 Employee Training

Training is an important component of heat illness prevention. Employees are instructed to recognize and treat heat-related illnesses during 8-hour health and safety refresher and first aid training courses. The conditions, symptoms, and treatment for heat-related illnesses are listed below in Table 1.

TABLE 1
HEAT ILLNESS CONDITIONS

Condition	Causes	Signs and Symptoms	Treatment
Heat cramps	Fluid loss and electrolyte imbalance from dehydration	• Painful muscle cramps, especially in legs and abdomen • Faintness • Profuse perspiration	• Move affected worker to cool location • Provide sips of liquid such as Gatorade® • Stretch cramped muscles • Transport affected worker to hospital if condition worsens
Heat Exhaustion	Blood transport to skin to dissipate excessive body heat, resulting in blood pooling in the skin with inadequate return to the heart	• Weak pulse • Rapid and shallow breathing • General weakness • Pale, clammy skin • Profuse perspiration • Dizziness • Unconsciousness	• Move affected worker to cool area • Remove as much clothing as possible • Provide sips of cool liquid or Gatorade® (only if conscious) • Fan the person but do not overcool or chill • Treat for shock • Transport to hospital if condition worsens
Heat Stroke**	Life threatening condition from profound disturbance of body's heat-regulating mechanism	• Dry, hot, and flushed skin • Constricted pupils • Early loss of consciousness • Rapid pulse • Deep breathing at first, and then shallow breathing • Muscle twitching leading to convulsions • Body temperature reaching 105 or 106 degrees Fahrenheit (°F) or higher	• Immediately transport victim to medical facility • Move victim to cool area • Remove as much clothing as possible • Reduce body heat promptly by dousing with water or wrapping in wet cloth • Place ice packs under arms, around neck, at ankles, and wherever blood vessels are close to skin surface • Protect patient during convulsions
**** Any of these symptoms require immediate attention. If heat stroke is suspected, emergency medical personnel should be immediately contacted and on-site first aid provided.**			

Employee training procedures include, but are not limited to, the following:

- All employees (including and especially newly hired employees) will receive heat illness prevention training prior to working outdoors.
- SSCs will hold short tailgate meetings daily to review important heat illness and prevention information with all field team members.
- All workers will be assigned a "buddy" or experienced coworker to ensure that they understood the training and follow the company procedures.
- PMs and SSCs will be trained before assignment to supervise outdoor workers.

6.0 Heat Illness Prevention and Monitoring Requirements

6.1 Identification of Work Conditions

Hot weather is a condition that will be encountered during Tetra Tech operations. When work takes place outdoors during warm weather, working conditions shall be identified for both heat stress conditions and UV exposure.

6.2 Heat Index

The Heat Index (HI) can be used as a first indicator of thermal comfort. The HI can be obtained by directly measuring the dry bulb temperature and relative humidity. The dry bulb temperature and relative humidity forecast can be obtained by checking the local weather station information or measured by using a wet bulb thermometer. A direct reading of HI can be obtained by placing a heat stress monitor in full shade at the workplace.

The HI does not take into account acclimation, clothing or nature of work; therefore, if the HI is at 80°F (26.7°C) or above, further evaluation is required to adjust workload and clothing.

6.3 Heat Exposure Limits and Measurement

The TLV is a means of providing heat exposure limits and gauging potential heat impacts. To determine the TLV, the Wet Bulb Globe Temperature (WBGT) index is measured. The WBGT is calculated using a formula that takes into account air temperature, speed of air movement, radiant heat from hot objects, sunshine and body cooling due to sweat evaporation. WBGT direct reading meters, often called 'heat stress analyzers,' are also available. These meters give direct WBGT readings; no calculations are necessary.

A trained person shall take WBGT measurements. If a WBGT direct reading meter is not available, two different methods are used to calculate WBGT in the workplace: one for workplaces with direct sunlight, and the other for workplaces without direct sunlight. In addition, when conditions of the workplace fluctuate widely, time-weighted WBGT is often used. The WBGT calculation is used in determining heat stress exposure guidelines and heat stress and clothing guidelines. Table 2 presents approximate WBGT values.

APPROXIMATE WBGT VALUE (°F) TABLE

Dry Bulb Temperature		Relative Humidity																			
°C	°F	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
18.33	65	59	59	60	61	62	62	63	64	64	65	66	67	67	68	69	70	70	71	72	73
18.89	66	59	60	61	61	62	63	64	65	65	66	67	68	68	69	70	71	71	72	73	74
19.44	67	60	61	61	62	63	64	65	65	66	67	68	69	69	70	71	72	72	73	74	75
20.00	68	60	61	62	63	64	64	65	66	67	68	69	69	70	71	72	73	74	74	75	76
20.56	69	61	62	63	63	64	65	66	67	68	69	69	70	71	72	73	74	75	75	76	77
21.11	70	62	62	63	64	65	66	67	68	69	69	70	71	72	73	74	75	76	77	77	78
21.67	71	62	63	64	65	66	67	68	69	69	70	71	72	73	74	75	76	77	78	79	79
22.22	72	63	64	65	66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
22.78	73	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
23.33	74	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
23.89	75	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
24.44	76	65	66	67	68	69	71	72	73	74	75	76	77	78	79	80	81	82	83	85	86
25.00	77	66	67	68	69	70	71	72	74	75	76	77	78	79	80	81	82	84	85	86	87
25.56	78	66	67	69	70	71	72	73	74	76	77	78	79	80	81	82	84	85	86	87	88
26.11	79	67	68	69	71	72	73	74	75	76	78	79	80	81	82	84	85	86	87	88	90
26.67	80	68	69	70	71	72	74	75	76	77	79	80	81	82	84	85	86	87	88	90	91
27.22	81	68	69	71	72	73	75	76	77	78	80	81	82	83	85	86	87	89	90	91	92
27.78	82	69	70	71	73	74	75	77	78	79	81	82	83	85	86	87	88	90	91	92	94
28.33	83	69	71	72	73	75	76	78	79	80	82	83	84	86	87	88	90	91	92	94	95
28.89	84	70	71	73	74	76	77	78	80	81	83	84	85	87	88	90	91	92	94	95	97
29.44	85	71	72	73	75	76	78	79	81	82	84	85	87	88	89	91	92	94	95	97	98
30.00	86	71	73	74	76	77	79	80	82	83	85	86	88	89	91	92	94	95	97	98	100
30.56	87	72	73	75	76	78	80	81	83	84	86	87	89	90	92	93	95	97	98	100	101
31.11	88	72	74	76	77	79	80	82	84	85	87	88	90	92	93	95	96	98	100	101	103
31.67	89	73	75	76	78	80	81	83	85	86	88	90	91	93	94	96	98	99	101	103	104
32.22	90	74	75	77	79	80	82	84	86	87	89	91	92	94	96	97	99	101	103	104	106
32.78	91	74	76	78	80	81	83	85	87	88	90	92	94	95	97	99	101	102	104	106	108
33.33	92	75	77	79	80	82	84	86	88	89	91	93	95	97	98	100	102	104	106	107	109
33.89	93	76	77	79	81	83	85	87	89	90	92	94	96	98	100	102	103	105	107	109	111
34.44	94	76	78	80	82	84	86	88	90	92	93	95	97	99	101	103	105	107	109	111	113
35.00	95	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	108	110	112	114
35.56	96	77	79	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116
36.11	97	78	80	82	84	86	89	91	93	95	97	99	101	103	105	108	110	112	114	116	118
36.67	98	79	81	83	85	87	90	92	94	96	98	100	103	105	107	109	111	113	116	118	120
37.22	99	79	82	84	86	88	91	93	95	97	99	102	104	106	108	111	113	115	117	120	122
37.78	100	80	82	85	87	89	91	94	96	98	101	103	105	108	110	112	115	117	119	121	124
38.33	101	81	83	85	88	90	92	95	97	100	102	104	107	109	111	114	116	119	121	123	126
38.89	102	81	84	86	89	91	93	96	98	101	103	106	108	111	113	116	118	120	123	125	128
39.44	103	82	84	87	89	92	94	97	100	102	105	107	110	112	115	117	120	122	125	127	130
40.00	104	83	85	88	90	93	96	98	101	103	106	108	111	114	116	119	121	124	127	129	132
40.56	105	83	86	89	91	94	97	99	102	105	107	110	113	115	118	121	123	126	129	131	134
41.11	106	84	87	89	92	95	98	100	103	106	109	111	114	117	120	122	125	128	131	133	136
41.67	107	84	87	90	93	96	99	101	104	107	110	113	116	119	121	124	127	130	133	136	138
42.22	108	85	88	91	94	97	100	103	106	108	111	114	117	120	123	126	129	132	135	138	141
42.78	109	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	131	134	137	140	143
43.33	110	86	90	93	96	99	102	105	108	111	114	117	120	124	127	130	133	136	139	142	145
43.89	111	87	90	93	97	100	103	106	109	113	116	119	122	125	128	132	135	138	141	144	148
44.44	112	88	91	94	98	101	104	107	111	114	117	121	124	127	130	134	137	140	143	147	150
45.00	113	88	92	95	99	102	105	109	112	115	119	122	126	129	132	136	139	142	146	149	153
45.56	114	89	93	96	99	103	106	110	113	117	120	124	127	131	134	138	141	145	148	152	155
46.11	115	90	93	97	100	104	108	111	115	118	122	125	129	133	136	140	143	147	150	154	158
46.67	116	90	94	98	101	105	109	112	116	120	123	127	131	134	138	142	146	149	153	157	160
47.22	117	91	95	99	102	106	110	114	118	121	125	129	133	136	140	144	148	152	155	159	163
47.78	118	92	96	100	103	107	111	115	119	123	127	131	134	138	142	146	150	154	158	162	166
48.33	119	92	96	100	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168
48.89	120	93	97	101	105	110	114	118	122	126	130	134	138	142	147	151	155	159	163	167	171

Notes: Calculated values assume outdoor work in full sun, with a light (<5 mph) wind.
WBGT of green-shaded cells is less than dry-bulb temperature.

6.4 Heat Stress Exposure Guidelines

Heat stress exposure guidelines recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) are shown in Table 3: ACGIH Screening Criteria for Heat Stress Exposure. This table is used to determine the allocation of work in a work/rest cycle, which is dependent on the type of work and WBGT values.

Table 3: ACGIH Screening Criteria for Heat Stress Exposure

PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUE															
Clothing Type	**Summer Lightweight**			**Cotton Coveralls**			**Winter Work**			**Permeable Water Barrier (Tyvek)**			**Fully-Encapsulating Suit (Level 4)**		
Work Load	**Light**	**Moderate**	**Heavy**	**Light**	**Moderate**	**Heavy**	**Light**	**Moderate**	**Heavy**	**Light**	**Moderate**	**Heavy**	**Light**	**Moderate**	**Heavy**
Work/Rest Schedule / WBGT	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**	**(°F)**
Continuous Work	86	80	77	82	76	73	79	73	70	75	69	66	68	62	59
75% Work, 25% Rest / Hr	87	82	79	83	79	75	80	75	71	76	72	68	69	64	61
50% Work, 50% Rest / Hr	89	85	82	85	81	79	81	78	75	78	74	71	71	67	64
25% Work, 75% Rest / Hr	90	88	86	86	84	82	83	81	79	79	77	75	72	70	68

Notes: Temperature is approximate WBGT from accompanying tables, based on outdoor work, temperature, and relative humidity measurement during work activities. Light Work includes walking, writing notes, handling samples, and similar activities (metabolic rate up to 200 kilocalories [kcal]/hour). Medium Work includes bailing wells, moving light equipment, driving nails, and similar tasks (metabolic rate of 200-350 kcal/hour). Heavy Work is digging, heavy lifting, cutting trees, using heavy hand tools, and similar tasks (metabolic rate above 350 kcal/hour).

Table 3 is based on five-day work weeks and eight-hour work days with conventional breaks. Conventional breaks include a 15-minute break in a four-hour period and a half-hour lunch in an eight-hour period. The ACGIH exposure limits are intended to protect most workers from heat-related illnesses. The limits are higher than that if they had been developed to prevent discomfort. A safety factor should be used to protect sensitive individuals or increase comfort. Examples to clarify work load intensity:

- Rest: sitting (quietly or with moderate arm movements).
- Light work: sitting or standing to control machines, performing light hand or arm work (e.g., using a table saw), occasional walking, driving.
- Moderate work: walking about with moderate lifting and pushing or pulling, walking at a moderate pace, scrubbing in a standing position.
- Heavy work: digging, carrying, pushing/pulling heavy loads, walking at a fast pace, pick and shovel work, carpenter sawing by hand.
- Very heavy: very intense activity at a fast to maximum pace (e.g., shoveling wet sand).

For example, in order to minimize heat stress exposure, an employee who is acclimated and is performing heavy work such as shoveling dirt in a temperature of 78°F (25.6°C), would fall into a work/rest regimen of 100% work.

TLVs assume that workers who are exposed to these conditions are adequately hydrated, are not taking medication, are wearing lightweight clothing and are in generally good health.
When the WBGT is at a temperature that exceeds the TLV, 'Stop Work' should be enforced.

6.5 Heat Stress and Clothing Guidelines

The exposure limit should be adjusted for workers wearing heavy clothing. ACGIH recommendations for these conditions are listed in Table 4: Correction of TLV for Clothing.

Table 4: Correction of TLV for Clothing

Clothing Type	WBGT Correction (in °F [°C])
Work Clothes (long-sleeved shirts and pants)	0 (0)
Cloth coveralls (woven material)	+3 (0)
Spunbonded Meltdown Spunbonded polypropylene coveralls	+6 (+0.5)
Polyolefin coveralls	+8 (+1)
Double-layer woven clothing	+9 (+3)
Limited-use vapor-barrier coveralls	+18 (+11)

For example, an acclimated worker wearing double-layer woven clothing doing moderate work in 30°C would have a corrected exposure level of 30 + 3 = 33°C (91.4°F). This would lower the allowable exposure to 0-25% work from 25-50% work.

For Fire Retardant Clothing (FRC), there is no WBGT correction. FRC can be obtained in various weight materials. The lightest weight FRC should be worn during work in warm environments. No second layer of clothing should be worn except for cotton undergarments.

These values are not to be used for completely encapsulating suits. The assumption is that coveralls are worn with only modest clothing underneath, not a second layer of clothing.

6.6 Identifying At-risk Employees

A screening program for identifying at risk employees shall include identification of health conditions that are aggravated by extreme environmental temperatures. How a person functions under conditions of heat stress will be unique that person and will depend on:

- Age.
- Weight.
- Metabolism.
- Alcohol or drug use.
- Pre-existing medical conditions.

- Level of physical fitness.
- Use of medications.
- Individual sensitivity to heat.
- Possibility of hypertension.

Note: Employees with any 'at-risk' conditions shall have more stringent work/rest regimens or controls

6.7 Health and Safety Controls

Controls shall be based on a risk assessment approach. Conditions and available controls will vary from site to site. Therefore, the HASP shall define and document the site specific control plan. Controls shall be appropriate for the risks that are associated with heat hazards.

6.7.1 Acclimation

The human body can adapt to heat exposure to some extent. This physiological adaptation is called acclimation. Acclimation is a response by the body that results in increased heat tolerance.

People differ in their ability to acclimate to heat. Usually, acclimation is obtained in four to five days. However, it is lost in approximately the same amount of time. After a period of acclimation, the same activity will produce fewer cardiovascular demands. The worker will perspire more efficiently, leading to better evaporative cooling, and thus will more easily be able to maintain normal body temperatures.

All site workers who could be exposed to hot weather conditions shall be acclimated or go through an acclimation process, as necessary. Where workers are already acclimated, no acclimation process is necessary. A previously acclimated person is someone who has already been in similar working and heat conditions.

6.7.2 Fluid and Nutrient Replacement

Cool (50°-60°F [10°-15°C]) water or other cool liquid, except alcoholic beverages, should be made available to workers.

<u>Provision of Water (Not Temperature Dependent)</u>

Water is the principal preventive measure to minimize the risk of heat-related illnesses. Tetra Tech employees shall have access to potable drinking water (or electrolytic sports drink). Where the supply of water is not plumbed or otherwise continuously supplied, water shall be provided in sufficient quantity at the beginning of the work shift to provide **1 quart per employee per hour for drinking for the entire shift**. Frequent drinking of water shall be encouraged by the SSC. Water provision requirements include the following:

- At least 2 quarts of water per employee will be available at the start of the shift.
- The SSC will monitor water containers every 30 minutes, and employees are encouraged to report low levels or dirty water to the SSC when observed.
- The SSC will provide reminders to the field team members to drink frequently, and more water breaks will be provided as needed.
- During the daily tailgate safety meeting each morning, the SSC will remind the field team about the importance of frequent water consumption throughout the shift.
- Water containers will be placed as close to the workers as safety conditions allow.
- When drinking water levels within a container drop below 50%, the water shall be replenished immediately.
- If a common water source is used, disposable/single-use drinking cups will be provided to employees each day.
- Communication devices such as radios, cell phones, or air horns may be used to remind field team members to take water breaks.

Although some commercial replacement drinks contain salt, this is not necessary for acclimated people, because most people have enough salt in their normal diets. Commercial replacement drinks contain high amounts of sugar and may contribute to an individual's inability to cope with the warm environment. If used, commercial replacement drinks should not be used at full strength and should be diluted with water on at least a one-to-one ratio.

Energy drinks shall not be used while working in warm environments.

Poor nutrition, over eating and under eating are factors contributing to heat stress. During hot conditions, employees should eat small, regular meals.

6.7.3 Additional Control Measures

Outdoor workers are exposed to not only potential heat illness, but also UV radiation. Long-term exposure to UV radiation poses additional risks and can lead to a variety of skin disorders, including skin cancer and cataracts of the eyes.

Protection from UV exposure, sunscreen and appropriate eye protection should be considered in addition to the additional controls listed below:

Access to Shade (Not Temperature-Dependent)

Access to rest and shade or other cooling measures are important preventative steps to minimize the risk of heat-related illnesses and exposure to UV radiation. Tetra Tech employees suffering working in extreme temperatures for any period of time shall be provided access to an area with shade that is either open to the air or provided with ventilation or cooling. Such access to shade shall be permitted at all times. Procedures for the provision of shade include the following:

- SSC will set up an adequate number of shaded areas as needed. Examples of shaded areas include vehicles with air conditioning, umbrellas, canopies, or other portable devices. Shading should be placed in close proximity to the work activity (no more than 50-100 yards away, or at the closest location safety conditions allow).
- Employees should have access to an office, construction trailer, or other places with air conditioning.
- Every morning a short tailgate meeting will occur to remind workers about the importance of rest breaks and the location of shade.

- Other cooling measures may be used **if (and only if)** these can be deemed effective as shade.

- As safety conditions allow, SSCs shall provide areas for employee breaks that are:
  - Readily accessible
  - In the shade, open to air, and ventilated
  - Near sufficient supplies of drinking water

7.0 Heat Illness Monitoring

A medical monitoring program shall be planned with the assistance of a medical or industrial hygiene professional. The monitoring program shall be specify the leading indicators to be used (e.g. heat rate, body temperature, blood pressure, respiration rate, and other) and frequency of measurement.

Heat illness monitoring will be conducted by the SSC or his/her designee when work conditions warrant implementation of a work/rest schedule based on temperature conditions and PPE requirements associated with project activities. Monitoring will be conducted as follows:

- Heart Rate: Count the radial (wrist) pulse during a 30-second period as early as possible in the rest period; if heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third without changing the rest period.
  - If the heart rate still exceeds 110 beats per minute at the next period, shorten the following work cycle by one-third.

- Body Temperature: If body temperature exceeds 99.6 degrees Fahrenheit (°F) (37.6 degrees Celsius [°C]), shorten the next work cycle by one-third without changing the rest period. If body temperature still exceeds 99.6 °F at the beginning of the next rest period, shorten the following work cycle by one-third. Do not permit a worker to wear impermeable PPE when his or her body temperature exceeds 100.6 °F (38.1 °C). Use any of the following thermometers:

- Oral Thermometer – Use a clinical thermometer (3 minutes under the tongue) to measure the oral temperature at the end of the work period.
- Tympanic (ear) Thermometer
- Temporal (swipe) Thermometer

The SSC will document throughout the entire work shift results of heat illness monitoring for each team member participating in work activities.

8.0 EXTREME CONDITIONS

Extra Measures During Heat Waves

Extreme environmental conditions during a heat wave can cause an employee's physical and mental conditions to change rapidly into a serious medical condition. Workers previously fully acclimatized are at risk for heat illness during a heat wave because during a heat wave, the body does not have enough time to adjust to a sudden, abnormally high temperature or other extreme conditions. The onset of heat illness may be confused with other problems and may not always be obvious before it becomes life-threatening. Therefore, the following extra measures may be required to prevent and/or respond to heat illness.

- **Alertness to the Weather** – Make sure to monitor the weather and the specific locations where work activities are occurring. Continue to stay updated throughout the work shift on the changing air temperatures and other environmental factors. Use current weather information to make the appropriate adjustments in work activities throughout the workday.
- **Extra Vigilance** – Apply real-time communication and the "Buddy System" to account for the whereabouts of employees at more frequent intervals throughout the work shift and at the end of the work shift.
- **Additional Water Consumption** – Encourage employees to drink small quantities of water more frequently, and have effective replenishment measures in place for provision of extra drinking water to ensure available supplies.

- **Additional Cooling Measures** – Other alternative cooling measures may be necessary in addition to shade (e.g., allowing employees to spend time in air conditioned places or having them spray themselves with water).

- **Additional and/or Longer Rest Breaks** – Allowing employees to take more frequent and longer breaks may be necessary.

- **Change of Work Scheduling and Assignments –** One or more of the following additional measures may be necessary:

  - Start the work shift earlier in the day or later in the evening.
  - Cut work shifts short or stop work altogether.
  - Bring in more personnel to accommodate longer, more frequent breaks as necessary to meet production requirements.
  - Reduce the severity of work by scheduling slower paced, less physically demanding work during the hot parts of the day, and the heaviest work activities during the cooler parts of the day (early morning or evening).

9.0 Establish Emergency Response

Specific procedures to be followed for heat related emergency response shall be established and documented in the HASP.

10.0 Variation to the Heat Illness Prevention and Monitoring Program

Before deviation from the requirements of this document, a designated manager shall authorize the variation. The exception process does not need to be followed for variations that impose more stringent requirements that those outlined in this document.

11.0 Disclaimer

This safe work practice (SWP) is the property of Tetra Tech, Inc. (Tetra Tech). Any reuse of the SWP without Tetra Tech's permission is at the sole risk of the user. The user will hold harmless Tetra Tech for any damages that result from unauthorized reuse of this SWP. Authorized users are responsible for obtaining proper training and qualification from their employer before performing operations described in this SWP.

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This safe work practices (SWP) describes situations where cold stress is likely to occur and discusses procedures for the prevention and treatment of cold-related injuries and illnesses. Cold conditions may present health risks to employees during field activities. The two primary factors that influence the risk potential for cold stress are temperature and wind velocity. Wetness can also contribute to cold stress. Other factors that increase susceptibility to cold stress include age (very young or old), smoking, alcohol consumption, fatigue, and wet clothing. Hypothermia can occur at temperatures above freezing if the individual has on wet or damp clothing or is immersed in cold water. The combined effect of temperature and wind can be evaluated using a wind chill index as shown in Table 1.

Bare flesh and body extremities that have high surface area-to-volume ratios such as fingers, toes, and ears are most susceptible to wind chill or extremely low ambient temperatures. Because cold stress can create the potential for serious injury or death, employees must be familiar with the signs and symptoms and various treatments for each form of cold stress. Table 2 provides information on frostbite and hypothermia, the two most common forms of cold-related injuries.

1.0 Training

Training is an essential component of cold stress prevention. Employees are taught to identify and treat cold-related injuries during various mandatory training events such as, but not limited to, the 8-hour HAZWOPER refresher, site-specific training, tailgate meetings, and first aid training courses.

2.0 Cold stress assessment

If a worker is or may be exposed to cold stress conditions, employees should conduct a cold stress assessment to determine the potential for hazardous exposure of workers. The first step in a cold stress assessment is to determine the areas, occupations, or tasks that place workers at risk of hypothermia or cold-related injuries. Consider factors such as the following:

- Areas with an equivalent chill temperature (ECT) below 19.4°F (see below)
- Fine dexterity tasks that require work with bare hands
- Contact with metal surfaces or use of evaporative liquids (gasoline, alcohol, or cleaning liquids)
- Working on or near bodies of water

- Areas about which employees have expressed concern

Once the areas or tasks that should be monitored are determined, the risk of developing hypothermia or a cold-related injury should then be evaluated. A cold stress assessment shall include determining the air temperature (below 45ºF) and wind speed (to determine the "equivalent wind chill temperature"). This information is available by obtaining weather, temperature, and wind information from a local weather source, or if there is a monitoring station close to the area in which the work is to be conducted. The site safety officer (SSO) shall check temperature, wind speed, and the conditions of the worker every hour to determine appropriate controls.

Wind chill is a concern when the equivalent chill temperature is less than 19.4°F (See Table 1). The conditions when this occurs are:

- The air is calm and the temperature falls below 19.4°F
- The wind speed is 5 mph or greater and the air temperature is 23°F
- The wind speed is 10 mph or greater and the air temperature is 32°F
- The wind speed is 20 mph or greater and the air temperature is 41°F

As part of the risk assessment, the potential for worker exposure to artificially generated air velocities should also be considered, for example when working in walk-in refrigerators and freezers, when riding all-terrain vehicles or snowmobiles, or when exposed to helicopter rotor downwash.

A general assessment of contact cooling for exposed skin, particularly the hands, should consider the following when workers are in contact with metal:

- Below 59°F - Prolonged contact may impair dexterity.
- Below 44°F - Prolonged contact may induce numbness.
- Below 32°F - Prolonged contact may induce frostnip or frostbite.
- Below 19.4°F - Brief contact with may induce frostnip or frostbite.

For materials other than metal, such as plastics and wood, the temperatures will be lower than those noted above since they are less conductive than metal. Contact with metal or other like-conductive materials should be avoided if possible. Any contact with liquids at subzero temperature is also of concern and should be avoided if possible.

Workers should be provided with gloves or other method of warming the hands when the air temperature is below:

- 61°F for sedentary work
- 39°F for light work
- 19.4°F for moderate work

3.0 Cold Exposure Control Plan

If a worker is or may be exposed to cold stress conditions, the employer shall assign a buddy system and develop and implement a cold exposure control plan on site. Some specific components of the cold exposure control plan, as they relate to education and training of workers are described below.

3.1 Control Plan Education and training

This element should contain initial and ongoing training and education that will be provided to all workers who work in areas where there is a reasonable likelihood of exposure to conditions that could cause cold stress.

The training and education material provided to workers who have not previously worked in a cold stress environment should include the following information:

- Recognition of the signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur
- Recognition of impending frostbite
- Proper re-warming procedures and appropriate first aid treatment
- Proper use of clothing
- Proper eating and drinking practices
- Safe work practices appropriate to the work that is to be performed

As previously noted, those workers exposed to cold-stress environments, Tetra Tech provides refresher training and education to ensure that workers remain knowledgeable about the above-mentioned items.

3.2 Engineering controls

Tetra Tech reduces the exposure hazard of workers to thermal conditions that could cause cold stress or injury using a hierarchy of control methods: engineering controls, followed by administrative controls and, as a last resort, personal protective equipment.

Here are some examples of engineering controls Tetra Tech uses to reduce cold exposure:

- Isolate the worker from the environment, where possible.
- Use local heating for the body and especially bare hands. This may include the use of warm air jets, radiant heaters, or contact warming plates.
- Provide barricades or other structures to block air or reduce air velocities at the work location.
- Provide a designated shelter to warm up during breaks.
    - At extreme temperatures employees will be directed to the warm shelters at regular intervals, or anytime cold stress signs or symptoms develop.
    - The shelter will be the designated area to change into dry clothing
- Provide heated metal tools and equipment handles or cover them with thermal insulating materials.
- Use machine controls and tools designed so that workers do not have to remove mittens or gloves to use them.

3.3 Administrative controls

If the above action is not practicable, Tetra Tech will reduce the exposure hazard by providing effective administrative controls to reduce the exposure hazard of workers to thermal conditions that could cause cold stress or injury.

Several administrative controls Tetra Tech commonly uses to reduce worker exposure to cold stress are described below:

- Work/warm-up schedules
    - A work/warm-up schedule (see Table 3) refers to the period a worker spends working in a cold environment and the time spent in a warm area.
    - Worker acclimatization should be a major factor in determining work/rest schedules for extreme cold (ECT of 10°F or less)

- Scheduling and organization of work – Tetra Tech will schedule tasks so as to minimize the length of time of exposure and to maximize the temperatures to which workers may be exposed. For example:
    - Schedule tasks for the warmest part of the day or when the wind is the most calm.
    - Minimize standing or sitting still for long periods in cold conditions (ECT of 10ºF or less).
    - Identify employees with conditions and risk factors which could contribute to cold stress
        - Require more frequent work/warm up schedule, mandatory insulated clothing, and establish a "buddy system".
        - These individuals shall be excluded from work in temperatures of 30ºF or below.
    - Schedule routine maintenance and repair work for warmer seasons of the year.
    - Postpone non-urgent tasks when equivalent chill temperatures are in the "great danger" portion of the "Cooling Power of Wind" ACGIH table (Table 1).
    - Take the equivalent chill temperature (Table 1) into account when planning or scheduling work activities.
    - Warm shelters are made available when work is performed continuously in cold weather with an ECT at or below 20°F
- Fluid replacement and diet
    - An ample supply of warm drinks and/or soup should be available, and workers encouraged to drink them in order to replace fluids lost through breathing and perspiration.
    - Workers should restrict their intake of coffee because of diuretic and circulatory effects.
    - A diet high in fats and carbohydrates will help to maintain body temperature.
- Appropriate measures such as warm vehicles/shelters, clothing and blankets will be available for cold related injuries.
- Heavy work shall not be assigned as to cause heavy sweating that will result in wet clothing.
-

Employees should be thoroughly cognizant of the signs and symptoms of frostbite and hypothermia (see Table 3) in themselves as well as in coworkers. All instances of cold stress should be reported to the site safety coordinator. If a worker exposed to cold shows signs or reports symptoms of cold stress or injury, the worker must be removed from further exposure

and treated by an appropriate first aid attendant, if available, or a physician. Work schedules may be adjusted and warm-up regimes imposed as needed to deal with temperature and wind conditions. Continuous skin exposure is not permitted when air speed and temperature results in an Equivalent Chill Temperature (ECT) of 25°F (32°C)

3.4 Personal Protective Equipment

If the above actions are not practicable, Tetra Tech will reduce the exposure hazard by providing effective PPE to reduce the exposure hazard of workers to thermal conditions that could cause cold stress or injury.

Several examples of PPE Tetra Tech commonly uses to reduce worker exposure to cold stress are described below:

- Protecting of exposed skin surfaces with appropriate clothing (such as face masks, handwear, and footwear) that insulates, stays dry, and blocks wind;
- Using adequate insulating clothing to maintain a body core temperature of above 98.6° F (36 °C);
- Providing extra insulating clothing on site in case of extreme temperature drops within a single shift;
- If an employee's clothing becomes wet while working below 40°F, he or she will automatically be given a change of clothing and checked for cold stress symptoms.
- Additional cold weather clothing will be identified for individuals with predisposed conditions that contribute to cold stress situations;

TABLE 1
COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS EQUIVALENT TEMPERATURE

The ACGIH criteria, in the Fahrenheit scale, are listed in the following table as it appears in "Cold Stress" portion of the 2011 Threshold Limit Values and Biological Exposure Indices (or most current). The table shows the cooling power of wind on exposed flesh. If there is a wind, use the wind speed in the first column and the actual temperature across the top to find what the equivalent temperature would be under calm conditions.

Estimated wind speed (in mph)	**Actual temperature reading** (degrees Fahrenheit)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent chill temperature (degrees Fahrenheit)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
Wind speeds greater than 40 mph have little additional effect	**LITTLE DANGER** In < 1 hour with dry skin. Maximum danger of false sense of security.				**INCREASING DANGER** Danger from freezing of exposed flesh within one minute.				**GREAT DANGER** Flesh may freeze within 30 seconds.			
	Trench foot and Immersion foot may occur at any point on this chart.											

Note: Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36 C (96.8 F) per cold stress TLV.

TABLE 2
TWO OF THE MOST COMMON COLD STRESS CONDITIONS

Condition	Causes	Signs and Symptoms	Treatment
Frostbite	Freezing of body tissue, usually the nose, ears, chin, cheeks, fingers, or toes	• Pain in affected area that later goes away • Area feels cold and numb • Incipient frostbite (frostnip) - skin is blanched or whitened and feels hard on the surface • Moderate frostbite - large blisters • Deep frostbite - tissues are cold, pale, and hard	• Move affected worker to a warm area • Immerse affected body part in warm (100 to 105 °F) water—not hot! • Handle affected area gently; do not rub • After warming, bandage loosely and seek immediate medical treatment
Hypothermia	Exposure to freezing or rapidly dropping temperatures	• Shivering, dizziness, numbness, weakness, impaired judgment, and impaired vision • Apathy, listlessness, or sleepiness • Loss of consciousness • Decreased pulse and breathing rates • Death	• Immediately move affected person to warm area • Remove all wet clothing and redress with loose, dry clothes • Provide warm, sweet drinks or soup (only if conscious) • Seek immediate medical treatment

TABLE 3
WORK/WARM-UP SCHEDULE FOR A 4-HOUR SHIFT

A WORK/WARM-UP SCHEDULE IS AN EXAMPLE OF AN ADMINISTRATIVE CONTROL. THE ACGIH STANDARD CONTAINS A WORK/WARM-UP SCHEDULE FOR A 4-HOUR SHIFT FOR WORKERS WHO ARE PROPERLY CLOTHED.

Table 3 TLVs Work/Warm-up Schedule for Outside Workers based on a Four-Hour Shift*

Air Temperature - Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°F (approx)	°C (approx)	Max. work Period	No. of Breaks**	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-15° to -19°	-26° to -28°	(Norm breaks) 1		(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4
-20° to -24°	-29° to -31°	(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4	30 min.	5
-25° to -29°	-32° to -34°	75 min.	2	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease	
-30° to -34°	-35° to -37°	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease			
-35° to -39°	-38° to -39°	40 min.	4	30 min.	5	Non-emergency work should cease					
-40° to -44°	-40° to -42°	30 min.	5	Non-emergency work should cease							
-45° & below	-43° & below	Non-emergency work should cease									

Notes:

1. Schedule applies to moderate to heavy work activity with warm-up breaks of ten (10) minutes in a warm location. For light-to-moderate work (limited physical movement): apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with four breaks in a 4-hour period (step 5).

2. The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.

3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: (1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1,750 W/m2; (2) all non-emergency work should have ceased at or below a wind chill of 2,250 W/m2. In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.

4. TLVs apply only for workers in dry clothing.

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Biological hazards, or "biohazards," include plants, animals or their products, and parasitic or infectious agents that may present potential risks to worker health. This safe work practice (SWP) discusses procedures for working with biohazards, preventive guidelines, and first-aid procedures for the most common hazards field staff are likely to encounter. This SWP does not address biohazards such as those associated with medical waste. Procedures for working with this type of biohazard should be addressed in the site-specific health and safety plan (HASP), construction health and safety plan (C-HASP), job safety analyses (JSAs), activity hazard analyses (AHAs), or other health and safety project planning documents on a case-by-case basis.

During preparation for site work, the document preparer should consider which plants, animals, and other biological agents may be encountered; assess their potential risk to project personnel; and attach this SWP to the document if necessary. Office health and safety representatives should become familiar with biological hazards indigenous to the geographical area in which most of their office personnel work and assist in evaluating the risks to personnel on projects staffed from their offices. SWPs for insects, snakes, animals, plants, waterborne pathogens (giardia), and hantavirus are provided below.

1.0 INSECTS

SWPs for reducing the chance of insect bites or stings and for treating bites or stings are listed below.

- Workers should keep as much skin area covered as possible by wearing long-sleeved shirts, long pants, and a hat. Pant legs should be tucked into socks or boots and shirts into pants. In addition, workers should wear light colored clothing.
- A proven insect repellent should be used on bare skin and clothing.
- When possible, tall grasses and brush that could harbor ticks should be avoided.
- Several times during the day and at the end of the work day, each worker should perform a check for evidence of imbedded ticks or previous bites. Particular attention should be paid to the scalp, neck, ankles, back of the legs, and waist.

- When opening well covers, vaults, or other closed items, workers should watch for hornet or wasp nests and black widow or brown recluse spiders. Workers should never reach into spaces with unprotected arms.
- Workers should watch carefully for bees around open soft drinks or food.
- If a worker is stung by a bee, the stinger should be carefully removed, if present. The wound should be washed and a cold pack applied. Allergic reaction should be watched for and is evidenced by extreme swelling, redness, pain, or difficulty breathing.
- If a worker is stung or bit by a spider or scorpion, medical attention should be obtained immediately.

2.0 SNAKES

SWPs for encounters with snakes and for treating snakebites are listed below.

- Workers should avoid walking in areas known to harbor snakes. Workers should be cautious when picking up or moving items that have been on the ground.
- Workers should wear boots made of heavy material that protect the ankles and pants. Heavy work gloves should be worn for picking up items.
- If one snake is encountered, others may be present. Workers should leave the area by retracing their steps.
- If a worker is bitten, the wound should be washed and the injured area immobilized and kept lower than the heart, if possible. Ice or a tourniquet should not be applied to a snake bite. The wound should not be cut. If medical care is more than 30 minutes away from a work site, a snakebite kit should be available on site and workers should know how to use it.

3.0 ANIMALS

SWPs for encounters with animals and for treating associated wounds are listed below.

- If workers encounter a wild animal, the animal should be observed for unusual behavior such as a nocturnal animal out during the day, drooling, an appearance of partial paralysis, irritability, meanness, or a strangely quiet demeanor.
- Workers should never touch the body of a dead animal because certain diseases could be carried by fleas still on the body.
- Workers should avoid animal droppings (including bird droppings). Pathogens, some of which can become airborne, may still be present in the droppings.
- If a worker is bitten, he or she should get away from the animal to avoid further bites. Workers should not try to stop, hold, or catch the animal.
- If the wound is minor, it should be washed with soap and water. Any bleeding should then be controlled, and an antibiotic ointment and dressing should be applied. All animal bite wounds should be watched for signs of infection.
- If the wound is bleeding seriously, the bleeding should be controlled but the wound should not be cleaned. Medical assistance should be summoned immediately.
- If a rabid animal is suspected, immediate medical attention should be summoned. If possible, workers should try to remember what the rabid animal looked like and the area in which it was last seen. The animal should be reported by calling the local emergency number.

4.0 PLANTS

SWPs for plants are as follows:

- Workers should be aware of the types and appearances of poisonous plants in the work site area. Poison ivy, oak, and sumac are the most frequently encountered plants that can cause reaction from casual contact. If a worker is extremely sensitive to these plants, he or she should avoid the area entirely because airborne drift could be sufficient to cause a reaction. Other plants, such as fireweed, can cause painful, short-term irritation and should be avoided as well. Workers should avoid touching face and eye areas after contact with any suspicious plant.

- Workers should wear proper clothing if working in or near overgrown areas. Disposable outerwear should be used, if necessary, and workers should not touch the material with bare hands during removal if the outerwear may have contacted poisonous plants.

- If contact with a poisonous plant has occurred, the affected area should be immediately washed thoroughly with soap and water. If a rash or weeping sore has already begun to develop, a paste of baking soda and water should be applied to the area several times a day to reduce discomfort. Lotions such as Calamine or Caladryl should be applied to help soothe the area. If the condition gets worse and affects large areas of the body or the face, a doctor should be consulted.

- Bushy and wooded areas should be thoroughly checked for thorn-bearing trees, brush, and bramble. In some cases, impalement can cause severe pain or infection.

5.0 WATERBORNE PATHOGENS-GIARDIA

Giardia is a waterborne pathogen consisting of a protoplasmic parasite of the mammalian digestive tract. Giardia is present worldwide, with the highest occurrence in areas with poor sanitation. In the United States, most reported cases are in mountainous regions where drinking water is obtained from streams and is unfiltered or untreated.

Giardia is contracted by ingesting water contaminated with giardia cysts in the dormant state. Giardia parasites can only thrive in the digestive tracts of mammals. Dormant giardia organisms enter water through the feces of infected animals or humans. Giardia symptoms include severe diarrhea and upset stomach. Some people are asymptomatic but can transmit the disease to others. Medical treatment of giardia can be difficult and unpleasant; therefore, prevention is critical. Precautions for preventing exposure to giardia are listed below.

- Workers should assume that all fresh water streams are infected with the giardia organism and not drink any untreated water.

- Team members collecting sediment and water samples from streams should wash their hands thoroughly with soap and water after collecting the samples.

- Giardia parasites are relatively easy to destroy or filter. Water should be treated for drinking or cooking with iodine or another recommended giardia treatment before use.

6.0 HANTAVIRUS

Hantavirus pulmonary syndrome (HPS) is a potentially fatal infection caused by a rodent-borne hantavirus. HPS begins with a brief illness most commonly characterized by fever, muscle pain, headache, coughing, and nausea or vomiting. Other early symptoms include chills, diarrhea, shortness of breath, abdominal pain, and dizziness. In the first identified cases of HPS, this stage of the infection lasted 2 to 5 days before victims were hospitalized. Typically, by the time of hospitalization, victims were found to have tachycardia (a heart rate of greater than 100 beats per minute) and tachypnea (a breathing rate of greater than 20 breaths per minute). Fever was also common. In most cases, death occurred within 2 to 16 days of the onset of symptoms, and victims exhibited pulmonary edema and severe hypotension.

Currently, experts believe that HPS is spread by the deer mouse (*Peromyscus maniculatus*). Though the deer mouse has been found to be the primary host of hantavirus, several other rodent species have also tested positive for the virus. Pinon mice (*Peromyscus truei*), brush mice (*Peromyscus boylii*), and western chipmunks (*Tamia spp.*) are also likely to carry the virus. Also, cases of HPS have been reported in areas of the United States where these particular rodents are not indigenous.

Infected rodents shed the virus in their urine, feces, and saliva. Humans can be exposed to the virus through (1) inhalation of suspended rodent excreta or dust particles containing rodent excreta, (2) introduction of rodent excreta into the eyes or broken skin, and (3) ingestion of food or water contaminated by rodent excreta. HPS has a reported mortality rate of 55 percent. Transmission of hantavirus from infected individuals to healthy persons has not been documented.

Prevention of HPS infection is essential because no known antidote and no specific treatment exists for treating HPS. Therefore, employees should practice risk reduction and control measures. Guidelines for workers in locations that may have rodent infestations or habitats are listed below.

- The best approach for HPS control and prevention is through environmental hygiene practices that deter rodents from colonizing the work environment.

- Information about the symptoms of HPS and detailed guidance on preventive measures should be provided to all employees assigned to field activities.

- Medical attention should be sought immediately for workers who develop a febrile or respiratory illness within 45 days of the last potential exposure to rodents. Attending physicians should be advised of each worker's potential for occupational exposure to hantavirus. Physicians should contact local health authorities promptly if hantavirus-associated illness is suspected. A blood sample should be obtained from the affected worker and forwarded with the baseline serum sample through the state health department to the Centers for Disease Control and Prevention for hantavirus antibody testing.

- Respiratory protective equipment should be worn when handling rodents, when removing rodents from traps, and when working in areas with evidence of rodent droppings or hair. Respiratory protective equipment should include, at a minimum, a half-face air-purifying respirator (APR) or powered APR equipped with a high-efficiency particulate air (HEPA) filter (P100). Full-face regulators may be needed under some circumstances. Respiratory protective equipment should be used in accordance with Occupational Safety and Health Administration regulations.

- Dermal protection should be worn when handling rodents or traps containing rodents, or if contact with contaminated surfaces could occur. Dermal protection should include rubber or plastic gloves that should be washed and disinfected before removal.

- A trap contaminated with rodent urine or feces or in which a rodent was captured should be disinfected with a commercial disinfectant or a 0.4 percent bleach solution. A dead rodent should be disposed of by placing the carcass in a plastic bag containing enough general-purpose household disinfectant to thoroughly wet the carcass. The bag should be sealed and disposed of by burning or by burying it in a 2- to 3-foot-deep hole. Local and state health departments can also provide appropriate disposal methods.

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1.0 PURPOSE

Numerous types of injuries can result from unsafe or improper handling and storing of materials. Workers should be able to recognize the methods for eliminating—or at least minimizing—the occurrence of such incidents. Employers and employees should examine their workplaces to detect any unsafe or unhealthful conditions, practices, or equipment and take corrective action.

This Health and Safety Safe Work Practice (SWP) describes the potential hazards of handling materials and provides information on training, education, and applying general safety principles that will help reduce workplace accidents involving moving, handling, and storing of materials.

2.0 POTENTIAL HAZARDS FOR WORKERS

Workers frequently cite the weight and bulkiness of objects that they lift as major contributing factors to their injuries. Bending, twisting, and turning were the more commonly cited movements that caused back injuries. Other hazards include falling objects, improperly stacked materials, and the potential for injury from the use of various types of equipment.

Potential injuries that can occur when manually moving materials include:

- Strains and sprains from lifting loads improperly or from carrying loads that are too large or too heavy.
- Fractures and bruises caused by being struck by materials or by being caught in pinch points.
- Cuts and bruises caused by falling materials that have been improperly stored or by incorrectly cutting ties or other securing devices.

In addition, mechanical handling equipment operation can present hazards. Refer to the Tetra Tech Health and Safety Safe Work Practices (SWP) 05-45; Forklift Safety and SWP 05-37 Critical Lift Safe Practices for information on the training components and safe work practices for operating forklifts and working around cranes.

3.0 PRECAUTIONS WHEN MOVING, STACKING AND WORKING WITH STORED MATERIALS

This section describes the precautions workers should take when manually or mechanically moving materials, when stacking materials, and when working with stored materials. In addition, a number of material handling tools are posted online in the toolkit section including 1) Body Strain Risk Worksheet, 2) Back Checklist – Lifting and Material Handling Guide, and 3) Strain Prevention Behavior Checklist. For critical lifts requiring rigging refer to the Tt SWP 05-37; Critical Lifts.

3.1 Moving Materials Manually

Proper lifting technique is critical to back safety, but proper planning may be even more important. Before you lift that box, tool, or piece of equipment, take a moment to consider your action:

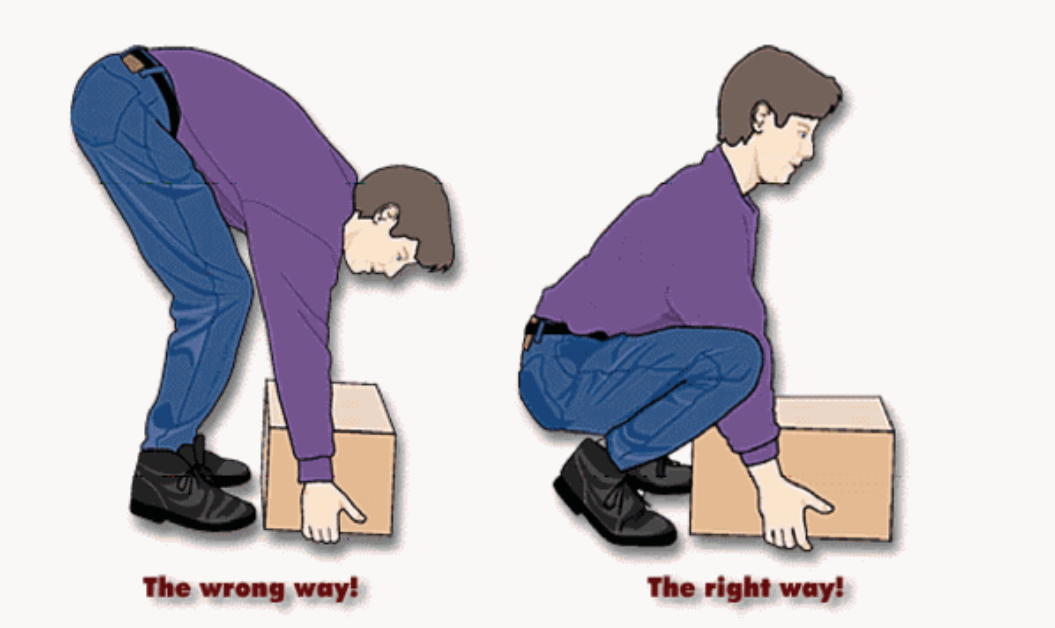
- Do you need to lift the item manually?
- How heavy is it?
- Where are you moving the item?
- Where does it have to go?
- What route do you have to follow?

Workers should always wear appropriate personal protective equipment (e.g., gloves, eye protection, steel-toed safety shoes or boots) and use proper lifting techniques when manually moving materials.

3.1.1 Proper Lifting Technique

- Wear shoes with non-slip soles.
- Clear a space around the object.
- Check your route. Make sure that the floors are not slippery and that there are no obstacles to maneuver around.
- Stand close to the object. Keep your feet apart, staggered if possible.
- Keeping your back upright, lower your body by bending your knees.
- Grip the object firmly.
- Tighten your abdominal muscles.
- Lift with a straight back, pushing with your legs for strength. Keep your head up and look straight ahead.
- Do not hold your breath.
- If you must turn - turn with your feet and your ENTIRE body. Never jerk or twist!
- Hold the object close to your body.
- Make sure you can see over the object.
- Lift and lower the load slowly and smoothly.
- Do not rely on a belt.

- If unsure about technique or weight of the object, ask for help
- If at anytime during lifting there are signs of discomfort or a problem, set down the load and get help.



3.1.2 Workers should seek help to lift items in the following circumstances:

- When a load is too heavy.
- When a load is so bulky that they cannot properly grasp or lift it.
- When they cannot see around or over a load.
- When they cannot safely handle a load.

3.1.3 Follow these procedures to prevent injury from oversize loads:

- Always practice safe lifting techniques
- Position yourself as close to the load as possible when moving an item from a hard-to-reach place. Slide it out to get it closer, and be sure that you have adequate room for your hands and arms.
- Provide sufficient headroom under overhead installations, lights, pipes, and sprinkler systems.

- Be aware of adjacent obstructions, on either side or above the load. Think about where the item will be placed once you've lifted it. Will it be overhead? Under an overhang? In a narrow spot?
- Allow as much room as possible to set the load down. You can always shift it slightly later.
- Check your path from place to place. Remove tripping hazards.
- Make sure that the lighting is sufficient to see where you are going. Stabilize uneven or loose ground, or choose an alternate route. The shortest way isn't always the fastest, or the safest.
- When loading or unloading equipment or materials from a pickup truck, always do so from the back end with the tailgate down. Do not lift anything over the sides of the bed and never stand on the tires to gain access.
- When possible, attach handles or holders to loads and use blocking materials to manage loads safely. When placing blocks under a raised load, be sure that the load is not released before you can remove your hands from under the load. Blocking materials and timbers should be large and strong enough to support the load safely. Do not use materials with rounded corners, cracks, splintered pieces, or dry rot.
    - Handle only stable or safely arranged loads.
    - When using mechanical help, remember to push, not pull – you'll have more control and greater leverage.
    - Fasten the load to the equipment so sudden stops or vibrations don't jar it off.

3.2 Moving Materials Mechanically

Use mechanical help – a dolly, hand truck, or forklift – wherever possible. However, keep in mind that using mechanical equipment to move and store materials may increase the potential for employee injuries due to hazards associated with the equipment being used. Follow these general safety rules.

- Let the weight, size, and shape of the material being moved dictate the type of equipment used. All materials-handling equipment has rated capacities indicating the maximum weight the equipment can safely carry and the conditions under which it can handle the weight. The department or project manager must ensure that the capacity is displayed on each piece of equipment and that it is not exceeded.
- Do not place extra weight on the rear of a counterbalanced forklift to allow an overload.

- Center the load on the platform as close to the support as possible to minimize the potential for tipping over or the load to fall.
- Adjust the load to the lowest position when traveling.
- Follow the equipment manufacturer's operational requirements.

3.3 Stacking Materials

Stacking materials can be dangerous if workers do not follow safety guidelines. Falling materials and collapsing loads can crush or pin workers, causing injury or death. To help prevent injuries, follow these general safety rules:

- Consider the need for availability of the material.
- Paint walls or posts with stripes for quick reference of the maximum stacking heights.
- Ensure that stacks are stable and self-supporting.
- Stack bags and bundles in interlocking rows to keep them secure.
- Step back the layers and cross-key bags at least every 10 layers. To remove bags from the stack, start from the top row first.
- Band or secure boxed materials with crossties or shrink plastic fiber.
- Do not store pipes and bars in racks that face main aisles, where it may create a hazard to passersby when supplies are removed.

3.4 Avoiding Storage Hazards

Workers must be aware of the height and weight of stored materials, their accessibility, and the condition of the containers where the materials are being stored. To prevent creating hazards when storing materials, the following guidelines should be used:

- Keep storage areas free from materials that could cause tripping, fires, explosions, or that may harbor rats or other pests.
- Place stored materials inside buildings that are under construction and at least 6 feet from hoist ways, or inside floor openings and at least 10 feet away from exterior walls.
- Separate materials that are not compatible (refer to SWP 05-13; Flammable Hazards and Ignition Sources).

4.0 OTHER IMPORTANT SAFETY MEASURES

Injuries from handling and storing materials may be reduced by adopting sound ergonomics practices, taking general fire safety precautions, keeping aisles and passageways clear and using ladders safely. Managers are expected to periodically evaluate current work station configurations

and employees' work techniques to assess the potential for and prevention of injuries. Injuries caused by improper lifting will be inviestigated in accordance with Tetra Tech DCN 02-02 Incident Reporting and Investigation Program. Investigatvive findings will be incorporated into work procedures to avoid future injuries. The following general guidelines are provided to aid managers and workers in these areas.

4.1 Ergonomics

Ergonomics (the study of work) is based on the principle that the job should be adapted to fit the person rather than forcing the person to fit the job. Workplace conditions should be restructured or changed to make the job easier and reduce stressors that cause musculoskeletal disorders. Ergonomic principles may require reducing the size or weight of the objects lifted, installing a mechanical lifting aid, or changing the height of a pallet or shelf. Although no lifting approach completely eliminates back injuries, a substantial number of injuries can be prevented by implementing sound ergonomic practices and by training employees in appropriate lifting techniques.

Not all back injuries are a result of sudden trauma; most are of a cumulative type, where a repeated minor injury has flared up, continued use of a heavy tool in the same position has caused pain, or a great deal of time is spent in the same position.

4.2 Fire Safety

Flammable and combustible materials must be stored according to their fire characteristics. Flammable liquids, for example, must be separated from other material by a firewall. Other combustibles must be stored in an area where smoking and using an open flame or spark-producing device is prohibited. Dissimilar materials that are dangerous when they come into contact with each other must be stored apart.

4.3 Aisles and Passageways

Allow sufficient clearance of aisles at loading docks, through doorways, at turning points, and in other parts of the workplace when mechanically moving materials. Providing sufficient clearance will prevent workers from being pinned between the equipment and fixtures, such as walls, racks, posts, or other machines. Sufficient clearance will also prevent the load from striking an obstruction and falling on an employee.

Ensure that passageways remain clear of obstructions and tripping hazards. Do not store materials in excess of supplies needed for immediate operations in aisles or passageways.

5.0 TRAINING AND EDUCATION

OSHA recommends that employers establish a formal training program to teach workers to recognize and avoid materials handling hazards. Training of Tt personnel on this topic will be implemented through the issuance of this SWP and periodic discussion of the topic during monthly health and safety meetings, as well as during pre-project and tailgate safety meetings. The training should reduce workplace hazards by emphasizing the following factors:

- Avoidance of unnecessary physical stress and strain.
- Awareness of what a worker can comfortably handle without undue strain.
- Proper use of equipment.
- Recognition of potential hazards and how to prevent or correct them.
- Prevention of back injuries

Prevention of back injuries should receive special emphasis because of the high incidence of back injuries. Training on proper lifting techniques should cover the following topics:

- Health risks of improper lifting vs. the benefits of proper lifting.
- Body strengths and weaknesses and determining one's own lifting capacity.
- Physical factors that might contribute to an accident.
- Safe postures and timing for smooth, easy lifting.
- Warning signals from your body to watch for when lifting.

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	Name	
11/27/2013	Chris McClain	Update from 1998 format

By far, the most common cause of skin cancer is overexposure to the sun. Ninety percent of all skin cancers occur on parts of the body that not usually covered by clothing. People who sunburn easily, and those with fair skin and red or blond hair are more prone to develop skin cancer. The amount of time spent in the sun also affects a person's risk of skin cancer. Premature aging of the skin also occurs with prolonged sun exposure. Tetra Tech encourages personnel to avoid prolonged exposure to the sun, and recommends the following:

- Sunburn can occur during any time of the year. To avoid sunburn, wear hats with wide brims.
- Use sunscreen with a Sun Protective Factor (SPF) rating of 15 or higher.
- To prevent skin cancer:
    - Cover up with a wide brimmed hat and a bandanna for your neck. Wear long-sleeved shirts and pants which the sun cannot penetrate.
    - Use sunscreens to help prevent skin cancer as well as premature aging of your skin. Use a Sun Protective Factor (SPF) rating of 15 or higher.
    - Apply sunscreen at least an hour before going into the sun and again after swimming or perspiring a lot.
    - Do not use indoor sun lamps, tanning salons/parlors, or tanning pills.
- You can still get burned on a cloudy day. Try to stay out of the direct sun at midday, because sun rays are their strongest between 10 a.m. and 3 p.m. Beware of high altitudes - where there is less atmosphere to filter out the ultraviolet rays. Skiers should remember that snow reflects the sun's rays, too.
- Know your skin. Whatever your skin type, do a monthly self-examination of your skin to note any moles, blemishes or birthmarks. Check them once a month and if you notice any changes in size, shape or color, or if a sore does not heal, see your physician without delay.

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10/1/2008	Chris McClain	NEW

This safe work practice (SWP) provides guidelines for proper and thorough cleaning of respiratory protection equipment. The Occupational Safety and Health Administration (OSHA) regulates the use of respiratory protection for general industry in Title 29 of the *Code of Federal Regulations* (CFR) Part 1910.134, "Respiratory Protection." Appendix B-2 of the standard outlines mandatory requirements for respirator cleaning and is used as the basis for this SWP. This SWP supplements Document Control Number (DCN) 2-6, "Respiratory Protection Program." It provides specific respirator cleaning and disinfection procedures and shall be included as an attachment to the site-specific health and safety plan for projects for which respirator use is planned or is a contingency.

1.0 APPLICABILITY

This SWP shall apply to any project that involves use of respirators with reusable facepieces.

Respirators shall be cleaned and disinfected as discussed below.

- Respirators issued for the exclusive use of an employee shall be cleaned and disinfected as often as necessary to be maintained in a sanitary condition.
- Respirators issued to more than one employee shall be cleaned and disinfected before being worn by different individuals.
- Respirators maintained for emergency use shall be cleaned and disinfected after each use.
- Respirators used in fit testing and training shall be cleaned and disinfected after each use.

2.0 CLEANING AND DISINFECTION PROCEDURES

Mandatory respirator cleaning procedures as defined in 29 CFR Part 1910.134, Appendix B-2, are listed below. All wash and rinse water should be warm, with a maximum temperature of 110 °F (43 °C).

1. Remove filters, cartridges, or canisters. Disassemble facepieces by removing speaking diaphragms, demand and pressure-demand valve assemblies, hoses, and any other components as recommended by the manufacturer. Discard or repair any defective parts.

2. Wash components in warm water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.

3. Rinse components thoroughly in clean, warm, preferably running water. Drain all components.

4. When the cleaner does not contain a disinfecting agent, respirator components should be immersed for 2 minutes in one of the following:

    - Hypochlorite solution [50 parts per million (ppm) of chlorine] made by adding approximately one milliliter of laundry bleach to 1 liter of warm water

    - Aqueous solution of iodine [50 ppm iodine made by adding approximately 0.8 milliliter of tincture of iodine (6 to 8 grams ammonium and/or potassium iodide per 100 cubic centimeters of 45 percent alcohol) to 1 liter of warm water]

    - Other commercially available cleansers of equivalent disinfectant quality when used as directed if their use is recommended or approved by the respirator manufacturer

5. Rinse components thoroughly in clean, warm, preferably running water. Drain all components. The importance of thorough rinsing cannot be over emphasized. Detergents or disinfectants that dry on facepieces may cause dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.

6. Components should be air-dried or hand-dried with a clean, lint-free cloth.

7. Reassemble the facepiece. Replace filters, cartridges, and canisters prior to next use.

8. Test the respirator to ensure that all components work properly.

9. Place the respirator in a clean bag and seal for storage.

Depending on work conditions, respirator facial sealing surfaces may need periodic cleaning during the course of daily use. Cleaning of the facial sealing surface during work breaks can reduce the chance of facial irritation caused by sweat, natural skin oil, or irritating materials that may have deposited on the facepiece. Facial sealing surfaces can be cleaned using disinfectant

wipes soaked in isopropyl alcohol or benzalkonium chloride. After use of the disinfectant wipe, the sealing surface should air dry or be dried thoroughly using paper towels or tissues.

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This safe work practice (SWP) was developed to ensure the proper use of respirators in routine and foreseeable emergency situations. The SWP supplements Document Control No. 2-6, "Respiratory Protection Program." This SWP shall be included as an attachment to the site-specific health and safety plan (HASP) for projects for which respirator use is planned or is a contingency.

1.0 APPLICABILITY

This SWP shall apply to any project that involves use of air purifying respirators and shall not be used for situations involving the use of supplied air systems such as self-contained breathing apparatuses and air-line apparatuses.

2.0 ROUTINE RESPIRATOR USE PROCEDURES

The procedures below apply to the routine use of air purifying respirators:

- Respirators shall not be issued to or worn by individuals when conditions prevent valve function or a good facial seal. These conditions may include but are not limited to facial hair, such as the growth of beard, sideburns, or excessive mustaches, and possibly the wearing of corrective eyeglasses.
- If spectacles, goggles, face shields, or welding helmets must be worn with a facepiece, they will be worn so as not to adversely affect the seal of the facepiece to the face.
- For all tight-fitting respirators, a positive and negative pressure seal check shall be performed each time the respirator is donned. Seal checks shall be performed as follow:
  - *Negative pressure check:* Close off the inlet opening of the canister or cartridge(s) by covering it with the palm of the hand(s), inhale gently so that the facepiece collapses slightly, and hold the breath for 10 seconds. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is satisfactory.
  - *Positive pressure check*: Close off the exhalation valve and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. The exhalation valve cover may have to be removed to perform this procedure.

- *Manufacturer's recommended seal check*: If the respirator manufacturer recommends specific procedures for performing a user seal check, these procedures may be used instead of the negative and positive pressure checks.

- Work areas must be monitored for conditions that may adversely affect the effectiveness of respiratory protection. Employees may leave the work area where respirators are required under the following conditions:

  - To wash the face and respirator facepieces as necessary to prevent eye or skin irritation;

  - If vapor or gas breakthrough, changes in breathing resistance, or leakage of the facepiece is detected;

  - To replace the respirator or the filter, cartridge, or canister elements;

  - If established monitoring instrument action levels are exceeded; or

  - For any other criteria as established in a site-specific health and safety plan (HASP), construction health and safety plan (C-HASP), job hazard analysis (JHA), job safety analysis (JSA), work permit or other site-specific health and safety document.

3.0 RESPIRATOR USE DURING EMERGENCY SITUATIONS

Emergency situations may arise during the wearing of respiratory protection. These situations could include medical emergency, respirator failure, fire, chemical spills or leaks, and other events that pose an immediate risk. Procedures for respirator use during emergency situations are summarized below.

- When an emergency situation arises that creates or has the potential to create immediately dangerous to life and health (IDLH) conditions, the work environment shall be evacuated immediately and shall not be reentered by employees without suitable protective gear.

- Work environments with the potential for the development of atmospheres that may present IDLH conditions shall only be entered by employees using the buddy system.

- When an emergency situation arises that includes physical hazards that may interfere with the proper use of respiratory protection, the work environment shall be evacuated.
- Under no circumstances shall respirator users remove facepieces in hazardous atmospheres. In the event of respirator malfunction, users should leave the hazardous environment immediately and proceed to a known safe location before removal of the facepiece.
- Episodes of respirator failure shall be thoroughly investigated before work activities begin again. The investigation shall include re-evaluation of work area atmospheric conditions, review of the respirator selection criteria and service life calculations, and an evaluation of the working conditions under which respirator failure occurred.

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The safe work practice (SWP) addresses the need for proper and thorough procedures for qualitative fit testing of respirators. The Occupational Safety and Health Administration (OSHA) regulates general industrial use of respiratory protection under Title 29 of the *Code of Federal Regulations* (CFR), Part 1910.134. Appendix A of the standard outlines mandatory procedures to use for both qualitative fit tests (QLFT) and quantitative fit tests (QNFT). This SWP was written in accordance with the requirements of Appendix A for QLFTs. This SWP must be used in conjunction with the Tetra Tech, Inc. (Tetra Tech), "Respiratory Protection Program," Document Control Number (DCN) 2-6.

The following sections describe the SWP's applicability, qualifications of fit testers, and fit testing procedures for use during QLFTs.

1.0 APPLICABILITY

This SWP applies to all Tetra Tech employees who use respirators on the job and to employees who conduct any fit testing. In addition, when a Tetra Tech company or office uses an outside service to perform fit testing, the organization conducting the fit testing shall meet the minimum requirements for QLFT and QNFT procedures specified in Appendix A of the standard.

Respirator fit testing shall be conducted at the following intervals:

- Prior to initial use of a respirator;
- Whenever a different respirator facepiece (size, style, model, or make) is used;
- At least annually thereafter; or
- After any reported or observed changes in an employee's physical condition that could affect respirator fit. This includes but is not limited to, facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight.

If an employee notices that the fit of a respirator has become unacceptable, he or she will be given an opportunity to select another respirator facepiece.

2.0 QUALIFICATION OF FIT TESTERS

Tetra Tech employees who conduct QLFTs must demonstrate sufficient understanding and expertise in the required testing procedures. Fit testers shall qualify through appropriate education,

experience, or both. Qualifications of fit testers shall be determined on a case-by-case basis by operating unit health and safety managers (HSMs) based on the fit tester's demonstrated knowledge of OSHA-mandated fit test procedures and performance of a simulated fit test. The HSM must ensure that persons administering fit tests are able to prepare test solutions, calibrate and operate equipment, perform tests properly, recognize invalid tests, and ensure that test equipment is in proper working order. The fit tester must also demonstrate how to clean and maintain equipment to operate within the parameters for which it was designed.

3.0 FIT TESTING PROCEDURES

Appendix A of 29 CFR 1910.134 provides instruction for five OSHA-accepted QLFT procedures. Tetra Tech has selected two of these procedures for its fit-test program. The sections below describe general requirements that must be followed during all fit tests and for any fit test method used. The Both Bitrex™ QLFT protocol is discussed below.

3.1 General Requirements

QLFTs must be conducted in accordance with the general requirements discussed below.

- The test subject shall be shown how to put on a respirator, position it on the face, set strap tension, and determine an acceptable fit. A mirror shall be available to assist the subject in evaluating the fit and positioning the facepiece.
- The test subject must be allowed to choose from a sufficient selection of models and sizes to identify a respirator that fits correctly and is comfortable. The subject shall be informed that he or she is being asked to select the respirator that provides the most acceptable fit. The subject shall be asked to hold each chosen facepiece up to the face and eliminate those that obviously do not provide an acceptable fit.
- The subject shall don the most comfortable respirator and wear it for at least 5 minutes to assess comfort. If the subject is not familiar with a particular respirator, the subject shall be directed to don the mask several times and to adjust the straps each time to become adept at setting proper strap tension.
- The tester shall review the following points with the subject and allow the subject adequate time to determine the comfort of the respirator:
  - Position of the mask on the nose

  - Room for eye protection
  - Ability to talk
  - Position of the mask on the face and cheeks

- The following criteria shall be used to help determine the adequacy of the respirator fit:
  - Chin properly placed
  - Adequate strap tension (not overly tight)
  - Fit across nose bridge
  - Proper size to span distance from nose to chin
  - Tendency of respirator to slip
  - Self-observation in a mirror to evaluate fit and respirator position

- The subject shall conduct a user seal check using the negative- and positive-pressure seal check procedures described in Appendix A of this SWP. Before conducting the check, the subject shall be instructed to seat the mask on the face by moving the head from side to side and up and down slowly while taking a few slow, deep breaths. If the seal checks fail, the subject shall choose another facepiece.

- Seal checks and fit testing shall not be conducted if there is any facial hair growth such as stubble beard growth, beard, mustache, or sideburns that interferes with the facepiece sealing surface. Any interfering apparel shall be altered or removed.

- If the subject experiences difficulty in breathing during testing, the testing shall stop immediately and he or she shall be referred to a company physician for assessment.

- If the subject finds the fit of the respirator unacceptable, the subject shall be given the opportunity to select a different respirator and to be retested.

- Prior to commencement of the fit test, the subject shall be given a written description of the respirator user seal check procedures (see Appendix A) and exercises to perform during the testing. Exercises and a prepared text to be read during the test are included in Appendix B of this SWP.

- All exercises in Appendix B must be performed for all QLFT methods.

3.2 BITREX™ Solution Qualitative Fit Test Protocol

Bitrex™ solution (denatonium benzoate) is a taste aversion agent. To conduct a QLFT using Bitrex™, the test subject must first pass a taste threshold screening. The entire procedure must be explained to the test subject before the screening is conducted. The sections below describe taste threshold screening and fit test procedures. Particulate filters (cartridges) are used during this test.

3.2.1 Taste Threshold Screening

The taste threshold screening is intended to determine whether the individual tested can detect the taste of Bitrex™. The procedures below shall be used for the taste screening.

- Prior to testing, the tester shall prepare a quantity of threshold check solution by adding 13.5 milligrams (mg) of Bitrex™ to 100 milliliters (mL) of 5 percent salt solution in distilled water. A nebulizer for taste screening shall be clearly marked to distinguish it from the fit test solution nebulizer. The taste screening nebulizer shall be thoroughly rinsed in water, shaken to dry, and refilled at least each morning and afternoon or at least every 4 hours.

- During the taste screening as well as during the fit testing, subjects shall wear an enclosure around the head and shoulders that is approximately 12 inches in diameter by 14 inches tall. The front portion of the enclosure shall be clear from the respirator and allow free movement of the head when a respirator is worn. An enclosure substantially similar to the 3M hood assembly, parts #14 and #15 combined, is adequate.

- The test enclosure shall have a 0.75-inch hole in front of the test subject's nose and month area to accommodate the nebulizer nozzle.

- The test subject shall don the test enclosure. Throughout the threshold screening test, the test subject shall breathe through his or her slightly open mouth with tongue extended. The subject is instructed to report when he or she detects a bitter taste.

- Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the threshold check solution into the enclosure. To produce the aerosol, the nebulizer bulb is firmly squeezed so that the bulb collapses completely. The bulb is then

released and allowed to fully expand. Correct use of the nebulizer means that approximately 1 mL of liquid is used at a time in the nebulizer body.

- The nebulizer should be rapidly squeezed 10 times and then the test subject is asked whether the Bitrex™ solution can be tasted. If the subject reports tasting the bitter taste during the 10 squeezes, the screening test is complete. The taste threshold is noted as 10 regardless of the number of squeezes actually completed.

- If the first response is negative, the nebulizer is rapidly squeezed 10 more times and the test subject is again asked whether the Bitrex™ solution is tasted. If the test subject reports tasting the bitter taste during the second 10 squeezes, the screening test is completed. The taste threshold is noted as 20 regardless of the number of squeezes actually completed.

- If the second response is negative, the nebulizer is rapidly squeezed 10 more times and the test subject is again asked whether the Bitrex™ solution is tasted. If the test subject reports tasting the bitter taste during the third 10 squeezes, the screening test is completed. The taste threshold is noted as 30 regardless of the number of squeezes actually completed.

- If the Bitrex™ solution is not tasted after 30 squeezes, the test subject is unable to taste the Bitrex™ solution and cannot be fit tested using the Bitrex™ solution test.

- The tester will note the number of squeezes required to solicit a taste response. When a taste response has been elicited, the test subject shall be asked to note the taste for reference in the fit test.

3.2.2 Bitrex™ Solution Fit Test Procedures

The procedures below must be followed to conduct the actual Bitrex™ solution fit test:

- A fit test solution is prepared by adding 337.5 mg of Bitrex™ to 200 mL of a 5 percent salt solution in warm water. A second nebulizer dedicated to fit testing shall be clearly marked to distinguish it from the taste screening solution nebulizer. The nebulizer shall be thoroughly rinsed in water, shaken to dry, and refilled at least each morning and afternoon or at least every 4 hours.

- The test subject shall be instructed not to each, drink, smoke, or chew gum for 15 minutes before the test.

- The person being fit tested shall don the respirator without assistance and perform the required user seal check (see Appendix A).
- The fit test uses the same enclosure described for taste threshold screening in Section 3.2.1. The test subject shall don the enclosure while wearing the respirator selected as described in the general requirements in Section 3.1. The respirator shall be properly adjusted and equipped with particulate filter(s).
- As before, the test subject shall breathe through his or her slightly opened mouth with tongue extended, and shall be instructed to report is he or she tastes the bitter taste of Bitrex™
- The nebulizer is inserted into the hole in front of the enclosure, and an initial concentration of the fit test solution is sprayed into the enclosure using the same number of squeezes (either 10, 20, or 30) based on the number of squeezes required to elicit taste response noted during the screening test.
- After generating the aerosol, the test subject shall be instructed to perform the test exercises provided in Appendix B.
- Every 30 seconds, the aerosol concentration shall be replenished using one half the number of squeezes used initially (such as 5, 10, or 15).
- The test subject shall indicate to the tester if at any time during the fit test the taste of Bitrex™ solution is detected. If the test subject does not report tasting the Bitrex™ solution, the test is passed.
- If the taste of Bitrex™ solution is detected, the fit is deemed unsatisfactory and the test is failed. A different respirator shall be tried, and the entire test procedure (screening and test) is repeated.

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APPENDIX A

RESPIRATOR USER SEAL CHECK PROCEDURES

APPENDIX A

RESPIRATOR USER SEAL CHECK PROCEDURE

Individuals using tight-fitting respirators must perform a user seal check each time a respirator is put on to ensure that an adequate seal is achieved. Two methods are available for use; one is the positive- and negative-pressure check and the other is the respirator manufacturer's method. Either the positive- and negative-pressure checks described below may be used or, if a manufacturer of a particular respirator brand has developed its own recommended seal check method, that method may be used in place of the negative- and positive-pressure seal checks. User seal checks are not a substitute for qualitative or quantitative fit tests. The user check procedures described below are as described in the mandatory Appendix B-1 of Title 29 of the *Code of Federal Regulations*, Part 1910.134.

- Positive-Pressure Check

  Close off the exhalation valve and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators, this method of leak testing requires the wearer to first remove the exhalation valve cover before closing off the exhalation valve and then carefully replace it after the test.

- Negative-Pressure Check

  Close off the inlet opening(s) of the canister or cartridge(s) by covering the opening with the palm of the hand(s) or by replacing the filter seal(s). Inhale gently so that the facepiece collapses slightly, and hold the breath for 10 seconds. The inlet opening of some cartridges cannot be effectively covered with the palm of the hand. In this case, the test can be performed by covering the inlet opening of the cartridge with a thin latex or nitrile glove. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is considered satisfactory.

APPENDIX B

RESPIRATOR FIT TEST EXERCISES

RESPIRATOR FIT TEST EXERCISES

Test subjects shall perform the exercises below during fit test process. Prior to the actual fit test, the test subject shall (1) select a suitable and comfortable respirator; (2) don, adjust, and then wear the respirator for 5 minutes to assess comfort; (3) conduct a user seal check in accordance with the procedures outlined in Appendix A, (4) report any difficulties breathing while wearing the respirator, (5) select a different respirator if the fit and level of comfort is unacceptable, and (6) perform the fit test exercises described below in the order listed. The qualitative fit test (QLFT) shall be performed in a test environment.

Test Exercises

Each exercise below shall be conducted for 1 minute. During testing, the subject will be questioned and observed to determine if the respirator is comfortable. The respirator shall not be adjusted during the fit testing procedure. Any adjustment voids the test, and the test must be repeated from the beginning.

1. **Normal breathing.** In a normal standing position without talking, breathe normally.
2. **Deep breathing.** In a normal standing position, breathe slowly and deeply. Be careful not to hyperventilate.
3. **Turning head from side to side.** Standing in place, slowly turn the head from side to side between the extreme positions on each side. Hold the head at each extreme momentarily and inhale at each side.
4. **Moving head up and down**. Standing in place, slowly move the head up and down. Inhale in the up position (such as when looking toward the ceiling).
5. **Talking.** Talk out loud slowly and loud enough to be heard clearly by the fit tester. Read the entire “Rainbow Passage” on the next page.
6. **Bending over.** Bend at the waist as if to touch the toes.
7. **Normal breathing.** Complete the same exercise as item 1 above.

After these test exercises are completed, the tester shall ask the test subject about the comfort of the respirator. If the respirator is uncomfortable, another respirator shall be tried and the fit test, as well as user check and screening procedures, will be repeated.

RAINBOW PASSAGE

"When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow."

Source: Appendix A of Title 29 of the *Code of Federal Regulations,* Part 1910.134

This safe work practice (SWP) presents guidance regarding encounters with dangerous or aggressive animals, and is based on reasonably anticipated animal hazards Tetra Tech, Inc. (Tetra Tech), field staff may encounter in their work.

THIS SWP APPLIES TO ALL TETRA TECH EMPLOYEES WHO MAY PERFORM WORK THAT COULD RESULT IN ENCOUNTERS WITH DANGEROUS OR AGGRESSIVE ANIMALS.

1.0 RESPONSIBILITIES

In preparation for project-related activities, the Project Manager (PM) is responsible for the following:

- Identify the types of dangerous or aggressive animals that could be encountered, based on the location and schedule of the planned work
- Ensure that potential risks to personnel are properly assessed, and
- Ensure that Tetra Tech personnel are provided with appropriate tools to control the anticipated hazards.

When applicable, this SWP must be attached to the health and safety plan. Project managers will ensure that appropriate measures have been taken regarding awareness of the potential threats from dangerous or aggressive animals and that preventative actions are implemented as feasible. This responsibility may be delegated to the site safety coordinator for a specific project.

2.0 PROCEDURES

Procedures for employee prevention and reaction to dangerous or aggressive animals are discussed below. While few preventative actions are likely to work in every situation, the procedures present the most reasonable means of minimizing or controlling confrontations with dangerous or aggressive animals.

1.2 KNOW BEFORE YOU GO

When feasible, workers should identify and contact residents or property owners in advance of visiting private residences to inform them of the schedule for work in the area. Such notifications should include

a request to restrain animals during this time for the protection of the animal and of the employee. During such notifications, workers should remember to inquire about any other known or potential hazards in the area (such as bee hives, wasp nests, and stray animals).

Dangerous or aggressive animals may be encountered anywhere — indoors or outdoors; as well as in urban or rural and remote areas. One of the most important steps in prevention is to understand the employee's work environment and predicting the types of animals that may be encountered. Any animal can become aggressive. Aggressive behavior could result if the animal feels threatened, is ill, is protecting its young, or many other factors. The subsections below discuss examples of animals that could typically be found in domestic and rural areas. Animal behaviors can be unpredictable, and therefore the information below should not be used as an absolute resource but instead as a general guide for awareness. After the employee's work environment has been identified, additional research may be necessary to realize what particular animals may exist in those areas and to obtain tips on how to prevent and respond to encounters.

Some examples of animals that could be encountered in domestic areas and tips on preventing negative encounters are listed below:

Dogs — One of the most common animals encountered in domestic areas and during project activities is the canine. "Dog mace", or pepper spray for canines may be an appropriate for areas with known sightings of aggressive dogs. Always exercise caution when approaching any dog, because all dogs have the potential to bite. Initial observations can be misleading. Telltale signs such as growling ears drawn back, or tails tucked between the hind legs may be absent, yet this does not guarantee that a dog will not act aggressively. For example, some dogs express nervousness by wagging their tail, which typically signifies a non-aggressive posture. If a dog displays unusual or awkward behavior, the worker should leave the area to avoid a negative encounter. Employees should request that residents and property owners restrain the animal while activities are under way. If a dog attempts to strike, the employee should try to block the dog using a backpack, stick, or other object for the dog to bite instead of the body. The employee should then immediately flee the area.

General safety tips for aggressive dog encounters:

- Employees should not approach any unfamiliar dog.
- Do not run from a dog or scream.
- Remain motionless ("be still like a tree") when approached by an unfamiliar dog.
- If the dog continues to be aggressive slowly back away from the dog until you can reach safe area.
- If knocked over by a dog, roll into a ball and be still.
- Do not attempt to pet or play with any dog that you are unfamiliar with, even if the owner is present and tells you that you can do so.
- Immediately report stray dogs or dogs displaying unusual behavior to your team leader and site safety officer.
- Avoid direct eye contact with a dog.
- Do not disturb a dog that is sleeping, eating, or caring for puppies.
- If bitten, clean the wound and seek medical direction from Work Care. Report the incident to your Supervisor, the Project Manager, and in TOTAL. (See section 2.3 for reporting procedures).

Cats — Like any other animal, a cat's behavior can be unpredictable. Employees should request that residents and property owners restrain the animal while work is under way. If a cat displays unusual or awkward behavior, the worker should leave the area to avoid a negative encounter.

Other Animals That Could be Encountered in Residential Areas — In addition to dogs and cats, domestic animals that may be encountered at a residence could include animals such as other mammals, reptiles, or insects (such as spiders or bee hives). When work is conducted in residential areas, the employees should maintain awareness and speak with residents concerning the presence of the any pets, requesting that they be restrained while activities are in progress.

Farm Animals — Employees should inquire with property owner about the types of animals in the areas where activities will be conducted and requesting that the animals be restrained from "free range" while work is being conducted. Many different farm animals can be aggressive and cause injury, including horses, cattle, swine, goats, and others.

Snakes — Snakes may be encountered in domestic or rural areas in both interior and exterior spaces. It is important to be aware of the poisonous snakes that may be present in the geographical area. Employees should maintain awareness of where they are stepping, sitting, and storing equipment and supplies.

Guidelines for encounters with snakes and for treating snakebites are listed below.

- Workers should avoid walking in areas known to harbor snakes.
- Be aware of snakes that may be swimming in the water to reach higher ground and of those that may be hiding under debris or other objects.
- If you see a snake, back away from it slowly and do not touch it.
- Workers should be cautious when picking up or moving items that have been on the ground.
- Workers should wear boots made of heavy material that protect the ankles and snake chaps. Heavy work gloves should be worn for picking up items.
- If one snake is encountered, others may be present. Workers should leave the area by retracing their steps.

Responding to a Snake Bite:

- If a worker is bitten, try to see and remember the color and shape of the snake, which can help with treatment of the snake bite.
- Lie or sit the person down with the bite below the level of the heart. This position can slow down the spread of venom if the snake is poisonous.
- Tell him or her to stay calm and still.
- Cover the bite with a clean, dry dressing.
- Seek medical attention as soon as possible.

- Dial 911 or call local Emergency Medical Services.
- Apply first aid if you cannot get the person to the hospital right away.

For more information, see "How to Prevent or Respond to a Snake Bite" (www.bt.cdc.gov/disasters/snakebite.asp).

Rodents — Rats and mice may be encountered in interior or exterior areas. Employees should inquire with residents or commercial property owners regarding any knowledge of their presence and maintain awareness of rodents on interior and exterior areas. Employees should be alert for signs such as droppings, small holes (that may be used for entry and egress by a rodent), and gnawed areas that may indicate the presence of rodents. Rodents are known vectors for Hanta Virus and many other serious illnesses (See Biohazard Safety SWP 5-17). It may be difficult to spot these animals in dark areas. Employees should be equipped with a flashlight when they enter dark rooms. Any bites or contact with droppings or nesting materials should be reported to your project manager and Safety Manager immediately.

Raccoons —- Raccoons can be found in domestic or rural areas and particularly in or near trash storage areas, but are primarily nocturnal. Raccoons present during the day may indicate illness, such as rabies. They are able to open lids on trash cans and dumpsters when locks or additional controls are not in place. It may be difficult to spot these animals in dark areas. Employees should be aware of and avoid the areas where the potential to encounter raccoons is high. Employees should be equipped with a flashlight when entering dark areas.

- If a raccoon approaches too closely, make yourself appear larger: stand up, shout, and wave your arms. If he continues to approach, throw or spray water, or even stones if needed.

- A raccoon that is very aggressive – or too tame, or seems to be disoriented or staggers may be sick or injured. Do not approach the animal yourself; instead contact your team leader and site safety officer (also, you may contact a local wildlife department or a wildlife management professional.

Other Animals — Some examples of animals that may be encountered in rural or forested areas that could result in a negative encounter include bear, coyote, wolf, wild boar, muskrat, and beaver. Awareness is the key to prevention of encounters with animals in the wild. The employee is in the animal's home and it could react aggressively if it feels threatened. Find out what types of animals could be encountered in the rural area where the work is to be conducted and review the information with the project team before work begins. You may need to make contact with Local/State/Federal wildlife officials (Fish and Game, Forest Service, etc.) in regard to appropriate procedures. If a wild animal is encountered or observed, the employee should calmly leave the area, tracking the path they use to enter it.

2.2 BUDDY SYSTEM

Whenever possible, workers should conduct activities using the buddy system. Operating under the buddy system doubles visual awareness for prevention of a negative encounter with a dangerous or aggressive animal. Should a worker need to conduct activities as a lone worker, procedures detailed within SWP 5-32, Lone Worker Safe Practices, should be reviewed and followed.

2.3 PROCEDURES FOR ENCOUNTERS WITH DANGEROUS OR AGGRESSIVE ANIMALS

If an encounter with a dangerous or aggressive animal occurs, the worker should immediately assess the situation for appropriate action and follow the SWP guidelines. If the worker is bitten, he or she should immediately leave the area to avoid multiple bites. If the animal is or may be poisonous (venomous, rabid, etc.) or the wound is bleeding seriously, the employee should immediately seek medical attention (Call 911, then contact your project manager/safety manager). If possible, the employee should be aware of any unusual behavior that may indicate the animal is ill (rabid). Any wound should be cleaned, dressed, and reported to the project manager and safety manager within an hour. Work Care should be notified as soon as possible for non-life threatening injuries at (800-455-6155) or (888-449-7787). SWP 5-17, Biohazard Safety, provides additional guidance on the biological hazards of animals and should be reviewed as an additional resource.

Revision Date	Document Authorizer		Revision Details
	Name	Approval Date	

TETRA TECH, INC.

HEALTH AND SAFETY MANUAL

VOLUME III

SAFE WORK PRACTICES (SWP)

RADIATION SAFETY PRACTICES

SWP NO.: 6-21

ISSUE DATE: JULY 1998

REVISION NO.: 1

RADIATION SAFETY PRACTICES

This safe work practice (SWP) applies to employees who work at sites where ionizing radiation (radiation) is a known or suspected hazard. This SWP applies to ionizing forms of radiation only and does not address hazards or SWPs for nonionizing forms of radiation such as infrared, ultraviolet, microwave, radio waves, and so on. This SWP addresses the requirements of Title 29 of the *Code of Federal Regulations* (CFR), Part 1910.96, "Ionizing Radiation," and the requirements of 10 CFR, Part 20, "Standards for Protection Against Radiation" (applicable to environmental consultants and engineers). Health and safety plans (HASP) for work sites with known or suspected ionizing radiation shall include this SWP as an attachment. General guidelines, exposure limits, and procedures are discussed below.

1.0 GENERAL GUIDELINES

Tetra Tech, Inc. (Tetra Tech), intends to keep all employee radiation exposure levels as low as reasonably achievable (ALARA). Field workers should use a combination of engineering controls, administrative controls, and personal protective equipment (PPE) to limit external and internal radiation doses. Basic protection control measures that apply to all forms of radiation include (1) reducing exposure time, (2) increasing distance from the radiation source, and (3) using a shield between the radiation source and employees. Additional guidelines are listed below.

- Employees less than 18 years of age shall not be allowed to work in areas with known or suspected radiation hazards.
- Personnel will be protected from internal and external radiation exposure hazards through general and site-specific training, use of PPE, adherence to strict work practices, and proper decontamination procedures.
- Ingestion of contaminated material will be prevented through good personal hygiene.
- Eating, drinking, and smoking are <u>not</u> permitted in potentially contaminated areas.
- Washing hands when leaving a contaminated area and before eating is required.
- Employees with open cuts or abrasions are <u>not</u> allowed to handle contaminated material because handling may allow entry of the material into the bloodstream.

- Pregnant employees will be advised not to work in areas with known or suspected radiation hazards. However, if a pregnant woman wants to work, limits on declared pregnant workers defined in 10 CFR, Part 20 apply.

The site safety coordinator (SSC) is responsible for ensuring that personnel are appropriately monitored for exposure to ionizing radiation. A radiation protection officer (RPO) may be assigned to a site to assist the SSC.

2.0 EXPOSURE LIMITS

Ionizing radiation presents a hazard as both a source of external exposure and as a contaminant of surfaces and media. Radiation exposure limits as established by the Nuclear Regulatory Commission (NRC) are presented below.

Type of Exposure	Annual Limit
Whole body (head and trunk), active blood-forming organs, or gonads	5 roentgen equivalent in man (rem) per year, total effective dose
Lens of the eye	15 rem per year
Extremities	50 rem per year
Skin of the whole body	50 rem per year

In addition to the whole-body doses listed above, the NRC has also established derived air concentrations (DAC) for airborne radioactive materials (RAM) exposures. Table 1 of Appendix B, 10 CFR, Part 20, lists DACs for RAMs. The DAC values are designed to maintain internal exposure doses below the annual limit for intake (ALI), assuming a 40-hour per week exposure period. Total body dose calculations must factor in the contribution of airborne RAM to the total dose. The table in 10 CFR, Part 20, should be consulted when calculating internal exposures through inhalation of specific radionuclides.

3.0 PROCEDURES

The following sections discuss procedures related to personal monitoring, environmental monitoring, restricted areas, training, PPE, decontamination, and exposure and medical records associated with work at sites involving potential exposure to radiation.

3.1 PERSONAL MONITORING

Each individual working at a site with the potential for radiation exposure will participate in a monitoring program designed to measure worker external and internal radiation doses. The instrument and devices used for this monitoring as well as monitoring procedures and protocol are discussed below.

3.1.1 External Radiation Dosimetry

External radiation exposure can be measured by thermoluminescent dosimeters (TLD), film badges, and pocket dosimeters. The determination of the appropriate dosimeter for a specific project will be made based on site history and potential risk for exposure to external ionizing radiation. Specific badge handling procedures will be provided on a case-by-case basis.

TLDs that measure x-ray, beta, and gamma radiation are general use dosimeters that measure external ionizing radiation levels to which personnel are exposed. At some work locations, a TLD that also detects fast neutron radiation will be used. The TLDs are analyzed after each calendar quarter to comply with Occupational Safety and Health Administration (OSHA) and NRC requirements. Tetra Tech shall provide TLDs to field workers who routinely work in areas with potential radiation hazards. TLD badges should be ordered from a reputable dosimetry vendor. All personal dosimeters must be worn on the front of the body between the neck and waist. TLDs must be worn outside of any protective clothing. Dosimeters should be protected from inclement weather conditions.

If TLDs are needed for long-term projects lasting more than 5 months, a full TLD program should be set up with a vendor. Employee names, social security numbers, birth dates, and genders must be supplied to the vendor to establish a quarterly monitoring program. At the end of each monitoring period, all TLDs and a control TLD must be returned to the vendor for analysis. The official and permanent record of the cumulative external dose received by each employee is obtained from the quarterly interpretations of the

TLD. Billing and exposure reports will be managed by the regional health and safety representative (RHSR) or subsidiary health and safety representative (SHSR). The RHSR or SHSR must be contacted to add employees to the radiation dosimetry program.

Under certain circumstances, Tetra Tech may allow use of film badges rather than TLDs. Film badges are used to measure external exposure to x-ray and gamma radiation. Film badges are typically analyzed on a monthly basis. Placement and use of film badges is similar to those for TLDs.

Employees scheduled for short-term field work where potential radiation hazards exist should use pocket dosimeters. Pocket dosimeters should be used for field work lasting 1 to 2 days. Pocket dosimeters can be used along with TLDs to provide real-time exposure monitoring. Employees using a pocket dosimeter in areas exceeding the applicable radiation exposure action levels must record the radiation dose daily in a field logbook. A copy of recorded exposures above background levels must be submitted to the RHSR or SHSR within 15 calendar days of field work completion. If the pocket dosimeter indicates that an individual has received a radiation dose of 100 millirems or more, the individual will be removed from field work and his or her TLD will be processed immediately. Pocket dosimeters must be requested through the Tetra Tech equipment vendor.

In the event of a lost or damaged TLD, the site RPO or SSC will determine a dose estimate for the individual by using values recorded on direct-reading instruments. If such a dose cannot be determined, the maximum permissible radiation dose for the time period in question for the affected employee will be recorded in the field logbook.

3.1.2 Airborne Radioactive Material Measurement

Airborne RAM may enter the body during inhalation resulting in an internal radiation dose. NRC regulations require the measurement of airborne RAM concentrations whenever inhalation exposures may result in an intake in excess of 10 percent of the ALI for that RAM as defined in Appendix B, Table 1, of 10 CFR, Part 20. In accordance with principles of ALARA, Tetra Tech shall require monitoring of airborne RAM under all circumstances of potential exposure.

Airborne RAM may be emmitted by processes involving RAM or from radioactive contamination in dirt, debris, and on surfaces that have been disturbed. Monitoring shall be conducted using air sampling devices appropriate for personal monitoring and shall account for all potential periods of exposure. Samples shall be submitted to an accredited laboratory for analysis as soon as possible.

3.2 ENVIRONMENTAL MONITORING

The types of radiation sources, RAM, and types and extent of impacts to the site (such as surficial contamination), will determine which survey instruments are necessary to characterize the site. Both area radiation levels and surface contamination levels will be monitored. Survey instruments will be specified in the HASP. Tetra Tech can obtain the necessary radiation survey instruments for area monitoring through equipment vendors.

During initial site entry, personnel will monitor site conditions with direct-reading instruments when site information is sufficient to show that the potential for ionizing radiation exposure exists or when specific site information is not sufficient to eliminate the possibility of radiation sources or contamination. The initial site evaluation will include a review of available site data, including site history.

Upon startup of field activities, regular monitoring will be conducted if necessary to track the locations and intensities of RAM. Monitoring of airborne RAM within work areas and at the site's downwind perimeters is also required.

Results of radiation and contamination surveys shall be documented in the field logbook and the logbook shall remain on site for the duration of site activities. As work progresses at the site, survey and contamination maps shall be updated accordingly.

3.3 RESTRICTED AREAS

Restricted areas are designated to control personnel exposures to RAM and to prevent the spread of contamination out of the area. The posting of warning signs around restricted areas shall follow the requirements of 10 CFR, Part 20, Subpart J. Restricted areas shall be designated in the HASP as the exclusion zone or a portion of the exclusion zone.

3.4 TRAINING

Specific training requirements for work assignments involving potential exposure to RAM or radioactive contamination should be included in the site-specific HASP. Training requirements are not specified in 10 CFR, Part 20. However, Tetra Tech will require employees working with or potentially exposed to RAM to receive specific training on RAM and the hazards associated with the specific site. General RAM training will include the following topics:

- Types and properties of ionizing radiation
- Acute and long-term health effects of exposure to ionizing radiation
- Exposure routes
- PPE for RAM
- Administrative and engineering exposure controls
- Personal, area, and contamination monitoring devices and their uses
- Basic requirements of 10 CFR, Parts 19 and 20

Site-specific training will address the following topics:

- Types of RAM and ionizing radiation at the site
- Locations of RAM at the site
- Designated restricted and contaminated areas
- Decontamination methods
- Personal, area, and contamination monitoring devices designated for the site
- Emergency procedures for RAM incidents

3.5 PERSONAL PROTECTIVE EQUIPMENT

A minimum of full Level C protection with disposable coveralls must be worn in any potentially radiation-contaminated area. Tetra Tech personnel will use full face air purifying respirators with high-

efficiency particulate air (P100) cartridges to prevent inhalation of airborne alpha particles and radionuclides. This level of protection will prevent or minimize radioactive material from contacting skin. PPE must be thoroughly decontaminated with extreme care to prevent the spread of contamination to other areas. Contaminated material on the skin must be removed as quickly as possible. Supplied air respirators can also be used depending on the hazard and work activity.

3.6 DECONTAMINATION

Generally, decontamination procedures for RAM are the same as for hazardous waste (see Document Control No. 3-8, "Decontamination Program," in Volume II). However, employees should take the following additional precautions:

- Minimize the spread of contamination by following SWPs
- Know where contamination is and avoid tracking equipment and personnel through it
- Use proper decontamination techniques
- Use straight detergent, soap and water, or commercially prepared solutions to remove RAM (solutions containing ethylenediamine tetraacetic acid, such as Radiacwash®, will bind up RAM and maintain the RAM in solution before rinsing)
- Consider all decontamination materials to be contaminated; decontamination waste will contain RAM and must be disposed of properly

3.7 EXPOSURE AND MEDICAL RECORDS

Tetra Tech shall maintain records of radiation exposure of all employees for whom personnel monitoring was conducted. Records will be evaluated to verify that exposures are maintained at ALARA levels. Tetra Tech is obligated to evaluate ionizing radiation exposure data to verify that exposures are maintained at ALARA levels and will provide a yearly summary exposure report to each participating employee. Tetra Tech will notify each employee who has worn a dosimeter during the year of his or her annual exposure in February of the following year. If quarterly results indicate high exposure, the employee will be notified immediately. Retained radiation exposure records will indicate exposure in millirems per calendar quarter, DAC hours of airborne radiation exposure, and the calculated combined

dose for the total body (summary of the external and internal doses) using methods for calculating total body dose presented in 10 CFR, Part 20.1202.

Special medical examinations may be necessary when excessive external or internal doses of radioactive materials are suspected to have occurred. Medical evaluation needs will be established on a case-by-case basis with the advice of the Tetra Tech consulting physician. Any instance of suspected overexposure should be reported immediately to the SSC. The SSC will contact the appropriate RHSR or SHSR for recommendations on how to proceed with follow-up medical evaluations.

Tetra Tech shall maintain exposure records for former employees along with their medical records as stated in Document Control No. 1-4, "Recordkeeping and Reporting Program," in Volume I and Document Control No. 3-2, "Medical Surveillance Program," in Volume II. These records will be available to former employees within 30 days of receipt of a written request for them.

ATTACHMENT C4

RADIATION PROTECTION PROGRAM

NORTHERN AGENCY TRONOX MINES

APPENDIX D, ATTACHMENT D-6

RADIATION PROTECTION PROGRAM
RESPONSE, ASSESSMENT, AND EVALUATION SERVICES (RAES)

MARCH 26, 2018
REVISION 0

Prepared By:

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Northern Agency Tronox Mines

Appendix D, Attachment D-6

Radiation Protection Program
Response, Assessment, and Evaluation Services (RAES)

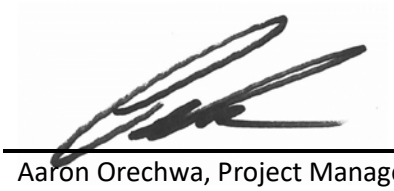
Prepared for: **Tetra Tech, Inc.**
Oakland, CA

Prepared by: **Environmental Restoration Group, Inc.**
Albuquerque, NM

Radiation Safety Officer Approval:

Neil Wrubel, Health Physicist — April 2018 Date

Project Manager Approval:



Aaron Orechwa, Project Manager — April 2018 Date

Radiation Protection Policy Statement

Tetra Tech, Inc. (Tetra Tech) fully embraces the two basic principles of radiation protection, which are:

- There should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure.
- Every effort should be made to maintain radiation exposures and doses to ALARA.

Tetra Tech is committed to effective radiation protection by adherence to sound practices and the ALARA principle.

The ALARA principle is the regulatory concept that every effort should be made to maintain radiation doses to levels that are as low as is reasonably achievable below regulatory requirements. “Reasonable” means that the costs, benefits, and risks are considered in the attempt to keep doses low. This principle assures that governmental requirements are met and potential risks to human health, safety and the environment are minimized. Adherence to the ALARA principle promotes the safe, effective control of radioactive materials and provides a consistent, responsible framework for discussions with governmental agencies and the public.

The implementation and effectiveness of a successful radiation protection and ALARA program is the responsibility of Tetra Tech management, the Radiation Safety Officer, and all site workers. Tetra Tech management will ensure that the following are provided:

- A strong commitment to and continuing support for the effective implementation of the radiation protection and ALARA programs;
- Information and policy statements to employees, contractors, and visitors;
- An audit program that includes periodic reviews and procedural and operational efforts to maintain exposures ALARA;
- Continuing evaluation of the radiation protection program, its staff and allocation of adequate resources; and
- Appropriate briefings and training in radiation safety, including ALARA concepts for all site employees and, when appropriate, for contractors and visitors.

Tetra Tech is committed to maintaining radiation exposures ALARA for the Removal Site Evaluations (RSE) at the Cove and Tse Tah Area Abandoned Uranium Mines on the Navajo Nation pursuant to the Removal, Assessment, and Evaluation Services (RAES) contract with the U.S. Environmental Protection Agency. The provisions of this RPP are designed to keep radiation doses ALARA, but not all circumstances and factors can be anticipated.

Some examples of practices that are consistent with the ALARA policy for the RAES project include:

- Offering suggestions at daily safety meetings of reasonably achievable ways to further reduce potential radiation exposures, given cumulative observations and pending objectives.
- Planning activities to be performed in higher gamma radiation (gamma) areas in advance to maximize the efficiency with which the work can be performed, thus minimizing the amount of time needed to complete the work in such areas.
- Washing hands and face with moist towelettes frequently, not necessarily just prior to eating or drinking during the work day. This can further reduce the potential for intake of small amounts of contaminated soil or water by way of incidental contact.
- Maintaining close observation of the work environment and communicate any previously unidentified conditions that may pose a radiological hazard to the Field Manager and other site workers (e.g. sudden development of winds and airborne dust, previously unidentified "hot spots" of gamma, etc.).
- Leading by example, vocally encourage safe work practices consistent with the provisions of the RPP and underlying ALARA philosophy. Commend co-workers who suggest methods to further reduce the potential for exposures while performing the work at hand.

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ACRONYMS

ALARA	as low as is reasonably achievable
ALI	annual limit on intake
AUM	abandoned uranium mine
CCA	controlled contamination area
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
cm^2	square centimeter
CFR	*Code of Federal Regulations*
DAC	derived air concentration
DDE	deep dose equivalent
dpm	disintegrations per minute
gamma	gamma radiation
GPS	global positioning system
h	hour
ICRP	International Commission on Radiological Protection
m^2	square meter
µR/h	microroentgens per hour
µCi/ml	microcuries per milliliter
mrem	millirem
mR/h	milliroentgens per hour
mg	milligram
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
OSL	optically stimulated luminescent
PPE	personnel protective equipment
RAES	Response, Assessment, and Evaluation Services
rem	Roentgen equivalent man
RLGs	radiation level guides
RPP	Radiation Protection Program
RSE	Removal Site Evaluation
RSO	radiation safety officer
RWP	radiation work permit

TEDE	total effective dose equivalent
Tetra Tech	Tetra Tech, Inc.
TLD	thermoluminescent detector
USEPA	U.S. Environmental Protection Agency
XRF	X-ray fluorescence
wk	week
yr	year

GLOSSARY

ALARA	Acronym for "as low as is reasonably achievable", keeping doses to workers and members of the public as far below regulatory dose limits as is practicable, given the work that must be accomplished.
Alpha (α)	Alpha radiation in the form of a relatively large charged particle ejected from the nucleus of an unstable atom. An alpha particle contains two protons and two neutrons (no electrons), equivalent to the nucleus of a helium atom. It carries a 2+ charge and is thus highly effective at ionizing or "stripping" large numbers of electrons from atoms in the vicinity of its path of travel.
Beta (β)	Beta radiation in the form of a relatively small charged particle ejected from the nucleus of an unstable atom. Beta particles carry a 1- charge and are indistinguishable from electrons except that they originate in the nucleus. Some radionuclides decay with a beta particle that carries a 1+ charge (known as a positron). Smaller and carrying less charge than alphas, betas ionize far fewer atoms per unit length of travel and as a result, are more penetrating in matter versus alpha particles.
Bq	Becquerel (Bq), a Système International (SI) unit definition of a quantity of radioactivity equal to 1 radioactive transformation per second. See *Curie* for equivalent traditional units of radioactivity.
CDE	Committed Dose Equivalent, absorbed dose in a given tissue or organ following an intake of radionuclides into the body, adjusted with a radiation weighting factor to account for the relative effectiveness of the type of radiation involved at producing detrimental biological effects, and with biological retention and radioactive decay properties considered to determine the total future committed dose to the affected tissue or organ over the remaining lifetime of the person (usually evaluated as a 50-yr dose commitment).
Curie (Ci)	Curie (Ci), a traditional unit of measure of a quantity of radioactivity, defined as 3.7×10^{10} radioactive transformations per second. Because 1 becquerel (Bq) = 1 radioactive transformation per second (see *Bq*), the Système International (SI) unit equivalent of the curie is 3.7×10^{10} Bq. One curie is approximately equal to the amount of radioactivity in 1 gram of pure Ra-226.
dpm/100cm^2	Radioactive disintegrations per minute per 100 square centimeters. Commonly used in a context of evaluating the degree of radioactive contamination present on the surfaces of work areas, materials, and equipment.
Dose	Unless otherwise specified or implied by use of special units, dose refers to "absorbed" dose: the average energy absorbed (imparted) from incident ionizing radiation within a specified mass of matter. Defined for any type of radiation and any material, but for the purposes of this manual the term is generally used in a context of energy deposited in human tissue. The fundamental units of dose are joules of energy absorbed per kilogram of tissue [1 J/kg = 1 Gray (SI units) = 100 rad (traditional units)].

Gamma (γ)	Gamma radiation, a form of electromagnetic radiation (see *photons*) that originates in the nucleus of an unstable atom. Similar to x-rays but differs in origin (the nucleus versus orbital electron shells) and its higher kinetic energies. Gamma radiation and x-rays are highly penetrating in matter as they have no mass or charge. Both have sufficient kinetic energy to result in ionization of electrons from atoms, but unlike charged particles (see *alpha* and *beta*) they are not considered directly ionizing because electrical coulomb forces are not involved in such interactions, only the transfer of kinetic energy.
Half-life	The amount of time required for an initial quantity of a radioactive element to decay to one half of its initial amount. Half-lives for radioactive elements range from fractions of a second to billions of years. The shorter the half-life, the more radioactive the nuclide.
Ionizing radiation	Radiation with sufficient energy to strip an electron from an atom to form an ion.
Isotopes	Nuclides or atoms with the same number of protons in their nuclei (i.e. the same element in the periodic chart) but having different numbers of neutrons in their nuclei.
OSL	Optically stimulated luminescent dosimeter, a device for monitoring external radiation doses.
Photon	A fundamental quantum or discrete “wave-packet” of light or other form of electromagnetic radiation that exhibits properties of a particle but has no rest mass or electronic charge, and travels with a velocity equal to the speed of light in empty space. Like all particles in motion, photons exhibit properties of particles and waves. Photons with wavelengths shorter than 100 nanometers (x-rays and gamma radiation) can have sufficient kinetic energy to result in the indirect ionization of electrons from atoms.
Radiation	Refers, for the purpose of this RPP, to ionizing radiation unless otherwise specified and is defined as any elementary particle or photon emitted from a source and having sufficient electrical coulomb forces and/or kinetic energy to eject an electron from an atom as a result of an interaction between the incident particle and the atom.
Radiation Worker	Any person who in the course of their occupation is likely to receive an annual effective dose in excess of 100 millirem, excluding background and medical radiation doses. Member of the public means any individual except when that individual is receiving an occupational dose.
Radioactivity	The spontaneous emission of radiation from an unstable atom, generally in the form of alpha or beta particles from the nucleus, often accompanied by emission gamma rays from the nucleus or x-rays from orbital electron shell transitions.
Radionuclide	An atom that is unstable and decays by emitting ionizing radiation.

rem	A modified unit of absorbed dose to human tissue, adjusted with a radiation weighting factor to account for the relative effectiveness of the type of radiation involved at producing detrimental biological effects, and for internal doses, further adjusted with a tissue weighting factor to account for the relative radiosensitivity of the tissue or specific target organs in question. The term is derived from the phrase "Roentgen Equivalent Man". In equivalent Système International (SI) units, 1 rem = 0.01 Sievert (Sv).
Roentgen	A unit of measurement for ionizing photon radiation (gamma radiation and x-rays), defined as the absorbed dose rate to air at a specific point of interest. One roentgen of absorbed dose to dry air produces an electrostatic charge of 2.58 x 10^{-4} coulombs per kilogram due to ionizations. The roentgen is often referred to as "exposure rate" in air in a context of a location at which a person may be present and subject to potential external doses.
Scintillator	A scintillator is a material that exhibits scintillation — the property of luminescence, when excited by ionizing radiation. Luminescent materials, when struck by an incoming particle, absorb its energy and scintillate, (i.e. re-emit the absorbed energy in the form of light).
TEDE	Total Effective Dose Equivalent, the sum of the deep-dose equivalent (DDE) for external exposures, and the committed effective dose equivalent (CEDE) for internal exposures. Expressed in units of rem or Sievert (see *rem*). DDE = dose equivalent at tissue depth of 1 cm for external whole-body exposure (in units of rem or Sv) CEDE = sum of products of all committed dose equivalents for affected organs (CDE values in units of rem or Sv) multiplied by respective radiation tissue weighting factors.
WL	Working level, a measure of exposure to short-lived radon decay products in air. Defined as any combination of short-lived decay products of radon in 1.0 liter of air under ambient temperature and pressure that will ultimately result in the emission of 130,000 MeV of alpha particle energy. Approximately equal to 100 pCi/L of Rn-222 in equilibrium with its short-lived decay products (Po-218, Pb-214, Bi-214, and Po-214).
WL_C	Working level concentration, a measure of the concentration of radon decay products in air, expressed in terms of working level (WL): $$WL_c = \text{measured radon conc.} \left(\frac{\text{pCi}}{\text{L}}\right) \text{x equilibrium ratio x} \left(\frac{1\text{WL}}{100\,\frac{\text{pCi}}{\text{L}}}\right)$$
WLM	Working Level Month, a measure of exposure to a given working level concentration (WL_C) in one working month (170 hours).
µR/h	Microroentgen per hour (see *Roentgen*).

1.0 INTRODUCTION

The objective of this site-specific Radiation Protection Program (RPP) is to establish the procedures, personnel responsibilities, and training necessary to provide radiological health and safety to all on-site personnel; and the public and environment during the Removal Site Evaluations (RSEs) at the Cove and Tse Tah Area Abandoned Uranium Mines (AUMs) and Non-AUM targets addressed in Task Order 001 of Response, Assessment and Evaluation Services (RAES) contract number EP-S9-17-03 in accordance with the As Low As Is Reasonably Achievable (ALARA) principle, internal Tetra Tech, Inc. (Tetra Tech) programs, and regulatory requirements.

The requirements and procedures in the RPP will be updated as necessary, based on an on-going assessment of site conditions and radiological measurements.

The standard operating procedures (SOPs) necessary for following the work in the RPP are provided in Attachment D-5 of the HASP and listed below:

- RPP SOP 001 Calibration of a Radiological Survey Detector
- RPP SOP 002 Calibration of a Radiological Survey Meter
- RPP SOP 003 Contamination Surveys for Unrestricted Release
- RPP SOP 004 General Equipment Decontamination
- RPP SOP 005 Performing an Alpha Beta Surface Contamination Survey
- RPP SOP 006 Personnel Environmental and Work Area Air Sampling
- RPP SOP 007 Radiation Work Permits
- RPP SOP 008 Operational Checkout of Dual-Channel Alpha Beta Detector with Meter
- RPP SOP 009 Operational Checkout of Single Detector with Meter

2.0 SITE BACKGROUND

A site is defined in this RPP as 1) one of the AUM sites or Target sites and 2) its claim boundary (if applicable) plus the geographically proximate areas where waste material associated with an AUM site or Target site has been deposited, stored, disposed of, placed, or otherwise come to be located. Target sites consist of non-AUM targets or AUM related sites. This includes surface water drainages that drain the sites and contain impacted sediments, and former haul roads associated with the sites that contain impacted soils. A location map of the sites plus individual site maps is included in the RSE Work Plan (Tetra Tech 2018).

The AUMs listed in Task Order 001 of the RAES contract are comprised of 39 AUM sites and 36 Target sites identified by the U.S. Environmental Protection Agency (USEPA). There are 21 known associated burial cells located within or near the identified AUM sites and Target sites. The Target sites are located in the same area and may or may not be associated with a specific AUM site. The AUM sites were operated by Kerr McGee, identified during the Tronox settlement, and are spread across three distinct regions:

- Cove Region: Located along the mesas of the Lukachukai Mountains. The sites are spread over approximately 30 square miles of high peaks and mesas, south of Cove, Arizona.
- Tse Tah Region: Located at the base of the Carrizo Mountains. The sites are spread over approximately 1.5 square miles near the Toh Atin Mesa anticline, southeast of Red Mesa, Arizona.
- Cove/Round Rock Region: Located on the southern ridge of the Lukachukai Mountains. The sites are spread over approximately 1.8 square miles northwest of Lukachukai, Arizona.

Mining activities in the area began in the spring of 1950, with the majority of operations concluding in early 1968. During this period, approximately 724,754 tons of ore averaging 0.24 percent U3O8 were removed from the Lukachukai Mountains.

Uranium ore in the Northern AUM Region was mined primarily from mesa tops, rims, and from canyon walls (i.e., surface mining) from the late 1940's through 1967; however, a number of mines in the Lukachukai Mountains also had extensive underground workings.

2.1 Current site conditions

Field personnel can expect to encounter a variety of conditions at the sites in terms of topography, rocky to unobstructed ground, relatively flat to deeply incised drainages, known and unknown mine shafts and/or exploration borings, closed and open adits, pits, high walls, piles of debris, vegetation, presence or absence of waste rock, and weather. These conditions can affect the degree to which personnel are exposed to ionizing radiation.

2.2 Known Radiological Contaminants and Hazards

Contaminants of Concern for soils and sediments related to historical mining operations include the uranium series radionuclides and the following metals: arsenic, molybdenum, selenium, and vanadium.

Evidence of mining activity and/or soils with gamma measurements above presumed background are expected conservatively at each site. Some areas of sites may contain elevated levels of radioactivity due to elevated concentrations of radionuclides in terrestrial materials, primarily those associated with the uranium-238 radioactive decay series. The highest exposures field personnel can expect to encounter, in general, will be in and around waste rock and the mines themselves.

Uranium series radionuclides (the series is presented in Table 2-1) largely co-occur in soils and sediments. The series exists because uranium-238 (the parent radionuclide) decays to thorium-234, which itself is radioactive. The decays continue through decay progeny including radium-226 and radon-222 to lead-206, which is a stable isotope.

Uranium series radionuclides in the waste material present the following potential radiation hazards: inhalation of radioactive dust, inhalation of radon progeny; ingestion and injection of radionuclides, external exposure; and contamination of equipment, vehicles, and personnel. Thorium series radionuclides may be present. These radionuclides present the same hazards and will be considered on a case-by-case basis.

Table 2-1: The Uranium Series (PHS 1970)

Uranium Series (4n + 2)*

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities† α	β	γ
$^{238}_{92}U$	Uranium I	4.51×10^{9}y	4.15 (25%) 4.20 (75%)	---	---
$^{234}_{90}Th$	Uranium X_1	24.1d	---	0.103 (21%) 0.193 (79%)	0.063c‡ (3.5%) 0.093c (4%)
$^{234}_{91}Pa^{m}$	Uranium X_2	1.17m	---	2.29 (98%)	0.765 (0.30%) 1.001 (0 60%)
99.87% | 0.13%					
$^{234}_{91}Pa$	Uranium Z	6.75h	---	0.53 (66%) 1.13 (13%)	0.100 (50%) 0.70 (24%) 0.90 (70%)
$^{234}_{92}U$	Uranium II	$2\ 47\times10^{5}$y	4.72 (28%) 4.77 (72%)	---	0.053 (0.2%)
$^{230}_{90}Th$	Ionium	8.0×10^{4}y	4.62 (24%) 4.68 (76%)	---	0.068 (0.6%) 0.142 (0.07%)
$^{226}_{88}Ra$	Radium	1602y	4.60 (6%) 4.78 (95%)	---	0 186 (4%)
$^{222}_{86}Rn$	Emanation Radon (Rn)	3.823d	5.49 (100%)	---	0.510 (0.07%)
$^{218}_{84}Po$	Radium A	3.05m	6 00 (~100%)	0 33 (~0.019%)	---
99.98% | 0.02%					
$^{214}_{82}Pb$	Radium B	26.8m	---	0 65 (50%) 0.71 (40%) 0.98 (6%)	0.295 (19%) 0.352 (36%)
$^{218}_{85}At$	Astatine	~2s	6.65 (6%) 6.70 (94%)	? (~0.1%)	---
$^{214}_{83}Bi$	Radium C	19.7m	5.45 (0.012%) 5.51 (0.008%)	1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
99.98% | 0.02%					
$^{214}_{84}Po$	Radium C'	164μs	7.69 (100%)	---	0.799 (0.014%)
$^{210}_{81}Tl$	Radium C''	1.3m	---	1.3 (25%) 1.9 (56%) 2.3 (19%)	0.296 (80%) 0.795 (100%) 1.31 (21%)
$^{210}_{82}Pb$	Radium D	21y	3.72 (.000002%)	0.016 (85%) 0.061 (15%)	0.047 (4%)
$^{210}_{83}Bi$	Radium E	5.01d	4.65 (.000007%) 4.69 (.00005%)	1.161 (~100%)	---
~100% | .00013%					
$^{210}_{84}Po$	Radium F	138.4d	5 305 (100%)	---	0.803 (0.0011%)
$^{206}_{81}Tl$	Radium E''	4.19m	---	1.571 (100%)	---
$^{206}_{82}Pb$	Radium G	Stable	---	---	---

*This expression describes the mass number of any member in this series, where n is an integer
Example: $^{206}_{82}Pb$ (4n + 2).....4(51) + 2 = 206
†Intensities refer to percentage of disintegrations of the nuclide itself, not to original parent of series.
‡Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

Data taken from: Table of Isotopes and USNRDL-TR-802.

Section 4.0 addresses the potential pathways of human exposures to these radionuclides.

2.3 Overview of Work Tasks

RSE activities will consist of, in general order, site clearance studies, baseline studies, site characterization and assessment, and interim response actions, if any.

2.3.1 Site Clearance Studies

Site clearance studies will be performed at each site and include an evaluation of site access, cultural and biological surveys; starting with natural resource surveys (cultural resources, vegetation, and wildlife), and mapping of features and physical attributes of each site.

2.3.2 Baseline Studies

Baseline studies will consist of the mapping of physical hazards and performance of background studies, field surveys using a portable x-ray fluorescence (XRF) analyzer, evaluations of water wells and surface water, global positioning system (GPS)-based gamma radiation (gamma) walk-over surveys (gamma surveys), and correlation studies.

These activities largely involve field personnel walking over the sites, making observations and x-ray and gamma measurements. These activities pose little disturbance of surface soils: the only activity expected to disturb the soil during the baseline studies is the collection of surface soil samples during the background and correlation studies and XRF surveys.

Physical hazards will be demarcated by field personnel by way of the placement of perimeter flagging. Any hazards that present an imminent risk for local residents or site visitors will be documented and reported to the representative of the USEPA.

Background studies will consist of field XRF and GPS-based gamma surveys and soil sampling in relatively small areas considered to be representative of site conditions.

The GPS-based gamma surveys of the sites will be performed to define the lateral extent of surface soils and sediments with elevated gamma readings at each site, bearing in mind physical obstacles to access. Areas outside the original survey boundaries with elevated gamma readings may be encountered. These will be referred to as go back areas and will be surveyed during the Site Characterization step, subsequent to additional land access permission and clearances of natural resources.

The correlation studies will entail making gamma and exposure rate measurements and sampling of surface soils to establish statistical correlations between the gamma survey instrument responses; and exposure rates and radium concentrations.

2.4 Site Characterization and Assessment

In this stage, the lateral and vertical extent of surface and subsurface soils and sediments impacted by historic mining operations will be further characterized at the sites using GPS-based surveys, downhole gamma logging and confirmatory soil sampling. Site characterization will include surface water channels,

former haul roads, and "go back areas" identified during the Baseline Studies. Confirmatory surface soil and sediment samples will be collected for offsite laboratory analysis.

Water samples will be collected from selected accessible wells identified and evaluated during the site clearance and baseline studies and analyzed offsite.

The current potential for exposure to radiation will be assessed outside on or near piles of waste rock; and in adits, drainages and background areas; and inside selected mine buildings, homes, and other structures that are present at the sites, and that have not already been assessed by the Agencies. Exposure will be assessed by way of sampling and analyzing radon concentrations in air inside the structures or homes and making gamma or exposure rate measurements.

2.4.1 Interim Response Actions

Interim response actions may be implemented to mitigate any hazards that present an imminent risk for local residents, site visitors, or the personnel executing the RSEs.

3.0 KEY PERSONNEL AND RESPONSIBILITIES

The purpose of this RPP is to assign responsibilities to Tetra Tech and contractor personnel, establish personnel protection standards, establish safety practices and procedures, and provide for contingencies that may arise while baseline and characterization activities are being conducted at the sites. The provisions of this plan are mandatory for all on-site workers engaged in radioactive materials management activities including, but not limited to, site assessments, occupational and environmental monitoring, decontamination, waste removal, waste disposal and reclamation.

The organizational structure for the RSE project is shown in Figure 3-1.

3.1 Radiation Protection Responsibilities

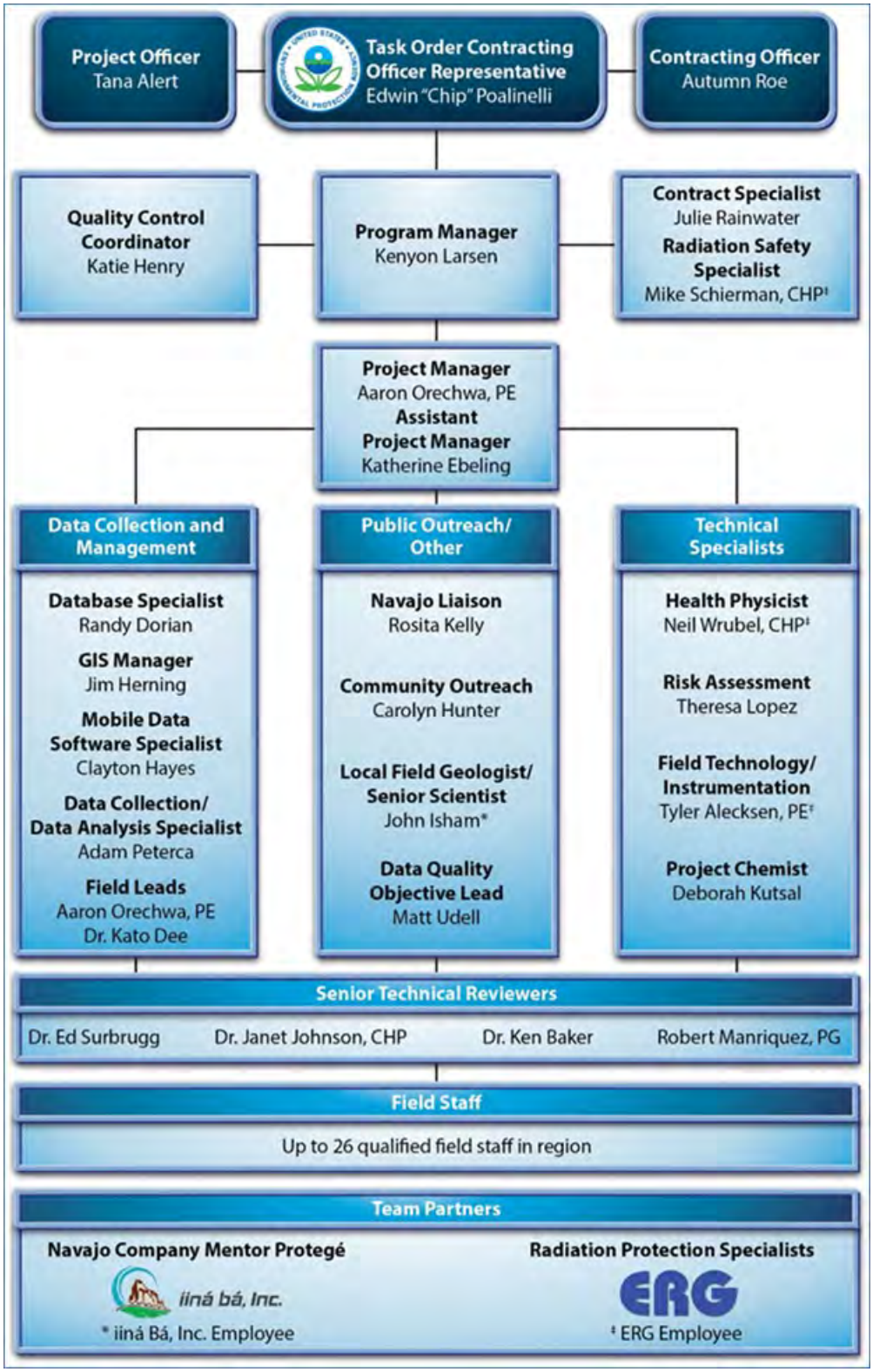
3.1.1 Health and Safety Personnel

The Tetra Tech Project Manager has overall responsibility for health and safety during the site operations, is responsible for reclamation operations at the site, and ensures that such operations are conducted in conformance with all health and safety requirements.

The Tetra Tech Project Manager will act promptly on the recommendations of the radiation safety officer (RSO) or his designee pertaining to radiation safety and the security of radioactive materials.

The Tetra Tech Project Manager reports to the Tetra Tech Program Manager who, in turn, reports to the USEPA Project Manager.

Figure 3-1: Function Organizational Chart for Removal Site Evaluation Project



The RSO and RSO designee are responsible for ensuring that all regulatory radiation protection and Tetra Tech requirements are met at the sites, including maintaining radiation doses ALARA, and ensuring that:

- All heath physics-related procedures and requirements are implemented.
- All health physics-related procedures are revised, and appropriate equipment are used as required based on new information gathered during site inspections and monitoring.

The RSO and RSO designee have other responsibilities as specified in this plan. To maintain radiation doses ALARA, the RSO and RSO designee are responsible for:

- Determining the required monitoring, levels of personnel protection, and decontamination in work areas and posting same.
- Upgrading or downgrading the required levels of personnel protection, based on site monitoring and observations.
- Informing site workers of the type of radioactive/hazardous/toxic substances that may be present and the associated appropriate monitoring, engineering controls, personnel protective equipment (PPE), and potential adverse health effects associated with exposure to these substances.

In addition, the RSO and RSO designee have the authority to suspend any site activity that threatens the health and/or safety of site workers, people off-site, or the local environment.

3.1.2 Other On-Site Personnel

All other on-site workers are responsible for the following:

- Following all aspects of this RPP.
- Following procedures and instructions issued by the RSO and RSO designee.
- Notifying the RSO or RSO designee of hazardous or potentially hazardous incidents or working conditions/situations.
- Reporting immediately all injuries, no matter how slight, to appropriate supervisors.

3.2 Radiation Safety Personnel Qualification Requirements

3.2.1 Radiation Safety Officer

The RSO shall have at least a Bachelor of Science degree in radiological or environmental sciences, or a related field, from an accredited college. The RSO shall have formal training with a minimum of one week of course work specifically applied to health physics problems at radioactive materials facilities. The RSO shall have at least one year of “hands on” experience in radiation safety and occupational health, at least six months of this experience at the supervisory level.

A Master's Degree (or a more advanced degree) may be substituted for the training requirement above.

3.2.2 Radiation Safety Officer Designee

The RSO designee must have an associate degree or two or more years of academic study in the physical sciences, engineering, or a health-related field. The RSO designee must have at least four weeks of generalized training (up to two weeks may be on-the-job) in radiation health protection. The RSO designee must also have one year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures. The RSO designee will be required to demonstrate a working knowledge of personnel dosimetry requirements and the proper operation of health physics instruments, surveying and sampling techniques.

4.0 PROJECT HAZARD ANALYSIS

4.1 Introduction

The potential hazards to site workers associated with the planned characterization activities at these sites can be summarized as follows:

- Exposure to ionizing radiation;
- Exposure to inorganic chemical contaminants;
- Exposure to physical hazards and agents (e.g., heat and cold stress, noise, falling); and
- Exposure to biological agents (e.g., hantavirus, snakes, spiders).

The public could potentially be exposed to ionizing radiation, and inorganic chemical contaminants as a result of site activities. Releases to the environment also are possible. Hazards other than exposure to ionizing radiation listed above will be controlled using methods described in other Tetra Tech administrative documents such as the health and safety plan for the project.

4.2 Ionizing Radiation Hazards

Ionizing radiation is of two types: particle and electromagnetic. Particle radiation is the motion of atomic or subatomic particles that have mass and, in most cases, electric charge, and which transfer energy. Alpha and beta particles are of concern at these sites. Gamma and x-rays are electromagnetic radiations, similar to light and pure energy. These electromagnetic radiations of concern are referred to as direct or penetrating radiation.

Uranium-238 and its associated decay products each emit one or more of these types of ionizing radiation. Exposure to these radionuclides can result in external beta, gamma, and x-ray radiation doses due to the proximity of individuals to the sources of the radiation, or by skin deposition of these contaminants. Internal doses from uranium and its associated decay products can result from inhalation, ingestion, skin absorption, or skin penetration as a result of trauma. Generally, the foremost potential radiation hazards for this project are the inhalation of alpha particle emitting radionuclides and working in proximity to penetrating radiation emitting sources.

The primary health risks associated with exposure to the radioactive materials at these sites are due to chronic, long-term effects: specifically, carcinogenesis.

The five principal exposure pathways by which individuals could be exposed to ionizing radiation resulting from site activities (see Figure 4-1) are:

- Inhalation of radon-222 and its decay products;
- Direct exposure to penetrating radiation, primarily gamma;
- Inhalation of air particulates contaminated with long-lived radionuclides;
- Ingestion of soil or surface and groundwater contaminated with radionuclides; and
- Ingestion of foods contaminated with radionuclides.

The principal radionuclides to which potentially consequential human exposures could occur are in the uranium decay series. While other radionuclides may be present in the wastes, the associated potential human doses are expected to be comparatively insignificant due to their low quantities. However, thorium series radionuclides will be considered on a site-by-site basis.

In terms of potential doses, significant radionuclides in the uranium decay series include:

- Uranium-238 (U-238),
- Uranium-234 (U-234),
- Thorium-230 (Th-230),
- Radium-226 (Ra-226),
- Radon-222 (Rn-222),
- Short-lived decay products of Rn-222 (Rn-222 progeny)
- Polonium-210 (Po-210), and
- Lead-210 (Pb-210).

The remaining uranium series radionuclides provide comparatively insignificant contributions to potential radiation doses.

4.3 Project Operation and Task Hazards

Individuals engaged in specific operations and tasks may encounter potential hazards unique to that particular operation or task. Conversely, some operations and tasks may involve potential hazards that are common throughout the activity.

The RSE activities discussed in Section 2.0 were examined for common tasks and associated hazards. Tables 4-1 and 4-2 were developed to assist in relating specific characterization tasks to associated potential ionizing radiation hazards and monitoring requirements for solids and liquids, respectively.

Table 4-1: Removal Site Evaluation Task Hazard Summary: Solids

Operation	Task(s)	Potential Radiological Hazards	Required Monitoring
Baseline Study and Site Characterization	Civil surveying & mapping	Minimal	Personal Dosimeters Exit scanning
	Geomorphological, Field XRF and GPS-based gamma radiation surveys	Whole body exposure Surface contamination Internal deposition	Personal Dosimeters Ring Dosimeters for XRF users Exit scanning
	Surface soil/sediment sampling	Whole body exposure Surface contamination Internal deposition	Personal Dosimeters Exit scanning Lapel air sampling for select personnel
	Subsurface soil logging and sampling	Whole body exposure Surface contamination Internal deposition	Personal Dosimeters Exit scanning Lapel air sampling for select personnel
	Facility/equipment surveys	Whole body exposure Surface contamination Internal deposition	Personal Dosimeters Exit scanning Lapel air sampling for select personnel
	Geotechnical field measurements	Whole body exposure Surface contamination Internal deposition	Personal Dosimeters with neutron capabilities Exit scanning Lapel air sampling for select personnel

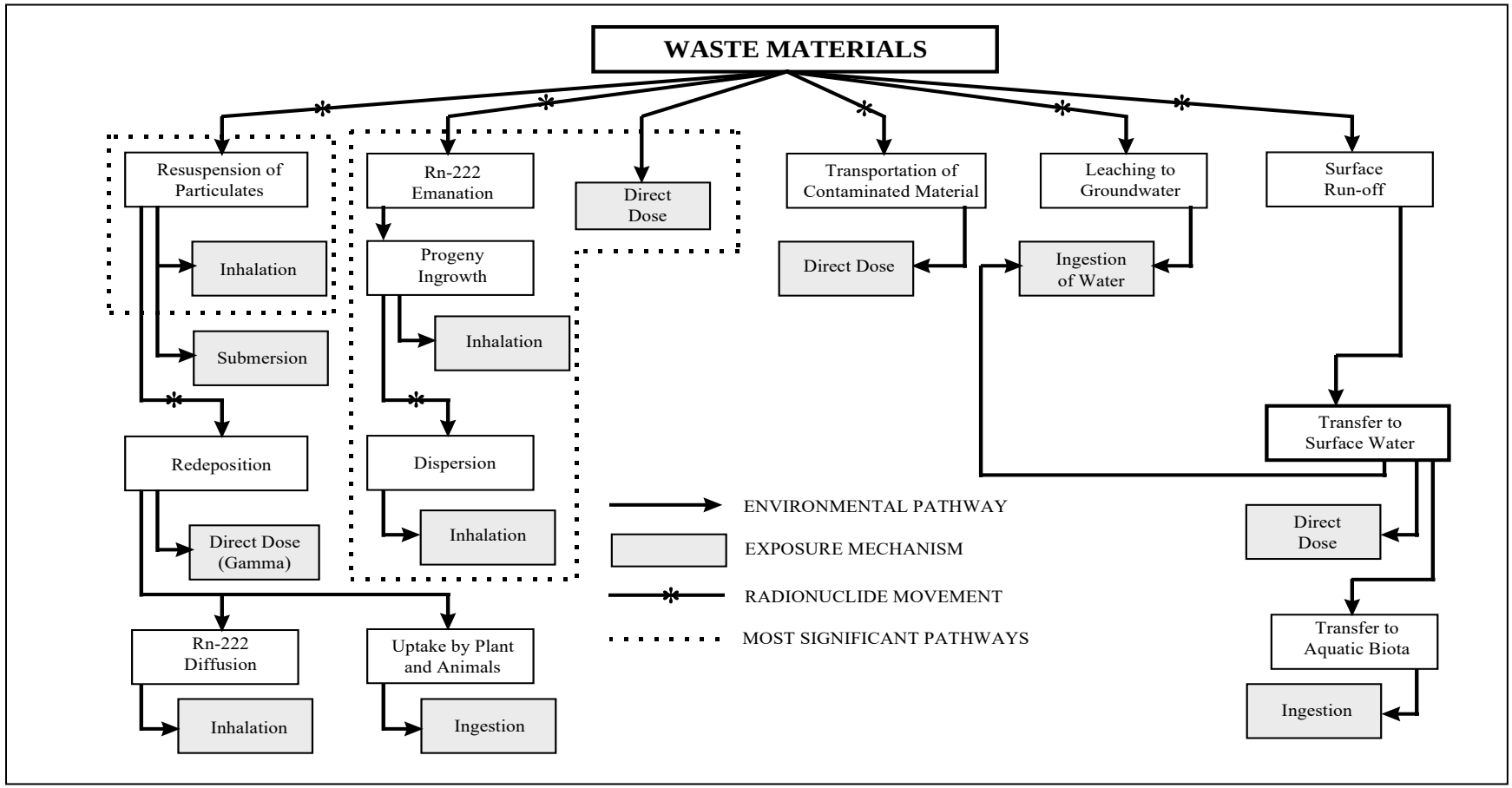
Notes:

GPS global positioning system
XRF x-ray fluorescence

Table 4-2: Removal Site Evaluation Task Hazard Summary: Liquids

Operation	Task(s)	Potential Radiological Hazards	Potential Required Monitoring
Baseline Study and Site Characterization	Surface water/sediment-sampling	Whole body exposure Surface contamination	Personal Dosimeters Exit scanning
	Groundwater sampling	Surface contamination	Personal Dosimeters Exit scanning
Collection/disposal	Groundwater pumping/disposal	Surface contamination	Personal Dosimeters Exit scanning
	Groundwater well installation	Surface contamination	Personal Dosimeters Exit scanning

Figure 4-1: Potential Radiation Exposure Pathways to Workers and Members of Public



4.3.1 Site Characterization Operations: Solids

The common operations in the assessments of solids typically include sampling, surveys, measurements, and monitoring related to the characterization of soils and sediments.

4.3.2 Site Characterization Operations: Liquids

The common operations in the assessments of liquids typically include surveys for drinking water wells; and their construction, development, and monitoring. Surveys and monitoring also applies to seeps and springs.

5.0 RADIATION PROTECTION LIMITS AND ACTION LEVELS

It is important to distinguish between distinct radiation protection standards: basic limits, derived or secondary limits or concentrations, and administrative action levels. The basic, primary regulatory limits are bifurcated into limits for workers and public individuals. These primary regulatory limits are, with one exception, integrated dose limits over discrete periods of time periods, typically one year. The secondary limits designed to control internal exposures are effluent concentrations in air and water for public individuals, and derived air concentrations (DACs) and annual limits of intake (ALIs) for workers.

Administrative action levels may take the form of reference, recording, investigation, or levels of intervention. The intent of such action levels is to identify in advance a course of action to be taken when a particular value of a quantity is predicted to or exceeds the established threshold or action level. The action may range from simply recording the information, conducting investigations into cause and consequences, and implementing intervention measures.

5.1 Primary Limits

The upper bounds on the allowed intakes by and doses to workers, and the doses to public individuals, are stipulated by State and Federal regulations and are the basis for derived radiation protection guides for concentrations of radioactivity in air and water. The radiation protection requirements of Occupational Safety and Health Administration (OSHA) are applicable to the RAES project. However, OSHA adopted its ionizing radiation standard (29 Code of Federal Regulations [CFR] 1910.1096) in 1971, using the version of 10 CFR 20 that was based on International Commission on Radiological Protection (ICRP) Publication 2 (ICRP 1959). The current requirements in 10 CFR 20 are more conservative in most cases and based on ICRP Publication 26 (ICRP 1977).

The primary radiation protection limits are provided in Table 5-1. In addition to these limits, radiation doses must be kept ALARA.

5.2 Secondary Limits

The fundamental secondary limits are designed to limit 1) occupancy in radiation fields and 2) the annual intake of radionuclides such that the primary limits are not exceeded. Table 5-2 summarized the relevant secondary limits. Additional secondary limits include 10 CFR 20, Appendix B, Table II, Effluent Concentrations (if applicable).

Table 5-1: Primary Radiation Protection Limits

Public Individuals	Limits	Source
TEDE (excluding sanitary sewerage discharges)	0.1 rem/y	10 CFR 20.1301
Dose (external sources)	0.002 rem/h	10 CFR 20.1301
Dose equivalent (whole body excluding radon/progeny)	25 mrem/y	40 CFR 190
Workers[a]	**Limits**	**Source**
TEDE	5 rem/y	10 CFR 20.1201
DDE plus CDE (any organ or tissue except lens of eye)	50 rem/y	10 CFR 20.1201
Dose equivalent (lens of eye)	15 rem/y	10 CFR 20.1201
Shallow-dose equivalent (skin or any extremity)	50 rem/y	10 CFR 20.1201
Soluble uranium intake[b]	10 mg/wk	10 CFR 20.1201
Dose (embryo/fetus of declared pregnant woman)	0.5 rem/pregnancy	10 CFR 20.1201

Notes:

[a]No employee under 18 years of age is allowed a dose or intake above 10 percent of the above limits.
[b]The limit on uranium intake is based on its chemical toxicity.

CDE	committed dose equivalent
CFR	Code of Federal Regulations
DDE	deep dose equivalent
mg/wk	milligrams per week
rem/h or /y	Roentgen equivalent man/hour or year
TEDE	total effective dose equivalent

Table 5-2: Secondary Radiation Protection Limits

Internal Exposure	Annual Occupational Limits
Intake, all pathways	1 ALI
Inhalation (all but radon/progeny)	2,000 DAC-h
Inhalation, Rn-222 with progeny	4 Working Level Months
Posting	**Required At**
“Caution, Airborne Radioactivity Area”	>DAC
“Caution, Airborne Radioactivity Area”	>0.6% ALI/wk
“Caution, Radiation Area”	>0.005 rem/h
“Caution, High Radiation Area”	>0.1 rem/h

Notes:

ALI	annual limit on intake
DAC-h	derived air concentration-hours
rem/h	Roentgen equivalent man/hour

5.3 Administrative Action Levels

5.3.1 External Radiation

The following will result in investigations of affected workers:

- Measured individual worker external whole body deep radiation doses above 125 millirem (mrem) per monitoring period or 500 mrem per calendar year.
- Measured individual worker shallow-doses (skin) above 1,250 mrem per monitoring period or 5,000 mrem per calendar year.

Measured individual worker external whole-body radiation deep doses above 312 mrem per monitoring period or 1,250 mrem per calendar year may result in work restrictions for the affected workers until an investigation has determined that cumulative internal and external EDEs for the year are unlikely to exceed 5 rem, and that the doses are ALARA.

5.3.2 Internal Radiation

Administrative action levels for internal radiation exposure will be based on occupational air sampling as described below.

Air Sampling

Table 5-3 lists the frequencies of occupational air sampling are listed by action levels. These action levels will be used for occupational monitoring of intakes at the sites.

Air sampling will be implemented for representative workers involved in the following activities: surface or subsurface soil sampling, oversight of drilling or soil boring, and working around heavy equipment.

Table 5-3: Air Sampling Recommendations Based on Estimated Intakes and Airborne Concentrations

Worker's estimated annual intake as a fraction of ALI	Estimated airborne concentrations as a fraction of DAC	Air sampling recommendations
<0.1	<0.01	Air sampling is generally not necessary. However, monthly or quarterly grab samples or some other measurement may be appropriate to confirm that airborne levels are indeed low.
	>0.01	Some air sampling is appropriate. Intermittent or grab samples are appropriate near the lower end of the range. Continuous sampling is appropriate if concentrations are likely to exceed 0.1 DAC averaged over 40 hours or longer.
>0.1	<0.3	Monitoring of intake by air sampling, bioassay, or combinations of these measurements, is required by 10 CFR 20.1204.
	>0.3	A demonstration that the air samples are representative of the breathing zone air is appropriate if air samples are (1) area type, (2) intakes of record will be based on air sampling, and (3) concentrations are likely to exceed 0.3 DAC averaged over 40 hours (i.e., intake is more than 12 DAC-hours in a week).
Any annual intake	>1	Air samples should be analyzed before work resumes the next day when potential intakes may exceed 40 DAC-hours in 1 week. When work is done in shifts, results should be available before the next shift ends. Air samples will be counted at least 5 hours after collection. According to NRC Regulatory Guide 8.25, credit may be taken for protection factors if a respiratory protection program is in place (NRC 1992).
	>5	Continuous air monitoring should be provided if there is a potential for intakes to exceed 40 DAC-hours in 1 day. Credit may be taken for protection factors if a respiratory protection program is in place, as above.

Notes:

Working levels will be determined at select locations such as the entrances to mines, at the discretion of the RSO.

ALI annual limit on intake
CFR Code of Federal Regulations
DAC derived air concentration
NRC U.S. Nuclear Regulatory Commission

5.3.3 Exposure of Declared Pregnant Workers

A "declared pregnant woman" is a woman who has declared in writing to Tetra Tech or its contractor that she is pregnant. The RSO will be notified and determine additional precautions or actions that may be required to limit a potential dose to the fetus.

All female employees of Tetra Tech and female contractors and female visitors who will be entering the sites will be given special instruction about the concerns for exposure to the fetus and the regulations concerning such, their options and responsibilities. Such instructions are based on the information provided in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 8.13 (NRC 1999).

External Radiation
Work restrictions will be imposed on all declared pregnant workers to preclude any and all work activities for the affected individuals in areas where the whole-body gamma exposure rates have been measured, or are believed to exist, in excess of 250 microroentgens per hour (μR/h) at one meter above ground surface.

Internal Radiation
Work restrictions will be imposed on all declared pregnant workers to preclude any and all work activities for the affected individuals during the gestation period where radionuclide air concentrations could exceed 10 percent of the DAC.

In no case will a declared pregnant worker be allowed to accrue an internal deposition of any radionuclide in excess of 0.05 ALI during the gestation period.

5.3.4 Contamination Action Levels

Controlled Contamination Areas (CCAs) are established to control personnel exposures to radiation and contamination within those areas, and to prevent the spread of contamination out of those areas. CCAs will be established at the sites for drilling and remedial activities, during which the potential for the contamination of personnel; and materials and equipment is highest.

A CCA is any area where removable surface contamination on any exposed surface exceeds any of the levels presented below (adopted from 10 CFR 835 Appendix D):

	Contamination Levels, disintegrations per minute (dpm)/100 square centimeter (cm^2)	
Contaminant	Removable Alpha	Total Alpha
Natural uranium w/ decay products	1,000	5,000

5.4 Derived Radiation Protection Guides

Derived guides, in the form of Radiation Level Guides (RLGs), are numerical values for the ambient gamma, or x-ray, radiation levels such that continuous exposure at these levels would result in the primary limits being met in the twelfth month of exposure.

Derived guides, in the form of DACs, are numerical values for the average concentration of radionuclides in air such that normal intake of or submersion in air for one year would result in the intake of one ALI.

The numerical values of the occupational RLGs and DACs for the significant radioactive contaminants anticipated at the sites are presented in Table 5-4.

Table 5-4: Occupational Radiation Level Guides and Derived Air Concentration Guides

Exposure Condition	Occupational RLG or DAC	Action Level	Action	Critical Organ	Lung Class[a]	Medium
Gamma or x-ray radiation	2.5 mR/h	0.25 mR/h	Continuous personnel monitoring	Whole body	NA	Air
Uranium and its daughters in ore dust[b]	$6x10^{-11}$ µCi/ml	$2 x10^{-11}$ µCi/ml	Apply engineering controls and/or upgrade level of protection	Bone surfaces	Y	
Site-specific DAC	$6 x10^{-11}$ µCi/ml	$2 x10^{-11}$ µCi/ml		Lungs	Y	
Soluble U-nat	10 mg/wk	3 mg/wk		Kidneys	D	
Radon-222 and progeny	0.33 WL	0.10 WL		Lungs	D	

Notes:

[a]The lung clearance classes D, W or Y correspond to clearance halftimes from the pulmonary region of the lung on the order of days, weeks or years, respectively.
[b]10 CFR 20 Appendix B, Table 1

D	days
µCi/ml	microcuries per milliliter
mg/wk	milligrams per week
mR/h	milliroentgens per hour
NA	Not applicable
WL	Working Level
Y	years

6.0 EXPOSURE MONITORING PLANS

The RPP covers only radiological aspects of the project. The exposure monitoring plans detailed here do not cover any of the potential chemical and physical hazards that may be encountered during the project.

The occupational radiological monitoring plan is directed at evaluating the exposure of workers to radiation and radioactive materials and determining the associated radiation doses.

The radiological hazards and specific exposure control and monitoring requirements for each remedial action operation are determined prior to conducting the work. In this plan, a radiological hazard summary was prepared. Table 6-1 presents the summary, which relates the potential radiation hazards to the nature and extent of contamination and lists the associated monitoring requirements.

Table 6-1: Summary of Radiological Hazards/Monitoring/PPE for the Removal Site Evaluation

Radiological Condition	Potential Hazard	Required Monitoring	Personal Protection[a]
Penetrating exposure > 250 µR/h	Whole body exposure Finger and hand exposure	External dosimeters Ring dosimeters Surveys	Time, distance, and shielding training
Removable alpha > 1,000 dpm/100 cm^2	Surface contamination Internal deposition	Exit scanning	Long pants and shirts (or coveralls), boot covers (if not wearing coveralls), gloves
Radionuclides in air other than radon progeny > 0.3 DAC	Internal deposition	Air sampling	Long pants and shirts (or coveralls), boot covers (if not wearing coveralls), gloves, respiratory protection
Radon-222 progeny in air > 0.1 WL	Internal deposition	Air sampling	Long pants and shirts (or coveralls), boot covers (if not wearing coveralls), gloves, respiratory protection

Notes:

[a]Upgrades or downgrades of PPE levels will be based on near real-time monitoring.

DAC	derived air concentration
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
µR/h	microroentgens per hour
WL	working level

The radiological monitoring plan was developed to appraise the following:

- Total and removable radioactive contamination on workers, equipment, and vehicles;
- Gamma and beta-gamma exposure and dose rates;
- Long-lived alpha emitting radionuclide concentrations in air particulates; and
- Radionuclide concentrations in bioassay samples.

Table 6-2 summarizes the occupational radiological monitoring plan. The acceptable surface contamination levels for PPE and equipment are adopted from NRC Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors (NRC 1974).

Table 6-2: Occupational Monitoring Plan for Radiological Hazards for the Removal Site Evaluation

		Sample Collection			Sample Analysis				
Measurement Type	**No.**	**Location**	**Method**	**Frequency**	**Frequency**	**Type**	**Method**	**Action Level[a]**	**Action**
Total alpha surface contamination (equipment /vehicles)	As required	Representative access point	Direct, near contact scanning, counting	All equipment released from radiologically controlled areas for unrestricted use	Each point of measurement	Gross alpha	Ratemeter/scaler with zinc sulfide scintillator or equivalent	5,000 dpm/100 cm^2 averaged over 1m^2, 15,000 dpm/100 cm^2 averaged over 100 cm^2	Decontaminate equipment or vehicles
Total alpha surface contamination (personnel)	Each worker	Hands and feet		At each exit from CCAs				Detectable activity above background	Decontaminate personnel, investigate if needed
Total alpha surface contamination (work and break areas outside CCAs such as in trailers)	As required	Floors, tables, counter-tops, etc.		Monthly during site activities				Detectable activity above background	Decontaminate, investigate, survey weekly until less than or equal to background

Table 6-2: Occupational Monitoring Plan for Radiological Hazards for the Removal Site Evaluation

		Sample Collection			Sample Analysis				
Measurement Type	**No.**	**Location**	**Method**	**Frequency**	**Frequency**	**Type**	**Method**	**Action Level[a]**	**Action**
Removable alpha surface contamination (equipment/ vehicles)	As required	Representative access points	Wipes or smears	All facilities and equipment released for unrestricted use	Each smear	Gross alpha	Scaler with zinc sulfide scintillator or equivalent	1,000 dpm/100 cm^2	Decontaminate facilities and/or equipment
Removable alpha surface contamination (work and break areas outside CCAs such as in trailers)	As required	Floors, tables, counter-tops, etc.		Monthly during site activities				Detectable activity above background	Decontaminate, investigate, survey weekly until less than or equal to background
Gamma radiation dose rates in air (surveys)	As required	Work areas	Direct gamma or exposure rate measurements	As required	Each measurement point	Gross gamma or exposure rate	Ratemeter/scaler with sodium iodide scintillator or equivalent with calibration corrections	0.25 mR/hr 5 mR/hr 100 mR/hr	Use OSLs Post as Radiation Area Evacuate, notify RSO
Beta/gamma radiation dose rates (personal whole body)	As required	Worker torso	OSL dosimeter or equivalent	Based on logical period corresponding to site activities but not more than one year.	Each dosimeter	Deep, shallow, and eye lens dose	optically stimulated luminescence	Deep-125 mrem/period Shallow-1,250 mrem/period Eye-375 mrem/period Deep-1,250 mrem/period	Investigation Investigation Investigation Work restriction

Table 6-2: Occupational Monitoring Plan for Radiological Hazards for the Removal Site Evaluation

		Sample Collection			Sample Analysis				
Measurement Type	**No.**	**Location**	**Method**	**Frequency**	**Frequency**	**Type**	**Method**	**Action Level[a]**	**Action**
Beta/gamma radiation dose rates (personnel extremity)	As required	Wrist or finger	TLD dosimeter or equivalent	Based on logical period corresponding to site activities but not more than one year.	Each dosimeter	Shallow dose	optically stimulated luminescence	1,250 mrem/period 12,500 mrem/period	Investigate Work restriction
Gamma radiation dose rates (infrequent workers/visitors)	As required	Worker torso	Exposure Rate Equipment	Each visit or work cycle of selected individuals	Each device	Deep dose	Exposure rate equipment	10 mrem/wk	Investigate
Beta/gamma radiation dose rates (declared pregnant workers)	As required	Worker torso	OSL dosimeter or equivalent	Monthly	Each device	Deep, shallow, and eye lens dose	optically stimulated luminescence	Deep-20 mrem/mo	Investigate
Gamma radiation dose rates in air (surveys of declared pregnant worker work areas)b	As required	All associated work areas	Direct gamma measurements	As required	Each measurement point	Gross gamma	Ratemeter/scaler with sodium iodide scintillator or equivalent with calibration corrections	250 µR/hr	Work restriction
Radon-222 progeny in air	As required	Selected work areas	Minimum 2.5 l/m breathing zone, grab, or area air particulate	At RSO discretion	Each sample	Gross alpha	Modified Kusnetz or equivalent	0.1 WL	Apply engineering controls and/or upgrade PPE. Monitor weekly

Table 6-2: Occupational Monitoring Plan for Radiological Hazards for the Removal Site Evaluation

		Sample Collection			Sample Analysis				
Measurement Type	**No.**	**Location**	**Method**	**Frequency**	**Frequency**	**Type**	**Method**	**Action Level[a]**	**Action**
Airborne particulate radionuclides	As required for representative personnel	Lapel or breathing zone	Minimum 2.5 l/m, time-integrated, breathing zone sample	As needed to estimate intakes or for RWPs	Each sample	Gross alpha	Scaler with zinc sulfide scintillator and delayed alpha counting or equivalent	> 0.1 DAC > 0.3 DAC	Upgrade monitoring Investigate and employ respiratory protection

Notes:

[a]Total and removable alpha surface contamination levels adopted from NRC Regulatory Guide 1.86 (NRC 1974).
[b]Additional surveys will be conducted to assist declared pregnant worker to keep doses to fetus ALARA below the action level.

CCA controlled contamination area
DAC derived air concentration
dpm/100 cm^2 disintegrations per minute per 100 square centimeters
m^2 square meter
µR/hr microroentgens per hour
mrem millirem
mR/hr milliroentgens per hour
OSL optically stimulate luminescent
PPE personal protective equipment
rem Roentgen equivalent man
RWP radiation work permit
TLD thermoluminescent detector
WL working level

7.0 ENGINEERING CONTROLS

Engineering controls will provide the first line of defense against radiation hazards during this remedial action. Tetra Tech will use, to the extent practicable, process or other engineering controls (e.g., containment, ventilation, dust control) to control the concentrations of radioactivity in air. On this project, engineering controls will be used primarily to limit surface and airborne contaminant concentrations.

Engineered contamination controls will include safe work practices, site control and work zones, worker and workplace surface contamination monitoring, and decontamination, as required (see Section 10.0 of this RPP).

Details regarding engineering controls are described in the project HASP.

8.0 PERSONAL PROTECTIVE EQUIPMENT

PPE will be limited to those specified in the project HASP.

Respiratory protection will not be needed on the project because airborne radioactivity is expected to be negligible during activities that do not disturb the soil. In addition, dust control will minimize the hazard of inhaling radioactive particulates during activities that disturb the soil.

9.0 WORK ZONES AND SITE CONTROL

Access to the sites are not currently controlled via fences and locked gates. Tetra Tech will establish controlled areas within the sites when work occurs, as required, and ensure that workers are properly trained, attired, and monitored. Controlled areas will be those in which adits, waste rock, and contaminated drainages are observed. They can include either NORM or TENORM, should elevated levels of radioactivity occur therein. Accordingly, personnel entering a site will be required to comply with the site-wide health and safety requirements. Additionally, personnel entering a specific work area will be required to conform to the associated health and safety requirements for that respective area, which will generally exceed the site-wide requirements.

The Tetra Tech project manager is responsible for security, fencing, and area control and will ensure adequate security to protect against unauthorized removal of radioactive materials when its personnel and contractors are present.

Tetra Tech personnel will establish and/or maintain site controls to (1) minimize the possibility of worker exposure to contaminants, and (2) minimize off-site release of contaminants.

To attain these goals, personnel will use the following concepts, as necessary:

- Site Access Control and Security;
    - Fences, rope, barrier tape, signs,
    - Sign-in procedures, and

  - Controlled access points.
- Minimize Personnel and Equipment on Site;
- Appropriate training;
- Necessary briefings;
- Established Work Zones; and
- Established Decontamination Procedures (see Section 10.0).

9.1 Site Control

Site control will focus on giving access to authorized personnel and equipment, to assure that individuals entering controlled areas have the required protective equipment and follow appropriate safety procedures, control personnel exposure, and limit the spread of radioactive and chemical contamination.

The RSO or RSO designee will determine site-specific activities to be performed at access control points. The activities may include, but are not limited to:

- Maintain a log of personnel and equipment entering and exiting the controlled area.
- Ensure that personnel who enter controlled areas have the requisite training.
- Ensure that personnel who enter controlled areas meet the posted access control point requirements.
- Issue the proper protective clothing and equipment to personnel.
- Provide general instructions and precautions to personnel and notify them of any changes in work restrictions or site conditions.

9.1.1 Postings

Radioactive material signs, labeled as follows, will be placed in areas where the public could potentially enter work areas:

“Caution - Radioactive Material”

Areas designated as Radiation, High Radiation, Airborne Radioactivity, or CCAs will be posted as such. Signs and labels used will be magenta (purple) or black and yellow in color and bear the standard radiation warning symbol, as well as the required wording. These areas will be posted as required in Table 9-1.

Table 9-1: Posting Requirements.

Posting Required	Required At
"Caution - Airborne Radioactivity Area"	> DAC
"Caution - Airborne Radioactivity Area"	> 0.6% ALI/wk
"Caution - Radiation Area"	> 0.005 rem/h
"Caution - High Radiation Area"	> 0.1 rem/h
"Caution - Controlled Contamination Area"	> 1,000 dpm removable alpha/100 cm^2 and/or > 5,000 dpm total alpha/100 cm^2

Notes:

ALI/wk	annual limit on intake per week
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
rem/h	Roentgen equivalent man per hour

9.1.2 Controlled Area Entry Requirements

Personnel will follow the controlled area entry and working requirements, also known as work rules, identified in Section 11.2.

9.1.3 Contamination Control

As stated in Section 5.3.4, CCAs will be established at the sites for drilling and remedial activities, during which the potential for the contamination of personnel; and materials and equipment is highest. Controlling the spread of radioactive contamination within and out of radiation restricted areas is critical to minimize radiation doses to workers and the public.

Area-specific radiation surveys will be routinely performed to characterize the distribution of radioactive materials in the respective areas.

Subsequently, contamination control activities include, but are not limited to:

- Either clearly post at the CCAs or state during safety meetings information relative to contamination levels, exposure rate measurements, and any other appropriate information for effective contamination control.
- Establish an access or contamination control point to limit general access and to assure that personnel, equipment, and other items leaving a site have been properly monitored for radioactivity prior to proceeding beyond the contamination control point.
- Provide proper receptacles for contaminated and uncontaminated waste materials and provisions for temporary storage of contaminated items.
- Monitor all items for radioactivity, such as protective equipment, tools, and vehicles, prior to departure from the contamination control point. If such items are not leaving the direct control of Tetra Tech, absence of removable radioactivity is all that is required prior to leaving the contamination control point.
- Monitor radioactivity on all personnel prior to their departure from the contamination control point.

- Supervise the decontamination of personnel and equipment, when required, prior to the release from the contamination control point.

A reasonable effort will be made to remove all detectable radioactive contamination from personnel and equipment prior to exit or release from a site. However, when complete contamination removal is not practical, the levels provided in Table 9-2 are acceptable for the release of personnel and equipment from a site.

Table 9-2: Surface Contamination Limits for Unrestricted Release (NRC 1974)

	Surface Contamination Limit (dpm alpha / 100 cm^2)		
	Total Average[a]	**Total Maximum**	**Removable**
Equipment and Vehicles	5,000	15,000	1,000

Notes:

[a]The levels may be averaged over 1 square meter (m^2) provided the maximum activity in any area of 100 cm^2 is less than 3 times the limit value, i.e., less than the maximum.

9.2 Work Zones

Work zones are addressed in the project HASP.

10.0 DECONTAMINATION PROCEDURES

This section describes decontamination procedures for PPE, equipment, vehicles, and personnel.

10.1 PPE, Equipment, and Vehicles

Equipment and vehicle decontamination at these sites will be directed primarily at radioactive materials and will include decontamination of:

- PPE prior to reuse; and
- Equipment and vehicles for unrestricted release.

To minimize the need for the decontamination of protective clothing and other equipment, and minimize generation of radioactively contaminated liquids, disposable project supplies will be used when practicable.

The reusable protective clothing may include:

- cotton or similar heat-resistant coveralls for personnel working around open flames and welding;
- rubber or similar outer boots; and
- cotton, leather, etc. gloves.

Health physics personnel will survey decontaminated clothing periodically, to assess the effectiveness of decontamination.

10.2 Decontamination for Release for Unrestricted Use

While there will be essentially no salvage of equipment and/or materials from the sites for unrestricted release, every practicable effort will be made to decontaminate the equipment used in the site remedial action for unrestricted release. Vehicles will be surveyed as warranted for contamination and decontaminated accordingly.

The primary associated decontamination method to be employed is washing with water. If washing with water is unsuccessful in attaining the release criteria, more aggressive methods may be employed stepwise, including:

- High pressure washing;
- Steam cleaning;
- Vacuum cleaning with high efficiency particulate air filters;
- Washing with detergents, complexing agents, etc.; and
- Abrasion.

Decontamination liquids will be controlled and managed to limit the spread of contamination and preclude releases to waterways.

10.3 Decontamination of Personnel

In spite of controls, contamination of the skin of workers there is always possible and, therefore, the need for associated decontamination procedures.

The wastes at these sites are generally rock- or soil-like materials and, with the exception of radon progeny deposited from contaminated atmospheres, are generally easily removed by soap and water washing.

Health physics personnel will guide the decontamination of personnel. If clothing or safety gear are contaminated with electrochemically-deposited radon progeny (from working in a radon progeny contaminated atmosphere), health physics personnel will collect and isolate the item (e.g., in a plastic bag) until sufficient time (5 hours) has passed to allow for decay of the radon progeny (combined half-life of about 35 minutes).

Field personnel will be instructed to have spare clothing available in case this occurs. If the contamination is persistent, the item or portions of the item will be disposed of.

11.0 SAFE WORK PRACTICES

There are simple, safe work practices that can be followed to limit, and sometimes prevent, the exposure of workers to potentially hazardous substances (e.g., radioactive materials) and physical conditions. There are also monitoring and "vigilance" programs that can be effective in identifying new ways to control and/or mitigate workplace radiation hazards.

11.1 General Requirements

All personnel potentially exposed to radioactive substances will be trained in the following areas:

- Safeguards and engineering controls;
- The use of ppe;
- Work practices that can minimize risks from hazards; and
- Medical surveillance requirements.

All personnel actively participating in remedial action activities at the sites will be under medical surveillance, as required, to be authorized to use the required PPE.

The following list of general health and safety guidelines will be followed:

- Workers will use only designated areas for eating, drinking, and smoking.
- Workers will follow the established criteria for protection levels and decontamination procedures.
- Workers will follow the buddy system described in the project HASP.
- The RSO or RSO designee will conduct regular radiation safety meetings.

11.2 Working in a Controlled Area

Working in a controlled area will require planning to maintain exposures ALARA. The work areas established for soil boring or drilling or working around heavy equipment will have been evaluated radiologically a priori, and areas with exposures greater than 5 milliroentgens per hour (mR/hr) delineated on a site map and in the field. The RSO will establish time limits for these areas, if necessary.

General Work Rules

- Wear required PPE, dosimeters, and air samplers, as required.
- Obey posted, verbal, and written radiological control instructions.
- Remedial action personnel entering controlled areas will enter at the access control point unless an alternate location has been approved by the Tetra Tech project manager and RSO/RSO designee.

- Remedial action personnel leaving controlled areas will go through a full check-out procedure at the established exit point before passing into an uncontrolled or clean area.
- Use a survey meter, as directed, to monitor exposure when in a contaminated area. Personal dosimeters may be issued by the RSO or RSO designee. These dosimeters may be used for a period of time not exceeding 1 year. They should be worn at all times on site and returned to the RSO or RSO designee upon request or to a storage area designated by the RSO or RSO designee when leaving a site.
- Do not loiter in radiation areas and airborne radioactivity areas.
- There will be no eating, smoking, or chewing allowed in controlled areas. Furthermore, food stuffs, tobacco or other smoking products, chewing material (e.g., gum, tobacco), and beverages will not be taken into controlled areas. Potable water in single use bottles may be stored and used within the controlled area if approved by the RSO or RSO designee. Do so only in areas designated by the RSO or RSO designee.
- Potable water or food may not be stored in containers similar to sample containers, to avoid inadvertent ingestion of contaminated materials. Food and drink containers must be readily distinguishable from sample containers.
- Minimize the possibility of a radioactive spill by carefully following procedures.
- For a known or possible radioactive spill, minimize its spread and notify the RSO or RSO designee promptly.
- Do not unnecessarily touch a contaminated surface or allow your clothing, tools or other equipment to do so.
- As practical, place all contaminated equipment such as tools and sampling bottles on disposable surfaces (e.g., sheet plastic) when not in use and inside proper disposal containers when work is finished.
- Plan the work and follow good “housekeeping” practices to minimize the amount of material to be decontaminated or disposed of as radioactive waste.
- Report the presence of open wounds; e.g., exposed blood-bearing tissue, to your supervisor prior to work in areas where radioactive contamination exists. If a wound occurs while in such an area, report immediately to radiological control personnel.
- Follow all other health and safety requirements described in the project HASP.

11.3 Radiation Work Permits

The RSO or RSO designee will prepare a radiation work permit (RWP) prior to the start of any work or maintenance at any location at a site which has radiation safety implications and for which no written procedure exists. The RSO or RSO designee may, at his/her discretion, require a RWP for any work.

It is the joint responsibility of the Tetra Tech Project Manager, the Site Field Manager and the RSO to ensure that RWPs are in place, as appropriate.

The information to be provided on the RWP will include:

- RWP requester name;
- Date and time of the RWP request;
- RWP number;
- Location(s) and nature of the work to be done;
- Results of recent, appropriate radiological measurements of the work area(s);
- Estimated time to complete the work;
- Names and/or job functions of the supervisor(s) and employee(s) working under RWP;
- List of monitoring requirements;
- Specific engineering controls required;
- Specific PPE required by task;
- Decontamination requirements;
- Approval signature of the RSO or RSO designee; and
- Sign-off of supervisors and/or employees working under the RWP, acknowledging they understand the conditions of the permit.

The active RWP will be posted at the work area access control point or otherwise made available to workers throughout the conduct of the associated work.

Upon completion of the work, the RWP will be terminated; copies of associated monitoring data will be attached or filed. The entire data package will be retained for no less than five years.

11.4 As Low As Is Reasonably Achievable (ALARA) Program

There are two basic conditions necessary in any program for keeping occupational exposures as far below the specified limits as is reasonably achievable (ALARA). The management of the project should be committed to maintaining exposures ALARA, and the personnel responsible for radiation protection should be continually vigilant for means to reduce exposures (NRC 1977).

According to NRC Regulatory Guide 8.31, these two conditions are met by designing and implementing an ALARA program that integrates facility design and work planning, personnel qualifications and training, clear authorities and responsibilities, surveys and monitoring, routine reviews, and inspections and audits (NRC 1983).

11.4.1 Management Commitment

Tetra Tech management's commitment to maintain doses and exposures to all worker and public radiation exposures ALARA is exemplified by the approval and implementation of this plan including the ALARA Policy Statement provided in the forward.

11.4.2 Work Planning

All work planned that incorporates radiation safety will be conducted using health physics monitoring procedures, work plans, and if necessary, RWPs.

11.4.3 Personnel Qualifications and Training

The required qualifications of the key radiation safety personnel are provided in Section 3.2. All personnel, from management to health physics personnel to site visitors will receive the appropriate instruction and training as provided in Section 12.0.

11.4.4 Clear Authorities and Responsibilities

The authorities and responsibilities of management, the RSO and radiation protection staff, and on-site workers are summarized in Section 3.1 of this RPP.

Management will provide the following:

- A strong commitment to and continuing support for the development and implementation of the RPP and ALARA practices.
- Information and policy statements to employees, contractors, and visitors.
- A periodic management audit program that reviews procedural and operational efforts to maintain exposures ALARA.
- Continuing management evaluation of the RPP, its staff, and allocation of adequate resources.
- Appropriate briefings and training in radiation safety, including ALARA concepts for all relevant employees, contractors and visitors.

The RSO has primary responsibility for the technical adequacy and correctness of the radiation protection and ALARA program and has continuing responsibility for surveillance and supervisory action in the enforcement of the program.

The RSO is assigned the following:

- The development and administration of the RPP with sufficient authority to enforce regulations and administrative policies that affect any aspect of the program.
- Responsibility to review and approve plans for new equipment, process changes, or changes in operating procedures to ensure that the plans do not adversely affect the protection program against radioactive materials.
- Adequate equipment and laboratory facilities to monitor relative attainment of the ALARA objective.

Because an RPP is only as effective as the workers' adherence to the program, all workers at the sites will be responsible for the following:

- Adhering to all rules, notices, and operating procedures for radiation safety established by management and the RSO.
- Reporting promptly to the RSO, RSO designee and/or management of any equipment malfunctions or violations of standard practices or procedures that could result in increased radiological hazard to any individual.
- Suggesting improvements to the RPP and ALARA practices.

11.4.5 Surveys and Monitoring

The RSO and radiation protection staff are responsible for performing all routine and special radiation surveys as required by this RPP, regulations, procedures, and as necessary to assure that radiation exposures and doses are ALARA. The necessary surveys and monitoring are provided in this RPP and/or the documents referenced in Section 15.

11.4.6 Routine Reviews

The RSO or RSO designee will conduct monthly reviews of the results of inspections and radiological monitoring performed since the last review. The monthly reviews will be documented in monthly reports submitted to the Project Manager. The monthly reports will include a summary of the most recent available personnel exposure data, including bioassays, breathing zone results, and a summary of all pertinent available radiation survey records.

The performance of the ALARA program will be reviewed as needed by the RSO or RSO designee, the results of which will be included in the next monthly report to the Project Manager. In addition, the performance review will specifically address any trends or deviations from the radiation protection and ALARA programs.

To ensure that proper radiation protection principles are being applied, written procedures will be reviewed and approved in writing by the RSO before being implemented and whenever a change in a procedure is proposed. In addition, the RSO will review all existing operating procedures at least annually.

11.4.7 Inspections and Audits

During site work activities, periodic inspections of all active work areas and storage areas will be conducted by the RSO or RSO designee, to ensure that the RPP is being implemented as required. Any deviation from operating procedures or safety practices affecting radiological safety will be documented, reviewed with management or employees, and corrected (if applicable).

The RSO or RSO designee will audit the inspection logs, reports, and all radiological monitoring data annually. The RSO will summarize this information and submit an annual written report to the Tetra Tech project manager recommending any necessary corrective actions, including an evaluation of the adequacy of the implementation of this RPP.

12.0 EMERGENCY RESPONSE

Emergency response is addressed in the project HASP.

13.0 TRAINING REQUIREMENTS

The radiation safety training requirements for individuals engaged in activities at the sites (e.g., regular site workers, occasional site workers, and visitors) is described below.

13.1 Radiation Safety Training

13.1.1 Initial Training

All site workers and supervisors will be instructed by means of a formal, documented training class in the inherent risks of exposure to radiation and the fundamentals of protection against exposure to natural uranium and thorium and their associated decay products before beginning work at the sites. Additional guidance to be provided as appropriate is found in NRC Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure (NRC 1999), and NRC Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure (NRC 1981).

The course of instruction will include the following topics:

- Fundamentals of Health Protection
    - The radiological and toxic hazards of exposure to natural uranium and thorium and their progeny;
    - How natural uranium and thorium and their progeny enter the body (inhalation, ingestion, and skin penetration); and
    - Why exposures to ionizing radiation should be kept ALARA.
- Personal Hygiene
    - Wearing protective clothing;
    - Using respirators correctly;
    - Eating, drinking, and smoking only in designated areas; and
    - Using proper methods for decontamination (e.g., showers).
- Facility-Provided Protection (if applicable)
    - Ventilation systems and effluent controls;
    - Cleanliness of the work place;
    - Features designed for radiation safety for process equipment;
    - Standard operating procedures; and
    - Security and access control to designated areas.

- Health Protection Measurements
    - Measurement of airborne radioactive materials;
    - Proper use of XRF;
    - Bioassays to detect radionuclides;
    - Surveys to detect contamination of personnel and equipment; and
    - Personnel dosimetry.
- Radiation Protection Regulations
    - Regulatory authority of OSHA;
    - Employee rights in 10 CFR 19; and
    - Requirements for radiation protection in 10 CFR 20.
- Emergency/contingency Plans

A written or oral test will be given to each worker, with questions directly relevant to the principles of radiation safety and health protection at the sites and as covered in the training course. The instructor will review the test results with each worker. The instructor will discuss any wrong answers to test questions with the worker until he or she understands the correct answer. Workers who fail the test (achieve a score below 70 percent) will be retested after receiving additional training. Tests and results will be maintained on file.

In addition, all new workers will be given specialized instruction on the health and radiation safety aspects of the specific jobs they will perform. This instruction will be in the form of individualized on-the-job training. Radiation safety matters of concern that arise during operations will be discussed with all workers during regular safety meetings.

13.1.2 Refresher Training

Each permanent worker and supervisor will be provided an abbreviated retraining course annually. Successful completion of the retraining course also will be documented and maintained on file. Retraining will include relevant information that has become available during the past year, a review of safety problems that have arisen during the year, changes in regulations, exposure trends, and other current topics.

13.1.3 Visitor Training

All visitors will be escorted by someone trained and knowledgeable about the hazards at the sites. At a minimum, visitors will receive a briefing at the sites, including specific instruction on what they should do to avoid possible radiological hazards in the areas they will be visiting.

13.1.4 Contractor Training

Contractors having work assignments at the sites also will be given appropriate training and safety instruction. This training is the responsibility of the contractor, except where site-specific conditions may

exist. Only job-specific radiation safety instruction is necessary for contract workers who have previously received full training on prior work assignments.

13.1.5 Training Documentation

All employees will be required to sign a statement that they have received radiation safety training. The statement will indicate the content of the training, the date(s) the training was received, and will be co-signed by the instructor. This documentation will be prepared and maintained for initial and refresher, trainings.

Tetra Tech has developed and will implement a site-specific medical surveillance program for site workers. This plan will address exam frequency and content as well as other applicable information. The Medical Surveillance Program is not addressed specifically in this RRP but exists in the project HASP.

14.0 RECORDKEEPING REQUIREMENTS

10 CFR 20 Subpart L enumerates the recordkeeping requirements for workers who may be exposed to radioactive materials. Such records are valuable in that they may be of legal significance, and sources of information indicating trends in site conditions or general information to support future work planning. For these records to be meaningful and useful, it is important that they be legible, factual, clear, complete, concise, dated, and signed by those recording the information.

14.1 Radiological Health Records

The primary function of radiological health recordkeeping is to document annual, committed, and cumulative (lifetime) radiation doses of individual workers, as appropriate. This may be accomplished through a combination of external dose measurement records and internal dose calculations based on bioassay and exposure (workplace) measurements. Workers must also provide documentation of prior radiation exposures and doses to the extent practicable through prior employer records. If this information is not obtained, the worker may not participate in any planned special exposures. Planned special exposures to an adult are defined in 10 CFR 20.1206 that would receive doses in addition to and accounted for separately from the doses received under the limits specified in § 20.1201 and listed in Table 5-1 of this RPP.

14.2 Surveys and Monitoring

The results of surveys and monitoring will be maintained in Tetra Tech project files.

14.3 Exposure/Dose Records

Prior to the start of field work for the RSE, Tetra Tech will request and maintain the exposure records of all personnel who can expect their annual CEDE to exceed 5 rem (10 CFR 20.1201(a)(1)(i)) or 2 rem/y average for 5 years, 5 rem in any year, or 10 rem total in 5 years (ICRP 1991).

The RSO will calculate and update quarterly the total effective dose equivalent (TEDE: sum of deep dose equivalent [DDE] from the dosimeters and CEDE determined from air monitoring), for all personnel who have been assigned dosimeters. It is expected that all Tetra Tech and ERG personnel on field teams will

be assigned dosimeters. Air monitoring will be conducted only 1) during activities that disturb the soil (e.g. surface or subsurface soil sampling or soil boring or drilling and 2) for one representative worker on the field teams involved in activities that disturb the soil (e.g., one member of an XRF crew who is collecting surface soil samples). The CEDEs for these representative workers will be applied to the co-workers on his or her field team.

Tetra Tech will maintain records of doses received by all individuals for whom monitoring is required by 10 CFR 20.1502. These records will include when applicable, the:

- DDE to the whole body, eye dose equivalent, shallow dose equivalent to the skin, and shallow dose equivalent to extremities;
- Estimated intake of radionuclides, when required;
- CEDE assigned to the intake of radionuclides;
- Specific information used to calculate the CEDE;
- TEDE when required; and
- Total of the DDE and the committed dose to the organ receiving the highest total dose when required.

14.4 Other Records

Tetra Tech also is required to maintain records of public dose monitoring and waste disposal pursuant to 10 CFR 20.2107 and 10 CFR 20.2108, respectively.

14.5 Records Retention

10 CFR 20.2101 specifies the periods for records retention for the project.

15.0 REFERENCES

10 CFR 19. Notices, Instructions and Reports to Workers: Inspection and Investigations

10 CFR 20. Standards for Protection Against Radiation

10 CFR 20.1201. Occupational dose limits for adults.

10 CFR 20.1204. Determination of internal exposure.

10 CFR 20.1301. Dose limits for individual members of the public.

10 CFR 20.1502. Conditions requiring individual monitoring of external and internal occupational dose.

10 CFR 20.2101. General provisions

10 CFR 20. 2107. Records of dose to individual members of the public.

10 CFR 20. 2108. Records of waste disposal.

10 CFR 20 Appendix B. Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage.

10 CFR 20 Subpart L. Records.

29 CFR 1910.1096. Ionizing radiation.

40 CFR 190.Environmental Radiation Protection Standards for Nuclear Power Operations.

ICRP, 1959. Report of Committee II on Permissible Dose for Internal Radiation, International Commission on Radiological Protection, ICRP Publication 2.

ICRP, 1977. Recommendations of the International Commission on Radiological Protection, ICRP Publication 26, January 17, 1977.

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NRC, 1974. U. S. Nuclear Regulatory Commission, Termination of Operating Licenses for Nuclear Reactors, Regulatory Guide 1.86, June 1974.

NRC, 1977. U. S. Nuclear Regulatory Commission, Operating Philosophy For Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable, Regulatory Guide 8.10, May 1977.

NRC, 1981. U. S. Nuclear Regulatory Commission, *Instruction Concerning Risks From Occupational WRadiation Exposure,* Regulatory Guide 8.29, July 1981.

NRC, 1983. U. S. Nuclear Regulatory Commission, Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable, Regulatory Guide 8.31, May 1983.

NRC, 1987a. U. S. Nuclear Regulatory Commission, Interpretation of Bioassay Measurements, NUREG/CR-4884, June 1987.

NRC, 1992. U. S. Nuclear Regulatory Commission, Air Sampling in the Workplace, Regulatory Guide 8.25, Rev. 1, June 1992.

NRC, 1999. U. S. Nuclear Regulatory Commission, Instruction Concerning Prenatal Radiation Exposure, Regulatory Guide 8.13, Rev. 3, June 1999.

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Environmental
Standard Operating Procedure

SOP No. 001
Calibration of a Radiological Survey Detector

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for the calibration of general purpose radiological survey detectors in a manner that meets the applicable sections of the ANSI N323A-1997 American National Standard Radiation Protection Instrumentation Test and Calibration.

A radiological survey detector (detector) is used with a compatible radiological survey meter (meter) to measure radiation in integrated scaler count and/or ratemeter modes. There are several types of detectors including single channel alpha, beta, high-energy gamma, and low-energy gamma; dual channel alpha/beta; Geiger-Mueller which detects gross combined alpha/beta/gamma, and others. *NOTE: Environmental Restoration Group, Inc. (ERG) does not calibrate exposure rate, dose rate, or very high range detectors/meters.* These are sent to a calibration facility having the National Institute of Standards and Technology (NIST)-traceable radiological check sources necessary to perform such a calibration. Even with their differences most detectors operate and are calibrated in a similar manner. A detector is calibrated using an appropriate meter and NIST-traceable check source of known activity. Typically, if a single-channel detector is calibrated then a single-channel meter is required, and similarly if a dual-channel detector is calibrated then a dual-channel meter is required. The type of detector also dictates the check source(s) used. During the calibration process the detector is also inspected for any physical damage that might affect its functionality; e.g., a punctured mylar, cracked housing. Calibration of any survey detector is required prior to initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect instrument operation.

To calibrate a radiological survey detector the Instrument Technician must show proficiency on the detector, the accompanying meter, and be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 EQUIPMENT AND MATERIALS

The following equipment is required to calibrate a radiological survey detector:

- Radiological survey detector – Ludlum Model 43-5 (zinc-sulfide, alpha), Model 43-68 (gas proportional, alpha/beta), Model 43-93 (zinc sulfide + plastic, alpha/beta), Model 44-9 (GM "Pancake", alpha/beta/gamma), Model 44-10 (sodium iodide, high-energy gamma), Field Instrument for Detecting Low Energy Radiation (FIDLER, sodium iodide, low-energy gamma), or similar.
- Calibrated meter appropriate for use with the detector to be calibrated
- NIST-traceable calibration check source with known activity. Use a thorium 230 (Th-230) source for typical calibration of an alpha detector. Use a technetium 99 (Tc-99) or strontium-yttrium 90 (Sr/Y-90) source for typical beta detector calibration. Use a cesium 137 (Cs-137) for typical gamma detector calibration. Check sources used depend on the goal of the survey. While the sources listed above are for typical calibrations, they are not definitive.
- Calibration jig; used to ensure consistent detector position relative to check source.
- Cable to connect detector and meter.
- Flathead precision screwdriver.
- ERG Certificate of Calibration form or access to ERG equipment rental database.

3.0 PROCEDURE

The following procedures will be used for the general detector calibration process. Not all detectors have the same features or calibration needs. When unsure, check the manufacturer's Technical Manual for confirmation and/or assistance. *NOTE: If detector calibration is in conjunction with a meter calibration then some of the initial calibration steps may be performed as part of the initial meter calibration.*

1. **PHYSICAL INSPECTION** – Check detector for damaged tube (e.g., GM detector), punctured or dirty mylar window, cracked welds or other damage to detector housing, and/or loose cable connector or screws, as applicable to detector type and model. *NOTE: Punctured mylar window or cracked welds may be difficult to assess visually.* Turn instrument audio on and rotate detector to/from a light source, such as a bright lamp or sunlight, to assist in identifying any possible light leaks. Repair or replace detector components as necessary.
2. Open up the ERG Equipment Rental database and locate the appropriate meter/detector specific form. If access to the database is not possible then record calibration data on a printed form.
3. Input the Manufacturer, Model Number, and Serial Number for the meter and/or detector being calibrated on the form.
4. Input the atmospheric pressure of the calibration location; barometric pressure, temperature, and relative humidity.
5. Prior to connecting the meter to the detector set meter to appropriate starting high voltage (HV). If unsure, then start at around 500 volts.
6. Connect the meter to the detector being calibrated and turn on.
7. Note condition of battery as indicated by display. If the indicated battery power is not within BATT OK range on analog meter or not greater than 5.0 in digital LCD display then replace.
8. **GM DETECTOR TYPE** – The calibration of a GM Pancake detector or other GM detector is simply a confirmation of functionality. All GM type detectors are set at a model-specific single operating HV. For example, the Ludlum Model 44-9 GM Pancake detector operates at 900 V. Check the model-specific operating HV if other than a Model 44-9 and set the meter HV to this value. GM Pancake detectors typically operate at an input sensitivity, or threshold (THR), setting of 30 mV to 40 mV. Confirm the detector model THR in the Technical Manual if unsure of value, and set the meter THR to this value.
9. **SCINTILLATION AND GAS PROPRTIONAL DETECTOR TYPES** – With the exception of the GM detectors, the operating voltage for most detectors is determined based on the its response to changes in the operating high voltage (HV) as observed in a plateau curve, instrument efficiency, cross-talk, and background counts.
    a. Single-channel scintillation detectors typically operate at a THR setting of 10 mV. Dual-channel scintillation detectors typically operate at an alpha THR setting of 120 mV, and beta THR and WIN settings of 3.5 mV and 35.0 mV, respectively. Gas proportional detectors typically operate in a THR range of 2 to 5 mV if in single-channel use, and at an alpha THR setting of 100 mV, and beta THR and WIN settings of 3.5 mV and 35.0 mV, respectively if in dual-channel use. Confirm the model THR and WIN settings in the Technical Manual if unsure of value, and set the meter THR and WIN to these values.
    b. If using a Model 2221 confirm that the window (WIN) switch is turned OUT.

c. Place the detector and the appropriate check source in the calibration jig such that they are in the appropriate and repeatable detector-to-source geometry. For alpha and/or beta sources this is directly underneath the detector face. For gamma sources this is typically 3 to 6 inches away from the detector.

d. With the HV already set at an appropriate beginning HV gradually increase the voltage until the meter begins to register counts, then increase to the next higher 50 V increment (i.e., if you begin to get audible counts at 620 V then continue to increase HV to 650 V). *NOTE: Use of the meter audio is helpful here. After the initial starting HV is identified the audio volume may be turned down/off.*

e. If the meter has only analog ratemeter function then record the count rate for this HV setting. If the meter has scaler function then perform a 1-minute scaler count and record the scaler count result for this HV setting instead.

f. Remove the source and repeat measurement at this HV, and record as the background count result for this HV setting.

g. Replace the check source, increase HV to next incremental setting, and repeat the previous step until the source or background count rate begins to increase rapidly with increased voltage. *NOTE: Under no circumstances should the operating voltage exceed 1200 V for scintillation detectors or 1800 V for gas proportional detectors.* HV incremental increases vary by model number. *NOTE: In some cases it might be 25 V increments, and others it might be 100 V increments.* Choose the appropriate increments to generate an acceptable plateau curve.

10. **EVALUATE PLATEAU CURVE –** Prepare a graph of count rate versus HV setting. *NOTE: If using the ERG Rental database the calibration forms generate this graph automatically as data are entered.* The graph should consist of a curve showing a rise in count rate as the HV is increased, which then flattens out to a relatively flat section where there is little increase in count rate over a voltage range of up to several hundred volts, and then possibly a very sharp increase in count rate. This initial curve is known as the “knee”, which then transitions into the flatter region known as the “plateau”, and then into the “region of continuous discharge”. An example HV voltage plateau curve is shown in Figure 1 below.

11. **SET OPERATING HV –** The detector operating HV should be set somewhere above the knee and below the region of continuous discharge, preferably 50 to 100 volts above the knee. *NOTE: Operating HV setting depends on several variables, including desired background counts, detector efficiency, and condition of detector crystal and photomultiplier tube.*

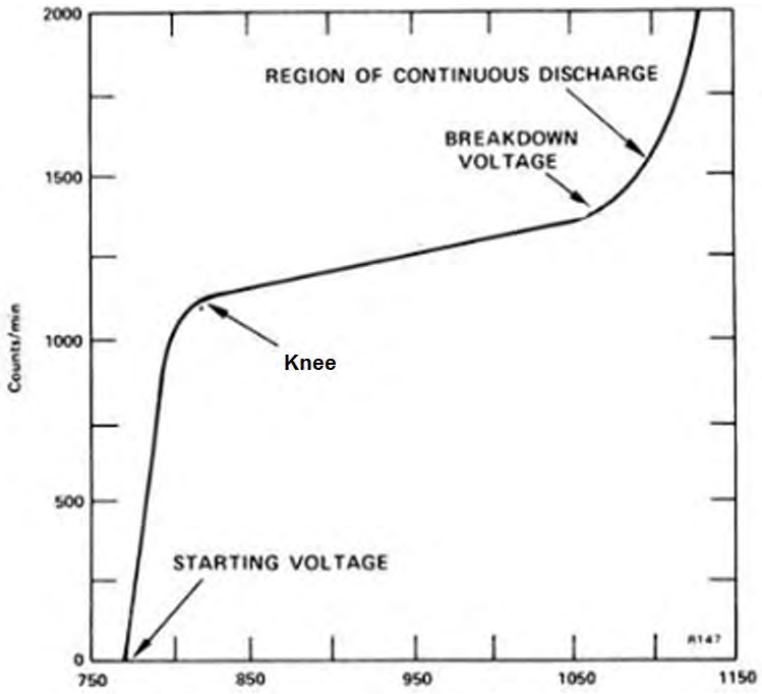

Figure 1 – Example of a High Voltage Plateau Curve

4.0 RECORDS

A detector calibration is documented using the appropriate meter/detector-specific Certificate of Calibration form (form) found in the ERG Equipment Rental database. If access to the database is not available, then a blank Certificate of Calibration form for the appropriate meter/detector specific calibration may be completed manually. When a calibration is completed the Certificate of Calibration form must be printed, protected, and retained per the ERG Document Retention Schedule and ANSI N323A-1997.

Environmental
Standard Operating Procedure

SOP No. 002
Calibration of a Radiological Survey Meter

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for the calibration of general purpose radiological survey meters in a manner that meets the applicable sections of the ANSI N323A-1997 American National Standard Radiation Protection Instrumentation Test and Calibration.

A general purpose radiological survey meter (meter) is used with a compatible detector to measure radiation in integrated scaler count and/or rate modes. A meter is calibrated using a pulse generator, also known as a pulser. The pulser allows for the high voltage, threshold, window setting, and analog/digital count rate to be tested. During the calibration process the meter is also inspected for damaged buttons, switches, etc., or any physical damage that might affect functionality. Calibration of any survey meter is required prior to initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect instrument operation.

To calibrate a radiological survey meter the Instrument Technician must show proficiency on the meter, and be recognized on their ERG Training Qualification Form as qualified to perform this procedure

2.0 EQUIPMENT AND MATERIALS

The following equipment is required for the calibration of a radiological survey meter:

- Radiological survey meter – Ludlum Model 12, 177, 2000, 2221, 2241, 2360, 2929, or similar.
- Calibrated pulse generator – Ludlum Model 500 pulser, or similar.
- Calibrated Fluke multimeter, or similar.
- Cable to connect meter and pulser.
- Flathead precision screwdriver.
- ERG Certificate of Calibration form, or access to ERG Equipment Rental database.

3.0 PROCEDURE

The following procedures will be used for general meter calibration. Not all meters have the same features or calibration needs. When unsure check the manufacturer's Technical Manual for confirmation and/or assistance.

1. Open up the ERG Equipment Rental database and locate the appropriate meter/detector specific form.
2. Input the Manufacturer, Model Number, and Serial Number for the meter and/or detector being calibrated on the form.
3. Input the atmospheric pressure of the calibration location; the barometric pressure, the temperature, and the relative humidity.
4. **PHYSICAL INSPECTION** – Check meter for broken components that may affect operation (e.g., broken parts including latches, knobs, buttons, switches; misaligned knobs; and loose screws). When everything is found to be in proper working order check the Mechanical Check box on the form.

5. **AUDIO CHECK** – Check that the meter audio feature is in proper working order. If so, then check the Audio Check box on the form.
6. **RESET CHECK** – Check that the Reset button is in proper working order. If so, then check the Reset Check box on the form.
7. **BATTERY CHECK** – Check that the battery level is of sufficient (minimum of 4.4 VDC, or within "BAT TEST" range on meter dial). If so, then check the Battery Check box on the form.
8. Connect the pulser to the meter being calibrated.
9. **HV CHECK** – Check the high voltage level at 500, 1000, 1500 volts to see if the meter readings matches the pulser readings (± 2.5%). If so, then check the 500 V, 1000 V, and 1500 V boxes on the calibration form. If the readings do not match, then refer to the Technical Manual on how to adjust the meter HV to match the pulser output, and recheck.
10. **THR/WIN OPERATION** – If applicable to the meter being calibrated, determine if the input sensitivity, or threshold (THR), and window (WIN) features are operating correctly. Not all meters will have an adjustable THR or a WIN feature. Determine what the THR and WIN settings are on the meter. Use the THR and WIN buttons that display the settings when pressed. The THR setting is typically detector specific, and the WIN setting is use/project specific. By adjusting the amplitude on the pulser, check to see if the set displayed THR and WIN settings correspond to actual. If so, then check the THR/WIN Operation box on the form. If the readings do not match, then refer to the Technical Manual on how to adjust the meter THR and WIN to match the pulser output, and recheck. For dual channel alpha/beta meters repeat the THR check for both channels. Only the beta channel (lower channel) will have a WIN.
11. **FAST/SLOW RESPONSE CHECK** – With the pulser providing a count rate of less than 500 counts per minute (CPM) and the pulse multiplier in the X1 position switch the pulser multiplier to the X100 or X1000 range. With the RESP switch in the F (fast) position the meter should indicate a count rate in the set range within 4 ± 1 seconds. With the RESP switch in the S (slow) position the meter should indicate a count rate in the set range in 22 ± 2 seconds. If so, then check the F/S Response Check box on the form.
12. **GEOTROPISM** – If applicable to the meter being calibrated, determine if the unit is experiencing geotropism, or a change in the analog meter reading due to gravity. Check the needle position by holding the meter in three different orientations (meter face flat, meter face up, and meter face on its side). If the meter reads the same in all three orientations then the meter successfully passes the geotropism check, check the Geotropism box on the form.
13. **METER ZEROED** – Press the ZERO button and release. The meter should zero out. If so, then check the Meter Zeroed box on the form.
14. **RANGE TEST** – Set the scale multiplier on the meter and check the ranges indicated on the appropriate calibration sheet. Set the count rate on the pulse generator to its highest reference setting indicated on the calibration sheet. Set the meter to the proper ratemeter range scale, observe, and record the instrument analog reading. Record this value in the "As Found Reading" column on form. If the reading is not ± 10% of what the pulser reads then use a precision flathead screwdriver to adjust the appropriate internal meter potentiometer so the meter reading matches the pulser output. If unfamiliar with this process then refer to Technical Manual. If /when the reading is within ± 10% then record in the Meter Reading column on form. If applicable to the meter being calibrated, switch the ratemeter range scale to LOG and record value in the Log Scale Count column on form. Repeat this for the remaining reference settings. NOTE: As the count rate

and range setting are changed on the pulser, allow time for the analog meter movement to respond, as this may take several seconds to happen if in slow response mode.

15. **INTEGRATED COUNT** – If applicable to the meter being calibrated check the integrated counts feature (i.e., check the ability to collect counts for a set time span), for example: one minute; then perform a one-minute integrated count. For dual channel alpha/beta meters repeat the integrated count process for both channels. Do this for each scale range of counts specified on form.
16. **INSTRUMENT WITHIN TOLERANCE** – If the instrument passes all checks above then check the Instrument found within tolerance check box.
17. At the bottom of the form check the appropriate pulser serial number box, and Fluke multimeter box if used.
18. If no detector is to be calibrated with the meter then print out form, sign and date form enter a calibration due on form (no more than one year from calibration date), and submit for review to someone else qualified to perform a radiological survey meter calibration. If a detector is to be calibrated with the meter then continue on to that procedure.

4.0 RECORDS

A meter calibration is documented using the appropriate meter/detector specific Certificate of Calibration form (form) found in the ERG Equipment Rental database. If access to the database is not available then a blank Certificate of Calibration form for the appropriate meter/detector specific calibration may be manually completed. When a calibration is completed the Certificate of Calibration form must be printed, protected, and retained per the ERG Document Retention Schedule and ANSI N323A-1997.

Environmental
Standard Operating Procedure

SOP No. 003
Contamination Surveys for
Unrestricted Release

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

February 2018

CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide a method for the monitoring of potentially contaminated materials and equipment for unrestricted release to the general public.

All potentially contaminated equipment and materials must be monitored for contamination prior to access to, or release from radiologically-controlled areas. Levels of alpha and beta-gamma contamination will be determined and compared to release criteria based on the two general categories, fixed and removable contamination. Determination of fixed and removable surface contamination is necessary prior to release. Decontamination must be performed to ALARA levels with limits for total and removable contamination provided in Table 1.

For purposes of this procedure, "potentially contaminated" means the likelihood for radiological contamination to be present on materials or equipment based on the professional judgment of the person performing the release survey.

2.0 PRECAUTIONS

The following precautions will be observed during surveying:

- Some equipment does not qualify for being released by the methods described in this document. It is the responsibility of the surveyor to get the necessary guidance from the health physics staff or RSO for determining if an item or material qualifies for unrestricted release.
- The equipment being released may not be removed from the site until all smears have been processed and results indicate all levels are below the investigation criteria.

3.0 EQUIPMENT AND MATERIALS

The following equipment is required for performing contamination surveys:

- Alpha/Beta survey instruments – Ludlum Model 2360 dual channel ratemeter/scaler with a Ludlum Model 43-93 (dual channel alpha: zinc sulfide phosphor/beta: plastic scintillator), or similar radiation meter and detector.
- Alpha/Beta counting instruments - Ludlum Model 2929 with Ludlum Model 43-10-1 Probe scintillation alpha and beta counter for counting swipes, or equivalent.
- Removable smears
- Radiological check source - For typical function check of an alpha radiation and/or a beta radiation detector use a thorium-230 (Th-230) alpha source and/or a technetium-99 (Tc-99) or strontium/yttrium-90 (Sr/Y-90) beta source. Check sources used are dependent upon the goal of the survey. While the sources listed above are for typical function checks, they are not required to be NIST traceable. NOTE: Select check sources that will provide a minimum accumulation of 5,000 gross counts during the counting interval, typically one minute.

4.0 PROCEDURE

The following procedures will be used for scanning items and equipment for unrestricted release.

4.1 INSTRUMENT SETUP

Connect cabling between ratemeter/scaler/counters, detectors, and data loggers or controller, as necessary. Use sufficient cabling such that it will be safe and secure from damage or unintended disconnection.

4.2 RELEASE SURVEY

The Health Physics staff, or qualified personnel shall assess the item being released to determine if it qualifies for unrestricted release. For example, some items such as water pumps may have internal surfaces not accessible to being surveyed yet may have a high potential for contamination.

4.2.1 Evaluation of Equipment for Release

The health physics staff shall use professional judgement to determine the potential for contamination.

4.2.1.1 No Release – the item may not be released by the methods described in this procedure. The item or equipment must remain on-site until further guidance is provided by the health physics staff.

4.2.1.2 Release by Radiological Survey – the item requires a radiation survey prior to being released from the site for unconditional use.

4.2.2 Radiological Survey

If health physics staff determine that the equipment may be released, the survey may be performed using the techniques as outlined in section 4.3. If the survey results exceed the investigation limits, the health physics staff shall be notified, and the equipment should be subjected to one of the following options:

4.2.2.1 Decontamination – the equipment shall be decontaminated and resurveyed until the survey results are below the investigation limits.

4.2.2.2 No Release – the equipment shall not be released from the site.

If the survey results are below the investigation limits, the documented results shall be reviewed by the health physics staff and the equipment may be released for unrestricted use.

4.3 SURVEY TECHNIQUES

The radiological survey of the item or equipment for unrestricted release is made by measuring for total alpha, total beta; and removable alpha and beta activity. The Minimum Detectable Activity (MDA) for instruments also is addressed in this section.

4.3.1 Total Alpha Activity

Measured by using the Ludlum Model 43-93, 43-5, or similar.

4.3.2 Total Beta Activity

Measured by using the Ludlum Model 43-93 connected to a dual-channel meter, such as the Ludlum Model 2360, or similar.

4.3.3 Removable Alpha and Beta Activity

Measured by using the removable smear to wipe approximately 100 cm^2 of area, then counting the smear using a Ludlum Model 2929, or similar.

4.3.4 Minimum Detectable Activity

The MDA of a measurement refers to the quantity of radioactive material that can be statistically measured above background, at a predefined confidence level.

4.3.4.1 Fixed Point Minimum Detectable Activity

The MDA for surface activity can be calculated by:

$$MDA = \frac{2.71 + 4.65\sqrt{B\,t}}{t\;E\;\frac{A}{100}} \qquad \text{(Eq. 1)}$$

Where:

MDA = activity level in dpm/100cm^2

B = background count rate in cpm

t = counting time in minutes

E = total detector efficiency in cpm/dpm

A = active probe areas in cm^2

4.3.4.2 Scanning Minimum Detectable Activities for Handheld Alpha Scanning

Scanning for alpha emitters differs significantly from scanning for beta and gamma emitters, in that the expected background response of most alpha detectors is expected to be near zero. Since the time an area of elevated residual radioactivity is under the probe varies and the background count rate is often less than 1 cpm, it is not practical to determine a fixed MDA for scanning. Instead, the approach described in Section 6.7.2.2 of MARSSIM is used. The two-step process (scanning and a long, i.e., static count) is considered to meet guidelines regarding contamination. Given a desired activity and known scan rate, the probability of detecting an area of elevated residual radioactivity can be calculated using Equation 2:

$$P(n \geq 1) = 1\text{-}e^{-G\varepsilon d/60v} \qquad \text{(Eq. 2)}$$

where:

P(n≥1) = probability of observing a single count

G = contamination activity (dpm)

ε = detector efficiency (4π)

d = width of detector in direction of scan (7 cm for a Model 43-93)

v = scan speed (cm s-1)

The alpha scan MDA at a 90 percent probability of detecting a count can be estimated from Equation 2 above by solving for G (Ablequist, 2001):

$$MDA_{scan} = \frac{-\ln(1 - P(n \geq 1)) \times 60}{\varepsilon_i \times \varepsilon_s \times \mathrm{t}} \qquad \text{(Eq. 3)}$$

where:

ε_i = instrument efficiency

ε_s = source efficiency

t = observation interval (1.4 s) for 5 cm s^{-1} scan speed with 7 cm detector width

4.3.4.3 Scanning Minimum Detectable Activities for Handheld Beta Scanning

The framework for determining the beta scan MDA for conventional measurement systems is based on the premise that there are two stages of scanning: a first stage of continuous monitoring and a second stage of stationary sampling. The continuous (i.e., scanning) stage is dependent on the scan speed (e.g., 5 cm s^{-1}) and is the limiting factor for determining the scan MDA. The second stage measurement is a longer duration (3 or 4 seconds) and is the decision point for whether a one-minute static measurement is required. Equation 4 is used to calculate the MDA for scanning surfaces in the building for beta emitters (MARSSIM (NRC, 2000) Equation 6-10):

$$MDA_{scan} = \frac{MDCR}{\sqrt{p} \times \varepsilon_i \times \varepsilon_s \times \frac{A}{100 cm^2}} \qquad \text{(Eq. 4)}$$

where:

MDCR = s_i (60/i) and, s_i =d' √b_i

d' = the index of sensitivity, 2.16, from Table 6.5 in MARSSIM which suggests that a high performance level is required at the first scanning stage of 95 percent correct detections (Type II error of 5 percent) and that a high rate of 30 percent false positive detections (Type I error rate of 30 percent) is tolerated to increase the scan efficiency, because the consequence of the Type I decision error is simply performing the stationary stage.

b_i = number of background counts in time interval (i) (counts) and is calculated by (mean background cpm) (observation interval in seconds [10 seconds for an assumed 50 cm wide hotspot and 5 cm s^{-1} scan speed])(1 min/60 s conversion)

p = surveyor efficiency, 0.5, from MARSSIM, Section 6.7

ε_i = instrument efficiency for emitted radiation (cpm/emission per minute [epm])

ε_s = source efficiency for emissions/disintegration

A = area of detector (cm^2)

4.3.5 Total Alpha/Beta Radiation Survey

4.3.5.1 Ensure that the audio of the meter can be heard clearly and that the switch is set so that both alpha and beta counts can be heard.

4.3.5.2 Place the probe no more than ½ - cm off the surface and slowly scan the area. The scanning speed should not exceed 5 cm s^{-1}. If an increase in beta counts, or an alpha count is heard, stop the probe over that location for no less than 3 s to see if the increase in counts continues. If a noticeable increase in beta counts is observed, or a sequence of alpha counts, take a static measurement at that location, otherwise continue scanning the area. To determine the counting time for the static measurement, use Equation 1 to verify that the MDA of the instrument is below the release limits listed in Table 1. Alternatively, Figure 1 can be used to approximate the MDA given an instrument efficiency. Use a one-minute counting time as the minimum interval.

4.3.5.3 If no increase in counts was observed, take a one-minute static measurement at the center of the area scanned and document the result in the logbook or a form.

4.3.5.4 At each location where the static measurement was made, use a swipe to smear approximately 100cm^2 of area.

4.3.5.5 Count the sample and record the record the results. If the removable alpha or beta activity limit shown in Table 1 is exceeded, the material shall not be released until the material has been decontaminated to meet the limits.

Figure 1. Static MDA for a One-Minute Count

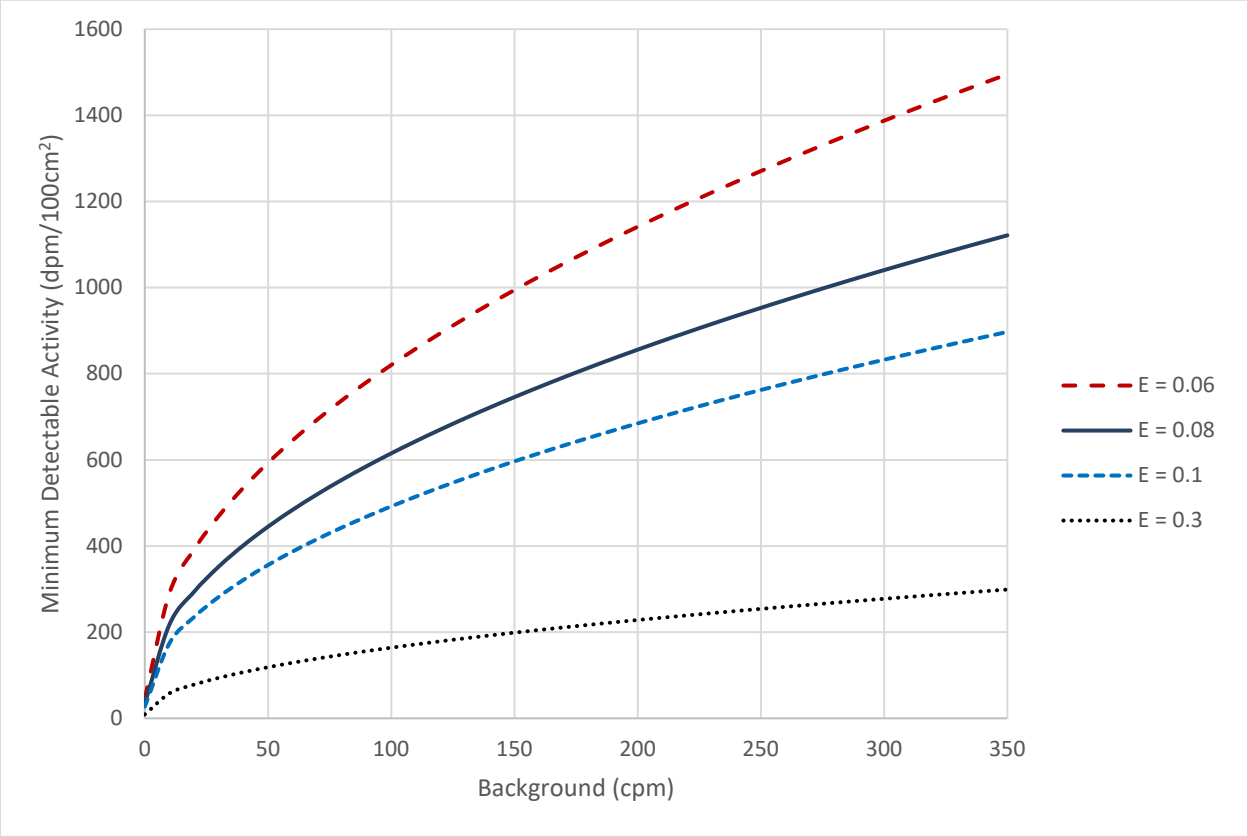

Table 1. Surface Contamination Limits

	Surface Contamination Limit (dpm alpha / 100 cm²)		
	Total Average[1]	**Total Maximum**	**Removable**
Equipment and Vehicles	5,000	15,000	1,000

[1]The levels may be averaged over 1 square meter (m²) provided the maximum activity in any area of 100 cm² is less than 3 times the limit value, i.e., less than the maximum.

4.4 QUALITY ASSURANCE / QUALITY CONTROL

4.4.1 Instrument Quality Checks

All instruments being used for the contamination survey must be function checked prior to, and after the survey. The instruments shall be function checked using the methods outlined in the SOP for Operation Checkout of Single-Channel Detector with Meter, or the SOP for Operational Checkout of Dual-Channel Alpha/Beta Detector with Meter, as appropriate.

Tetra Tech, Inc.

Environmental
Standard Operating Procedure

SOP No. 004
General Equipment Decontamination

February 2018

CONTENTS

1.0 BACKGROUND

All nondisposable field equipment must be decontaminated before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross-contamination.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating equipment in the field.

1.2 SCOPE

This SOP applies to decontaminating general nondisposable field equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

1.3 DEFINITIONS

Alconox: Nonphosphate soap, obtained in powder detergent form and dissolved in water

Liquinox: Nonphosphate soap, obtained in liquid form for mixing with water

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1992a. "Guide to Management of Investigation-Derived Wastes." Office of Solid Waste and Emergency Response. Washington D.C. EPA 9345.3-03FS. January.

EPA. 1992b. "RCRA Ground-Water Monitoring: Draft Technical Guidance." Office of Solid Waste. Washington, DC. EPA/530-R-93-001. November.

EPA. 1994. "Sampling Equipment Decontamination." Environmental Response Team SOP #2006 (Rev. #0.0, 08/11/94). http://www.ert.org/mainContent.asp?section=Products&subsection=List.

1.5 REQUIREMENTS AND RESOURCES

The equipment required to conduct decontamination is as follows:

- Scrub brushes
- Large wash tubs or buckets
- Squirt bottles
- Alconox or Liquinox
- Tap water
- Distilled water
- Plastic sheeting
- Aluminum foil

- Methanol or hexane
- Isopropanol (pesticide grade)
- Dilute (0.1 N) nitric acid

2.0 PROCEDURE

The procedures below discuss decontamination of personal protective equipment (PPE), drilling and monitoring well installation equipment, borehole soil sampling equipment, water level measurement equipment, general sampling equipment, and groundwater sampling equipment.

2.1 PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off site or to clean areas. All used disposable protective clothing, such as Tyvek coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums (refer to Section 3.0).

Personnel decontamination procedures will be as follows:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean water. Remove booties and retain boots for subsequent reuse.
4. Wash outer gloves in Liquinox or Alconox solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.
5. Remove Tyvek or coveralls. Containerize Tyvek for disposal and place coveralls in plastic bag for reuse.
6. Remove air purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily or sooner depending on use and application. Place respirator into a separate plastic bag after cleaning and disinfecting.
7. Remove disposable gloves and place them in plastic bag for disposal.
8. Thoroughly wash hands and face in clean water and soap.
9. A representative sampling of used PPE and used decontamination towelettes will also be surveyed directly with an alpha probe for evidence of measurable alpha activity in excess of pre-established instrument baseline at the survey station. It is not expected that used PPE/towelettes will contain measurably elevated radioactivity, but confirmatory survey checks will be performed at the end of each sampling trip. If elevated activity is not detected, the used PPE/towelettes will be managed in the same manner as other ordinary trash generated during the project. In the unlikely event of measurably elevated activity on used towelettes, the biodegradable trash bags and used towelettes will be buried at one of the waste rock piles for ultimate management as part of remedial plans for the mine waste.

2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated at a designated location on site before drilling operations begin, between borings, and at completion of the project. Decontamination may be conducted on a temporary decontamination pad constructed at satellite locations within the site area in support of temporary work areas. The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Decontamination pads may be constructed of concrete, wood, or plastic sheeting, depending on the site-specific needs and plans. Wash waters and contaminated soil generated during decontamination activities should be considered contaminated and thus, should be collected and containerized for proper disposal.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned and placed on polyethylene sheeting on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

The drilling auger, bits, drill pipe, any portion of drill rig that is over the borehole, temporary casing, surface casing, and other equipment used in or near the borehole should be decontaminated by the drilling subcontractor as follows:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. Remove loose soil using shovels, scrapers, wire brush, etc.
4. Steam clean or pressure wash to remove all visible dirt.
5. If equipment has directly or indirectly contacted contaminated media and is known or suspected of being contaminated with oil, grease, polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol.
6. To the extent possible, allow components to air dry.
7. Wrap or cover equipment in clear plastic until it is time to be used.
8. All wastewater from decontamination procedures should be containerized.

2.3 BOREHOLE SOIL SAMPLING DOWNHOLE EQUIPMENT DECONTAMINATION

All soil sampling downhole equipment should be decontaminated before use and after each sample as follows:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. Prior to sampling, scrub the split-barrel sampler and sampling tools in a wash bucket or tub using a stiff, long bristle brush and Liquinox or Alconox solution.
4. After sampling, steam clean the sampling equipment over the rinsate tub and allow to air dry.

5. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
6. Containerize all water and rinsate; disposable single-use sampling equipment should also be containerized.
7. Decontaminate all equipment placed down the hole as described for drilling equipment.

2.4 WATER LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. Wipe the tape and probe with a disposable Alconox- or Liquinox-impregnated cloth or paper towel.
4. If immiscible layers are encountered, the interface probe may require steam cleaning or washing with pesticide-grade isopropanol.
5. Rinse with deionized water.

2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. If possible, perform dry decontamination of sampling equipment with dedicated decontamination towlettes to remove all visible gross contamination. Place used towelettes in a biodegradable plastic bag for future disposal.
4. If dry decontamination is unsuccessful, use an Alconox wash; a tap water wash; a solvent (isopropanol, methanol, or hexane) rinse, if applicable, or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (isopropanol, methanol, or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.
5. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
6. Containerize all water and rinsate.

2.6 GROUNDWATER SAMPLING EQUIPMENT

The following procedures are to be employed for the decontamination of equipment used for groundwater sampling. Decontamination is not necessary when using disposable (single-use) pump tubing or bailers. Bailer and downhole pumps and tubing decontamination procedures are described in the following sections.

2.6.1 Bailers

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. Evacuate any purge water in the bailer.
4. Scrub using soap and water and/or steam clean the outside of the bailer.
5. Insert the bailer into a clean container of soapy water. Thoroughly rinse the interior of the bailer with the soapy water. If possible, scrub the inside of the bailer with a scrub brush.
6. Remove the bailer from the container of soapy water.
7. Rinse the interior and exterior of the bailer using tap water.
8. If groundwater contains or is suspected to contain oil, grease, PAH, PCB, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol.
9. Rinse the bailer interior and exterior with deionized water to rinse off the tap water and solvent residue, as applicable.
10. Drain residual deionized water to the extent possible.
11. Allow components to air dry.
12. Wrap the bailer in aluminum foil or a clean plastic bag for storage.
13. Containerize the decontamination wash waters for proper disposal.

2.6.2 Downhole Pumps and Tubing

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of personal protection as was used for sampling.
3. Evacuate any purge water in the pump and tubing.
4. Scrub using soap and water and/or steam clean the outside of the pump and, if applicable, the pump tubing.
5. Insert the pump and tubing into a clean container of soapy water. Pump/run a sufficient amount of soapy water to flush out any residual well water. After the pump and tubing are flushed, circulate soapy water through the pump and tubing to ensure that the internal components are thoroughly flushed.
6. Remove the pump and tubing from the container.
7. Rinse external pump components using tap water.
8. Insert the pump and tubing into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump to evacuate all of the soapy water (until clear).
9. If groundwater contains or is suspected to contain oil, grease, PAH, PCB, or other hard to remove organic materials, rinse the pump and tubing with pesticide-grade isopropanol.

10. Rinse the pump and tubing with deionized water to flush out the tap water and solvent residue, as applicable.
11. Drain residual deionized water to the extent possible.
12. Allow components to air dry.
13. For submersible bladder pumps, disassemble the pump and wash the internal components with soap and water, rinse with tap water, isopropanol (if necessary), and deionized water, and allow to air dry.
14. Wrap pump and tubing in aluminum foil or a clean plastic bag for storage.
15. Containerize the decontamination wash waters for proper disposal.

3.0 INVESTIGATION-DERIVED WASTE

Investigation-derived waste (IDW) can include disposable single-use PPE and sampling equipment, soil cuttings, and decontamination wash waters and sediments. Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage will be provided in project-specific documents, or separate direction will be provided by the project manager. The following guidelines are provided for general use:

1. Assume that all IDW generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.
2. Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.
3. Label IDW storage containers with the facility name and address, date, contents, company generating the waste, and an emergency contact name and phone number.
4. Temporarily store the IDW in a protected area that provides access to the containers and allows for spill/leak monitoring, sampling of containers, and removal following determination of the disposal method.

Environmental
Standard Operating Procedure

SOP No. 005
Performing an Alpha/Beta Surface Contamination Survey

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the method for performing an alpha/beta radiation survey, also referred to as total surface contamination, using an alpha and/or beta radiation detector and associated meter.

An alpha/beta contamination survey is often performed to evaluate the radiological condition of an area, a piece of equipment, or vehicle.

To perform an alpha/beta surface contamination survey, personnel must be recognized on their Training Qualification Form as qualified to perform this procedure

2.0 PRECAUTIONS

The following precautions will be observed surface contamination surveys:

- Use the designed survey scan speed/range

3.0 EQUIPMENT AND MATERIALS

The following equipment is required to perform an alpha/beta surface contamination survey:

- Alpha/Beta survey instruments – Ludlum Model 2360 dual channel (alpha/beta) ratemeter/scaler or Ludlum Model 4612 counter matched with a Ludlum Model 43-93 (dual channel α: zinc sulfide phosphor/β: plastic scintillator), or similar radiation detector.
- Radiological check source – Use a thorium-230 (Th-230) alpha source and/or a technetium-99 (Tc-99) or strontium/yttrium-90 (Sr/Y-90) beta source for typical function check of an alpha radiation and/or a beta radiation detector. Check sources used depend on the goal of the survey. While the sources listed above are for typical function checks, they are not required to be NIST-traceable. NOTE: Select check sources that will provide a minimum accumulation of 5,000 gross counts during the counting interval, typically one minute.
- All appropriate C-cables from meter to detector, and others as necessary.

4.0 PROCEDURE

The following procedures will be used for performing an alpha/beta surface contamination survey.

4.1 SETUP

Setup the detector or survey system, as appropriate. Connect cabling between ratemeter, scaler, counters; and detectors, and data loggers or controller, as necessary. Use sufficient cabling such that it will be safe and secure from damage or unintended disconnection.

4.2 FUNCTION CHECK

Perform function check of the radiological survey instrument(s) per RPP SOP No. 008 Operational Checkout of Single-Channel Detector with Meter, RPP SOP No. 009 Operational Checkout of Dual-Channel Alpha/Beta Detector with Meter; whichever is applicable, before and after each day of use.

4.3 SURVEY

4.3.1 Survey Design

Perform the survey by following the survey design, typically provided in a work plan. The survey design depends on the goal of the survey and the equipment being used to conduct the survey. It should consider the radiation detector type and model choice, survey scan speed, detector spacing, and height of the detector above ground during the survey. Some of these design parameters may depend on the terrain of the survey area terrain.

1. Detector - Choose a detector that is appropriate to meet the goals and/or requirements of the survey. The project work plan will typically prescribe the detector type to be used.
2. Survey Scan Speed - Use the designed survey scan speed or choose a survey scan speed that is appropriate to meet the goals and/or requirements of the survey. A survey scan speed that is too fast may not allow for a detector to physically be present over a localized area of elevated gamma count rates long enough to adequately represent the conditions. For an area believed to have homogenous gamma count rates a slower survey scan speed may be unnecessary and inefficient. The project work plan will typically prescribe the survey scan speed.

4.3.2 Automated System Survey

Open a new survey file and give it a unique file name indicative of the survey. The file name could include the survey date and/or time, the surveyor initials, and/or the site name.

1. Begin and end a survey data file at a point/location where it is desirable to collect data.
2. If movement is pauses during the survey for greater than 10 seconds, then pause the data collection. Remember to resume data collection upon resuming the survey.
3. Close the survey file upon completion of the survey. Create a new survey file for each new survey area/room.

4.3.3 Non-automated System Survey

Record all survey data on appropriate project form, log sheet, or in field log book. Data should include information on the location and/or item surveyed, survey design and instruments used, and survey data/results.

1. Record information regarding the location or item surveyed, including the building, room, floor, wall location, item description, etc. Make drawings, as necessary.
2. Record information about the instrument(s) used and survey design; such as meter/detector make and model, serial number(s), calibration due dates, detector efficiencies, and survey design.

3. Record all survey results and note observations.

4.4 DATA PROCESSING AND REVIEW (AUTOMATED SURVEY SYSTEMS)

Upon completion of an alpha/beta surface contamination survey visually inspect the processed data for possible errors and/or missing data. Resurvey areas where data is unexplainably missing, corrupt, or there is reason to believe the results are in error.

Environmental
Standard Operating Procedure

SOP No. 006
Personnel, Environmental, and Work Area Air Sampling

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes three techniques for determining the concentration of airborne radioactive particulates. The techniques differ only in sample collection; the analytical technique for determining the concentration from the filter media is the same for each sample collection method.

2.0 PRECAUTIONS

- N/A

3.0 EQUIPMENT AND MATERIALS

The following equipment is required for the collection of air samples:

- Air Sampler: Either Area, Breathing Zone, or High Volume
- Particulate Filters GFA (25mm or 47mm, to fit air sampler). Envelopes for filter storage or petri dishes.
- Timing Device
- Counting Instruments: Ludlum 2929 or equivalent
- Air Particulate Sampling Survey Forms

4.0 PROCEDURE

The following procedures will be used for air sampling, depending on the sample being taken.

4.1 WORK AREA SAMPLES

1. Select a calibrated Regulated Air Sampler (RAS-1) and install the appropriate size filter in the filter head.
2. Select a suitable location for sampling. The location chosen is based on an evaluation of the operation being performed. The ideal location for personnel monitoring in a work area would approximate the breathing zone of a worker and would be between the source of the potential airborne material and the location of the worker(s).
3. Determine the time and flow rate necessary to sample a volume sufficient to ensure an adequate Lower Limit of Detection (LLD).
4. Turn on the air sampling unit, adjust the flow rate to a calibrated value, and record the serial number, starting time, flow rate, vacuum and initials of the technician.
5. Record the exact location of the air sampling unit and the nature of the work being performed.
6. Periodically check air sampler unit for proper operation.

7. After the minimum collection time to meet the LLD requirement, record ending flow rate, vacuum and time, and turn off the air sampling unit. Remove the air filter and place in sample envelope or petri dish and label it.

4.2 EVIRONMENTAL SAMPLES

1. Select a calibrated Regulated Air Sampler (RAS-1) and install the appropriate size filter in the filter head.
2. Select a suitable location to place the sampler. Ideally, a series of samplers should be deployed at the perimeter of the worksite with a greater number of samplers placed down wind of the prevailing winds.
3. Turn on the air sampling unit, adjust the flow rate to a calibrated value, and record the serial number, starting time, flow rate, vacuum and initials of the technician.
4. Continuous Air Monitoring

    a. If the deployed sampler(s) is for continuous air monitoring, the filter will need to be changed periodically. The filter change interval should be determined on factors such as flow rate and filter loading.

    b. When a filter needs to be changed, record the ending flow rate, vacuum and time and turn off the sampling unit. Remove the filter from the filter head and place it in a marked envelope.

    c. Place a new filter into the filter head and turn on the sampler unit. Record the start flow rate, vacuum and time.

5. If continuous air monitoring is not required, record the ending flow rate, vacuum and time and turn off the air sampler if there is no work activity.

4.3 LAPEL SAMPLES

1. Select a calibrated lapel air sampler and install a 25 mm diameter filter in the filter cassette head. Install the cassette into the cyclone.
2. Determine the time and flow rate necessary to sample a volume sufficient to ensure that an adequate LLD is obtained. When used with Gillian Part Number 800061 cyclones, limit the flow rate to 2.0 liters per minute. Due to the low flow rate of lapel air sampling pumps, it is usually necessary to operate the pump for a longer period of time than the RAS-1 pumps. A four (4) to eight (8) hour sample, if possible, is preferable.
3. Select a worker with the highest potential for exposure to airborne radioactive materials. Instruct the worker regarding the wearing of the lapel sampler. Position the filter head in the breathing zone.
4. Record the name of the worker and the nature of the work being performed. Record any other pertinent information.
5. Turn on the air sampling pump, adjust the flow rate to a calibrated value, and record the start time, start flow rate, sample identifier, and initials of the issuing technician.
6. Periodically, check the work area and air sampling unit for proper monitoring and operation.

7. Record the ending flow rate and ending time, and turn off the air sampling unit. Remove the air filter and place it in the sample envelope or petri dish and label.

   NOTE: Any period of time which the sampler is left running outside work area (e.g., during lunch break) shall be deducted from the total run time used in calculating airborne concentrations.

5.0 COUNTING INSTRUCTIONS

1. An initial 24 hour decayed count may be performed for informational purposes. Allow a minimum of 72 hours from the end of sample collection before counting sample (to allow for decay of interfering short-lived radon-222 daughters) as appropriate. If Th-232 is a site contaminant, a minimum of 7 days must be allowed for the decay of Ra-220 decay products. The LLD should be at least 10% of the MPC for the final counting of the sample.
2. After waiting at least 24 hours (or 72 hours for thoron decay) from the end of the sample collection, place the sample in the detector and make a count of a time that has been prescribed in the project work plan, radiation protection plan, or equivalent. Record the start time and the result on the appropriate forms. (NOTE: Count time must be increased if LLD is greater than 10% of the limit.)
3. Use the following formula to calculate the long-lived alpha or beta concentration:

$$C = \frac{(S - B)(FA)}{(2.22x10^6)(E)(V)}$$

where:

C = concentration in air, µCi/ml

S = Sample alpha count rate (cpm) = gross sample counts / sample count time (min)

B = Background count rate (cpm) = background counts / background count time (min)

E = Detector efficiency, cpm/dpm

V = Volume sampled (mL) = Average actual flow rate (Lpm) x sample collecting time (min) x 1000 mL/L

FA = Filter absorption factor, 1.25 for glass fiber filter, 1.00 for beta counting

2.22×10^6 = Conversion factor, dpm to µCi

4. Compare the concentration in the sample to the most restrictive limit for the radionuclides present at the site. If the limit is exceeded, the sample must be stored for at least 72 hours and a sample count repeated. This is to allow any radon or thoron daughters collected on the filter to decay. If the result still exceeds the applicable limit, notify the site Radiation Safety Officer or Health and Safety Officer.

Environmental
Standard Operating Procedure

SOP No. 007
Radiation Work Permit

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the contents and use of the Radiation Work Permit (RWP). The Radiation Safety Officer (RSO) or his/her designee shall issue an RWP for all work requiring an RWP. All work at a site that has radiation safety implications for which no written procedure exists must be performed under the guidance of an RWP or SOP. An RWP is used to maintain radiation exposures of workers to as low as is reasonable achievable (ALARA). The RWP controls exposures to radiation by establishing radiation protection requirements and any radiological monitoring necessary.

2.0 PRECAUTIONS

- Not applicable

3.0 EQUIPMENT AND MATERIALS

The following documents are required for the radiation work permit:

- Radiation Work Permit
- Radiation Work Permit Signature Form

4.0 PROCEDURE

The following procedures will be used where radiation work permits are required.

4.1 COMPLETING THE RWP

1. All work at the site for which no SOP exists shall be authorized by the RSO or his/her designee in advance by issue of an RWP.
2. An RWP may be initiated by any individual or subcontractor who is responsible for the work in the control area, but it requires the approval of the RSO or his/her designee.
3. The RSO shall review past data and determine the radiological status of the work area prior to approval of the RWP. If radiological conditions have changed in the work area, a survey may be necessary to properly complete certain sections of the RWP. Any other Health Physics survey requirement shall be specified on the RWP.
4. The RSO will estimate the worker's radiation exposure based upon the work description and the other information provided in the RWP.
5. Any Personal Protective Equipment (PPE) and radiation monitoring equipment necessary shall be assembled by the Health Physics staff.
6. Personnel involved in performing the work shall be given a pre-job briefing by the RSO that will inform them of the work restrictions and other RWP requirements. Discussions shall include scope of work, dosimetry, PPE, control area rules, survey results, radiation hazards, and emergency procedures. All personnel in the briefing shall sign off on the RWP signature form. This will indicate

that they have read the RWP and that they fully understand the requirements, conditions, and hazards related to their work.

7. Work detailed on an RWP shall only begin after the above requirements have been met.

8. The RWP and RWP signature form shall contain details of all required protection procedures and shall identify all personnel involved in the work, including the Health Physics staff.

9. The RWP may be terminated at any time as specified by the RSO. Reasons for termination may be a change in work scope or a change in radiological conditions. An RWP may be amended with approval by the RSO.

4.2 FIELD

1. The RWP and signature form shall be posted or kept in a convenient, accessible location to the workers.
2. Access by all workers must be in compliance with the Site Radiation Protection Plan (or program) and Site Health and Safety Plan.

4.3 POST-OPERATION

1. The terminated RWPs and any other paper work generated by this procedure shall be maintained in the project files.

Environmental
Standard Operating Procedure

SOP No. 008
Operational Checkout of Dual-Channel Alpha/Beta Detector with Meter

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

CONTENTS

1.0 PURPOSE

To provide a method for the operational checkout, or "function check" of a dual-channel alpha/beta meter and detector set to ensure proper working order.

A radiological survey detector (detector) is used with a compatible radiological survey meter (meter) to measure radiation in integrated scaler count and/or ratemeter modes. This standard operating procedure (SOP) is specific to dual-channel alpha/beta detectors compatible for use with a dual-channel meter. A dual-channel meter counts the higher voltage alpha pulses in one channel and the lower voltage beta pulses in another channel. During the operational check-out process (function check) the detector is also inspected for any physical damage that might affect functionality, such as punctured mylar or cracked housing. An aluminized mylar window covering (mylar) is used to eliminate light from entering the detector window. If this mylar is punctured even slightly, it may return inaccurately high readings or may have no count rate due to light overload. Repair or replace mylar windows as necessary, noting the repair/replacement in a field notebook or on Form x.xx. Calibration of any survey detector is required prior to initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect instrument operation.

To calibrate a radiological survey detector the Instrument Technician must show proficiency on the detector, the accompanying meter, and be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 EQUIPMENT AND MATERIALS

The following equipment is necessary to function check a radiological survey detector:

- Radiological survey detector – Ludlum Model 43-93 detector (zinc sulfide + plastic, alpha/beta), Ludlum Model 43-10-1 tray counter, or similar.
- Calibrated dual-channel meter – Ludlum Model 2360, Ludlum Model 2929, or similar.
- Radiological check sources with known activity and emission rate. Use a thorium 230 (Th-230) source for typical calibration of an alpha detector. Use a technetium 99 (Tc-99) or strontium-yttrium 90 (Sr/Y-90) source for typical beta detector calibration. A dual-channel detector will need to be calibrated using both alpha and beta sources. Check sources used depend on the goal of the survey. While the sources listed above are for typical calibrations, they are not definitive. *NOTE: Select check sources that will provide a minimum accumulation of 1,000 gross counts during the counting interval, typically one minute.*
- Calibration jig; used to ensure consistent detector position relative to check source. *NOTE: For tray counter calibration and checkout a calibration jig is not necessary and any reference to one in the steps below may be disregarded.*
- C-cable to connect detector and meter.
- Function Check Form – A function check form must be created and maintained for each individual meter and detector combination. The meter-detector combination should be function checked, and the function check form updated, before and after each day of use.

The function check form must be protected and retained per the ERG Document Retention Schedule.

3.0 PROCEDURE

The following general procedures for a dual-channel detector function check process. Not all meters and detectors have the same features or function check needs. When unsure check the manufacturer's Technical Manual for confirmation and/or assistance.

If not already done, fill in the meter, detector, source, and comments information on the function check form.

- PHYSICAL INSPECTION – Check the meter, detector, and cable for any visible damage. If damage is present then repair, or tag and remove from service.
- TURN ON – Connect the detector and meter using the C-cable, then turn the instrument power on.
- BATT CHECK – Turn the instrument to the BATT position. Note condition of battery as indicated by display. If the battery power is marginal (as indicated by the needle below the BATT OK level on analog meter face), the batteries should be replaced. If battery power is acceptable then indicate on the function check form with a check mark in the Battery Condition box. NOTE: For instruments that are AC powered this step may be ignored.
- HV CHECK – Toggle the RESET/TEST HV switch and check the meter high voltage (HV). If the HV is within ± 25V of the recommended operating HV as found on the detector calibration paperwork and calibration sticker then record on the function check form. If not then adjust accordingly or tag and remove from service.
- BACKGROUND COUNT – Place the detector in proper orientation and position onto a clean calibration jig and begin a count. For tray counters empty the tray and close. Upon completion record the alpha and beta channel background counts onto the function check form. If the results are not within project-specific tolerances then confirm you are using the correct detector to calibration jig geometry and perform a repeat count. If the second count is also out of tolerances, then remove detector from service until issue can be resolved and notify/consult with the Project Instrument Manager (if applicable) and/or Project Manager.
- ALPHA SOURCE COUNT – Place the alpha source on to calibration jig or in tray, place the detector in proper orientation and position over the source or close and lock tray, and begin a count. Upon completion record the alpha and beta channel counts for the alpha source onto the function check form. If the results are not within project-specific tolerances, then confirm you are using the correct detector to calibration jig geometry and perform a repeat count. If the second count is also out of tolerances, then remove detector from service until issue can be resolved and notify/consult with the Project Instrument Manager (if applicable) and/or Project Manager.
- BETA SOURCE COUNT – Place the beta source on to calibration jig or in tray, place the detector in proper orientation and position over the source or close and lock tray, and begin a count. Upon completion record the alpha and beta channel counts for the beta source onto the function check form. If the results are not within project-specific tolerances, then confirm you are using the correct detector to calibration jig geometry and perform a repeat count. If the second count is also out of tolerances, then remove detector from service until issue can be resolved and notify/consult with the Project Instrument Manager (if applicable) and/or Project Manager.

- The individual performing the function check should record their initials in the appropriate box on the function check form upon completion of the function check.

3.1 EFFICIENCY DETERMINATION

The efficiency of the instrument can be calculated per guidance in NUREG 1579 (MARSSIM) and ISO 7503-1 Annex as follows:

$$Total\ Efficiency = e_i \times e_s$$

where:

e_i = Instrument efficiency, where efficiency is calculated as the net detector response (cpm) divided by the check source surface emission rate (cpm). *NOTE: The surface emission rate is not the total activity rate (dpm).*

e_s = Source efficiency factor, where for alpha = 0.25, low energy beta (≤ 400 KeV) = 0.25, and high energy beta (> 400 KeV) = 0.50.

3.2 MINIMUM DETECTABLE ACTIVITY

The minimum detectable activity (MDA), or the smallest amount of activity distinguishable from background quantified at a given confidence level (typically 95%), can be calculated as follows:

$$MDA = \frac{2.71 + 3.29\sqrt{R_b t_s [1 + \frac{t_s}{t_b}]}}{t_s e_i}$$

where:

MDA = minimum detectable activity in disintegrations/minute/100 cm^2.

R_b = background count rate in cpm.

t_s = sample counting time in minutes.

t_b = background counting time in minutes.

e_i = instrument efficiency (counts/disintegration).

Environmental
Standard Operating Procedure

SOP No. 009
Operational Checkout of
Single Detector with Meter

Tetra Tech, Inc.

Environmental Restoration Group, Inc.

ERG

February 2018

CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for the operational checkout, or "function check" of a single-channel detector and meter set to ensure its proper working order.

A radiological survey detector (detector) is used with a compatible radiological survey meter (meter) to measure radiation in integrated scaler count and/or ratemeter modes. This standard operating procedure (SOP) is specific to single-channel detectors compatible for use with a meter. In some cases, the detector and meter maybe contained in a single housing. During the operational check-out process (function check) the detector also is inspected for any physical damage that might affect functionality, such as a cracked housing. Calibration of any survey detector is required prior to initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect instrument operation.

To function check a radiological survey detector the Instrument Technician must show proficiency on the detector, the accompanying meter, and be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 EQUIPMENT AND MATERIALS

The following equipment is required to function check a radiological survey detector:

- Radiological survey detector – Ludlum Model 44-10 detector, Ludlum Model 19, Ludlum Model 43-5, Ludlum Model 44-9, or similar.
- Calibrated meter – Ludlum Model 12, Ludlum Model 2221, Ludlum Model 2241, or similar.
- Radiological check sources with known activity and emission rate. Use a thorium 230 (Th-230) source for typical alpha detector calibration. Use a technetium 99 (Tc-99) or strontium-yttrium 90 (Sr/Y-90) source for typical beta detector calibration. Use a cesium 137 (Cs-137) or americium 241 (Am-241) source or for typical function check of a high-energy gamma detector or low-energy gamma detector such as a FIDLER, respectively. Check sources used depend on the goal of the survey. While the sources listed above are for typical function checks, they are not definitive. NOTE: Select check sources that will provide a minimum accumulation of 1,000 gross counts during the counting interval, typically one minute.
- Calibration jig – used to ensure consistent detector position relative to check source.
- Single-Channel Function Check Log – A function check log form must be created and maintained for each individual meter and detector combination. The detector combination should be function checked, and the function check log form updated, before and after each day of use. The function check log form must be protected and retained per the ERG Document Retention Schedule.

3.0 PROCEDURE

The following procedures will be used to function check a radiological survey detector.

If not already done, fill in the meter, detector, source, and comments information on the function check log form.

- PHYSICAL INSPECTION – Check the meter, detector, and cable for any visible damage. If damage is present then repair, or tag and remove from service.
- TURN ON – Connect the detector and meter using the C-cable, then turn the instrument power on.
- BATT CHECK – Turn the instrument to the BATT position. Note condition of battery as indicated by display. If the battery power is marginal (as indicated by the needle below the BATT OK level on analog meter face, below 4.4 on Ludlum Model 2221, or when battery indicator appears on Ludlum Model 2241), replace the batteries. If battery power is acceptable then indicate on the function check log form with a check mark in the Battery Condition box.
- HV CHECK – Toggle the RESET/TEST HV switch or press the HV button and check the meter high voltage (HV). If the HV is within ± 25V of the recommended operating HV as found on the detector calibration paperwork and calibration sticker, then record on the function check log form. If not, then adjust accordingly or tag and remove from service.
- BACKGROUND COUNT – Place the detector in proper orientation and position onto a clean calibration jig. If using a scaler meter begin a count. If using a ratemeter let value stabilize. Upon completion, record the background counts onto the function check log form. If the results are not in project-specific tolerances, then readjust the detector to calibration jig and repeat the count. If the second count is also out of tolerances, then remove detector from service and notify/consult with the Project Instrument Manager (if applicable) and/or Project Manager.
- SOURCE COUNT – Place the source on to calibration jig and place the detector in proper orientation and position over the source. If using a scaler meter begin a count. If using a ratemeter let value stabilize. Upon completion, record the source counts onto the function check log form. If the results are not within project-specific tolerances, then confirm you are using the correct detector to calibration jig geometry and repeat the count. If the second count is also out of tolerances, then remove detector from service until issue can be resolved and notify/consult with the Project Instrument Manager (if applicable) and/or Project Manager.
- The individual performing the function check should record their initials in the appropriate box on the function check form upon completion of the function check.