DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 49TH WING (ACC)
HOLLOMAN AIR FORCE BASE, NEW MEXICO

ENTERED

28 June 2016

ADAM M. KUSMAK, GS-13, USAF
Chief, Installation Management Flight (49 CES/CEI)
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JUN 30 2016
NMED
Hazardous Waste Bureau

New Mexico Environment Department
Attn: Mr. John Kieling, Chief
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6063

Re: **Final Groundwater Monitoring Plan, SS-017 – Base Exchange Gas Station Fuel Spill (Area of Concern Q)**
Holloman Air Force Base, Alamogordo, NM
Contract No. FA8903-13-C-0008

Dear Mr. Kieling,

Attached is the *Final Groundwater Monitoring Plan, SS-017 – Base Exchange Gas Station Fuel Spill (Area of Concern Q)* 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,

Digitally signed by KUSMAK.ADAM.M.1263331806
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USAF, cn=KUSMAK.ADAM.M.1263331806
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ADAM M. KUSMAK, GS-13, USAF

Attachment(s):

Final Groundwater Monitoring Plan, SS-017 – Base Exchange Gas Station Fuel Spill (Area of Concern Q). Hard copy and CD.

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

FINAL GROUNDWATER MONITORING PLAN
SS-017 – BASE EXCHANGE GAS STATION FUEL SPILL (AREA OF CONCERN Q)

June 2016

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

HOLLOMAN AIR FORCE BASE, NEW MEXICO

FINAL GROUNDWATER MONITORING PLAN FOR SITE SS-017

June 2016

Prepared for:

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

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14. ABSTRACT
This Groundwater Monitoring Plan specifies the activities that will be performed in support of the groundwater monitoring to be conducted at Site SS-017, Holloman Air Force Base, New Mexico. The purpose of this plan is to provide guidance for the groundwater sampling and water level measurements of wells installed at the site required to evaluate impacts to groundwater associated with the site and the efficacy of actions taken to address those impacts.

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Site SS-017, groundwater monitoring, total petroleum hydrocarbons, volatile organic compounds

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PREFACE

This Groundwater Monitoring Plan addresses the groundwater monitoring activities that will be performed for SS-017, Base Exchange Gas Station Fuel Spill, at Holloman Air Force Base, New Mexico. The purpose of the plan is to provide guidance for the annual groundwater sampling of 23 existing groundwater monitoring wells located at and within the vicinity of the site. The samples will be analyzed for volatile organic compounds, polynuclear aromatic hydrocarbons, total petroleum hydrocarbons (gasoline-range organics, diesel-range organics, and oil-range organics), total dissolved solids, total iron, total and dissolved manganese, and anions.

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 Air Force Base Environmental Restoration Chief, Ms. DeAnna Rothhaupt. URS Group, Inc., as a subcontractor to FPM Remediations, Inc., has prepared this Groundwater Monitoring 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 Program Project Sites at Holloman Air Force Base.

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ACRONYMS AND ABBREVIATIONS

AISEB	Aerobic In Situ Enhanced Bioremedation
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
amsl	above mean sea level
bgs	below ground surface
COCs	Constituents of Concern
EPA	U.S. Environmental Protection Agency
DCE	1,1-Dichloroethene
FPM	FPM Remediations, Inc.
ft	feet
IRP	Installation Restoration Program
GMP	Groundwater Monitoring Plan
MW	monitoring well
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
PCE	Tetrachloroethene
PCS	Petroleum Contaminated Soil
QA/QC	Quality Assurance/Quality Control
SIM	selected ion monitoring
SOP	standard operating procedure
SSL	Soil Screening Level
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TOC	top of casing
TPH	Total Petroleum Hydrocarbons
URS	URS Group, Inc.
USAF	U.S. Air Force
UST	underground storage tank
VOC	volatile organic compound
µg/L	microgram per liter

1.0 INTRODUCTION

This Groundwater Monitoring Plan (GMP) addresses the groundwater monitoring activities that will be performed for the Spill Site #17 (SS-017) located on the southwest side of First Street in the main portion of the Holloman Air Force Base (AFB) approximately 2,500 feet (ft) from the main gate. 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. (FPM), has prepared this GMP in accordance with the Performance-Based Remediation Contract for Cannon, Holloman, and Kirtland AFBs located in New Mexico, and Luke AFB located in Arizona. Monitoring will be performed to refine the current understanding of the nature and extent of constituent impacts on groundwater underlying the site. In addition, monitoring will support the evaluation of interim measures undertaken to address constituents that are adversely impacting the groundwater and to confirm that those measures have adequately reduced constituent concentrations to levels that no longer pose an unacceptable risk to human health and the environment.

Current facilities adjacent to the SS-017 site include the Base Medical Facility located approximately 420 ft to the northeast, an intermediate school located approximately 600 ft to the northwest, and residential base housing located 200 ft to the southwest. The former base exchange (BX) gas station occupied approximately 1.5 acres, began operations in the early 1950s, and contained five underground storage tanks. In January of 1981, discrepancies in the gasoline storage inventories led to the discovery of leaking underground fuel lines (Walk, Haydel & Associates [WHA], 1988). Subsequent excavations in the vicinity of the tanks verified that the fuel lines had leaked. The five tanks were removed in February 1992 and were replaced with aboveground storage tanks. The gas station was demolished with a new facility construction 0.5 miles to the north along the east side of First Street in 2001 where it remains in operation today.

1.1 Purpose and Scope

This plan describes the long-term groundwater monitoring requirements for SS-017. The purpose of this plan is to provide guidance for the groundwater sampling and gauging at the 23 existing monitoring wells at the SS-017 site located within the area defined by the SS-017 groundwater plume. This plan presents the following elements:

- General site map showing Holloman AFB in relation to the State of New Mexico and the location of SS-017 within Holloman AFB
- A site map showing the location of the existing groundwater monitoring wells
- General site description and history
- Groundwater monitoring requirements
- Quality assurance/quality control (QA/QC) sample requirements
- Documentation and reporting requirements

The groundwater monitoring activities may be revised to reflect changes in the monitoring scope or schedule upon agreement with the New Mexico Environment Department (NMED).

2.0 BACKGROUND AND HISTORY

The following sections present a brief background and history of previous investigations and a discussion of a treatment system and injection wells that had been installed at the site to address the groundwater impacts.

2.1 Previous Investigations

A brief discussion of the SS-17 site history is presented in this subsection. All of the information was obtained from the following documents:

- *Gasoline Extent Investigation, Exchange Texaco Station, Holloman Air Force Base, New Mexico* (El Paso Testing Laboratories, 1981).
- *Installation Restoration Records Search For Holloman Air Force Base, New Mexico* (CH2M Hill, 1983).
- *Installation Restoration Program, Phase II Site 17 Field Evaluation Base Exchange Service Station Report, Holloman AFB, New Mexico* (Dames & Moore,1984).
- *Phase IV, Recovery Project BX Gas Station Leak Data, SS-17 (Hazardous Materials Technical Center [HMTC]*, June 1987).
- *Final Installation Restoration Program Remedial Investigation Site 17 BX Station Technical Report Holloman Air Force Base, New Mexico* (WHA, 1988).
- *Final Installation Restoration Program, Remedial Investigation Report, Site 17 BX Service Station Addendum 1, Holloman Air Force Base, New Mexico* (WHA,1990).
- *Final Corrective Action Plan for Site SS-17, BX Service Station, Holloman Air Force Base, Alamogordo, New Mexico* (WHA, 1992).
- *SVE Remediation System BX Service Station, Holloman Air Force Base, New Mexico* (Foster Wheeler Environmental Corporation [FWENC], 1995).
- *Draft Final Work Plan Remediation at Site SS-17 BX Service Station, Holloman Air Force Base, New Mexico Volume I – Field Operations Plan* (Ebasco Services Inc., 1995).
- *2005 Final Long Term Monitoring Report, Holloman Air Force Base, New Mexico (Bhate Environmental Associates Inc.* (Bhate, Environmental [Bhate], 2006).
- *Groundwater Characterization Report Site SS-17, Holloman Air Force Base, New Mexico* (NationView, 2011a).
- *Supplemental Accelerated Corrective Measures Work Plan, SS-17 BX Gas Station Fuel Leak, Holloman Air Force Base, New Mexico* (NationView, 2013)
- *Final SS-17 (AOC-Q) Long Term Monitoring Annual Report – 2015, Holloman Air Force Base, New Mexico* (NationView, 2016).

The Basewide LTM program was designed as a 10 year program with monitoring performed once every two years at multiple sites across HAFB. LTM sampling events were conducted by FWENC in August 1995, September 1997, September 1999, September 2001, and April 2003. The final LTM sampling event was performed by Bhate in December 2005. Throughout the LTM program, groundwater samples collected from monitoring wells at SS-17 were analyzed for volatile organic compounds (VOCs) and total dissolved solids (TDS). Due to construction activities and well abandonment, only three of the 22 previously installed monitoring wells at SS-17 remained operational by December 2005, MW-BX-01, MW-BX-02, and W-4. Of the three monitoring wells sampled during the 2005 LTM, only groundwater from one well (MW-BX-02) had constituent concentrations (benzene and 1,2-dichlorethane [1,2-DCA]) above applicable action levels. Historically, 1,2-DCA was utilized as an anti-knock additive in leaded fuels (to note, the spill occurred during 1970's – 1980's).

Excavations of petroleum impacted soils were conducted annually between August 2003 and December 2012, with the exception of 2010 and 2011. Table 1 summarizes the areas, depth, and volumes excavated during each of the annual campaigns. Petroleum contaminated soil (PCS) excavation operations were conducted in a series of annual removal actions which were initiated in 2003 and have continued to the present day. To determine the effectiveness of the PCS removal actions, confirmation samples were collected from the sidewalls and bottom of the excavations and analyzed for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC) and TPH in accordance with the Revised Final Letter Work Plan for Petroleum Contaminated Soil Excavation at SS-17, FT-31, and West POL Yard, Holloman Air Force Base, New Mexico (FWENC, 2003). PCS were transported offsite to either the NMED permitted FT-31 Landfarm, or the Rhino Environmental Landfarm, located in Otero County, New Mexico.

Due to an insufficient number of monitoring wells (3) comprising the SS-17 monitoring well network, NationView was contracted to expand the network (up gradient, down gradient, and cross gradient) to evaluate the petroleum related groundwater impacts in the vicinity of the former BX Gas Station. In May 2012, NationView installed and developed 19 new monitoring wells (SS17-MW01 through SS17-MW03 and SS17-MW05 through SS17-MW20).

In June 2012, the 22 wells were sampled and the samples submitted for analysis of VOCs, semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), Target Analyte List (TAL) metals, TDS, and monitored natural attenuation (MNA) parameters. The primary constituents of concern (COCs) detected in the groundwater samples above applicable action levels included several fuel related compounds (e.g. benzene, toluene, ethylbenzene, xylenes, naphthalene, and TPH). Results of the June 2012 sampling event identified that the distribution of groundwater impacts were centered within the northeastern boundary of the site along First Street.

PCS removal actions (2012) were completed subsequent to the demolition of the former Thrift Shop . During demolition of the former Thrift Shop (Bldg 19) SS17-MW12 was destroyed (August 24-26, 2012). NMED, in correspondence dated October 5, 2012 (NMED, 2012b) requested soil samples be collected from two up gradient locations and approved the installation of three additional monitoring wells (SS17-MW21, SS17-MW22, and SS17-MW23) to help delineate the up gradient and down gradient extents of the groundwater impacts identified at SS-17.

An Aerobic In Situ Enhanced Bioremedation (AISEB) treatment system was installed at the SS-17 Site and began operation in May 2013 (The AISEB system is described in greater detail in Section 2.2). NationView installed monitoring wells at the northern and southern extents of the AISEB treatment zones (SS17-MW21 and SS17-MW23) and SS17-MW22 northwest of the former Thrift Shop (Bldg 19) location, in order to replace SS17-MW12, which was destroyed during the demolition of the Thrift Shop. Groundwater monitoring wells SS17-MW21 through SS17-MW23 were installed in May 2013.

In accordance with the *Final Supplemental Accelerated Corrective Measures Work Plan, SS-17 BX Gas Station Fuel Leak, Holloman Air Force Base, New Mexico* (NationView, 2013), six wells (MW-05, MW-07, MW-08, MW-21, MW-22 and MW-23; shown on Figure 2) were sampled quarterly (August 2013, November 2013, February 2014, and May/June 2014) for VOCs, SVOCs, TPH, TAL metals, TDS, and MNA parameters. These events constituted Quarters 1 through 4 of fiscal year 2014 monitoring. Based on the results of prior sampling activities (August 2011 through May 2012 [Refer to Appendix B of the supplemental work plan, Tables 2-8 through 2-10 for historic groundwater and soils data]), the primary COCs detected in the SS-17 groundwater samples above applicable action levels included several fuel related compounds (e.g. benzene, toluene, ethylbenzene, xylenes, naphthalene, and TPH). Results of the quarterly monitoring events identified that the distribution of groundwater impacts remained centered within the northeastern portions of the SS-17 site, along First Street.

In 2015, well SS17-MW15 was accidentally destroyed during on-going construction activities. Given the cross-gradient location of the well along the eastern edge of the plume and the presence of other wells in the vicinity, the loss of this well should not adversely impact the overall monitoring network for SS-017.

In May 2014, NationView collected samples at six soil boring locations in the northeast portions of the SS-17 site, along the walkway that borders First Street. The analytical results support the findings that the impacts are centered along First Street, in the northeastern portions of the SS-17 site. The subsurface soil data collected from the excavation sidewall sampling (October 2012) and the subsurface soil investigation (November 2012) served as the baseline soil sampling event for performance monitoring.

2.2 Treatment System and Injection Wells

NationView prepared the *Final Supplemental Accelerated Corrective Measures Work Plan, SS-17 BX Gas Station Fuel Leak, Holloman Air Force Base, New Mexico* (USACE Contract Number W9128F-09-D-0055, Task Order 0004), to perform remedial actions at Site SS-017. The selected SS-017 remedy in place included excavation of the accessible PCS source areas located in the vicinity of the former BX Gas Station and in-situ treatment (via oxygen injection) in areas where the excavation of PCS is not feasible (i.e., beneath First Street and the utility corridors).

An AISEB treatment system was installed and began operation at the SS-017 site in May 2013. Two wells were installed so the screened sections were located in the aquifer at or immediately below the contamination zone beneath First Street. This configuration was believed to have maximized the injection wells radius of influence, aided in oxygen distribution to Treatment Zones A and B, and limited the untreated volume of "dead-zones" or areas that did not receive oxygen immediately from the wells. Natural groundwater flow direction assist in oxygen delivery throughout the aquifer. Injection wells SS17-IJ01 and SS17-IJ02 are used in conjunction with the AISEB treatment system to treat approximately 100,500 cubic feet (3,722 cubic yards) of PCS contained in the groundwater beneath First Street. Figure 3, extracted from Figure 2-6 of the *Final SS-17 (AOC-Q) Long Term Monitoring Annual Report – 2015, Holloman Air Force Base, New Mexico* (NationView, 2016) shows the location of the AISEB treatment system and inlets to injection wells SS17-IJ01 (Zone A) and SS17-IJ02 (Zone B).

The treatment system included a rotary vane blower, programmable logic controller, control panel, manifold header, and electrically actuated solenoid valves. The treatment system was housed in a self-contained, fully enclosed utility trailer with locking capability. The trailer was mobilized to the site and leveled, followed by the installation of hurricane tie-down straps for relative permanence. Upon completion, a chain link fence equipped with a locking gate was installed around the treatment trailer.

The AISEB system installed was designed to deliver only enough oxygen to enhance microbial degradation of the petroleum-based contaminants. The system was automated, using timer-controlled solenoid valves to alternate between Zone A and Zone B which correspond to injection wells SS17-IJ01 and SS17-IJ02, as each injection point was individually piped and controlled to allow for discrete adjustments to the system.

The system pressurized both Zone A and Zone B injection wells, continually. Peak performance for Zone A required 74 cubic feet per minute; Zone B required 50 cubic feet per minute. In accordance with the system design, one injection well was operated at peak performance, while the second zone was reduced to a managed pressurization rate, to ensure moisture did not gather in the injection wells. As such, performance pressurization was alternated between Zone A and Zone B, on a daily basis.

Upon review of the analytical groundwater data in 2015, it was determined that the system was not effectively treating the constituents as desired. Therefore, operation of the system was discontinued and aboveground system components have been removed.

3.0 LONG-TERM GROUNDWATER MONITORING

3.1 Monitoring Requirements

Groundwater samples will be collected from the 23 existing monitoring wells associated with and in the vicinity of SS-017 as described in the *Final Uniform Federal Policy Quality Assurance Project Plan, SS-017, Holloman Air Force Base, New Mexico* (URS 2015b). Groundwater sampling and analysis will initially be conducted in 2016 to establish a current analytical baseline for the site. Following the completion of interim measures to address groundwater contamination at the site tentatively scheduled to occur in 2017, quarterly monitoring will be performed for a period of up to two years to demonstrate that the interim measures were successful in reducing constituent concentrations to levels that no longer impact groundwater.

The proposed groundwater monitoring network is displayed on Figure 2. Table 2 lists the monitoring wells to be sampled within the monitoring well network associated with the SS-017 site and incorporates survey and well construction information for each well.

Groundwater sampling of the monitoring wells will be conducted initially to provide a baseline dataset, then quarterly following implementation of the interim measures for a period of up to two years. Water level measurements will be taken prior to well purging and sample collection during each sampling event. Samples will be collected and analyzed for the parameters as provided in Table 3. Water quality parameter measurements will be collected during sampling. Sample handling, analyses, and quality assurance/quality control (QA/QC) procedures will comply with the requirements defined in the *Final Uniform Federal Policy Quality Assurance Project Plan, SS-017, Holloman Air Force Base, New Mexico* (URS, 2016b).

Annual LTM reports will be submitted to present the analytical data collected.

3.2 Pre-Sampling Activities

The Holloman AFB personnel will be contacted, as necessary, prior to the annual monitoring events to provide notification of impending activities. The NMED will be notified, as required, of groundwater sampling events to allow for coordination of regulatory oversight activities. The project laboratory will also be notified of each groundwater sampling event, including the number of samples expected to be collected for each specified analysis.

3.3 Health and Safety

All field work will be completed in accordance with 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)* (URS, 2014). A daily safety tailgate meeting will be conducted at the beginning of each work day. This will include reviewing site-specific safety concerns and the job safety analyses. Personal protective equipment required for this work is not expected to exceed Level D which includes steel-toed boots, nitrile gloves for sample collection, leather gloves, hard hats, safety glasses, and a high-visibility reflective safety vest when on site.

3.4 Groundwater Level Measurements

Groundwater level measurements will be collected in accordance with the requirements delineated in Appendix A-1, “Measurement of Groundwater and Fluid Levels in Wells”. 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 23 existing monitoring wells located at SS-017 at the time of sample collection. Static water levels and total well depth will be measured prior to purging activities.

3.5 Sample Collection Methods

The monitoring wells will be purged and groundwater samples will be collected in accordance with the requirements delineated in Appendix A-2, “Monitoring Well Purging and Groundwater Sampling”. During the purging of each well, field parameter data will be collected in accordance with Appendix A-3, “Measurement of Groundwater Field Parameters”.

3.6 Equipment Decontamination

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

3.7 Sample Labels

Each sample will be labeled with a unique identifier and recorded in the field logbook (Appendix A-5, “Sample Identification, Management, and Handling”) 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., SS17-MW01)
- Date sampled (MMDDYY)

Under this sample designation format, sample “SS17-MW01-072516” corresponds to a sample collected from monitoring well SS17-MW01 on July 25, 2016.

3.8 Chain-of-Custody

All samples will be accompanied by a chain-of-custody in accordance with Appendix A-5, “Sample Identification, Management, and Handling”. 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.

4.0 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.

4.1 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. The precision goal for field duplicate analyses will be plus or minus a 35 relative percent difference.

4.2 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.

4.3 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.

4.4 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.

5.0 INVESTIGATION-DERIVED WASTE

The investigation-derived waste generated during the groundwater monitoring will include spent and unused sample material, personal protective equipment, miscellaneous sampling supplies, decontamination water, purge water, and samples. The investigation-derived waste will be managed in accordance with Appendix A-6, "Investigation Derived Waste Management". 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)

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 New Mexico Administrative Code 6.2).

A Notice of Intent to discharge purge and decontamination water classified as non-hazardous will be prepared following each sampling event 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.

6.0 RECORDKEEPING

URS will maintain a field logbook in accordance with Appendix A-5, “Documentation”, 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
- General observations

7.0 REPORTING

Upon receipt of analytical results from sampling activities, URS will prepare a written report summarizing the groundwater monitoring. The annual monitoring reports will summarize field activities, observations, and results. The report will include the evaluation of trends and statistical analysis, as appropriate.

Analytical results will also be presented within the report in a table format, and include sample identifier, date and time of collection, sample location, and concentrations. Analytical results will be compared to the applicable NMWQCC standards. Field notes and laboratory reports will be included as appendices within the report.

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

8.0 REFERENCES

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20 § 6.2 NMAC. Ground and Surface Water Protection, New Mexico Administrative Code, Title 20, Chapter 6, Part 2. Current Revision.

TABLES

Table 1. Summary of Excavations Conducted from 2003 to 2012

Year	Area (sq ft)	Average Depth (ft bgs)	Volume (cubic yards)
2003	23,000	10	7,000
2004	13,000	10	3,000
2005	7,000	15	9,300
2006	21,000	15	11,800
2007	12,500	12.5	5,900
2008	39,000	13.5	18,750
2009	13,100	13.5	6,640
2012	23,400	12.5	11,000

bgs – below ground surface
ft - feet
sq ft – square feet

Table 2. Groundwater Monitoring Well Network

Well	Northing	Easting	Elevation TOC (ft amsl)	Diameter (inches)	Screen Interval (ft bgs)	Total Depth (ft bgs)
SS17-MW01	3633858.80	399355.25	4072.97	2	6.25 - 16.25	17
SS17-MW02	3633803.70	399298	4069.81	2	6.75 - 16.75	17
SS17-MW03	3633802.39	399375.54	4071.89	2	6.75 - 16.75	17
SS17-MW05	3633800.92	399429.49	4073.1	2	6.75 - 16.75	17
SS17-MW06	3633759.82	399406.23	4072.88	2	6.75 - 16.75	17
SS17-MW07	3633767.16	399459.7	4072.84	2	5.75 - 15.75	17
SS17-MW08	3633745.89	399478.26	4072.73	2	6.75 - 16.75	17
SS17-MW09	3633730.15	399329.99	4069.4	2	6.75 - 16.75	17
SS17-MW10	3633729.58	399370.45	4070.91	2	6.75 - 16.75	17
SS17-MW11	3633712.23	399398.99	4071.22	2	6.75 - 16.75	17
SS17-MW13	3633695.68	399360.38	4069.53	2	6.75 - 16.75	17
SS17-MW14	3633749.65	399518.65	4073.39	2	6.75 - 16.75	17
SS17-MW16	3633674.96	399582.81	4072.33	2	6.75 - 16.75	17
SS17-MW17	3633623.75	399372.85	4069.63	2	6.75 - 16.75	17
SS17-MW18	3633646.88	399431.37	4070.14	2	6.75 - 16.75	17
SS17-MW19	3633599.62	399401.96	4069.51	2	6.75 - 16.75	17
SS17-MW20	3633581.63	399477.17	4067.82	2	6.75 - 16.75	17
SS17-MW21	3633813.227	399393.976	4071.851	2	7 – 17	17
SS17-MW22	3633716.174	399439.047	4073.108	2	7 – 17	17
SS17-MW23	3633717.162	399479.803	4072.622	2	7 - 17	17
W-4	3633814.300	399442.23	4074.62	2	5 - 15	15
MW-BX-01	3633684.42	399480.19	4073.32	Unknown	Unknown	Unknown
MW-BX-02	3633678.68	399409.21	4070.04	Unknown	Unknown	Unknown

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

Table 3. Groundwater Sample Analyses and Methods

Analysis	Method
Volatile organic compounds	SW-846 Method 8260B
Semivolatile organic compounds (polynuclear aromatic hydrocarbons)	SW-946 Method 8270 SIM
Total petroleum hydrocarbons	SW-846 Method 8015M
TPH-Gasoline-range organics	SW-846 Method 8015M
TPH-Diesel-range organics	SW-846 Method 8015M
TPH-Oil-range organics	SW-846 Method 8015M
Iron	SW-846 Method 6010C
Manganese	SW-846 Method 6020A
Total dissolved solids	SW-846 Method 2540C
Sulfate and Chloride	EPA Method 300.0
Nitrate/Nitrite	EPA Method 353.2
EPA – U.S. Environmental Protection Agency SIM – Selective Ion Monitoring	

FIGURES

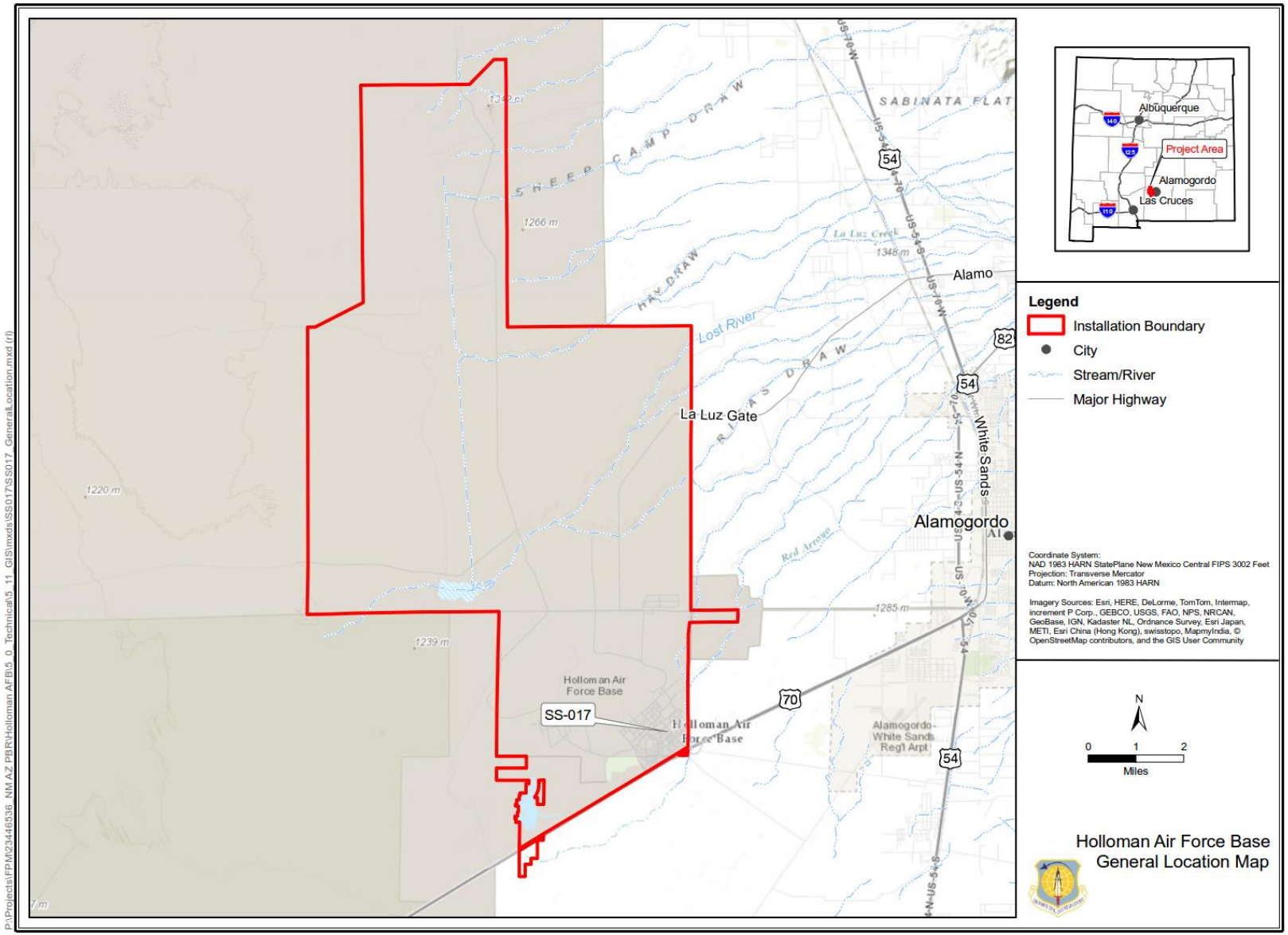

Figure 1. SS-017 Site Location

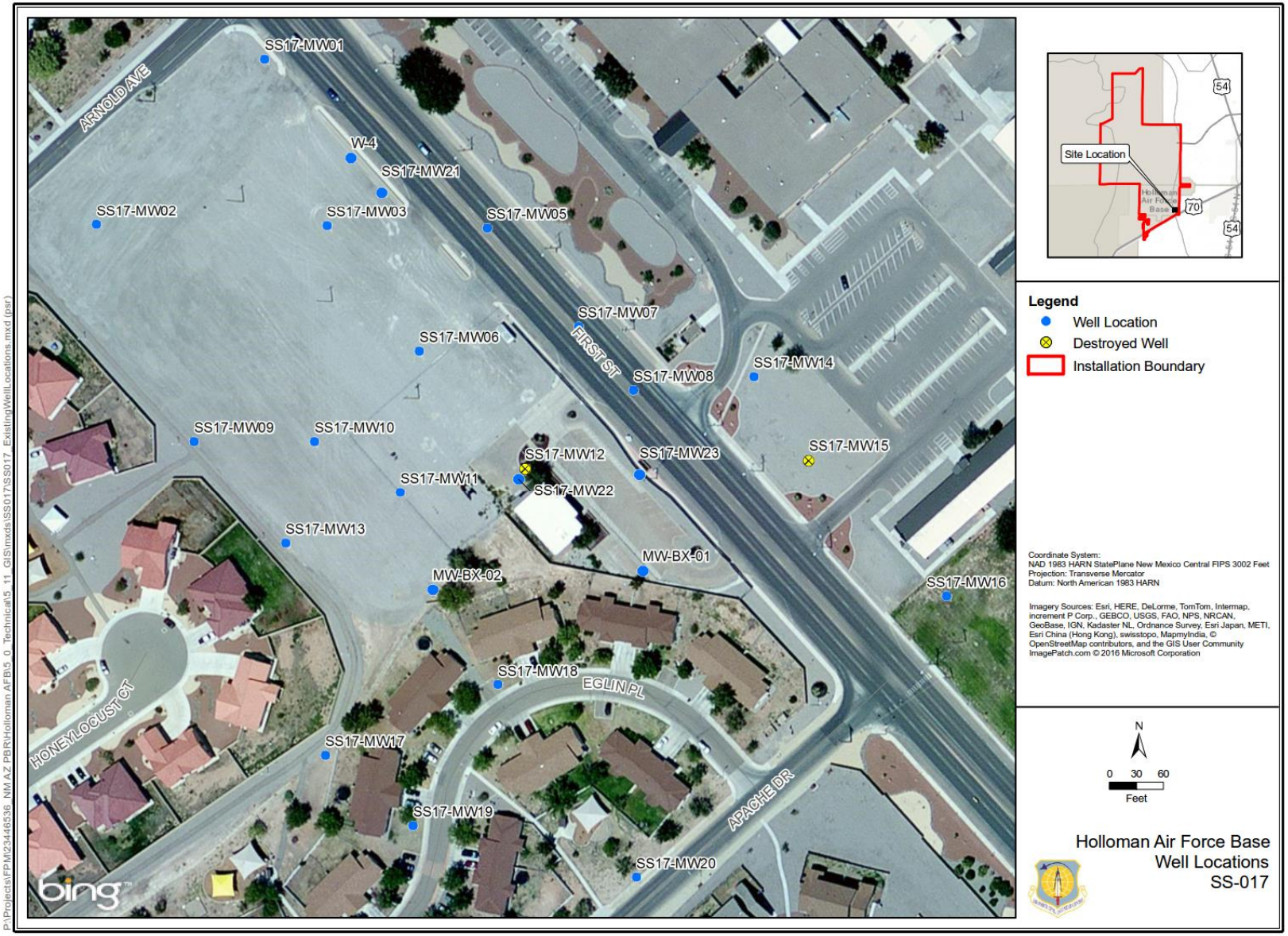

Figure 2. Existing Monitoring Well Locations

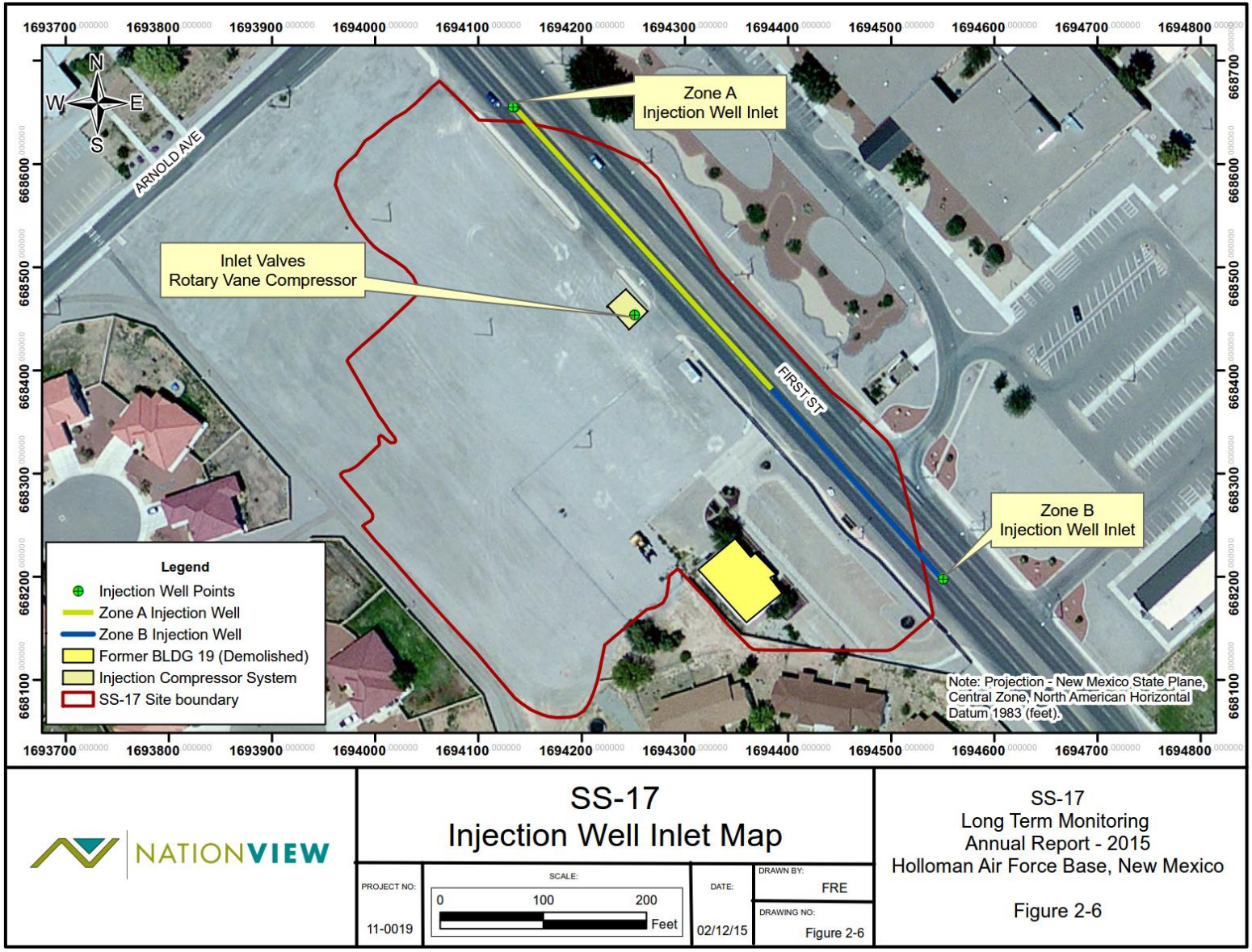

Figure 3. Aerobic In Situ Enhanced Bioremediation Treatment System

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