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New Mexico Environment Department
Attn: Mr. John Kieling, Chief
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2905 Rodeo Park Drive East, Building 1
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Re: **Final SS-039 Missile Fuel Spill Area Resource Conservation and Recovery Act Facility Investigation and Groundwater Monitoring Work Plan**
Holloman Air Force Base, Alamogordo, NM
Contract No. FA8903-13-C-0008

Dear Mr. Kieling,

Attached is the *Final SS-039 Missile Fuel Spill Area Resource Conservation and Recovery Act Facility Investigation and Groundwater Monitoring Work Plan* for your review and comment. Included with the hardcopy of the report is a CD that contains native and PDF files of the subject document.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

If you have any questions regarding this submittal, please contact me at (575) 572-6675 or by email at adam.kusmak@us.af.mil.

Sincerely,

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Attachment(s):

Final SS-039 Missile Fuel Spill Area Resource Conservation and Recovery Act Facility Investigation and Groundwater Monitoring Work Plan. Hard copy and CD.

cc: Mr. Dave Strasser, NMED HWB (w/Atch)
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HOLLOMAN AIR FORCE BASE
NEW MEXICO

FINAL SS-039 – MISSILE FUEL SPILL AREA RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION AND GROUNDWATER MONITORING WORK PLAN

June 2016

49 CES/CEI
550 Tabosa Avenue
Holloman AFB, New Mexico 88330-8458

HOLLOMAN AIR FORCE BASE, NEW MEXICO

SS-039 – MISSILE FUEL SPILL AREA

RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION AND GROUNDWATER MONITORING WORK PLAN

June 2016

Prepared for

Department of the Air Force, 772nd ESS/PKB
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Contract FA8903-13-C-0008

Submitted by

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NOTICE

This Resource Conservation and Recovery Act Facility Investigation and Groundwater Monitoring Work Plan was prepared for the Air Force Civil Engineer Center by URS Group, Inc in association with FPM Remediations, Inc. to aid in the implementation of a final remedial action plan under the Installation Restoration Program. As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the Installation Restoration Program, along with the evolving knowledge of Site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate.

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14. ABSTRACT
This Resource Conservation and Recovery Act Facility Investigation and Groundwater MonitoringWork Plan specifies the activities that will be performed in support of the site investigation activities to be conducted at Site SS-039 - Missile Fuel Spill Area, Holloman Air Force Base, New Mexico. The purpose of this plan is to provide guidance for the borehole installation/sampling and groundwater monitoring well sampling to be performed at the site. The additional data gathered as a result of this investigation are required to support refinement of the nature and extent of groundwater contamination underlying the site.

15. SUBJECT TERMS
Site SS-039, groundwater monitoring, soil sampling,volatile organic compounds, trichloroethene, perchlorate, nitrate, total dissolved solids

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PREFACE

This Resource Conservation and Recovery Act Facility Investigation and Groundwater Monitoring Work Plan addresses the activities that will be performed in support of investigation of the extent of contamination associated with the groundwater underlying the SS-039 Missile Fuel Spill Area at Holloman Air Force Base, New Mexico. The primary activities that will be performed include continued monitoring of groundwater wells installed in the area and further evaluation of the vadose zone to aid in evaluation of constituent impacts on underlying groundwater, as well as assessment of potential impacts with regard to vapor intrusion in adjacent buildings. Groundwater monitoring will continue to be performed on a semi-annual basis in accordance with requirements specified herein.

This work will be performed under the authority of the requirements of the Air Force Civil Engineer Center Contract No. FA8903-13-C-0008. This program is conducted under the Holloman AFB Installation Restoration Section Chief, Ms. DeAnna Rothhaupt. URS Group, Inc., as a subcontractor to FPM Remediations, Inc., has prepared this Resource Conservation and Recovery Act Facility Investigation and Groundwater Monitoring Work Plan as defined in the Performance-Based Remediation Contract for Cannon, Holloman, and Kirtland Air Force Bases located in New Mexico, and Luke Air Force Base located in Arizona. Mr. Steven Geiger is the URS Group, Inc. Installation Manager for Installation Restoration Project Sites at Holloman Air Force Base.

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
CFR	Code of Federal Regulations
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
HASP	health and safety plan
HWA	Hazardous Waste Act
HWB	Hazardous Waste Bureau
IDW	investigation-derived waste
IRP	Installation Restoration Program
JP-4	jet fuel
MCL	Maximum Contaminant Level
µg/L	microgram per liter
mg/kg	milligram per kilogram
mg/L	milligram per liter
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMSA	New Mexico State Rules Act
NMGWQS	New Mexico Ground Water Quality Standard
NMWQCC	New Mexico Water Quality Control Commission
QAPP	Quality Assurance Project Plan
Radian	Radian Corporation
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SSL	soil screening level
SWMU	Solid Waste Management Unit
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethene
TDS	total dissolved solids
UDMH	unsymmetrical dimethylhydrazine
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
VOC	volatile organic compound

1.0 INTRODUCTION

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Groundwater Monitoring Work Plan addresses the activities that will be performed in support of the refinement of the nature and extent of contamination at the Spill Site #39 (SS-039) Missile Fuel Spill Area at Holloman Air Force Base (AFB), New Mexico, hereinafter referred to as the Site. The Site location is shown in Figure 1. This plan was prepared in accordance with the requirements of the Air Force Civil Engineer Center (AFCEC) Contract No. FA8903-13-C-0008. URS Group, Inc. (URS), as a subcontractor to FPM Remediations, Inc. has prepared this Work Plan in accordance with the Performance-Based Remediation Contract for Cannon, Holloman, and Kirtland AFBs located in New Mexico, and Luke AFB located in Arizona.

Evaluation of the Site is limited to impacts to the groundwater; therefore, any sampling and analysis of soils associated with the Site is being performed with regard to potential impacts of constituents on the groundwater. This plan describes the additional sampling and groundwater monitoring requirements to further characterize and evaluate the site for potential future actions.

Groundwater monitoring at SS-039 will be performed on a biannual basis with one event occurring in mid-Summer (e.g., July) and the second event occurring in mid-Winter (e.g., January) as required by the New Mexico Environment Department (NMED). A total of 14 wells will be sampled and analyzed for volatile organic compounds (VOCs), total metals, dissolved metals, nitrate/nitrite, perchlorate, and total dissolved solids (TDS).

In addition, soil vapor sampling will be performed immediately adjacent to Building 1176 which overlies the impacted groundwater associated with SS-039 to aid in evaluation of potential vapor intrusion impacts on occasional site workers who occupy the building and work in the immediate vicinity. Three vapor monitoring points will be installed along the south side of the building closest to the source and one point along each of the other three sides. The vapor monitoring points will be sampled for VOCs and abandoned.

1.1 Purpose and Scope

The purpose of this investigation is to refine the understanding of the nature and extent of constituent impacts on groundwater underlying the Site. This plan provides the strategy to:

- Evaluate the impacts of and nature and extent of the trichloroethene (TCE), perchlorate, and nitrate in the groundwater underlying the Site SS-039;
- Evaluate the Site for other constituents that may pose an unacceptable risk and provide data to support development of a final corrective action, if needed, to address potential impacts to groundwater underlying the Site;
- Maintain compliance with all decision documents and plans, currently in place or to be approved, until associated activities are no longer required or an alternate approach is approved; and
- Improve the understanding of the conceptual site model and constituent sources to support future actions.

This overall approach may be modified as additional data are generated during the investigation outlined herein. Groundwater monitoring activities may be revised to reflect changes in the monitoring scope or

schedule. Any revision to the approach will be initially discussed with the U.S. Air Force and the scope agreed upon with concurrence of the NMED prior to implementation.

Ultimately, the information generated during this investigation will support the determination as to whether the impacts to groundwater associated with the Site SS-039 require active remediation, long-term monitoring, or no action at all. The evaluation of the data collected during the described groundwater monitoring and site evaluation activities will support the development of the corrective measures necessary to address the constituent impacts to the groundwater should it be determined that they indeed pose an unacceptable risk to human health and the environment.

1.2 Regulatory Setting

Pursuant to the RCRA permit, Installation Restoration Program (IRP) activities conducted at Holloman AFB are performed under the New Mexico Hazardous Waste Act (HWA), the New Mexico Hazardous Waste Management Regulations, and RCRA. The NMED Hazardous Waste Bureau (HWB) has regulatory enforcement authority for the State of New Mexico.

The media of concern for the Site includes subsurface soil and groundwater underlying the Site. Pursuant to the RCRA permit and with guidance provided by NMED, cleanup levels for impacted groundwater will be in accordance with the latest revision of NMED and U.S. Environmental Protection Agency (EPA) regulations at the time of Work Plan approval and/or execution of the fieldwork. Currently, these levels include the residential soil screening levels (SSLs) presented in the following:

- New Mexico Environment Department Risk Assessment Guidance for Site Investigations and Remediation. NMED soil screening levels for residential soil; and
- EPA Regional Screening Levels for Residential Soil available online at https://www.epa.gov/risk/regional-screening-levels-rsls.

For groundwater, the applicable action levels are available in the following:

- New Mexico Water Quality Control Commission (NMWQCC) Regulations (New Mexico Administrative Code [NMAC] 20.6.2);
- Applicable federal standards include EPA maximum contaminant levels (MCLs) as found in 40 Code of Federal Regulations (CFR) 141 and 40 CFR 142;
- New Mexico Ground Water Quality Bureau Voluntary Remediation Program limits for tapwater as found in the *Technical Background Document for Development of Soil Screening Levels* (NMED, 2006); and
- EPA Regional Screening Levels for Tapwater available online at https://www.epa.gov/risk/regional-screening-levels-rsls

Additionally, the RCRA permit requires groundwater cleanup levels to be set at the more conservative of those specified by either the NMWQCC as protective of human health or by EPA's MCLs.

Given that the organic impacted groundwater comprising SS-039 underlies Building 1176 (see Figure 2) which is occasionally used in support of base operations, the vapor intrusion pathway requires investigation. Vapor concentrations will be evaluated in accordance with the "Office of Solid Waste and Emergency Response Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)" (EPA, 2002) and the *Risk Assessment*

Guidance for Site Investigation and Remediation (NMED, 2014) and compared to the action levels provided in the following:

- EPA Regional Screening Levels for Industrial Air available online at https://www.epa.gov/risk/regional-screening-levels-rsls; and
- NMED Vapor Intrusion Screening Levels available online at http://www.nmenv.state.nm.us/HWB/documents/RA_Guidance_for_SI_and_Remediation_12-24-2014.pdf.

1.3 Work Plan Organization

This Work Plan is divided into the following six sections:

- Section 1 – Introduction;
- Section 2 – Background and history;
- Section 3 – Procedures for implementation;
- Section 4 – Reporting;
- Section 5 – Project schedule; and
- Section 6 – References.

2.0 BACKGROUND AND HISTORY

The Missile Fuel Spill Area, Site SS-039, comprises four solid waste management units (SWMUs) (165, 177, 179, and 181) that are listed in Table A of the Holloman AFB Hazardous Waste Facility Permit. Table A of the permit includes those sites requiring further corrective action. Site SS-039 is located in the central portion of Holloman AFB along the northern slope of the Lost River Basin (see Figure 1). The area consists of the Test Sled Launch Area Collection Basin, the Propellant Spill Drain Discharge Box, the Building 1176 Drainage System, and the Former Utilized Rocket Engine Storage Area. These facilities are spread out over an area of approximately 10 acres. The SWMUs 165, 177, 179, and 181 consist of the Building 1176 pond, Building 1176 drainage sumps, the discharge box, and the two 1-foot wide drainage troughs, respectively. Previous reports indicate that SWMU 165 is located between Building 1176 and the Lost River; however, no evidence of the pond was found at the reported location or at any location in the vicinity of Building 1176.

Historically, spilled oxidizers and fuels were delivered to separate drains, diluted with water, and flushed into the Lost River Basin. In 1975, catch basins were installed to collect the spilled liquid fuels. Since 1975, no propellants have been intentionally released to the open drains. Waste propellants are currently collected, treated, and disposed of in the treatment system located in Building 1176. Throughout the history of the test track, fuels have included jet fuel (JP-4), unsymmetrical dimethylhydrazine (UDMH), aniline, inhibited red fuming nitric acid, liquid oxygen, JPX (JP-4 and UDMH), dyes, solid rocket propellants, and other compounds. In addition, TCE was commonly used for sled maintenance in Building 1176.

Previous investigations of the SS-39 Site have included a Phase I remedial investigation in 1991, a Phase II RFI in 1993, a Supplemental Groundwater Investigation in 1998, long-term groundwater monitoring, and Supplemental RFI activities in 2006.

The Phase I investigation (Radian Corporation [Radian], 1992) included the sampling of two soil borings at two depth intervals each, collection of five soil samples (0 to 2 feet) via hand augering, and the installation and sampling of four groundwater monitoring wells. Arsenic, lead, TCE, tetrachloroethene, and total petroleum hydrocarbons exceeded the applicable SSLs. Soil results are provided in Table 1. Groundwater analytes which exceeded the EPA MCLs for drinking water consisted of cadmium, 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene, carbon tetrachloride, TCE, and nitrate/nitrite.

The Phase II RFI (Radian, 1994) provided for the collection of samples from an additional 15 soil borings with groundwater samples collected from the groundwater encountered at the bottom of the borings prior to abandonment. Soil samples were analyzed for metals (barium, cadmium, chromium, lead, and silver) and selected samples for polynuclear aromatic hydrocarbons by SW-846 Method 8270. None of the analytes exceeded risk-based levels. Soil analytical results are provided in Tables 2, 3, and 4 as extracted from the RFI report. For soil, benzo(a)anthracene exceeded the residential SSL. Groundwater samples exceeding the MCLs consisted of 1,1,1-TCA, TCE, vinyl chloride with 1,1-dichloroethane included in the New Mexico Ground Water Quality Standard (NMGWQS).

As discussed in the Supplemental RCRA Facility Investigation, DP-30/SD-33 (SWMU 113), SS-39 (SWMUs 165, 177, 179, and 181), and SD-27 (SWMU 141), Holloman Air Force Base, Alamogordo, New Mexico (HydroGeoLogic, Inc., 2007), the 2006 Supplemental RFI provided for the collection of sediments, additional borehole samples, and installation of four permanent wells and five pre-pack temporary wells. Of the sediments, only lead exceeded SSLs for the residential, industrial, and construction worker (see Table 5). Of the soil samples, arsenic, barium, cadmium, chromium, and lead exceeded the residential SSLs (see Table 6). Groundwater samples were collected and submitted for analysis of VOCs, total and dissolved metals, perchlorate and TDS. The TCE, arsenic, and lead results

exceeded MCLs for certain wells. Perchlorate concentrations ranged from 12 micrograms per liter (µg/L) to 130 µg/L with TDS ranging from 15,700 milligrams per liter (mg/L) to 141,000 mg/L.

2.1 Groundwater Impacts

The 1998 Supplemental Groundwater Investigation (GTI, 1998) provided for the collection of samples from 16 temporary locations with TCE exceeding MCLs at 7 of the 16 locations. Long-term monitoring documented the presence of TCE in the groundwater with occasional minor detections of other organic compounds. The monitoring confirmed the high TDS that were prevalent in these wells, and perhaps more importantly, the presence of perchlorates with a maximum concentration of 220 µg/L as compared to the NMGWQS of 24.5 µg/L.

The primary concern for groundwater was the continuing presence of TCE at concentrations ranging from non-detect to 470 µg/L, as compared to the MCL of 5 µg/L and perchlorates as discussed above. The perchlorate concentrations were highest within the Lost River drainage basin and decreased in groundwater samples collected upslope. The source of TCE impacts has been confirmed to be associated with SWMU 177 soils (the drainage sumps). The 2006 Supplemental RFI recommended removal of the sumps and impacted soils to mitigate the contribution of surface sources to groundwater impacts. It further recommended continued monitoring for TCE only and maintained that additional monitoring for perchlorate is not warranted because its presence could not be attributed to the Site. Removal of the sumps and impacted soils has not taken place. Groundwater monitoring of the site will be continued as required by NMED. Arguably, the continued monitoring for perchlorate is warranted given the elevated concentrations present in wells associated with the Site.

Additionally, the Final Nitrate Characterization Study Work Plan, Holloman Air Force Base, New Mexico (U.S. Army Corps of Engineers [USACE], 2012) was prepared to conduct a base-wide background investigation of nitrate concentrations in groundwater and soil to establish reliable background levels. The study work plan also provided for a nitrate source area investigation at various sites at Holloman AFB (including SS-039) where nitrate is a suspected groundwater contaminant.

As documented in the Final Nitrate Characterization Study Report – Holloman Air Force Base, New Mexico (USACE, 2014), 11 soil samples (including two duplicates) were collected from three soil borings drilled at the Site SS-039 on June 24, 2013. The samples were analyzed for nitrate, nitrite, ammonia, and total Kjeldahl nitrogen. The nitrate concentrations ranged from 2.5 milligrams per kilogram (mg/kg) to 110 mg/kg. Ammonia was detected in nine samples with concentrations ranging from 0.37 mg/kg to 3.3 mg/kg. The total Kjeldahl nitrogen results for the seven samples with detections ranged from 40 mg/kg to 450 mg/kg. Nitrite was non-detect in all soil samples.

Groundwater samples were collected from 13 of the 14 groundwater monitoring wells in June 2013, including two new wells (NSA39-MW01 and NSA39-MW02) and analyzed for nitrate, nitrite, ammonia, and total Kjeldahl nitrogen. The nitrate concentrations ranged from 38 mg/L to 250 mg/L. Nitrite was detected in one groundwater sample at a concentration of 0.013 mg/L. Ammonia was detected in 9 of the 13 groundwater samples at concentrations ranging from 0.05 mg/L to 1.2 mg/L. The total Kjeldahl nitrogen results ranged from 0.23 mg/L to 20 mg/L.

Primary constituents impacting groundwater include chlorinated VOCs (most notably TCE), perchlorate, and nitrate. Figures 3, 4, and 5 provide iso-concentration maps for TCE, perchlorate, and nitrate, respectively, based on the most recent groundwater monitoring data collected in January 2016. Figure 6 provides a groundwater contour map showing the primary flow direction to be in a southerly to southwesterly direction. TDS exceeds 10,000 mg/L precluding the groundwater from consideration as a potable drinking water source. The most recent groundwater sampling event at Site SS-039 took place in

January 2016. Samples were collected from 11 of the 14 permanent monitoring wells installed in the vicinity of SS-039. Table 7 presents a summary of the chlorinated VOCs, perchlorate, nitrate, and TDS data from that event. Two of the permanent monitoring wells (MW39-03 and MW39-04) could not be sampled because the wells were compromised with one having a blockage and the other appearing to have a well screen that has failed. Efforts will be undertaken to rehabilitate these two wells. A third permanent monitoring well (NSA39-MW01) was not sampled because it was not originally identified in the sampling documentation. It will be included in future monitoring events.

2.2 Conceptual Site Model

Existing site-specific and regional data were used to develop a preliminary conceptual site model for SS-039. Site SS-039 is located in the central portion of Holloman AFB along the northern slope of the Lost River Basin. Groundwater is encountered approximately between 7 and 25 feet below ground surface and generally flows in a southerly direction toward the Lost River Basin.

SS-039 is primarily undeveloped and moderately vegetated with salt cedars, shrubs, and grasses. The area immediately north of the site is relatively flat and heavily improved with the construction of Building 1176 and two asphalt paved vehicle lots east and west of the building. This portion of the site is the only section that has been improved with site features. Although relatively flat, an overall area-wide southerly dip is present towards the Lost River. The area immediately south of Building 1176 represents the only other developed portion of SS-039. Two concrete-lined, 1-foot wide drainage troughs (SWMU 181) extend south-southeast and southwestward from the southern corners of the building. Each trough discharged to separate sumps (SWMU 177) as shown in Figure 2. These sumps received discharges from the building and occasionally overflowed releasing wash water containing residual fuel components composed of both perchlorate and nitrate-based propellants to the surrounding soil. In addition, solvents such as TCE were commonly used for sled maintenance in Building 1176 and may have been discharged as well. Historic evaluation of soil adjacent to the sumps indicates that TCE in these soils is the primary contributor to TCE impacts on groundwater in the area.

The following sections describe the geology and hydrogeology of Holloman AFB.

2.2.1 Physiography and Topography

Holloman AFB is located within the Basin and Range physiographic province in the Sacramento Section on the western edge of the Sacramento Mountains at a mean elevation of 4,093 feet above mean sea level (New Mexico Bureau of Geology and Mineral Resources, 2003). The region is characterized by high tablelands with rolling summit plains, cuesta-formed mountains dipping eastward, and west-facing escarpments with the wide bracketed basin forming the basin and range complex. Holloman AFB is within the Tularosa Basin, which is part of the Central Closed Basins (NMED, 2004). The bordering mountains rise abruptly to altitudes of 7,000 to 12,000 feet above mean sea level. The basin is bound by the San Andres Mountains approximately 30 miles to the west and the Sacramento Mountains approximately 10 miles to the east. At its widest, the basin is approximately 60 miles east to west and stretches approximately 150 miles north to south.

2.2.2 Climate

As a whole, New Mexico has a mild, arid to semiarid continental climate characterized by light precipitation totals, abundant sunshine, relatively low humidity, and relatively large annual and diurnal temperature ranges (Western Regional Climate Center, 2013). The climate of the Central Closed Basins varies with elevation. The Base is located in the lower elevation areas, characterized by warm temperatures and dry air. Daytime temperatures often exceed 100 degrees Fahrenheit (°F) in the summer

months and are in the middle 50-degree range in the winter. A preponderance of clear skies and relatively low humidity permits rapid cooling resulting in average diurnal temperature ranges of 25° to 35°F.

Potential evapotranspiration, at 73 inches per year, significantly exceeds annual precipitation, usually less than 10 inches. Arid conditions resulting from very low rainfall amounts, coupled with topographically induced wind patterns and combined with sparse vegetation, tend to cause localized "dust devils." The annual rainfall for Alamogordo is 12 inches per year. Much of the precipitation falls during the mid-summer monsoonal period (July and August) from brief, yet frequent, intense thunderstorms culminating in 30 to 40 percent of the total annual rainfall (Western Regional Climate Center, 2013).

2.2.3 Regional Geology

The sedimentary rocks, which make up the adjacent mountain ranges, are between 500 and 250 million years old (Weir, Jr., 1965). During the period when the area was submerged beneath the shallow intracontinental sea, the layers of limestone, shale, gypsum, and sandstone were deposited. In time, these layers were pushed upward through various tectonic forces, forming a large bulge on the surface. Approximately 10 million years ago, the center began to subside, resulting in a vertical drop of thousands of feet leaving the edges still standing (the present-day Sacramento and San Andres mountain ranges). In the millions of years following, rainfall, snowmelt, and wind eroded the mountain sediments, depositing them in the valley (i.e., Tularosa Basin). Water carrying eroded limestone, dolomite, gravel, and other materials continued to flow into the basin.

As the Tularosa Basin is a bolson-type basin, which is a basin with no surface drainage outlet, sediments carried by surface water into a closed basin are bolson deposits. The overlying alluvium generally consists of unconsolidated gravels, sands, and clays. Soils in the basin are derived from the adjacent ranges as erosional deposits of limestone, dolomite, and gypsum. A fining sequence from the ranges towards the basin's center characterizes the area with the near surface soils being alluvial, eolian, and lacustrine deposits. The alluvial fan deposits are laterally discontinuous units of interbedded sand, silt, and clay, while the eolian deposits consist primarily of gypsum sands. The eolian and alluvial deposits are usually indistinguishable due to the reworking of the alluvial sediment by eolian processes. The playa, or lacustrine deposits, consist of clay containing gypsum and are contiguous with the alluvial fan and eolian deposits throughout the Base. Stiff caliche layers, varying in thickness, have been identified at different areas of the Base.

2.2.4 Regional Soils

The United States Natural Resources Conservation Service (formerly Soil Conservation Service) has identified two soil associations in the vicinity of Holloman AFB—the Holloman-Gypsum Land-Yesum Complex and the Mead silty clay loam (Derr, 1981). The hydraulic conductivity of these horizons ranges from 4×10^{-4} to 1×10^{-3} centimeters per second. The Holloman-Gypsum Land-Yesum Complex (0 to 5 percent slopes) consists of larger areas of shallow and deep, well-drained soils and areas of exposed gypsum. The Holloman soil makes up about 35 percent of the complex. Typically, the surface layer is light brown, very fine sandy loam approximately 3 inches thick. The upper 13 inches of the substratum is pink, very fine sandy loam that is very high in gypsum. Below that, the substratum is white gypsum to a depth of more than 60 inches. This soil is calcareous and mildly to moderately alkaline throughout. Permeability is moderate, and available water capacity is very low.

Gypsum Land makes up approximately 30 percent of the Holloman-Gypsum Land-Yesum Complex (0 to 5 percent slopes). Typically less than 1 inch of very fine sandy loam overlies soft to hard, white gypsum. The deeper Yesum horizon consists of very fine sandy loam that makes up approximately 20 percent of the complex. Typically, the surface layer is light brown, very fine sandy loam approximately 3 inches

thick. The upper 9 inches of the substratum is light brown, fine sandy loam that is very high in gypsum. Below that, the substratum is pink, very fine sandy loam to a depth of more than 60 inches. The soil is calcareous throughout and is mildly alkaline. Permeability is moderate, and available water capacity is moderate. Many fine gypsum crystals are found throughout the profile.

The soil type found across the main drainage area for the Base is Mead silty clay loam (0 to 1 percent slopes). This deep, poorly drained, nearly level soil occurs on outer fringes of alluvial fans. This soil formed in fine-textured alluvium over lacustrine lake sediment. It is very high in salt content because of periodic flooding and poor drainage. Slopes are smooth and concave. Typically, the surface layer is reddish-brown, silty clay loam and clay loam approximately 5 inches thick. The substratum, to a depth of 48 inches, is light reddish-brown clay that has a high salt content. Below that, the substratum is lacustrine material of variable texture and color to a depth of more than 60 inches. Included within this soil are areas of Holloman soils and Gypsum Land along the margins of the unit of steep, short gully sides and knolls.

Inclusions make up approximately 15 percent of the map unit for this soil type. Individual areas are generally smaller than 10 acres. This soil is moderately calcareous throughout and is moderately to strongly alkaline. It has a layer of salt that is more soluble than gypsum. Permeability is very low, and available water capacity is low (URS, 2009).

2.2.5 Regional Hydrogeology

Groundwater occurs as an unconfined aquifer in the unconsolidated deposits of the central basin, with the primary source of recharge as rainfall percolation and minor amounts of stream runoff along the western edge of the Sacramento Mountains (Basabilvazo et al, 1994). Surface water/rainfall migrates downward into the alluvial sediments at the edge of the shallow aquifer near the ranges and flows downgradient through progressively finer-grained sediments towards the central basin. Because the Tularosa Basin is a closed system, water that enters the area leaves either through evaporation or percolation. This elevated amount of percolation results in a fairly high water table.

Beneath Holloman AFB, groundwater ranges from 5 to 50 feet bgs. Flow for the Base is generally towards the southwest with localized influences from variations in topography. In the northern and western portions of the Base, groundwater flows more to the west towards the Ritas Draw, Malone Draw, and Lost River drainages. Groundwater flow is affected by local topography in areas immediately adjacent to arroyos, where groundwater flows directly toward the drainages regardless of the regional flow pattern.

Groundwater in the Tularosa Basin is of potable quality at the recharge areas in close proximity to the Sacramento Mountains and becomes increasingly mineralized toward the central portion of the basin and discharge areas. The majority (over 70 percent) of the IRP sites located across Holloman AFB have groundwater monitoring wells containing water with an average TDS concentration greater than 10,000 mg/L (Basabilvazo et al, 1994). These TDS data support the hypothesis that TDS concentrations below 10,000 mg/L at Holloman AFB are caused by dilution of natural groundwater quality from leaking water lines and surface irrigation from the domestic water supply. TDS concentrations greater than 10,000 mg/L exceed the NMWQCC limit for potable water, and therefore, the groundwater beneath Holloman AFB has been designated as unfit for human consumption. Likewise, the EPA guidelines have identified the groundwater as a Class IIIB water source, characterized by TDS concentrations exceeding 10,000 mg/L and a low degree of interconnection with adjacent surface water or groundwater of a higher class. Groundwater at Holloman AFB does not discharge or connect to any adjacent aquifers because the Tularosa Basin is a closed basin. Adjacent surface waters include Lost River and Lake Holloman, which also have high concentrations of TDS and are not considered potential drinking water sources.

2.2.6 Regional Surface Water Hydrology

The Tularosa Basin contains all of the surface flow in its boundaries (NMWQCC, 2006). The nearest inflow of surface waters to the Base comes from the Lost River, located in the north central region of the Base. The upper reaches of the Three Rivers and Sacramento River are perennial in the basin. Holloman AFB is dissected by several southwest-trending arroyos that control surface drainage. Hay Draw arroyo is located in the far north. Malone and Ritas draws, which drain into the Lost River and Dillard Draw arroyos, are located along the eastern perimeter of the Base. Indications are that the climate was much wetter approximately 10,000 years ago.

The present-day Lake Otero formerly encompassed a much larger area, possibly upwards of several hundred square miles. Its remains include the Alkali Flat and Lake Lucero. Lake Lucero is a temporary feature merely a few inches deep during the rainy season. Ancient lakes and streams deposited water-bearing deposits over older bedrock basement materials. Fractures, cracks, and fissures in the Permian and Pennsylvanian bedrock yield small quantities of relatively good quality water in the deeper periphery. Potable water is only found in wells near the edges of the basin with more saline water found towards the center. Two of the principal sources of potable water are a long narrow area on the upslope sides of Tularosa and Alamogordo and another area in the far southwestern part of the basin. A portion of the city of Alamogordo's water, as well as the Holloman AFB's water, was formerly supplied from Bonito Lake (which is in the Pecos River Basin) prior to the Little Bear Fire, in 2012.

2.2.7 Current and Future Land and Water Use

The land surrounding Holloman AFB consists of residential areas to the east and northeast (city of Alamogordo), rangeland to the south, White Sands National Monument to the west, and areas where military activities are conducted to the north. The desert terrain immediately surrounding Holloman AFB has limited development, Mesa Verde Ranch operates along the eastern border, and there are no residential communities, or large industrial operations located adjacent to the Base. Holloman AFB is an active military installation and is expected to remain active for the foreseeable future. No transfer of military property to the public is anticipated, and public access to the Base is restricted (Foster Wheeler, 2002). Future land use is not expected to differ significantly from current land use practices (Foster Wheeler, 2002). Operations in the vicinity of the Site SS-039 are anticipated to remain the same as currently taking place.

Currently, there are no potable supplies of groundwater or surface water located on the Base (Foster Wheeler, 2002). Holloman AFB obtains its water supply from the city of Alamogordo and Holloman AFB wells in the Boles, San Andres, and Douglas well fields at the base of the Sacramento Mountains. No water supply wells are located on or near the Base due to poor groundwater quality with TDS concentrations greater than 10,000 mg/L. There are no potable or irrigation wells near or immediately downgradient of the Base.

Historical activities within and adjacent to SS-039 have included the fueling, detanking, and routine maintenance of test sleds. Spilled oxidizers and fuels were delivered to separate drains, diluted with water, and flushed into the Lost River through drainage sumps connected into Building 1176 as shown in Figure 2. Impacted groundwater associated with SS-039 underlies Building 1176 which still sees occasional use in support of base operations, specifically activities at the test track facility.

2.2.8 Source of Contamination

As discussed in Section 2.0, the source of the groundwater impacts is attributed to past operations conducted at the facilities associated with Site SS-039. Direct discharges that impacted groundwater have

ceased; however, operations continue in the area that have the potential for releases that could adversely impact surrounding soils resulting in leaching of constituents to the shallow groundwater.

2.2.9 Fate and Transport and Potential Receptors

The primary constituents impacting groundwater associated with Site SS-039 include TCE, perchlorate, and nitrate. The TDS concentrations for the samples collected exceed the 10,000 mg/L screening level, thereby precluding the groundwater from consideration as a potable water source. Hence, the ingestion pathway is not considered to be viable.

The maximum TCE concentration obtained during the August 2015 sampling event was 95.2 µg/L as compared to a historic reported maximum concentration of 477 µg/L obtained from a field duplicate sample collected from monitoring well MW39-06D in January 2009. Historic data for this well have ranged from 276 µg/L in January 2012 to the 477 µg/L. It is possible that natural attenuation may be contributing to the decrease in TCE concentrations, but additional monitoring data are necessary to support such an assertion. Potential exposure pathways which may be present onsite include the following:

- Dermal contact with groundwater;
- Outdoor soil vapor inhalation resulting from vapor migration from the groundwater to the soil column; and
- Soil vapor inhalation due to vapor intrusion to indoor air in Building 1176, which is immediately adjacent to the Site and any other buildings currently in the vicinity or that may be built in the future.

Potential human receptors include military/civilian workers, potential future residents, and construction workers performing intrusive activities in the vicinity of the Site.

3.0 REQUIREMENTS FOR IMPLEMENTATION

This section includes general requirementss for implementing the RFI activities to be undertaken. Several supporting project-related plans have also been prepared as described in the following sections, including a Site-specific QAPP, a health and safety plan (HASP), and a groundwater monitoring plan.

The following specific tasks will be applied to the Site subject to investigation under this Work Plan:

- Pre-mobilization activities;
- Mobilization/Site setup;
- Monitoring well installation;
- Surveying;
- Monitoring well development;
- Groundwater monitoring; and
- Borehole installation.

3.1 Applicable Regulations and Standards

Federal and state regulations and standards that may be applicable to these activities consist of the following:

- Holloman AFB RCRA Permit No. NM6572124422, February 2004 (NMED, 2004);
- RCRA Permit No. NM6572124422 Modification, October 2009 (NMED, 2009);
- NMED residential SSLs;
- EPA residential RSLs;
- NMWQCC groundwater cleanup levels protective of human health (20.6.2.3103 NMAC);
- EPA MCLs;
- New Mexico HWA (New Mexico State Rules Act [NMSA] 1978, §74-4-1);
- New Mexico Hazardous Waste Management Regulations, (20.4.1.100 NMAC);
- RCRA, 40 CFR 260-268, Management of Hazardous Waste. In the event that investigation-derived waste (IDW) sampling and analysis indicate the presence of constituents of potential concern at concentrations rendering them hazardous, storage and disposal protocols will be followed in accordance with RCRA hazardous waste regulations, as adopted by NMED; and
- United States Department of Transportation 49 CFR 172, 173, and 178: Applies to packaging IDW for removal off Site and addresses hazard-class diamond labeling.

The latest revision of NMED and EPA documents at the time of Work Plan approval and/or execution of the field work will be used.

3.2 Pre-Mobilization Activities

Prior to mobilization of equipment, subcontracted services (e.g., drilling subcontractor, licensed surveyor, analytical laboratory) will be procured. All necessary permits (e.g., digging permits) will be initiated. All Site activities will be coordinated with appropriate Holloman AFB personnel.

Prior to initiating intrusive activities, a completed and approved Air Force Form 332 will be obtained for authorization of construction work at Holloman AFB. A request for locating underground utilities in the area will be submitted to the local one-call utility notification center, as applicable. Additionally, Air Force Form 103 will be submitted to request that the location of underground utilities be marked at the specified areas. Drilling locations will be identified with paint, flags, or stakes, as appropriate to the surface material. Utility clearance approvals will be completed by the appropriate Holloman AFB utility office (e.g., telephone, sewer, water, natural gas, etc.).

3.3 Mobilization Setup

Personnel, equipment, and resources necessary to implement this RFI Work Plan will be mobilized to the Site. Site setup will occur at the SS-039 Site. Warning signs and safety fencing may be used, where necessary, to indicate the danger of entering a work zone and to keep the work area clear of obstructions such as facility worker vehicles. Setup will also include establishing a location for material storage and other equipment staging areas.

3.4 Subsurface Evaluation

The primary focus of the RFI will be to evaluate the soils for the presence of nitrate and perchlorate that may be impacting groundwater underlying the Site. Previous investigations failed to adequately assess the nature and extent of both nitrate and perchlorate concentrations in the soil at Site SS-039 specifically citing that a need did not exist to evaluate perchlorate based on it not being used at the Site. This did not take into account the use of solid rocket motors at the Site, some of which used double-base solid propellant that consists of both nitrate- and perchlorate-containing compounds in the propellant formulation. Depending on the handling of these motors at the Site, the potential exists for impacts to the surrounding soil with the potential to leach vertically to the underlying groundwater. The RFI evaluation will aid in identifying potential sources of both nitrate and perchlorate impacts that may be affecting the groundwater underlying the Site and support development of a corrective measure to address the groundwater impacts should the need be identified.

3.5 Long-Term Groundwater Monitoring

The *Draft Groundwater Monitoring Plan, SS-039 – Missile Fuel Spill Area* (URS, 2016a) has been developed outlining the sampling requirements necessary for the on-going monitoring of the Site SS-039. Figure 2 shows the locations of the groundwater monitoring wells associated with Site SS-039. Table 8 provides construction details for the monitoring wells. Groundwater sampling will be conducted on a semi-annual basis for up to four years. The monitoring frequency and analytical suite may be modified based on technical recommendations from the URS project team and upon approval by AFCEC with concurrence from NMED. After four years, the frequency will be reduced to annual with approval of AFCEC and NMED. Water level measurements will be taken prior to well purging and sample collection during each sampling event. Samples will be collected and analyzed via the following analyses:

- VOCs by SW-846 Method 8260B
- Total metals by SW-846 Methods 6010B/6020/7470A

- Dissolved metals by SW-846 Method 6010B/6020/7470A
- Nitrate/Nitrite by EPA Method 353.2
- Perchlorate by SW-846 Method 6850
- TDS by Standard Method 2540C

3.5.1 Groundwater Level Measurements

Groundwater level measurements will be collected in accordance with the requirements delineated in A-1, "Measurement of Groundwater and Fluid Levels in Wells," provided in Appendix A. During the course of collecting water level measurements, observations of well conditions will be collected and recorded. Water level measurements will be collected from the 14 monitoring wells located at SS-039 at the time of sample collection. Static water levels and total well depth will be measured prior to purging activities.

3.5.2 Sample Collection Methods

Groundwater samples will be collected in accordance with the requirements delineated in A-2, "Monitoring Well Purging and Groundwater Sampling," provided in Appendix A. Each well will be purged and sampled in accordance with the A-2. During the purging of each well, field parameter data will be collected in accordance with A-3, "Measurement of Groundwater Field Parameters," also provided in Appendix A.

3.5.3 Equipment Decontamination

Non-dedicated sampling equipment will be decontaminated between sample locations following the procedures described in A-4, "Decontamination," provided in Appendix A. Dedicated sampling equipment will not require decontamination.

3.5.4 Sample Labels

Each sample will be labeled with a unique identifier and recorded in the field logbook (A-5, "Sample Identification, Management, and Handling" provided in Appendix A) as it is collected. The sample identification will be documented on the chain-of-custody form. Data pertinent to each sample such as sample identification, location, color, time, and date will be recorded on field data sheets. Each analytical sample will be assigned a unique number in the following format:

- Groundwater Sampling Location (i.e., MW39-01)
- Date sampled (MMDDYY)

Under this sample designation format, sample "MW39-01-072516" corresponds to a sample collected from monitoring well MW39-01 on July 25, 2016.

3.5.5 Chain-of-Custody

All samples will be accompanied by a chain-of-custody in accordance with A-5, "Sample Identification, Management, and Handling" provided in Appendix A. The chain-of-custody form will be completed by the field sampling technician collecting the sample and will accompany each sample cooler. Whenever a sample is transferred to another responsible party in an unsealed cooler, the receiving party must sign-off on the chain-of-custody form.

The original chain-of-custody form will accompany the samples to the laboratory with a copy retained by field staff, and a final copy will be returned with the analytical results.

3.6 Vapor Intrusion Evaluation

The vapor intrusion pathway will be evaluated in accordance with the "Office of Solid Waste and Emergency Response Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)" (EPA, 2002) and Section 2.5.2 of the *Risk Assessment Guidance for Site Investigation and Remediation* (NMED, 2014) and compared to the action levels provided in the following:

- EPA Regional Screening Levels for Industrial Air available online at https://www.epa.gov/risk/regional-screening-levels-rsls.
- NMED Vapor Intrusion Screening Levels available online at http://www.nmenv.state.nm.us/HWB/documents/RA_Guidance_for_SI_and_Remediation_12-24-2014.pdf.

The NMED Vapor Intrusion Screening Levels are provided in Table A-3 of the risk assessment guidance.

Evaluation will consist of comparison of groundwater analytical data to the Residential Groundwater screening levels specified in the table. In addition, three soil vapor monitoring points will be installed along the south side of Building 1176 closest to the TCE source and one along each of the other three sides of the building (see Figure 7). The soil vapor samples will be submitted for VOC analysis in accordance with Method TO-15.

Prior to mobilization of equipment, subcontracted services (e.g., drilling subcontractor, analytical laboratory) will be procured. All necessary permits (e.g., digging permits) will be initiated. All Site activities will be coordinated with appropriate Holloman AFB personnel.

Prior to initiating intrusive activities, a completed and approved Air Force Form 332 will be obtained for authorization of construction work at Holloman AFB. A request for locating underground utilities in the area will be submitted to the local one-call utility notification center, as applicable. Additionally, Air Force Form 103 will be submitted to request that the location of underground utilities be marked at the specified areas. Drilling locations will be identified with paint, flags, or stakes, as appropriate to the surface material. Utility clearance approvals will be completed by the appropriate Holloman AFB utility office (e.g., telephone, sewer, water, natural gas, etc.).

3.6.1 Soil Vapor Point Advancement

URS will subcontract with a qualified and New Mexico-licensed drilling contractor to advance the temporary soil vapor sampling points. Once the surface cover is removed, the 1.5-inch-diameter soil vapor sampling apparatus will be advanced to a depth of 5 feet bgs using direct-push technology and subsequently retracted 6 inches. The sampling apparatus will be equipped with a disposable tip that remains in place when the rod is retracted, opening a 6 inch gap at the total depth of the boring. Approximately 7 feet of 1/8-inch outside-diameter Nylaflow® tubing (0.079-inch inside-diameter) will be installed to the total depth of each sampling point and equipped with a shutoff valve at the surface to prevent contamination with ambient air. Each sampling point will then be sealed at the surface using hydrated bentonite paste to create a temporary soil vapor sampling point. Once constructed, all soil vapor points will be allowed to equilibrate for a minimum of 20 minutes prior to purging and collection of a soil vapor sample.

3.6.2 Soil Vapor Purging and Sampling

Prior to sample collection, each soil vapor point will be purged using a variable-flow electric pump. A minimum of three volumes of air will be purged from each vapor point based on the calculated volume of 174 milliliters (mL) for the open space created by retracting the sampling apparatus, and 5.6 ml for the internal volume of the Nylaflow® tubing based on manufacturer specifications. The total volume of "deadspace" is calculated to be 180 mL and the total purged volume to be 540 mL. Each sampling point will be purged at a rate of 100 milliliters per minute (mL/min) resulting in an estimated purge time of 5 minutes and 24 seconds prior to sample collection.

Immediately following purging, an evacuated 1-liter Summa® canister equipped with a 100 mL/min flow controller will be connected to the sample train, opened and allowed to capture soil vapor for a period of 10 minutes. A vacuum gauge on the canister will be used to record initial vacuum and final vacuum on the canister to verify that the canister has filled. To ensure the sample train is sealed, a leak detection compound, 1,1-diflouroethane (1,1-DFA), will be exposed to the system by saturating a cloth with 1,1-DFA and placing it next to the sample train. Once the sample is collected, the Summa® canister will be sealed, removed from the sampling train, labeled, and prepared for delivery to the laboratory for analysis of VOCs.

Prior to sample collection, an equipment blank will be collected by passing laboratory-supplied nitrogen gas through the sample collection tubing and into a 1-liter Summa® canister. An ambient air sample will also be collected adjacent to the f area at a location estimated to be the 'upwind' side of the site. For quality assurance/quality control (QA/QC) purposes, a duplicate sample will collected by attaching two 1-liter Summa® canisters to the sampling train to provide simultaneous collection of two soil vapor samples at one sampling location. A total of 15 vapor samples (12 field originals, one duplicate, an ambient air sample, and equipment blank) will be collected.

Soil vapor sampling record sheets (see Appendix B) will be completed for each sample collected.

3.6.3 Boring Closure

At the conclusion of sampling activities, all equipment, with the exception of the disposable tip, will be removed from the boring and the boring will be filled with hydrated bentonite chips. The disposable tip of the sampling assembly will be abandoned in place. The surface will be patched to match the existing area.

3.7 Quality Assurance Project Requirements

Environmental analyses are critical, because decision-making based on inaccurate measurements or data of unknown quality can have significant economic and health consequences. Data verification and validation will be performed to ensure data meet the project requirements. Method data validation is the process whereby analytical data are reviewed against set criteria to ensure that the results conform to the requirements of the analytical method and any other specified requirements. All laboratory-generated data will be validated in accordance with established criteria. The field-generated data will not be validated, but the quality of the field-generated data will be ensured through adherence to established operating procedures and use of equipment calibration and standardization, as appropriate.

Overall, both field and laboratory precision will be evaluated through the results of duplicate groundwater samples, equipment rinsates, and trip blanks. The duplicate samples and equipment rinsates will be analyzed for the same suite of analytes as the regular groundwater samples. Trip blanks to be analyzed for VOCs will be included in each cooler container VOC samples shipped to the analytical laboratory.

3.7.1 Duplicate Samples

Field duplicates are samples that are collected at the same time, from the same source, and at the same depth or sample location as the associated field sample. Field duplicates are submitted to the project laboratory as separate samples. The purpose of collecting field duplicates is to assess the consistency of the overall sampling effort, including collection, shipping, and analysis. The purpose of submitting them to the laboratory is to assess the consistency or precision of the laboratory's analytical system. One duplicate sample will be collected and analyzed for the same parameters as the groundwater samples to evaluate sampling and analytical precision. Field duplicates are collected at a frequency of 5 percent of the primary samples collected, with a minimum of one duplicate collected.

3.7.2 Equipment Blanks

Field equipment blanks are samples that are prepared in the field by pouring deionized water over decontaminated sampling equipment and collecting the water in laboratory provided sampling containers. The water is analyzed as a sample. The field equipment blank gives an indication of contamination from field procedures (e.g., improperly cleaned sampling equipment, cross-contamination). One equipment rinsate blank will be collected per 20 field samples during each annual groundwater monitoring event.

3.7.3 Trip Blanks

Trip blanks are used to evaluate if VOCs may have been introduced to the environmental samples during shipment, handling, or storage. Trip blanks are prepared by the laboratory, shipped to the project site, and then transported back to the laboratory with the field samples. Trip blanks will be analyzed for VOCs only. Trip blanks will be submitted and analyzed with each cooler containing VOC samples.

3.7.4 Data Validation/Verification

The laboratory will provide Level IV Quality Control laboratory data packages. All data packages will be evaluated for sample-specific parameters and the following laboratory performance parameters: tuning, initial calibration, continuing calibration verification and laboratory control sample recoveries, as applicable to the method. In addition, a minimum of 10% of samples collected per event will be evaluated for result recalculation and the raw data reviewed; to include data from each method performed.

3.7.5 Data Usability Assessment

The data usability assessment is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment is used to determine whether the project execution and resulting data meet the project objectives. Both the sampling and analytical activities must be considered, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made using the data. To this end, precision, accuracy, representativeness, comparability, and completeness will be determined for each sampling event.

Precision will be evaluated by measuring the agreement among individual measurements of the same property under similar conditions. Field precision is measured through the collection and analysis of field duplicate samples. Laboratory precision is measured through the analysis of laboratory duplicate control samples, matrix spike duplicates, or sample duplicates. Total precision is a measurement of the variability associated with the entire sampling and analytical process.

Accuracy reflects the total error associated with a measurement. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within

acceptable limits. Analytical accuracy will be measured by comparing the percent recovery of analytes spiked into a laboratory control sample to a control limit. For many methods of organic compound analysis, the surrogate compound recoveries will also be used to assess accuracy and method performance for each sample analyzed.

Representativeness is a qualitative term that refers to the degree in which data accurately and precisely depicts the characteristics of a population, whether referring to the distribution of a contaminant within a sample, a sample within a matrix, or the distribution of a contaminant at a site. Representativeness will be determined by employing an appropriate sampling design with consideration of elements such as sampling locations, sample collection methods, and temporal influences. Assessment of representativeness will be achieved through the use of standard field sampling and analytical procedures.

Comparability is a qualitative indicator of the confidence with which one data set can be compared to another data set. The objective for this project is to produce data with the greatest possible degree of comparability. The number of matrices that are sampled and the range of field conditions encountered are considered in determining comparability. Comparability will be achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats. Complete field documentation using standardized data collection forms supports the assessment of comparability. Historical comparability will be achieved through consistent use of methods and documentation procedures throughout the project. Assessment of comparability is considered subjective, and the results will be interpreted by experienced environmental professionals with knowledge of the sampling objectives and project decisions.

Completeness is a measure of the amount of valid data obtained compared with the amount that was expected to be obtained under correct, normal conditions. It is calculated for the aggregation of data for each analyte measured for any particular sampling event or other defined set of samples as set out in the specific project quality objectives. Valid data are data which are usable in the context of the project goals. Completeness will be calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results expressed as a percentage determines the completeness of the data set. For completeness requirements, valid results are all results not rejected during the validation process. The goal for completeness is 95% for aqueous samples and 90% for all other matrices.

3.8 Health and Safety Plan

The *Health and Safety Plan – Selected Sites Under the Air Force Civil Engineer Center (AFCEC) Contract No. FA8903-13-C-0008 (SS-017;SS-018; DP-030/SD-033; SS-039; OT-037/OT-038; SS-065; SS-069; SD-027)* (United States Air Force [USAF], 2014) has been prepared and addresses the tasks and conditions to be encountered during this project. The HASP presents the health and safety requirements and guidelines for field operations addressed under the IRP at Holloman AFB, specifically for the 10 sites being administered by URS New Mexico and Phoenix offices under terms of the AFCEC Contract No. FA8903-13-C-0008. The purpose of the HASP is to identify and educate personnel of the potential hazards associated with field activities at Holloman AFB. Subcontractors working for URS at task sites will be responsible to provide their own HASPs and provide documentation to URS that describes their plan for addressing applicable health and safety requirements for activities that are unique to their scope of services. The HASP is a living document and may be updated as conditions dictate. The HASP covers the following items:

- Project team organization and responsibilities;
- Training and medical monitoring requirements;

- Site hazard analysis;
- Emergency response plan;
- Personal protective equipment and medical screening;
- Frequencies and types of air monitoring;
- Site control measures and safe work practices;
- Decontamination procedures;
- Site inspections; and
- Recordkeeping.

The Health and Safety Plan – Selected Sites Under the Air Force Civil Engineer Center (AFCEC) Contract No. FA8903-13-C-0008 (SS-017;SS-018; DP-030/SD-033; SS-039; OT-037/OT-038; SS-065; SS-069; SD-027) (USAF, 2014) is augmented by the URS Health and Safety Program's relevant Safety Management Standards that were developed under the company's Health and Safety Management System and are required to be available on-Site during all activities.

3.9 Investigation-Derived Waste

The IDW generated during the sampling activities will include spent and unused sample material, personal protective equipment, miscellaneous sampling supplies, decontamination water, and purge water. Prior to performing sampling, the field team leader will discuss with the field sampling personnel waste reduction methods. Practices to be instituted to support waste minimization include, but are not limited to, the following:

- Restriction of materials (especially hazardous materials) to those needed for performance of work;
- Substitution of recyclable materials for disposable items;
- Reuse of items, when practical;
- Segregation of contaminated from uncontaminated waste;
- Segregation of reusable items (such as personal protective equipment and tools); and
- Waste characterization will be evaluated based on the comparison of analytical results with applicable regulatory levels.

Wastewater from pre-sampling well purging and equipment decontamination will be stored in tanks pending the receipt of the groundwater analytical results. A sign posted on each tank will identify the contents and convey a warning that no material should be added or removed. Waste characterization will be performed by reviewing the groundwater sample analytical results from the wells. The detected constituent concentrations will be compared to the NMWQCC Regulations, Part 2, 3103, A, B, and C groundwater quality standards (20 NMAC 6.2).

A Notice of Intent to discharge development, purge, and decontamination water will be prepared and submitted to NMED Ground Water Quality Bureau for approval prior to discharging any groundwater to surface. Results from laboratory analyses will be summarized and concentrations evaluated for individual containers based on the volume added from the wells from which the purge water and decontamination water originated. The maximum concentrations will be used to determine whether purge water meets the

discharge requirements. After NMED provides their approval, the water will be discharged to the ground surface at the Site. If the results indicate that the water cannot be released to the ground surface, it will be disposed at an appropriate facility.

All personal protective equipment and disposable equipment will be placed in double plastic bags and sealed for disposal in dumpsters at the Base.

As part of the contract with the subcontracted laboratories, all laboratory and sample waste is managed in accordance with the subcontract. Analytical waste streams may include unused/unaltered sample material, analytical residues, and sample containers. Unused/unaltered sample material will be generated from the sampling activities in the form of groundwater not required for analysis. Generally, the laboratory will be responsible for disposal of the unused/unaltered sample material. In those cases where samples must be returned from the laboratory, this excess material will be documented and disposed in accordance with the requirements for disposal of purge and decontamination water. Analytical residues will be generated from the sample analytical activities conducted by the subcontracted laboratories. Although the laboratories are required to dispose of analytical residues under terms of the subcontract, the potential does exist for return of analytical residues. If analytical residues are returned, this will be documented and the waste disposed at an appropriate facility.

Sample containers will become a waste stream following analyses. The laboratories are required to dispose of the sample containers in accordance with established waste management procedures. Sample containers will only be returned to the project should unused/unaltered sample material need to be returned as discussed above.

4.0 REPORTING

Reporting will be comprised of an RFI report, well completion reports, and annual groundwater monitoring reports.

4.1 Resource Conservation and Recovery Act Facility Investigation Report

Documentation of the project will include field notes and forms, photographs, and analytical data. The RFI report will be prepared following completion of the activities described herein documenting the results of the drilling, sampling, and analyses. The report will be submitted for U.S. Air Force (USAF) and NMED review. The RFI report will include, at a minimum, the following elements:

- A description of the field activities completed;
    - Borehole advancement
    - Groundwater monitoring well installation
- Summaries of analytical results;
- Summaries of problems encountered and deviations from the planned work scope;
- Summaries of accomplishments and evaluation of the results; and
- Recommendations for future disposition of the Site.

4.2 Groundwater Monitoring Reports

During each fiscal year, two semi-annual sampling events will be conducted. Following the completion of the first groundwater monitoring event, a letter report will be prepared and submitted. Following completion of the second semi-annual monitoring event, an annual groundwater monitoring report will be prepared to document the results of the groundwater sampling and well gauging activities completed during the fiscal year. Each annual monitoring report will provide evaluation of the data and associated trends and provide recommendations as to future monitoring requirements and optimization actions. Concentration versus time trend analysis for key constituents will be performed using appropriate statistical analysis software such as the Monitoring and Remediation Optimization System, which was developed by GSI Environmental Inc. of Houston, Texas and the University of Houston for the Air Force Center for Environmental Excellence in accordance with the organization's Long-Term Monitoring Optimization guide. Other appropriate statistical methods may be employed with approval of the USAF.

In addition to the above reports, analytical data will be exported for upload to AFCEC's Environmental Restoration Program Information Management System database within 90 days of sample collection.

5.0 RECORDKEEPING

URS will maintain a field logbook in accordance with A-5, “Documentation,” found in Appendix A, which requires that field logbooks be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. The primary document used to record site data is the field logbook. Entries will be made in indelible ink and corrections made by a single stroke through the error with the recorder’s initials. All entries to the logbook will include, at a minimum:

- Location, date, start and finish times;
- Names of personnel present;
- Names of visitors;
- General weather conditions;
- Health and safety briefings;
- Details of work performed;
- Summary of samples collected;
- Field measurement readings and field equipment calibration information;
- Photograph log and drawings/sketches; and
- General observations.

6.0 PROJECT SCHEDULE

An integrated master schedule has been prepared for the overall anticipated sequence of activities to be performed in support of the investigation at the Site. The schedule is dependent on many factors including, but not limited to, USAF and NMED review and comment, subcontractor availability, weather, and Site conditions. The USAF and NMED will be notified 30 days prior to the implementation of field activities. Additionally, during implementation of the field activities, weekly status reports will be submitted to Holloman AFB IRP personnel by electronic mail. These reports will summarize the previous week's activities, the planned activities for the following week, and any other pertinent information.

The RFI schedule will allow for evaluation of screening level data during field work to allow for timely response to changing conditions. Groundwater monitoring will be continued on a semi-annual basis to:

- Monitor impacts of contaminants; and
- Augment evaluation of the Site as needed to develop future actions as determined to be needed.

Changes to groundwater monitoring or interim measures based on monitoring results will be documented in the annual monitoring report. Any reduction in scope or change in interim measures employed will be communicated in writing either prior to implementation or within one week of implementation if the change is immediately necessary because of potential impacts to safety or the environment.

The RFI field work is slated to occur between June and September 2017 with the RFI report transmittal to NMED for review occurring in February 2018. Groundwater monitoring will take place approximately in January and July each year with annual reports transmitted in September. All reports will be submitted for review and approval by USAF and NMED personnel.

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TABLES

Table 1. Phase 1 Investigation – Soil Analytical Data

Analytes	Bkgd(1)	NMED Soil Screening Levels (2)			SB-39-01		SB-39-02		HA-39-01	HA-39-02	HA-39-03	HA-39-04	HA-39-05
		Residential	Industrial	Construction Worker	91JULHO39-001	91JULHO39-002	91JULHO39-003	91JULHO39-004	91JULHO39-007	91JULHO39-008	91JULHO39-009	91JULHO39-005	91JULHO39-006
					7.5 - 9.5 ft bgs	10 - 12 ft bgs	10 - 12 ft bgs	15 - 17 ft bgs	0 - 2 ft bgs	0 - 2 ft bgs	0 - 2 ft bgs	0 - 2 ft bgs	0 - 2 ft bgs
SW820 - Volatile Organic (µg/kg)													
1,1,1-Trichloroethane	NA	563,000	563,000	563,000	< 130	430,000 D	87,000 D	900	< 140	< 110	< 150	< 120	< 130
1,1,2-Trichloroethane	NA	11,900	30,200	194,000	< 130	95 J	< 140	< 140	< 140	< 110	< 150	< 120	< 130
1,1-Dichloroethane	NA	1,400,000	1,420,000	1,420,000	< 130	260	170	69 J	< 140	< 110	< 150	< 120	< 130
1,1-Dichloroethene	NA	206,000	777,000	678,000	< 130	< 130	< 140	44 J	< 140	18 J	< 150	< 120	22 J
1,2-Dichloroethane	NA	6,040	15,200	64,200	< 130	140	< 140	< 140	< 140	< 110	< 150	< 120	< 130
Chloromethane	NA	21,800	53,400	284,000	44 J	< 270	< 280	< 270	< 280	< 230	< 300	< 240	< 260
Ethyl benzene	NA	128,000	128,000	128,000	2.9 J	4.3 J	81 J	< 140	< 140	< 110	< 150	< 120	5.9 J
Methylene chloride	NA	182,000	490,000	2,630,000	510 B	630 B	1,400 B	530 B	720	350	36 J	54 J	260
Tetrachloroethene	NA	12,500	31,600	134,000	< 130	430	***95,000 D***	300	< 140	< 110	< 150	< 120	28 J
Toluene	NA	252,000	252,000	252,000	12 JB	3,400 B	82 JB	12 JB	91.1 J	8 J	9.1 J	8.9 J	9.3 J
Trichloroethene	NA	638	1,560	33,600	< 130	***40,000 D***	***11,000 D***	47 J	< 140	< 110	< 150	< 120	< 130
Xylenes	NA	82,000	82,000	82,000	8.1 J	23 J	290	< 140	< 140	< 110	< 150	38 J	13 J
EPA 418.1 - TRPH (mg/kg)	NA	200(3)	200(3)	NA	***678***	26.3	***2,620***	***543***	50.2	***660***	***811***	***20,700***	95.6
SW6010 - Metals (mg/kg)													
Beryllium	1.3	156	2,250	56.2	< 0.36	< 0.49	< 0.45	0.58	< 0.46	0.57	0.58	< 0.48	< 0.47
Cadmium	1	39	564	154	0.98	< 1.2	30	4.3	< 1.2	7.3	7.8	38	4
Chromium, total	24.6	210(4)	450(4)	500(4)	5.6	3.2	78	25	8.6	26	47	190	130
Copper	21.2	3,130	45,400	12,400	6	< 4.9	82	5.1	14	91	140	110	19
Nickel	18.1	1,560	22,700	6,190	< 3.6	< 4.9	14	8.6	6.5	23	21	31	58
Silver	0.73	391	5,680	1,550	< 1.8	< 2.4	< 2.3	< 2.4	< 2.3	< 1.8	12	< 2.4	< 2.4
Zinc	48.7	23,500	100,000	92,900	52	8.4	380	60	30	250	180	540	130
SW7060 - Arsenic (mg/kg)	6.9	3.9	17.7	85.2	2.6	0.66	2	2	1.6	***28***	***34***	3.7	0.99
SW7421 - Lead (mg/kg)	12.3	400	800	800	16	1	77	9.2	180	***1,300***	***1,100***	210	10
SW7471 - Mercury (mg/kg)	NA	6.11(5)	68.4(5)	23.8(5)	< 0.056	< 0.064	< 0.068	< 0.060	< 0.064	0.063	< 0.069	0.074	< 0.06

NOTE: Table presents only constituents detected in soil at this site.
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) TPH value obtained from Table 2a (NMED, 2006a)
(4) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
(5) Methyl mercury screening criteria used as a surrogate for mercury.
bgs – below ground surface
mg/kg – milligrams per kilogram
NA- not applicable
NMED – New Mexico Environment Department
TRPH – total recoverable petroleum hydrocarbons
µg/kg – micrograms per kilogram

Laboratory Qualifier
D – secondary dilution required for this analyte
B – analyte detected in laboratory blank analysis, no blank subtraction performed

Validation Qualifier
J – detected below the limit of quantitation

Bolded, italicized, and highlighted value indicates analyte concentration exceeds the applicable soil screening levels.

Table 2 – Phase II Investigation – Soil Analytical Data - Metals

Analytes	179-A01	179-A01	179-A01	179-A02	179-A02	179-A02	179-A03	179-A03	179-A03	179-A04	179-A04	179-A04
	179A01-01-01	179A01-02-01	179A01-03-01	179A02-01-01	179A02-02-01	179A02-03-01	179A03-01-01	179A03-02-01	179A03-03-01	179A04-01-01	179A04-02-01	179A04-03-01
	0-2 ft bgs	2-4 ft bgs	8-10 ft bgs	2-4 ft bgs	4-6 ft bgs	8-10 ft bgs	2-4 ft bgs	4-6 ft bgs	8-10 ft bgs	2-4 ft bgs	4-6 ft bgs	8-10 ft bgs
SW6010 - Metals (mg/kg)												
Barium	84	80	143	41.7	32	48	36.6	30.7	25.2	33.1	22.9	57.5
Cadmium	11.3	22.4	6.3	2.33	<0.314	<0.28	0.296	<0.288	<0.267	1.09	0.582	<0.253
Chromium	47.8	188	38.6	12.8	4.05 B	8.71	8.14	4.59	3.67	4.84	4.61	11.1
Silver	<0.159	1.5	0.282	<0.169	<0.2	<0.179	<0.18	<0.183	<0.171	<0.153	<0.169	<0.161
SW7421-Lead (mg/kg)												
Lead	109 S	94.2 S	22.6 SB	5.84 S	0.592 S	0.11 SB	6.77 S	1.1 S	0.535 SB	43.8 S	44.4 S	13.6 S

bgs – below ground surface
ft – feet
mg/kg – milligrams per kilogram

Laboratory Qualifier
S – lab-specific qualifier (no information provided)
B – analyte detected in associated blank analysis

Table 3. Phase II Investigation – Soil Analytical Data – Metals and Semi-Volatile Organic Compounds

Analytes	NMED Soil Screening Levels (2)				179-A05	179-A05	179-A05	179-B01	179-B01	179-B01	179-B01
					179A05-01-01	179A05-02-01	179A05-03-01	179B01-01-01	179B01-02-01	179B01-03-01	179B01-04-01
	Bkgd (1)	Residential	Industrial	Construction Worker	0-2 ft bgs	4-6 ft bgs	8-10 ft bgs	0-2 ft bgs	2-4 ft bgs	4-6 ft bgs	6-8 ft bgs
SW8270-SVOCs (mg/kg)											
Acetophenone	NA	1,480	1,480	1,480	52.9	38.8	62	44	60.8	77.1	37.4
Anthracene	NA	22,000	100,000	86,000	0.364 B	0.332 B	0.796 B	<0.29	<0.279	<0.266	<0.273
Benzo(a)anthracene	NA	6.21	23.4	212	**10.6**	**15.8**	**7.74**	**7.18**	**6.43**	**7.09**	5.97
Benzo(a)pyrene	NA	0.621	2.34	21.2	<0.139	<0.151	<0.122	0.239	0.282	<0.17	0.207
Benzo(b)fluoranthene	NA	6.21	23.4	212	—	—	—	—	—	—	—
Benzo(g,h,i)perylene	NA	NA	NA	NA	275	59.2	46.3	14.4 S	2.29 S	2.28 S	1.84 S
Benzo(k)fluoranthene	NA	62.1	234	2,120	—	—	—	—	—	—	—
Chrysene	NA	615	2,310	21,200	—	—	—	ND	—	—	—
Di-n-octylphthalate	NA	NA	NA	NA	—	—	—	ND	—	—	—
bis(2-Ethylhexyl)phthalate	NA	347	1,370	4,660	—	—	—	ND	—	—	—
Fluoranthene	NA	2,290	24,400	8,730	—	—	—	ND	—	—	—
Indeno(1,2,3-cd)pyrene	NA	6.21	23.4	212	—	—	—	ND	—	—	—
Phenanthrene	NA	1,830	20,500	6,990	—	—	—	ND	—	—	—
Pyrene	NA	2,290	30,900	9,010	—	—	—	ND	—	—	—
SW6010-Metals (mg/kg)											
Barium	84.4	15,600	100,000	60,200	—	—	—	ND	—	—	—
Cadmium	1	39	564	154	—	—	—	ND	—	—	—
Chromium, total	24.6	210 (3)	450 (3)	500 (3)	—	—	—	ND	—	—	—
Silver	0.73	391	5,680	1,550	—	—	—	ND	—	—	—
SW7421-Lead (mg/kg)											
Lead	12.3	400	800	800	—	—	—	ND	—	—	—

Notes:
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
bgs – below ground surface
ft – feet
NMED – New Mexico Environment Department
NA – not applicable
ND – not detected
SVOC – semi-volatile organic compound
—- not analyzed

Laboratory Qualifier
S – lab-specific qualifier (no information provided)
B – analyte detected in associated blank analysis

Bolded value indicates analyte concentration exceeds NMED residential soil screening level.

Table 3. Phase II Investigation – Soil Analytical Data – Metals and Semi-Volatile Organic Compounds

Analytes	NMED Soil Screening Levels (2)				179-B02	179-B02	179-B02	179-B03	179-B03	179-B03	179-B03
					179B02-02-01	179B02-03-01	179B02-04-01	179B03-01-01	179B03-02-01	179B03-03-01	179B03-04-01
	Bkgd (1)	Residential	Industrial	Construction Worker	2-4 ft bgs	4-6 ft bgs	6-8 ft bgs	0-2 ft bgs	2-4 ft bgs	4-6 ft bgs	6-8 ft bgs
SW8270-SVOCs (mg/kg)											
Acetophenone	NA	1,480	1,480	1,480	38.5	67.8	34.7	50.6	44.5	37.7	73.1
Anthracene	NA	22,000	100,000	86,000	<0.232	<0.254	<0.27	0.499 B	<0.291	<0.272	<0.263
Benzo(a)anthracene	NA	6.21	23.4	212	**7.18**	**8.96**	5.61	**8.36**	**6.73**	5.82	**8.79**
Benzo(a)pyrene	NA	0.621	2.34	21.2	0.183 B	<0.162	<0.172	0.178 B	0.238 B	<0.173	0.392 B
Benzo(b)fluoranthene	NA	6.21	23.4	212	—	—	—	—	—	—	—
Benzo(g,h,i)perylene	NA	NA	NA	NA	1.57	1.46	0.43	0.256	4.91	0.494	1.62
Benzo(k)fluoranthene	NA	62.1	234	2,120	—	—	—	—	—	—	—
Chrysene	NA	615	2,310	21,200	—	—	—	ND	—	—	—
Di-n-octylphthalate	NA	NA	NA	NA	—	—	—	ND	—	—	—
bis(2-Ethylhexyl)phthalate	NA	347	1,370	4,660	—	—	—	ND	—	—	—
Fluoranthene	NA	2,290	24,400	8,730	—	—	—	ND	—	—	—
Indeno(1,2,3-cd)pyrene	NA	6.21	23.4	212	—	—	—	ND	—	—	—
Phenanthrene	NA	1,830	20,500	6,990	—	—	—	ND	—	—	—
Pyrene	NA	2,290	30,900	9,010	—	—	—	ND	—	—	—
SW6010-Metals (mg/kg)											
Barium	84.4	15,600	100,000	60,200	—	—	—	0.0167 J	—	—	—
Cadmium	1	39	564	154	—	—	—	ND	—	—	—
Chromium, total	24.6	210 (3)	450 (3)	500 (3)	—	—	—	0.0169 J	—	—	—
Silver	0.73	391	5,680	1,550	—	—	—	ND	—	—	—
SW7421-Lead (mg/kg)											
Lead	12.3	400	800	800	—	—	—	0.0159 J	—	—	—

Notes:
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
bgs – below ground surface
ft – feet
NMED – New Mexico Environment Department
NA – not applicable
ND – not detected
SVOC – semi-volatile organic compound
— - not analyzed

Laboratory Qualifier
S – lab-specific qualifier (no information provided)
B – analyte detected in associated blank analysis

Bolded value indicates analyte concentration exceeds NMED residential soil screening level.

Table 3. Phase II Investigation – Soil Analytical Data – Metals and Semi-Volatile Organic Compounds

Analytes	NMED Soil Screening Levels (2)				179-B04	179-B04	179-B05	179-B05	179-B05	179-B05
					179B04-01-01	179B04-02-01	179B05-01-01	179B05-02-01	179B05-03-01	179B05-04-01
	Bkgd (1)	Residential	Industrial	Construction Worker	0-2 ft bgs	2-4 ft bgs	0-2 ft bgs	2-4 ft bgs	4-6 ft bgs	12-14 ft bgs
SW8270-SVOCs (mg/kg)										
Acetophenone	NA	1,480	1,480	1,480	38.9	54.6	39.9	56	22.9	114
Anthracene	NA	22,000	100,000	86,000	<0.304	<0.236	<0.262	<0.287	<0.247	<0.219
Benzo(a)anthracene	NA	6.21	23.4	212	**7.84**	4.93	5.73	**8.95**	4.11	**14.3**
Benzo(a)pyrene	NA	0.621	2.34	21.2	0.55 B	<0.15	<0.167	0.286	<0.158	<0.14
Benzo(b)fluoranthene	NA	6.21	23.4	212	—	—	—	—	—	—
Benzo(g,h,i)perylene	NA	NA	NA	NA	5.22	0.531	6.07 S	4.44 S	2.48 S	5.98 S
Benzo(k)fluoranthene	NA	62.1	234	2,120	—	—	—	—	—	—
Chrysene	NA	615	2,310	21,200	ND	—	ND	—	—	—
Di-n-octylphthalate	NA	NA	NA	NA	ND	—	ND	—	—	—
bis(2-Ethylhexyl)phthalate	NA	347	1,370	4,660	ND	—	ND	—	—	—
Fluoranthene	NA	2,290	24,400	8,730	ND	—	ND	—	—	—
Indeno(1,2,3-cd)pyrene	NA	6.21	23.4	212	ND	—	ND	—	—	—
Phenanthrene	NA	1,830	20,500	6,990	ND	—	ND	—	—	—
Pyrene	NA	2,290	30,900	9,010	ND	—	ND	—	—	—
SW6010-Metals (mg/kg)										
Barium	84.4	15,600	100,000	60,200	ND	—	ND	—	—	—
Cadmium	1	39	564	154	ND	—	ND	—	—	—
Chromium, total	24.6	210 (3)	450 (3)	500 (3)	ND	—	ND	—	—	—
Silver	0.73	391	5,680	1,550	ND	—	ND	—	—	—
SW7421-Lead (mg/kg)										
Lead	12.3	400	800	800	ND	—	ND	—	—	—

Notes:
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
bgs – below ground surface
ft – feet
NMED – New Mexico Environment Department
NA – not applicable
ND – not detected
SVOC – semi-volatile organic compound
— - not analyzed

Laboratory Qualifier
S – lab-specific qualifier (no information provided)
B – analyte detected in associated blank analysis

Bolded value indicates analyte concentration exceeds NMED residential soil screening level.

Table 3. Phase II Investigation – Soil Analytical Data – Metals and Semi-Volatile Organic Compounds

Analytes	NMED Soil Screening Levels (2)				179-B06	179-B06	179-B06	179-B06	179-B07	179-B07	179-B07	179-B07
					179B06-01-01	179B06-02-01	179B06-03-01	179B06-04-01	179B07-01-01	179B07-02-01	179B07-03-01	179B07-04-01
	Bkgd (1)	Residential	Industrial	Construction Worker	0-2 ft bgs	2-4 ft bgs	4-6 ft bgs	12-14 ft bgs	4-6 ft bgs	6-8 ft bgs	8-10 ft bgs	14-16 ft bgs
SW8270-SVOCs (mg/kg)												
Acetophenone	NA	1,480	1,480	1,480	50.1	55	19.1	18.8	47	35	19.2	21.2
Anthracene	NA	22,000	100,000	86,000	0.57 B	0.578 B	<0.245	0.29 B	<0.288	<0.252	<0.252	<0.267
Benzo(a)anthracene	NA	6.21	23.4	212	**10.7**	**8.71**	3.88	4.41	5.75	5.96	3.9	5.39
Benzo(a)pyrene	NA	0.621	2.34	21.2	0.233	0.382	0.156	<0.175	<0.183	<0.161	<0.161	<0.17
Benzo(b)fluoranthene	NA	6.21	23.4	212	—	—	—	—	—	—	—	—
Benzo(g,h,i)perylene	NA	NA	NA	NA	288 S	28.6 S	0.782 S	0.56 S	0.933 SB	1.42 SB	0.616 SB	1.36 SB
Benzo(k)fluoranthene	NA	62.1	234	2,120	—	—	—	—	—	—	—	—
Chrysene	NA	615	2,310	21,200	0.0234	—	—	—	ND	—	—	—
Di-n-octylphthalate	NA	NA	NA	NA	0.024	—	—	—	ND	—	—	—
bis(2-Ethylhexyl)phthalate	NA	347	1,370	4,660	0.119	—	—	—	ND	—	—	—
Fluoranthene	NA	2,290	24,400	8,730	0.0985	—	—	—	ND	—	—	—
Indeno(1,2,3-cd)pyrene	NA	6.21	23.4	212	0.17	—	—	—	ND	—	—	—
Phenanthrene	NA	1,830	20,500	6,990	0.0232 J	—	—	—	ND	—	—	—
Pyrene	NA	2,290	30,900	9,010	0.17	—	—	—	ND	—	—	—
SW6010-Metals (mg/kg)												
Barium	84.4	15,600	100,000	60,200	1.02	—	—	—	ND	—	—	—
Cadmium	1	39	564	154	0.281	—	—	—	ND	—	—	—
Chromium, total	24.6	210 (3)	450 (3)	500 (3)	0.23	—	—	—	ND	—	—	—
Silver	0.73	391	5,680	1,550	0.0351	—	—	—	ND	—	—	—
SW7421-Lead (mg/kg)												
Lead	12.3	400	800	800	0.206	—	—	—	ND	—	—	—

Notes:
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
bgs – below ground surface
ft – feet
NMED – New Mexico Environment Department
NA – not applicable
ND – not detected
SVOC – semi-volatile organic compound
— - not analyzed

Laboratory Qualifier
S – lab-specific qualifier (no information provided)
B – analyte detected in associated blank analysis

Bolded value indicates analyte concentration exceeds NMED residential soil screening level.

Table 3. Phase II Investigation – Soil Analytical Data – Metals and Semi-Volatile Organic Compounds

Analytes	NMED Soil Screening Levels (2)				179-B08	179-B08	179-B08	179-B08
					179B08-01-01	179B08-02-01	179B08-03-01	179B08-04-01
	Bkgd (1)	Residential	Industrial	Construction Worker	0-2 ft bgs	2-4 ft bgs	4-6 ft bgs	10-12 ft bgs
SW8270-SVOCs (mg/kg)								
Acetophenone	NA	1,480	1,480	1,480	38.1	46.4	46.7	33.4
Anthracene	NA	22,000	100,000	86,000	<0.276	<0.249	<0.21	<0.277
Benzo(a)anthracene	NA	6.21	23.4	212	5.3	5.97	**6.35**	6.13
Benzo(a)pyrene	NA	0.621	2.34	21.2	0.6	<0.159	0.178	0.555 B
Benzo(b)fluoranthene	NA	6.21	23.4	212	—	—	—	—
Benzo(g,h,i)perylene	NA	NA	NA	NA	12.5 S	1.56 SB	2.05 S	3.54 S
Benzo(k)fluoranthene	NA	62.1	234	2,120	—	—	—	—
Chrysene	NA	615	2,310	21,200	ND	—	—	—
Di-n-octylphthalate	NA	NA	NA	NA	ND	—	—	—
bis(2-Ethylhexyl)phthalate	NA	347	1,370	4,660	ND	—	—	—
Fluoranthene	NA	2,290	24,400	8,730	ND	—	—	—
Indeno(1,2,3-cd)pyrene	NA	6.21	23.4	212	ND	—	—	—
Phenanthrene	NA	1,830	20,500	6,990	ND	—	—	—
Pyrene	NA	2,290	30,900	9,010	ND	—	—	—
SW6010-Metals (mg/kg)								
Barium	84.4	15,600	100,000	60,200	ND	—	—	—
Cadmium	1	39	564	154	ND	—	—	—
Chromium, total	24.6	210 (3)	450 (3)	500 (3)	ND	—	—	—
Silver	0.73	391	5,680	1,550	ND	—	—	—
SW7421-Lead (mg/kg)								
Lead	12.3	400	800	800	ND	—	—	—

Notes:
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
bgs – below ground surface
ft – feet
mg/kg – milligrams per kilogram
NMED – New Mexico Environment Department
NA – not analyzed
ND – not detected
SVOC – semi-volatile organic compound
— - not analyzed

Laboratory Qualifier
S – lab-specific qualifier (no information provided)
B – analyte detected in associated blank analysis

Bolded value indicates analyte concentration exceeds NMED residential soil screening level.

Table 4. 1994 Remedial Investigation Soil Analytical Results

Analytes	NMED Soil Screening Levels (2)				181-B01	181-B02
					181-B01-01-01	181-B02-01-01
	Bkgd (1)	Residential	Industrial	Construction Worker	6-8 ft bgs	8-10 ft bgs
SW8270-Semi-volatile Organic Compounds (mg/kg)						
4-Chloro-3-methylphenol	NA	NA	NA	NA	ND	4.25
p-Chloroaniline	NA	240 (3)	8,200 (3)	2,700 (3)	ND	1.69
Bis(2-Ethylhexyl)phthalate	NA	347	1,370	4,660	ND	19.7 B
2-Methylnapthalene	NA	NA	NA	NA	ND	6.05
Naphthalene	NA	79.5	300	262	ND	1.91
SW8270-Semi-volatile Organic Compounds TICs (mg/kg)						
Ethylmethylbenzene	NA	NA	NA	NA	ND	50
Trimethylbenzene	NA	NA	NA	NA	ND	20

Notes:
(1) Radian, 1992 and 1993. Background provided for reference only.
(2) Obtained from Table A-1 (NMED, 2006c)
(3) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
bgs – below ground surface
ft – feet
mg/kg – milligrams per kilogram
NA – not applicable
ND – not detected
TIC – tentatively identified compound

Table 5. 2006 Supplemental RFI Sediment Analytical Results

Analyte (1)	Bkgd (2)	NMED Soil Screening Level (3)			SD39-01 – 5/19/2006
		Residential	Industrial	Construction Worker	0-1 ft bgs
Semi-Volatile Organic Compounds (µg/kg)					
Acetophenone	NA	1,480,000	1,480,000	1,480,000	2,680
Diethyl phthalate	NA	48,900,000	100,000,000	100,000,000	932 J
Dimethyl phthalate	NA	100,000,000	100,000,000	100,000,000	1,120 J
Metals (mg/kg)					
Barium	84.4	15,600	100,000	60,200	168
Cadmium	1	39	564	154	7.31
Chromium, total	24.6	210 (4)	450 (4)	500 (4)	43.2
Lead	12.3	400	800	800	***1,430***
Mercury	NA	6.11 (5)	68.4 (5)	23.8 (5)	0.0516
Silver	0.73	391	5.68	1.55	0.136 J

Notes:

(1) Sample analyzed for SVOCs, UDMH, aniline, and metals. UDMH and aniline not detected.
(2) Radian, 1992 and 1993. Background provided for reference only.
(3) Obtained from Table A-1 (NMED, 2006c)
(4) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
(5) Methyl mercury screening criteria used as a surrogate for mercury.

bgs – below ground surface
ft – feet
J – estimate positive detection
mg/kg – milligrams per kilogram
NA – not applicable
NMED – New Mexico Environment Department
SVOC – semivolatile organic compound
µg/kg – micrograms per kilogram
UDMH – unsymmetrical dimethylhydrazine
Bolded, italicized, and highlighted value indicates analyte concentration exceeds the applicable soil screening levels.

Table 6. 2006 Supplemental RFI Soil Analytical Results

Analyte (1)	Bkgd (2)	NMED Soil Screening Level (3)			SB3901R 18-May-2006		SB3902R 18-May-2006			SB39-17 18-May-2006		HA3901R 18-May-2006		HA3902R 18-May-2006	
		Residential	Industrial	Construction Worker	2-4 ft bgs	8-10 ft bgs	2-4 ft bgs	8-10 ft bgs	8-10 ft bgs	2-4 ft bgs	9-10 ft bgs	2-4 ft bgs	7-8 ft bgs	2-4 ft bgs	8-9 ft bgs
Metals (mg/kg)															
Arsenic	6.9	3.9	17.7	85.2	0.228 U	0.228 U	0.228 U	0.228 U	0.228 U	0.228 U	0.228 U	**8.27 U**	0.228 U	0.228 U	0.228 U
Barium	84.4	15.6	100,000	60,200	**25.6**	**19.9**	**124**	**70.7**	**78.8**	**19.6**	11.5	**36.8**	**21.6**	**64.4**	**33.1**
Cadmium	1	39	564	154	2.25	0.0795 U	36.3	23.4	**50.7**	0.0795 U	0.0795 U	0.294	0.0795 U	0.0795 U	0.0795 U
Chromium, total	24.6	210 (4)	450 (4)	500 (4)	16.9	3.01	178	**287**	**290**	0.528 J	0.615 J	10.4	3.82	6.48	4.38
Lead	12.3	400	800	800	18.8	0.65 U	342	177	**612**	0.65 U	0.65 U	102	53	20.7	5.05
Mercury	NA	6.11 (5)	68.4 (5)	23.8 (5)	0.0879	0.0088 U	0.435	0.0802	0.0625	0.0088 U	0.0088 U	0.0095 J	0.0088 U	0.0094 J	0.0088 U
Silver	0.73	3.91	5.68	1,550	0.787	0.834	6.34	0.0444 U	0.0444 U	0.991	0.536	0.994	1.09	0.0444 U	0.473

Notes:
(1) Samples analyzed for UDMH, aniline, and metals. UDMH and aniline not detected.
(2) Radian, 1992 and 1993, Background provided for reference only.
(3) Obtained from Table A-1 (NMED, 2006c)
(4) Obtained from Region 6 Human Health Medium Specific Screening Levels (EPA, 2007)
(5) Methyl mercury screening criteria used as a surrogate for mercury.
bgs – below ground surface
ft – feet
mg/kg – milligrams per kilogram
NA – not applicable
NMED – New Mexico Environment Department
UDMH – unsymmetrical dimethylhydrazine

Laboratory Qualifier
J – estimated positive detection
U – non-detect result, value presented indicates reporting limit

Bolded value indicates analyte concentration exceeds NMED residential soil screening level

Table 7. Holloman AFB Site SS-039 January 2016 Analytical Data Summary

Well	Total Dissolved Solids (mg/L)	Nitrate/Nitrite (mg/L)	TCE (µg/L)	1,1-DCE (µg/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	PCE (µg/L)	Perchlorate (µg/L)
MW39-01	**12,900**	**50.7**	< 1	< 1	< 1	< 5	< 1	4.39
MW39-02	**14,000**	**81.0**	**7.70**	< 1	2.02	1.70	< 1	**22.5**
MW39-05	**60,300**	**227**	1.71	< 1	< 1	< 5	< 1	**22.0**
MW39-06	**29,400**	**110**	**95.2**	0.509	1.13	1.56	< 1	**24.4**
MW39-06D	**11,400**	**202**	**63.6**	< 1	< 1	< 5	< 1	**29.8**
MW39-07	**41,300**	**60.9**	1.02	< 1	< 1	< 5	< 1	**43.2**
MW39-13	**17,200**	**102**	**5.18**	< 1	< 1	1.76	1.12	**41.7**
MW39-14	**16,100**	**85.7**	**5.54**	< 1	2.60	1.36	< 1	**14.6**
MW39-15	**14,800**	**75.0**	3.88	< 1	< 1	0.393	< 1	7.94
MW39-16	**22,100**	**99.7**	**16.7**	< 1	0.914	0.501	< 1	12.0
NSA39-MW02	**30,600**	**112**	**76.1**	0.462	< 1	0.516	< 1	**15.9**
Number of Detects	11	11	10	2	4	7	1	11
Minimum	11,400	50.7	ND	ND	ND	ND	ND	4.39
Maximum	60,300	227	95.2	0.509	2.60	1.76	1.12	43.2
Average	24,600	110	27.7	0.486	1.67	1.11	N/A	21.7
Regulatory Level	500	10	5	5	5	100	5	13.8
Source	EPA Secondary Standard	NMWQCC EPA MCL	EPA MCL	NMWQCC	EPA MCL	NMWQCC	EPA MCL	NMED Tap Water RBSL

BOLD – indicates regulatory level exceedance
DCE – dichloroethene
EPA – U.S. Environmental Protection Agency
MCL – maximum contaminant level
mg/L – milligrams per liter
ND – non-detect
NMED – New Mexico Environment Department
NMWQCC – New Mexico Water Quality Control Criteria
PCE - tetrachloroethene
RBSL – risk-based screening level
TCE - trichloroethene
µg/L – micrograms per liter

Table 8. Groundwater Monitoring Well Network

Well	Northing	Easting	Elevation TOC (ft amsl)	Diameter (inches)	Screen Interval (ft bgs)	Total Depth (ft bgs)
MW39-01	685830.00	1671298.00	4,061.89	2	17.75 - 27.25	27.5
MW39-02	685113.11	1670479.98	4,053.06	2	14.75 – 24.25	24.5
MW39-03	685124.02	1670833.30	4,042.71	2	4.25 – 13.75	14.0
MW39-04	685323.31	1671166.37	4,055.48	2	13.35 – 22.85	23.1
MW39-05	684944.84	1669838.81	4,038.53	2	5.0 – 15.0	15.33
MW39-06	684858.13	1670521.45	4,040.88	2	6.0 – 16.0	16.3
MW39-06D	684846.26	1670531.07	4,040.23	2	16.5 – 26.5	26.8
MW39-07	684804.01	1671083.81	4,040.13	2	4.7 – 14.4	14.78
MW39-13	684977.26	1670660.10	4,037.01	2	1.91 – 6.91	7.21
MW39-14	685034.30	1670473.19	4,045.85	2	11.9 – 21.9	22.2
MW39-15	685027.62	1670301.20	4,045.60	2	11.43 – 21.43	21.73
MW39-16	684891.53	1670302.95	4,040.97	2	6.85 – 16.85	17.15
NSA39-MW01	686109.46	1670460.15	4,055.48	2	21 – 31	31
NSA39-MW02	684917.66	1670119.12	4,036.75	2	6 – 16	16

amsl – above mean sea level
bgs – below ground surface
ft - feet
TOC – top of casing

FIGURES

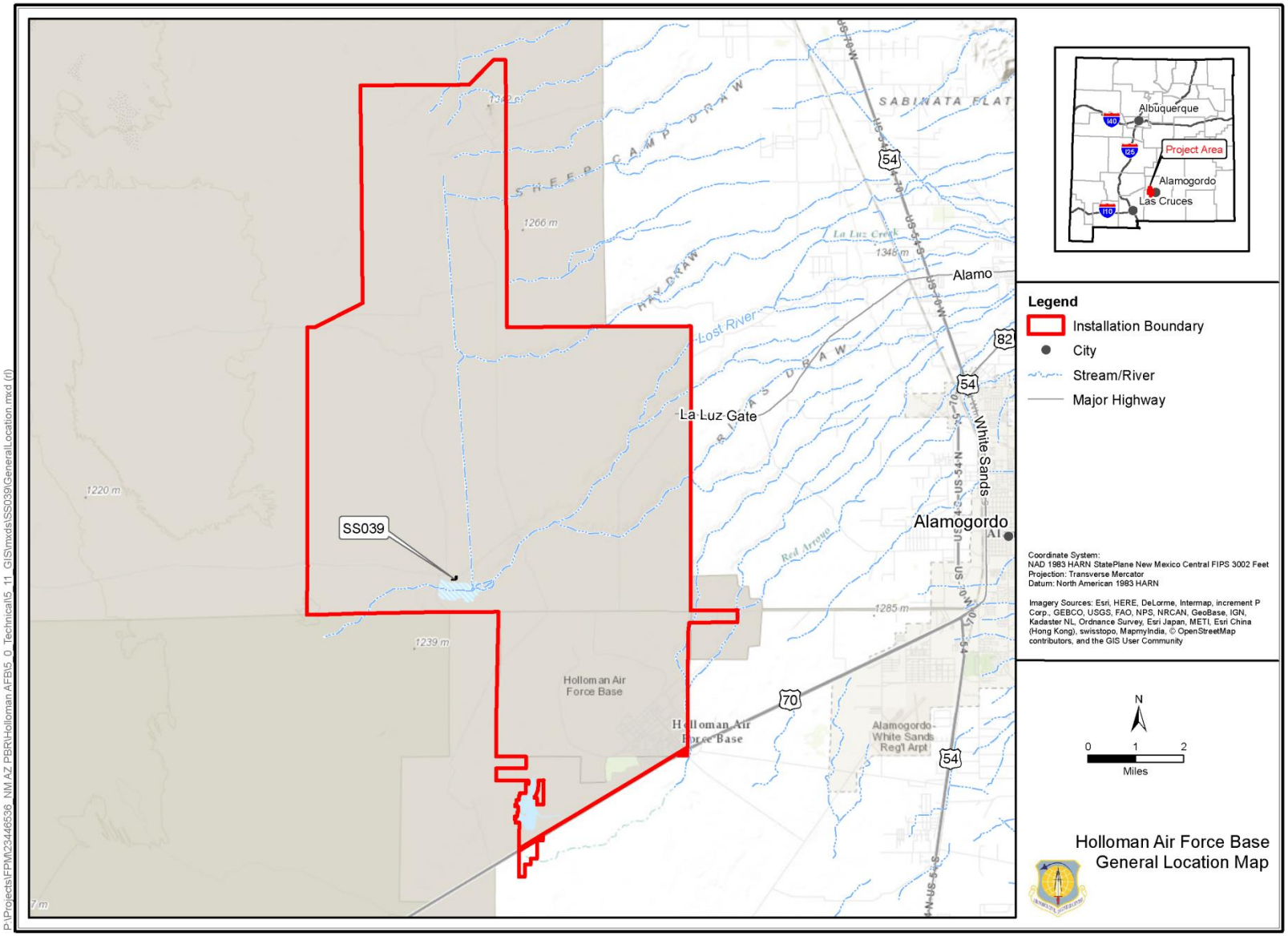

Figure 1. Site Vicinity Map

Figure 2. Groundwater Monitoring Wells

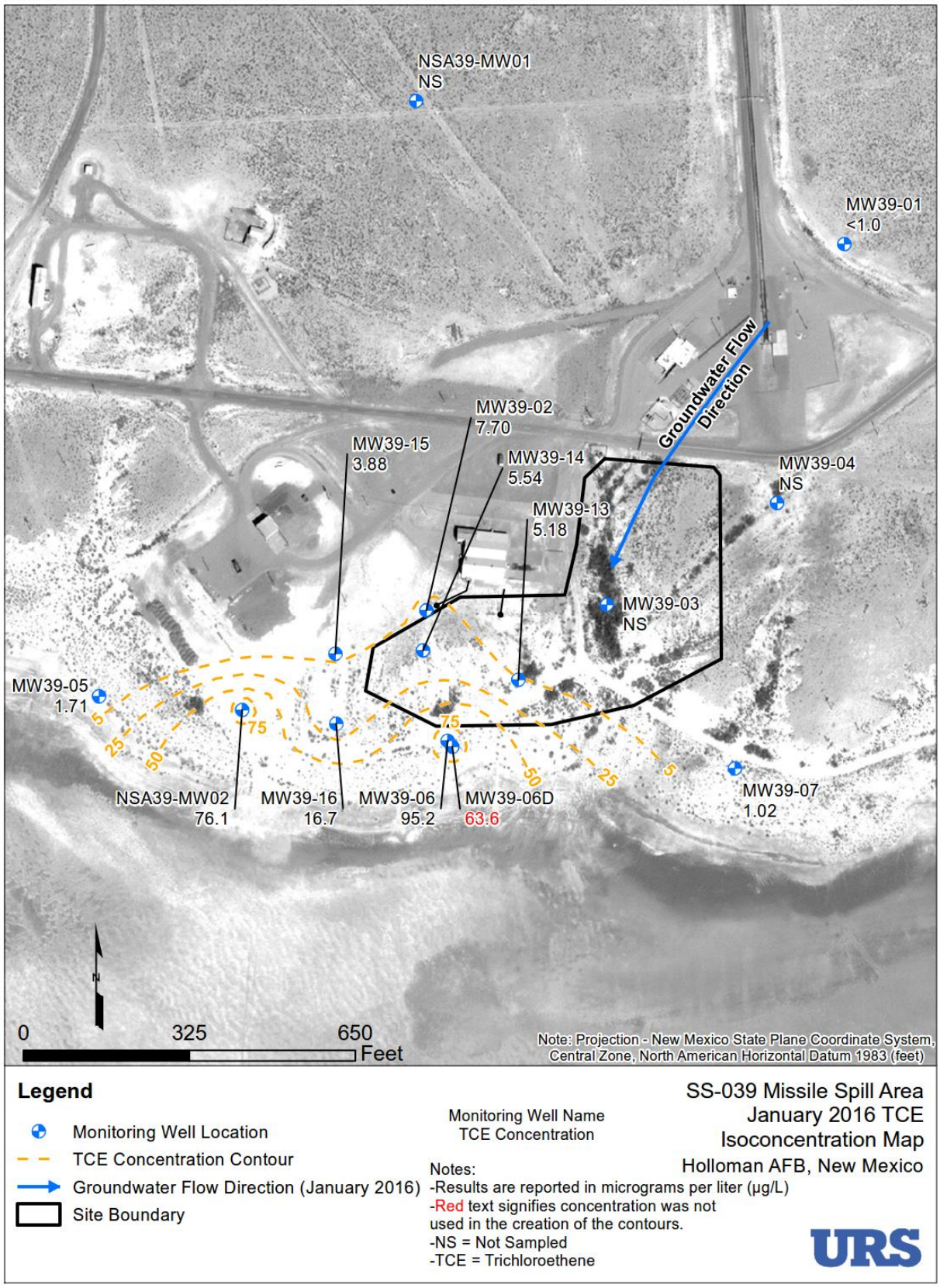

Figure 3. Trichloroethene Isoconcentration Map – January 2016

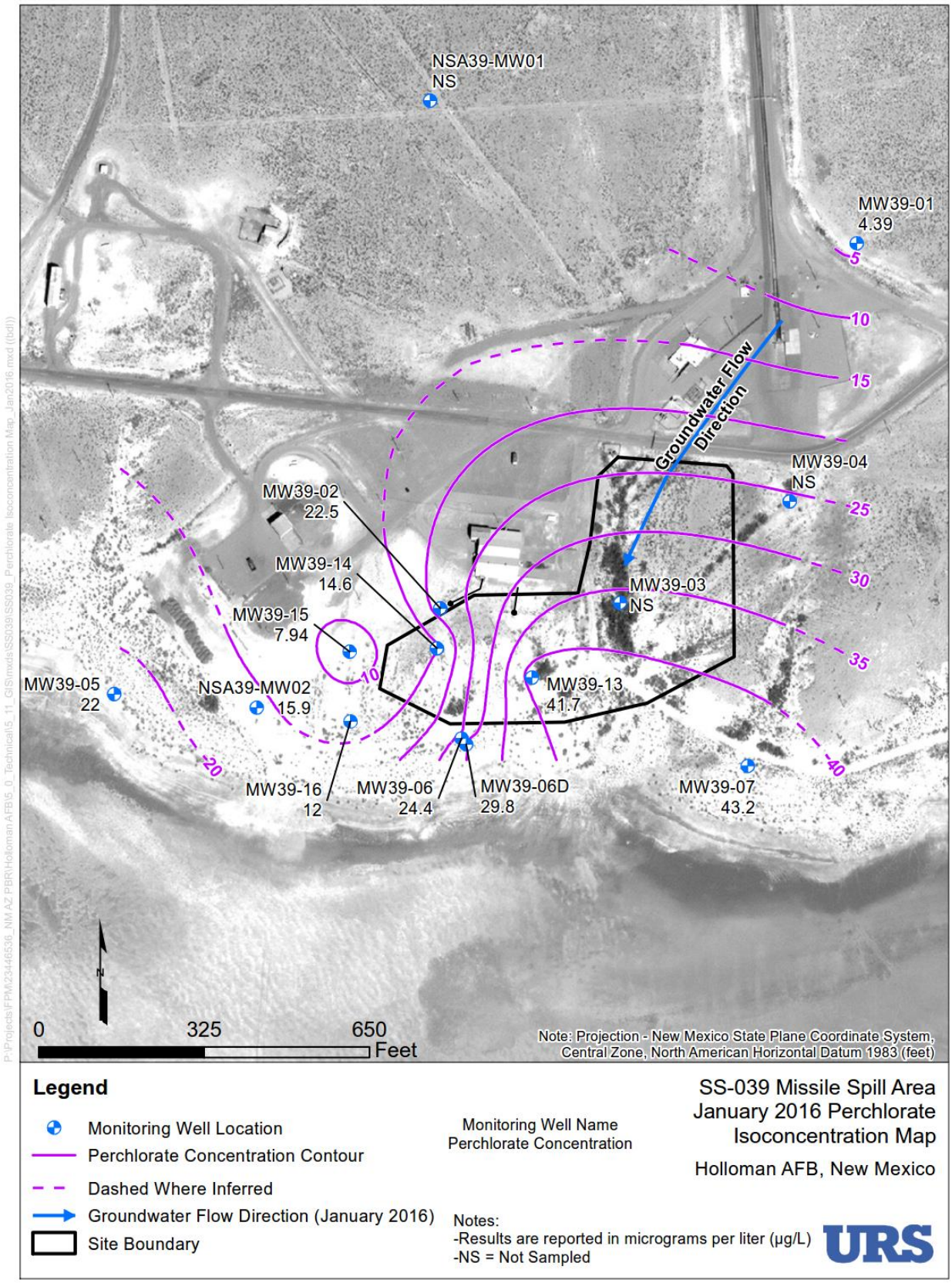

Figure 4. Perchlorate Isoconcentration Map – January 2016

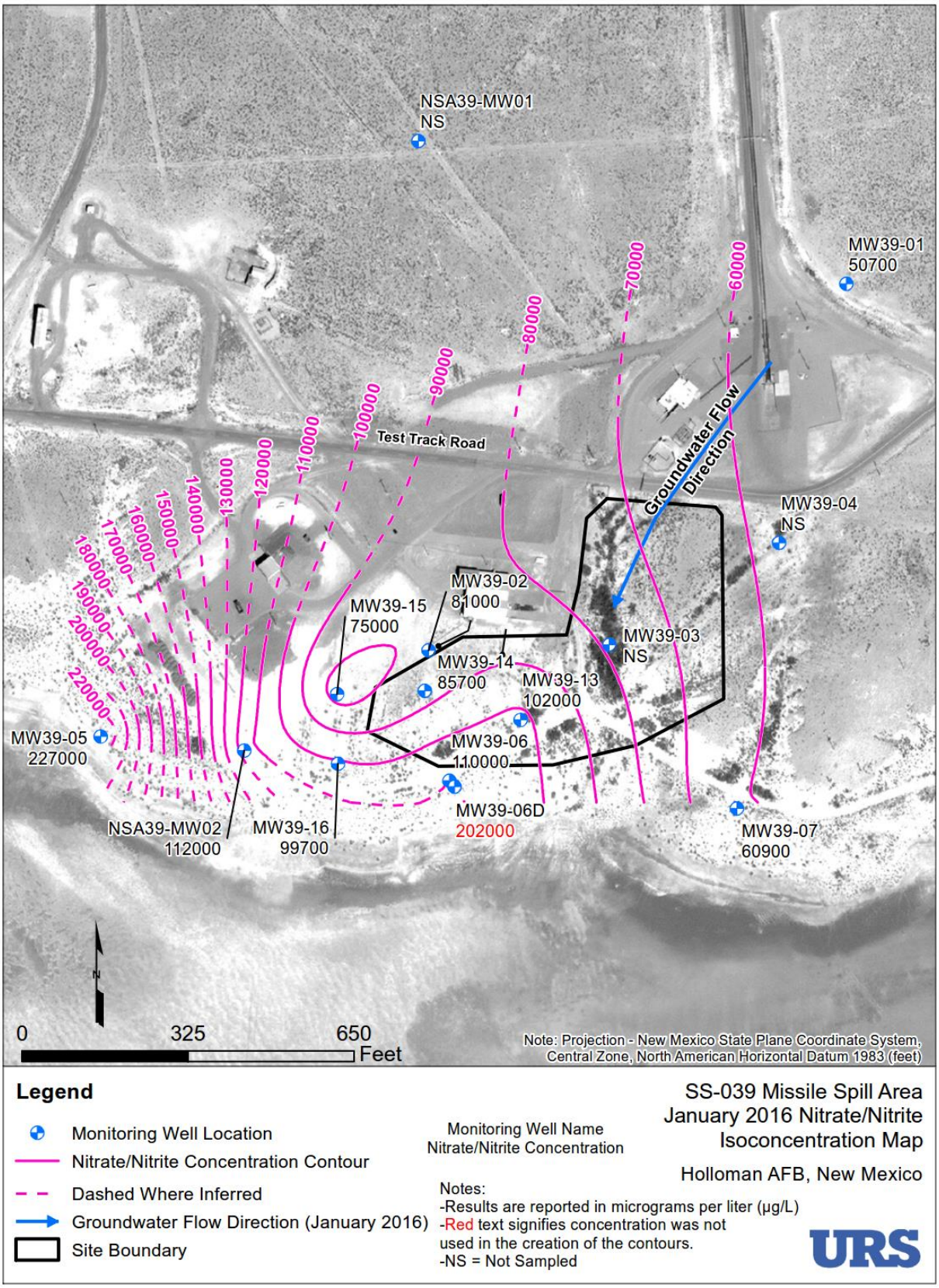

Figure 5. Nitrate/Nitrite Isoconcentration Map – January 2016

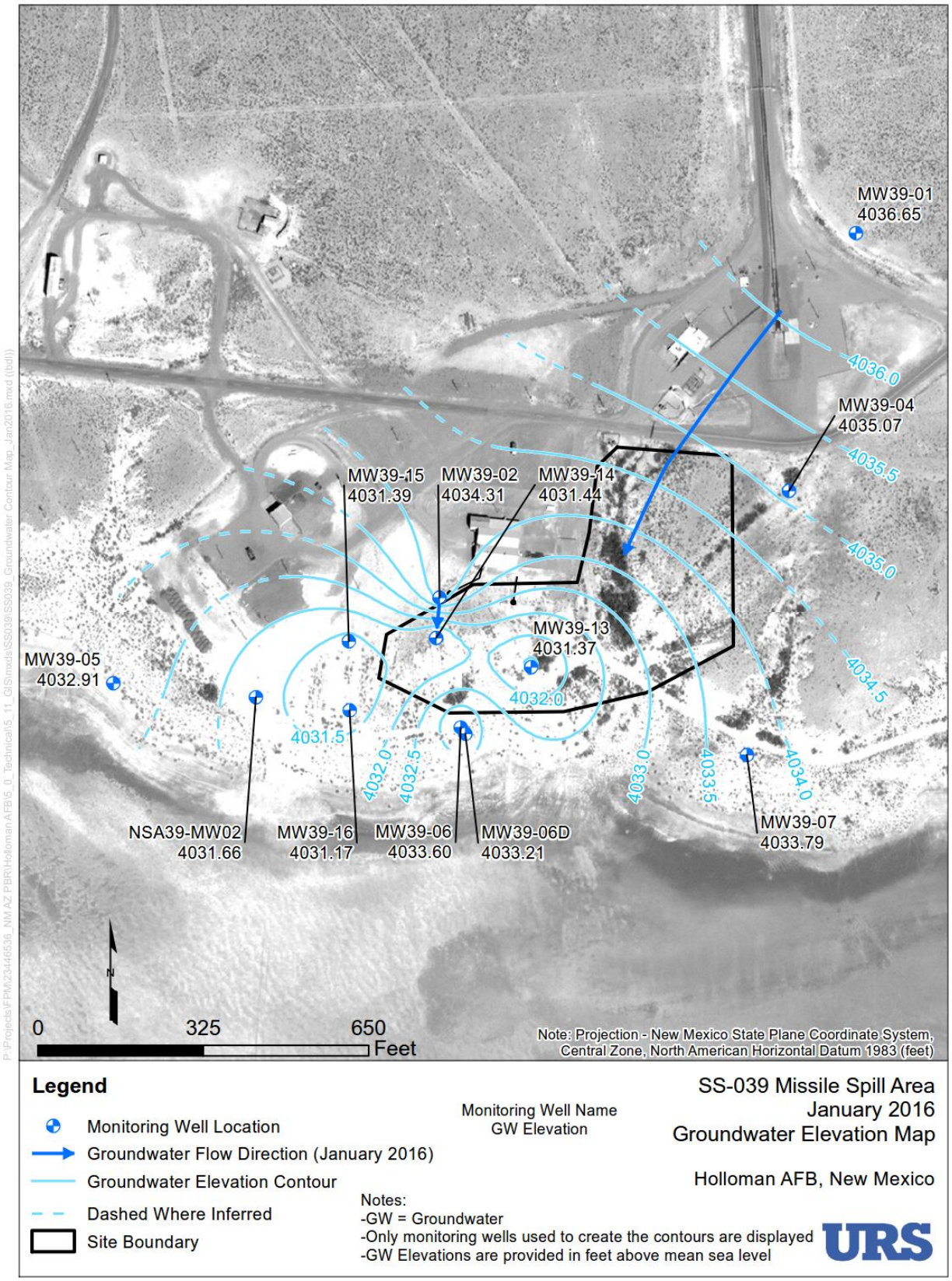

Figure 6. Groundwater Elevation Map – January 2016

Figure 7. Vapor Sample Locations

APPENDIX A

Procedures

Appendix A-1 Measurement of Groundwater and Fluid Levels in Wells

Appendix A-2 Monitoring Well Purging and Groundwater Sampling

Appendix A-3 Measurement of Groundwater Field Parameters

Appendix A-4 Decontamination

Appendix A-5 Sample Identification, Management, and Handling

Appendix A-6 Investigation Derived Waste Management

This procedure provides technical guidance and methods to be used for measurement of groundwater and fluid levels in wells (well gauging). In addition to groundwater, fluid levels that are routinely monitored are light and dense non-aqueous phase liquids (LNAPL and DNAPL, respectively). Where possible, well gauging should be conducted first in areas least affected by Site constituents, followed by increasingly affected areas. Sampling locations are specified in the long-term monitoring plan. All activities will be conducted in accordance with the site-specific Health and Safety Plan (HASP).

1.0 EQUIPMENT AND MATERIALS

The following equipment is may be used for the collection of fluid level data:

- Field log book
- Monitoring well gauging form (Attachment 1 to Appendix A-1)
- Electronic water level indicator with depth intervals marked to the nearest 0.01 feet
- Oil/water interface probe with depth intervals marked to the nearest 0.01 feet
- Weighted steel measuring tape with decimal foot increments (if depth to the bottom of the well is to be determined)
- Peristaltic pump (for evaluating the presence/absence of DNAPL)
- Standard hand tools (wrench, pliers, screwdrivers, cutting tools, etc.)
- Keys to well locks
- Decontamination equipment
- Appropriate health and safety equipment as required by the HASP
- Personal protective equipment (PPE) as required by the HASP

2.0 METHODOLOGY

The methodology for measuring groundwater levels, well depths, LNAPL levels, and DNAPL levels is provided below. The owner's manual for the water level indicator meter and the oil/water interface probe shall be referenced to ensure proper operation of the instruments.

2.1 GROUNDWATER LEVEL MEASUREMENTS

Groundwater level measurements will be performed using a water level indicator meter that has been decontaminated in accordance with Appendix A-4. Efforts should be made to complete the groundwater level gauging event during one day. Should one day prove to be insufficient time, gauging shall be completed over further consecutive days, as necessary.

The following procedures will be followed to measure the depth to groundwater in wells:

1. Locate and open the monitoring well or piezometer. Sometimes vapor pressure builds up within the well casing due to the well cap restricting the ability of the well to vent to atmosphere. The pressure build up may depress the water/fluid level in the well. Allow fluid levels to equilibrate to atmospheric pressure for several minutes prior to gauging.

2. Check the operation of the water level indicator meter by turning on the indicator switch and pressing the test button.
3. Holding the water level meter above the well casing, lower the probe into the well until the indicator contacts the water surface. The contact with water is indicated by the buzzer sounding and illumination of the indicator light.
4. Record the point on the graduated cable that corresponds to the surveyed well casing measuring point when the alert is first produced. If necessary, grasp cable with thumb and index finger exactly at the measuring point marked at the top of the well casing. Pull tape out of well slowly and read measurement.
5. Record the depth to water surface to the nearest 0.01 ft on the gauging form.
6. Remove the water level cable and probe from the well. Inspect the probe for evidence of LNAPL. Evidence includes petroleum or solvent odor or a visible oil sheen or film on the probe. Record presence or absence of LNAPL on the gauging form (see Section 2.3 for instructions on LNAPL level measurements).
7. Decontaminate the water level probe in accordance with Appendix A-4.

2.2 MEASURING TOTAL DEPTH OF WELL

In situations where it is necessary to measure the total depth of a well (such as during well development, etc.), the following procedures may be followed:

1. Lower a weighted steel measuring tape slowly from center of well to sound the bottom of the well. Sounding the bottom of the well prior to sampling of the well is not recommended due to the potential for re-suspension of settled formation solids in the well.
2. When the weight is felt to hit the bottom or tape slackens noticeably, draw tape up very slowly until it is taut again.
3. Record the well depth at the surveyed well casing measuring point to the nearest 0.1 feet.
4. A water-level indicator or oil/water interface probe may also be used; however, the depth measured on the tape may reference a point other than the tip of the probe. In this case, a measurement from the tip of the probe to the measuring point should be made and that length added to the total measured depth.

2.3 LNAPL LEVEL MEASUREMENTS

The following steps will be followed to measure the thickness of LNAPL in wells:

1. LNAPL level measurements will be preceded by groundwater level measurements. Complete Steps 1 through 8 of Section 2.1 prior to measuring LNAPL levels.
2. Use a clean oil/water interface probe that has been decontaminated in accordance with Appendix A-4.

3. Lower the oil/water interface probe into the well until the air/LNAPL interface is detected by the instrument. Record the depth relative to the well casing measuring point to the nearest 0.01 foot on the well gauging form or in the field logbook.
4. Continue to lower the oil/water interface probe in the well to detect the oil/water interface. Once the instrument detects the water surface, continue to lower the probe approximately one foot and gently raise the probe up and down in the water column to rinse off LNAPL that has adhered to the probe that may affect the reading. Then slowly raise the probe to detect the water/oil interface and record the depth relative to the well casing measuring point to the nearest 0.01 foot on the well gauging form or in the field logbook. *Note: If the thickness of LNAPL is small enough that the lower bound of LNAPL cannot be measured with the oil/water interface probe, then record this observation as a film or sheen on the fluid level gauging form or field logbook.*
5. If gauging of DNAPL level is also to be performed in the well, proceed to Section 2.4. If not, proceed to Step 6 below.
6. Remove the oil/water interface cable and probe from the well.
7. Decontaminate the oil/water interface probe and cable in accordance with Appendix A-4.

2.4 DNAPL LEVEL MEASUREMENT

The oil/water interface of DNAPL in a well, if present, will be estimated using the following procedures:

1. DNAPL level measurements will be preceded by groundwater level measurements (Section 2.1) and LNAPL level measurements (Section 2.3), if LNAPL exists in the well.
2. After measuring the thickness of LNAPL in the well (if present), lower the oil/water interface probe in the well until DNAPL is encountered, if any. Measure the depth to the water/oil interface of DNAPL in the same manner as that for air/oil interface of LNAPL, as described in Section 2.3 above.
3. A high suspended solids content at the bottom of a well has been found to produce false positive results for the detection of DNAPL with an oil/water interface probe. Therefore, if DNAPL is detected using an oil/water interface probe, a peristaltic pump, or similar methods, should be used to confirm the presence or absence of DNAPL. About one pint of fluid may be pumped from the bottom of the well for visual inspection of the presence or absence of DNAPL.
4. The results of the visual inspection will be recorded on the well gauging form or in the field logbook.
5. Peristaltic pump tubing, if not dedicated, will be disposed of in accordance with IDW handling specified in Appendix A-6. The oil/water interface probe and cable will be decontaminated in accordance with Appendix A-4.

3.0 DOCUMENTATION

Documentation during well purging and sampling will be in accordance with Appendix A-5. Documentation of the observations and data acquired in the field will provide information on the

activities conducted and also provide a permanent record of field activities. Observations and data will be recorded on a well gauging form and in the field logbook.

3.1 FIELD NOTES

The following information will be recorded in a bound field logbook using indelible ink:

- Names of gauging personnel
- Weather conditions
- Date
- Start time of gauging
- End time of gauging
- Gauging locations
- Gauging equipment used
- Any significant difference in time between gauging individual wells
- Decontamination records
- Any other pertinent information

3.2 FIELD FORMS

A well gauging form will be completed for each day of gauging. The form will contain entries for each well gauged during that day. The following information will be recorded:

- Project name / number
- Location
- Date
- Gauging personnel
- Monitoring well identification numbers
- Static LNAPL depths (if any)
- Static water depths
- Static DNAPL depths (if any)
- Well depth (sounding), if measured

Attachment 1

Water Level Measurement Form

URS

8181 E. Tufts Avenue
Denver, Colorado 80237
Tel: 303.694.2770
Fax: 303.694.3946

Groundwater Level Measurement Form

Date: _____

Page _____ of _____

Project Name: _____ **Location:** _____

Project Number: _____ **Measured By:** _____

Well ID	TOC Elevation (ft MSL)	LNAPL Depth (ft bTOC)	Water Depth (ft bTOC)	DNAPL Depth (ft bTOC)	Comments

Casing Volume

Casing I.D. (in.)	Unit Casing Volume Gal/Lin. Ft.)
1.0	0.04
1.5	0.09
2.0	0.16
2.2	0.20
3.0	0.37
4.0	0.65
4.3	0.75
5.0	1.00
6.0	1.55
7.0	2.00
8.0	2.60

Additional Remarks

This procedure provides technical guidance and methods that will be used for monitoring well purging and groundwater sampling using low-flow sampling methods. The samples will be analyzed to provide data on the presence and concentration of Site constituents in groundwater on the site. The procedures outlined herein are accordance with groundwater sampling methods recommended by the U.S. Environmental Protection Agency (EPA) (1992, 1996). Details on site-specific sampling activities, equipment selection (i.e., pumps), site-specific field parameters, and laboratory analyses are presented in the Work Plan and/or the Quality Assurance Project Plan (QAPP).

This procedure will provide descriptions of equipment, field procedures, and documentation necessary to properly collect groundwater samples for laboratory analysis. Sampling locations are specified and shown in the long-term monitoring plan.

All activities will be conducted in accordance with the site-specific Health and Safety Plan (HASP).

1.0 EQUIPMENT AND MATERIALS

- Field log book
- Electronic water level indicator or interface probe
- Peristaltic pump, bladder pump, centrifugal pump, bailer, or submersible pump
- Appropriate power source and cords for pump (i.e., generator, compressor, or inverter)
- Flow-rate controller for pump, as applicable
- Graduated cylinder or other volumetric measuring device
- Plastic sheeting or other clean work surface
- Disposable polyethylene discharge tubing
- Disposable Pharmed®, Tygon®, or equivalent tubing (for peristaltic pump only)
- Water quality meters (at a minimum pH, conductance, and temperature; ORP, and turbidity may also be used)
- New disposable or decontaminated stainless-steel bailer, if specified in the Work Plan
- Rope or twine: nylon, polypropylene, or similar
- Watch
- Purge water collection system (bucket(s) with lid(s), drum, etc.)
- Standard hand tools (wrench, pliers, screwdrivers, cutting tools, etc.)
- Keys to well locks
- Decontamination equipment per Appendix A-4
- Appropriate health and safety equipment as required by the HASP
- Personal protective equipment (PPE) as required by the HASP

- Paper towels
- Copies of well drilling and installation records, including boring logs and well completion diagrams for the wells to be sampled
- 0.45-µm in-line filter or other appropriate filtering approaches (for dissolved constituents only), if applicable
- Flow-through cell
- Sample containers (including temperature blanks)
- Sample labels
- Sample logs / well sampling forms
- Chain of custody forms
- Custody seals
- Shipping labels / AirBills
- Strapping / shipping tape
- Garbage bags
- Ziploc®, or similar, bags
- Cooler(s)
- Ice

2.0 PURGING AND SAMPLING METHODOLOGY

Groundwater sampling incorporates several phases of multiple steps in order to achieve the highest possible accuracy and precision of laboratory analytical results. Proper preparation, purging, and sampling techniques greatly reduce the risk of cross-contamination or other unwanted variances of the analytical data. Where possible, sampling should be conducted first in areas least affected by Site constituents, followed by increasingly affected areas. The proper information will be recorded in the field log book or well sampling form as specified in Section 3 of this procedure.

2.1 PREPARATION FOR SAMPLING

Preparation for sampling includes inspecting the condition of the well, monitoring health and safety conditions, and calibrating and decontaminating sampling equipment. General procedures are presented below:

1. Make sure area around well head is clean and free of debris.
2. Inspect condition of well (e.g., well locked, loose-fitting cap, measuring point well marked, surface casing disturbed, well casing straight, condition of concrete pad). Indicate condition of well on the sampling form.

3. Remove well cap. If the HASP identifies organic compounds as potential contaminants of concern and requires breathing zone monitoring, screen well headspace and breathing zone headspace for organic vapors using the appropriate field monitoring instrument.
4. All equipment should be decontaminated in accordance with Appendix A-4 before introduction to each well. Protective latex or nitrile gloves should be worn during possible water-contact or equipment-contact activities. At a minimum, gloves should be changed between each well or when introduction of potential contaminants to the well is possible.
5. Measure water level using a decontaminated electronic water level meter as described in Appendix A-1. Sounding the bottom of the well using a weighted tape (i.e., for well casing volume calculations) prior to sampling is not recommended due to the potential for resuspension of settled solids in the formation. Well depth information should be obtained from the well logs or collected after sampling activities are complete, if possible.
6. If light non-aqueous phase liquid (LNAPL) is suspected, measure fluid level in accordance with Appendix A-1.
7. Calculate the well casing volume as follows:

   $$\text{well casing volume (gal)} = \pi\,(r^2)(h)(7.48\ \text{gal/ft}^3)$$

   Where h = height of water in the well casing (i.e., depth to bottom of the well minus depth to water (in ft), and r = radius of well casing in feet. Record this volume on the well sampling form.
8. Calibrate water quality meters for measuring field parameters as specified by the equipment manufacturer(s). At a minimum, temperature, pH, and specific conductance measurements will be collected during purging and prior to sampling; however, do not immerse water quality meter probes into purge water containing free product. Other field parameters, including dissolved oxygen, Eh (redox, ORP), and turbidity (recommended for inorganics), etc. may be required as specified in the Work Plan. Record equipment calibration and maintenance in the field book. Decontaminate meters between wells by rinsing with distilled water. Manage rinse water used for these measurements in the same manner as purge water, as defined in the Work Plan.

2.2 WELL PURGING METHODS

Monitoring wells will be purged prior to collecting groundwater samples for analyses. Low flow purging procedures (EPA 1996) generally will be followed; however, certain wells or sites may also be sampled by purging three well volumes of groundwater prior to sample collection. The purpose of well purging is to remove stagnant groundwater from the well (which has interacted with air in the well casing). Field parameters (i.e., pH, temperature, and specific conductance) are measured during the purging process to verify that stagnant water has been removed and groundwater conditions are stable prior to sampling. A variety of pumps may be used to purge and sample the monitoring well: the pump type will be specified in the Work Plan. Refer to the manufacturer's instructions for operation of the specified pump. General procedures for purging are outlined below:

1. Lower the pump intake, bailer, or tubing (as applicable) into the water column. The pump intake or tubing should be placed at the middle or slightly above the bottom of the screened interval.
2. For low-flow purging, conduct purging at a rate that will minimize drawdown in the well (i.e., purge at a rate less than or equal to recharge, if possible). Recommended purge rates are generally less than 0.13 gal/min (0.5 L/min), or a rate that results in minimal drawdown in the well (e.g., less than 1 foot). Actual purge rates will vary based on aquifer material and well construction.
3. Continue purging the well until field parameters have stabilized within 10 percent, according to Appendix A-3. Once field parameters have stabilized, reduce the pump rate to approximately 0.025 to 0.13 gal/min (0.1 L/min to 0.5 L/min). The pump should continue to operate at the lower rate to allow the water collected at that rate to travel to the surface discharge point.
4. In the event that even very low purge rates result in evacuation of the well, groundwater samples for laboratory analyses should be collected as soon as sufficient groundwater accumulates in the well, regardless of field parameters or total volume purged.
5. If the three-volume purge method is utilized, field parameters will be recorded after each well volume of groundwater is purged.

2.3 GROUNDWATER SAMPLING METHODS

Groundwater sampling is conducted following purging of the well. Where possible, groundwater samples for analyses should be collected directly from the pump discharge at the lowest rate possible to minimize cross contamination, suspension of solids, and aeration of the sample. Bladder pumps, peristaltic pumps, and submersible pumps (e.g. Grundfos®, Whale, Typhoon) are generally suitable for purging and sampling of all groundwater parameters. Bailers are generally not recommended for purging or sampling of groundwater monitoring wells due to the potential for agitating solids in and adjacent to the well; however, the three-volume purge method often uses bailers, especially when turbidity of the groundwater is not a concern.

Target analytes, container types, and preservatives are specified in the Work Plan, or QAPP.

The general procedures for groundwater sample collection are as follows:

1. Groundwater samples should be introduced directly from the pump discharge into the proper sample container and filled to capacity.
2. In general, groundwater samples collected for multiple compounds should be collected in the following order (EPA 1992):
   - VOCs
   - Dissolved gases and total organic carbon (TOC)
   - SVOCs
   - Metals and cyanide
   - Major water quality cations and anions

- Radionuclides
- Other analytes

3. When collecting samples for VOCs, direct flow from the pump discharge down the interior side of the sample container to minimize aeration. Hold caps in hand to minimize contamination of sample. Fill all VOC sample containers to the top. A positive meniscus at the top of the container will help ensure that no air is trapped inside when cap is screwed down on the container. No air bubbles should be trapped in the sample when the container is sealed.
4. In some cases, field filtration may be required (recommended for dissolved metals). If applicable, attach a new, disposable filter cartridge (typically 0.45 µm) to the discharge line. Filtered water should be introduced directly into the appropriate sample container. Alternate field filtration methods may be specified in the Work Plan or QAPP. *Although not recommended, the laboratory can sometimes filter the samples if the samples are NOT preserved and are filtered within 24–48 hours of collection.*
5. Collect quality assurance and quality control (QA/QC) samples (i.e., field duplicate, laboratory matrix spike, and laboratory matrix spike duplicate, as applicable) at the same time by filling all bottles from the same flow. Ambient or field blanks should be filled using distilled or de-ionized (DI) water (supplied by the laboratory) in the same area as the primary samples. The number and types of QA/QC samples are specified in the Work Plan or QAPP.
6. Sample bottles must be labeled with date, sample number, time, sampler's name, and type of preservative, as described in the QAPP. Sample bottles must be placed in a cooler or on ice to keep the sample cool (≤6 °C). Samples must be cooled continuously from time of collection to time of receipt at the laboratory.
7. Disconnect the peristaltic pump from the dedicated tubing in the well. If using a submersible pump, remove the pump and tubing from the well. Close and lock the well. Decontaminate the sampling equipment in accordance with Appendix A-4. Purge, wash, and rinse water should be managed as specified in the Work Plan.
8. Complete chain-of-custody forms, package samples for shipment, and ship samples or arrange for courier to laboratory.
9. All field observations made and data generated in conjunction with the sample collection will be documented on the groundwater field sampling form.

3.0 DOCUMENTATION

Documentation during well purging and sampling will be in accordance with the work plan. Documentation of the observations and data acquired in the field will provide information on the activities conducted and also provide a permanent record of field activities. Observations and data will be recorded on a well sampling form and in the field logbook.

3.1 FIELD NOTES

The following groundwater purging and sampling information will be recorded in a bound field logbook using indelible ink:

- Names of sampling personnel
- Weather conditions
- Date and time of sampling
- Sampling locations, including locations of QA/QC samples
- Start and stop time for each well sampled
- Decontamination and calibration records
- Other information as specified in the Work Plan
- Any other pertinent information that may have a bearing on sample quality

3.2 FIELD FORMS

A well sampling form will be completed for each well sampled. The following information will be recorded:

- Project name / number
- Location
- Date
- Sampling personnel
- Monitoring well identification number
- Static water depth
- Well depth and diameter
- Water column thickness and well volume, if necessary
- Depth of pump or tubing intake
- Time of purge monitoring readings
- Sample time
- Identification of QA/QC samples
- Sampling equipment (pump and tubing types, etc.)
- Sampling pump rate

4.0 REFERENCES

EPA. 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste, Washington, DC EPA/530/R-93/001, NTIS PB 93-139350, November.

EPA. 1996. Low-flow (minimal drawdown) ground-water sampling procedures, by R.W. Puls and M.J. Barcelona. U.S. EPA Ground Water Issue: EPA/540/S-95/504, April.

Attachment 1

Example of Well Sampling Form

URS
8181 E. Tufts Avenue
Denver, Colorado 80237
Tel: 303.694.2770
Fax: 303.694.3946

Groundwater Sample Collection Form

Well Identification _____

Page _____ of _____

Project Name: _____
Project Number: _____
Location: _____
Date: _____

Sampled By: _____
Sample ID: _____
Sample Date: _____
Sample Time: _____

Equipment

Purging Method/Equipment _____
Sampling Equipment _____
Filtering Equipment _____

Field Parameters

Initial Water Temp. (C) _____
Initial pH: _____
Initial Conductance (mS/cm): _____
Reference Point _____

Sampling Packaging

Number	Type and Volume of Container(s)	Filtered	Preservatives	Parameters

Purging Information

Casing I.D. [a] (in.): _____
Unit Casing Volume [b] (gal/ft) _____
Depth to Water [c] (ft, bgs): _____
Depth to Bottom of Well [d] (ft, bgs): _____

Length of Static Water Column [e] = [d] - [c] (ft): _____
Casing Water Volume [f] = [b] x [e] (gal) _____
Total Purged Volume [g] (gal): _____
Number of Purged Volumes [h] = [g] / [f]: _____

Volume Purged (gal)	Temp (C)	pH	Conductance (mS/cm)	Time	DO (mg/L)	Turbidity (NTU)	Water Description

Total Volumes Removed (gallons): _____ **Time:** _____ **Purged Dry (Y/N):** _____

Casing Volume

Casing I.D. (in.)	Unit Casing Volume Gal/Lin. Ft.)
1.0	0.04
1.5	0.09
2.0	0.16
2.2	0.20
3.0	0.37
4.0	0.65
4.3	0.75
5.0	1.00
6.0	1.55
7.0	2.00
8.0	2.60

Additional Remarks

This procedure provides technical guidance and methods that will be used for field measurement of water quality parameters (e.g., pH, specific conductance, oxidation-reduction potential, dissolved oxygen, and temperature) in the field. The measurements will be taken to provide data on the general quality of surface water and groundwater, as well as to verify the presence of non-stagnant groundwater during monitoring well sampling. The procedures outlined herein are in accordance with groundwater sampling methods recommended by the U.S. Environmental Protection Agency (U.S. EPA 1992, 1996). Details on Site-specific sampling activities are presented in the Work Plan. Where possible, field parameter measurement should be conducted first in areas least affected by Site constituents, followed by increasingly affected areas.

This procedure will provide descriptions of equipment, field procedures, and documentation necessary to properly measure selected field parameters. Due to the variety and complexity of water quality meters available, calibration and measurement procedures should be conducted in accordance with manufacturer's recommendations for specific meters used.

All activities will be conducted in accordance with the site-specific Health and Safety Plan (HASP).

1.0 EQUIPMENT AND MATERIALS

- Field log book
- Water quality parameter multimeter or meters specific to parameters of interest (i.e., pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature, and turbidity)
- 250- to 500-mL beakers or flow-through cell for groundwater
- Calibration solutions and deionized distilled water
- Sample logs / well sampling forms
- Sampling equipment

2.0 METHODOLOGY

Calibrate meter(s) in the field at the beginning of each day of field or laboratory work when water quality parameters will be measured. Check meters with calibration standards after every four hours of continuous use. If drift is evident, recalibrate. Record appropriate information in accordance with Section 3 of this procedure.

The measurement of surface water and groundwater field parameters will be conducted in the following steps:

1. Fill multimeter cell, beaker, or jar with fresh sample water.
2. Immerse electrodes in sample while swirling the sample, if needed, to provide thorough mixing. If a flow-through cell is used, install probes and connect sample water to bottom port of flow-through cell, directing sample water up through the cell, exiting through the top port. Direct effluent tubing into an appropriate container for storage and handling.
3. When the readings have stabilized, record the measurements displayed on the meter. It is important to determine that the correct units and unit scale are displayed on the meter and

recorded for each parameter measured. Record and correct any problems encountered during measurement. Note: parameter measurements may not stabilize for a given measurement when using a flow-through cell- professional judgment should be used when selecting parameters to be recorded in this case.

4. If available, field measurement results should be compared to previous measurements for quality control.

3.0 DOCUMENTATION

Documentation during water quality parameter measurement will be in accordance with the work plan. Documentation of the observations and data acquired in the field will provide information on the activities conducted and also provide a permanent record of field activities. Observations and data will be recorded on a sampling log (i.e., well sampling form) and in the field logbook.

3.1 FIELD NOTES

The following water quality parameter measurement information will be recorded in a bound field logbook using indelible ink:

- Names of sampling personnel
- Weather conditions
- Decontamination and calibration records
- Other information as specified in the Work Plan
- Any other pertinent information that may have a bearing on data quality

3.2 FIELD FORMS

A well sampling form will be completed for each well location where field water quality parameters are measured. The following information will be recorded:

- Project name / number
- Location
- Date and time of parameter measurement
- Sampling personnel
- Monitoring well identification number or sampling location
- Static water depth
- Depth of pump or tubing intake
- Water quality measurement equipment (meter model, etc.)
- Sampling locations, including locations of QA/QC samples

4.0 REFERENCES

U. S. EPA. 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste, Washington, DC EPA/530/R-93/001, NTIS PB 93-139350, November.

U.S. 1996. Low-flow (minimal drawdown) ground-water sampling procedures, by R. W. Puls and M.J. Barcelona. U.S. EPA Ground Water Issue: EPA/540/S-95/504, April.

This procedure details the procedures for decontamination of personnel and equipment during field activities. Decontamination of personnel and equipment (e.g., water and soil sampling equipment, vehicles, etc.), is required to minimize the possibility of cross-contamination of environmental samples between sampling locations. In addition to this procedure, refer to the site-specific Health and Safety Plan (HASP) for additional requirements regarding decontamination procedures.

1.0 EQUIPMENT

The following is a list of equipment that may be necessary to perform decontamination activities:

- Personal protective equipment (PPE) as outlined in the HASP
- Paper towels
- Alconox® / Liquinox® detergent (or equivalent)
- Potable or non-potable water
- Deionized or distilled water
- Water sprayers or hand-held spray bottles
- Disposable nitrile gloves
- Clean plastic sheeting, and/or trash bags

2.0 DECONTAMINATION PROCEDURES

Section 2 describes decontamination of sampling equipment that may be utilized to prevent cross-contamination between sampling locations. Decontamination procedures to be implemented for the protection of worker and public health, safety, and the environment are also set forth in the following section. Different types of decontamination may be necessary for the following:

- Soil sampling equipment;
- Water sampling equipment;
- Instruments; and
- Vehicles and personnel.

2.1 DECONTAMINATION OF SAMPLING EQUIPMENT

The procedures in this section are designed to prevent cross-contamination of samples collected in different sample locations. Procedures for decontamination of sampling equipment apply to equipment that is re-usable (e.g. funnels and shovels) and contacts a sampled medium (e.g., water). Decontamination of sampling equipment may be performed at each sample collection location upon completion of sampling.

General requirements for decontamination are listed below:

- Personnel may wear appropriate safety equipment to reduce personal exposure, as required by the HASP.
- New nitrile gloves may be worn when performing equipment decontamination.
- Detergent and rinse solutions to be used for decontamination procedures may be replaced with new solutions between sample collection events unless the solution is stored in a water sprayer.
- Bulk contamination, such as large pieces of soil, may first be removed by hand or tools.
- Equipment may then be washed in a detergent/water solution, using brushes and other tools, as appropriate, until clean. The water used may be clean and may be potable, non-potable, deionized, or distilled.
- Washed equipment may be rinsed first by potable water, or by deionized/distilled water, if potable water is not available.
- A final rinse may be by deionized or distilled water.
- Equipment may be inspected for visible contamination and washed again if necessary.
- Equipment may be dried and stored in a clean location. Air-drying is an acceptable method for most equipment.

2.2 DECONTAMINATION OF PERSONNEL

The procedures in this section are designed to protect the worker and public health, safety, and the environment. Procedures for decontamination of personnel apply to any person (including clothing) who is exposed to contaminated site material such as groundwater or soil. Decontamination of personnel may be performed prior to leaving the site, or as necessary to protect health and safety.

General requirements for decontamination are listed below:

- Personnel may wear appropriate safety equipment to reduce personal exposure, as required by the HASP.
- Bulk contamination, such as large pieces of soil, may first be removed by hand or tools, with special attention to boots and coveralls.
- Personnel and clothing may then be washed with a detergent/water solution, using brushes and other tools, as appropriate, until clean. The water used may be clean and may be potable, non-potable, deionized, or distilled.
- Following washing, a water rinse may be conducted to flush contaminated media and detergents from the affected area.

2.3 DECONTAMINATION OF VEHICLES

The procedures in this section are designed to protect the worker and public health, safety, and the environment. Procedures for decontamination of vehicles apply to any vehicle or piece of heavy equipment that is exposed to contaminated site material such as groundwater or soil. Decontamination of vehicles may be performed prior to leaving the site, or as necessary to protect health and safety.

General requirements for decontamination are listed below:

- Personnel may wear appropriate safety equipment to reduce personal exposure, as required by the HASP.
- Bulk contamination, such as large pieces of soil, may first be removed by hand or tools, with special attention to tires or tracks, wheel-wells, and compartments such as dump truck beds and excavator or backhoe buckets.
- A rinse with water may be conducted to flush contaminated media from the affected area. If necessary, a high-pressure washer and/or detergent solution may be used to remove contaminated media.

2.4 INVESTIGATION DERIVED WASTE MANAGEMENT

Solid and liquid IDW generated during decontamination procedures may be managed as described in Appendix A-6 for IDW.

Solid IDW generated during decontamination procedures may consist of: (1) PPE used during the decontamination process and (2) disposable material used to decontaminate equipment.

Liquid IDW may generally consist of wash/rinse water, and may contain a substantial amount of solids. It is permissible, after solids settle, to decant clear water from such a container to another IDW container, thus separating solid and liquid IDW.

3.0 DOCUMENTATION

Sampling personnel may document the decontamination that occurs within a sample collection site in the field log book. The information entered in field log books concerning decontamination may include the following:

- Decontamination personnel
- Date/time
- Location
- Type of containment for decontamination fluids
- Other pertinent information

This procedure provides technical guidance and methods that will be used for sample identification, labeling, packing, documentation, and Chain-of-Custody (COC) procedures. All activities will be conducted in accordance with the site-specific Health and Safety Plan (HASP).

1.0 EQUIPMENT NECESSARY FOR SAMPLE HANDLING, SHIPPING, AND DOCUMENTATION

The following equipment may be used for sample labeling, packing, documentation, and COC procedures:

- Personal protective equipment (PPE) as specified in the Health and Safety Plan (HASP)
- Decontamination equipment and supplies
- Clean sample containers with preservatives, if required.
- Shipping coolers
- Re-sealable plastic bags (Ziplock® or equivalent)
- Sample labels
- Shipping forms (provided by shipping courier)
- Shipping labels (e.g. Fragile, This Side Up, etc.)
- Chain-of-Custody forms
- Custody seals
- Bubble wrap or equivalent packing material
- Tape (e.g., clear tape, strapping/packing tape)
- Ice or other refrigeration method
- Paper towels
- Large trash bags

2.0 SAMPLE IDENTIFICATION

Each sample collected will have a unique sample identification (ID). These IDs are necessary to identify and track each sample collected for analysis during the project. Accurate and comprehensive sampling records are necessary to create a complete record of field procedures, including circumstances of collection and integrity of a given sample.

3.0 SAMPLE HANDLING, SHIPPING, AND DOCUMENTATION PROCEDURES

3.1 FIELD SAMPLE PROCESSING AND CUSTODY

A Chain-of Custody (COC) for each sample will be maintained and documented from the sampling location through its delivery to the laboratory for analysis. Each sample must be in the custody of the sampling team or Sample Manager from the moment it is extracted and containerized until sample shipment. Samples will be containerized and labeled at the sample collection location. Samplers may relinquish containerized samples to the Sample Manager for completion of the documentation and preparation of the samples for shipment. Changes in custody (e.g. from sampler to Sample Manager) will be documented in logbooks that identify the personnel relinquishing custody and personnel receiving the custody of the samples. The COC accompanies the samples and is used by the Sample Manager to document transfer of custody from the field team to the shipping agent.

3.2 SAMPLE LABELING

Sample labels may be filled out partially before field sampling activities begin. The date, time, and sampler's initials or signature should not be completed until the time of sample collection. Sample labels will be filled out using waterproof ink.

Care will be taken during labeling and taping to preclude the possibility of sample contact with label or tape adhesive.

3.3 SAMPLE HANDLING

This section discusses proper sample containers, preservatives, and handling and shipping procedures.

3.3.1 Sample Containers

Commercially clean sample containers will be obtained from a subcontracted analytical laboratory or vendor and filled with sample material in accordance with these procedures.

3.3.2 Sample Preservation and Storage

All samples collected for chemical analysis will be stored on ice (or similar) in an insulated cooler to maintain a temperature of <6°C and shipped on ice (or similar) to the laboratory for preparation and analysis.

3.3.4 Sample Packaging and Shipping

The Sample Manager is responsible for confirming that samples collected by the sampling team have been properly containerized, packed, and labeled. Once the Sample Manager has custody of samples, he/she is responsible for maintaining custody (i.e., keeping samples in the designated secure location), and packaging and shipping the samples in a timely and proper manner.

Samples and sample containers will be packaged properly to protect the integrity of the sample and its seal, prevent breakage of containers, and prevent leakage of contents.

A copy of the shipping bill will be retained by the Sample Manager for attachment to the corresponding copy of the COC form, and these forms will be maintained by the URS Field Manager in accordance with this procedure.

Packing and Shipping Samples for Chemical Analysis

- Place sufficient amounts of packing material (e.g., bubble wrap) in the bottom and sides of the shipping cooler to prevent movement of contents.
- Line the inside of the cooler with a plastic trash bag, add enough ice (in double bags) to the cooler to maintain the required temperature of <6°. Line the bottom, sides, and top of cooler to retain proper shipment temperature; using at least 3-4 one gallon bags of ice per 48-quart cooler is recommended.
- A bottle containing tap water and identified as a temperature blank will be included with each cooler containing samples cooled to <6°C. Upon receipt of the samples at the laboratory, the temperature blank will be used to determine the cooler temperature. The temperature blank will not be assigned a sample identification number and will not appear as a line item on the chain-of-custody form.
- Place samples and temperature blank inside the bag in an upright position. Tie shut the trash bag holding the samples and ice.
- Fill excess space in the cooler with ice bags or other packing material (e.g., bubble wrap) to prevent movement of sample containers.
- Place the original signed copy of the COC form inside a plastic bag, and tape the bag inside the cooler lid, reserve the carbon copy or photocopy of the COC for URS' records.
- Close the cooler lid, and seal the cooler and the cooler spout with appropriate packaging tape.
- Place two custody seals (tampering seals) after signing and dating on the cooler in separate areas across the gap between the lid and the cooler base. Tape the custody seals to the cooler to confirm that custody seal is adequately affixed.

Samples may be shipped for Saturday delivery; however, Saturday delivery will require laboratory approval before shipment.

3.3.5 Sample Container Tampering

If, at any time after samples have been sealed and secured, custody seals on the sample container, or cooler are identified as having been tampered with, the following procedures will be conducted:

- Check with personnel having access to sample coolers/containers to evaluate whether inadvertent tampering can be documented.
- Document findings of the incident in a logbook.

If it cannot be confirmed and documented that the custody seal was broken inadvertently and that the integrity of samples is unimpaired, the samples will be re-collected and the URS Project Manager and URS Quality Assurance Manager (QAM) will be notified.

3.3.6 Holding Times and Analyses

The holding time is specified as the maximum allowable time between sample collection and analysis or extraction, based on the analyte of interest, stability factors, and preservative (if any) used. Any storage of samples on Site will be scheduled to be kept to the minimum period, based on logistic considerations (e.g. samples will not be shipped over weekends unless advance arrangements for receipt have been made with the laboratory).

4.0 CHAIN-OF-CUSTODY PROCEDURES

The custody of samples shall be documented on the COC. These forms document possession of the sample from collection through laboratory receipt, including transfer, handling, and shipping of samples.

Sample custody and documentation procedures will be followed to preserve sample integrity and to confirm the validity of field and laboratory data. As a result, sample data will be traceable from the time and location of sample collection through chemical analyses and data reporting. The following information will be recorded on the COC form that will accompany samples to the laboratory:

- Sample ID
- Sampling date and time
- Required analyses
- Number of containers
- Sample Manager (or designee) signature

The objective of the custody identification and control system for the samples is to confirm, to the extent practicable, that the following occur:

- Samples scheduled for collection are uniquely identified.
- The correct samples are analyzed and are traceable to their records.
- Samples have been appropriately preserved.
- Samples are protected from loss or damage.
- A record of sample integrity is established.
- Legally traceable custody and possession records are maintained.

Observe general documentation rules, including the use of blue or black ink. Make any changes to the COC form by drawing a single line through the incorrect information and initialing the mark-out. Put a line through and initial blank lines on the COC form.

Upon receiving the samples, the laboratory's representative shall do the following:

- Sign and keep copies of shipping documents.
- Sign the COC form and return the second copy to the URS Project Manager or designee (may be included with the analytical results).
- Measure and document the temperature of the samples using temperature blank.
- Document the condition of the custody seals and of the samples.
- Notify the URS Project Manager or designee if any breakage or improper preservation has occurred or if there is a discrepancy between the COC form, sample labels, and requested analyses.
- Provide copies of the above documentation to the URS Project Manager or designee with the final laboratory data package.
- At the laboratory, custody of samples will be in accordance with the laboratory's SOPs from sample receipt through sample residual disposal.

This procedure provides technical guidance and methods for the management, storage, characterization, transportation, and disposal of waste generated. Waste generated at the Site during field activities is referred to as Investigation Derived Waste (IDW). The project has been carefully designed to avoid the creation of a substantial volume of IDW. IDW will be properly managed and disposed off-Site in compliance with RCRA, CERCLA, and other applicable legal authorities as detailed below or in the Work Plan. All activities will be conducted in accordance with the site-specific Health and Safety Plan (HASP).

1.0 MATERIALS AND EQUIPMENT

- Personal protective equipment (PPE) as outlined in the HASP; and
- Labeling materials (e.g., permanent markers, labels, etc.).

2.0 APPLICABLE LAWS, REGULATIONS, AND GUIDANCE

This procedure is designed to confirm that all waste generated during the course of the investigation is managed in compliance with applicable laws and regulations. It is also based on waste management policy and guidance documents, such as the "*Guide to Management of Investigation-Derived Wastes"* (U.S. Environmental Protection Agency [EPA] 1992). CERCLA activities conducted entirely on Site must comply with the substantive requirements of other applicable laws and regulations, but not permitting and other procedural requirements. CERCLA activities conducted off Site, however, must comply with both administrative and substantive requirements. See CERCLA Section 121 (e).

Off-site disposal of CERCLA waste will be in compliance with CERCLA Section 121 (d)(3) and 40 C.F.R Section 300.440 (also known as the "CERCLA Off-Site Rule"), as well as applicable NRC, DOT, RCRA, and state regulations, as further explained below or in the Work Plan.

3.0 TYPES AND MANAGEMENT OF IDW

<u>Solid IDW may include the following</u>:

- Drill cuttings or soil/rock.
- Disposable used PPE (e.g., gloves) and other disposable investigation materials (e.g., paper towels).
- Trash

PPE and trash will be disposed of in a normal trash receptacle following their usage in the field.

<u>Liquid IDW may include the following</u>:

- Groundwater produced by well development or purging, etc.
- Decontamination water.

Solid and liquid IDW shall be containerized in proper containers, in good repair, which are suitable for short-term storage, transportation, and disposal by a subcontractor. Examples of proper containers include DOT-approved steel or plastic drums, roll-off containers, and fractionation tanks.

Spray bottle discharge from the washing of small sampling equipment within each sample collection point. The spray discharge may be considered *de minimis* and may be discharged to the ground at the corresponding sampling locations.

4.0 LOG BOOK DOCUMENTATION

An inventory log of waste will be entered into the log book and must include the following**:**

- Project Name
- Name of person logging the waste
- Date waste generated
- Type of waste material (e.g., PPE, instrument, or trash), and solid or liquid
- Estimated waste volume
- Characterization and disposition of equipment and instruments.
- Comments
- Any variance to procedures described in this procedure

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1992 (April). *Guide to Management of Investigation-Derived Wastes*. Office of Emergency and Remedial Response Hazardous Site Control Division. OSWER Publication Number 9345.3-03FS.

U.S. Occupational Safety and Health Administration (OSHA) Standard – Ionizing Radiation – 29 C.F.R. 1910.1096

U.S. OSHA Standard – Ionizing Radiation – 29 C.F.R. 1926.53

Department of Transportation Standard – Hazardous Materials and Oil Transportation – 49 C.F.R. 100-180